MARINE SCIENCE

Paper 9693/11
Theory

Key messages

Candidates should ensure they identify and follow the command word in each question to ensure they give a relevant response.

When adding labels to diagrams, candidates should ensure their lines are clear and indicate a precise point.

General comments

Candidates generally answered all questions and appeared to have sufficient time to complete the paper, but few candidates completed the middle column for **Question 2(a)**. There were some candidates whose handwriting was hard to read which made understanding their answers in full difficult.

A significant number of candidates showed poor exam technique and is an area that some candidates, in particular the weaker candidates, need to develop in terms of understanding how to approach different types of question, such as 'discuss' or 'explain'. Weaker candidates found the essay questions particularly difficult and were often unable to make more than one or two relevant comments, showing a lack of depth of understanding. Stronger candidates were able to assimilate information from different areas of the specification to develop a complete answer.

Most candidates showed a poor understanding of classification and the features of different groups, particularly the difference between types of photosynthetic organisms, or knowledge of the features of vertebrates in early development. Some misconceptions were evident, with some candidates indicating cartilaginous fish are invertebrates, that zooxanthellae are a zooplankton or not understanding the differences between biotic and abiotic factors.

Comments on specific questions

Section A

Question 1

(a) Many candidates were able to identify the features shared by macroalgae and seagrasses but found correct identification of unique features of seagrass and macroalgae more difficult. Many placed the term 'blade' into seagrasses, as this is the term used for land grasses. A few candidates completely reversed the correct answers. Some candidates' misconception was that seagrasses included kelp, stating "seagrasses such as kelp" and then described the economic importance of kelp. Candidates need to develop a greater understanding of the differences between the different groups of photosynthetic organisms within the ocean.

(b) While some candidates paid close attention to the question and answered it for seagrasses, many candidates just gave generic answers, such as that it is used for food and medicine. Seagrasses are not eaten by humans, nor are seagrasses used for medicinal purposes. Several candidates also mentioned beauty products and vitamin pills. Candidates need to carefully consider the organisms being asked about and ensure they state either economic or ecological reasons as asked for.

(c) Many candidates scored at least partial credit, with most able to say that the statement meant there were a large number of different species, with the strongest candidates also mentioning the relative

abundance of the different species. Some candidates did not mention macroalgae, just stating there are lots of different species.

Question 2

(a) The majority of candidates correctly identified convergent and divergent plate boundaries in the first column, and many were able to state a feature or event that occurred at each. However, the majority of candidates omitted the middle column, which required two arrows to be drawn on each diagram, as shown in the completed row.

(b) Candidates were often too brief in their answers, stating "fossil record" or "plate tectonics". Some candidates stated "fossils on different continents", but this is not evidence as they could be very different fossil species. Some candidates also made weak statements such as "one half of a fossil was found in South America and the other half found in Africa" rather than that the same fossil species were found in each. More detailed and specific responses were required. Candidates often tried to mention mountain ranges, but again were sometimes vague, or talked about mountain ranges across a continent rather than mountain ranges that appeared to line up if the continents were placed next to each other, or that have the same rock layers or type of rocks, between two continents. A few candidates correctly named ranges and continents where mountain ranges did this.

Question 3

(a) Many candidates correctly named two types of weathering, but weaker candidates often stated wind and water, with some stating water erosion, rather than showing they understood the difference between weathering and erosion. Fewer were able to describe how the named weathering caused changes to the shore structure.

(b) (i) Candidates found this a challenging question, with many just stating the maximum temperature reached rather than calculating any range, and others approximating too much and calculating 25 °C – 0 °C rather than trying to read the graph with any degree of accuracy.

(ii) Again candidates found this challenging, with few recognising that the initial decrease in temperature was when water was starting to splash onto them, and when they were completely submerged. Candidates also had difficulty in reading a time from the graph.

(c) Many candidates were able to suggest two biotic factors, but weaker candidates often stated abiotic factors. Again, fewer were able to describe how these factors affected the distribution of the mollusc species.

Question 4

(a) (i) Some candidates were not very familiar with the different fins and could not identify them correctly, with many labelling pelvic fins as pectorals, and dorsal fin for caudal fin. Candidates should ensure they label carefully, using ruled straight lines, with no arrowheads, touching the feature. Some candidates drew a circle around the fin, which usually included other parts of the fish, or drew an unruled line, or included arrowheads.

(ii) Few candidates were able to give a correct answer here. A few mentioned cnidocytes, which was insufficient. The most common incorrect answers were Chordata or sea anemones.

(iii) Only the very strongest candidates answered this correctly. Many mentioned fins, or a named fin. Candidates need to be familiar with the stated features of all Chordates shown in early development.

(b) This question was often not well answered, with the most common point that achieved credit being that the nematocysts were used to catch prey. Many candidates thought that zooxanthellae are in trophic level 2 and that they eat phytoplankton, rather than having the knowledge that they are photosynthetic organisms living within the tissues which provide nutrients to their host organism.

(c) (i) Some candidates were able to suggest radioactive nitrogen was passed on from waste material from the sea anemone, while others thought that the zooxanthellae ate the sea anemone.

(ii) Responses here indicated that only the strongest candidates could associate nitrogen being present in proteins, amino acids, nucleic acids**,** enzymes or chlorophyll. Incorrect responses included calcium, hydrogen or one of the molecules from **Question 5**, showing a lack of understanding of elements and compounds.

(d) Many candidates were able to score at least partial credit here, with many achieving full credit. Candidates who did not score generally did not mention fins at all, just movement.

(e) Many candidates were able to recognise this is a mutualistic relationship and were also able to state at least one benefit correctly linked to the organism receiving/providing the benefit. A small number of candidates did also identify the predator – prey relationship seen by the clownfish eating the eggs.

Question 5

(a) (i) Many candidates were able to identify at least two of these molecules, with more identifying sodium chloride and oxygen than glucose and calcium carbonate. Weaker candidates sometimes drew more than one line from a model,

(ii) A few candidates misunderstood the question and named each molecule again. Many candidates were able to achieve partial credit, but some candidates mentioned hydrogen bonds.

(b) Candidates found this question challenging. Some of the stronger candidates understood that hydrogen bonds between water molecules keep the molecules closer together and so require a greater temperature to be broken, and that sulphur dioxide did not have these bonds between molecules. Other candidates could sometimes note that the boiling points of the two were different, but some candidates trying to make this point did not mention which needed a higher temperature, or just said the boiling points were different, which was too vague.

Section B

Question 6

Weaker candidates often stated that cartilaginous fish had more flexible skeletons and could get into smaller spaces, compared sizes of cartilaginous and bony fish, or just stated one is made of cartilage and one is made of bone. Stronger candidates understood the basic difference, that bony fish have a calcified skeleton, and cartilaginous fish do not, and many mentioned cartilage but did not mention the skeleton.

Question 7

(a) Candidates usually made a few relevant points, often that sandy shores are unstable, and that many organisms on sandy shores burrow. For the rocky shore, candidates were often too vague to score well. Some scored for stating that some organisms have a hard shell for protection from high energy waves or mentioned a muscular foot for attachment. A few mentioned macroalgae, but very few discussed the holdfast and its function, or how organisms prevent desiccation on the rocky shore.

(b) In this essay question, many candidates got intra- and inter-specific competition the wrong way around, but many were able to state reasons for competition, often food and attachment sites or space. Only the strongest candidates were able to describe how competition can lead to change in species distribution due to one being more successful than another, or that species may develop more specialised niches, by feeding at different times of the day, or on more specific prey.

Question 8

Many candidates were too vague here, making statements such as “plants produce oxygen”, rather than saying that photosynthesis releases oxygen, or “animals breathe taking oxygen out of the water”, rather than that animals respiring removes oxygen. Some candidates were able to correctly mention the effect of salinity and temperature on oxygen concentration, but some did not explain the effect of increasing (or decreasing) temperature on the oxygen concentration. A number of candidates mentioned upwelling, which would reduce the oxygen concentration as deep water has a lower oxygen concentration. Stronger candidates were able to link the idea of higher light availability to increased rates of photosynthesis occurring in shallower water.

MARINE SCIENCE

Paper 9693/12
Theory

Key messages

Candidates generally had a good understanding of how to approach questions, but weaker candidates may have benefitted from a better understanding of the difference between 'explain' and 'describe' questions to ensure they answer the question that is asked.

Candidates also need to ensure that when asked about the effect of one thing on another, (e.g. **Question 3(b)(ii)**) that they clearly state that relationship, e.g. 'as X increases, Y decreases', rather than 'as X increases, Y changes'.

General comments

Candidates usually answered all questions and appeared to have managed their time well to complete the paper. Candidates generally showed a good understanding across many aspects of the specification, but sometimes found linking these ideas more difficult. This is often required for essay questions to achieve high marks. As candidates seemed to have sufficient time to complete questions, candidates may need to be encouraged to think a little longer to try to draw in other aspects of the specification to their answers before completing their answers.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates demonstrated a good understanding of the diagrams provided. Many candidates could identify the two areas requested, but some failed to end the line touching the feature. With any labelling, candidates need to use a straight ruled line, with no arrowheads, to indicate the exact area they wish to indicate.

(ii) Stronger candidates gave excellent descriptions of how an abyssal plain is formed and gained full credit. Other candidates were usually able to identify the type of boundary it was formed from, and often mentioned sedimentation, while the weakest candidates often just mentioned plate boundaries without stating a type and gave vague answers.

(b) Many candidates correctly calculated this with common errors being 3 000, 400 or 40.

(c) Candidates found this question more challenging, with stronger candidates scoring partial credit. They needed to recognise that with a small entry from the Atlantic, water exchange was limited, which affected the water in the Mediterranean, allowing evaporation and increasing the salinity. Many candidates could explain that density increases with increasing water pressure, or that more dense water sinks below less dense water.

Question 2

(a) Many candidates knew this information and completed the table accurately. Weaker candidates sometimes gave the same change for both El Niña and El Niño.

(b) (i) Candidates did not always express themselves well, often omitting to mention height, distance or length, between high tide and low tide, stating "it's the difference between high tide and low tide".

(ii) Many candidates scored at least partial credit, but some forgot to mention which direction the wind would be blowing to push the wind onshore, or just stated “a change in air pressure” rather than stating lower air pressure. Candidates need to be encouraged to be specific in their answers.

(c) (i) Candidates generally achieved at least partial credit here. Many candidates showed a clear understanding between increased upwelling and increased nutrients leading to a higher productivity of phytoplankton, with this additional energy supply passing along the food chain to increase populations. Candidates who did not know that upwelling increased during La Niña often did not answer well, and some mentioned increased nutrients without stating where they had come from.

(ii) Candidates hard to get the order and words correct but there was a lot of variation. Candidates needed to mention tagging, releasing and recapturing in the correct order for credit to be awarded. Weaker candidates often placed capture as the first point, then tag and release, without mentioning recapturing.

Question 3

(a) (i) This was challenging for many candidates. Candidates needed to recognise that the transform boundary had split the seabed rock perpendicular to the ridge and draw a line at a perpendicular angle.

(ii) Many candidates were able to give a correct definition of a transform boundary, with some including small diagrams to help them explain it. A few contradicted themselves by stating “they move laterally to each other forming mid-Ocean ridges”.

(iii) Interpreting the diagram was a challenge for candidates, with many not linking the age of the rocks given to the area where the ridge is located within the central ‘white’ area.

(iv) Candidates were often too brief in their answers, stating “fossil record”, “geological features of mountains” or “plate tectonics” without giving the details required about the evidence. Some candidates stated “fossils are found on different continents”, but this was not sufficient, as they could be very different fossil species. Stronger candidates were more detailed. Candidates often tried to mention mountain ranges, or rock formations, but again were often vague, sometimes making statements such as “geological formation of different continents” or “matching geological features” without saying this occurs between continents, or if continents were placed next to each other these features would appear to be continuous. A few candidates correctly named ranges and continents where mountain ranges did this.

(b) (i) Candidates required a good understanding of kinetic particle theory and needed to be able to link this to changes occurring through the depths of the water column to answer this question well. Some candidates tried to link solubility changing with temperature, so had not considered all the information provided in the question. Weaker candidates gave more vague answers such as “different temperature and pressures at different depths affect the volume”, or stated the relationship of pressure and depth or temperature and depth the wrong way around. A few candidates mentioned changes in energy as the bubbles rose into warmer water, but needed to recognise this was a change in the kinetic energy of the molecules causing them to move faster.

(ii) While many candidates mentioned the correct change in temperature and its effect on density, some forgot to mention the effect on the density, e.g. “the temperature increases so the density is affected”. Candidates should be encouraged to give a directionality if asked about an effect or relationship between two factors and clearly state what the effect is, e.g. increasing temperature of the water decreases the density, rather than increasing the temperature of the water changes the density.

(iii) Most candidates made a good attempt at this question, with many able to show the electron configuration of the outer shells. Errors included mixing up the O and H, (i.e. showing HO_2) or forgetting to represent the electrons in the hydrogen atoms in a different way to the electrons in the oxygen atom.

Question 4

(a) Many candidates achieved at least partial credit by correctly stating this as a commensal relationship or knew the benefits to one or both organisms. A common error was stating the relationship as mutualistic or describing some adaptations of remora fish.

(b) (i) Candidates were generally able to state at least one difference between bony and cartilaginous fish, but sometimes were not precise enough, e.g. by stating bones/no bones. Candidates need to be careful when expressing themselves, as a small number of candidates who knew bony fish had calcified skeletons, stated “skeleton made of calcium” rather than showing an understanding that the cartilage of skeleton has been mineralised with calcium.

(ii) A few candidates omitted this question, with many weaker candidates unable to suggest one of the features of all chordates. This may have been due to them not being aware of the phylum they belong to.

(c) (i) Some weaker candidates suggested zooplankton were producers, absorbed light or provided energy to the rest of the food chain, rather than their lack of mobility and that they are consumers.

(ii) A significant number of candidates did not add any producer to the start of the food chain and added in remora fish feeding on the manta ray to the food chain. Some candidates forgot to add the arrowheads which are required in food chain diagrams to show they understand the energy flow. Candidates should also be encouraged to draw a food chain horizontally rather than vertically.

Section B

Question 5

(a) Many candidates answered this question well, with most able to make some relevant contribution, often that it was a valuable resource for fishing for human food, providing timber or wood for fuel, or that mangroves can attract tourists. Stronger candidates were able to give both economic and ecological reasons for its importance, with stronger candidates often scoring full credit.

(b) Stronger candidates were able to give a range of adaptations of the red mangrove, most commonly the presence of prop roots and their function, but fewer mentioned the fine substrate meaning they require these prop roots. Some candidates also mentioned lenticels in the roots to absorb oxygen from the atmosphere, or that the roots absorbed oxygen for the plant. Many suggested that the leaves store salt and they drop off taking excess salt with them, which is a theory that has been disproved now.

Question 6

Most candidates were able to score some credit on this question, most commonly for mentioning aspects related to photosynthesis, e.g. carbon dioxide being absorbed by plants and producing glucose, which could be passed onto other organisms. Many also mentioned dead organisms or faecal matter sinking, but often forgot to mention bacteria or microorganisms being involved in the decomposition process. Fewer candidates mentioned the formation of fossil fuels, their removal and combustion, or the formation of carbonate rocks locking the carbon in. Stronger candidates often gave a very complete account of the carbon cycle, linking the different aspects of the specification to do so.

Question 7

Many candidates found this essay question challenging, with some able to state a definition of the term ‘niche’ but they were not able to translate this into ideas about how the niches in tropical reefs and the open ocean may differ, or how competition in each area may differ.

MARINE SCIENCE

Paper 9693/13
Theory

Key messages

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Section B

Question 5

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Most candidates were able to score some credit on this question, most commonly for mentioning aspects related to photosynthesis, e.g. carbon dioxide being absorbed by plants and producing glucose, which could be passed onto other organisms. Many also mentioned dead organisms or faecal matter sinking, but often forgot to mention bacteria or microorganisms being involved in the decomposition process. Fewer candidates mentioned the formation of fossil fuels, their removal and combustion, or the formation of carbonate rocks locking the carbon in. Stronger candidates often gave a very complete account of the carbon cycle, linking the different aspects of the specification to do so.

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MARINE SCIENCE

Paper 9693/21
Data-Handling and Investigative Skills

Key messages

Candidates should read the questions and consider carefully 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 was often not awarded.

Candidates need lots of opportunities to carry out practical work 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**.

Candidates should always show their working out during calculations, as it is possible to gain credit for any correct working even if the final answer is incorrect.

Candidates should pay careful attention to the command word(s) in each question, particularly understanding 'evaluate' which generally is looking for the advantages and disadvantages of some presented data.

Candidates should be encouraged to critically evaluate investigations to identify sources of error in both method and results.

General comments

Almost all candidates completed the paper and there was no evidence of candidates being short of time. Although many found some of the questions very challenging, there were also some strong responses. B Many candidates displayed a poor understanding of basic practical skill for example describing methods, such as in the planning question, **Question 4(b)**, and also in the preparation of different salinities, **Question 3(b)**, which were not answered well. Relatively few candidates could correctly identify the use of universal indicator or pH probe to measure pH. Graphs and drawings rarely achieved full credit, with candidates often not showing the practical skills required at this level. Few candidates manipulated data to support answers.

Comments on specific questions

Question 1

(a) (i) Most candidates were able to provide examples of an independent and dependent variable but candidates needed to use the word 'volume' of oxygen released not 'amount'. A few answers had the independent and dependent variables reversed.

(ii) Most candidates were able to gain at least partial credit in this question. The most common correct answers included control of pH and salinity. Some candidates restated or incorrectly stated the independent and dependent variable from **(i)**. Very few candidates mentioned the concentration of carbon dioxide as a standardised variable. Amount of water was not accepted but volume of water scored partial credit.

(b) (i) Very few answers included the correct reference to a timer of some kind. Various incorrect answers included notebooks**,** thermometers and rulers.

(ii) This question was generally well answered with many candidates receiving full credit. Main areas to consider:

- The most common omission was to not include units on the axes.
- Many candidates plotted points with a dot rather than a cross or dot inside a circle. Often the dot drawn was too large.
- Some candidates used a scale that used up less than half of the graph paper provided.
- The line to join the plotted points was sometimes not carefully drawn which meant it did not pass through the correct points on the graph.
- Candidates sometimes extended the line beyond the first and last points so full marks could not be awarded.
- Candidates should be reminded to use a linear scale for plotting data.
- The use of pencil for drawing and plotting data is desirable.

Some candidates also plotted the three pieces of trial data and not the mean data which was incorrect. Very few candidates did not attempt to answer this question.

(iii) Only stronger candidates answered this fully correctly. Most answers did not link the production of oxygen and light intensity with the rate of photosynthesis. Some candidates quoted data but few manipulated it to support their answer. For example, quoting that 10 cm was 7.2 cm^3 and 60 cm was 2.4 cm^3 did not score credit. However, 7.2 cm^3 – 2.4 cm^3 = 4.8 cm^3 gained partial credit.

(c) (i) Most candidates gained at least partial credit, but many commented too generally. There were, many examples of numbers without units. Both numbers and units needed to be correct when recording the data. Some candidates were too general and answered in terms of "peaked at 15 – 20 °C or 17 – 20 °C" without linking the values to sets of results appropriately. Very few candidates manipulated the data. For example, the difference between the two arbitrary units was 19 – 13 au = 6 au.

(ii) Only stronger candidates answered this correctly. Increased rate of photosynthesis was the most common answer. The use of nitrates to increase synthesis of proteins or increase growth was rarely seen in answers. Where candidates mentioned the involvement of nitrates in these processes, they omitted to mention that there was an increase. There were very little understanding of what productivity means.

Question 2

(a) (i) This was generally answered well and candidates stated the correct answer, hydrogen. A very small number stated the answer of hydronium or $H_30^{+,}$ which was excellent.

(ii) Many answers were too vague and mentioned pH sticks/strips/litmus paper and pH colour scales. Candidates focused on ways to find if the solution was acidic/basic rather than finding the actual pH.

(b) A significant number of answers were in the form of a graph rather than a table, indicating that these candidates had not read the question carefully. Very little understanding of how to construct a table was seen and candidates would have benefitted from more practice in drawing tables with the help of a ruler. Of the tables drawn, many had just mass of coral and pH as column headings rather than increase/change in mass. Not many candidates referred to units for coral mass. A significant number of candidates gave a good answer in terms of percentage change or increase. A few candidates gave imperial units which were not accepted.

(c) (i) Only stronger candidates answered this correctly. Many candidates incorrectly identified species **A** as being affected more. Candidates who correctly referred to species **B** as being affected more, often went on to give the correct percentage change for each species. Many candidates commented on how the slopes increased, when the question asked about a decrease. Candidates seemed confused by the idea of a percent increase in mass rather than just mass alone. They did not understand that the species still grew when increase in mass got smaller.

(ii) Again, only stronger candidates answered this correctly. Many answers focused on the mass of species **A** and/or species **B** rather than the growth or increase in mass of the coral. Many candidates just talked about corals and not species **A** and **B**. Very few candidates extrapolated the lines on the graph which may have helped them understand what was happening at pH 7.0.

(d) Many candidates answered this question well. However, candidates needed to be more specific when giving examples. For example, “human activity” on its own was too vague, but “damage by divers”, “human harvesting” and “dynamite fishing” were accepted. Pollution unnamed did not score credit but “pollution with sun cream washing into the water” did.

Question 3

(a) There were many correct answers seen but some were not specific enough e.g. “strong/extensive roots” or “can tolerate salt”. Some candidates mentioned salt exclusion from leaves which is not a feature of red mangroves. Some candidates gave excellent descriptions of lenticles on prop roots.

(b) (i) This was often not well answered. Most candidates did not mention mass of salt or volume of water. Answers were far too vague and just described the different salinities rather than how to prepare them. Answers were often imprecise describing ‘amounts and ‘ppt’ instead of volume and mass. Many candidates described collecting water of different salinities from different types of water bodies. The use of a salinometer or refractometer to achieve the appropriate salinity was rarely seen. Laboratory experience for making different concentrations of salt solutions seemed to be lacking.

(ii) Many candidates gained at least partial credit. The most common misconceptions were that taking readings at shorter time intervals, more repeats and trials would improve the data.

(c) (i) Many candidates who made a good attempt did not extend their answer to include the conversion of a fraction to a percentage by multiplying by 100.

(ii) Many candidates achieved the correct answer. Candidates needed to clearly show their working so that any credit for the calculation could be awarded if the final number was incorrect.

(d) Many candidates scored at least partial credit for this question. The idea that site **A** will experience least mixing with fresh water was not a common answer. Many incorrect answers did not use comparative language. Some candidates described a totally different species or range of species, for example alligators, bull sharks and crabs. These candidates had a misunderstanding that the question was about mangrove seedlings.

(e) Many candidates repeated the question. Just saying that tide affects/changes the salinity of the water at location **B**, without describing what those changes would be did not score any credit. Many referred to the tidal cycle in the question so did not discuss what happened at low and high tides. Some candidates did not understand the impact of tides on salinity and tried to explain other factors such as evaporation or even upwelling on increasing salinity. Incorrect ideas that at high tide more water is present and therefore dilutes the salinity, less water at low tide and this increases the salinity were seen. Some candidates got the impact of high and low tide the wrong way around: high tide, low salinity, low tide, high salinity. Some referred to the arrangement of the Sun, Moon and Earth on the tidal cycle which did not score credit.

(f) Many candidates answered this question well. There were some really good descriptive answers relating to ecotourism, nursery grounds for fish, supply of timber, medicines and coastal protection which were all scoring points. A number of candidates tried to describe the role of mangroves relating to O_2 and CO_2.which did not score credit.

Question 4

(a) Many candidates answered this well. However, some candidates misunderstood the idea of ‘non-living’ and added ‘organism’ implying these are dead organisms. Candidates generally knew the answer, but some struggled to articulate it clearly, for example a factor is “not alive” was not credited.

(b) Many candidates found this a challenging question. Common answers included a description of mark, release and recapture which was not suitable for measuring the number of species, but a method of calculating population size. A number of candidates attempted to describe Lincoln Index or Spearman’s rank analysis. A few stronger answers described the use of a quadrat (but quadrant was often incorrectly used), either randomly spaced or placed at regular intervals on a belt transect. References to ethical treatment of organisms and relevant healthy and safety were also

seen. Some answers included sampling fish and these candidates had missed the idea of sampling from a shore and very few candidates mentioned taking sediment samples to look for species. A significant number of candidates did not attempt this question. It is important to give candidates experience of using sampling techniques on different shores for their understanding and development of practical skills.

(c) (i) Although stronger candidates answered this correctly, many others did not attempt this question even though the formula was given. Finding the correct value for n was a major difficulty. A number of candidates did not answer to two significant figures or did not give a negative sign in their answer. Candidates needed to show their working clearly so that any credit for the calculation could be awarded.

(ii) Most candidates were able to comment on a negative or strong correlation or a correct description. Very few candidates continued with the idea that the value was a negative number, or its value was close to (–)1.

(iii) Most candidates commented that the greater the slope and the greater the particle size, the lower the biodiversity. The idea that correlation does not mean causation and that the data only shows number not abundance was rarely seen. Many candidates repeated the previous question's answer and suggested negative correlation, demonstrating that they had not understood the meaning of the command work in the question, 'discuss'.

(d) Only stronger candidates answered this well. Many just repeated the description of the correlation or put the relevant answer to this question in the previous one **c(ii)**. There were many very general answers with no specific reasons why the number of species per m^2 were found on each shore. Incorrect answers included "because the smaller the particle size the greater the number of species" or "the greater the slope, the lower the biodiversity". There were lots of vague statements about adapting. The idea about particle size and ability to pass through the body to obtain food was not well known. The slope also affected the area of shore available and the impact of wave action, but these were again not well known. Reference to rocky shores was incorrect as the question was about sandy shores.

(e) Very few candidates answered this question correctly, indicating that they did not have a good understanding of what Simpson's Diversity Index and/or Spearman's rank test actually were and when they should be applied.

Question 5

(a) The outlines of the drawings generally required more care. They were either drawn in pen or drawn with gaps in the outline or with feathered lines. Many candidates made drawings which were not carefully drawn from the picture as the proportions were often significantly different. Candidates should ensure they use a sharp pencil and take care not to include shading and to draw a single outline. Several candidates drew a whole shark.

(b) There were some good answers here, but many did not give a clear description of the epipelagic zone. Many candidates stated most light/lots of light unqualified which did not score credit. Other candidates gave inappropriate depths relating to deeper in the ocean, which impacted on their answer to **d(iii)**.

(c) This was a well answered question and many candidates achieved full credit. Those that did not stated that carnivores eat other organisms/species, which could mean plants. Some candidates described a predator as being at the top of the food chain, not being eaten by any other animal which was incorrect for a predator.

(d) (i) Candidates needed to discuss catch and catch effort, not just catch or not just catch effort. Many answers were too general and candidates needed to look at the graphs more closely to identify whether there was a pattern in the data and any points where this pattern clearly changed, for example 2015. Candidates also compared the effort and catch in terms of numbers or relative heights on the graph and not trends. A trend is a pattern in a set of results displayed within a graph. For example, both catch and catch effort increase or if more effort was put into catching blue sharks, global catch increased.

(ii) Very few candidates recognised that the data related to catches and their figures depend largely on effort rather than populations. Most candidates thought the data was useful but in fact most of the data was of little use as the population size was unknown. The only real conclusion that could be drawn from this data was that if annual catch effort increases at the same time as annual catch decreases, then that could suggest the population of blue sharks is decreasing. Alternatively, if the catch was decreasing with an increasing effort, it would suggest a low population.

(iii) A common incorrect answer was “move a lot”. Blue sharks can move a lot but in the same area. Many candidates scored with the idea that blue sharks migrated. Other points included births and deaths, with both required for credit. The idea that the population is not evenly distributed and that the chance of recapturing marked individuals is very low was less well known.

MARINE SCIENCE

Paper 9693/22
Data-handling and Investigative Skills

Key messages

Candidates need to use standard scientific quantities correctly to describe variables. A number of candidates used the word 'amount' when describing a variable, but this word should be avoided wherever possible. For example, candidates should refer to 'the volume of oxygen produced', 'the concentration of dissolved oxygen', 'the intensity of light available' or 'the mass of salt dissolved'.

Candidates should expect to see questions which will present information in unfamiliar contexts, and should practise applying their knowledge and understanding to these as part of their exam preparation.

General comments

Many candidates had a thorough understanding of the specification and many high-quality responses were seen. Most candidates attempted all of the questions.

The syllabus contains key practical activities that the candidates are expected to be familiar with (marked **PA** in the specification). Candidates should expect aspects of these to be examined on this paper and should become familiar with the methods used (training videos are available on the School Support Hub). These may be presented in an unfamiliar context.

Candidates should expect that this paper will always contain questions requiring them to draw a biological specimen and use, or consider the results of, a statistical analysis.

When answering questions that require a discussion or evaluation of whether data supports a hypothesis/idea/conclusion, candidates should try to suggest both advantages and disadvantages. Candidates often just focused on one side of the discussion. For example, the data may show a pattern or correlation, but the sample size may be small, or a limited number of species/shores may have been studied.

Comments on specific questions

Question 1

(a) Most candidates correctly stated calcium or calcium carbonate.

(b) Many excellent drawings were seen and most candidates scored at least partial credit. Credit was awarded for the drawing being a suitable size, having a clear unbroken outline with no shading, being in proportion, and showing an acceptable level of detail. Most drawings were of sufficient size with drawing filling at least half of the space provided or being at least the size of the specimen in original image. The majority of drawings had a clear outline, but some candidates left gaps, or lines that overlapped beyond where they should have finished. Care should be taken to avoid this. Credit was not awarded if the diagram had been shaded. Care should also be taken to ensure that any unwanted lines are properly erased. Most drawings were in proportion, but some candidates did not represent the width of the shell correctly compared to the length. Most drawings had the correct level of detail and included main structural features (such as the aperture and siphon notch). Drawings did not need to include the fine detail such as individual pattern lines on the shell.

(c) (i) Most candidates answered correctly, but care needed to be taken to correctly state which values were being added together.

(ii) This was correctly calculated by the majority of candidates.

(iii) Most candidates scored at least partial credit. Only stronger candidates correctly discussed the difference in the ratio, with most concentrating on the shell length and shell aperture individually. Many candidates realised that the aperture size was linked to the dogwhelks ability to attach firmly to the rock surface.

(d) This question was only answered well by stronger candidates, who correctly interpreted the data. Many others gained partial credit for comparing the data, but few went on to explain that more light-shelled dogwhelks with higher fading scores indicates these dogwhelks had experienced greater exposure to sunlight. Only the strongest candidates suggested problems with the data, such as the different sample sizes, or only one shore being studied, or that another factor may be affecting the dogwhelks.

(e) Most candidates were able to make a sensible suggestion, such as using non-toxic paint or taking care not to damage the dogwhelks. Suggestions such as “to prevent harm” were too vague for credit and candidates needed to give a specific example of the harm caused.

Question 2

(a) (i) Many strong responses were seen that gained full credit. Candidates needed to state the independent, dependent and standardised variables in turn. Weaker candidates used the word ‘amount’ and needed to use more scientific language such as volume, concentration, and light intensity.
Some candidates suggested that the plant would release carbon dioxide rather than oxygen, and a few described counting the production of bubbles, which was not appropriate with this particular apparatus. Many candidates correctly included a timescale for the investigation, but some suggestions were too short e.g. “leave for 1 minute”, which would be insufficient time to allow enough oxygen to be collected. Only a minority of candidates correctly described how to standardise the available carbon dioxide with the addition of sodium hydrogen carbonate.

(ii) Most candidates were able to construct a suitable table with correct headings and units. Tables should be drawn with a ruler. Some candidates entered numbers into their table, which was not necessary. Some candidates did not give suitable units or used the word ‘amount’ instead of ‘volume’ for the oxygen collected. A few candidates drew axes for a graph rather than a results table.

(iii) This question was only answered well by stronger candidates and many other candidates did not realise that ‘rate’ involves the production of gas over time. Some candidates described how the rate would change over time, rather than how it would be calculated, with a few describing the calculation of the mean instead.

(iv) Most candidates gained at least partial credit for this question. Some candidates did not gain full credit as they did not show a plateau for the curve at higher light intensities.

(b) (i) Many strong answers were seen which accurately described the relative distribution of species **X**, **Y** and **Z** down the shore. Some candidates described the distribution up the shore, which was acceptable if clearly described. However, some candidates gave answers that were not specific enough. For example, species **Y** was commonly described as having “the most even distribution” or was “distributed evenly across the shore”. Another error sometimes seen was to describe species **X** as being found “further from the shore”, and species **Z** being found “closer to the shore”, rather than their relative position on the shore.

(ii) The majority of candidates realised that species **X** was likely to be best adapted to low light intensities due to being distributed closer to the MLWM, where it would spend longer submerged in deeper water. The most common error was for candidates to suggest species **Z** as they grow predominantly where light is more freely available.

(iii) Many candidates correctly suggested that species **Z** will spend longer uncovered by the tide and so will need to be adapted to prevent water loss/avoid desiccation. A number went on to describe adaptations of molluscs rather than algae, such as having a waterproof shell or forming a tight seal between their shell and the substrate.

Question 3

(a) The majority of candidates were able to give a correct use of nitrogen, most commonly for the synthesis of protein/amino acids/DNA. Some candidates simply suggested that it was an important nutrient, without giving an example of what it was used for, which was insufficient.

(b) (i) Most candidates were able to plot a graph which could then be used to answer **(b)(ii)** and **(c)(i)**. The most common error was for candidates to choose an unsuitable scale for the *y*-axis. The scale they chose needed to allow plots to cover at least half of the available grid. In this case choosing a scale of 5 °C per 20 mm large box would not allow for this. To obtain credit for plotting points, candidates should use a sharp pencil and use small crosses with the centre of each cross within 1 mm of the correct position. Small dots should be avoided as they can become lost in the line of best fit. Large crosses with a blunt pencil should also be avoided as it becomes difficult to identify the precise location. A number of candidates used a straight line of best fit, rather than an S shaped curve. Graphs showing temperature changes with depth should always be presented as a curve.

(ii) Most candidates were able to suggest a suitable range within the 60 m – 140 m tolerance, and link this to the greatest change in temperature.

(iii) Most candidates were able to make a correct suggestion, most frequently suggesting currents, upwelling and seasonal changes to air temperature. The most common incorrect answers were light intensity and temperature without further description.

(c) (i) Here candidates needed to find the maximum rate of nitrate uptake from **Fig. 3.1** and use that reading to determine the temperature from their plotted graph. Their answer needed to match the correct reading from the graph they had drawn, and many candidates managed to do this accurately.

(ii) Only stronger candidates answered this correctly. Few candidates linked the initial increase in rate of uptake to the increase in nitrate available. Most candidates linked the peak of nitrate uptake with the high population size of producers likely to be at that depth, with many going on to link the subsequent decrease to a decrease in producers at lower depths where the light intensity is lower. Lower temperatures in deeper water may also contribute to a reduction in the rate of nitrate uptake, but few candidates made this link.

(d) Candidates needed to use the information in **Fig. 3.2** to predict what would happen to the data in **Fig. 3.1**. Most candidates understood that the increased nitrate concentration and subsequent algal bloom would cause an increase in the rate of nitrate uptake, but only a minority realised that the peak uptake would occur at a shallower depth. Few candidates suggested that the algal bloom may reduce light intensities at lower depths, causing a decrease in nitrate uptake by producers living there.

Question 4

(a) To gain full credit candidates had to state that both organisms benefit in this relationship. Most candidates did this, but some simply described the benefit of each organism which only gained partial credit.

(b) Many correct answers were seen but some candidates suggested more general features that apply to various taxonomic groups, most commonly an exoskeleton or segmented body.

(c) Many candidates stated the correct phylum, but lots of incorrect spellings were seen. Candidates should carefully revise the correct spellings of taxonomic groups.

(d) (i) This was answered well by many candidates, but some responses focused on simply establishing if there was a correlation. This was already apparent in the scatter graph and candidates needed to say that the statistical analysis establishes whether there is a significant or strong correlation by comparing the ranks.

(ii) Many candidates were able to correctly calculate r_s and showed their workings clearly, stating the correct number of significant figures. The most common errors seen were selecting an incorrect value for n, and not correctly rounding calculated r_s value to two significant figures.

(iii) Here candidates needed to correctly interpret their calculated value for r_s from **(ii)**, regardless of whether their calculation was correct. Many candidates gained partial credit for correctly stating the correlation their answer suggested, but not all explained how they came to their answer by comparing their number to 1/0.

(e) (i) The majority of candidates were able to suggest a sensible disadvantage for not controlling the size of the anemones, most commonly regarding their ability to move/feed properly or expending more energy carrying the anemones.

(ii) Most candidates were able to use the information in **Fig. 4.3** to suggest that the investigation supports the idea, due to the differences in growth rates of attached, removed or never attached anemones. However, few candidates went on to describe any limitations such as not knowing the sample size for this data, or the idea that correlation does not necessarily mean causation.

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(a) Only stronger candidates answered this correctly. Many answers given were too vague, such as “acidity” and “amount of hydrogen ions”.

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(iii) This question was answered well, with most candidates able to describe at least 2 or 3 reasons, the most common being for food sources, sources of medicines and protection of the physical environment. Some candidates suggested economic benefits, but needed to describe examples, such as income from tourism/selling catches.

MARINE SCIENCE

Paper 9693/23
Data-handling and Investigative Skills

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MARINE SCIENCE

Paper 9693/31
A Level Theory

Key messages

- Candidates should use the correct scientific terms and precise language, for example 'habitat' and not 'homes'; 'damage the sea bed' and not 'hurt the environment'; 'larvae or juveniles' and not 'babies' and 'increase/decrease' instead of 'affect' or 'change'.
- It is expected that candidates write their answers in continuous prose for ***Section B*** questions, as stated in the syllabus. Those writing bullet points often lost credit as marking points could not be linked.
- Candidates need to read the questions carefully noting the number of marks available, so that their response provides sufficient detail and match what is being asked.

General comments

The strongest candidates performed well and had a good knowledge of the syllabus. However, a significant number of candidates showed minimal knowledge, especially on A Level topics and were not suited to the demands of this paper.

Stronger candidates spent time reading and processing the information in the question before writing their answers. This was evident in **Question 2** on Greenland sharks, in **Question 3(b)** on MPAs and in **Question 4** on Sandeel fishing in the North Sea. Weaker candidates often just repeated the information provided for these questions.

Comments on specific questions

Section A

Question 1

(a) (i) Stronger candidates were able to state that sediment or silt was brought to the estuary by the river and was then deposited to form mudflats in the estuary due to a decrease in water flow. Common errors were to state that the river transported mud or dirt or that the sediment or sand was brought in by wave action. Few references were made to the rate of sedimentation being greater than erosion and in many cases erosion was thought to cause the formation of mudflats.

(ii) Candidates were aware that the saltmarsh plants absorbed wave action or acted as a barrier. Although "roots" was often given as an answer, they anchored the plant in place rather than holding the sediment in place. References to particles, sand or soil rather than sediment were common. Candidates often referred to nutrients being taken in, used or consumed by plants rather than the more appropriate terms: absorbed or taken up. Only a few candidates were able to name a nutrient required by plants and provide its specific function. Stating that nutrients were required for photosynthesis was not enough.

(b) (i) Answers were often too vague or incomplete to gain credit. For example, incorrect responses stated that the increase was due to the weather or increased rainfall or referred to waste, pollution from the city or to pesticides or chemicals from agriculture. An increase in fertilisers was seen more frequently than sewage.

(ii) A majority of candidates were able to correctly state that mats of macroalgae blocked light, so decreased photosynthesis. There were fewer references to the decrease in growth. Common

errors were to state sun instead of sunlight or to light being required for photosynthesis, rather than stating its effect on photosynthetic rates.

(c) (i) That estuaries receive more run-off containing nutrients or that estuaries were a smaller body of water were common correct answers. Fewer candidates referred to the idea that there would be less water exchange.

(ii) Most candidates referred to chemosynthesis and stronger candidates also stated their energy source. Some candidates confused aerobic respiration with anaerobic respiration. Other common errors included stating that the bacteria carried out photosynthesis and that they produced or created energy.

Question 2

(a) (i) The majority of candidates gained at least partial credit, usually for stating that Greenland sharks move slowly to retain energy. Stronger answers referred to the reduced fin size as an adaptation to retain heat as they had a smaller surface area or that they reduced swimming speed. That Greenland sharks have a larger body was a common answer, but to gain credit the body needed to be bulkier to insulate the body from the cold water temperatures. Weaker candidates thought that the shark was warm blooded and that it had to save energy to maintain its body temperature. Answers needed to match the information provided in the photograph and table, so those which mentioned metabolism were ignored.

(ii) The lack of light and the use of other senses were common correct answers. Fewer candidates referred to Greenland sharks as apex predators, so would not need to look out for predators.

(b) Stating that retaining urea instead of removing it via the kidney and that this saved energy was a common correct answer. Weaker candidates stated that the urea in blood was a source of protein or that it was there to maintain body temperature, or that it made the shark denser so that it could sink to the seabed. Few references were made to the sea water having a higher concentration of water than the shark and that this resulted in water entering via osmosis. The terms hypotonic/hypertonic/lower or higher solute concentration were often used rather than water potential.

(c) Many answers did not refer to the question, stating that the Greenland shark would die or would have to adapt or that numbers would decrease, instead of stating an effect on the distribution of the shark.

Question 3

(a) (i) Most answers focused on legislation as a strategy used to conserve marine species. Examples included applying quotas or restrictions on fishing seasons or gear. Alternative correct answers included creating artificial reefs, marine zoos and aquaria as a source of information and ecotourism.

(ii) This question on why MPAs are created in coastal areas was answered well. Most candidates referred to mangroves, coral reefs or seagrass beds as having a high biodiversity and that they were important nursery areas or habitats for marine organisms. Fewer answers referred to their importance for producing oxygen or as carbon sinks.

(b) The majority of candidates gained partial credit, but full credit was rare. Common correct answers referred to the lack of monitoring or enforcement inside MPAs and a reference to the damaging effects of benthic trawling or dredging. However, some candidates thought that dredging was a fishing method that resulted in by-catch.

Question 4

(a) (i) Benthic trawling was a correct answer given by many candidates, but incorrect answers included purse-seine fishing, mid-ocean trawling and dredging. To gain credit candidates also had to state why benthic trawling was a suitable method for catching sandeels. That the net was dragged along the sea bed was not enough to gain credit.

(ii) Full credit for this calculation was rare. This was either because candidates did not state that there had been a decrease or that they had forgotten that values on the y-axis were in tonnes x 10^3. A common incorrect answer was therefore 520 – 60 = 460 tonnes.

(iii) Stronger candidates identified that the graph showed that the mass of spawning adult sandeels fluctuates and that, except for in a few years, it is below the maximum sustainable yield. Some candidates incorrectly stated that quotas were a success as the mass was below the MSY and contradicted themselves.

(b) Although stronger candidates answered this correctly, most candidates misunderstood the life cycle and did not understand the information in the question. It was important to note that if egg release was delayed, then the stages in the sandeel life cycle did not match with their prey. Many candidates stated that the eggs were now released too early, before the phytoplankton bloom rather than after the bloom. The egg has its own food store and does not need to feed on phytoplankton. The distinction between copepod larvae and sandeel larvae was often unclear, and weaker candidates thought that an increase in temperature would be helpful.

(c) Stronger answers referred to all the information provided, and gained credit for stating that sandeel numbers were reduced due to overfishing and that increasing sea temperatures decreased the supply of sandeels for kittiwakes. Most candidates referred to the increased chance of injury flying through the wind farm, but fewer stated that flying around the wind farm would result in extra energy being used or to the longer journey time. Although most candidates stated that there would be less food for adult birds, fewer stated that there would less food for their chicks. Answers such as “nests would be blown off the cliff” or that adult birds would migrate were ignored.

Section B

Question 5

This question asked candidates to compare gaseous exchange in coral polyps and tuna, which is Learning Outcome 6.3.3 in the syllabus. A significant number of candidates did not attempt this question, while others incorrectly described a supposed mutualistic relationship between coral polyps and tuna with photosynthesis in zooxanthellae providing tuna with oxygen and tuna providing corals with carbon dioxide. Some candidates did not understand the meaning of the term ‘gaseous exchange’ and produced answers relating to osmoregulation, feeding or urination.

Credit was most commonly awarded for tuna having gills and carrying out ram ventilation. However, some candidates were confused, stating that tuna carried out pumped ventilation or that they carried out both ram and pumped ventilation. Several candidates stated that coral polyps use diffusion and have tentacles to increase their surface area and stronger candidates went on to describe how the tentacles wave to create a current so maintaining a diffusion gradient. Tuna were then described as having a small surface area to volume ratio, instead of focussing on features of gills, which have filaments/lamellae to increase surface area and where there is a counter-current flow system for gases to diffuse into blood.

Question 6

(a) The majority of candidates gained at least partial credit for describing how ocean currents form but full credit was rarely awarded. That currents are formed by wind was the most common correct answer. It needed to be clear that there were differences in temperature or salinity to gain credit. Some answers mentioned the Coriolis effect, but needed to add more information, e.g. that it was caused by the Earth’s rotation. Few candidates mentioned tides as causing currents, but there were often long and complex descriptions of how the Sun, moon and gravity can influence currents. Stronger answers included a reference to tectonic plate movement and to density, while the shape of the coastline and the uneven heating of Earth’s surface were very rarely included.

(b) Stronger candidates were able to synthesise knowledge from the AS and A Level sections of the syllabus to answer this question on the importance of ocean currents. Common correct answers included that currents transport nutrients, gametes or larval stages and that they regulate temperature and salinity. That currents form migration routes was also seen, but some candidates just stated “transport routes” which was not enough. Stronger candidates were able to describe upwelling and the importance of nutrients to producers for photosynthesis or to increase productivity. Few candidates stated the importance of currents in diluting pollutants or to disperse algal blooms, or that currents can influence weather patterns. Only the strongest candidates

mentioned aquaculture and how currents are important to provide oxygen and food and to remove waste products. There were a few references to El Niño or La Niña, but without a description they were ignored.

Question 7

A significant number of candidates did not attempt this question, while others gave descriptions of the cell membrane rather than ion transport through the membrane. Stronger candidates named channel and carrier proteins rather than just proteins. There was sometimes confusion regarding which protein was used for passive transport and which for active transport. Many answers focused on diffusion instead of facilitated diffusion, while others did not mention ions at all, just the movement of molecules/polar molecules, substance or salt through the membrane. Weaker candidates described movement through a cell wall or through organelles such as the nucleus and ribosomes. Few answers mentioned that the proteins are specific, that channel proteins have a fixed shape or that sodium ions are charged.

MARINE SCIENCE

Paper 9693/32
A Level Theory

Key messages

- Candidates should spend time reading and processing the information provided in the question and should consider the command word or words before starting to write their answers.
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- Candidates are expected to understand and use subject specific vocabulary, as found in the syllabus.

General comments

There were some strong candidates entered for this paper who demonstrated a thorough knowledge of syllabus content and could link ideas from different sections to produce comprehensive answers. This was particularly evident for **Question 6(b)** on sources of carbon for marine organisms and why an increase in these sources poses a threat to hard corals. Stronger candidates performed well on **Question 2** on shrimp culture, **Question 3** on water potential and **Question 4** on photosynthesis as they took their time to read all the information provided in the question carefully. Weaker candidates generally performed well on **Question 1** on jellyfish and on **Question 5** on modern fishing technology, but they needed to try to avoid including irrelevant or vague descriptions.

Comments on specific questions

Section A

Question 1

(a) The majority of candidates could name cnidaria as the phylum to which jellyfish belong. Incorrect and answers included invertebrates and chordata.

(b) All candidates gained at least partial credit as they identified tuna as a predator of jellyfish and stated that commercial fishing for tuna would reduce predation. Few candidates stated that tuna were overfished and several mentioned fishing for turtles rather than catching them as by-catch. References to anchoveta fishing and the resulting increase in zooplankton, so increasing jellyfish prey, were rarely seen.

(c) This question was answered well and candidates were able to state the problems caused by jellyfish swarms to the fishing industry and to desalination plants. Occasionally answers were too vague, for example "jellyfish eggs damage desalination plants".

(d) (i) Stronger candidates were able to gain full credit for this question. Most candidates stated that bacterial numbers when jellyfish mucus was present increased more than those without mucus, but few gained further credit by quoting manipulated data. Nitrogen was usually linked to growth rather than used to making amino acids or proteins for growth. Answers relating to oil breakdown were uncommon.

(ii) Most candidates stated that jellyfish mucus could be used to increase bacterial breakdown of plastic or that it could be used in water treatment works before water release. Fewer candidates mentioned that the mucus could be used to trap the microbeads and some candidates incorrectly thought that the mucus was able to break down the microplastic and not the bacteria.

Question 2

(a) Those candidates who knew how a delta was formed gained full credit. Incorrect answers referred to erosion and fast-flowing water or just stated that a delta was formed where a river entered the sea.

(b) (i) Only a few candidates stated that ponds were allowed to dry out to ensure that parasites or disease-causing organisms were killed and therefore unable to pass on disease to the next harvest.

(ii) That calcium salts were used to make the exoskeleton or carapace of shrimp was a common answer, but some candidates incorrectly indicated that it was occasionally used to make bones or a skeleton. Stronger candidates knew that shrimp have complex life cycles and that they moult several times rather than just grow. References to removal of calcium salts when shrimp are harvested were rare.

(iii) Only the strongest candidates were able to express the idea of overharvesting of wild juvenile shrimp. The information provided in the question stated that “other marine species also reach the ponds”, so this should have prompted candidates to think about competition for food as a reason for shrimp becoming smaller in size due to decreased growth. References to evolutionary pressure were uncommon.

(iv) The majority of candidates stated that costs would be lower and provided a suitable example, such as lower set-up or maintenance costs, or that there was no need to buy food. References to labour or to sustainability were ignored.

(c) Candidates who spent time reading all the information provided usually answered well. Repeating information in the question, such as “shrimp grow in winter” and “rice grows in summer” did not gain credit. Many answers were too vague, for example that “the ponds flood in winter” without mentioning saline water, or that water was added but without stating whether this water was fresh water or saline water. Very few answers referred to the design of the ponds, included opening/closing gates or to inlet/outlet pipes.

Question 3

(a) Stronger candidates correctly stated that the thick, fleshy leaves of the splash zone plant stored water which could prevent desiccation. A common incorrect answer was that the leaves were better able to withstand wave action.

(b) Answers to this question on water potential were usually good, with most candidates gaining at least partial credit. Candidates needed to follow the instructions in the question and refer to water potential rather than using the terms hypertonic or hypotonic or making reference to solute concentrations. Some candidates did not refer to the term osmosis, so could not gain the initial available credit. Answers referring to cell expansion by the inner layer of cells were often confusing and did not compare these cells with these of the outer waterproof layer.

(c) (i) Full credit for this graph was rare. Common errors included missing labels on the axes, for example, the x-axis label was named “sucrose solution” instead of sucrose concentration and units were usually missing. The y-axis label was often missing or was just labelled as “curve” rather than an angle of curvature as stated in the question. The line on the graph was usually correct, but some candidates produced a curved line which started on the x axis. Several candidates did not attempt this question.

(ii) If candidates had drawn a line for their graph, then most could identify the point where the sucrose concentration was equivalent to the water potential of the tissues. However, a few candidates marked an arrow on their graph but the arrowhead was not touching the x-axis.

(iii) Stronger candidates stated that the strip would be straight or did not bend. Answers which stated that the strip would not change were ignored.

Question 4

(a) (i) That different colours of light have different wavelengths was a common correct answer. Few candidates were able to state that white light is made up of all wavelengths or all colours.

(ii) Only stronger candidates answered this correctly and knowledge of why rates of photosynthesis vary in different colours of light was limited in other cases. Most candidates did not mention chlorophyll, but knew that red light could only penetrate shallow waters. Few references were made to green algae lacking the pigments to absorb green light or to the fact that they would only be able to absorb blue light if they were in deeper water. References to higher rates of photosynthesis at the surface were also uncommon.

(iii) Only the strongest candidates could name the pigment (phycobilins) found in red algae and knew of its ability to absorb green light. The majority of answers focussed on a reduction in photosynthesis in red light rather than an increase in green light.

(b) (i) There were some vague definitions for both absorption spectrum and action spectrum. These included that absorption spectrum was “the absorbance of different pigment” or “the amount of light absorbed”. Few candidates gained any credit for action spectrum as they stated that it “showed the rate of photosynthesis” or “showed the wavelengths used by processes”.

(ii) Again, knowledge on carotenoids was limited, with many answers relating to the colour of carotenoids and stating that they were yellow/orange pigments. Few candidates referred to the figure which showed carotenoids absorbing wavelengths of around 500 nm. Fewer still noticed that the carotenoid did not cause a corresponding increase in the action spectrum and so did not cause an increase in photosynthesis in this macroalga.

Section B

Question 5

Candidates demonstrated a strong knowledge of the impacts of sonar, purse-seine fishing and especially benthic trawling on populations and habitats of marine organisms. Most answers described the impacts of each method in turn and answers were presented in continuous prose as stated in the syllabus. Many answers included the fact that industrial fishing can result in overfishing, so decreasing biodiversity and can affect predator/prey relationships in food webs.

Sonar was probably the least understood method, and many answers were too vague to gain credit. Examples included that sonar was used to locate fish instead of to locate shoals of fish, or that it could be used to show the size of fish instead of depth of fish or distance from the boat. Many candidates correctly stated that using sonar would make fishing more efficient as fish could be caught more quickly, while weaker candidates thought that sonar was a method of catching fish. Stronger candidates made reference to the fact that sonar has a negative effect on marine mammals and quoted dolphins or whales as suitable examples.

Most candidate described the net used for purse-seine fishing but did not emphasise the net size or the large area covered by the net. Few references were made to catching shoals of pelagic fish. Some candidates only mentioned by-catch and did not gain credit as it needed to be clear that this fishing method results in large amounts of by-catch. Only stronger candidates gave examples of by-catch such as sharks or turtles.

Knowledge of benthic trawling was excellent, with most candidates able to state that it involved dragging a net along the sea bed and that this caused damage to the benthic habitat. Again, it needed to be clear that there would be high levels of by-catch. Stronger candidates were able to describe how an increase in turbidity would affect marine organisms, for example by clogging the gills or fish or reducing light penetration for photosynthesis in producers.

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(a) Candidates demonstrated an excellent understanding of the importance of coral reefs to humans. All marking points were seen, especially the benefits to the economy through tourism, their role in dissipating wave energy for coastal protection and also as a source of medicines. References to their role as carbon sinks, oxygen produced for respiration and especially that coral reefs provide a safe anchorage for boats were far less common.

(b) Candidates needed to name the sources of carbon available to marine organisms. Candidates who just referred to carbon throughout were not awarded credit. Most candidates understood that carbon dioxide from the atmosphere dissolves in sea water to produce carbonic acid and that this acid reduces the pH, but some incorrectly stated that the pH increased. Most candidates stated that corals have a skeleton made of calcium carbonate and that it erodes with increased acidity. Answers stating that the increased acidity causes the shell to soften were ignored. Stronger answers referred to the carbonic acid dissociating to produce hydrogen carbonate ions and hydrogen ions, but a few answers could not be credited as the word 'ions' was missing. Many candidates then went on to state that the increase in hydrogen ions would cause a reduction in the availability of carbonate for corals. Coral bleaching needed to be linked to the increase in acidity for credit to be awarded. Very few candidates referred to carbon dioxide being used in photosynthesis to produce glucose for marine consumers, to weathering of rocks containing carbonate, or to respiration or decomposition producing carbon dioxide.

Question 7

Partial credit was common for this question on ecotourism, but full credit was rare. Some candidates had little idea of what was meant by ecotourism and described fishing restrictions such as quotas or a reduction in net sizes as examples. Correct answers often focused on ecotourism raising awareness and providing funds for conservation and for providing a source of income or employment for the local population. A misconception was that ecotourism causes no damage to the natural environment rather than it causing minimal damage. Stronger answers discussed the use of renewable energy sources such as solar panels or using bicycles instead of motorised transport. References to the limited use of fresh water and disposal of waste-water were rarely seen, as were references to recycling and the reduced use of plastic.

MARINE SCIENCE

Paper 9693/33
A Level Theory

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MARINE SCIENCE

Paper 9693/41
Data-Handling and Investigative Skills

Key messages

Candidates should:

- ensure that they have an understanding of all topics at an A-Level standard;
- make sure that they have a full understanding of what each of the different command words requires;
- use precise language when describing experimental planning, for example, referring to volume or mass rather than amount;
- have a full understanding of what the independent, dependent and standardised variables are.

General comments

The standard of responses from candidates was very mixed but there were many responses of an excellent quality. It was clear that many candidates had an excellent, detailed knowledge of all areas of the syllabus, had strong data analysis skills, and had an excellent understanding of the scientific method. It was also clear that many centres are preparing candidates thoroughly for the exams and have a good understanding of the demands of the new syllabus.

However, some candidates did not give answers with enough depth for an A-Level standard, did not have the confidence when handling data, and did not fully understand how to plan valid practical work. In future series, candidates should ensure that they have a detailed knowledge of all topic areas and that they are confident when handling data to draw conclusions. Mathematical skills were generally good, but a significant number of candidates found drawing a bar chart challenging. Candidates should make sure that they know all the strict criteria required for graph drawing such as, selecting linear scales, labelling bars or lines, including units on axes and leaving gaps between bars. Drawing skills were very mixed with some candidates producing excellent diagrams that were drawn with sharp pencils, had clear lines, were of a large size and did not have any shading. A significant number of candidates produced drawings in pen. Candidates should use pencil for drawings and graphs. A number of candidates also shaded diagrams or had inaccurate diagrams with poor quality lines.

Comments on specific questions

Question 1

(a) (i) This question required candidates to identify the Golgi body and rough endoplasmic reticulum within a cell. Most candidates were able to gain at least partial credit. A few candidates incorrectly suggested that the rough endoplasmic reticulum was the smooth endoplasmic reticulum.

(ii) Most candidates were able to correctly measure the structure as 1 cm or 10 mm. A few candidates used feet and inches. For this syllabus, metric units should be used. Many candidates were able to divide their measurement by 5000, but a few incorrectly multiplied the numbers. A significant number of candidates mixed up the units and gave the length in centimetres after measuring in millimetres or used micrometres without converting the units.

(b) (i) This question was answered well by most candidates. The question asked for a description of the growth of a leaf. Most candidates correctly identified that the growth increased up to 25 ppt and then decreased.

(ii) This question required candidates to discuss whether the data in a graph supported a conclusion. Most candidates were able to correctly state that the seagrass grew best at 25 ppt and that this supported the conclusion. Few referred to the error bars on the graph or the significance of overlaps. If error bars are given on graphs, it is good practice to refer to them in the answer.

(iii) This question drew the data about the effect of salinity on growth of seagrass and candidates' own knowledge about desalination plants together. Stronger answers explained that desalination plants release highly concentrated brine into the sea and that this would cause reduced growth of seagrass. A few candidates gave excellent answers that explained that the water potential of the water would decrease leading to water loss from the seagrass cells. Other strong answers referred to the toxins and/or the high temperature of the waste water from the desalination plants. A significant number of candidates incorrectly stated that a desalination plant would convert the water in the sea into fresh water, lowering the salinity of the water.

Question 2

(a) (i) This question required candidates to label the area of a chloroplast where the light independent reaction occurs (stroma). Many candidates incorrectly labelled the thylakoid membrane and a few labelled the chloroplast membrane. When using label lines, candidates should ensure that they are straight, ruler drawn, and do not have an arrowhead.

(ii) This question required candidates to produce a drawing of an area of the chloroplast in a circle. The quality of drawings seen was very variable. Good quality drawings had clear, unbroken lines that were drawn with sharp pencil, had no shading and showed the correct details in the correct proportions. A number of candidates presented drawings in pen instead of pencil and many shaded sections of their drawings. Full use of the available space should be made. Many candidates drew very small drawings.

(b) (i) Most candidates were able to calculate the mean, and most went on to give an answer to the correct number of significant figures.

(ii) (iii) Many candidates found these questions challenging. The question asked for the reasons for using a tube with chloroplasts and no light, and a tube with no chloroplasts in the presence of light. Stronger answers explained that the tubes showed the effect of chloroplasts on the DCPIP and the direct effect of light on the DCPIP. Many candidates gave very vague answers, such as that the tubes were controls, that placing foil on a tube removes light, and that the tube showed the effect of light on the experiment (rather than the colour of the DCPIP).

(iv) This question asked candidates to explain the effects of the experiment. Most were able to recognise that DCPIP decolourised faster with blue or red light compared with green light. Stronger candidates often went on to explain that the data showed that green light is not absorbed but blue or red light is absorbed and that if light is absorbed, chlorophyll is oxidised. Weaker answers often only gained partial credit for describing the data and did not give an explanation. Candidates should be careful to focus their answers on the command words given.

(v) This question asked candidates to name an accessory pigment present in deep sea algae and explain why it is needed. Stronger answers named pigments such as fucoxanthin and went on to explain that in deeper water there is no red light, and the accessory pigments enable other wavelengths to be absorbed. A significant number of candidates were not able to name an accessory pigment or referred to chlorophyll. Many candidates also incorrectly suggested that the pigments were the colours of light in the experiment or that red light penetrates most deeply into the ocean.

Question 3

(a) This question asked for a description of the relationship between *Riftia* and *Endoriftia*. Stronger answers explained the mutualistic nature of the relationship and how *Endoriftia* produces glucose by chemosynthesis, some of which is taken by *Riftia*, and that *Riftia* provides carbon dioxide for *Endoriftia*. Weaker candidates often gained partial credit for stating that the relationship is mutualistic but often gave confused descriptions, such as *Riftia* undergoing chemosynthesis. Candidates should also be careful to give specific examples of nutrients, such as glucose, rather than using the vague term of 'nutrients'.

(b) (i) This question required candidates to draw a bar chart to show the uptake of carbon dioxide by *Endoriftia* at different hydrogen sulfide concentrations, and water pressures. Many excellent bar charts were seen that were fully labelled, accurately drawn, and had linear scales. Several candidates did not use a linear *y*-axis and many failed to label axes or include units. A significant number tried to use two separate *y*-axes to show the carbon dioxide removed and the water pressure. Candidates should use rulers to draw bars and should draw all graphs with pencil.

(ii) This data analysis question required candidates to look carefully at the data showing the effects of hydrogen sulfide concentration and water pressure on the rate of carbon dioxide uptake. Most were able to correctly state that increasing hydrogen sulfide concentration increased the rate of carbon dioxide removal. Some stronger answers went on to correctly state that if the pressure is low, increasing the concentration of hydrogen sulfide had no effect. Stronger answers also often stated that increasing the pressure had no effect at the two lower concentrations of hydrogen sulfide but did when the concentration was higher. Stronger candidates often supported their answer with a numerical calculation, such as an increased remove of 0.3 mmol of carbon dioxide and went on to state that hydrogen sulfide and carbon dioxide are both needed for chemosynthesis.

Question 4

(a) This question asked candidates to describe how salmon are grown in extensive aquaculture systems. Candidates generally found this question challenging and often gave very vague descriptions of the use of tanks or shrimp ponds. Many candidates incorrectly stated that salmon eggs, alevins, or fry are placed into open water marine sea cages. Stronger answers described the placement of smolt into the sea cages in areas of ocean water. Stronger answers also often referred to the use of protein feed pellets, some form of monitoring for abiotic factors or disease, and the use of low stocking densities to minimise disease spread.

(b) (i) This question required candidates to use data in a table to calculate the mass of phosphate released by 400 kg of shrimp. Most candidates were able to correctly complete the calculation but a few did not recognise that the table gave data per 1000 kg and not per kg.

(ii) In this question, candidates were provided with data showing the effects of shrimp, salmon, mussel, and seaweed farming on different negative environmental impacts. Candidates were then asked to discuss if salmon aquaculture is less harmful than shrimp aquaculture. Most recognised that there was less release of phosphate or carbon dioxide, but few went on to give any effects of this, such as the reduced risk of eutrophication or reduced global warming. Candidates should be careful to not simply give a list of all the data in a table when asked to explain, evaluate or discuss.

(iii) This question explained that multi-trophic level aquaculture can be used to reduce negative impacts of aquaculture and asked candidates to use the data in the table to explain how growing seaweed and mussels together with salmon would reduce the environmental impacts. Most candidates recognised that there would be increased removal of carbon dioxide and phosphate but only a minority went on to give more detail, such as the role of photosynthesis by the seaweed removing the carbon dioxide and the reduced pressure on land if everything is grown in the same place.

Question 5

(a) This question asked candidates to give a description of the way in which microplastics are made. Stronger answers defined microplastics as being less than 5 mm in size and went on to suggest factors such as wave action and temperature that cause them to be produced. Weaker answers often gave vague references to the breaking up of larger pieces of plastic.

(b) (i) This question required candidates to fill in a Spearman's rank correlation table. Many were able to correctly calculate the values for D^2 and the sum of D^2. Common errors including incorrectly ranking the data and not adding the D^2 values up correctly.

(ii) Many candidates were able to use their answer to **(i)** to correctly calculate the Spearman's rank correlation coefficient.

(iii) Many excellent answers were seen that correctly stated that the calculated value was higher than the value for $p < 0.05$ so that there was a statistically significant correlation. Many correctly used the value of 0.587 as the critical value. Some candidates compared their value with 0.5 and others

incorrectly stated that the null hypothesis is accepted if the calculated value is greater than the critical value.

(c) This question drew the data about microplastics along with candidates own knowledge of microplastics together to suggest why eating mussels is potentially harmful. Many candidates recognised that the data showed that areas with higher human populations would have a high number of microplastics. These microplastics would be taken in by the mussels and then passed along the food chain when humans ate them.

Question 6

This final question was an experimental planning exercise. The question produced a wide spread of results. Stronger candidates gave an accurate hypothesis concerning the effect of pH on the number of oyster that settle. A significant number of candidates incorrectly referred to measuring how long it takes the oysters to settle. Stronger answers again correctly identified the different variables and suggested variables that need to be standardised. Common standardised variables included temperature, oyster species, and light intensity. Candidates should always try to give a method for maintaining these variables, such as the use of a lamp and metre ruler to maintain light intensity. Only the strongest candidates gave a sensible range of pH with many only suggesting three different pHs. Candidates should always try to give at least five values for the independent variable. A significant number of candidates suggested using unethical pHs, such as pH of 1 or 2. Candidates should always try to ensure that an experiment with living things is ethical. Only a few candidates suggested sensible methods of analysing the data including descriptions of the tables they would record results in and the graphs they would plot. It was not enough to simply state “I will use a results table” or “I will plot a graph”. Candidates needed to draw the table and state what type of graph and what axes labels they would use. Most were able to give an ethical method to prevent harm to the larvae. When asked for a safety feature, candidates should identify a specific risk, e.g. use of a toxic solution, and then give a precaution, e.g. use of eye protection to prevent the toxic solution splashing into eyes. Many candidates just gave vague statements such as wearing eye protection with no stated risk.

MARINE SCIENCE

Paper 9693/42
Data-Handling and Investigative Skills

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- practise drawing skills before the examination, being careful to use a sharp pencil;
- select sensible linear scales for graph axes to reduce the risk of incorrectly plotting points;
- use precise language when answering experimental planning question, for example always referring to volumes or masses rather than amounts.

General comments

There was a high overall standard and the majority of candidates demonstrated excellent factual knowledge of all areas of the syllabus, were confident with the use of technical vocabulary, had impressive analytical skills and had a full understanding of practical science and the scientific method. A small number of candidates gave answers that did not have enough detail and found mathematical calculations challenging. Some candidates completed the drawing question with shading and/or did not use clear, well-defined lines. Candidates should make sure that they draw all graphs and drawings in pencil.

Comments on specific questions

Question 1

(a) This first question presented candidates with a diagram of a cell membrane and asked them to identify a membrane protein and phospholipid. Most candidates correctly answered the question and gained full credit A few candidates confused the two structures and some incorrectly suggested that the protein was a peripheral protein.

(b) (i) This question presented candidates with the results of an experiment to investigate the uptake of potassium ions by mussel cells with and without respiratory inhibitors. Candidates had to use the graph to calculate the rate of uptake over a period of time and state the unit. Most were able to gain full credit and where candidates did not, it was typically for misreading the graph and/or stating an incorrect unit.

(ii) This question asked candidates to compare the uptake of potassium ions over time when cyanide was present with the uptake of potassium ions when cyanide was absent. Most candidates gained at least partial credit with many gaining full credit. If candidates are asked to compare data, they should look for both similarities and differences. Some candidates only gave similarities or only gave differences.

(iii) This question asked candidates to use the data to explain how mussel cells absorb ions. Many excellent answers were seen that explained that the ions must be taken up by both facilitated diffusion and active transport. Stronger answers explained the need for ATP in active transport and gave the correct directions of the concentration gradients. Only the very strongest candidates explained how the data showed that both diffusion and active transport must occur since some potassium still entered when there was no respiration. Weaker answers often gained partial credit but gave answers that often confused the directions of the gradients for active transport and confusion and/or the need for ATP.

Question 2

(a) (i) This mathematical question asked candidates to calculate the catch per unit effort of spearfishing using an equation and data in a table. Most candidates answered well but some candidates did not give the correct number of significant figures.

(ii) This question was often answered well. Candidates were asked to look at data in the table that compared catch per unit effort, fishing effort and catches when fishers use rod-and-line and purse seine fishing. The question required candidates to then discuss whether it was correct to state that rod-and-line is more sustainable. Stronger answers explained that purse seine took more catch and had fewer boat days so the fishing method is more efficient. Most candidates were able to gain at least partial credit, typically for stating that purse seine fishing is likely to lead to overfishing.

(b) (i) – (iv) These questions required candidates to complete a statistical analysis, calculating standard error and 95 per cent confidence limits. Most candidates were able to state a null hypothesis, correctly complete the calculations and at least state that if the confidence limits do not overlap, there is likely to be a significant difference. A few candidates mistakenly discussed correlations rather than differences both in the null hypothesis and the analysis.

(v) This question required candidates to look at the data on the size of the fish caught, the percentage of juvenile fish and the amount of bycatch of the two fishing methods, and then explain the likely impact of purse seine fishing. Most candidates were able to correctly state that purse seine fishing would cause reduced breeding due to the catching of fish that had not reached sexual maturity and that the bycatch could affect food webs.

(c) This question asked candidates to state three methods to ensure sustainable exploitation of a fishery. Most candidates were able to give two correct methods with many going on to give a third. A few candidates gave a list of three methods where two were similar, for example, regulations on gear and regulations on net type. Candidates should try to give distinct suggestions when asked for a list of methods.

Question 3

(a) Many stronger candidates answered this well. The question presented candidates with data about the percentage of unbleached coral in a reef and the Simpson's index of diversity, after fertiliser use had been banned. Candidates had to describe the negative impact of fertiliser. Stronger answers explained how fertiliser use leads to eutrophication, decomposition, bacterial respiration and loss of oxygen. Weaker answers often explained that algae would grow but did not go on to give any more detail. A few candidates confused fertilisers with pesticides.

(b) (i) This question asked candidates to draw a suitable graph to present the data in the table. Many excellent graphs were seen that had two linear y-axes, accurate plotting, keys for the lines or bars and fully labelled axes. Candidates should always use more than half of the grid and should try to use sensible, linear scales that make it easier to plot points accurately. Candidates should also ensure that they draw graphs in pencil rather than pen.

(ii) This question asked candidates to look at the data about the diversity on the reef and the percentage of bleached coral and then explain why the diversity on the reef increased. Most candidates gained at least partial credit with many gaining full credit. Many recognised that the increase in unbleached coral meant that there would be more photosynthesis, and more energy entering into the ecosystem. Some candidates gave vague answers that simply described that more species would be present rather than giving an explanation. Candidates should be careful to focus on the requirements of each command word.

(iii) This question asked candidates to suggest why it would not be possible to be certain that the coral reef recovery was due to the ban on fertiliser use. Stronger answers stated that the data showed a correlation rather than a causal effect and went on to suggest other factors that may have changed such as water temperature.

Question 4

(a) This question asked for a definition of the term euryhaline. Most candidates were able to correctly state that euryhaline species can live in water of different salinities. A small number of candidates confused the term euryhaline with the term osmoregulator.

(b) (i) This question presented candidates with an electron micrograph of a mitochondria and asked them to calculate the actual length of the mitochondrion when given the magnification. Most candidates were able to gain full credit. Candidates were asked to give their final answer in micrometres and a few candidates were unable to correctly convert their measured length into micrometres.

(ii) Candidates were required to draw a section of the mitochondrion. Many excellent drawings were seen that had clear, well-defined lines, no shading, accurate detail, were of a good size and in proportion. A few candidates used pen rather than pencil. A small number of candidates drew lines that had breaks. It is important to have clear, well-defined lines and no shading.

(c) (i) Candidates were presented with data about the consumption of oxygen, the gill surface areas, and the density of ionocytes in killifish placed into water of different salinities. Candidates were asked an experimental method question about the need for calculating the surface area per gram of fish. Stronger answers explained that the masses of the fish would vary so to make a valid comparison, the surface areas would have to be standardised by calculated the area per gram.

(ii) Most candidates were able to gain partial credit by describing the decrease and increase of oxygen use as salinity increased. Only a few candidates gained further credit by giving a manipulation of the data.

(iii) This question generated a wide range of responses. Stronger answers explained that the fish had fewer ionocytes and consumed less oxygen when in a salinity of 11 ppt suggesting that they had less need to osmoregulate and less need to pump salt in their gills. These answers also went on to explain why fish would lose water in high salinities and gain water in low salinities, and so have to pump salt in their gills. A few candidates confused the directions that salt would need to be pumped in water of different salinities suggesting that salt would need to be pumped out in fresh water. Stronger candidates also recognised that the concentration of dissolved oxygen is lower in water of higher salinity and so the gill surface area would need to be larger to obtain more water. Weaker answers tended to just give descriptions of the data rather than suggesting explanations. If asked to discuss data, candidates should explore all the data as fully as possible.

Question 5

(a) This question asked candidates to suggest the benefits of complex life cycles. Stronger answers explained that complex life cycles have a larval form, there must be metamorphosis and the larval form will enable distribution and reduces competition with adults. Weaker answers tended to focus on one aspect, gaining only partial credit.

(b) (i) Candidates were presented with data that showed how the consumption of microplastic by copepods varied by age and sex of the copepods. It also showed how the consumption varied between new plastic, and older plastic that became covered with algae. Candidates were asked to describe the patterns shown in the data. Stronger candidates correctly stated that adult males consume most of the older copepods, that all types of copepods consume more of the older microplastics than the newer microplastics, that females consume the newer microplastics, and that males have the highest proportional increase in consumption of older microplastic compared with the newer microplastic. Weaker answers tended to focus on just one or two patterns. Candidates should be advised to consider the mark allocation for questions and to ensure their answers give sufficient details to match this.

(ii) Many excellent answers were seen to this question that drew together the data in the table (that demonstrated that more of the older microplastic that is covered in algae are consumed than the newer microplastics) with candidates own knowledge of eutrophication near fish farms and the risks posed by microplastics. Stronger answers explained that there would be more nutrients in water near fish farms resulting in algal blooms that would coat the microplastics. These answers often went on to explain that the copepods would consume more of these microplastics, and any toxins absorbed by the microplastic would be passed on to the copepod, and along the food chain when salmon eat the copepods and humans eat the salmon. Weaker answers often correctly

stated that the microplastics would absorb toxins that would be passed along food chains but did not make the link with the algal blooms near fish farms.

(iii) This final question was an experimental planning question concerning the effect of temperature on the rate of breakdown of plastic sheeting. Many very good plans were seen, but a few candidates confused the terms ‘independent’ and ‘dependent’ variable, using vague terms such as ‘amount’ rather than volumes or masses, and not giving full details. Some candidates also correctly stated that results would be collected in a table and a graph would be drawn but did not give examples of details of the table or graph. Stronger answers gave a correct hypothesis that linked the temperature with the rate of breakdown of the plastic, correctly identified the variables and suggested a wide range of variables that would need to be standardised. Some very strong answers correctly explained how the data would be analysed, for example how a rate of breakdown would be calculated and what statistical tests would be used. These styles of question give candidates a bulleted list of things that they should include, and candidates should use this as a guide for their answer. When giving safety and ethical features, candidates should explain what safety feature they use and link it to the risk and explain how they will make the experiment more ethical. For example, to reduce harm to an organism or the environment as a whole.

MARINE SCIENCE

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