MARINE SCIENCE

Paper 9693/11
AS Level Theory

Key messages

Candidates need to develop their knowledge and understanding in chemistry. This will allow for greater detail and accuracy in responses.

Candidates would benefit from more practice in how to correctly present a word equation and in writing the formula of a molecule correctly using capital and lower case letters and superscript and subscript numbers accurately.

Candidates also need to ensure they read questions carefully to ensure they are using correct values in calculations.

Candidates should ensure they complete all parts of each question.

General comments

Candidates showed a good understanding of many parts of the specification, and stronger candidates were about to use scientific terminology well.

The majority of candidates answered most questions.

Comments on specific questions

Section A

Question 1

(a) (i) More candidates were able to state proton and positive than neutron and neutral. Some candidates also gave electron and negative or electron and neutral. Candidates should know both the type of charge and the size of the charge, e.g. proton 1+, electron 1–, neutron neutral. 'No charge' for neutron was not precise enough.

(ii) Many candidates incorrectly named sodium chloride here, but some candidates were able to name calcium carbonate. However, far fewer were able to accurately write the formula. Candidates should be aware that the formula is CaCO3, not CACO3 or CaCo3. Many candidates needed a greater understanding of how to correctly write chemical formulae.

(iii) Only stronger candidates answered this correctly. Others stated that hydrogen is positive rather than saying that hydrogen has a slight positive charge, or stated that sodium is partially positive when they had correctly stated that there was a slight charge for either hydrogen or oxygen. Some candidates thought the sodium and oxygen then bonded rather than just being attracted to each other.

(b) (i) Many candidates understood that water molecules slowed down or lost kinetic energy as water froze, but fewer were able to give more detail. Many candidates stated that the molecules became closer together and so density decreased, which was a contradiction.

(ii) Only stronger candidates recognised that there was a conversion to do before completing the calculation (mass was given in grams, density in kg/m3). Most candidates knew the correct formula

for the calculation, and so often gained partial credit. Some candidates over or under rounded their answers, and answers that were to 4, 5 or 6 significant figures were accepted. Candidates should apply the mathematical requirement of rounding to the same number of significant figures as given in the numbers for the calculation.

Question 2

(a) (i) Many candidates gained partial credit and demonstrated an understanding of features of vertebrates in early development. However, a significant number of candidates gave responses that were too imprecise for credit.

(ii) Many candidates were able to identify gill slits. Some candidates identified gill slits but they did not draw a line using a ruler or included arrowheads or simply drew a circle around the feature. The specification requires that candidates can correctly label using a straight line with no arrowheads to identify features.

(b) (i) The majority of candidates correctly identified kingdom and genus and *Carcharhinus melanopterus* in the correct places of the table. A few candidates gave both genus and species name for the species or incorrectly placed *Carcharhinus* and *melanopterus* in the opposite places.

(ii) Fewer candidates were able to give fatty acids and glycerol, with a significant number stating glucose instead of glycerol, and some giving amino acids and glucose as their answer.

(iii) Stronger candidates were able to correctly state phosphates, with many other candidates stating phosphorus oxide. Slightly more candidates were able to state a use of phosphate ions correctly, often stating DNA.

(c) Most candidates were able to interpret the information provided with many candidates scoring at least partial credit and many gaining full credit. Weaker candidates gave the information in the question without adding anything further to their answer.

Question 3

(a) Candidates showed some understanding of the differences between weathering and erosion. Some candidates understood that one was the breakdown of rocks, and the other was removal of the sediment, but gave them in the incorrect places, and in the weathering section some candidates made statements such as ‘weathering is the erosion of rocks’. Candidates need to use these terms accurately and be aware of the difference between them.

(b) Only the strongest candidates gained full credit here. More candidates mentioned salt exclusion by the roots, than air taken in by the roots, with many also mentioning lenticels. A few candidates mixed up denticles with lenticels. For the prop roots, candidates often did not mention prop or they just stated ‘prop roots’ without any further description of them.

(c) (i) Many candidates mentioned global warming or deforestation as one of their responses, which would have been more relevant in **(ii)**.

(ii) Candidates gave a range of reasons why human activities have led to a reduction in mangrove cover, often global warming and deforestation. Many candidates wrote ‘pollution’ without any further detail, which was required at this level. Candidates who referred to pollution from runoff, oil pollution or water pollution gained credit.

(iii) Some candidates did not round, or rounded incorrectly to give their answer to 3 significant figures. Most candidates were able to correctly identify 1200 and 1900 as being relevant numbers, but a significant number did not understand how to complete the calculation correctly.

Question 4

(a) A number of candidates did not recognise that the map was slightly different to maps they may be used to seeing, in that the Pacific Ocean was in the centre. Many candidates labelled the Pacific as being to the right of North America and South America. For the Southern Ocean, candidates were often not very careful about where they labelled it with a significant number labelling it in the Indian

Ocean or too high within the Pacific Ocean (e.g. on the coast of South America). A very small number of candidates used a label line to identify the location.

(b) (i) Candidates often only focused on one aspect of the graph, either the depths or the surface temperatures, with few considering both aspects. Many candidates achieved partial credit by correctly identifying that tropical and polar regions have more stable temperatures throughout the year, or the polar regions would not reach the higher temperature that the temperate regions did, or that the tropical regions would not go as low as the temperate region. Relatively few made any comments on the thermocline depths changing but a few mentioned that the one in March was more like a polar thermocline.

(ii) Many candidates knew that colder water is denser and gave the correct answer.

(iii) A significant number of candidates stated that primary productivity would be different rather than stating when it would be higher and then explaining their choice. Candidates needed to consider which factors would affect productivity leading to an increase in photosynthesis. Stronger candidates sometimes mentioned nutrient availability or hours of daylight.

(iv) Many candidates did not show an understanding of how to write a word equation correctly. A significant number of candidates used mixed word and symbol equations which was not acceptable and many used an equals sign rather than an arrow to show the reaction occurring. Some stronger candidates were able to correctly add sunlight and chlorophyll above and below the arrow but many candidates wrote sunlight as a reactant in the equation. Some candidates just gave carbon as a reactant rather than carbon dioxide. Some candidates needed a greater awareness of the differences between carbon, a solid, and carbon dioxide, a gas.

Section B

Question 5

Stronger candidates were aware of the two methods of feeding that the coral polyps may use, usually giving a good description of the symbiotic relationship with zooxanthellae, and gaining credit for capturing prey using their nematocysts. Weaker candidates usually made no mention of prey capture, but gave a good explanation of the symbiosis. Weaker candidates often spoke of the corals themselves photosynthesising, or knew there was a relationship with something else, but could not give any further details. A few candidates stated ‘zooplankton’ instead of ‘zooxanthellae’.

Question 6

There were many aspects to this question that candidates could have discussed, with some candidates able to give wide ranging answers covering a variety of points. Some candidates did not mention the zones on a rocky shore, instead talking about oceanic zones and the differences in light levels. Weaker candidates demonstrated a lack of knowledge in this area, and were often unable to give the names of the different zones, or anything about how these factors changed in the different zones, or how tides may cause the different conditions within the zones. Stronger candidates were often able to suggest species that resided in the different zones, or suggested species which showed competition between themselves, or with another named species.

Question 7

(a) Candidates found this a challenging question, with few commenting that the meltwater would be freshwater that could affect the salinity of the seawater. Many correctly stated that the meltwater would be colder and therefore denser, but often thought this would make the water move more slowly. A few candidates had a better understanding of the process and discussed the idea that the freshwater would float on the seawater due to its lower density. Some candidates gave a good explanation of the global conveyor belt, which gained credit, but they did not reflect on how the meltwater may influence these processes.

(b) Many candidates were able to score at least partial credit here, with many stating that drought conditions would occur in Australia. Other stronger candidates explained that this was because the prevailing winds were greatly reduced or reversed, so they would no longer travel to Australia across the Pacific Ocean. Some linked this with increasing temperature and a reduced fish stock or

reduction in crop production as a consequence. A few candidates were not clear in their answer, sometimes mentioning South America and conditions there instead.

MARINE SCIENCE

Paper 9693/12
AS Level Theory Paper

Key messages

- Calculations were generally done well. When completing calculations, candidates should remember to show all the workings and should express the value to an appropriate number of significant figures. An important skill that candidates should practise is the conversion of units in calculation questions. **Question 1(a)(ii)** was an example where this skill was particularly beneficial.

- A skill that candidates should practise is drawing and labelling of diagrams. All straight lines should be drawn with a ruler and care should be taken over accuracy of any labelling of lines and diagrams drawn. Some candidates did not gain the full credit available due to inaccurate drawing. Questions where this was particularly important were **Questions 4(b)(i)** and **4(c).**

- It is important to understand the difference between the command words in terms of response required. The terms 'describe', 'explain' and 'state' require different responses. Candidates should know the difference between these terms and the requirements of each. The difference in the responses required by the command words 'describe' and 'explain' were particularly important for **Questions 2(c)** and **4(b)(ii)**.

General comments

There was a high standard of scientific knowledge and understanding seen with many candidates providing detailed and accurate responses. There were very few questions where candidates did not offer any response, with most candidates attempting all questions on the paper.

Many candidates had a broad knowledge of the syllabus, but it was evident that some areas were better known than others.

For longer prose question in ***Section B***, it may be beneficial for candidates to plan out their answers on the blank pages to organise their thoughts before attempting the question. Very occasionally, candidates did not include all the information necessary to answer the question completely and planning out their responses may have aided them in answering each question fully.

Comments on specific questions

Question 1

(a) (i) Candidates were generally able to identify the core and the mantle. A common error was that candidates did not separate the continental crust and oceanic crust and instead labelled one of these the crust and the other an incorrect label, such as the lithosphere or the asthenosphere. Occasionally some candidates tried to separate the core into inner and outer core, then labelled the oceanic crust as the mantle and the continental crust as the crust.

(ii) Most candidates calculated this correctly with workings clearly shown. Some candidates did not pay attention to the units and did not convert their value from m to km.

(b) (i) The question asked for how continents provided evidence for continental drift, not just general evidence for continental drift. This led to some candidates describing other evidence, for example the spreading of the seafloor or carbon dating, which did not gain credit. However, correct answers relating to evidence from continents were frequently seen.

(ii) Most candidates were able to identify the direction of movement of the plates.

(iii) Most candidates gave the correct response of divergent.

(iv) Very occasionally there were some unclear responses that referred to too much pressure or lack of light preventing any life at the bottom of the sea. However, most candidates were able to suggest the formation of new rock or seafloor as the reason for the lack of fossils.

Question 2

(a) The majority of candidates could identify examples of the different types of weathering. Candidates should be reminded to draw straight lines with a ruler. Occasionally candidates drew lines to more than one box. Physical weathering was sometimes linked with transport of rocks.

(b) It appeared that some candidates confused weathering and erosion, giving the answers of physical, chemical and organic. Some candidates gave different examples of water erosion.

(c) For this question, there were many unclear descriptions and not many explanations. Many candidates referred to organisms fastening onto rock with no mention of muscular foot. Many talked about wave action and not desiccation and did not link this to the close-fitting shell. This question required two separate points; a description of the feature and then how it adapts it for the environment. Candidates often gave only partially complete explanations.

Question 3

(a) This question was generally answered well. A common error was to confuse the pelvic with the anal fin or pectoral fin.

(b) Candidates were generally able to match the group with the example from the blue shark. Occasionally the domain was given as Animalia and the phylum sometimes given as Eukarya.

(c)(i) Calculations were done well and workings shown but often the value of 60 per cent rather than 40 per cent was given.

(ii) The question asked for possible reasons for the decrease in export of dried shark fins. Many candidates gave several reasons for the decrease in shark population, which was not what question asked for, although this was one factor. The strongest responses included a variety of suggestions including reasons relating to legislation, catch effort and demand.

(d) Some candidates tried to answer this with no reference to sunlight. Another issue was quoting incorrect distances for both zones. Candidates seemed to be more familiar with the epipelagic than the mesopelagic zone. A few candidates described the mesopelagic zone as having no light, which did not gain credit.

Question 4

(a) Some candidates tried to describe the different types of plankton. Candidates should be reminded to use scientifically correct language. Several candidates described plankton as being small instead of microscopic. Many also referred to plankton's mobility rather than the more correct term of motility.

(b)(i) Candidates were generally able to draw an accurate pyramid of biomass. Sometimes the pyramids were drawn in order of size and not trophic level. Occasionally the pyramids were drawn as an actual pyramid rather than rectangular boxes.

(ii) Some candidates did not take their explanations far enough. Many talked about an increase in biomass rather than an explanation in terms of increased photosynthesis and reproduction, increasing population size and consumption. Candidates needed to explain the reason for the biomass increase or decrease. The strongest responses referred to photosynthesis and linked this to an increase in population and therefore biomass resulting in a larger food source for the copepods and so an increase in copepod population size.

(c) Most candidates were able to complete the food chain. Candidates should be reminded to use a ruler when drawing diagrams and to use the stimulus material as a guide to the expected look of the diagram. Some candidates tried to add another box for cucumber flesh instead of realising this would be the same organism as the sea cucumber. Some did not include an arrow going from sea cucumber to copepods. Candidates needed to draw the additions to the food web in the same style by placing the organisms in boxes with ruled straight lines for the arrows and the arrows touching the boxes.

Question 5

(a) There were some excellent responses seen, with many candidates laying out their work logically and with relevant detail. Some responses did not explain fully how the alignment of the Earth, Sun and Moon affected the strength of the gravitational pull on the water on Earth. Few candidates gave an initial explanation about how the Moon has a greater gravitational pull as it is closer to the Earth. Descriptions of resulting spring and neap tides were generally excellent.

(b) Very occasionally candidates repeated the information for **(a)**. However, many candidates were able to give reasonable explanations and did not just list the factors that affected tide height. Many candidates were able to give several different factors and a relevant explanation for each. Occasionally candidates showed a lack of detail in their responses and referred to, for example, onshore winds affecting tide height, without giving further detail as to how onshore winds affect tide height.

Question 6

(a) There were some excellent responses seen. Some candidates concentrated only on the description of the contents of sea water and did not describe the chemical properties enabling water to dissolve salt and other substances. Candidates who did describe the chemical properties of water, generally used scientifically correct terminology, referring to the polar nature of water and how this enables water to be a solvent. A common omission from many candidates was mention of the role of dissolved nutrients such as glucose in sea water.

(b) It was evident that some candidates had a lack of understanding about pH. Many knew about the effect of increase of atmospheric carbon dioxide and the resulting dissolution leading to a decrease in pH of sea water. The effect of a change in pH on coral reefs was often described in an unclear manner and was lacking in appropriate detail. Many candidates could describe coral bleaching, but fewer were able to explain the effect in terms of the calcium carbonate skeleton dissolving or the reduction in ability of coral to take up calcium carbonate.

MARINE SCIENCE

Paper 9693/13
AS Level Theory Paper

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(b) It was evident that some candidates had a lack of understanding about pH. Many knew about the effect of increase of atmospheric carbon dioxide and the resulting dissolution leading to a decrease in pH of sea water. The effect of a change in pH on coral reefs was often described in an unclear manner and was lacking in appropriate detail. Many candidates could describe coral bleaching, but fewer were able to explain the effect in terms of the calcium carbonate skeleton dissolving or the reduction in ability of coral to take up calcium carbonate.

MARINE SCIENCE

Paper 9693/21

AS Level Data-Handling and Investigative Skills

Key messages

Candidates should read the questions carefully and consider what the questions are asking them to do.

Candidates must use precise language. The use of the word 'amount' rather than specific quantities such as 'volume', 'number' or 'mass' sometimes meant that responses were not clear enough for credit to be awarded.

Candidates should be encouraged to practise graph construction and drawings along with drawing lines of best fit.

Candidates should be reminded of the need to manipulate data to support answers. There were many candidates who wrote down figures from data tables and graphs but did not manipulate them.

Candidates should always show their working out during calculations as it may be possible to gain partial credit even when the final answer is not correct.

Candidates should pay careful attention to the command word(s) in each question. Command words and what they mean can be found on page 39 of the syllabus.

Candidates should be encouraged to critically evaluate investigations to identify sources of error in both method and results. Evaluation of procedures and data is a part of A03. Centres can find more information in the 9693 Marine Science AS & A level syllabus.

General comments

Almost all candidates completed the paper but many found some of the questions very challenging. Candidates should be encouraged to carry out practical work in the classroom and in the field using simple appropriate equipment so that they gain confidence in describing scientific methods when required. Practical work is indicated in the syllabus with the symbols 'PA'. Describing methods, such as in **Question 4(a)(i)** based around taking samples on a shore and determining the solubility of salts in water **Question 5(b)(i)** were challenging for candidates.

Comments on specific questions

Question 1

(a) Many candidates made a good attempt at the drawing. Some candidates used a grid system for drawing the copepod which was good practice. The sizing of the diagrams was generally appropriate and this was usually credited. However, often not enough attention was taken to include the 8 extensions on the tail region and bristles along the length of the antennae. Some drawings were too sketchy. Candidates should draw well defined lines to create the outline. Most diagrams had reasonable proportions but many candidates drew antenna that were unequal in length. Some candidates used a pen instead of a sharp pencil.

(b) Many correct answers described the role of zooplankton as both consumer and consumed. Reference was made to appropriate terminology including consumer, herbivore, carnivore, predator

and trophic levels. The most common errors were describing zooplankton as primary producers, photosynthetic or being the base of the food chain.

(c) (i) Most candidates answered this question correctly with the number 3 or gave the correct letters of the three species A, E and H.

(ii) Some candidates completely misunderstood the data. These candidates described species A as having compositions of 80 – 100% which decreased with depth. Very few candidates indicated that both species A and H have very similar percentage compositions at 0 – 200 m. Many answers included the fact that the percentage composition of both species increased as depth increased and that there was a greater increase for species H. Often candidates did not manipulate the data and percentages were just quoted from the bar chart. For example, A = 7% at 0 –200 m and 14% at 201 – 500 m did not gain credit. A 7% increase did gain credit because the candidate had subtracted the two numbers.

(iii) Most candidates gained credit for identifying at least one of the changing conditions as depth increases, for example salinity, temperature and predation. Many candidates suggested light, but did not use specific enough language, for example stating 'amount of light' instead of light intensity/penetration. Fewer candidates mentioned the idea of being adapted to different depths. The word 'adaptation' did not appear very often.

(d) (i) Most candidates gained credit here. The most common error was to incorrectly round up the second figure to 0.057 or 0.060. Candidates need to round correctly and record $(n/N)^2$ values to the same level of precision to that of the similar data provided in the question.

(ii) A significant number of candidates correctly used their answer from **(i)** to achieve credit in this question. Quite a few candidates did not understand the equation and attempted to carry out additional incorrect calculations. They did not use the sum of the values for $(n/N)^2$ from the previous table but used other figures from the table. Most answers seen were correctly given to three significant figures.

(iii) Most candidates were able to correctly link their value of D to the correct description of the change in biodiversity with the change in depth. Fewer answers included the reference to the closer the value of D is to 1, then the higher the biodiversity. Some candidates described possible explanations for the differences in terms of the composition of the species of zooplankton or adaptations which were more appropriate to **(c)**.

Question 2

(a) Relatively few candidates gave a precise answer which included reference to both shore and high and low tide. Without reference to the shore the area between high and low tides could equally describe the area above or below the surface of the sea. Many candidates did not understand the term 'littoral zone' and described zones in the ocean and the most common was the photic zone where photosynthesis occurs. Other candidates described deeper ocean zones. A very common answer was that it is where the ocean meets the sand.

(b) (i) Many candidates correctly described the lack of trials or made the reference to a mean time. Many incorrect answers suggested including columns for every individual disc, or adding columns for other variables such as temperature and salinity.

(ii) Many candidates gained partial credit for temperature. However, they often did not use specific terminology for scientific quantities. Many candidates used 'amount', for example, 'amount of water' instead of depth of water. Also 'size' of disc instead of diameter, thickness or mass of the disc. Some candidates also restated the standardised variables pH and salinity which were given in the question.

(iii) Relatively few candidates realised that it was the production of oxygen from photosynthesis that caused the discs to rise. Many candidates gave answers describing the discs actively moving towards the light or using air bladders. Some references were made to the differences in density which were credited but not when these were linked with explanations in terms of temperature or salinity differences. Many candidates used the word 'rise' which was found in the question, rather than a change in density or buoyancy.

(c) (i) Only stronger candidates correctly suggested species R due to its shortest time to rise to the surface in the lowest light intensities. Of those candidates who correctly identified R, fewer were able to correctly link this to the reduced light availability when the algae were submerged lower down the shore and R's faster rate of photosynthesis. There was some confusion with the interpretation of the y axis of the graph with candidates believing that the lower value in seconds meant the disc would rise faster, rather than the higher the value, the faster it would rise. This confusion also gave many candidates the incorrect answer of P.

(ii) Only stronger candidates answered this correctly. The scale on the y axis appeared challenging to many candidates, who did not realise that one small square represented 3 seconds.

Question 3

(a) This question was well answered by the majority of candidates. The standard of graph construction was often good. Plots were generally precise and graphs generally received full credit. However some candidates could not be awarded full credit as they:

- drew points and/or the line of best fit in pen
- missed off 'arbitrary units' on the x axis
- drew a line dot to dot with a ruler rather than a line of best fit which was modelled on the graph provided for wrasse
- used a non-linear scale, for example plotting 48, 84, 116, 130, 138 and 141 on the y axis
- produced an extrapolation of the line beyond the plots.

(b) Many candidates gained credit for stating that the greater the concentration of CoTS larvae available, the greater number eaten by both the damselfish and wrasse. Candidates often included the idea that the damselfish ate much more CoTS than wrasse. Very few candidates commented on the levelling off at the higher larvae concentration of predation by both damselfish and wrasse. Manipulation of data was missing from many answers. It was not sufficient to just state values taken directly from the table. For example, at an initial concentration of CoTS larvae of 300, damselfish consumed 141 and wrasse consumed 42. This in itself did not gain credit. If it was followed by stating that the difference between the two was 99, then this was credited. Many candidates described the larvae eating the wrasse and damselfish, which was incorrect.

(c) (i) Many candidates understood that the coral eating organisms would increase in numbers and eat more of the corals if predatory fish were removed. Very few candidates stated that more larvae would reach maturity and become coral eating adult starfish. In addition, the decreased predation of CoTS larvae was mentioned very rarely. Some candidates suggested that CoTS larvae eat coral, which is incorrect.

(ii) Many candidates did not evaluate the information at all just summarised the findings from **(a)** and **(b)** and so did not gain credit. Some candidates gained credit for commenting on the lack of a direct link to the damage caused to corals. A few candidates mentioned a lack of repeats and the idea that the investigation was laboratory based and might not be the same on coral reefs. Many candidates thought there was sufficient evidence to support the scientist's hypothesis without really thinking about what evidence they had been given. Some candidates suggested there was enough data, or that a graph had been plotted which then showed that the evidence was sufficient.

Question 4

(a) (i) This question was challenging for many candidates. However, most candidates gained at least partial credit for counting casts, quadrats, transects and safety. Very few candidates gave a complete answer on how the sampling could be effectively carried out. Some candidates attempted to describe the mark-release-recapture method which was not credited. 'Quadrant' was commonly used for 'quadrat'. A number of candidates mentioned using drones and photographs but these also needed some reference to a scale or area being measured to be correct. Just stating 'protective clothing' without identifying a good example was not credited.

(ii) Many candidates were awarded at least partial credit. Some candidates did not realise that the casts were made fresh during each tidal cycle and referenced older casts which was incorrect. Other misconceptions included the lugworms living in the casts and the miscounting of casts due to tides washing then away. All the casts will be washed away. Due to the short time scales involved, migrating and dying lugworms could not be awarded credit.

(b) (i) Very few candidates gave an appropriate hypothesis linking organic matter to the population density of lugworms. Many candidates made good attempts but lacked the precision of the wording required. The terms 'population density' or 'number of casts per m^2' were required for a correct answer. A number of imprecise answers such as 'amount of organic matter in the sediments will affect the population density of the lugworms' were seen.

(ii) Many candidates gained partial credit here. Some candidates gave answers identifying the need to study other shores or change the organic matter content. Statistical analysis was rarely mentioned in response to this question as a test for the hypothesis.

(c) (i) Many candidates gained credit for increasing and decreasing rate, and some went on to give two correct values of flow rate from the graph. Few candidates were specific enough about the repeating cycle using terms such as 'about' or 'around' or 'roughly' followed by the number of minutes which was not precise enough for credit. Some candidates misunderstood what the data showed and some thought the peaks and troughs were water moving in/out of the burrow. Some candidates linked the rise and fall to the rise and fall of the tides. Quite a few candidates commented that the flow remained the same, rather than the cycle/pattern remaining the same.

(ii) Many candidates correctly stated that pumping water into the lugworm's burrow introduced oxygen, food and removed waste. There were many references to keeping the lugworm hydrated, to maintaining the temperature of the burrow or making the sand easier to burrow into if wet, but none of these points gained credit. Very often there was a reference made to nutrients in the water, without indicating that it was in the form of food or organic matter.

Question 5

(a) (i) This question was answered well. Some candidates could have used better alternatives for solute. For example, stating that something or a component that dissolves in a solvent, instead of using the term 'substance', did not gain credit. The most common errors were 'mixing' instead of dissolving and 'water' instead of solvent.

(ii) Only stronger candidates stated the correct formulae for one or both of the salts. A few candidates gave the correct formula for sodium chloride but the correct formula for magnesium sulfate was rarely seen.

(b) (i) This was a very challenging question for all candidates. Most answers described a method to compare the time taken to dissolve the salt or the effect of different temperatures on the rate of dissolving. Those candidates who came close to the answer were too imprecise referring only to 'amount' or 'cup' of water instead of a known volume of water or the 'amount' of salt instead of its mass. Only the very strongest candidates showed an understanding of the basic preparation or analysis of solutions of different salinities.

(ii) A lack of reference to the two oceans and/or their corresponding temperatures meant that few candidates gained full credit. Credit was available for the manipulation of data but again this was lacking from the majority of answers. Some candidates quoted lots of figures from the graph which was not enough for credit.

(c) (i) Divergent/constructive boundary layer was well known by the majority of candidates**.**

(ii) There were very few accurate answers here demonstrating a lack of understanding of how hydrothermal vents form. Many responses included references to sea water being heated when drawn into the vent, but this was not linked to increased solubility of minerals. The cooling of the mineral rich hot water was often not linked to a reduction in solubility causing the salts to precipitate out of solution. Many candidates described high pressure, black smoke and magma cooling instead of linking their answer to solubility. Many candidates instead of stating minerals, used 'nutrients' and 'sediments' which could not be credited.

(d) (i) Most candidates found it difficult to accurately extract data from **Fig. 5.3** for the mean annual evaporation and the mean annual precipitation at latitude 50 ^{o}N. Many candidates attempted the calculation but responses were not usually clearly laid out and some candidates seemed to reverse the numbers in the sum, for example 45 – 100 = 55, instead of 100 – 45 = 55. Many candidates were awarded partial credit for correctly subtracting incorrect numbers taken from the graph.

(ii) Many candidates stated ‘ppt’ or other valid alternatives. Other candidates left this question blank or put incorrect units.

(iii) A majority of candidates gave a correct answer here.

(iv) Most candidates gained partial credit here but a number of candidates were not clear enough in comparing ocean surface salinity in terms of higher or lower salinity, using increased or decreased salinity. Candidates found some marking points more difficult, referring to temperature as a reason or being closer to the equator. Some candidates became confused with north and south as a reason for it being hotter or colder. There was often no comparison between rate of precipitation with the rate of evaporation and often candidates just stated one of the two.

MARINE SCIENCE

Paper 9693/22

AS Level Data-handling and Investigative Skills

Key messages

Candidates need to ensure they identify the correct command word in questions, and carefully check what the question is asking.

Candidates also need to ensure they have answered questions in sufficient detail for this level, for example **Question 3(c)**.

General comments

The standard of responses was often very high. Candidates usually provided answers that were clear and well thought through, demonstrating an excellent understanding and knowledge across the breadth of the specification. Most questions were attempted.

Comments on specific questions

Question 1

(a) (i) The majority of candidates achieved at least partial credit here, with many achieving full credit. Most candidates were able to state that light was required for photosynthesis, but some missed the importance of carbon dioxide for photosynthesis in the zooxanthellae. Stronger candidates generally also mentioned that oxygen was required for respiration in either organism.

(ii) Stronger candidates gained partial or full credit, demonstrating a clear understanding of independent and dependent variables. Weaker candidates sometimes had the correct variables but put them in the incorrect place, or just said zooxanthellae rather than the number of them released. A few candidates gave an incorrect variable.

(b) (i) The majority of candidates correctly identified 1840 as the anomalous result.

(ii) Many candidates correctly calculated the mean, but some included the anomalous result. The number of damaged cells needed to be given to 3 or 4 significant figures, (a mathematical requirement of the specification) so if candidates had not rounded correctly, they could not achieve full credit.

(iii) This question had the highest omission level of the paper. A few candidates did not understand that the total number of damaged zooxanthellae goes above the bar for the total number of healthy zooxanthellae, and some placed the top of the black bar at 1530, and so did not achieve credit. Some candidates did not draw the bar to the relevant degree of accuracy. The total height should have been at 2080, so the bar should have been above the 2000 line, but not on the 3000 line. Some candidates drew it to the 2000 or 3000 line.

(iv) Many candidates gained partial credit on this question, with the most frequent correct answer being that the highest number of zooxanthellae were released as the water temperature changed. Fewer candidates stated that the numbers then returned to levels similar to before the change. A small number of candidates considered the data sufficiently to recognise that after the change more damaged cells were released.

(c) Most candidates gained partial or full credit on this question, with errors usually being not showing working or giving an answer to an incorrect magnitude, e.g. 5500.

Question 2

(a) (i) Candidates generally scored partial credit on this question, usually for making a drawing of a relevant size and a neat outline or having proportions correct. Some candidates did not draw the caudal fin to a suitable size.

(ii) The most common errors here were labelling the anal fin as the pelvic fin and not using a ruled straight line without arrowheads for label lines.

(iii) Many candidates knew that the swim bladder aids buoyancy for fish and applied this knowledge to the information from the question to explain that the juveniles needed to float to be able to gain food, but that the adults stayed in the benthic zone so buoyancy was no longer important. A few candidates seemed to have the misconception that all animals in the benthic zone were immobile, and stated that as adults they did not move.

(b) The most common error was naming the two species rather than giving the letters of the fish as required in the question. Using only the names did not show that the candidate had worked through the key, as they were asked for the two species in the same genus. Identifying which are in the same genus was the first step.

(c) Most candidates achieved partial or full credit.

Question 3

(a) The majority of candidates gained full credit here, correctly substituting the numbers into the equation.

(b) (i) Most candidates were able to give some relevant points for systematic sampling, but a small number of candidates stated ‘use a random method’ and so limited the credit that could be awarded. Credit was most frequently awarded for quadrats and a line transect, with the quadrat placed at equal intervals, and the number of polyps being counted.

(ii) Some candidates evaluated the strength of the evidence rather than answering the question. Those who achieved partial credit often achieved this for understanding there would be less grazing of the algae, and that the algae may block light from the polyps, stopping photosynthesis by the zooxanthellae. Very few mentioned that the increase in algae on the rocks meant that the polyps would have few attachment spaces available to them.

(c) Candidates often stated the omnivores may eat the coral polyps, but few used the phrase ‘as well’. Some stronger candidates explained that omnivores eat meat and plant material before saying the polyps may be eaten as well. Some other candidates correctly explained that the omnivores may have a preference for polyps over the algae.

Question 4

(a) (i) Most candidates achieved at least partial credit, usually for noting that as water temperature increases the rate of photosynthesis also increases. Fewer noted that there was a limit to that.

(ii) Some candidates redrew the water temperature line while others recognised it should be similar to the phytoplankton line and included two peaks. A few candidates drew their peaks and troughs before the phytoplankton peaks and troughs, which was not enough for credit.

(b) Candidates found this a challenging question. Some candidates gave a list of factors that would be different, without discussing why they would differ. Candidates were most likely to correctly explain how the salinity differed between the two areas, how sediment varied, with some relating this to water flow speeds, and some discussing pH variations. Some candidates had difficulty in interpreting the photograph and thought **J** was the ocean water.

(c) (i) Most candidates achieved partial credit, usually for the initial subtraction, but some did not give a negative sign to show it was a drop in value, and some forgot to multiply by 100 to convert it to a percentage. Many stronger candidates achieved full credit.

(ii) Candidates needed to provide answers that explained both increases and decreases in phosphate ion levels, but some candidates only gave reasons for the increases. Most candidates were able to give at least one reason why the levels may be increased, usually mentioning runoff, and some gave upwelling and others noted that increased precipitation would increase river flow bringing more nutrients. Those who gave a reason for the decrease often referenced the reason organisms use phosphate, e.g. DNA production. A few candidates linked the changes to the different times of the year.

(iii) This question was answered well, with many candidates achieving at least partial credit, demonstrating a good understanding of this topic. Most candidates gave a reason nitrate ions are important for organisms, and the effect of the reduction of the nitrate ions on the organism.

(d) (i) With several variables to choose from, many candidates gave a correct answer, most frequently stating temperature, with others giving salinity, pH or water volume. The most frequent incorrect answer was light intensity.

(ii) Candidates seemed to be familiar with this investigation and many gave very good, detailed explanations of the method. The points least often seen were a screen or water bath (to prevent temperature changes) and the addition of a hydrogen carbonate to provide sufficient carbon dioxide for photosynthesis.

(iii) Most candidates were able to draw a neat and relevant table, but some did not include units or used incorrect units for the method they chose. Some candidates did not discuss repeats or a mean.

Question 5

(a) Most candidates were awarded partial credit here, with many stating that there were no or very few razor clam species above a latitude of 55º North and South. Some noted that there was a greater diversity in the North than the South, showing they had looked carefully at the data provided. Some candidates stated that numbers increased up to the equator, whereas both in the North and South numbers dropped a little at 5º. A few candidates stated numbers from the graph at different latitudes without comparing these values.

(b) (i)-(iii) Many candidates demonstrated a good understanding of Spearman's rank correlation data with most candidates giving mean sea surface temperature for **(i)** as it had the highest positive value for the Southern hemisphere. Significantly fewer gained credit for **(ii)**, with many giving 'range of sea surface temperature' instead. This showed a lack of understanding that the closer to 1, the stronger the negative correlation is for negative numbers, but many candidates showed a strong understanding of this for the positive numbers. For **(iii)** candidates needed to note that it was a negative correlation or an inverse relationship. Stronger candidates gave a full description of a strong correlation, but some candidates did not state it was negative.

(iv) Candidates found this question challenging. Some stated the values, but far fewer made the point that the correlation in the Northern hemisphere was a moderate negative, but in the Southern hemisphere it was a weak positive. Many weaker candidates stated 'they do show a causal relationship' without any evaluation of the data to try to support that, or they only gave data for one hemisphere and stated that was the correlation.

MARINE SCIENCE

Paper 9693/23

AS Level Data-handling and Investigative Skills

Key messages

Candidates need to ensure they identify the correct command word in questions, and carefully check what the question is asking.

Candidates also need to ensure they have answered questions in sufficient detail for this level, for example **Question 3(c)**.

General comments

The standard of responses was often very high. Candidates usually provided answers that were clear and well thought through, demonstrating an excellent understanding and knowledge across the breadth of the specification. Most questions were attempted.

Comments on specific questions

Question 1

(a) (i) The majority of candidates achieved at least partial credit here, with many achieving full credit. Most candidates were able to state that light was required for photosynthesis, but some missed the importance of carbon dioxide for photosynthesis in the zooxanthellae. Stronger candidates generally also mentioned that oxygen was required for respiration in either organism.

(ii) Stronger candidates gained partial or full credit, demonstrating a clear understanding of independent and dependent variables. Weaker candidates sometimes had the correct variables but put them in the incorrect place, or just said zooxanthellae rather than the number of them released. A few candidates gave an incorrect variable.

(b) (i) The majority of candidates correctly identified 1840 as the anomalous result.

(ii) Many candidates correctly calculated the mean, but some included the anomalous result. The number of damaged cells needed to be given to 3 or 4 significant figures, (a mathematical requirement of the specification) so if candidates had not rounded correctly, they could not achieve full credit.

(iii) This question had the highest omission level of the paper. A few candidates did not understand that the total number of damaged zooxanthellae goes above the bar for the total number of healthy zooxanthellae, and some placed the top of the black bar at 1530, and so did not achieve credit. Some candidates did not draw the bar to the relevant degree of accuracy. The total height should have been at 2080, so the bar should have been above the 2000 line, but not on the 3000 line. Some candidates drew it to the 2000 or 3000 line.

(iv) Many candidates gained partial credit on this question, with the most frequent correct answer being that the highest number of zooxanthellae were released as the water temperature changed. Fewer candidates stated that the numbers then returned to levels similar to before the change. A small number of candidates considered the data sufficiently to recognise that after the change more damaged cells were released.

(c) Most candidates gained partial or full credit on this question, with errors usually being not showing working or giving an answer to an incorrect magnitude, e.g. 5500.

Question 2

(a) (i) Candidates generally scored partial credit on this question, usually for making a drawing of a relevant size and a neat outline or having proportions correct. Some candidates did not draw the caudal fin to a suitable size.

(ii) The most common errors here were labelling the anal fin as the pelvic fin and not using a ruled straight line without arrowheads for label lines.

(iii) Many candidates knew that the swim bladder aids buoyancy for fish and applied this knowledge to the information from the question to explain that the juveniles needed to float to be able to gain food, but that the adults stayed in the benthic zone so buoyancy was no longer important. A few candidates seemed to have the misconception that all animals in the benthic zone were immobile, and stated that as adults they did not move.

(b) The most common error was naming the two species rather than giving the letters of the fish as required in the question. Using only the names did not show that the candidate had worked through the key, as they were asked for the two species in the same genus. Identifying which are in the same genus was the first step.

(c) Most candidates achieved partial or full credit.

Question 3

(a) The majority of candidates gained full credit here, correctly substituting the numbers into the equation.

(b) (i) Most candidates were able to give some relevant points for systematic sampling, but a small number of candidates stated ‘use a random method’ and so limited the credit that could be awarded. Credit was most frequently awarded for quadrats and a line transect, with the quadrat placed at equal intervals, and the number of polyps being counted.

(ii) Some candidates evaluated the strength of the evidence rather than answering the question. Those who achieved partial credit often achieved this for understanding there would be less grazing of the algae, and that the algae may block light from the polyps, stopping photosynthesis by the zooxanthellae. Very few mentioned that the increase in algae on the rocks meant that the polyps would have few attachment spaces available to them.

(c) Candidates often stated the omnivores may eat the coral polyps, but few used the phrase ‘as well’. Some stronger candidates explained that omnivores eat meat and plant material before saying the polyps may be eaten as well. Some other candidates correctly explained that the omnivores may have a preference for polyps over the algae.

Question 4

(a) (i) Most candidates achieved at least partial credit, usually for noting that as water temperature increases the rate of photosynthesis also increases. Fewer noted that there was a limit to that.

(ii) Some candidates redrew the water temperature line while others recognised it should be similar to the phytoplankton line and included two peaks. A few candidates drew their peaks and troughs before the phytoplankton peaks and troughs, which was not enough for credit.

(b) Candidates found this a challenging question. Some candidates gave a list of factors that would be different, without discussing why they would differ. Candidates were most likely to correctly explain how the salinity differed between the two areas, how sediment varied, with some relating this to water flow speeds, and some discussing pH variations. Some candidates had difficulty in interpreting the photograph and thought **J** was the ocean water.

(c) (i) Most candidates achieved partial credit, usually for the initial subtraction, but some did not give a negative sign to show it was a drop in value, and some forgot to multiply by 100 to convert it to a percentage. Many stronger candidates achieved full credit.

(ii) Candidates needed to provide answers that explained both increases and decreases in phosphate ion levels, but some candidates only gave reasons for the increases. Most candidates were able to give at least one reason why the levels may be increased, usually mentioning runoff, and some gave upwelling and others noted that increased precipitation would increase river flow bringing more nutrients. Those who gave a reason for the decrease often referenced the reason organisms use phosphate, e.g. DNA production. A few candidates linked the changes to the different times of the year.

(iii) This question was answered well, with many candidates achieving at least partial credit, demonstrating a good understanding of this topic. Most candidates gave a reason nitrate ions are important for organisms, and the effect of the reduction of the nitrate ions on the organism.

(d) (i) With several variables to choose from, many candidates gave a correct answer, most frequently stating temperature, with others giving salinity, pH or water volume. The most frequent incorrect answer was light intensity.

(ii) Candidates seemed to be familiar with this investigation and many gave very good, detailed explanations of the method. The points least often seen were a screen or water bath (to prevent temperature changes) and the addition of a hydrogen carbonate to provide sufficient carbon dioxide for photosynthesis.

(iii) Most candidates were able to draw a neat and relevant table, but some did not include units or used incorrect units for the method they chose. Some candidates did not discuss repeats or a mean.

Question 5

(a) Most candidates were awarded partial credit here, with many stating that there were no or very few razor clam species above a latitude of 55º North and South. Some noted that there was a greater diversity in the North than the South, showing they had looked carefully at the data provided. Some candidates stated that numbers increased up to the equator, whereas both in the North and South numbers dropped a little at 5º. A few candidates stated numbers from the graph at different latitudes without comparing these values.

(b) (i)-(iii) Many candidates demonstrated a good understanding of Spearman's rank correlation data with most candidates giving mean sea surface temperature for **(i)** as it had the highest positive value for the Southern hemisphere. Significantly fewer gained credit for **(ii)**, with many giving 'range of sea surface temperature' instead. This showed a lack of understanding that the closer to 1, the stronger the negative correlation is for negative numbers, but many candidates showed a strong understanding of this for the positive numbers. For **(iii)** candidates needed to note that it was a negative correlation or an inverse relationship. Stronger candidates gave a full description of a strong correlation, but some candidates did not state it was negative.

(iv) Candidates found this question challenging. Some stated the values, but far fewer made the point that the correlation in the Northern hemisphere was a moderate negative, but in the Southern hemisphere it was a weak positive. Many weaker candidates stated 'they do show a causal relationship' without any evaluation of the data to try to support that, or they only gave data for one hemisphere and stated that was the correlation.

MARINE SCIENCE

Paper 9693/31
A Level Theory Paper

Key messages

- Candidates should ensure that they are familiar with all topics on the syllabus.
- Candidates need to be encouraged to read the whole question carefully and to consider the information provided before starting on their answers.
- Questions stating a specific number of answers, for example 'State **one** reason' or 'Suggest **two** advantages' are list questions and additional responses should not be added. List questions are explained on each mark scheme.
- Candidates should avoid using less precise terminology, for example 'negative impact on', 'affects top predators', 'hurts corals' or 'mess-up the food chain'. More precise language should be used, for example candidates should use 'larvae' or 'juveniles' not 'babies' or 'kids' when referring to life cycle stages in shrimp or whales.

General comments

Stronger candidates performed well and demonstrated a clear understanding of biological processes. This was particularly evident in ***Section B***. A significant number of weaker candidates demonstrated minimal knowledge of A Level topics and often were not able to read and interpret the questions, resulting in responses that did not answer the question being asked.

Stronger candidates spent time processing the information provided before starting their answers. This was particularly evident in **Question 1** on conservation in Salinas y Arenales Regional Park and for **Question 2**, where candidates needed to spend time studying **Fig. 2.1** before answering the questions about mussel aquaculture.

A significant number of candidates demonstrated minimal knowledge and understanding, especially of A Level topics such as mussel aquaculture, price tariffs, diffusion and water potential. Answers from these candidates were well below the standard required for this theory paper.

Comments on specific questions

Section A

Question 1

(a) The strongest candidates were able to provide a correct definition of ecological diversity. Common errors referred to the environment or to the variety of species or organisms within an area.

(b) (i) Most candidates knew that an endangered species had low numbers and was at risk of extinction.

(ii) Stronger candidates were able to state that the salt would be present in the gravel and mud from the salt ponds and therefore provide the correct conditions. Fewer responses referred to the fact that soil could contain seeds that would produce plants, or that soil could contain toxins.

(iii) Some stronger answers mentioned an increase in prey or breeding areas. The fact that the stones provided a place to hide from predators was less common. Some candidates gave less precise answers, for example that the stones 'provide a hiding place' or that 'more food would be available for the killifish' instead of stipulating more prey or more small fish, as it was stated in the question that killifish are carnivores.

(iv) Most candidates stated there was competition between the yellow-legged gull and native species but to gain credit they needed to specify that the competition was for food or for nesting sites. Stronger answers referred to algal blooms or eutrophication, but very few then went on to refer to decomposition by bacteria or to the resulting effect of a lower oxygen concentration on respiration. Answers that stated that the increase in nitrogenous waste had a 'negative affect' did not gain any credit as they did not state how this would impact biodiversity.

(c) Competition with native species was usually mentioned but sometimes without naming a resource such as light or water, or candidates stated 'food' which was incorrect. The idea that these species take over the dunes was also frequently seen. Many candidates recognised the lack of natural predators and the disruption to the food chain or food web. Fewer responses referred to the high growth rate or to the loss of habitat or nesting sites for native species.

Question 2

(a) (i) Stronger candidates were able to state that metamorphosis involved a change of form or a change from larva to adult. Weaker candidates stated that metamorphosis involved a change from 'larva to juvenile' or a 'change of state'.

(ii) Many candidates referred to harvesting methods for adult mussels, not understanding the process of using the hatchery to produce larvae or spat. Weaker candidates also referred to dredging or bycatch. Common correct advantages were that abiotic conditions such as temperature or pH needed to be controlled, or that there were no predators present in a hatchery.

Many disadvantages referred to cost or money, but these were often not detailed enough. Weaker candidates made references to antibiotics being routinely applied.

(iii) The majority of answers just referred to Method **A** having the mussels in their natural environment or being less crowded, so there would be less competition for food. Few candidates understood that the mussels were always submerged and therefore able to feed constantly, which increased their growth rate. Some answers related to harvesting or dredging rather than the growth of the mussels.

(iv) Most candidates stated the disadvantages of dredging compared with harvesting by hand, but it was important to state that there would be damage to the benthic habitat. Some responses were incomplete, for example stating that dredging produced sediment without stating how this would impact marine organisms. Where pollution from the boat was mentioned, it had to be clear that this would be oil pollution in the water and not gases into the air.

(b) (i) This question was answered well by most candidates, who often included all marking points in their responses. Weaker candidates referred to low salinity causing acidification of the water. Low salinity was sometimes only linked to low salt content without any mention of calcium or carbonate. Weaker candidates gave answers stating that the shell would be soft instead of weak or brittle.

(ii) The majority of candidates gained full credit, usually for stating that mussels should be checked for disease, predators or for growth.

Question 3

(a) The majority of candidates gained credit here. The most common error was to state 'number of times an item of clothing is worn' instead of stating that it was the average number of times as stated on **Fig 3.1**. Occasionally candidates confused the lines on the graph and thought that clothing sales had decreased as the average number of times an item of clothing is worn increased. The inverse relationship or negative correlation was sometimes recognised but some candidates said there was a positive correlation.

(b) Stronger candidates gained full credit and most candidates gained partial credit. Common errors included stating that increased temperatures could 'hurt or damage coral' or that 'corals die' instead of corals bleach. If zooxanthellae were included, it had to be clear that these would be expelled and not just die. Some examples of incorrect answers included references to ocean acidification or to temperature affecting the pH. Weaker responses only stated that corals are sensitive to temperature or can only survive in a narrow range of temperatures, without giving any effects.

(c) Stronger candidates referred to the possibility that the dyes could be toxic, or to the lack of sunlight for producers, and to the subsequent reduction in photosynthesis and productivity. Fewer candidates continued their argument by referring to the effects this could have upon consumers and the food chain, for example that consumers would have less food which could result in death or in migration to other areas.

(d) There was much confusion between the terms bioaccumulation and biomagnification. Answers stating that 'bioaccumulation occurs up the food chain' or 'bioaccumulation and biomagnification occur' did not demonstrate the difference between these two terms. Few responses included that more prey would be consumed. Many candidates were aware of the problems due to plastics in general, for example, trapping animals and blocking digestive systems and gills, but fewer candidates specifically talked about microplastics. Toxins were sometimes mentioned but not always with the effect on the top predator.

(e) Answers stating that less synthetic dyes or non-synthetic dyes or less synthetic fabrics or non-synthetic fabrics should be used were not enough to gain credit as candidates were expected to suggest suitable alternatives, for example, using natural or biodegradable dyes or fibres. The most common answers were that clothes should be recycled or worn for longer.

Question 4

(a) (i) Very few candidates understood the implications of introducing tariffs. Many misunderstood who would benefit from the tariffs, assuming it would be the salmon producers rather than the importing government. However, a few candidates realised that this would mean an increase in domestic production and would therefore encourage consumers to purchase locally. Many candidates answered this from a global point of view and included overfishing or transport costs and did not realise exactly what the question was asking.

(ii) Many candidates did not understand the terms 'export' and 'import', so could not work out which countries were exporting and to where. They also did not recognise that the lower tariffs meant that the exporters paid less to send fish into China. Some candidates gained credit for the idea of more salmon sales to China and the decreased cost of salmon to Chinese consumers. Incorrect answers often related to overfishing.

(b) (i) The majority of candidates explained that consumers may be confused or suspicious when presented with these many differing certifications. Weaker candidates gave answers relating to increased costs.

(ii) Answers stating that there would be an increase in all three regions were common. Many responses quoted figures from the graph, but fewer manipulated these figures to gain credit. Only the strongest candidates discussed what the data might represent about sustainable fishing, for example, that sustainable fishing or education and awareness about sustainability fishing has increased over the five years.

Section B

Question 5

To answer this question candidates were required to use information from both the AS and A Level sections of the syllabus. Most answers gained at least partial credit. The most common reason for candidates not being awarded credit was them referring to roots, stems and leaves instead of to holdfast, stipe and blades. Weaker candidates referred to the benefits of macroalgae to other marine organisms, for example, that they were a habitat or breeding area for them, providing oxygen for respiration, or that they reduced coastal erosion by absorbing wave action.

Although holdfast was better known, (sometimes incorrectly called a ‘steadfast’) it was often used to attach the kelp to sand or sediment rather than to rock or substrate. The fact that the holdfast held the kelp in place during tidal fluctuations and during stormy weather was generally well understood. Some candidates mistakenly thought that the holdfast takes up nutrients.

The fact that the gas bladders hold kelp up towards the light was also well understood. Other features, such as the stipe and blades were less well discussed. This included the fact that blades (usually referred to as leaves) were long rather than thin for easy diffusion of gases, or that they were flat rather than having a large surface area to maximise light absorption. There were a few references to avoiding desiccation, but this was usually due to having a waxy cuticle rather than being covered in mucilage.

References to the pigments in blades, such as chlorophyll *a* or named accessory pigments such as fucoxanthin absorbing certain wavelengths of light for photosynthesis, which form much of Section 7.1 of the syllabus on photosynthesis were extremely rare.

Question 6

(a) Only stronger candidates answered this correctly and gave detailed descriptions of diffusion, or fully defined the term. Very few candidates referred to the random movement of particles. Most candidates correctly stated that diffusion happens from a high concentration to a low concentration. Many remembered that it is a passive process which does not require energy.

A significant number of responses included a description of active transport (often referred to as ‘active diffusion') requiring energy and movement from a low concentration to a high concentration. Active diffusion is not an alternative term for active transport and any answer that included active transport or active diffusion in terms of moving against the concentration gradient did not answer the question.

Very few responses referred to features such as having a large surface area to volume ratio or to increased temperature, so increasing diffusion rates. Most credit was awarded for naming oxygen and carbon dioxide as examples of gases that moved by diffusion. Another common answer was that diffusion occurred in gills of larger marine organisms and that diffusion was important in processes such as respiration or photosynthesis. Stating that it was important for breathing was not relevant.

Some weaker candidates thought that diffusion involved the movement of cells, while others gave accounts of osmoregulation and/or ventilation. Many weaker candidates did not attempt this question.

(b) There was a great deal of confusion regarding the terms hypertonic, isotonic and hypotonic. Candidates are advised to use the syllabus term ‘water potential’ throughout. Answers should have stated that water moves from a high water potential to a lower water potential. Answers substituting concentration for water potential were not credited.

Most candidates knew that water moved by osmosis, but many candidates thought that water moved by active transport Some answers were not specific enough, for example, ‘cells lose water and shrink’. This only applies to animal cells. The terms turgid or plasmolysed were rarely seen when referring to water gain or loss from plant cells. Fully labelled diagrams would have been an alternative way of gaining credit for this question.

Weaker candidates may have misread the question and so produced answers describing osmoregulation in freshwater and saltwater fish, stenohaline and euryhaline fish, ventilation in fish or water uptake by roots in plants and loss of water through leaves, with no mention of cells. A significant number of candidates did not attempt this question.

Question 7

The majority of candidates gained partial credit, but full credit was rare. Candidates needed to ensure that they were comparing the life cycle of shrimp and whales. Answers describing the life cycle of shrimp followed by a description of a life cycle in whales were very common and often could not be awarded credit. For example, it needed to be clear that shrimp undergo metamorphosis and have larval stages, but that whales do not. The range of habitats needed by shrimp was often included but usually without the requirements for the whale.

A majority of candidates were aware that whales have a simple life cycle, whereas that of shrimp is complex. In many cases, candidates were well informed about *r* and *k* strategies and that fertilisation in shrimp is external whereas in whales it is internal.

The credit available for discussing that both showed paired mating, breeding season and are non-sessile was rarely awarded. Candidates should consider including a table for this type of question, making it easier to identify similarities and differences.

MARINE SCIENCE

Paper 9693/32
A Level Theory Paper

Key messages

- Candidates should understand the difference between a 'list question' where a specific number of answers are required and other questions.
- Candidates must use precise language. Imprecise wording should be avoided, for example 'toxins harm coral', 'toxins negatively affect coral' or that the 'salinity will change' .
- Candidates should understand what is expected of them in questions asking for a comparison and should consider similarities and differences.
- Candidates should ensure that they are familiar with all topics on the specification and have factual detail at the required standard for A Level.

General comments

The standard of responses was generally high, with many candidates demonstrating a thorough knowledge of both AS and A level sections of the syllabus. This was particularly evident in **Question 7** on the conditions required for the formation of a mangrove forest and the benefits of replanting mangroves to fisheries. To answer this question candidates were required to use information from both AS and A Level topics. Stronger candidates performed well on **Question 2** on aeration, **Question 3** on salmon aquaculture and on **Question 4** on seagrass and microplastics as they took their time to read and process all the information provided in the questions carefully. Most candidates performed well on **Question 1** describing the effects of flooding and dredging on corals and fish stocks along part of the Great Barrier Reef.

Comments on specific questions

Section A

Question 1

(a) Most candidates stated that it was the difference between high tide and low tide, but they needed to specify that it was the height difference to gain credit.

(b) (i) Partial credit was often awarded, usually for stating that sediment caused an increase in turbidity and reduced light. For full credit, candidates were required to state not only that there would be less photosynthesis, but this would take place in zooxanthellae. Coral bleaching or that zooxanthellae would be expelled was a common correct answer. A reference to toxins in sediment was rare and was usually not linked to its effect on coral. Answers such as 'sediment affects light for corals' or 'there is less growth in corals' were not enough to gain credit.

(ii) Some candidates misread the question and produced answers which referred to the effect of fresh water on marine organisms rather than on sea water as stated in the question. For example, these candidates sometimes stated that fresh water would affect osmoconformers or stenohaline organisms. Wording such as 'fresh water affects or impacts the salinity' or the 'salinity changes', or that it 'affects the concentration of gases' were not credited. References to increasing sea levels were ignored.

(c) This question asked about the effect that maintenance dredging would have on local fish stocks. Answers referring to seabed damage or to the effect on corals were ignored. Answers such as 'sediment harms' or has 'a negative effect on fish' were also ignored as answers needed to state how the sediment damaged fish stocks.

Question 2

(a) (i) The majority of candidates could correctly state that aeration provided oxygen. Fewer stated that it was required for aerobic respiration and fewer still made reference to the fact that oxygen has a low solubility in water.

(ii) The idea that fish in intensive aquaculture would be densely packed compared with extensive aquaculture was well understood. Only stronger candidates made a reference to increased demand for oxygen or that aeration could circulate the water in tanks so distributing food or oxygen evenly. However, many responses referred to oxygen distribution occurring naturally in the sea by tides or currents.

(b) Answers relating to these aerators causing damage or scaring fish were ignored as was the idea that much of the air was lost to the atmosphere. The most common correct answer was that only surface waters received air.

(c) Stronger candidates studied the information in **Table 2.1** before attempting their answer. Common answers included that the nanobubbles would have a larger surface area and they would rise to the surface more slowly. Weaker candidates misinterpreted the data in the table, stating that nanobubbles rose more quickly than fine and microbubbles. Few references were made to nanobubbles delivering more oxygen and to a larger area due to their winding route to the surface.

Question 3

(a) Weaker candidates did not understand the meaning of the term abiotic and gave incorrect answers that referred to feed or to disease. Temperature and pH were common factors, but these cannot be controlled by using a thermometer or pH probe. The use of a water bath to control temperature was ignored. Turbidity or waste product removal using a filter was rarely seen.

(b) The majority of answers gained at least partial credit, usually for stating that food would be available for longer or that uneaten food could be removed. Only stronger candidates referred to sinking pellets being lost under nets and decomposing or that floating pellets would be more cost effective as more would be eaten by salmon.

(c) (i) Most answers referred to deeper water being colder than surface water.

(ii) Only the strongest candidates gained full credit. Common answers included overcrowding of salmon and increased competition for food or oxygen which resulted in starvation or that salmon were unable to respire. Fewer references were made to waste products collecting here and that they would be decomposed by bacteria so lowering the oxygen concentration further.

(iii) The increase in water temperature was sudden, so this could not be attributed to global warming cycles or to El Niño. A reference to sunspots or solar activity was also ignored as they would not give a sudden increase in water temperature.

Question 4

(a) (i) Most candidates misinterpreted the question and included answers such as seagrass beds providing a habitat or nursery area, providing oxygen for respiration or protection for coastlines. Only stronger candidates gained credit, but answers needed to be specific, for example, that seagrass was found in shallow water where light intensities would be high, for increased photosynthesis, so increasing biomass.

(ii) Many answers did not focus on the economic benefits of seagrass as required by the question. Common correct answers stated that seagrass beds provided nursery areas, so increasing numbers of marine organisms for fishers to catch and sell. Other correct answers quoted the economic gain from tourism.

(b) UV light and wave action were the two most common correct answers for causing the breakdown of plastic.

(c) (i) Partial credit was awarded for stating that there was more microplastic in seagrass beds than on bare sediment. Fewer candidates manipulated figures from the table or stated that there was not enough data to make a valid conclusion to gain further credit.

(ii) This question was specifically about primary consumers, so references to biomagnification from one trophic level to another were ignored. Many candidates did not show understanding of the terms bioaccumulation and biomagnification, stating that 'bioaccumulation and biomagnification occurs' or that 'bioaccumulation and biomagnification occur along the food chain'. Few responses stated that many seagrass leaves were consumed or described the effect toxins released from microplastics had on the primary consumer.

Section B

Question 5

There were some excellent answers to this question describing the light-dependent stage of photosynthesis with many stronger candidates gaining full credit. A few candidates added information about the production of glucose in the light-independent stage, which was not required.

Some answers were not specific enough, for example, stating that this stage occurred in the 'chloroplast' rather than in the 'thylakoid membrane', that 'light' was required instead of 'light energy' or that light was 'used by chlorophyll' instead of being 'absorbed by chlorophyll'. Common correct answers included a reference to photoactivation and photolysis. Fewer references were made to photophosphorylation, to chlorophyll *a* absorbing specific wavelengths of light, or to ATP and reduced NADP providing an energy source for the light-independent stage.

Credit was awarded for ATP and reduced NADP if details of how both were formed during the light-dependent stage were missing.

Question 6

(a) The most common answers to this question about the IWC were that it was set up to protect whales, that it was an international organisation involving many countries and that it introduced legislation. Stronger responses stated that the whales could be protected by banning whaling or introducing quotas and that bans did not apply if the whale was killed for research purposes. Some answers included references to fines and confiscation of fishing equipment instead of stating that monitoring and enforcement would be difficult to apply.

(b) Although there were many creditworthy answers, there were also some confused responses, especially over the terms 'oviparity', 'ovoviviparity' and 'viviparity'. Most candidates gave a description of fertilisation and subsequent development in sharks, followed by a description in whales. Common errors included stating that sharks carry out external fertilisation and that groups of sharks care for their young after birth.

Many responses were not specific enough to achieve credit, for example, stating that the young are 'fed by the parent' but without mention that they were fed via a placenta or yolk sac, that both produce few young when it needed to be specified that whales have only one calf, or that the whale calf is fed, but without mention of providing milk.

Very few responses referred to males introducing sperm into the female's body or to the fact that internal fertilisation is more guaranteed. Candidates could have considered using a table for this question so that it was clear that they were making a comparison, noting the similarities and differences.

Question 7

Most candidates gained partial credit and could state some of the conditions required for the formation of a mangrove forest. The most common correct answers were that they require a tropical climate and a substrate of mud or sediment. Stating a specific temperature or range of temperatures or stating that 'warm temperatures were required' was not enough as it had to be clear that these were throughout the year.

Benefits of replanting mangroves had to focus on fisheries as stated in the question. Answers such as it provides oxygen for marine organisms or that it protected coastlines from storms were therefore ignored.

Most answers included that it provided a nursery area which increased fish stocks, enabling more catch for fishermen.

Very few references were made to mangrove forests being used for aquaculture, that they provided employment or that there was migration of stocks to other fishing areas such as coral reefs.

MARINE SCIENCE

Paper 9693/33
A Level Theory Paper

Key messages

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General comments

The standard of responses was generally high, with many candidates demonstrating a thorough knowledge of both AS and A level sections of the syllabus. This was particularly evident in **Question 7** on the conditions required for the formation of a mangrove forest and the benefits of replanting mangroves to fisheries. To answer this question candidates were required to use information from both AS and A Level topics. Stronger candidates performed well on **Question 2** on aeration, **Question 3** on salmon aquaculture and on **Question 4** on seagrass and microplastics as they took their time to read and process all the information provided in the questions carefully. Most candidates performed well on **Question 1** describing the effects of flooding and dredging on corals and fish stocks along part of the Great Barrier Reef.

Comments on specific questions

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Most answers included that it provided a nursery area which increased fish stocks, enabling more catch for fishermen.

Very few references were made to mangrove forests being used for aquaculture, that they provided employment or that there was migration of stocks to other fishing areas such as coral reefs.

MARINE SCIENCE

Paper 9693/41

A Level Data-Handling and Investigative Skills

Key messages

In future series, candidates should:

- ensure that they give detailed answers that are of an A Level standard
- ensure that they understand the requirements of all command words
- have a thorough understanding of all the mathematical requirements of the specification
- draw diagrams using pencil without shading
- read questions thoroughly so that they write answers that are relevant.

General comments

Some responses were of a very high standard. Many candidates planned investigations with a full understanding of the scientific method and used accurate and precise vocabulary. A few candidates presented sketchy drawings produced with ink rather than pencil. Graph skills were generally good with many candidates able to select suitable linear scales, label axes and join points with straight lines. For mathematical skills many candidates were able to calculate rates of change, understood how to use significant figures and were able to calculate micrograph sizes using magnifications. However, some candidates were unable to complete all the calculations and answer the data analysis questions.

Some candidates did not complete several sections of the paper. The command words were usually clearly understood with only a few candidates confusing commands such as ‘explain’ and ‘describe’.

Comments on specific questions

Question 1

(a) Most candidates were able to correctly state that the cell nucleus contains nucleic acids or genetic material. A significant number of candidates gave answers that were too simplistic, such as ‘the brain of the cell’.

(b) (i) This question required candidates to calculate the actual length of the nucleus by using a given magnification. The answer needed to be rounded to two significant figures. Many candidates were able to correctly calculate the size. However, other candidates did not give their answer to two significant figures or did not convert the units correctly. It is good practice to always measure using millimetres rather than centimetres as this makes the unit conversions easier.

(ii) This question required candidates to draw an area of the micrograph that was included inside a circle. Some excellent drawings were seen that were of a suitable size, had no broken lines, no shading and had all the details in the correct proportions. However, a significant number of candidates produced idealised drawings or drew the wrong area of the micrograph. Many others added shading, had structures missing or had inappropriate proportions. Candidates should be fully aware of all scientific drawing conventions listed in the specification.

(c) (i) Stronger candidates described features such as both algae growing the least with yellow light, the deep water alga growing the most with blue light and the surface water alga growing the most with purple light. Many also made comparisons between the two algae in terms of which grew more with each light colour. Weaker candidates tended to give imprecise answers such as ‘the surface alga

grew better with some colours'. Candidates should make sure that they give specific detail in their answers.

(ii) Some excellent answers were seen for this question that pointed out that the extra growth of the deep water alga in some wavelengths of light suggested that it had additional, accessory pigments and that there is no red light below a certain depth. Some candidates were confused about the depths to which the different colours penetrate, suggesting that red penetrates the deepest. Very few candidates stated that the data had no direct evidence for different pigments being present.

Question 2

(a) (i) This question asked candidates to outline the process of chemosynthesis by *Endoriftia.* Stronger answers described the role of hydrogen sulfide, energy and carbon dioxide. The command word, 'outline', indicated that excessive detail was not required. Common errors included the use of light energy and the process of photosynthesis.

(ii) This question required candidates to explain the relationship between *Riftia* and *Endoriftia*. Stronger answers explained that the relationship is an example of mutualism and that *Riftia* gains carbohydrates as an energy source and *Endoriftia* gains substances such as carbon dioxide, minerals and a habitat. Weaker answers were often imprecise, typically suggesting that each organism benefits. Some candidates referred to symbiosis, parasitism or commensalism. Candidates should try to use correct vocabulary. Many referred to *Riftia* providing a home rather than a habitat.

(b) This question presented candidates with data showing the populations of chemosynthetic bacteria at three hydrothermal vents and an area of seabed. The data also had the concentrations of hydrogen and methane at each location. Most candidates correctly recognised that there was a higher population of bacteria at the vents compared with the seabed. Fewer suggested an explanation based on the use of the gases as energy sources. The strongest candidates recognised that the key limiting factor was the concentration of methane, rather than the hydrogen gas. Weaker candidates often just gave descriptions of the data rather than explanations which was what the question asked for.

(c) (i) In this question, candidates were asked about the significance of error bars on the graph. Stronger candidates recognised that the large error bars around the means for the vents meant that there was a high variability in the data. Some candidates also went on to correctly state that conclusions about the difference between consumptions at the vents would be less reliable due to overlaps of error bars and that for the seabed there was no overlap so it would be more reliable to conclude that there was a difference. The use of error bars on graphs is a key part of the mathematical skills listed in the syllabus and candidates should make sure that they are confident with interpreting them.

(ii) When discussing a conclusion, candidates should explore how strongly it is supported by both the data and the design of the investigation. Most candidates recognised that the higher consumption of the bacteria at the vents supported the role of the bacteria in the vents and many went on to explain that this means that the bacteria are the producer organisms, fixing energy into food chains. Fewer candidates looked at the experimental design and why it would not support the conclusion. However, a few candidates recognised that the investigation only showed a small aspect of the food chains and would be very different to the situation at the vent and seabed. When discussing conclusions, candidates should explore how well data supports the conclusions and how good the experimental design is.

Question 3

(a) (i) Many candidates gave imprecise, generic descriptions of aquaculture and did not describe the specific methods used in shrimp aquaculture. A number of candidates confused shrimp aquaculture with salmon aquaculture and referred to the use of ocean cages, smolt and fry. Stronger answers described the use of nursery tanks, the transfer of larvae to other tanks and the final stages where the shrimps are grown out in raceway ponds. Stronger candidates also gained credit for describing how the shrimp are fed and maintained.

(ii) Many candidates recognised that long term success of aquaculture requires factors such as availability of food and clean water. Several candidates gave imprecise suggestions regarding

sustainability and environmental impact rather than focusing on the long-term needs of aquaculture. Common correct answers included ensuring that there is food, labour, space, clean water, market share and disease management.

(b) (i) This question assessed candidates' understanding of how to calculate a rate of change from a graph, which is a typical maths skill. Candidates also had to determine the unit. Stronger candidates correctly calculated the difference in nitrate concentration over the six days and went on to divide this by six to determine the mean rate. Many candidates did not recognise that the unit would be the change in concentration of nitrate per day. Some candidates were distracted by the term, 'mean', and tried to work out what the average concentration of nitrate was per day.

(ii) This question required candidates to describe the effects of adding the different densities of mussels on the nitrate concentration over the six-day period. Stronger candidates gave detailed descriptions of each density. For the condition with eight mussels, candidates needed to give full detail and recognise that the increase in nitrate occurred after day two.

(c) (i) Many candidates gained at least partial credit here. The question required candidates to recognise that the concentration of oxygen increased when there were no mussels present due to the microalgae in the water. Stronger candidates explained that photosynthesis would occur leading to the production of oxygen. Many candidates also recognised that there would be less respiration using the oxygen if there were no mussels present.

(ii) Many excellent answers were seen that described the changes in concentrations of oxygen and nitrate and went on to explain how the consumption of algae by different densities of mussels would alter the concentration of nitrate. Stronger candidates also considered the effects of photosynthesis by the algae and respiration by mussels and decomposer bacteria.

Question 4

(a) This question required candidates to draw a line graph with two separate y-axes. Most candidates were able to select sensible linear scales for each axis. Candidates should not try to use the left-hand side of the grid for both scales, but should use both the left and right side. Candidates should also select scales that enable the points to be plotted over at least half of the grid and that have sensible increments. Only a few candidates incorrectly drew bar charts. Points should be joined with straight lines with no extrapolation. Some candidates did not plot points correctly. The x-axis was given here and it was important that candidates identified the value of each increment.

(b) Stronger answers explained that carbon dioxide dissolves in the water to produce carbonic acid which then dissociates and results in a loss of carbonate ions in the water. Weaker answers tended to gain only partial credit for recognising that the shells would be weaker but often did not give any other detail. Some candidates clearly knew that carbonic acid was involved but gave answers confusing hydrogen-carbonate ions with hydrogen ions.

(c) Most candidates were able to identify the independent, dependent, and standardised variables. Candidates needed to state clearly which variable was which. Candidates should have also suggested at least five different values for the independent variable and these should have been within ethical limits as living organisms were being used. When listing standardised variables, candidates should be careful with the terminology used, for example, 'amount of water' is not enough for credit but 'volume of water' has the level of precision required. Candidates should give practical methods in the plan, for example, the use of pH buffer solutions or water baths. Some candidates had clearly read the instructions carefully and so structured their answers in the same way as the instructions. Some suggested methods of analysis. Graphs needed to be described in terms of what would be on the axes, tables needed to be drawn with headers, and any calculations and statistical tests described. There needed to be an explanation of why repeats were carried out, for example, to calculate means or to identify outliers. When asked to give safety and ethical considerations, candidates should explain their reasons, for example, the wearing of eye protection in order to minimise the risk of getting a buffer solution in their eye. Weaker candidates tended to confuse the variables and used imprecise language (e.g. amount of solutions).

Question 5

(a) This question asked candidates to explain why international cooperation and legislation is needed for the conservation of marine species. Stronger candidates explained that marine species do not

respect national boundaries and that there are areas of ocean that are international water. These candidates also referred to the migratory behaviour of many marine species. Weaker answers tended to simply rephrase the question.

(b) (i) Most candidates were able to extract information from the graph and then use it to calculate the percentage that ten salmon had moved upstream but only about half went on to correctly calculate a percentage. Many rounded the value incorrectly, giving 6.6%, rather than 6.7%.

(ii) This question required candidates to discuss the effects of acclimatising the salmon. Most candidates were able to gain at least partial credit for stating that more acclimatised salmon moved downstream. Stronger candidates went on to discuss the timings of the salmon movements, often correctly pointing out that acclimatised salmon moving downstream tended to move later. Only a few candidates commented on other factors that may have affected the data. The strongest candidates commented on the quality of an investigation or other factors that may have influenced results.

(c) This question required candidates to complete and interpret a chi squared test. Many candidates were able to complete the test successfully and many good explanations were given as to whether or not to accept a null hypothesis based on the calculated value. Similarly to **(b)(i)**, some candidates incorrectly rounded their calculations. A few candidates correctly completed the table but were unable to calculate the chi squared value. Interpretation of the results was generally very good, with many candidates giving the correct number of degrees of freedom and identifying the correct critical value as being 3.841.

MARINE SCIENCE

Paper 9693/42

A Level Data-Handling and Investigative Skills

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- draw diagrams using pencil without shading
- read questions thoroughly so that they write answers that are relevant.

General comments

Some responses were of a very high standard and it was clear that many candidates had prepared thoroughly for the examination. Most candidates demonstrated detailed factual knowledge, excellent mathematical skills and an excellent understanding of scientific method. Most candidates showed impressive drawing skills and experimental planning. Graph skills were also very strong and most candidates are able to select appropriate linear scales. Paper 4 typically has a statistical test and in this case it was Spearman's rank test, which the majority of candidates were able to complete. There were few questions that candidates found especially challenging.

Comments on specific questions

Question 1

(a) (i) This question required candidates to determine the actual length of a goblet cell using a magnification. The question also required a unit conversion and the final answer to be given to three significant figures. Most candidates were able to complete the calculation correctly. Typical errors included using the wrong number of significant figures or not converting units correctly. Candidates are recommended to measure using millimetres rather than centimetres as this reduces the risk of using the wrong order of magnitude when converting between units.

(ii) Most candidates were able to correctly name two cell structures that are present in plant cells but not the goblet cell. Common answers included chloroplasts and vacuoles.

(b) Most candidates were able to gain at least partial credit with many gaining full credit. The standard of drawing was very high with few candidates incorrectly adding shading, using broken lines or drawing incorrect structures. Candidates should ensure that their drawing is larger than the photograph that they are using.

Question 2

(a) (i) This question asked candidates to state what is meant by the term 'euryhaline' and was answered well. Most candidates stated that euryhaline organisms can survive in a range of different salinities.

(ii) This question asked candidates to describe the effect of placing killifish into freshwater on the rate of ATP breakdown. Most candidates stated that there was a rise in ATP breakdown and most went on to gain full credit by stating that it rose in the first day and then remained constant. If a description is allocated two marks, it is good practice to identify turning points.

(iii) This question asking for an explanation of the effect of placing the killifish into freshwater on the rate of ATP breakdown was answered well. Many candidates gained at least partial credit and gave detailed answers, clearly explaining the osmotic effect on the fish, the role of active transport and the need to pump salts into the body. A few candidates went on to explain that the fish would produce large volumes of urine and so would lose salts. A few weaker answers simply gave descriptions without any explanation.

(iv) Many candidates found this practical skills question challenging. It required candidates to state why skin cells were also used. Stronger answers stated that this was a control experiment and showed what happened with cells that are not used for osmoregulation.

(b) (i) This question was a simple, percentage change calculation that most candidates were able to complete correctly. A few candidates only gained partial credit as they calculated the change but did not convert it into a percentage.

(ii) This challenging question asked candidates to explain the results of the experiment. Many excellent answers were seen that fully explained how water would move by osmosis and that the mussels are clearly an osmoconformer species. A few weaker answers suggested that the changes in mass were due to growth of the mussels or changes in salt uptake. It is good practice to explain the direction of water movement in relation to the water potential gradient in questions where osmosis is involved.

Question 3

(a) (i) Graph drawing skills were excellent and many candidates selected sensible, linear scales that used over half the grid. Most candidates correctly used separate scales on the left and right sides of the grid. Credit was awarded for labelling the lines or using a key. Most candidates followed the instruction to join the points with straight lines, rather than plotting a bar chart.

(ii) This question required candidates to explain why the mean length of female haddock changed due to *Nephrops* fishing. Most correctly stated that the mean length decreased, and a significant number went on to explain that smaller/younger fish would escape through the mesh of the nets so the proportion of small haddock would increase.

(iii) Many candidates found stating what the mode shows challenging and a significant number confused it with the median.

(iv) This question was answered well with many candidates gaining at least partial credit and many going on to gain full credit. The question required candidates to assimilate all the information given to discuss the impact of fishing on haddock populations. Many identified that the populations increased but that this may be due to the reduced age of maturity of the fish causing them to breed at a younger age. Many also identified that the age structure of the haddock population clearly shifted to a population with a higher proportion of younger, smaller fish.

(b) This question required candidates to give methods for monitoring and enforcing fishing methods. Most candidates were able to gain at least partial credit with many gaining full credit. Common, correct answers included the use of air and sea patrols, satellite tracking, fines and prison sentences.

Question 4

(a) (i) Candidates were given the formula for calculating CPUE and asked to evaluate how accurately it would enable fish stocks to be measured. In evaluation questions, candidates need to give both sides of the argument to gain full credit. Most candidates were able to suggest reasons why the measurement was inaccurate, such as discarded catch, migration of stocks, and differing fishing gear. Fewer gave a reason why CPUE would be accurate. The most common reason was that higher populations would be easier to catch so would have a higher CPUE.

(ii) This question was answered well with most candidates stating that it slowly improved until four years after which there was a steeper increase and compared this to the control area which clearly decreased.

(iii) Candidates generally answered this question well. The question asked for an explanation for how the no-take zone changed the CPUE. Most recognised that there would be higher rates of breeding as the zone had nursery sites and that fish would spill over into the surrounding water. Many candidates also correctly stated that habitats would be less damaged due to there being no fishing.

(b) Most candidates were able to gain some credit with many gaining full credit. A few were able to calculate the coefficient but did not use it appropriately in **(iv)**. Candidates should always state the critical value that the calculated value is compared with and state whether it is higher or lower. In **(v)**, candidates had to discuss the sociological effects of the imposition of fishing restrictions. Many excellent answers were seen that considered both positive and negative effects for both the short term and long term. Common correct answers included loss of income and jobs, lower living standards, food shortages, loss of service industries, and breakdown of relations with authorities. Stronger candidates went on to say that in the long-term, having a sustainable fish population would ensure that there is long-term employment and food for future generations. On longer, discussion questions, candidates should try to explore a topic as much as possible.

Question 5

(a) (i) Most candidates were able to complete a percentage calculation and included the unit.

(ii) This question assessed candidates' understanding of the impacts of global warming. Most were able to list at least one consequence of global warming on the marine environment. Candidates needed to be careful to give two clearly different effects.

(iii) This question was very well answered by many candidates who showed they had an outstandingly detailed understanding of the syllabus. The question asked candidates to describe how carbon dioxide in the atmosphere reduces carbonate availability in the seas. Most correctly stated that the carbon dioxide dissolves in water to form carbonic acid which dissociates into hydrogen ions and hydrogen-carbonate ions. A few candidates recognised that the carbon dioxide dissolves in the water but did not extend their answers any further.

(b) This question required candidates to plan an investigation into the effect of pH on the rate of growth of mussels. Many outstanding plans were seen. Most candidates gave a correct hypothesis. Most were able to correctly identify the independent, dependent, and standardised variables but a small number confused the independent and dependent variables. Many candidates were able to suggest at least five pHs with a sensible range. When experiments use living organisms, candidates need to be careful to give a range that is ethically acceptable. Most candidates suggested methods such as the use of buffers and water baths. Many had clearly read the instructions carefully and so structured their answers in the same way as the instructions. Most suggested some methods of analysis. Graphs needed to be described in terms of what would be on the axes, tables drawn with headers, and any calculations and statistical tests described. There needed to be an explanation of why repeats were carried out, for example, to calculate means or to identify outliers. Safety features and ethical issues also needed to be explained, for example, it was not enough to just describe the use of eye protection, it needed to be linked to a risk factor.

MARINE SCIENCE

Paper 9693/43

A Level Data-Handling and Investigative Skills

Key messages

In future series, candidates should:

- ensure that they give detailed answers that are of an A Level standard
- ensure that they understand the requirements of all the command words
- have a thorough understanding of all the mathematical requirements of the specification
- draw diagrams using pencil without shading
- read questions thoroughly so that they write answers that are relevant.

General comments

Some responses were of a very high standard and it was clear that many candidates had prepared thoroughly for the examination. Most candidates demonstrated detailed factual knowledge, excellent mathematical skills and an excellent understanding of scientific method. Most candidates showed impressive drawing skills and experimental planning. Graph skills were also very strong and most candidates are able to select appropriate linear scales. Paper 4 typically has a statistical test and in this case it was Spearman's rank test, which the majority of candidates were able to complete. There were few questions that candidates found especially challenging.

Comments on specific questions

Question 1

(a) (i) This question required candidates to determine the actual length of a goblet cell using a magnification. The question also required a unit conversion and the final answer to be given to three significant figures. Most candidates were able to complete the calculation correctly. Typical errors included using the wrong number of significant figures or not converting units correctly. Candidates are recommended to measure using millimetres rather than centimetres as this reduces the risk of using the wrong order of magnitude when converting between units.

(ii) Most candidates were able to correctly name two cell structures that are present in plant cells but not the goblet cell. Common answers included chloroplasts and vacuoles.

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