MARINE SCIENCE

Paper 9693/11
AS Level Theory Paper

Key messages

Some candidates had clearly referred to past papers and mark schemes when preparing, which provided them with a good understanding in formatting their responses. This often enabled candidates to express themselves well, providing succinct responses.

It is expected that candidates write their answers in continuous prose for ***Section B*** questions, as stated in the specification. Those writing bullet points often could not be credited as the bullet points were not linked and consisted of a list of terms and short statements in a random and unclear sequence This was particularly the case for 'explain' and 'discuss' questions, where the linking is essential for candidates to demonstrate they have a depth of understanding. Some stronger candidates noted one- or two-word bullet points that were seen in the margins, which acted as a scaffolding for their answers, allowing them to write in prose, ensuring they had covered all the main points they had thought of. However, such short bullet points alone are not sufficient for full credit.

Candidates often needed a greater precision in their use of language and scientific terms. Precise language was required for **Question 3(a)(ii)** where the words 'partial' and 'ions' were required to be used correctly to gain credit, and **Question 5(b)** where 'increasing height' was too vague.

Candidates need to ensure they read questions carefully and may need to refer back to the start of a question to remind themselves of the information provided to them, to help answer different parts within an overall question. This was evident for some candidates in **Questions 2(c) and 5(a)(iii)**.

General comments

Some candidates gave complete answers, showing a strong understanding of the meaning of the specification terms and were able to combine information from different areas of the specification.

Other candidates clearly had gaps in their knowledge of the basic scientific principles required to gain credit. These candidates would have benefited from developing a greater understanding of the basic principles so that they could give some statements of relevance to questions, before developing a deeper understanding of some of the more complex aspects of the specification.

The use of the word 'amount' should be discouraged. Instead, candidates should consider what the 'amount' is – mass, volume, temperature, pressure, density, salinity, or concentration. This was seen particularly in **Question 3(a)(ii)**. Candidates also need to be more familiar with defined terms from the specification, as very few gave specification definitions, but their own versions of them that were often too vague or failed to use scientific terminology. This was apparent in **Questions 3(a)(iii)** and **5(a)(i)**.

Comments on specific questions

Question 1

(a) Candidates were generally able to state that calcium was found in skeletons and shells. However, some did not gain credit as they were asked for the essential element, and they gave calcium carbonate. Many just stated 'protein', not understanding what was meant by element, even though examples were provided in the question. Correct answers for chlorophyll and DNA were split fairly evenly, but some candidates stated 'phosphate' rather than phosphorous for DNA.

(b) Candidates found this question more difficult than **(a)** with fewer able to state fatty acids and glycerol. Some gave amino acids and others gave triglycerides, a type of lipid. More candidates gained partial credit for fatty acids that for glycerol. Many candidates stated elements or biological molecules given in **(a)**.

Question 2

(a) (i) Few candidates were able to correctly name this as a holdfast, with the vast majority stating roots, and some crossing out the correct answer to give root. They were told it was a macroalgae in the question and candidates were expected to know the different anatomy of the types of producers in the ocean. The functions given were often vague, or incorrect, such as 'holding the plant into the soil'. Stronger candidates were able to give the correct name and function.

(ii) Candidates found this a challenging question with many giving vague answers. Some stated that kelp is a producer but did not say that it absorbs carbon to photosynthesise. Few recognised the role of respiration by the kelp, or the organisms that ate them, as a way carbon is returned to the atmosphere. Few candidates mentioned that the carbon was then fixed into glucose, which could be passed along the food chain as an energy source.

(b) (i) Most candidates were able to identify crabs as the omnivore, but weaker candidates often suggested sea otters or small fish.

(ii) Many candidates were able to state they had a variety of different food sources available, but some just stated what an omnivore is.

(iii) Stronger candidates often gained full credit for the calculation, with weaker candidates not having a clear understanding of what they needed to do with the figures to calculate the percentage decrease. A number of candidates gained partial credit for calculating 8 but did not realise they needed to subtract this from 100 to complete the calculation. Candidates should be encouraged to consider if the answer they have calculated looks like a reasonable answer. In this case 8% should not have looked like a reasonable estimate for the answer.

(iv) Stronger candidates drew this carefully, constructing the rectangles with a ruler and ensuring each box was a similar height and that the relevant dimensions changed appropriately, i.e., the parasites box was wider than the sea otter box. Some candidates did not understand that the pyramid required 5 levels, and others did not understand where to place the parasites, often putting them in the incorrect position on the pyramid. Some candidates tried to draw a triangle and split that into the sections, rather than drawing out a pyramid using rectangular boxes, as required.

(c) Many candidates gained partial credit here for stating one or two valid ways that kelp is of economic importance to humans. A few candidates talked about the ecological importance instead.

Question 3

(a) (i) Stronger candidates drew a clear diagram showing the oxygen and two hydrogen atoms with electrons clearly shown, often using different symbols for the electron of the hydrogen and the electrons of the oxygen, and some annotated their drawings to explain the shared electron pair. Some candidates drew one hydrogen and two oxygen atoms showing they did not understand what the formula for water means. Those who drew the correct molecule then needed to show the positions of the electrons and some showed one for hydrogen being shared with oxygen but then drew another on the opposite side of the hydrogen atoms, giving hydrogen 2 electrons, but not both being shared with the oxygen atom. Others only showed the hydrogen atoms sharing their electron with oxygen, without the oxygen electron also being shared with the hydrogen as a shared pair. A few candidates also drew the hydrogen separated from the oxygen by a line, so not showing that the electrons are shared. A few candidates showed hydrogen bonding instead.

(ii) Candidates often made errors on this question and so were unable to score credit. Stronger candidates were able to talk about the different partial charges on Hydrogen and Oxygen atoms within the water molecule (but many forgot the 'partial') and many talked about the charges on sodium and chloride but did not state that these were ions with the charge. If candidates referred to chloride and its charge and attraction to hydrogen, they could achieve partial credit, (as chloride is the name of the chlorine ion) but not if they referred to chlorine, as that is the molecular term.

(iii) There are a few definitions within the specification that candidates are expected to know and be able to precisely state what the terms mean. Salinity is one of those, defined as 'the concentration of dissolved salts in sea water'. However, few candidates were able to give the specification definition, often just stating 'the amount of salt' rather than using any scientific terminology in their definition.

(b) Many candidates found this a challenging calculation, with few recognising that for this example, 500 cm^3 or ½ litre, all they needed to do was divide 34 by 2. Some candidates multiplied 500 by 34 to give 17 000 g, or 17 Kg of salt in 500 cm^3 which was not a realistic answer.

(c) Stronger answers described the ice as being a thermal insulator and the effect of that on the water below and then discussed its use as a habitat for different types of organisms either on the top or the underside of the ice and achieved full credit. Many mentioned that it acts as an insulator, but candidates needed to be careful with language to ensure they did not say it warmed the water below, but reduced heat loss from the water below.

Question 4

(a) (i) Some candidates did not read the question carefully and stated the range, 9.5–20, rather than calculating the range as asked. Some candidates calculated a mean for several readings from the graph rather than just for the highest high tide and lowest low tide.

(ii) Few candidates recognised the pattern as a regular tidal cycle. Therefore, often only partial credit was achieved for mentioning evaporation or precipitation rather than the movement of seawater into and out of the estuary leading to the cyclical change in salinity shown in **Figure 4.2**.

(b) (i) Candidates needed to use their knowledge and understanding of the conditions required for the formation of a mangrove forest to apply to the estuary shown in **Figure 4.1**, and many candidates found this difficult. The most common answers were that the water flow was low, or that it was in a tropical climate. Stating it was near the equator was not enough for credit as candidates needed to interpret **Figure 4.1** rather than just stating what they could see in the figure. Other features sometimes mentioned were mud sedimentation or a muddy substrate, and that the water must be shallow due to the islands becoming exposed at low tide.

(ii) Candidates did not answer this with accuracy, often mentioning roots, but not prop roots, which could only be awarded partial credit if they stated that these stabilised the tree in their substrate. Some candidates gave vague answers such as "the roots balance the salinity" or just stated "salt exclusion" without stating the roots excluded the salt.

Question 5

(a) (i) This was another definition that candidates need to know and understand from section 3.2.8 of the specification, where it is stated as 'the rate of production of biomass per unit area' or 'the volume of biomass produced per unit of time' but candidates often stated the 'amount of biomass made' with no reference to a rate or time.

(ii) Stronger candidates were able to gain some credit, but many candidates only talked about the seasons, winter or spring, without recognising this was in the southern hemisphere, so the seasons are reversed. Candidates should always refer to the data provided on the graph, in this case the months, to ensure they do not make this type of error. Some were able to select appropriate features of the differences in the lines of the graph in **Figure 5.1**, such as the number or height of the peaks and compare them, but others only stated what happened to one line or compared different features. Candidate needed to be precise if they mentioned the peaks. They needed to state when the peaks occurred, not just the entire period of the increase in height of the line.

(iii) Candidates needed to read the question carefully, as they were asked for factors decreasing productivity, and many just stated a factor that would affect productivity, without giving any directionality to it, i.e., reduced nutrients or lower carbon dioxide concentration.

(b) Many candidates were able to give a correct answer here, but some only talked about the heights increasing rather than the range increasing, or the high values being higher and the low values being lower. This answer required careful wording to ensure the response was precise.

Question 6

Most candidates achieved partial credit, often for recognising that conditions on the shore may be different due to the effect of tides. Few discussed the range of abiotic factors that can change as a result of the changing tides. Some candidates talked almost exclusively about the adaptations organisms have for the rocky shore without referring to the factors leading to the requirements for these different adaptations. Candidates often mentioned the problems of being in the splash zone that may render organisms susceptible to desiccation, and a few mentioned how organisms such as the limpet overcome these problems. Many also discussed the differences in water availability in the different zones, but very few mentioned other conditions that change in the different zones, such as temperature, in any meaningful way. Few recognised that the temperature of water is much more stable (due to its high specific heat capacity) and that when exposed to air the temperature range the organisms are exposed to may be much greater than when submerged, or that there would be a temperature difference between the water and air. A few mentioned wave action but again did not discuss how that varied within the zones of the rocky shore. Fewer candidates mentioned competition, but some stronger candidates were able to clearly explain both inter and intra specific competition within a zone and how that may affect distribution of organisms. Other candidates mentioned competition but did not state what resource there may be competition for.

Question 7

Many candidates talked about the formation of hydrothermal vents rather than volcano formation, limiting the credit that could be awarded. Those who tried to discuss the formation of volcanoes were often quite vague, e.g., ‘magma erupts’ without showing any understanding of why the magma may erupt near convergent boundaries. Some candidates talked about formation of a volcano at a divergent boundary and could often gain partial credit.

Question 8

(a) Diagrams were not required for this question, but some candidates produced accurate diagrams to support their answers and often answered well as they named different parts and their functions. Other candidates could not draw anything resembling a polyp, as they did not really know anything about them. These candidates could rarely be awarded any credit. Some candidates mentioned a holdfast, others discussed the mutualistic relationship between coral polyps and zooxanthellae, and some candidates were not clear on the relationship of the tentacles and the nematocysts. Stronger candidates had a clear knowledge of the structures and their functions for the polyp and gave clear, accurate answers.

(b) Most candidates were able to give at least one reason for coral reef erosion. However, some answers were too vague to gain credit, such as ‘pH change’, ‘temperature change’ rather than stating that the water temperature was increasing, or ‘human activity’ rather than stating a human action that would lead to the loss of coral polyps. Many candidates also stated that loss of coral would lead to a reduction in biodiversity and some of the impacts this may have on human communities, such as loss of a fishing resource or loss of coastal protection. Some candidates chose to use bullet points in this question, which is not appropriate for a ‘discuss’ question. The specification states that for a discuss question candidates should ‘write about topics in depth in a structured way’.

MARINE SCIENCE

Paper 9693/12
AS Level Theory Paper

Key messages

The chemistry content of the syllabus tends to be a weaker area amongst some candidates. It is worth ensuring that fundamental information on subatomic particles and bonding is well known. This is required for answers to specific questions but can also be used as part of longer prose questions.

Candidates would benefit from practicing mathematical skills such as conversion of units. This was a key skill with which many candidates found challenging.

General comments

There was a high standard of scientific knowledge and understanding evident, with many candidates providing detailed and accurate responses. Weaker responses lacked detail. Candidates should use the mark allocation of the question as a guide to how many specific points they need to make in their responses.

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

Comments on specific questions

Section A

Question 1

(a) (i) Stronger candidates were able to give the correct response of viviparous, although were a variety of spellings seen. The most common incorrect response was asexual reproduction.

(ii) Many candidates were able to suggest that propagules were more likely to survive than seeds, but fewer were able to explain why. Some candidates gave unsuccessful explanations in terms of reduction of competition.

(b) There were some excellent responses linking trapping of sediment to a reduction in turbidity, resulting in more sunlight for photosynthesis. Some candidates tried unsuccessfully to relate this to a marine food chain.

(c) (i) Many candidates answered this question correctly.

(ii) Many candidates answered this question correctly. The few weaker responses given referred to harvesting but needed detail to specify if it was harvesting of fish or timber.

Question 2

(a) (i) Most candidates were able to give the correct charge of the subatomic particles. Occasionally candidates suggested the incorrect numbers of protons and electrons for a sodium atom.

(ii) The most common incorrect response was to give the name of the particle as an ionic compound rather than an ion.

(b) (i) Weaker candidates made errors such as using lower case o for Oxygen or not writing 3 as a subscript. Candidates should be reminded to take care when writing chemical formulae.

(ii) Many candidates were able to give a good initial description and were able to describe how parts containing calcium carbonate descended to the seafloor. Many candidates needed to give more specific explanations of cementation and formation of sedimentary rocks.

(c) There were many excellent responses seen, with many candidates clearly linking magnesium with chlorophyll synthesis and the effect of this on photosynthesis. Only the strongest candidates were able to take the explanation further and link the production of glucose to biomass or other carbohydrate compounds the plants require for growth.

Question 3

(a) Many candidates answered this question correctly.

(b) This question specifically asked for evidence found in rocks. Some candidates gave other evidence of plate tectonics. Candidates should be encouraged to read questions carefully.

(c) (i) This question was answered well. Many candidates were able to identify the names of the different plate boundaries. The most common error was to refer to the transform plate boundary as the transverse boundary.

(ii) Many candidates who were able to identify the different names of the plate boundaries were also able to identify the boundary where a mid-ocean ridge would form.

(d) (i) Weaker responses commonly referred to solidification rather than precipitation of minerals as they cool. Using the correct terminology was important here, and candidates should be encouraged to use precise specific terminology in their explanations.

(ii) Many candidates answered this question correctly and were able to relate the conditions at a hydrothermal vent to the lack of photosynthesis.

Question 4

(a) (i) Many candidates gave weak responses that needed more specific detail. Candidates should be reminded to use the descriptions of key terms as provided by the syllabus.

(ii) Most candidates could describe weathering and erosion.

(iii) This question was answered well with candidates giving a variety of suitable advantages of having a shell.

(iv) This question specifically asked for the name of the equipment. Some candidates incorrectly gave the name of a technique, such as mark-release-recapture or using a transect. Candidates should also be reminded to take care with spelling of key pieces of apparatus.

(b) This question was well answered. Many candidates were able to explain this in terms of consuming both producers and consumers that occupy different trophic levels.

(c) (i) The four elements found in all proteins were well known. Occasionally incorrect elements such as phosphorus were given.

(ii) Many candidates were not able to covert between grams and milligrams. Candidates may find practise converting units beneficial.

(iii) This question asked for the effects on the food web. Some candidates gave answers that were not related to the food web but wider ecological concerns. Candidates should be reminded to read the question fully and carefully.

Section B

Question 5

There were some excellent responses to this question. Many candidates were able to describe two different methods that coral polyps use for nutrition and accurately refer to the structures responsible. Weaker responses were too vague or were inaccurate with some candidates referring to tentacles capturing prey rather than referring to the role of nematocysts. The role of zooxanthellae and the importance of photosynthesis were generally well described.

Question 6

(a) There was a lack of precision in some responses to this question. Most candidates recognised that bond X was a hydrogen bond. However, many candidates referred to oxygen being negative instead of being slightly negatively charged and hydrogen being positive instead of slightly positively charged. Few candidates were able to explain that the reason for the difference in charges is due to the unequal attraction or sharing of electrons.

(b) Many candidates were able to refer to ice's properties as a thermal insulator and a platform for organisms. Some candidates were also able to explain the reasons for the difference in densities between ice and liquid water and the importance of sea ice in a marine ecosystem.

(c) The strongest responses referred to named salts and named gases such as carbon dioxide and oxygen and explained their importance to marine organisms. Some candidates needed to answer in terms of specific substances that were dissolved and to explain their importance to marine organisms. Few candidates were able to explain the importance of the specific heat capacity of water.

MARINE SCIENCE

Paper 9693/13
AS Level Theory Paper

Key messages

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Candidates would benefit from practicing mathematical skills such as conversion of units. This was a key skill with which many candidates found challenging.

General comments

There was a high standard of scientific knowledge and understanding evident, with many candidates providing detailed and accurate responses. Weaker responses lacked detail. Candidates should use the mark allocation of the question as a guide to how many specific points they need to make in their responses.

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

Comments on specific questions

Section A

Question 1

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(b) There were some excellent responses linking trapping of sediment to a reduction in turbidity, resulting in more sunlight for photosynthesis. Some candidates tried unsuccessfully to relate this to a marine food chain.

(c) (i) Many candidates answered this question correctly.

(ii) Many candidates answered this question correctly. The few weaker responses given referred to harvesting but needed detail to specify if it was harvesting of fish or timber.

Question 2

(a) (i) Most candidates were able to give the correct charge of the subatomic particles. Occasionally candidates suggested the incorrect numbers of protons and electrons for a sodium atom.

(ii) The most common incorrect response was to give the name of the particle as an ionic compound rather than an ion.

(b) (i) Weaker candidates made errors such as using lower case o for Oxygen or not writing 3 as a subscript. Candidates should be reminded to take care when writing chemical formulae.

(ii) Many candidates were able to give a good initial description and were able to describe how parts containing calcium carbonate descended to the seafloor. Many candidates needed to give more specific explanations of cementation and formation of sedimentary rocks.

(c) There were many excellent responses seen, with many candidates clearly linking magnesium with chlorophyll synthesis and the effect of this on photosynthesis. Only the strongest candidates were able to take the explanation further and link the production of glucose to biomass or other carbohydrate compounds the plants require for growth.

Question 3

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(d) (i) Weaker responses commonly referred to solidification rather than precipitation of minerals as they cool. Using the correct terminology was important here, and candidates should be encouraged to use precise specific terminology in their explanations.

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Question 4

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(iv) This question specifically asked for the name of the equipment. Some candidates incorrectly gave the name of a technique, such as mark-release-recapture or using a transect. Candidates should also be reminded to take care with spelling of key pieces of apparatus.

(b) This question was well answered. Many candidates were able to explain this in terms of consuming both producers and consumers that occupy different trophic levels.

(c) (i) The four elements found in all proteins were well known. Occasionally incorrect elements such as phosphorus were given.

(ii) Many candidates were not able to covert between grams and milligrams. Candidates may find practise converting units beneficial.

(iii) This question asked for the effects on the food web. Some candidates gave answers that were not related to the food web but wider ecological concerns. Candidates should be reminded to read the question fully and carefully.

Section B

Question 5

There were some excellent responses to this question. Many candidates were able to describe two different methods that coral polyps use for nutrition and accurately refer to the structures responsible. Weaker responses were too vague or were inaccurate with some candidates referring to tentacles capturing prey rather than referring to the role of nematocysts. The role of zooxanthellae and the importance of photosynthesis were generally well described.

Question 6

(a) There was a lack of precision in some responses to this question. Most candidates recognised that bond X was a hydrogen bond. However, many candidates referred to oxygen being negative instead of being slightly negatively charged and hydrogen being positive instead of slightly positively charged. Few candidates were able to explain that the reason for the difference in charges is due to the unequal attraction or sharing of electrons.

(b) Many candidates were able to refer to ice's properties as a thermal insulator and a platform for organisms. Some candidates were also able to explain the reasons for the difference in densities between ice and liquid water and the importance of sea ice in a marine ecosystem.

(c) The strongest responses referred to named salts and named gases such as carbon dioxide and oxygen and explained their importance to marine organisms. Some candidates needed to answer in terms of specific substances that were dissolved and to explain their importance to marine organisms. Few candidates were able to explain the importance of the specific heat capacity of water.

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' meant that credit could often not be awarded.

Candidates should be encouraged to carry out practical work in the classroom and in the field using simple appropriate equipment, so they gain confidence in describing scientific methods when required. Practical work is indicated in the syllabus with the symbols PA. It will be tested on this paper. Many candidates were unable to describe basic practical skills. Describing methods, such as designing the experiment in **Question 2(b)** to investigate the relationship between the concentration of nitrate ions and the growth of seagrass was not answered well. Candidates also found **Question 4(c)** where they were required to describe how to use the apparatus in the diagram to determine the permeability of sediment samples challenging. Centres need to refer to the syllabus, for guidance. There is a list of steps candidates should be able to follow when constructing a scientific method.

Candidates should be encouraged to use a sharp pencil when drawing and constructing graphs.

Candidates need to be able to manipulate data to support answers. There were many candidates who wrote down figures from tables and graphs but did not make the next step of using the data to formulate an answer.

Candidates should always show their working out during calculations as it may be possible to gain partial credit for correct working. Candidates should always check their working. There were examples in **Question 1(b)(i)** were all the numbers were correctly placed into the equation and then incorrectly calculated.

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

General comments

Almost all candidates completed the paper, but many found some of the questions very challenging.

Comments on specific questions

Question 1

(a) (i) Many candidates used a ruler for a straight label line and correct annotation. Other candidates produced poorly drawn lines with the line falling short of the carapace and the line ending in an arrow. Label lines should always be drawn with a ruler, as a single straight line, not free hand. They must reach the structure and must not end in an arrow. A significant minority of candidates did not attempt this question.

(ii) Many answers were too vague, often 'jointed' was not included when describing limbs and just 'antennae' rather than two pairs of antennae. Such statements were not sufficient to gain credit. There were many incorrect answers which included claws, eyes, pentameric symmetry, hard shell, 6 or 8 legs and spines.

(iii) Frequently, the initial credit for the outline of the drawing was not awarded due to the broken or scribbled nature of the outline. Not enough care was taken to construct a neat, unbroken pencil line. There were some excellent artistic sketches with the perfect proportion and detail, but shading meant these could not be credited. Also, some candidates drew in pen instead of a sharp pencil. Centres need to refer to 'Presentation of data and observations (AO3) of the 9693 Marine Science AS and A level syllabus where it states the 'use pencil for drawing'. Nearly all candidates gained credit for showing the nodules and spines reflecting excellent observational skills. When considering the size of the drawing, it must be at least as big as the original diagram.

(b) (i) Most candidates gained at least partial credit. However, many candidates rounded incorrectly or did not round to three significant figures at all. A small number of candidates wrote the numbers down correctly and then calculated the answer incorrectly. Candidates need to check their working.

(ii) Many candidates gained at least partial credit for births/deaths and migration. Very few candidates recognised the limited area covered or uneven distribution of crabs. Many candidates commented on the marks being lost, marks making crabs more vulnerable and human error which did not gain credit.

(c) Few candidates manipulated the data well in this question. Most of those that attempted to, gave vague answers using numbers with descriptions of 'roughly/almost/about' or just quoted data from the graph without any calculations. Most candidates recognised an increase in the population with many candidates going on to achieve credit for additional detail and relevant comments. Some candidates used non-scientific language, for example the terms 'spiking' and 'skyrocketing', when describing the trends in the data.

Question 2

(a) Many candidates were unable to give a definition of the term 'ion'. There were some very confused answers and some incomplete answers stating that an ion was an atom with one type of charge only, rather than an atom that could have a negative or positive charge.

(b) (i) This question was very challenging for most candidates. Most answers given were very vague just including a description of what the apparatus would be used for. For example, 'lamp – light for photosynthesis, sediment – to hold the roots of the plant so it stays upright' and not how it would be used to conduct a valid experiment. Very few attempted to describe a method using the apparatus shown in the question to carry out an experiment. Candidates need to know how variables involved in an experiment should be manipulated, controlled or measured in terms of scientific quantities such as 'mass' and 'volume' and not 'amount'. Very few candidates showed an understanding of rate and so did not mention time. Most measured growth without any indication of needing a before and after measurement of height. One of the general rules of writing a method is that it should be in enough detail for another student to be able to follow the experimental method correctly.

(ii) Only stronger candidates gained full credit with others omitting either a suitable column heading or a suitable unit. A number of candidates tried to put data or units into the body of the table. Many candidates were awarded credit for the unit but 'inches' was given quite often. A few candidates constructed a graph with labelled axes which was not creditworthy.

(iii) This question was answered well by the majority of candidates. Some candidates did not mention both variables, giving answers such as "the growth rate would increase" without mentioning concentration or "nitrate ions increase growth". A few candidates stated that an increase in nitrate concentration would decrease the growth rate which did not gain credit.

(c) Only a few candidates seemed to know the biological molecules that contained nitrogen. For example, proteins (amino acids), chlorophyll and DNA. Other marking points such as 'growth', 'respiration', 'energy' and 'photosynthesis' were more often seen.

(d) (i) The majority of candidates used the word 'amount' or 'type' instead of 'number', 'mass' or 'species' and therefore did not gain credit. Typical answers included "the amount of pipefish", "type of seagrass" or "amount of seagrass". A few candidates incorrectly named abiotic factors, for example temperature and salinity.

(ii) Many correct answers seen for this question. The most common incorrect answer was 62, which was the percentage obtained from the graph not the number of pipefish.

(iii) A few candidates mistakenly thought species **S** and **R** were the predators of the pipefish. Responses suggested candidates had looked at the lines on the graph but did not link their conclusions to the label on the y axis which was the percentage of newborn pipefish surviving. There were also a lot of references to tank numbers, rather than species.

(iv) Most of the marking points were seen and there were some very good answers, for example, "the tank environment is not representative of conditions found in the sea", "not enough time" and "only one trial, no repeats".

Question 3

(a) Most candidates stated the correct answer. Very few candidates stated 'convergent' which was incorrect.

(b)(i) This question was answered well by the majority of candidates. Plots were generally precise, and graphs drawn for this question generally received full credit. Only a few candidates used over large plots. Candidates should be reminded:

- to draw points and/or the line in pencil rather than pen
- to ensure they do not omit units on the labelling of the axes
- to avoid using a non-linear scale, for example plotting 39, 55, 67, 88, 100, 115 and 140 on one of the axes, instead of it being regularly spaced, 20, 40, 60, 80, 100, 120 and 140
- not to extrapolate the line beyond the plots.

Candidates made lots of different choices with their scale intervals. Some of these made plotting the points much more difficult than others. Candidates need to think about how accurately they can plot their points when choosing their scale intervals.

(ii) Only a minority of candidates seemed to be familiar with Spearman's rank.

(c) (i) The most common observation from the graph was that both peaked at 2 km. Many candidates stated that both hydrogen sulfide and turbidity increased and then decreased but the idea that the concentration of hydrogen sulfide concentration decreased more rapidly than turbidity was less well observed.

(ii) Many candidates were unable to calculate the range correctly. Many appeared to use the wrong scale. They used the scale for hydrogen sulfide concentration not for turbidity. Some candidates gave the upper and lower values as the range instead of the difference between them.

(iii) This question was well answered by the majority of candidates.

(iv) The majority of candidates found this question challenging. Many answers were vague, did not include sufficient detail and included lots of references to adaptations. The most common credit awarded was for the use of hydrogen sulfide for chemosynthesis and the difficulty in tolerating the extreme conditions. A few candidates referenced increased productivity. Many candidates suggested changes in the conditions at the vent itself rather than in the vent plume. Some candidates stated changes in temperature but did not relate these to growth rates and the solubility of gases, resulting in less oxygen available. Other candidates suggested a lower pH or becoming more acidic, without explaining that this is due to the increased dissolved minerals in the water.

Question 4

(a) (i) Candidates were asked to compare the permeability of samples from locations **A**, **B** and **C**. Many candidates misread the question, and they described the different types of sediment in each location. Some candidates got the way in which particle size relates to permeability the wrong way round, with clay particles being more permeable. A few candidates stated the effect of erosion or ease with which sediment was moved by the water which were both incorrect.

(ii) This question was challenging for most candidates. Very few candidates understood that larger particles would have bigger gaps between them, so allowing more water to pass through or pass through easily. Often candidates suggested that larger particles would block water flow or that the water would go through the sediment particles themselves. Reference was also made to erosion and sedimentation which were incorrect. Overall candidates did not understand the concept of permeability and how it is affected by particle size.

(b) (i) Candidates often did not discuss permeability in answers to this question. Many answers were vague, and many did not specifically mention population density. Some candidates incorrectly stated that the flounders prefer or like the type of sediments rather than just stating higher or lower population densities. Some candidates described the composition of each location without relating it to the distribution of flounder. Many candidates linked particular particle types to relative population density but did not link these to particle size. Examples of where candidates did not link it to particle size included “sand consists of large particles” and “silt and clay are smaller particles”.

(ii) Most candidates were able to score at least partial credit. Quite a number of candidates correctly suggested the need to hide or camouflage as being an influencing factor on the distribution of the flounder. However, some of these candidates did not make reference to predator or hunting prey and therefore did not gain credit. Other candidates correctly mentioned the type of sediment present, the availability of prey and the ability to reproduce.

(c) The majority of candidates found this question extremely challenging. Candidates had to describe how the apparatus shown in the diagram could be used to determine permeability of sediment samples. The only credit that was frequently given was the mention of a timer, stop clock or graduated cylinder as additional pieces of equipment needed. A number of candidates used the word ‘amount’ instead of ‘volume’ or ‘mass’ or ‘depth’. Answers given were often too vague and lacked the necessary detail. When writing out a method, there should be enough detail for another student to be able to conduct the experiment accurately without having to query any of the steps. Candidates would benefit from practice in this during their course of study.

Question 5

(a) This question was often answered well. Stronger candidates scored full credit with ‘symbiotic relationship’ and ‘one organism gains and the other is harmed’. Few candidates described the need for the parasite to be in close proximity to the host. Candidates should be reminded to use appropriate terminology, for example avoiding terms such as ‘hurt’ and ‘negatively affected’ here.

(b) (i) The majority of candidates gained credit for noticing that the gobies with copepods tended to travel further from their hiding space than the unaffected gobies. ‘Travel more’ or ‘longer or higher’ did not gain credit. Very few candidates noticed that as more gobies compete for each hiding space the distance travelled from their hiding place increases for both gobies with parasites and without parasites. In addition, very few candidates were able to explain the difference in the gradients of the two lines.

(ii) Many candidates found it very difficult to suggest ways that the copepod could affect the gobies behaviour. Many candidates suggested that the gobies would die which was incorrect. Many candidates were not specific enough, often giving irrelevant information and describing some physical consequence such as eating the goby’s tongue. Very few candidates stated that it might result in smaller gobies and that the change in their behaviour could increase the chances of predation.

(c) (i) Many candidates gave the answer as the number of species not genus groups. For example, 4 for manta ray species and 2 for remora species.

(ii) A large number of candidates calculated the number of *Mobula birostris* with *Remora remora.*

(iii) Candidates found this question challenging with candidates using vague terminology such as they ‘preferred’ or ’liked’ each other, which could not be credited. Very few candidates were awarded further credit. There was often incorrect manipulation of data and lifting of numbers from the table.

MARINE SCIENCE

Paper 9693/22

AS Level Data Handling and Investigative Skills

Key messages

Candidates should be reminded to use appropriate scientific language, particularly when describing experimental equipment.

Candidates should ensure they use a sharp pencil and a ruler in the examination. A ruler should be used to label diagrams or draw graphs. Lines for labelling should be straight without an arrowhead. Label lines should also touch the feature being labelled.

Candidates are expected to use a calculator and demonstrate appropriate rounding to a suitable number of significant figures or decimal places. Some candidates were able to round values appropriately, but a significant number confused decimal places with significant figures. Candidates should always show their working out during calculations, as it may be possible to gain partial credit even when errors mean an incorrect final answer is given.

General comments

Candidates are expected to have carried out the practical activities stated in the syllabus and should use this experience to demonstrate their awareness of practical techniques in similar investigations with different materials or methods. Candidates need to demonstrate an understanding of key aspects of the syllabus and be able to apply this to unfamiliar contexts and data.

Stronger candidates made links across different aspects of the syllabus and were able to demonstrate a good understanding of density in unfamiliar investigations, including describing how to measure the density of objects. Weaker candidates were not able to describe how to use appropriate equipment in investigations from the information given. These candidates also often used imprecise language to describe quantities, such as ‘amount’ instead of ‘volume’, ‘number’ or ‘population’, and ‘weight’ instead of ‘mass’.

Comments on specific questions

Question 1

(a) Most candidates were able to describe an ethical aspect of tagging the turtles. Few candidates gave a clear outline of how to carry out a mark-release-capture investigation with sufficient detail.

(b) This question was well answered. Most candidates were able to correctly calculate the population using the equation.

(c) Many candidates achieved at least partial credit for the graph. The most common omission was an appropriate scale. Many candidates started the population axis at zero, resulting in the plots occupying less than half the grid. Some candidates used the table data as the scale for their axis. This was not appropriate and could not be awarded the credit for scale or plotting.

(d) Most candidates correctly described the trend.

(e) Many candidates recognised the results would be inaccurate, but only stronger candidates understood that this would have resulted in a higher estimate for the population.

Question 2

(a) (i) Many candidates were able to identify all three features but some used inappropriate lines or arrows to indicate these imprecisely.

(ii) Most candidates were able to state the genus correctly.

(b) Most candidates were able to identify the correct species using the key.

(c) (i) Most candidates recognised that hunting sharks for the research was unethical. Few candidates realised that to investigate the internal parasites, the sharks needed to be dead. Many candidates therefore described a need to reduce the harm to sharks before they were released again.

(ii) Most candidates were able to describe at least one advantage or disadvantage to the parasites of living inside the shark. Some candidates described advantages and disadvantages to the sharks instead of to the parasites. Candidates should be encouraged to read questions carefully.

(iii) Many candidates were able to give two appropriate features for crustaceans.

(d) (i) Most candidates answered this question well. The most common mistake was incorrect rounding of the $(n / N)^2$ value as 0.337.

(ii) Most candidates were able to correctly calculate the two values for diversity.

(iii) Most candidates correctly compared the two values for diversity. A few candidates incorrectly stated that species F contained more parasites instead of being more diverse.

Question 3

(a) Most candidates were able to state three conditions affecting the density of water.

(b) (i) Most candidates recognised the need to use mass and volume to calculate density. Few candidates were also able to describe how to measure mass and volume and the appropriate equipment to use. Weaker responses referred to beakers to measure volume and scales to measure mass. In particular scale is not appropriate scientific language when referring to measurements as most measurements use a scale to measure against.

(ii) Many candidates presented a suitable table.

(c) (i) Most candidates recognised that mid-ocean ridges occur at divergent plate boundaries. Fewer candidates gave appropriate descriptions of the process of sea floor spreading.

(ii) Many candidates gave an appropriate value by missing out the anomalous value of 806.

(iii) Many candidates recognised that the number or size of holes would vary, and some understood the composition of the minerals could also vary.

(iv) Some candidates gave excellent explanations of the difficulties in measuring the density of pumice, describing water entering the pores and using the density data given to describe the pumice floating and therefore not displacing the full volume of the rocks.

(d) (i) Most candidates described currents moving the rocks around, but few demonstrated an awareness that all the oceans are interlinked allowing movement between them.

(ii) Most candidates stated that weathering occurred but few gave suitable descriptions of weathering processes. Many candidates stated that rocks would be deposited as sediment on beaches.

Question 4

(a) Many candidates drew appropriately sized diagrams. Most candidates' diagrams had appropriate proportions and details included. Candidates should be reminded that the outline of their diagram needed to be unbroken and drawn in pencil.

(b) (i) Many candidates were able to describe at least 2 advantages of collecting data from the public.

(ii) Most candidates were able to describe a limitation of this approach to collecting data.

(iii) Some candidates were able to suggest an appropriate strategy to reduce the effect of this limitation.

(iv) Most candidates recognised that jellyfish sting or have nematocysts.

(v) Most candidates suggested avoiding touching the jellyfish. Few candidates were able to give a second appropriate precaution.

(c) (i) Many candidates did not understand that jellyfish are predators, incorrectly stating that the jellyfish feed on phytoplankton. Some candidates also incorrectly stated that jellyfish take in the nutrients directly from the water instead of through food chains.

(ii) Many candidates gave an appropriate description of why more jellyfish would wash up on beaches when their population increases.

(iii) Some candidates drew appropriate lines that followed a similar trend to the phytoplankton. Few candidates added a suitable delay to the curve, suggesting that reasoning for this delay was not well understood.

(d) (i) Most candidates described the trend appropriately.

(ii) Some candidates correctly calculated the percentage increase. Common incorrect answers were 400% or 25%.

(iii) Most candidates recognised the lack of data for nitrate and phosphate, that the different species showed different trends, or that other factors could be affecting the population. Few candidates were able to identify 3 different reasons the figure did not provide suitable evidence.

MARINE SCIENCE

Paper 9693/23

AS Level Data Handling and Investigative Skills

Key messages

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General comments

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(iii) Some candidates drew appropriate lines that followed a similar trend to the phytoplankton. Few candidates added a suitable delay to the curve, suggesting that reasoning for this delay was not well understood.

(d) (i) Most candidates described the trend appropriately.

(ii) Some candidates correctly calculated the percentage increase. Common incorrect answers were 400% or 25%.

(iii) Most candidates recognised the lack of data for nitrate and phosphate, that the different species showed different trends, or that other factors could be affecting the population. Few candidates were able to identify 3 different reasons the figure did not provide suitable evidence.

MARINE SCIENCE

Paper 9693/31
A Level Theory Paper

Key messages

Candidates should ensure that they are familiar with all topics on the specification and have factual detail at the required standard for A Level.

Candidates should read each question carefully and answer with precision, paying particular attention to the command words such as 'describe', 'explain', 'compare'. For list questions, candidates should take care to only include the number of answers specified in the question.

Answers to ***Section B*** questions should be written in continuous prose as stated in the syllabus.

General comments

The standard of responses was mixed with few strong candidates who demonstrated a thorough knowledge of A Level topics.

Some questions required candidates to use the information provided, or to extract information from a graph to help them complete their answers. Stronger candidates performed well on these questions and were able to integrate information with relevant knowledge in a logical way.

Weaker candidates performed well on topical subjects such as oceans interaction with the atmosphere and carbon cycle as well as conservation of marine ecosystems. However, many of these candidates demonstrated minimal knowledge of A Level topics, particularly on osmoconformers, photosynthesis and salmon aquaculture.

Comments on specific questions

Section A

Question 1

(a) (i) Stronger candidates could clearly state the meaning of the term 'tidal range'. Weaker responses often missed out 'height' or 'difference' and only referred to the range/distance between high tide and low tide. Several candidates incorrectly assumed it was the difference between the distance on the beach reached by high and low tide.

(ii) Most candidates only gave part of the answer and needed to give more detail in an explanation. For example, stating that water in the lagoon would be calmer or shallower but not then explaining that it was warmer due to being heated more easily or faster. Weaker responses referred to the industry or human activity as reason for the increased temperatures. Few candidates mentioned a lack of mixing with cooler water from the Mediterranean Sea. Some candidates linked temperature with salinity. However some candidates thought the Mar Menor was a freshwater lagoon unlike the Mediterranean Sea.

(iii) Run-off containing fertilisers was often suggested, but fewer candidates could name a correct nutrient present in fertilisers. Phosphorus was a common incorrect response. The resulting increase in growth or photosynthesis and/or increased rate of reproduction were credited but more often only 'eutrophication' or a 'bloom' was referred to.

(iv) Most candidates could state that the phytoplankton bloom prevented light from reaching the macroalgae and seagrass below. Fewer included that the phytoplankton bloom covered the surface

or that it used up the nutrients required by the plants. Decomposition and subsequent oxygen depletion were occasionally mentioned, but this was often linked to the plants rather than the phytoplankton. Some weaker candidates thought that phytoplankton consumed the plants or that phytoplankton are bacteria.

(b) (i) Most candidates were able to identify that waste from a desalination plant would increase salinity or making the water more saline. Weaker responses identified only that salinity would change or incorrectly stated that the waste was freshwater and would decrease salinity.

(ii) Most candidates identified that silt would block light from reaching producers in the lagoon. Few candidates were able to give details of the consequences of this. Some candidates referenced silt blocking gills but few candidates correctly linked this to respiration. Candidates more frequently referred to breathing. Many candidates correctly identified the difficulty of finding prey or avoiding predators and that silt could release toxins. Candidates needed to make the meaning of bioaccumulation or biomagnification clear if referenced in their response.

(c) Many candidates knew that the higher temperature would reduce the oxygen held in the water but often did not fully explain this, stating only that there was 'less oxygen for respiration'. Some candidates recognised the increase in salinity but few made the reason for death clear. Some candidates recognised that photosynthesis would be prevented but few mentioned enzyme. Weaker responses only referred to the fish not being used to the higher temperatures causing 'stress', 'going into shock' or that they were 'unable to adapt'.

Question 2

(a) (i) Most candidates correctly described the increase in the concentration of the body fluids as the salinity increased, some referring to the relationship as a positive correlation. Few candidates were then able to explain the relationship in terms of oysters being osmoconformers or having the same salinity as their surroundings. There was some confusion over the terms 'osmoconformers' and 'osmoregulators'.

(ii) Only stronger candidates identified that as the salinity increased, body mass would decrease and correctly drew a line on the graph. A few candidates drew lines which levelled off.

(iii) Most candidates who gave the correct answer in **(ii)** were able to explain the decrease in body mass by loss of water, and some candidates references osmosis in their response. Few candidates referenced water potential difference, and when it was mentioned a higher concentration of solutes was often linked to a higher water potential, rather than a lower one. Most candidates who drew lines in **(ii)** describing body mass increasing with salinity were able to correctly describe the trend they had drawn. Many of these candidates gave incorrect reasons for increased body mass such as "more salinity gives more salt" or "increases growth".

Question 3

(a) (i) Few candidates correctly interpreted the graph. In particular the fish oil value was often given as 74% and 8%, instead of 24% and 4%. Some candidates misread the y-axis scale. Most candidates were able to read of correct values for the percentage of fishmeal. While some candidates calculated the percentage decrease for each raw material, some candidates quoted values that were not specific enough or did not quote any figures, particularly for 2030.

(ii) A common correct answer was that the decrease was due to alternative sources being cheaper. Few candidates referenced to sustainability or to the decline in small fish stocks to supply fishmeal and fish oil. Some responses just compared fishmeal with fish oil.

(iii) Incorrect answers included inaccuracy of predictions or inaccurate data collection. Some candidates referred to the existing downward trend for plants products shown on the graph and suggested that this could continue. Few candidates considered the implications of increasing the percentages from plants, for example on the amount of land required or to possible effects of climate change on future production.

(iv) Many candidates recognised the idea that this was the optimum percentage of vitamins and minerals or that adding more would not further improve the growth of the salmon. However, many candidates gave answers related to eutrophication and algal blooms which were not relevant.

(b) (i) Most candidates identified that the molecule shown was a carbohydrate, but needed to specify that it was glucose. Incorrect answers included lipid, protein, calcium carbonate and nitrogen.

(ii) Stronger responses referred to bacteria using waste products and having a faster growth rate. Few candidates referred to sustainability. Incorrect responses included that feed produced by bacteria would provide salmon with immunity or resistance to disease or that it would contain "better nutrients".

Question 4

(a) (i) Only stronger candidates correctly identified two features shared by all Chordata. A few candidates stated "having a neural chord", rather than notochord or dorsal neural tube. Many candidates gave incorrect answers which did not specifically refer to organism in the phylum Chordata. For example, lateral line, a named fin, operculum or swim bladder.

(ii) Most candidates were able to identify a visible feature present in bony fish, usually dorsal or anal fin or gills covered by an operculum. Common incorrect answers included the lateral line and swim bladder.

(iii) The question was well answered. Candidates usually gave poor swimming or body covered in skin rather than scales. Some candidates need to give more precise answers, such as stating 'they have a tail' rather than qualifying this by adding that there was no caudal fin. Many candidates knew that males gave birth to young.

(b) Most candidates were able to suggest some of the reasons for decrease in seahorse numbers. Common correct answers were that seahorse numbers had been reduced due to litter from tourism, oil pollution from boats and habitat destruction. Many responses included a reference to commercial fishing which caught seahorses as by-catch. Some candidates confused this with deliberate fishing of seahorses. Weaker responses gave reasons that needed more specific detail, such as "boats use the channels where seagrass is found" or "too many tourists use the beaches" or "disruption from boats/tourism".

(c) Many candidates answered this question well with some excellent suggestions on research topics. Some candidates listed 'fishing', 'tourism' or 'pollution' and needed to also explain that it was the effect of these which was important.

(d) Most candidates could state that fishing or tourism needed to be regulated. Some responses elaborated on this idea instead of providing other suggestions such as creating an MPA or creating more habitat. Fewer responses included the idea of captive breeding on land, legislation, or fines.

Section B

Question 5

This question required candidates to explain how chloroplast structure was related to photosynthesis. Most candidates who attempted the question were able to give some correct explanation. Many candidates gave more general answers relating to photosynthesis rather than directly addressing the question. Few responses referred to membrane permeability, to chloroplasts having a large surface area to volume ratio, to thin membranes so allowing easy diffusion of gases and water entry by osmosis. Candidates should be reminded to read the question carefully and to focus their responses on the question asked. Weaker candidates demonstrated very little knowledge on this subject and the question was frequently not attempted.

Most candidates understood that the light-dependent and light-independent stages of photosynthesis occurred within a chloroplast and that light energy was absorbed during the light-dependent reaction. Many candidates knew the location of the chlorophyll in the thylakoids. Although many candidates stated that green light was reflected, fewer included the absorption of red and blue light by chlorophyll. Stronger candidates added that accessory pigments were also present and usually quoted an example. Many candidates were able to explain the role of rubisco to fix carbon dioxide in the light-independent reaction. Some candidate also referred correctly to photolysis or photoactivation or to the roles of ATP and reduced NADP.

Question 6

(a) Most candidates were able to describe some of the different ways that carbon compounds could enter the ocean. Most responses included carbon dioxide dissolving or being absorbed by the ocean, often by wave action, run-off from the land, respiration and death decomposition. A few candidates referred to hydrothermal vents, or mining or volcanoes under the water. Few candidates referred to the weathering of rocks or erosion of shells in their response. Many candidates discussed carbon compounds being used during shell formation or during photosynthesis which was relevant to **(b)**

(b) Most candidates recognised that oceans act as carbon sinks and absorb carbon dioxide from the atmosphere to limit its increase. Photosynthesis of marine plant was often mentioned but the idea of storing the carbon in organic compounds which pass along a food chain was seen less often. Stronger candidates included its use to form shells and coral reefs or that it could be stored in ice sheets. If decomposition was mentioned, it was very rarely linked to marine snow sinking to the ocean floor. Some accounts included irrelevant information such as the acidification of the ocean and coral bleaching. Weaker candidates were confused as to what to include for each part of this question, so respiration and run-off were included here and photosynthesis in **(a)**.

Question 7

Most candidates were able to identify some disadvantages to releasing adult salmon produced in a hatchery. Most responses also included advantages, but needed to give further detail and justification. For example stating that the salmon population would be increased, and that this would increase salmon catch for fishers, so increasing income or employment. Providing more food for predators was a common answer. Few candidates referred to survival rates in a hatchery, or that it is used if wild salmon are of conservation concern, or if rivers are blocked by dams preventing migration.

Disadvantages included the inability of hatchery produced adult salmon to adapt to ocean conditions, especially with regards to hunting for prey and avoiding predators. Candidates did not always include sufficient detail, for example, stating that the salmon lacked survival skills or ‘competition’. Here further specific detail about hunting for prey and avoiding predators was needed. Weaker candidates often correctly stated that the addition of adult hatchery salmon could disrupt food chains.

The effect on genetic diversity or gene pool and the potential spread of disease from hatchery produced salmon to the wild population (or vice versa) was not always expressed in a scientifically accurate way.

Some candidates produced lists words to do with salmon and their answers lacked the detail required. Candidates should be encouraged to write in continuous prose for section B.

MARINE SCIENCE

Paper 9693/32
A Level Theory Paper

Key messages

Candidates should ensure that they are familiar with all topics on the specification and have factual detail at the required standard for A Level. Candidates should also ensure that they understand the difference between biological terms such as bioaccumulation and biomagnification and between stenohaline and euryhaline.

Candidates should be encouraged to spend time reading and processing all the information provided before starting to write their answers, and to ensure that they understand the rules for 'list' questions and do not add extra answers beyond the number ask for in the question.

General comments

The standard of responses was generally high with stronger candidates able to identify the main points to make in questions assessing knowledge of syllabus topics. Some questions required candidates to use information provided or information from graphs to help them produce a complete and accurate response. Stronger candidates were able to integrate question paper information with their knowledge in a logical way.

Many candidates demonstrated limited knowledge of A Level topics such as aquaculture, osmoregulation and mitochondria. However, most candidates performed well questions regarding hydrothermal vents and plastic pollution.

Comments on specific questions

Section A

Question 1

(a) Most candidates could name one feature of a crustacean but many could not identify a second correct feature. Examples of incorrect responses included 'many legs', 'eight' or 'five pairs of' legs or 'segmented legs' rather than jointed legs, and stating 'shell' instead of carapace. Few candidates identified having two pairs of antennae.

(b) Most candidates were able to identify metamorphosis and the presence of a larval stage as two features of a complex life cycle.

(c) (i) Stronger candidates were able to use the information provided that read the information provided most stages in the snow crab life cycle were benthic, to explain that bottom trawling would catch more crabs than other methods. Few candidates referred to bottom trawling causing minimal damage to the mud substrate. Weaker candidates often only referred to bottom trawling as an 'efficient' method and needed to give a reason why this was the case.

(ii) Common incorrect answered were due to the candidate using an incorrect formula, often 1.9 divided by 11.7, or rounding up of the percentage to 84%.

(iii) Stronger candidates were able to use the information provided to state that the decrease in crab numbers meant that there were now insufficient numbers of males left to catch and link this to the idea that that are now too few male crabs left to breed, so recruitment rates would be low. Some

candidates referenced 'less breeding' but needed to give more specific detail in their response. Many candidates stated that the fishing ban would allow the snow crab population to recover.

(iv) Many candidates understood that eggs or larval stages would be damaged or that there would be too few cold-water pools for juvenile crabs to mature. Few candidates referred to a reduction in oxygen concentrations and the effect on respiration or to the effect of a change in salinity from either evaporation or ice melt, on water potential. Some candidates referred to algal blooms in their response. These, responses needed to be clear that the blooms might not coincide with larval hatch, or that increased temperatures would reduce the food available for larvae by limiting growth of phytoplankton as increased temperatures reduce upwelling making less nutrients available.

(d) Many candidates correctly suggested that that native species would now be predated by cod, so commercial fishers for snow crabs or native species would lose income or employment, or that commercial fishers could now fish for cod. Many candidates also referred to predation causing a change in food chains or webs.

Question 2

(a) Most candidates correctly stated that the ban might not be successful as illegal fishing for sea cucumbers would take place. Fewer stated that monitoring or enforcement would be problematic. Some candidates correctly suggested that the population could be too low for it to recover.

(b) Most candidates were able to identify the information required for successful growth of sea cucumbers in a hatchery.

(c) Stronger candidates we able to suggest advantages of involving the local community in the aquaculture project.

(d) That sea cucumbers digest waste products from fish was well understood. Fewer candidates we able to explain that nutrients were recycled as a result. Many candidates also referred to reduction in algal blooms and oxygen depletion with a corresponding reduction in disease. Fewer references were made to an extra source of income or that sea cucumbers would not require additional feeding.

Question 3

(a) Most candidates were able to state that phytoplankton provided a food source in extensive aquaculture but that in intensive aquaculture, food was provided. A few candidates referred to the role of phytoplankton in providing oxygen in ponds or included information on the negative aspects of algal blooms. Candidates should be encouraged to read questions carefully, and to focus their answers on the specific question asked.

(b) (i) Few candidates gave sufficient detail in their responses to this question. Most candidates were able to state that the dissolved oxygen concentration reached a maximum during the day, or at 18:00, but did not make refer to the oxygen concentration at night or compare high and low phytoplankton abundance. Few candidates used data from graph to support their statements.

(ii) Most responses referred only to the oxygen concentration and did not link this to the processes of photosynthesis or respiration. Only very strong candidates stated that the rate of photosynthesis was greater than the rate of respiration during the day and that only respiration occurred at night. Weaker responses often referred to 'oxygen levels' or 'oxygen rate' rather than oxygen concentration.

(c) Most candidates were able to state that increasing winds would increase the diffusion rate of gases into the water. Few candidates were able to explain the effect of increased oxygen concentration on respiration or the effect of increased carbon dioxide concentration on photosynthesis, and the subsequent changes in oxygen concentrations in the pond. Many responses did not include a reference to the expected change in shape of the graph. Some candidates referred only to high phytoplankton abundance rather than low phytoplankton abundance. Candidates should be encouraged to read the question carefully.

Question 4

(a) Most candidates could state the difference between the meanings of stenohaline and euryhaline. Some candidates had confused the two terms.

(b) Only the strongest candidates were able to answer this question correctly. Weaker responses often needed more specific detail**.** Common incorrect answers for process **A** included that it was the 'removal of salts' or that it was the 'removal of excess liquids'. Many candidates gave answers about ventilation rather than osmoregulation for process **B** such as 'the fish opens its mouth, and water is sucked in to pass over the gills'. Many candidates gave answers for process D which needed more specific detail, or were incorrect. For example, 'the kidney releases urine/waste products' or 'urine and faeces are removed'

(c) Most candidates could state that the ions were moved against a concentration gradient, but fewer stated that energy from ATP was required. Some responses referred to water potential differences rather than the differences in the concentration of sodium and chloride ions.

Section B

Question 5

This synoptic question required candidates to synthesise information from both AS and A Level topics. It was a topic that was well understood by most candidates.

Most candidates were able to state that the environment at hydrothermal vents was extreme and could quote two examples of extreme conditions, usually temperature and pressure. Fewer responses included that the site was toxic or that the pH was acidic. If the lack of light was stated, this was usually linked to the fact that photosynthesis could not take place. Most candidates were able to describe the relationship between Endoriftia and Riftia as a symbiotic relationship with both partners benefitting.

Most candidates understood that chemosynthesis would take place here. Fewer candidates were able to name the bacteria as the producer. Hydrogen sulphide was often named as a substrate, but fewer answers included that this, along with other minerals, was released from hydrothermal vents or that it was a source of energy to fix carbon sources to produce glucose.

Question 6

(a) Most candidates were able to give some reasons why green crabs pose a threat to native marine species and ecosystems. Common correct answers included that they feed on a variety of different prey, that they have a high reproductive rate and have few predators.

Stronger candidates were able to state that the green crab could outcompete native species for food or shelter. Weaker responses only stated that green crabs 'compete with native species' and needed to provide further detail. That the crab has a disruptive influence on food chains or webs was common and stronger responses also included that this would reduce biodiversity.

Few candidates were able to identify from the information provided that the crabs can inhabit a wide range of habitats or referred to the wide range in temperatures and salinity that would be encountered with such a wide distribution range. Few answers considered how the crab might be transported to a new habitat.

(b) Most candidates demonstrated some knowledge on plastic pollution in this question. Stronger candidates were able to provide specific examples, including entrapment to cause injury, or the ingestion of plastic by marine organisms such as turtles causing blockage and eventual starvation. Weaker responses, such as turtle 'suffer harm' or 'die', required more specific detail.

Responses stating that plastic could be broken down into microplastics were common and stronger candidates went on say that these could be consumed by zooplankton or by filter feeders. Stating that microplastic is consumed by phytoplankton is incorrect. Stronger candidates then continued their response by stating that plastic can contain toxins which bioaccumulate in organisms and biomagnify along food chains. Some candidates stated 'toxins bioaccumulate and biomagnify along a food chain' and needed to make a clearer distinction between these terms.

Question 7

This topic was poorly understood. Some candidates did not attempt the question and others showed little understanding in their response. Diagrams were frequently drawn, but many were unlabelled or contained incorrect information. Weaker candidates were only able to state that the function of a mitochondrion was ‘respiration’ rather than aerobic respiration. Some weaker responses stated that energy was ‘created’ rather than ‘released’ as a result of respiration. Few candidates referred to the size of a mitochondrion, the diffusion of gases, the permeability of the membranes or that the matrix contains enzymes. Most candidates knew that the inner membrane was folded to increase the surface area.

The term ‘cisternae’ was commonly seen instead of ‘cristae’. The matrix was often referred to as ‘cytoplasm’. The outer and inner membranes were sometimes referred to as cell membranes.

Some candidates referred to the origins of mitochondria which was not relevant. Candidates should be encouraged to focus their answers on the specific question asked.

MARINE SCIENCE

Paper 9693/33
A Level Theory Paper

Key messages

Candidates should ensure that they are familiar with all topics on the specification and have factual detail at the required standard for A Level. Candidates should also ensure that they understand the difference between biological terms such as bioaccumulation and biomagnification and between stenohaline and euryhaline.

Candidates should be encouraged to spend time reading and processing all the information provided before starting to write their answers, and to ensure that they understand the rules for 'list' questions and do not add extra answers beyond the number ask for in the question.

General comments

The standard of responses was generally high with stronger candidates able to identify the main points to make in questions assessing knowledge of syllabus topics. Some questions required candidates to use information provided or information from graphs to help them produce a complete and accurate response. Stronger candidates were able to integrate question paper information with their knowledge in a logical way.

Many candidates demonstrated limited knowledge of A Level topics such as aquaculture, osmoregulation and mitochondria. However, most candidates performed well questions regarding hydrothermal vents and plastic pollution.

Comments on specific questions

Section A

Question 1

(a) Most candidates could name one feature of a crustacean but many could not identify a second correct feature. Examples of incorrect responses included 'many legs', 'eight' or 'five pairs of' legs or 'segmented legs' rather than jointed legs, and stating 'shell' instead of carapace. Few candidates identified having two pairs of antennae.

(b) Most candidates were able to identify metamorphosis and the presence of a larval stage as two features of a complex life cycle.

(c) (i) Stronger candidates were able to use the information provided that read the information provided most stages in the snow crab life cycle were benthic, to explain that bottom trawling would catch more crabs than other methods. Few candidates referred to bottom trawling causing minimal damage to the mud substrate. Weaker candidates often only referred to bottom trawling as an 'efficient' method and needed to give a reason why this was the case.

(ii) Common incorrect answered were due to the candidate using an incorrect formula, often 1.9 divided by 11.7, or rounding up of the percentage to 84%.

(iii) Stronger candidates were able to use the information provided to state that the decrease in crab numbers meant that there were now insufficient numbers of males left to catch and link this to the idea that that are now too few male crabs left to breed, so recruitment rates would be low. Some

candidates referenced 'less breeding' but needed to give more specific detail in their response. Many candidates stated that the fishing ban would allow the snow crab population to recover.

(iv) Many candidates understood that eggs or larval stages would be damaged or that there would be too few cold-water pools for juvenile crabs to mature. Few candidates referred to a reduction in oxygen concentrations and the effect on respiration or to the effect of a change in salinity from either evaporation or ice melt, on water potential. Some candidates referred to algal blooms in their response. These, responses needed to be clear that the blooms might not coincide with larval hatch, or that increased temperatures would reduce the food available for larvae by limiting growth of phytoplankton as increased temperatures reduce upwelling making less nutrients available.

(d) Many candidates correctly suggested that that native species would now be predated by cod, so commercial fishers for snow crabs or native species would lose income or employment, or that commercial fishers could now fish for cod. Many candidates also referred to predation causing a change in food chains or webs.

Question 2

(a) Most candidates correctly stated that the ban might not be successful as illegal fishing for sea cucumbers would take place. Fewer stated that monitoring or enforcement would be problematic. Some candidates correctly suggested that the population could be too low for it to recover.

(b) Most candidates were able to identify the information required for successful growth of sea cucumbers in a hatchery.

(c) Stronger candidates we able to suggest advantages of involving the local community in the aquaculture project.

(d) That sea cucumbers digest waste products from fish was well understood. Fewer candidates we able to explain that nutrients were recycled as a result. Many candidates also referred to reduction in algal blooms and oxygen depletion with a corresponding reduction in disease. Fewer references were made to an extra source of income or that sea cucumbers would not require additional feeding.

Question 3

(a) Most candidates were able to state that phytoplankton provided a food source in extensive aquaculture but that in intensive aquaculture, food was provided. A few candidates referred to the role of phytoplankton in providing oxygen in ponds or included information on the negative aspects of algal blooms. Candidates should be encouraged to read questions carefully, and to focus their answers on the specific question asked.

(b) (i) Few candidates gave sufficient detail in their responses to this question. Most candidates were able to state that the dissolved oxygen concentration reached a maximum during the day, or at 18:00, but did not make refer to the oxygen concentration at night or compare high and low phytoplankton abundance. Few candidates used data from graph to support their statements.

(ii) Most responses referred only to the oxygen concentration and did not link this to the processes of photosynthesis or respiration. Only very strong candidates stated that the rate of photosynthesis was greater than the rate of respiration during the day and that only respiration occurred at night. Weaker responses often referred to 'oxygen levels' or 'oxygen rate' rather than oxygen concentration.

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Few candidates were able to identify from the information provided that the crabs can inhabit a wide range of habitats or referred to the wide range in temperatures and salinity that would be encountered with such a wide distribution range. Few answers considered how the crab might be transported to a new habitat.

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This topic was poorly understood. Some candidates did not attempt the question and others showed little understanding in their response. Diagrams were frequently drawn, but many were unlabelled or contained incorrect information. Weaker candidates were only able to state that the function of a mitochondrion was ‘respiration’ rather than aerobic respiration. Some weaker responses stated that energy was ‘created’ rather than ‘released’ as a result of respiration. Few candidates referred to the size of a mitochondrion, the diffusion of gases, the permeability of the membranes or that the matrix contains enzymes. Most candidates knew that the inner membrane was folded to increase the surface area.

The term ‘cisternae’ was commonly seen instead of ‘cristae’. The matrix was often referred to as ‘cytoplasm’. The outer and inner membranes were sometimes referred to as cell membranes.

Some candidates referred to the origins of mitochondria which was not relevant. Candidates should be encouraged to focus their answers on the specific question asked.

MARINE SCIENCE

Paper 9693/41

A Level Data-Handling and Investigative Skills

Key messages

In future series, candidates should:

- use terms such as volume, mass or number rather than 'amount' when writing experimental plans
- plan for at least five different values of the independent variable in experimental plans
- use the term 'significant' when interpreting the results of a statistical test
- understand how to rank all values when carrying out a Spearman's rank test
- use language and vocabulary that has a level of detail appropriate to A Level Marine Science
- check error bars if included on graphs, looking for overlaps.

General comments

The general standard of answers was very good. Answers requiring factual knowledge were generally of a high standard although a few candidates underestimated the level of detail needed to gain full marks on these questions.

Mathematical skills were generally very good, and most candidates were able to extract relevant data from graphs and tables. Graphical skills were generally very good. Most candidates were able to select linear scales, plot points accurately and label axes. Scales for graphs should be constructed so that they make the best use of the available grid. Many candidates were able to complete and interpret the Spearman's rank correlation test, but some were unsure how to rank two data points with the same value.

Experimental planning was excellent. Most candidates were able to identify the independent and dependent variables and suggest control variables and gave detailed answers. Some candidates gave vague answers that did not gain credit such as only suggesting three different concentrations of the independent variable, or referring to amounts of substances rather than masses, volumes, or numbers. When suggesting statistical tests for analysis and describing graphs that would be drawn, candidates should give detail, for example the reason why a test would be used and what would be placed on each graph axis.

Drawing skills were good with most candidates presenting diagrams drawn in pencil, of a good size, with no shading and with sufficient detail.

Analysis of data from graphs and tables was challenging for many candidates. When asked to discuss or explain data, candidates should first describe data patterns to help structure their answers and then go on to give reasons for the patterns as part of their explanations. A small number of candidates confused the demands of different command words, typically, 'describe' and 'explain'. Candidates should familiarise themselves with all the command words listed in the syllabus.

Comments on specific questions

Question 1

(a) (i) This question required candidates to identify a labelled organelle as the rough endoplasmic reticulum. Although many candidates correctly identified the organelle, common errors included reference to the smooth endoplasmic reticulum, Golgi apparatus or to 'endoplasmic reticulum' without stating 'rough'.

(ii) This question required candidates to describe the function of the rough endoplasmic reticulum. Many candidates gained at least partial credit for stating that it synthesises proteins but only a few

gave more detail to gain full credit. Many candidates incorrectly referred to the rough endoplasmic reticulum producing ribosomes, and some confused the function of the rough endoplasmic reticulum with the function of the Golgi.

(b) (i) Drawing skills were generally very good and most drawings had unbroken lines, no shading or stippling and were at least as large as the original diagram. Some candidates found drawing the cristae in proportion challenging but most made creditable efforts to draw proportionate diagrams with sufficient detail. A small number of candidates drew the whole mitochondrion and/or used pen.

(ii) Many candidates found this calculation challenging. The question required candidates to calculate the length of the mitochondrion. Most were able to correctly measure the length of the mitochondrion and divide by the magnification of 65 000 but a significant number of candidates did not recognise that there are 1 000 000 nm in 1 mm and confused nm with mm. When making measurements, candidates should use mm rather than cm.

(iii) This question presented candidates with data showing the percentage of white and red muscle tissue in salmon composed of mitochondria. Candidates had to describe and explain the data. Most were able to state that the percentage of tissue composed of mitochondria was higher in red muscles and the strongest candidates supported their answer with a calculation. A few candidates confused the percentage of muscle taken up by mitochondria with the percentage of muscle present in the salmon. Stronger answers went on to state that mitochondria perform respiration and that long distance swimming requires more muscle contraction and so more energy. Candidates should refer to ATP when discussing energy release.

Question 2

(a) This question required a description of the relationship between *Endoriftia* and *Riftia*. Stronger answers stated that the relationship is mutualistic, that *Endofitia* gains a habitat and/or carbon dioxide and that the *Riftia* gains energy or carbohydrates. Some candidates tended to confuse mutualism with commensalism or parasitism and gave incorrect substances that were transferred between the two organisms.

(b) (i) This calculation was generally completed well. Stronger candidates correctly calculated the areas as 7.5 m^2. A few candidates gave incorrect units, frequently stating that the unit was per m^2.

(ii) This challenging question required candidates to suggest why bone is colonised more than calcium carbonate due to the presence of nutrients that are released when it decomposes. A significant number of candidates described the data again rather than giving an explanation.

(iii) This question required candidates to bring together the data in the question to explain why there is higher colonisation of most substrates when methane is present. The strongest answers explained that methane is an energy source for chemosynthesis so there would be more primary productivity and so more energy flow through the food webs enabling more trophic levels and more complexity. Weaker answers tended to only give descriptions rather than explanations.

(iv) This question assessed practical skills. The question asked candidates to evaluate the evidence that the methane affected colonisation. As the question asked for an evaluation, there needed to be a point supporting the conclusion and a point not supporting the conclusion. Stronger candidates knew that the fact that all three substrates had an increase supported the conclusion and often stated that other factors could be causing the differences. Weaker answers tended to just restate the fact that there was more colonisation with methane rather than stating that the all three substrates showed an increase.

Question 3

(a) This question asked candidates to explain the role of a complex life cycle for sessile organisms. Stronger candidates referred to the role of larvae in dispersal, the reduction of competition and the increase in genetic diversity. Weaker candidates tended to simply describe metamorphosis and what larvae are rather than giving an explanation.

(b) (i) This question required candidates to extract information from the graph and use it to calculate the number of larvae from a sample of 500 larvae. Most candidates were able to correctly determine the percentage of larvae that did not survive and many went on to use this to calculate the number.

(ii) Most candidates were able to correctly determine the optimum conditions for larvae survival from the data.

(c) (i) This question required candidates to plot a graph with two linear axes. The standard of graph plotting was very good and most candidates had two linear axes on the left and right sides of the grid. A few candidates used linear scales that did not have sensible increments. Candidates should select sensible increments as it makes plotting points easier. The data should make best use of the grid provided. Some candidates' plots only covered a third of the grid. Line drawing was very good, with most candidates joining plots with ruler-drawn lines. Candidates should also remember to label all axes fully and should include units.

(ii) This challenging question required candidates to bring together all the information in the question and discuss why oyster harvests had declined. Most candidates gained at least partial credit but few went on to gain full credit. Many candidates gave vague answers rather than identifying the conditions in April and August. Stronger answers explained that the conditions in April were ideal for spawning but that the conditions in August would lead to few larvae surviving. The strongest answers then went on to state that the loss of one spawning period would lead to lower populations. When answering 'discuss' questions, candidates should explore all aspects of the data fully and should also consider the experimental design and other factors that might affect the results.

(d) This question assessed candidates understanding of the threats posed by fossil fuel use and how it related to the data in the question. Stronger answers stated that the release of carbon dioxide could lead to increased temperatures, increased acidification of the oceans and that this would cause larvae to die. A number of candidates referred to an increase in pH. Candidates should be careful to be accurate when referring to acidification and pH.

Question 4

(a) (i) This question required candidates to complete the Spearman's ranking table. Many candidates were unsure how to rank two data points with the same value but often gained partial credit for an error carried forward.

(ii) Most candidates were able to use their answer from **(i)** to calculate the correct value. A few candidates did not use the correct value of n in their calculation.

(iii) Stronger candidates identified the correct critical value, stated that the calculated value was higher than the critical value and that this meant that there is a significant correlation. Weaker candidates tended not to use the critical values or chose the incorrect value. Weaker candidates also tended to be unsure as to whether the calculated value needed to be higher or lower than the critical value to accept or reject the null hypothesis.

(b) This final part of the question required candidates to explain the association between activity levels of fish and gill surface area. Stronger answers noted that more active fish have a larger gill surface area for faster diffusion of oxygen into the blood and carbon dioxide out of the blood. So more aerobic respiration occurs which produces ATP for muscle contraction. Weaker answers tended to simply restate that gill areas vary and often did not refer to diffusion. When discussing gas exchange and gills, it is recommended that candidates always refer to diffusion.

Question 5

(a) This question asked candidates to give two other restrictions that can be used to maintain sustainable fish populations. Common answers included restrictions on method, fishing intensity, season and quotas. A few candidates confused restrictions with methods of enforcement or restated the restrictions already given in the question.

(b) This question asked candidates to give one sociological impact of fishing restrictions. Most candidates were able to give one impact and gained credit. Common correct answers included poverty, lack of food and unemployment.

(c) This challenging question gave candidates information about the change in biomass of fish in an area of reef after restrictions had been imposed. The graphs had error bars. If error bars are

included in graphs, candidates should look for overlaps and explain how this affects the likelihood of differences being significant or not. Many candidates gained partial credit for describing an increase and many also gained further credit for describing the small effect on higher trophic level species. To gain full marks candidates needed to describe how overlapping error bars indicated that there was no significant difference in the data and that the large error bars suggested a wide variation in biomass.

Question 6

(a) Most candidate gained at least partial credit for this question. Candidates referred to the toxicity of heavy metals in paints and many went on to explain how these metal ions can bioaccumulate and/or biomagnify along food chains. Some candidates also correctly referred to the role of TBT in imposex in molluscs.

(b) This experimental planning question asked candidates to plan an experiment to investigate the effect of bromospherol on barnacle growth. Most candidates were able to give a directional hypothesis. If candidates give a null hypothesis, they should be clear that it is a null hypothesis. Most correctly identified the independent and dependent variables, but not all suggested five different values for the independent variable. Candidates should be very clear about quantities of substances and values and refer to masses, concentrations, and volumes rather than amounts. Many correct methods were suggested for measuring the dependent variable, such as the area of substrate covered by barnacles, or mass of barnacles. Most candidates were able to give three control variables but fewer gave creditworthy experimental methods. However, many correctly suggested the use of water baths. Many correctly stated that replicates would be needed but a number of candidates did not go on to state that these could be used to calculate means or standard deviations. When describing analysis of data, candidates should fully describe the graphs that they would plot and explain the statistical tests they would use. Many candidates explained correct safety and ethical measures. Safety features should be appropriate and linked to a risk.

MARINE SCIENCE

Paper 9693/42

A Level Data-Handling and Investigative Skills

Key messages

In future series, candidates should:

- use terms such as volume, mass or number rather than 'amount' when writing experimental plans
- plan for at least five different values of the independent variable in experimental plans
- use the term 'significant' when interpreting the results of a statistical test
- use language and vocabulary that has a level of detail appropriate to A Level Marine Science
- check error bars if included on graphs, looking for overlaps.

General comments

Answers requiring factual knowledge were general of a high standard although a few candidates tended to underestimate the level of detail needed to gain full marks on questions requiring factual knowledge.

Mathematical skills were generally very good, and most candidates were able to extract relevant data from graphs and tables. Graphical skills were generally very good. Most candidates were able to select linear scales, plot points accurately and label axes. Scales for graphs should be constructed so that they make the best use of the grid. Many candidates were able to complete and interpret the Chi-squared value but a few candidates were unsure whether the calculated value needed to be less or greater than the critical value.

Experimental planning was excellent. Most candidates were able to identify the independent and dependent variables and suggest control variables, and gave detailed answers. Some candidates gave vague answers that did not gain credit such as only suggesting three different concentrations of the independent variable, or referring to amounts of substances rather than masses, volumes, or numbers. When suggesting statistical tests for analysis and describing graphs that would be drawn, candidates should give detail, for example the reason why a test would be used and what would be placed on each graph axis.

Drawing skills were good with most candidates presenting diagrams drawn in pencil, of a good size, with no shading and with sufficient detail.

Analysis of data from graphs and tables was challenging for many candidates. When asked to discuss or explain data, candidates should first describe data patterns to help structure their answers and then go on to give reasons for the patterns as part of their explanations. A small number of candidates confused the demands of different command words, typically, 'describe' and 'explain'. Candidates should familiarise themselves with all the command words listed in the syllabus.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified the structure as the nucleus. Common incorrect answers included the vacuole and a mitochondrion.

(ii) This question assessed candidates' drawing skills. Many excellent drawings were seen that gained full credit. Most candidates were able to produce drawings with no shading, of a suitable size and with enough detail. Most candidates also used sharp pencils and few used pen.

(b) (i) This question asked candidates to explain why hydrogen carbonate indicator solution turned red when algae were illuminated with blue light. Many candidates correctly stated that the algae had pigments that were able to absorb the blue light, and that the plant was able to photosynthesise and so take in carbon dioxide. Some candidates incorrectly referred to respiration and some referred to the release of oxygen.

(ii) Many excellent answers to this question were seen. Candidates had to analyse the data and use it to explain how the deep-sea alga was adapted. Most gained at least partial credit and were able to describe the effects of different light colours on the rates of photosynthesis. The strongest candidates explained how the possession of additional pigments meant that the deep-sea alga was able to photosynthesise at depths where no red light was present. A few candidates incorrectly referred to red light penetrating the furthest and some confused the colours of the pigments with the colours of the light.

(iii) This question was answered well by many candidates. Candidates who answered in detail, correctly explained that the algae would not photosynthesise but would continue to respire and so release carbon dioxide gas. Candidates should recognise that plants and algae respire continuously but only photosynthesise when light is present.

(iv) This question assessed practical skills and asked candidates to suggest why judging a colour change is not accurate. The strongest answers explained that judging colour is subjective and that it is difficult to see when the colours change.

Question 2

(a) (i) This question asked candidates to suggest why spearfishing was used to collect the lionfish. Most candidates recognised that the use of spearfishing would lead to less bycatch and less damage to coral reefs from discarded and lost fishing gear.

(ii) This calculation was completed well by many candidates. Most were able to calculate the increase in catch, and many went on to calculate the percentage increase correctly. Some candidates divided their answer by the wrong number and so did not gain full credit.

(b) (i) This question asked candidates to outline how the density of fish could be calculated. Many candidates suggested a method for determining the number of fish, such as mark-release-recapture but fewer went on to state the area of reef would need to be calculated as well.

(c) Most candidates were able to gain at least partial credit with many gaining full credit. Many candidates recognised that the price of the lionfish related to the number caught and reflected supply and demand. Many also recognised that the project was successfully controlling the population and others recognised that there could be a loss of the fishery and income for the people if the stocks were reduced too much.

Question 3

(a) This question asked candidates to explain how carbon dioxide affects acidity of water. Many excellent answers were seen that gained full credit giving detailed descriptions of the production of carbonic acid and dissociation into hydrogen ions and hydrogen carbonate ions. Some candidates confused increased pH with increased acidity. Candidates should refer to hydrogen ions rather than simply hydrogen.

(b) (i) This question required candidates to calculate the gradient of the line and to state the correct units. Many candidates calculated the gradient correctly and gave the correct unit. Some candidates incorrectly divided time by change in mass.

(ii) This question assessed candidates' ability to analyse the data in the question to explain why food webs would be affected by acidification. Many excellent answers were seen that fully explained that the deposition of calcium carbonate would be lower, that shells would be weaker so the population of the mollusc would fall and reduce food for higher trophic levels. Most candidates gained at least partial credit, usually for describing the data. Few candidates commented on the quality of the data. When discussing data, candidates should comment on the quality of data, e.g., looking for anomalies and wide variations.

(c) (i) This question asked candidates to complete a chi-squared table. Most candidates gained credit for calculating the values for 2007.

(ii) This question required candidates to use their answer from **(i)** to calculate the chi-squared value. Most were able to substitute their values into the formula successfully.

(iii) This question asked candidates to use the critical values table to interpret the statistical test. Many candidates were able to correctly identify the critical value, state that the calculated value was lower and go on to state that this meant the null hypothesis is not rejected and there is no significant difference. A few candidates selected the wrong critical value, and some candidates were unsure about whether the calculated value needed to be less or greater than the critical value.

(d) This question asked candidates to give two other benefits of using renewable energy. Most candidates were able to gain at least partial credit with many stating that the renewables will not run out, would not cause oil spills and would reduce the risk of acid rain.

Question 4

(a) (i) This question required candidates to produce a graph showing how mass and turgor pressure changed with concentration of sucrose. Many candidates presented excellent graphs. Most produced separate linear scales on each side of the grid and labelled all axes carefully. The sizes of graphs were generally excellent. Candidates should always make sure that their axes make full use of the grid. Most candidates labelled the axes correctly and joined the plots with ruler-drawn lines. A few candidates used non-linear scales. Candidates should always use linear scales with sensible increments.

(ii) This question required candidates to explain why the different sucrose concentrations affected the changes in mass of the mangrove tissue. Many excellent answers were seen that fully explained the movements of water and correctly referred to water potentials. Some candidates incorrectly stated that water potential increases with sucrose concentration. A few candidates misread the graph and suggested that the change in mass increased up to the isotonic point and then decreased. Candidates should be careful when describing complex data patterns.

(iii) This question was generally well answered with most candidates gaining at least partial credit. The question asked candidates to explain why the turgor pressure changes as concentration of sucrose increases. Stronger answers explained that the cell membrane would not touch the cell wall and so there would be less pressure.

(b) (i) This challenging question asked candidates to explain why, during reverse osmosis, a pressure needs to be applied to force water from salt water into fresh water. Stronger answers referred to how the concentration of salt lowers the water potential and so the movement of water is against the water potential gradient. Some candidates incorrectly stated that the fresh water would have a lower water potential.

(ii) This question asked candidates to explain why releasing high salinity water into the sea is potentially harmful to the environment. The question assessed candidates' understanding of the section of the syllabus focusing on desalination plants. Many candidates gained at least partial credit with many going on to gain full credit. The strongest answers explained that the salinity would affect osmoconformers and cause water to be lost, that salinity gradients would be affected and that the salinity would reduce the oxygen content of the water.

Question 5

(a) This question asked candidates to outline differences between pumped and ram ventilation. Stronger answers often referred to the opening and closing of the mouth in pumped ventilation, the use of pumped ventilation when not swimming, the need for energy to contract muscles in pumped ventilation and the opening and closing of the operculum. A few candidates only gave one or two differences and some incorrectly stated that ram ventilation requires opening and closing of the mouth.

(b) This question was the extended investigative planning question. The context of the question was the effect of carbon dioxide concentration on the rate of pumped ventilation in seatrout. Many

outstanding plans were seen. Stronger candidates gave correct hypotheses, identified the independent and dependent variables and suggested correct control variables. Many candidates gave five different independent variables and a correct method of measuring the dependent variables. Candidates should always ensure that they do not refer to ‘amounts’ when quantifying variables and should use terms such as volume, mass or number. Many candidates gave good methods and suggested ways of controlling variables such as the use of water baths and buffers. Many gave detailed methods of analysis such as descriptions of tables and graphs and the statistical tests that would be used. Candidates should always ensure that they explain why they would use a particular statistical test, and state that by having replicates the means and standard deviations can be calculated. Safety and ethics were considered by most candidates. However, to gain credit for this, candidates needed to give the reasons for particular precautions.

MARINE SCIENCE

Paper 9693/43

A Level Data-Handling and Investigative Skills

Key messages

In future series, candidates should:

- use terms such as volume, mass or number rather than 'amount' when writing experimental plans
- plan for at least five different values of the independent variable in experimental plans
- use the term 'significant' when interpreting the results of a statistical test
- use language and vocabulary that has a level of detail appropriate to A Level Marine Science
- check error bars if included on graphs, looking for overlaps.

General comments

Answers requiring factual knowledge were general of a high standard although a few candidates tended to underestimate the level of detail needed to gain full marks on questions requiring factual knowledge.

Mathematical skills were generally very good, and most candidates were able to extract relevant data from graphs and tables. Graphical skills were generally very good. Most candidates were able to select linear scales, plot points accurately and label axes. Scales for graphs should be constructed so that they make the best use of the grid. Many candidates were able to complete and interpret the Chi-squared value but a few candidates were unsure whether the calculated value needed to be less or greater than the critical value.

Experimental planning was excellent. Most candidates were able to identify the independent and dependent variables and suggest control variables, and gave detailed answers. Some candidates gave vague answers that did not gain credit such as only suggesting three different concentrations of the independent variable, or referring to amounts of substances rather than masses, volumes, or numbers. When suggesting statistical tests for analysis and describing graphs that would be drawn, candidates should give detail, for example the reason why a test would be used and what would be placed on each graph axis.

Drawing skills were good with most candidates presenting diagrams drawn in pencil, of a good size, with no shading and with sufficient detail.

Analysis of data from graphs and tables was challenging for many candidates. When asked to discuss or explain data, candidates should first describe data patterns to help structure their answers and then go on to give reasons for the patterns as part of their explanations. A small number of candidates confused the demands of different command words, typically, 'describe' and 'explain'. Candidates should familiarise themselves with all the command words listed in the syllabus.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified the structure as the nucleus. Common incorrect answers included the vacuole and a mitochondrion.

(ii) This question assessed candidates' drawing skills. Many excellent drawings were seen that gained full credit. Most candidates were able to produce drawings with no shading, of a suitable size and with enough detail. Most candidates also used sharp pencils and few used pen.

(b) (i) This question asked candidates to explain why hydrogen carbonate indicator solution turned red when algae were illuminated with blue light. Many candidates correctly stated that the algae had pigments that were able to absorb the blue light, and that the plant was able to photosynthesise and so take in carbon dioxide. Some candidates incorrectly referred to respiration and some referred to the release of oxygen.

(ii) Many excellent answers to this question were seen. Candidates had to analyse the data and use it to explain how the deep-sea alga was adapted. Most gained at least partial credit and were able to describe the effects of different light colours on the rates of photosynthesis. The strongest candidates explained how the possession of additional pigments meant that the deep-sea alga was able to photosynthesise at depths where no red light was present. A few candidates incorrectly referred to red light penetrating the furthest and some confused the colours of the pigments with the colours of the light.

(iii) This question was answered well by many candidates. Candidates who answered in detail, correctly explained that the algae would not photosynthesise but would continue to respire and so release carbon dioxide gas. Candidates should recognise that plants and algae respire continuously but only photosynthesise when light is present.

(iv) This question assessed practical skills and asked candidates to suggest why judging a colour change is not accurate. The strongest answers explained that judging colour is subjective and that it is difficult to see when the colours change.

Question 2

(a) (i) This question asked candidates to suggest why spearfishing was used to collect the lionfish. Most candidates recognised that the use of spearfishing would lead to less bycatch and less damage to coral reefs from discarded and lost fishing gear.

(ii) This calculation was completed well by many candidates. Most were able to calculate the increase in catch, and many went on to calculate the percentage increase correctly. Some candidates divided their answer by the wrong number and so did not gain full credit.

(b) (i) This question asked candidates to outline how the density of fish could be calculated. Many candidates suggested a method for determining the number of fish, such as mark-release-recapture but fewer went on to state the area of reef would need to be calculated as well.

(c) Most candidates were able to gain at least partial credit with many gaining full credit. Many candidates recognised that the price of the lionfish related to the number caught and reflected supply and demand. Many also recognised that the project was successfully controlling the population and others recognised that there could be a loss of the fishery and income for the people if the stocks were reduced too much.

Question 3

(a) This question asked candidates to explain how carbon dioxide affects acidity of water. Many excellent answers were seen that gained full credit giving detailed descriptions of the production of carbonic acid and dissociation into hydrogen ions and hydrogen carbonate ions. Some candidates confused increased pH with increased acidity. Candidates should refer to hydrogen ions rather than simply hydrogen.

(b) (i) This question required candidates to calculate the gradient of the line and to state the correct units. Many candidates calculated the gradient correctly and gave the correct unit. Some candidates incorrectly divided time by change in mass.

(ii) This question assessed candidates' ability to analyse the data in the question to explain why food webs would be affected by acidification. Many excellent answers were seen that fully explained that the deposition of calcium carbonate would be lower, that shells would be weaker so the population of the mollusc would fall and reduce food for higher trophic levels. Most candidates gained at least partial credit, usually for describing the data. Few candidates commented on the quality of the data. When discussing data, candidates should comment on the quality of data, e.g., looking for anomalies and wide variations.

(c) (i) This question asked candidates to complete a chi-squared table. Most candidates gained credit for calculating the values for 2007.

(ii) This question required candidates to use their answer from **(i)** to calculate the chi-squared value. Most were able to substitute their values into the formula successfully.

(iii) This question asked candidates to use the critical values table to interpret the statistical test. Many candidates were able to correctly identify the critical value, state that the calculated value was lower and go on to state that this meant the null hypothesis is not rejected and there is no significant difference. A few candidates selected the wrong critical value, and some candidates were unsure about whether the calculated value needed to be less or greater than the critical value.

(d) This question asked candidates to give two other benefits of using renewable energy. Most candidates were able to gain at least partial credit with many stating that the renewables will not run out, would not cause oil spills and would reduce the risk of acid rain.

Question 4

(a) (i) This question required candidates to produce a graph showing how mass and turgor pressure changed with concentration of sucrose. Many candidates presented excellent graphs. Most produced separate linear scales on each side of the grid and labelled all axes carefully. The sizes of graphs were generally excellent. Candidates should always make sure that their axes make full use of the grid. Most candidates labelled the axes correctly and joined the plots with ruler-drawn lines. A few candidates used non-linear scales. Candidates should always use linear scales with sensible increments.

(ii) This question required candidates to explain why the different sucrose concentrations affected the changes in mass of the mangrove tissue. Many excellent answers were seen that fully explained the movements of water and correctly referred to water potentials. Some candidates incorrectly stated that water potential increases with sucrose concentration. A few candidates misread the graph and suggested that the change in mass increased up to the isotonic point and then decreased. Candidates should be careful when describing complex data patterns.

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