# MARINE SCIENCE

**Paper 9693/11**
**AS Level Theory**

## Key messages

- Candidates should ensure they use scientific language when answering questions. The ability to explain observations and novel situations scientifically is essential for candidates to demonstrate their subject knowledge effectively.
- Candidates should be advised to look carefully at key words and command words to understand what is being asked of them, and to ensure they answer the question asked, particularly looking at how to approach an “explain” question differently to a “describe” question. Weaker candidates often failed to link the cause and effect when asked for an explanation or did not provide sufficient detail.

## General comments

There were some excellent, detailed answers provided by some candidates to questions showing they had prepared thoroughly for the examination. Some of the new areas of the syllabus were completed less well and candidates need to develop an equal depth of understanding of these new areas.

A few candidates used bullet points to answer questions throughout the exam but answering like this often meant candidates could not form links between points which are required for full credit in the more challenging questions and particularly in “explain” questions.

Many candidates rewrote the question again, instead of using that time to think further about the question and develop a concise and targeted answer.

## Comments on specific questions

### *Section A*

### Question 1

Candidates were asked to determine how different environmental factors affected gas solubility. Stronger candidates answered this correctly, but some other candidates showed a lack of understanding of this area.

### Question 2

**(a) (i)** Some candidates labelled the operculum incorrectly, for example near the tail. Some candidates drew a lateral line instead of labelling it on the figure. When labelling a diagram, candidates need to ensure that their line just touches and ends at the part being indicated.

**(ii)** Only stronger candidates answered this correctly. Most candidates gave answers such as named fins, a heart, gills, backbone or spinal cord. For credit to be awarded the exact scientific words from the syllabus were required, so notochord, post-anal tail, pharyngeal gill slits or dorsal neural tube.

**(iii)** The majority of candidates stated that zooplankton were consumers using a variety of ways of expressing this, with fewer stating they were free floating or drifted with currents. Weaker candidates often wrote about them being photosynthetic and starting the food chain.

**(b) (i)** Candidates were expected to analyse the information provided and to realise that the thermocline in tropical waters can be very shallow, due to limited mixing from stable atmospheric conditions.

**(ii)** Candidates generally showed a good understanding of the limitations of the Lincoln index. However, some candidates did not read the question carefully as they referenced tags / marks falling off, or cruelty due to marking / tagging the dolphins, suggesting that they had not understood the dolphins were photographed as a means of identification.

**Question 3**

**(a) (i)** Many candidates were able to state at least one condition required, usually the tropical nature of the area.

**(ii)** Candidates were not very familiar with this form of reproduction or demonstrated some confusion about the events occurring. Some candidates wrote about a seed throughout, lacking the understanding that the seed germinates and begins root development whilst still attached to the parent plant, utilising its nutrients and water supply. Others stated it was viviparous reproduction and mentioned propagules, but then reverted to calling them seeds. Some did understand that an advantage was to be able to float to new areas, but few understood that seeds would not be able to exclude the salt from the salt water if they did not have the root formed.

**(b) (i)** Many candidates were able to undertake the calculation correctly but did not include any units. A few candidates forgot to include the negative sign, or a comment in terms of loss for the Bombekota Bay calculation. Some candidates found it difficult to extract the units from the column heading and gave an answer in the form of "81 change in mangrove forest area / $km^2$". Weaker candidates needed to develop their understanding of SI units.

**(ii)** Most candidates were able to give at least one reason for the decrease, usually global warming or change in temperature. Some mentioned "cutting down trees" but this was insufficient, as sustainable harvesting can maintain the overall forest cover, so they needed to mention overharvesting or deforestation.

**(c)** Some candidates either did not give an ecological impact or did not link the ecological impact to the effect on the local human population, e.g., by stating there was a loss of biodiversity, and more coastal erosion.

**Question 4**

**(a)** Candidates found this question more challenging as they were not clear on the difference between weathering and erosion, often stating that "erosion is when particles are worn down into smaller pieces and carried away". As they had clearly given a definition of weathering this was not awarded credit, unless they had stated "weathering broke rocks into small pieces which are carried away by erosion". The most common correct response was that erosion can be caused by wind, water or waves, or that sedimentation was the deposition of particles. Stronger candidates were able to explain accurately what erosion and sedimentation were, but few achieved full credit as they did not mention anything relating to why sedimentation occurs at the shore, or which process occurs more.

**(b) (i)** Many candidates scored at least partial credit, but often gave two habitat answers rather than giving a different service it provides.

**(ii)** Most candidates stated that diatoms were photosynthetic or were primary producers. The main error was to state that they create or produce energy, rather than understanding that they convert light energy into chemical energy in the form of carbohydrates, as energy can be neither created nor destroyed.

**Question 5**

**(a)** Only stronger candidates answered this correctly. Many candidates stated two ions, in the form of sodium and chloride, rather than two they should have known about from the syllabus.

**(b) (i)** Many candidates were not clear on the differences between ionic and covalent bonding. Some candidates stated that oxygen is positive, and hydrogen is negative, so they attract. Sometimes candidates confused electrons with ions or atoms, for example stating oxygen needs more atoms in its outer shell, or that electrons need to be given to oxygen by hydrogen.

**(ii)** Some weaker candidates simply restated their answer to **(i)** and clearly did not understand what was being asked. Some who had talked about positive oxygen and negative hydrogen in **(i)** then talked about electron sharing here. Candidates need to develop a clear understanding of the role of covalent and hydrogen bonding in water.

**(iii)** Many candidates answered this well with the most common answer being that it acts as a habitat. Some candidates found it more difficult to try and explain thermal insulation and lacked the correct scientific vocabulary.

***Section B***

**Question 6**

Many candidates answered this question well demonstrating a good knowledge and understanding of the different forms of symbiosis. The most common errors were classifying copepods and marine fish as predator-prey, mutualism or commensalism. With the commensalistic relationship, some candidates did not gain full credit as they mentioned that the mantra ray did not benefit but did not say it was not harmed either. Others incorrectly stated that the manta ray could benefit in a commensalistic relationship.

**Question 7**

**(a)** Generally, candidates were able to give several relevant points, but some candidates thought the land masses sit on top of the plates, rather than being a part of the plates. Other errors included a lack of understanding over paleomagnetic striping in the rocks on the seabed, with some candidates mentioning stripes on the sea floor which could be in the sediment, and lacked the idea of them being magnetic, or being in the rocks of the sea floor. Stronger candidates gave an excellent description of paleomagnetic stripes, including the idea that the pattern was the same on either side of a mid-ocean ridge. Others mentioned fossils or rock formation, but often in quite vague terms such as “fossils were found all over the world” or “layers of rocks were similar” rather than understanding the fossils of the same species need to be found on different continents to form that evidence, or that the rock formations match those of a mountain range on a different continent. Some candidates only discussed the different types of plate boundaries and the consequences of movements at these boundary types.

Candidates need to ensure they read the questions with care, as this question asked for the theory as well as the evidence, so full credit was not available unless they discussed both.

**(b)** This question proved to be challenging for many candidates. Some candidates stated that the global ocean conveyor belt formed due to cold water sinking but often did not explain why it was sinking or the physical processes that occur to cause the water to sink, or to rise elsewhere in the system. Some candidates were very vague about what happened to the water, stating it warmed (in the ocean depths) at the equator and rose again, which only gave a partial explanation for the system. Others mentioned the oceans it passed through, without an explanation of physical processes occurring in the different oceans, such as warming. A few candidates mentioned thermohaline circulation, which is an important scientific term and others mentioned density and/or temperature differences within the ocean.

**Question 8**

Many candidates limited their responses to the carbon cycle, rather than discussing nutrients within the ocean, and how they may arrive at different parts of the oceans. While many talked about upwelling and run-off very well, some candidates simply mentioned dead organisms rather than what happens to their bodies once they are dead, i.e., decomposition by bacteria. Relatively few candidates mentioned tectonic activity, and if they did, sometimes referred to underwater vents or volcanoes releasing nutrients rather that releasing minerals, which then dissolve into the water to be absorbed by chemosynthetic organisms which convert them into nutrients, which are transferred to other organisms when they are consumed.

# MARINE SCIENCE

**Paper 9693/12**
**AS Level Theory**

## Key message

Candidates need to ensure they read questions carefully to ensure they are answering the question as it has been asked.

## General comments

Candidates were generally well prepared for the exam, with many candidates able to demonstrate their knowledge across the breadth of the new specification. There were a few areas of the new specification that candidates found more challenging, such as the different types of bonds within a water molecule and between water molecules, and how this causes water to be a solvent.

Weaker candidates did not always have a solid foundation of the basic principles, such as being able to identify the different oceans of the world, different types of molecular bonding and the monomers that make up different large biological molecules.

## Comments on specific questions

### *Section A*

### Question 1

**(a) (i)** Many candidates knew the types of bonding of each of the different molecules well, and most managed to correctly identify at least one of each type of molecule.

**(ii)** Many stronger candidates were able to give a good explanation of how hydrogen bonds are formed. Some weaker candidates just stated there were positive and negative charges on atoms but did not identify which atoms held which charge. Other candidates explained covalent bonding within the water molecule rather than hydrogen bonding between the molecules. Candidates needed to ensure they read the question carefully to ensure they answered with the correct form of bonding. Candidates also need to develop a clear understanding of the differences between each type of bonding.

**(iii)** Candidates found this question more difficult, but stronger candidates answered well. Some weaker candidates suggested that all of the ions could have any charge or stated the incorrect charge on some of the ions.

**(b) (i)** Most stronger candidates were able to give two correct responses for credit here. Some errors included nitrogen, fatty acids or amino acids.

**(ii)** Many candidates achieved partial credit, often for proteins and cellulose, while stronger candidates usually achieved full marks.

**(iii)** Many candidates achieved at least partial credit here, usually for photosynthesis, with many achieving full credit. Weaker candidates often made statements about carbon dioxide turning into carbohydrates without giving any more detail.

### Question 2

**(a)** Some candidates omitted this question, and some labelled the Pacific Ocean rather than reading the question carefully and labelling the Atlantic Ocean. While many candidates labelled the Indian

Ocean correctly, a significant number were not sure of the location of the Atlantic Ocean. Some candidates incorrectly labelled it well below the bottom of Africa, so placing it on the borders of the Atlantic, Indian and Southern Ocean.

**(b) (i)** Weaker candidates often made a correct statement about the alignment of the Sun, Moon and Earth, or they knew it was the gravitational pull of the Moon and Sun causing the tidal bulge. Stronger candidates were often able to gain full credit by commenting on the resultant gravitational force when the Moon and Sun are perpendicular to each other, or the additive effect when they form a horizontal line.

**(ii)** More candidates were able to state that the tide would be lower rather than explaining why that that was the case. In general, weaker candidates answered the question poorly.

**Question 3**

**(a) (i)** Most candidates correctly identified the described relationship as a mutualistic relationship.

**(ii)** Many candidates made a good attempt at this question, were able to explain that both species benefitted and often gave at least one way in which one of the species had benefitted. Stronger candidates were able to explain the benefit of the toxin to the alga. Few candidates took this to the final step of the impact of the relationship on the populations of each species.

**(b)** Many candidates were not aware of haemocyanin or KLH, and gave vague answers such as skin cream, skin treatment, shampoo, cod liver oil, or vitamins, some of which are nutritional supplements or cleaning agents rather than medical products. A few candidates provided suitable named alternatives which they had researched.

**Question 4**

**(a)** Some candidates incorrectly believed that the higher shore was closer to the sun, and so would be warmer, rather than understanding the upper shore is exposed to the atmosphere for longer than the lower shore, which would affect the temperature.

**(b)** Most candidates were able to describe how the oxygen concentration differed in rockpools in different regions of the shore, but fewer were able to give a full explanation. Most candidates who provided an explanation considered temperature, with some also correctly explaining the effect of the change in salinity due to increased evaporation.

**(c)** Some candidates did not understand the term “biotic factor” and gave either two abiotic factors, or one biotic and one abiotic factor. While some candidates stated “competition” they needed to give inter- or intra-specific, or what the competition would be for, such as food, shore position or space.

**(d)** Some candidates did not state the adaptations organisms have, but instead gave the purpose of the adaptation, such as “holding onto rocks” rather than the adaptation of a holdfast, or a muscular foot. Common correct answers included a strong shell, a holdfast, with few candidates mentioning animals trapping water under their shells (to prevent dehydration), or flexibility of seaweed fronds.

**Question 5**

**(a) (i)** While many candidates correctly named a nucleic acid or other acceptable answer, others suggested a variety of nutrients, or carbohydrates.

**(ii)** Again, most candidates were able to state protein or amino acids, and calcium. A wide variety of other named chemicals, nutrients and food groups were also suggested.

**(b)** Many candidates were able to provide a suitable response, usually suggesting that the algae bar would increase in size, but few candidates suggested why that happened.

***Section B***

**Question 6**

**(a)** Candidates who were familiar with this topic answered well and some gave excellent accounts with plenty of detail, and often added a labelled diagram. Other candidates did not seem familiar with this new aspect of the specification. A few candidates only named the features rather than giving their function, whilst others described the function but did not name the features. Some weaker candidates named and described features of a plant, such as a stem and roots, while others discussed the relationship between zooxanthellae and polyps, but did not describe the structure of the polyps at all.

**(b)** Many candidates gave good answers to this question. Some candidates gave well thought through and wide-ranging answers, covering many different aspects of the importance of a high biodiversity on a coral reef, while others focused on only two or three aspects, often restating their answer.

**Question 7**

Stronger candidates gave accurate descriptions of the processes of weathering, erosion and sedimentation on the formation of a muddy shore, from discussing how the silt particles were formed to start with, through to the effect of the slow current speed allowing sedimentation to occur. Most candidates seemed clear on the differences in the processes. Other candidates mentioned what each process was but did not give any further information on each process. Candidates should be encouraged to provide further detail regarding how these processes occur as well as what each process is.

**Question 8**

Candidates were often able to describe how the surface layer was heated, and the effect on the density of the water and many mentioned the thermocline, correctly describing it to achieve credit. Fewer mentioned the effect of evaporation on the density of sea water. Candidates sometimes stated the density increased but not that this made the saltier, denser water sink. Most candidates discussed causes of mixing as well.

# MARINE SCIENCE

**Paper 9693/13**
**AS Level Theory**

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## General comments

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Weaker candidates did not always have a solid foundation of the basic principles, such as being able to identify the different oceans of the world, different types of molecular bonding and the monomers that make up different large biological molecules.

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**(iii)** Candidates found this question more difficult, but stronger candidates answered well. Some weaker candidates suggested that all of the ions could have any charge or stated the incorrect charge on some of the ions.

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**(a)** Some candidates omitted this question, and some labelled the Pacific Ocean rather than reading the question carefully and labelling the Atlantic Ocean. While many candidates labelled the Indian

Ocean correctly, a significant number were not sure of the location of the Atlantic Ocean. Some candidates incorrectly labelled it well below the bottom of Africa, so placing it on the borders of the Atlantic, Indian and Southern Ocean.

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***Section B***

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**(a)** Candidates who were familiar with this topic answered well and some gave excellent accounts with plenty of detail, and often added a labelled diagram. Other candidates did not seem familiar with this new aspect of the specification. A few candidates only named the features rather than giving their function, whilst others described the function but did not name the features. Some weaker candidates named and described features of a plant, such as a stem and roots, while others discussed the relationship between zooxanthellae and polyps, but did not describe the structure of the polyps at all.

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# MARINE SCIENCE

**Paper 9693/21**

**AS Level 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” is often too vague for credit.

Candidates need lots of opportunities to carry out practical work using simple appropriate equipment, so they gain confidence in describing scientific methods when required.

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

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. However, some candidates found some of the questions very challenging.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates were able to provide examples of two variables that needed to be controlled. Often the number of damselfish was given as an example, which indicated that the question had not been read carefully. The question stated that 44 fish had been used. A significant number of candidates did not understand the meaning of “variables needed to be controlled”. They incorrectly stated the independent variable (material the coral is made from) and the dependent variable (time the fish associated with corals) as their answers.

**(ii)** This question was generally answered well. A few candidates misread the y axis of the graph and indicated that the fish spent minutes associating with the coral skeletons rather than the percentage of time. Many candidates used language which was too vague such as “liked” or “enjoyed”.

When asked to use information and data is provided, it is often helpful to manipulate the data. For example, material C had almost 3 times more time associated than the natural material and D.

Some candidates did not look at the heights of the bars relative to the *y*-axis scale carefully enough and gave figures which were inaccurate. Candidates should be encouraged to use a ruler, to lay it across the graph and to draw lines across. This will help them obtain the correct height of the bars. Candidates should also be encouraged to make comparisons between pieces of data on the same graph.

**(iii)** The majority of candidates gained credit for this question. The most common answers were predation and obtaining food. Only a few candidates correctly mentioned the use of coral for

reproductive purposes. Some candidates confused the terms prey and predator. The term nutrients was not appropriate for a consumer such has a fish.

**(b)** Many candidates only referred to one of the sets of data in their answers, limiting the credit that could be awarded. A common error was to refer to the graph as growth of coral over the 14 days rather than the percentage attachment.

Some candidates were confused which line was which in **Fig. 1.3**. A good technique would be to annotate the lines on the figure. Candidates need to be encouraged to compare two different data sets of a similar topic presented in different ways.

**(c)** Most candidates only used the interaction of the fish or the coral larvae growth and attachment results in their answers. Very few candidates stated any reasons why the results would not support the conclusion. Candidates needed to give reasons for not supporting conclusions to achieve full credit. Very few candidates described any limitations of the investigation. Candidates need to practice evaluating data and what improvements can be made to make data more reliable.

**(d) (i)** Most candidates answered this question well. However, some candidates produced drawings with poor sketchy lines with multiple outlines in place. Candidates must draw in pencil, so that if a mistake is made it can be corrected.

**(ii)** Most candidates correctly labelled at least one of the fins, usually the dorsal fin. Some candidates needed to identify the features more clearly with ruled pencil lines touching the feature being labelled.

**Question 2**

**(a)** A significant number of candidates described collecting samples of water from different places with different salinities and testing them in the laboratory. Many candidates described equipment and measurements for science investigations such as buckets, cups and teaspoons, which would not be appropriate. Candidates need to be familiar with electronic balances, measuring cylinders and metric (SI) measurements.

The term “scale” was often used but was inappropriate as it has other meanings in marine science: scales are found covering fish. Scales can be used to quantify almost any measurement. Candidates should use the term “balance” to measure mass.

**(b) (i)** Very few candidates described any suitable steps to carry out this investigation. Some candidates thought that the time the samples took to freeze was more important than the temperature at which they actually froze.

Centres could consider making use of the Resources plus videos and teaching resources published on the School Support Hub to help develop these practical skills.

**(ii)** Most candidates gained at least partial credit, most often for “more samples”. The term “measurement” instead of “unit” for salinity was seen in some responses. These are not the same as the measurements are the numerical values that need to be entered in the table.

**(iii)** Many candidates stated the wrong trend, stating that with increasing salinity, the freezing point increases. A significant number of candidates misunderstood the question and described the change in salinity as water freezes.

**(iv)** This was a well answered question and many candidates gained full credit. However, some answers referred to the effects of depth, density and temperature on salinity. Unless there was a link between rising temperature and evaporation which would increase salinity no credit was awarded. There was some confusion with run off, where some candidates incorrectly described this increasing salinity instead of decreasing it. Run off is extremely unlikely to be more saline than the ocean water it is entering.

**(c) (i)** Candidates achieved most credit for this question for stating the formula for density ($D = M / V$). Very few candidates described how the mass or volume of the samples can be measured, or the correct units of density.

**(ii)** This was generally answered well and most candidates drew an appropriate sketch graph. Some candidates did not realise that a sketch graph needs just the axes labelled and a trend line, not scales and plots.

**(iii)** Most candidates linked salinity to density but did not discuss the consequences of this water sinking. Some candidates related water density to temperature instead of salinity. Many candidates did not link density to the formation of layers or currents, instead making less appropriate comments about the importance to different species of different salinities.

**Question 3**

**(a)** Despite a line being drawn on the graph, a significant number of candidates did not state the trend of the line correctly. Some candidates simply stated there was no correlation. Few candidates used the data appropriately to support their answers. Many candidates did not read the values off the graph carefully enough. Using terms such as "about" or "almost" when describing plotted points was too vague. For example, "about 14" did not gain credit but "14.3" did.

**(b) (i)** This question produced quite a range of responses. Candidates should always show their working, as it is possible to gain partial credit for any correct working even if the final answer is incorrect. When asked for a number of significant figures, candidates should ensure final answers match the number of significant figures stated in the question.

**(ii)** Most candidates scored at least partial credit for stating that the hypothesis was supported as *D* was greater for the larger rockpool. Very few candidates clearly stated that a higher value of *D* means a greater diversity or that if the value is closer to 1, this indicates a greater diversity. Some candidates simply restated the figures without drawing a comparison.

**(b)** The majority of candidates found this question very challenging. Many incorrectly stated that there must have been a miscalculation or a mathematical error. A few candidates correctly stated that correlation does not mean cause or that the difference in results was not significant enough. Some candidates recognised that only two rockpools were sampled or that other conditions of each rockpool could have affected the results more than the volume of the pool. Very few suggested any limitations of the method used. Candidates should be encouraged to critically evaluate investigations to identify sources of error in both method and results.

**Question 4**

**(a) (i)** Some candidates incorrectly stated the upper and lower limits of the tides or days on which the highest tidal range occurred. Other candidates stated the correct upper and lower limits of the tides without calculating the range.

**(ii)** There were some excellent answers with many candidates gaining full credit. The most frequent omissions were not mentioning the Sun in alignment with the Moon and gravitational pulls. Candidates need to be careful with their language around gravitational pull as it is combined/reduced effect that changes, not the gravity itself. A number of candidates just discussed other factors such as wind and air pressure which do not affect the tidal range. They usually have a similar effect on high and low tide, so the tidal range remains unaffected.

**(b)** The majority of candidates found this question challenging**.** The use of correct and specific language about tidal height and tidal range were key to achieving credit. Some candidates described tidal height in terms of "most dramatic" change. Many candidates described lower or higher tidal cycles instead of tidal range. Very few candidates stated the idea of the reef preventing the movement of water in/out of the lagoon. Many incorrectly stated the lagoon would have a smaller tidal range due to reduced wave action or being a smaller body of water or simply that the lagoon is much shallower.

**(c)** Candidates needed to consider the effect of the constant rising and falling of the tides on abiotic and biotic factors within a lagoon**.** Many candidates were able to identify some biotic and abiotic factors, particularly nutrients, temperature, salinity, light, erosion, food availability and desiccation. Very few candidates could explain why these factors changed and how they changed within a lagoon. Some candidates did not understand the terms biotic and abiotic.

**Question 5**

**(a) (i)** There were many good answers to this question, but a number of candidates used vague language such as “copepods can harm dinoflagellates”.

**(ii)** Many candidates gave good answers to this question. A significant number of candidates used the term “amount” which was too vague. Examples such as “amount of dinoflagellates” or “amount of water” could not be credited. “Number of dinoflagellates” and “volume of water” were much more precise.

**(b) (i)** Many candidates made a good attempt at a graph. The most common error was a dot-to-dot line instead of a line of best fit. The graph provided had other plots with lines of best fit already provided which should have been used as a guide on how to draw this graph. A number of candidates put in an additional line of best fit for all the data on the graph, but this was not required. Some candidates did not complete the labels.

A significant minority of candidates used the data in the table and placed these numbers randomly along the axes with unequal intervals between each number. Scales on the axes must always be regular and have equal intervals along the length of the axes.

**(ii)** Most candidates described the positive correlation between the copepodamine concentration and light produced. Fewer candidates described the trends in light production linked to time or that, higher concentrations gave smaller increases. Some candidates stated the relationship between copepodamine concentration and light produced the incorrect way around and did not gain credit.

**(iii)** Most candidates gave a positive supporting point but very few recognised any limitations in the results, despite the lack of a predator in the investigation. Candidates should have the opportunity to practise giving both supporting and non-supporting arguments with evaluation and discussion type questions.

**(c)** A majority of candidates attempted this question and gave reasons why the data supported the conclusions that bioluminescence in dinoflagellates does help them avoid predation. Very few candidates gave reasons why the data might not support the conclusion. Many answers lacked detail and data to back up conclusions. In some answers the data taken from the graph was incorrect or imprecise.

# MARINE SCIENCE

**Paper 9693/22**

**AS Level Data-handling and investigative skills**

## Key messages

- Candidates should always try to avoid use of the word “amount” and try to find the correct scientific quantity, such as “mass” or “volume”.
- For statistical analyses, candidates should know how to present their calculations clearly when asked to show their working, and how to use the correct number of significant figures when required.
- Candidates should be prepared to apply their knowledge and understanding to data on unfamiliar contexts or to practical contexts.

## General comments

There was a high standard of response from many candidates. This was the first examination for the new format of Paper 2 following the major revision of the syllabus. As such it included questions on skills not previously examined, such as particular practical activities including drawing specimens (section 4.1.4). Centres should ensure that candidates are prepared for the way in which these aspects will be examined. This includes the size, proportion, clear outline, and correct level of detail shown in drawings, and the details of the required practical activity methods, in particular the correct manipulation of variables / quantities,

## Comments on specific questions

### Question 1

**(a) (i)** The majority of candidates correctly managed to identify the species of alga, but all alternatives were seen suggesting some candidates were unfamiliar with how to use the key.

**(ii)** Most candidates were able to correctly identify the genus. Credit was given for any errors carried forward if candidates had identified the wrong species in **(i)**.

**(b) (i)** A range of drawing skills were seen, with most candidates producing a good drawing that scored at least partial credit. Most drawings were of sufficient size. Generally, drawings need to fill at least half of the space provided or be at least the size of the specimen in original photograph provided. Most diagrams were in proportion, for example the width was correct compared to the length. In this case the mid-rib of the alga, also needed to be the correct size/width compared to the original specimen. Most diagrams had a clear outline, but some candidates used artistic sketch-like lines which are not acceptable for a biological drawing. This also applies to any internal detail such as the mid-rib on this specimen. There must also be no gaps or double lines apparent. Some candidates had clearly done a rough sketch and then erased it before drawing their finished outline. It is important that any sketch lines have been properly erased so that they are not visible on the finished drawing. Most candidates had drawn sufficient detail. For this specimen, the detail required was limited to having the correct serrated edge and the mid-rib drawn correctly. Other additions, such as the spots, or patches of different tone on the frond were ignored. Shading of areas was also ignored, and this should not form part of biological drawings.

**(c) (i)** Most candidates answered this question correctly. However, some had not noticed that the mean could be read from the graph and attempted to calculate it for themselves. This was acceptable if correct but will have wasted candidates’ time as a result of not looking carefully enough at the information provided.

**(ii)** Most candidates were able to take a correct reading from the graph, but not all then correctly calculated the percentage. An incorrect reading correctly calculated as a percentage could still gain

partial credit. A small number of candidates incorrectly rounded the number that they had calculated. If the number of significant figures is not asked for, then any correct rounding is acceptable.

**(iii)** Most candidates answered correctly but those that did not, usually offered a suggestion that was not economic.

**(iv)** Only stronger candidates answered this fully correctly. Very few candidates were able to link the temperature change to El Niño and the availability of nutrients in surface waters. A number of candidates gained partial credit for suggesting other reasons for the temperature change affecting growth, such as the activity of the enzymes involved, or the solubility of carbon dioxide.

**(v)** Answers to this question usually focused on variation in the catch effort, or the catch not being representative of the whole population.

**Question 2**

**(a)** This question was answered very well showing that the candidates had understood the graph.

**(b)** This question was also answered well with most candidates reading from the correct line on the graph. Some candidates attempted to calculate their own mean from all of the temperatures at 200 kPa.

**(c) (i)** Most candidates were able to score at least partial credit for this question, and some excellent answers were seen. However, some were not specific enough and showed a lack of care in extracting data from the graph, particularly when quoting depths which were sometimes vague or incorrect. For example, some stated that in both oceans the concentration of dissolved oxygen decreases significantly to a depth of 1000 m. Some candidates also stated that the concentration remained constant below 1000 m. Some candidates only described the patterns and did not offer any explanations for them.

**(ii)** Some candidates did not extract data carefully enough from the graph. Some excellent explanations for observed differences were given but only a minority of responses mentioned the relative impact of photosynthesis and respiration by organisms.

**Question 3**

**(a) (i)** The majority of candidates offered a suitable suggestion.

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

**(b) (i)** A number of candidates did not calculate the answer to this question correctly. Candidates are advised to use a calculator even for simple calculations, and to repeat the calculation to be sure they have not made an input error.

**(ii)** Most candidates correctly described the need for a fair comparison. The most frequent misconception was that percentages were needed due to the particle sizes having different masses.

**(iii)** Many candidates answered this correctly with many perfectly drawn bar graphs. Some candidates incorrectly plotted one or more of their bars as they were using 1 small square per percentage point. Good exam technique would be to carefully deduce and write down the value represented by each small square.

**(c) (i)** This particular piece of apparatus may not be one that candidates had used themselves, but many candidates who had a good understanding of measuring the permeability of a substrate were able to answer this question well. Some excellent responses were seen in which candidates had clearly thought carefully about how the variables involved would be measured or controlled. Both main ways in which candidates could measure the permeability of the substrate (the dependent variable) were described well (measuring the volume of water passing through in a set time, or measuring the time taken for a set volume of water to reach the bottom). However, some candidates were confused and described methods for measuring how quickly the substrate itself would wash out of the column. These candidates could still gain partial credit if they were able to describe control

variables, describe how they could measure their chosen dependent variable and talk about repeating the method and calculating a mean. If candidates are faced with writing a practical activity about which they are uncertain, they should still try to write a method of some kind in which a variable is changed (the independent variable), a variable is being measured (the dependent variable) and the variables that should be controlled to ensure reliable results are obtained, stating the equipment that would be used for any measurements taken.

**(ii)** To gain full credit for this question candidates simply needed to construct a basic table showing both the independent variable (substrate from shores A and B) and the dependent variable they had described in their method, including units. Some candidates successfully added columns for repeats, and calculating a mean, but this was not necessary and in some cases led to an overly complicated table. The most common error was a lack of suitable units in the column heading for their independent variable. Some candidates inserted expected results into their table, which was also not necessary.

**(iii)** The majority of candidates were able to identify shore A as most permeable due to having a greater proportion of larger particle types, but only a minority of candidates related this to the size of the spaces between them through which water could more easily pass.

**(d)** This question was well answered, with most candidates able to suggest at least one factor that could affect survival on a sandy shore. However, some just listed factors and did not relate them to the particle size of sediments.

**Question 4**

**(a)** Most candidates understood that intra-specific competition was competition within the same species, and therefore extracted the correct figure of 61% from the table.

**(b) (i)** Please note that due to an issue with question **(i)**, full marks have been awarded to all candidates for this question to make sure that no candidates were disadvantaged.

**(ii)** Only a minority of candidates were able to gain full credit for this question. Most understood the idea of looking for a correlation, but many did not then elaborate that it provides a numerical value for the degree or strength or significance of the correlation.

**(iii)** Many candidates gained full credit for this question. The strongest candidates carefully laid out each step in the calculation. This was important because if an error was made in one step, then credit could still be awarded for subsequent correct steps. Using significant figures correctly is a separate skill that will always be examined on this paper. Credit for this was awarded here for any incorrect answer that was correctly stated to three significant figures.

**(iv)** Having correctly calculated the value for $r_s$ in **(iii)**, a number of candidates were then not able to correctly interpret what the value meant about the correlation. Some candidates simply said whether the hypothesis was right or wrong which was insufficient.

**(c)** This question was only answered well by stronger candidates with many others simply listing biotic and/or abiotic factors that affect population size, without linking them to this specific example. Partial credit could be gained for more general statements, but candidates also needed to consider *P. victoriae* and the other species of fish present. **Table 4.1** showed candidates that different species had different feeding preferences, but few candidates referred to this.

**Question 5**

**(a) (i)** This question was correctly answered by the vast majority of candidates. Those getting it wrong usually suggested another form of plate boundary.

**(ii)** This question was very well answered by many candidates and some excellent descriptions were seen. The most common error was a description of subduction at a converging plate boundary.

**(b) (i)** The question asked candidates to explain the pattern shown. Some candidates simply described the pattern using only the terms provided in the question. Candidates needed to explain that the polarity of the rocks is reversing due to the state of the Earth's magnetic field at the time of the formation of the rocks on the ocean floor, and that the Earth's magnetic field reverses periodically.

**(ii)** Candidates answering this correctly provided some well worded descriptions of how the pattern of reversal will show a line of symmetry at the plate boundary / will be a mirror image either side of the plate boundary. A variety of answers was seen showing that a number of candidates were unaware of how to spot the position of the plate boundary.

**(iii)** Only stronger candidates answered this correctly. Candidates could still gain credit for a correct calculation using an incorrect distance from **(ii)**. It is important that candidates are aware of this rule so that they do not give up on subsequent parts of questions if they think they have got the first stage wrong. Some candidates used the correct numbers but arranged the calculation incorrectly. It is a good idea for candidates to reflect on whether the figure they have calculated seems realistic. In this case the age of rocks on the ocean floor away from the plate boundary is likely to be large number.

**(c)** This was a challenging question as candidates were provided with three separate graphs and then expected to suggest whether the data supported the idea of ocean floor spreading being linked to the carbon cycle. Candidates therefore needed to look for trends in the data, such as the overall decrease in atmospheric carbon dioxide and the overall decrease in rate of ocean floor spreading, and then decide whether or not this supported the idea. Some excellent answers were seen that expertly analysed the whether the data supported the idea. The strongest candidates were able to extract information that both supported and contradicted the idea. Most candidates found evidence that either did or did not support the idea, rather than looking for evidence from both perspectives. This question was also a good example of correlation not necessarily meaning causation, and only a minority of candidates mentioned this.

# MARINE SCIENCE

**Paper 9693/23**

**AS Level Data-handling and investigative skills**

## Key messages

- Candidates should always try to avoid use of the word “amount” and try to find the correct scientific quantity, such as “mass” or “volume”.
- For statistical analyses, candidates should know how to present their calculations clearly when asked to show their working, and how to use the correct number of significant figures when required.
- Candidates should be prepared to apply their knowledge and understanding to data on unfamiliar contexts or to practical contexts.

## General comments

There was a high standard of response from many candidates. This was the first examination for the new format of Paper 2 following the major revision of the syllabus. As such it included questions on skills not previously examined, such as particular practical activities including drawing specimens (section 4.1.4). Centres should ensure that candidates are prepared for the way in which these aspects will be examined. This includes the size, proportion, clear outline, and correct level of detail shown in drawings, and the details of the required practical activity methods, in particular the correct manipulation of variables / quantities,

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# MARINE SCIENCE

**Paper 9693/31**
**A Level Theory**

## Key messages

- Candidates need to be encouraged to read the whole question carefully and to use the information provided before starting on their answers. They should be advised on how to use data from tables and graphs, to manipulate this as necessary and to include units.
- It is important to identify the command word or words so that answers match what is being asked. Too few candidates were able to explain the graph in **Question 2** and limited their answer to a description only.
- Vague terms should be avoided e.g., “change” in temperature, or “affects” organisms, or “amount” of fish.

## General comments

Strong candidates performed very well indeed. They had a strong knowledge of the syllabus, including topics new to the 2022 syllabus, and were able to demonstrate excellent analytical skills when presented with unfamiliar material. This was particularly evident in **Question 3** on fishing for small pelagic fish and in **Question 4(b)** on the release of mercury from burning fossil fuels. However, many candidates showed very limited scientific knowledge and needed to spend longer reading and processing the information provided as their answers were often well below the standard required at this level. Some candidates displayed very little knowledge of topics which were new to the 2022 syllabus. This was particularly evident on **Question 1** on cell structure and **Question 2** on photosynthesis.

## Comments on specific questions

### *Section A*

### Question 1

**(a) (i)** Partial credit was common but full credit was rare. Most candidates could identify **A** as a mitochondrion, but most stated the pleural mitochondria, and **C** as ribosomes**. B**, the rough endoplasmic reticulum was sometimes confused with the Golgi body or with smooth ER. Stating a correct function was more difficult, but most candidates correctly stated that protein synthesis occurred in the ribosomes. Common errors were stating that the mitochondrion produced or created energy or was the powerhouse of the cell, or that the rough ER modified or even produced proteins or transported ribosomes. Some candidates could not be awarded credit as they did not note that the cell was from a fish and not a plant.

**(ii)** Candidates who identified mitochondria correctly were usually able to state that it provided energy for fish movement or swimming.

**(b)** There was a general misconception that carrier proteins transported protein to different parts of the cell and very few candidates gained full credit. Most answers were too vague. For example, candidates stated that the carrier proteins transported substances through the membrane or that carrier proteins were found inside the membrane. Others described the phospholipid bilayer. If a method of transport was mentioned, then both active transport and facilitated diffusion were required to gain credit. There were very few references to carrier proteins being specific or that they could change shape. A correct diagram was sometimes provided, but it usually lacked any labels, so no credit could be awarded.

**Question 2**

**(a) (i)** Candidates who had revised this topic, usually gained credit. However, the majority of candidates gave general answers naming the stage photosynthesis and saying that it occurred in the chloroplast or in chlorophyll or in the leaf. An exact location of where the light-dependent stage was required, in the thylakoid membrane, rather than just in the thylakoid or granum.

**(ii)** **C**andidates who understood this topic gained at least partial credit. However, many weaker candidates tried to fit the equation for photosynthesis into their answers, so that **A** became photosynthesis, **B** carbon dioxide, **C** glucose and **D** oxygen. Stronger candidates correctly identified **B** as oxygen and **C** and **D** as ATP and reduced NADP, but some did not include the word "reduced". Only the strongest candidates identified **A** as photolysis, with hydrolysis being a common incorrect answer.

**(b) (i)** Candidates were asked to describe and explain the graph showing the effect of light intensity on the rate photosynthesis. Correct descriptions were often seen, but few candidates could provide a correct explanation. Explanations were often too vague. For example, "light was needed for photosynthesis" was given when a more specific answer was required at this level. Only stronger candidates were able to make a correct reference to limiting factors, but some candidates did notice that temperature was at an optimum, so could not be a limiting factor in this experiment.

**(ii)** Those candidates who realised that the temperature had now increased above the optimum drew a correct line on the graph, below the existing one.

**(iii)** Answers needed to be specific to gain credit and include that at a higher temperature enzymes would denature, but credit was not awarded if it was stated that the cell denatured. Error carried forward was applied here for those candidates who drew their line above the existing line, but they had to state that the molecules would now have more kinetic energy, so increasing the rate of photosynthesis.

**Question 3**

**(a) (i)** Overfishing causing a reduction in fish numbers was a very common correct answer. Some candidates did not give enough detail, stating grow instead of more precise terms such as breed or mature or reproduce. There was some confusion about the reasons for the smaller fish sizes, including that they evolved that way to escape capture or that juveniles were breeding.

**(ii)** Several candidates missed the point of unsustainable fishing leading to less fish, but many noted that locals would have less food, fewer jobs and less money as fewer fish could be sold. Some candidates misread the question and answered in terms of benefit to foreign fishing fleets, while others addressed the problems of overfishing and not the sociological impacts on locals.

**(iii)** Few candidates understood the reason why acoustic surveys are useful. Answers to both parts of the question were often vague with references to fish instead of shoal or amount instead of size, mass or numbers.

**(iv)** Many candidates did not understand what consumer orientated tools are and gave answers relating to fishing methods or fishing gear and how these could be made more sustainable. Those candidates who understood the question provided excellent answers referring to labelling, advertising and the benefits of advertising the sustainably or ethical nature of the way the fish were caught. Some answers stated that the price could be reduced to sell more fish, but this needed to be linked to a reduction in price tariffs.

**(b)** Very few candidates realised that a warmer temperature would reduce the oxygen concentration, so there would be less oxygen for respiration and energy demands. Some mentioned the possible negative effects on reproduction, but most correct answers stated that there would be a reduction in prey. This whole question was about pelagic fish such as sardines and mackerel, not those inhabiting coral reefs, so references to coral reefs were ignored.

**Question 4**

**(a) (i)** Carbon dioxide, carbon monoxide and methane were the most common correct answers. The many incorrect answers included elements like carbon, nitrogen, sulfur, phosphorus, lead and greenhouse gases or smoke.

**(ii)** Some candidates thought that phytoplankton were marine animals that consumed or ingested the mercury, while others repeated the question by stating that the mercury is passed to phytoplankton. Most candidates gained partial credit for referring to rainfall or to the mercury dissolving or dissolution in sea water.

**(iii)** Very few candidates gained full credit. Some understood the concept, but the wording in answers was not precise enough. For example, some gave “the level of mercury increases up the food chain” rather than “the concentration increasing”. Others confused biomagnification with bioaccumulation. Although the idea of consumers eating many producers was often stated, no credit could be awarded as the consumer ate more or large amounts of prey rather than large numbers of prey. Few candidates mentioned that mercury could not be excreted from the body.

**(b) (i)** The link between a decrease in burning fossil fuels and a reduction in mercury concentration in the air and in the sea was a common correct answer. Some candidates quoted data from the table, but to obtain full credit this needed to be manipulated and units included. Some answers were too vague to gain credit, e.g., “a reduction in burning fossil fuels caused a reduction in the North Atlantic”.

**(ii)** Most candidates answered this correctly by stating that there would be an increase in burning fossil fuels. Others stated that mercury could be released from volcanoes or by dredging. General answers such as pollution or global warming did not gain credit.

***Section B***

**Question 5**

This question asked candidates to discuss the benefits and challenges posed by growing smolt to adults in land-based buildings rather than in sea cages. The question gave candidates a good opportunity to show what they had learned, and a few candidates gave excellent answers. The most common correct answers were for listing the benefits e.g., that the salmon were in controlled conditions, were easier to monitor, were less likely to be exposed to predators and less likely to escape. Stronger candidates also referred to the fact that salmon grown in land-based buildings were not affected by any pollution at sea or adverse weather.

Listing the challenges proved more difficult, but most candidates stated that the cost of the buildings or equipment or running costs would increase and that more labour would be required. Stronger candidates were able to state that oxygen would be necessary, but this was rarely linked to respiration.

Most candidates mentioned feeding, but many had the misconception that salmon grown in sea cages rely entirely on natural food brought via currents, which is incorrect. Some candidates also thought that the waste produced by the fish would drain into the ocean, so causing algal blooms. This again is incorrect as water is recirculated and continually filtered to remove pollutants such as ammonia and nitrates. Many answers were too vague e.g., stating that the water needed cleaning or that the waste built up. Disease was also mentioned in answers, but few candidates were able to gain credit for stating that it would be easier to spot and treat in a land-based building than in sea cages.

Answers relating to salmon being released into the sea when they reached adulthood and that these fish would be unable to cope with their natural habitat were ignored. A misconception by some candidates was that all salmon grown indoors were GMOs. Quite a few candidates did not read the question carefully enough and described the land-based building as a hatchery with tanks for breeding the salmon and tanks containing all stages of growth.

**Question 6**

**(a)** Most candidates gained at least partial credit, usually for stating that melting ice would cause the sea level to rise and deprive marine animals like polar bears of their habitat. Correct references to a decrease in biodiversity or to changes in food chains or food webs were common, as was a reference to ice as a thermal insulator. Stronger candidates also stated that the increased fresh

water would cause the salinity to decrease and that this would affect osmoconformers and stenohaline organisms. Few answers went on to state that the rise in sea level would cause flooding that could lead to erosion.

Weaker candidates used vague terms e.g., that the salinity or temperature changed, that species or currents would be affected, that more water would enter the sea or that animals would die. There was generally a lack of use of scientific terms e.g., home used instead of habitat and moving used instead of displacement or migration.

Only the strongest candidates were able to state that the effect of sea temperature changes on the solubility of salts or on density or on oxygen concentrations. They were also able to link the rise in sea levels to less light reaching benthic organisms, so causing a decrease in photosynthesis or death of corals.

**(b)** This question related to learning outcome 9.3.3 of the syllabus and there were some excellent answers which gained full credit. Even some weaker candidates were able to correctly state that carbon dioxide dissolved in sea water to create carbonic acid or acidic conditions and that this weak acid dissolved mollusc shells so increasing the chance of predation. Only the very strongest candidates made a reference to carbonic acid dissociating to form hydrogencarbonate ions and hydrogen ions. The word ion was often missing and so credit could not be awarded.

Weaker candidates often gained no credit as they gave confusing answers relating to carbon dioxide replacing oxygen and causing suffocation of molluscs, or stated that the increased carbon dioxide caused an increase in temperature of sea water. Others thought that molluscs were plants and that they could or could not perform photosynthesis.

**Question 7**

Partial credit for this question was common, usually for stating that marine zoos and aquaria provide a safe environment for endangered animals or a place where injured animals could be rehabilitated and cared for. Other common correct answers included the fact that they generated income for conservation and were places to educate the public on conservation.

References to breeding were common, but it was important to add that this was to increase population numbers to gain credit. Only a small minority of answers made reference to possible inbreeding and consequent reduction in genetic diversity or to the possibility of using AI or IVF for assisted reproduction.

# MARINE SCIENCE

**Paper 9693/32**
**A Level Theory**

## Key messages

- Candidates need to spend enough time reading the question carefully, analysing stimulus material e.g., a graph or a table, before starting on their answers.
- It is important to identify the command word or words so that answers match what is being asked. Too few candidates answered "describe and explain" or "suggest and explain" questions correctly.
- Some candidates displayed very little knowledge of topics which were new to the 2022 syllabus. This was evident on **Questions 1** and **2**.
- Candidates are advised to avoid using abbreviations such as bc (because), or arrows pointing up, down or sideways to indicate an increase, decrease or no change.

## General comments

Stronger candidates were well prepared and produced answers of a high quality. These candidates had a strong knowledge of the syllabus in general, including topics which were new for 2022. They were able to demonstrate excellent analytical skills when presented with unfamiliar material and were able to make correct links between different areas to produce comprehensive responses. This was particularly evident in **Question 3** on skipjack tuna fishing, in **Question 4** on wind farms and in **Question 5** on salmon aquaculture. However, many candidates performed very poorly on these questions and gave answers which showed that they had not referred to the information provided and had very limited scientific knowledge, well below the standard required at this level. Some candidates used bullet points for their answers, which often meant that they did not make adequate links between points, so could not access the full mark range.

## Comments on specific questions

### *Section A*

### Question 1

**(a) (i)** The majority of candidates could name three correct features. Common errors were stating vacuole (which was too vague as these are also present in animal cells), ribosomes, starch grains (which are not visible) and centrioles and microtubules (which are not on the syllabus).

**(ii)** Partial credit was common, usually for identifying **A** as the cell membrane and **C** as a mitochondrion. Note that mitochondria, which was stated by most candidates, is plural. Often **B** and **D** were referred to as endoplasmic reticulum, which was not specific enough to gain credit, and **D** was often confused with the Golgi body.

**(iii)** A few candidates named structures **E**, **F** and **G** instead of stating their function as required. The functions of **E** and **F** were well known, but a function for **G** (the nucleus) was often too simplistic e.g., "it contains hereditary information" or "it contains DNA".

**(b)** Many candidates found this question difficult to answer and some did not attempt it. There was some confusion over the terms hydrophobic and hydrophilic, while other candidates provided a correct diagram but because it was not labelled, it could not be credited.

**Question 2**

**(a) (i)** Stronger candidates gained full credit, whereas those unfamiliar with this topic could not be awarded any credit.

**(ii)** Again, those candidates who were familiar with the Calvin cycle could correctly name **A – D**. Common errors were confusing **B** and **C**, with ATP named for **B** and reduced NADP for **C**. Sometimes candidates stated NADP instead of reduced NADP or NADPH.

**(b) (i)** Partial credit was often awarded for this question as most candidates gave a correct description that as the temperature increased, so did the rate of photosynthesis and that after a certain point (optimum) the rate decreased with a further increase in temperature. However, the command words here were “describe and explain” and only stronger candidates provided an explanation for the graph. A common misconception was to state that the cells denature rather than enzymes. There were very few references to the solubility of gases.

**(ii)** The majority of candidates could draw the correct shape on the graph. Occasionally the peak of the graph was to the left of the existing peak, so this could not be credited.

**(iii)** Answers were mostly correct, usually stating that increasing carbon dioxide would increase the rate of photosynthesis.

**Question 3**

**(a) (i)** Most answers to this question were incomplete e.g., food, oxygen or nutrients. Some candidates misread the information provided and thought that sub-tropical areas had a higher temperature than tropical areas.

**(ii)** Those candidates who had spent time reading and processing the information provided performed well, often gaining full credit. Others just named FADs, purse seine nets and sonar, without stating how they could be used to increase catch. Very few candidates manipulated figures from the graph.

**(iii)** Answers to this question were often confusing. It had to be clear that if catch rate was higher than recruitment, then there would be no fish left to harvest in future.

**(iv)** To gain credit, answers had to relate specifically to changes to gear. Stating that there would be restrictions on mesh size was not enough as increase in mesh size was required or a reference to mesh size allowing juveniles to escape. Similarly, a reduction to net size was required.

**(b)** Incomplete logbooks or fishermen completing logbooks incorrectly to avoid fines or to avoid a decrease in quotas was a common correct answer. Fewer candidates made reference to the lack of observers or technology on boats, to the fact that skipjack tuna have no breeding grounds, that they breed throughout the year or to the fact that there was no data on natural mortality.

**Question 4**

**(a)** This was a list question, so if candidates provided more than two answers, only the first two could be credited. The most common answer was that wind energy was renewable or sustainable. There were no references to the idea of legislation to reduce carbon dioxide emissions and few references to wind farms having less effect on global warming.

**(b)** Those candidates who had not spent enough time reading the material, provided vague answers e.g., construction causes pollution, causes destruction of marine life or causes changes to food webs. Answers needed to emphasise what caused these changes to gain credit.

**(c)** Both rocks and reef balls provide a habitat suitable for marine organisms. Candidates needed to study the figure to explain how the structure of reef balls provided increased habitat opportunities. Most candidates correctly stated that the biodiversity increased but fewer could provide reasons why it increased. Few references were made to the holes dissipating wave energy, so causing less erosion, while references to rocks releasing toxins were ignored.

**(d)** Most candidates stated that the wind farms would act as fish aggregation devices or that they provided an area for fish to breed. Stating a correct disadvantage proved more difficult with some answers focussing on wind farm construction, which was not accepted.

***Section B***

**Question 5**

Whilst growing salmon in sea cages in shallow inshore waters would be familiar to candidates, growing them in sea cages offshore in deep water would not. Candidates were therefore required to study the diagram shown in the figure of a typical deep-water sea cage system, taking note of the labels, and using these to discuss the benefits and challenges of growing smolt to adult size in these cages.

A few candidates compared this deep-water system with a hatchery on land or discussed salmon breeding, both of which were incorrect and ignored. Many candidates did not notice that the cages were fully sealed units, so references to salinity changes affecting the fish or to natural feed entering the cage were also incorrect. Most candidates mentioned that there was more space available, but this was stated in the question so could not be credited.

There were some very good answers with many candidates making reference to the sealed cages ensuring that predators or parasites could not enter and that the fish were unable to escape. Also, that pollutants outside the cage would not affect the fish and that waste products inside the cage were removed, so could not affect the local habitat and cause algal blooms.

Few references were made to the winch, which is important to lower the cage during adverse weather conditions and to raise the cage to carry out maintenance checks and to harvest the fish. The fact that cage conditions are monitored from land would mean less visits to the cages to carry our maintenance were required.

Most candidates listed some challenges, the most common being the cost of setting up the deep-water system or the expense to maintain the system. Few references were made to the effects of adverse weather in the open ocean, to the fact that the cage could be subject to damage, or to the fact that it might not be possible to reach the cage during stormy conditions.

**Question 6**

**(a)** The majority of candidates named a greenhouse gas and stated that it trapped radiation. However, there were some confusing answers and often the wording was not precise enough to gain credit. Examples include “heat” or “rays from the sun”, confusion over short and long-wave radiation, confusion over greenhouse gases and the ozone layer and using the word bounce instead of reflect.

Many answers repeated the information provided in the question, that the greenhouse effect helps maintain a temperature on Earth that is suitable for life instead of emphasising that it maintains a higher temperature than would be present if there were no greenhouse gases.

**(b)** To answer this question, candidates were required to use information from both the AS and A Level section of the syllabus. Generally, candidates performed well with many gaining full credit. The most common answers were those describing coral bleaching and the subsequent effects on the number and distribution of species, and those which stated a suitable effect of melting sea ice e.g., that it caused a decrease in salinity or that it reduced the habitat for animals such as polar bears. Some answers were too vague to gain credit e.g., those stating that the melting ice caused the salinity to change.

Stronger candidates described the effects of increasing temperatures on productivity and photosynthesis and stated the effect of increased evaporation on salinity, but few then went on to state how this could affect osmosis or water potential in marine organisms. Those who mentioned a decrease in oxygen needed to add the effect on respiration to gain credit.

**Question 7**

Generally, candidates performed well on this question with many gaining full credit. Credit was commonly awarded for the importance of biodiversity in providing a food source, for reference to tourism or to the fishing industry increasing revenue or providing employment, and to providing a source of medicines. Stronger candidates made a correct reference to producers acting as a carbon sink and stated the importance of mangroves or coral reefs in preventing flooding and erosion of coastlines.

Few references were made to providing a stable ecosystem, to preventing extinction, to preserving genetic diversity or to some species depending on others for distribution.

# MARINE SCIENCE

**Paper 9693/33**
**A Level Theory**

## Key messages

- Candidates need to spend enough time reading the question carefully, analysing stimulus material e.g., a graph or a table, before starting on their answers.
- It is important to identify the command word or words so that answers match what is being asked. Too few candidates answered "describe and explain" or "suggest and explain" questions correctly.
- Some candidates displayed very little knowledge of topics which were new to the 2022 syllabus. This was evident on **Questions 1** and **2**.
- Candidates are advised to avoid using abbreviations such as bc (because), or arrows pointing up, down or sideways to indicate an increase, decrease or no change.

## General comments

Stronger candidates were well prepared and produced answers of a high quality. These candidates had a strong knowledge of the syllabus in general, including topics which were new for 2022. They were able to demonstrate excellent analytical skills when presented with unfamiliar material and were able to make correct links between different areas to produce comprehensive responses. This was particularly evident in **Question 3** on skipjack tuna fishing, in **Question 4** on wind farms and in **Question 5** on salmon aquaculture. However, many candidates performed very poorly on these questions and gave answers which showed that they had not referred to the information provided and had very limited scientific knowledge, well below the standard required at this level. Some candidates used bullet points for their answers, which often meant that they did not make adequate links between points, so could not access the full mark range.

## Comments on specific questions

### *Section A*

### Question 1

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**(b)** Many candidates found this question difficult to answer and some did not attempt it. There was some confusion over the terms hydrophobic and hydrophilic, while other candidates provided a correct diagram but because it was not labelled, it could not be credited.

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**(a) (i)** Stronger candidates gained full credit, whereas those unfamiliar with this topic could not be awarded any credit.

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***Section B***

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Few references were made to providing a stable ecosystem, to preventing extinction, to preserving genetic diversity or to some species depending on others for distribution.

# MARINE SCIENCE

**Paper 9693/41**

**A Level Data-handling and investigative skills**

## Key messages

Candidates should:

- ensure that they know what each command word means
- give full depth and detail in answers
- use scientific language
- have the confidence to apply their knowledge to unfamiliar data
- use linear scales for graphs
- be familiar with the rules for drawings
- be familiar with the requirements for planning an investigation.

## General comments

The standard of responses was often very high. Topics new to the syllabus such as plastic pollution, chemosynthesis, and the increased depth and detail required for transport across membranes were well understood by many candidates. The quality of many graphs, detailed experimental plans, and drawing skills was high. Mathematical skills were generally good, but some candidates found the statistical test more difficult. Some candidates found aspects of data analysis challenging.

## Comments on specific questions

### Question 1

**(a) (i)** Many candidates found this first question challenging. Plastic pollution is a new topic and a definition of microplastics is given in the syllabus. Many candidates gave vague answer such as "microplastics are small pieces of plastic". The definition in the syllabus states that microplastics have a size below 5 mm. Candidates should make sure that they are familiar with any key terms used in the syllabus.

**(ii)** This question was answered well by many candidates with most understanding that microplastics can enter food chains, bioaccumulate as they are not broken down, and that biomagnification occurs through the trophic levels. Fewer candidates stated that plastics often bind to toxins in the water. A few weaker candidates referred to humans directly consuming microplastics by being in contact with water.

**(b) (i)** Only stronger candidates gained full credit here. Many gave the unit as kg $km^{-2}$ rather than kg alone. A significant number used an incorrect reading from the graph and many incorrectly divided the number from the graph by the area of the sea. If candidates are asked to state the unit, it is an indication that credit will be awarded for use of the correct unit.

**(ii)** This question required candidates to recognise that the Mediterranean Sea had a very high density of plastic and then to suggest reasons for this. Stronger answers suggested factors such as the fact that the Mediterranean Sea is almost entirely surrounded by land and that the countries surrounding it have high levels of tourism and industry. Some candidates also correctly suggested that some countries around the Mediterranean Sea may not have sufficient disposal methods for plastic wastes.

**(c) (i)** Most candidates were able to correctly calculate the ratio of plastic: microplastic for the Indian Ocean and gave their answers to two significant figures.

**(ii)** Many candidates found this question challenging. Stronger candidates recognised that the low ratio of plastic: microplastic could be due to a relatively high level of microplastic and many then went on to explain how factors such as temperature and wave action could increase microplastic formation. Many candidates thought that the ratio was due to a large volume of large plastics and so discussed the dumping of plastic into the sea. Some candidates suggested that the ratio would be due to low wave action and temperature.

**Question 2**

**(a) (i)** This question required candidates to look carefully at a diagram of an osmotic power station and use their knowledge of osmosis to explain how it generates electricity. Some excellent answers were seen that explained how the higher concentrations of solutes in the seawater would lead to a lower water potential, thus drawing water into the seawater from the freshwater by osmosis. The diagram clearly labelled a partially permeable membrane within an osmosis module to lead candidates to an explanation focused on osmosis. When a question gives an instruction such as "use Fig. 2.1, and your own knowledge…" candidates should refer back to the diagram and then interpret it with knowledge relevant to the question.

**(ii)** This question was generally answered well. Candidates were required to explain why using the osmosis method would reduce fossil fuel dependency, reduce carbon dioxide emissions, and so help to prevent an enhanced greenhouse effect. Many candidates used excellent terminology. Weaker candidates showed a lack of depth in their answers, such as referring to pollutant gas release rather than carbon dioxide.

**(b) (i)** Many candidates gained at least partial credit for correctly defining the terms stenohaline and/or osmoconformer. Common errors included confusing stenohaline with euryhaline and giving vague answers, such as "stenohaline organisms can only live in a few conditions". Stronger candidates gave more precise, accurate definitions.

**(i)** Many candidates found this question about osmoregulation very challenging. A significant number did not seem to recognise that salmon are euryhaline species that can osmoregulate in saltwater and freshwater. A significant number thought that the salmon would lose water in fresh water and would need to keep drinking and removing salts from their gills.

**Question 3**

**(a)** This question required candidates to describe and explain the relationship between Endoriftia and Riftia. Many excellent answers were seen that described the mutualistic relationship and how this benefitted both organisms. A few candidates thought that the relationship was parasitic and/or that Riftia consumes Endoriftia, acting as a predator. Candidates should be encouraged to use precise, accurate scientific terminology, for example, referring to the transfer of carbohydrates or glucose rather than simply food.

**(b) (i)** Only stronger candidates gained full credit for this question but many gained partial credit. The question required candidates to explain one factor that should have been kept constant. The command word "explain" indicated that a reason needed to be given in the answer. Many candidates correctly stated that temperature would need to be kept constant but then did not go on to explain that temperature would affect enzymes or reaction rates.

**(ii)** Graph plotting was generally excellent. Most candidates were able to plot correct line graphs with lines labelled and linear scales. Some candidates chose unusual scales and increments of 7, 14 and 7.5 were seen. Using unusual scales often leads to errors in plotting.

**(iii)** Many candidates gained at least partial credit for this question, but few gained full credit. The question required candidates to recognise that when hydrogen sulfide is added, there is an increase in uptake of carbon dioxide over time but this levels off similarly to the experiment with no added hydrogen sulfide.

**(iv)** Most candidates were able to gain at least partial credit for this question, usually for stating that both increase the rate of carbon dioxide uptake. Many went on to state that hydrogen sulfide causes a bigger increase. Only a few candidates fully discussed the data by giving some explanations such as hydrogen sulfide providing more energy for chemosynthesis. When asked to discuss data, candidates should try to explore the data and information as much as possible.

**Question 4**

**(a)** This question about animal life cycles was answered well with many candidates gaining at least partial credit. Most recognised that there was no larval stage, and many others went on to state that metamorphosis is not involved or that there are no different locations for the different stages. Weaker answers tended to lack detail, often just stating that the juveniles look like the adults.

**(b)** This data analysis question was answered well by many candidates, but few gained full credit. Most were able to recognise that the line of best fit went upwards suggesting a positive correlation. Many other candidates went on to state that many points were not close to the line and so the correlation was weak. When asked to evaluate, candidates should make sure that they include both sides of an argument.

**(c) (i)** Statistical testing is a feature of the new syllabus. Many candidates showed a good understanding of this and were able to correctly calculate the sum of $D^2$. Some candidates did not seem to understand how to complete this calculation and so left it blank.

**(ii)** Many candidates were able to give a correct null hypothesis, but a significant number gave a hypothesis that there would be a correlation.

**(iii)** Candidates who correctly calculated $D^2$ often went on to calculate a correct Spearman's rank correlation coefficient. However, some candidates did not fully understand how to complete the calculation.

**(iv)** Some candidates gave excellent interpretations of what their calculated value meant. When answering these types of questions, candidates should state whether the null hypothesis is accepted or rejected, what the critical value is, and why they are accepting or rejecting the null hypothesis in terms of probability of the result being due to chance.

**(d)** Many candidates gained at least partial credit for this question and recognised that the female orcas would be able to help raise the young orcas so that the survival rate would be higher. A number of candidates thought that the role of the menopause in the whales would be to reduce competition for mates.

**Question 5**

**(a)** Drawing skills are a new feature of the syllabus. Candidates should always ensure that they:

- draw what they have been asked to draw without adding other details
- do not shade or have broken lines
- draw large diagrams.

Weaker answers were typically due to shading, having incorrect proportions, and/or missing features from the photograph.

**(b) (i)** Most candidates were able to correctly calculate the percentage the number of times that algal blooms occurred from the data.

**(ii)** This question was generally answered well with most candidates being able to interpret the relationship between urea concentration and the frequency of algal blooms.

**(iii)** Many candidates found this question challenging with very few gaining full credit. The question asked candidates to evaluate a conclusion that adding excess protein feed causes algal blooms. Many recognised that urea causes an increase in algal blooms and that urea is a product of the breakdown of protein feed. Few recognised that the data was about urea addition rather than

protein feed or recognised that there was a correlation rather than direct evidence. If data shows a correlation, candidates should always state this and then explain that this does not mean that there is necessarily a causal relationship.

**(c)** This question asked candidates to give two requirements for long term sustainability of aquaculture. Many candidates gave vague answers about reducing pollution, but only stronger candidates referred to factors such as viable markets and/or sources of clean water. Most focused on environmental sustainability rather than economic sustainability.

**Question 6**

A detailed experimental plan is a feature of the new syllabus. The investigations asked for may be unfamiliar to candidates, i.e., not core practicals, so they will need to draw on knowledge of core practicals. They test generic understanding of how to plan a practical investigation to generate valid results and conclusions. There is guidance in the question about what candidates should include in their answers. They should always ensure that they include the following:

- a hypothesis
- a clear statement of what the independent, dependent, and standardised variables are
- how they will change the independent variable – this should have detail, for example, use of pipettes or syringes to measure out volumes of ammonium nitrate solution. At least five different values should be given, and these should be stated.
- how the dependent variable will be measured and whether repeat values will be taken
- full practical details to describe how control variables will be kept constant, e.g., the use of water baths
- how the results will be analysed, for example, how rates and means are calculated and what statistical tests will be used
- the risks and how these are minimised, e.g., ammonium nitrate may be an irritant so eye protection will be worn
- how any ethical issues are dealt with, e.g., ammonium nitrate could cause environmental pollution so will not be released into the water.

Weaker responses to this question were characterised by:

- not stating the variables
- giving inadequate detail in the method
- using imprecise language, for example, referring to amounts rather than volumes or masses
- not giving the values of the ammonium nitrate concentrations
- not suggesting the calculation of means
- using imprecise language, for example, “use safety glasses” when not linked to a risk or “plot a graph” rather than stating exactly what will be plotted.

# MARINE SCIENCE

**Paper 9693/42**

**A Level Data-handling and investigative skills**

## Key messages

Candidates should:

- ensure that they know what each command word means
- give full depth and detail in answers
- use scientific language
- have the confidence to apply their knowledge to unfamiliar data
- use linear scales for graphs
- be familiar with the rules for drawings
- be familiar with the requirements for planning an investigation.

## General comments

The standard of responses was often very high. Topics new to the syllabus such as plastic pollution, chemosynthesis, and the increased depth and detail required for transport across membranes were well understood by many candidates. The quality of many graphs, detailed experimental plans, and drawing skills was high. Mathematical skills were generally good, but some candidates found the statistical test more difficult. Some candidates found aspects of data analysis challenging but many were prepared to answer questions confidently by applying their knowledge to unfamiliar situations.

## Comments on specific questions

### Question 1

**(a) (i)** This question required candidates to draw a graph with two different vertical axes. A small number of candidates did not recognise this and tried to produce a single combined vertical axis. However, most graphs were drawn to an excellent standard. Most candidates selected sensible linear scales, but a few used unusual increments. Candidates should try to select scales with increments such as 2s, 5s, 10s to reduce the risk of plotting errors. Nearly all candidates labelled axes and labelled the lines.

**(ii)** This question was answered well by many candidates and most recognised that the reduction in seagrass density near to the desalination plant correlated with the increased salinity of the water. Stronger candidates went on to explain that this could be due to water loss due to osmosis. A few candidates gave descriptions of the seagrass distribution rather than explanations. Candidates should be careful to give explanations rather than descriptions when required.

**(b)** Many candidates gave impressive answers to this question. The question required candidates to give an outline of osmoregulation by salmon in areas of high salinity. Most recognised that the water potential of the seawater would be higher than the water potential of the salmon body fluids leading to water loss by osmosis. Many candidates gave detailed answers with impressive use of vocabulary, clearly stating the roles of ion pumps in gills and the need for drinking of water to replace lost water.

**Question 2**

**(a)** This question investigated the concentration of mercury in the bodies of fish with different diets. Some candidates found the question demanding and did not recognise that the data showed the mercury concentration in the fish rather than in the food that the fish were eating. Stronger candidates recognised that fish from lower trophic levels had a lower concentration of mercury as mercury bioaccumulates and biomagnifies along food chains. Some recognised that fish that consume dead fish had the highest mercury concentration as these species would be at higher trophic levels and could be consuming fish that had died due to mercury poisoning. Some candidates gave impressive answers that used excellent, accurate terminology. Weaker candidates often did not recognise that the fish were obtaining mercury from their diets and sometimes thought that they were absorbing it directly from the water.

**(b) (i)** Most candidates were able to correctly calculate the mass of mercury found in 340 g of tuna and gave their answer to three significant figures. Mathematical skills were generally very strong across the paper.

**(ii)** Most candidates recognised that tuna are high trophic level predators and so consuming tuna would result in consuming large amounts of mercury. Many candidates also explained that the toxic nature of mercury would be particularly bad as it would harm a baby which has a lower mass than an adult.

**Question 3**

**(a) (i)** Most candidates were able to give the correct, balanced chemical symbol equation for respiration. A few weaker candidates were unable to give the correct formula for glucose or gave word equations.

**(ii)** Most candidates recognised that the experiment was carried out in the dark because light would cause zooxanthellae to photosynthesis and release oxygen. Stronger candidates went on to explain that this would mean that it would be impossible to see exactly how much oxygen had been removed from the water.

**(iii)** Stronger candidates were able to gain full credit for this question. Candidates had to use the graph to calculate the difference in oxygen after 15 minutes and then divide this by 15 minutes to get a rate. Credit was awarded for giving the correct unit. Weaker candidates often did not recognise that the mean rate is the gradient of the line.

**(b) (i)** This question was generally answered very well. It required a simple description of the effect of increasing water current speed on the rate of oxygen uptake. When asked to give a description of data, candidates should always look for turning points. Most gained partial credit for the idea of an increase, but many did not state when there was a turning point in the data. If a description is asked for, the answer will require more detail than a simple statement of a trend.

**(ii)** Most candidates were able to gain at least partial credit for this question but only the strongest went on to get full credit. Most recognised that the increase in rate of oxygen uptake would be due to the maintenance of a concentration gradient. Few mentioned increased movement of tentacles or gave reasons for the levelling off at higher speeds due to other limiting factors. Candidates should always be careful to explore all aspects of data that are presented to them as many seemed to focus simply on the increase.

**(c)** A detailed experimental plan is a feature of the new syllabus. The investigations asked for may be unfamiliar to candidates, i.e., not core practicals, so they will need to draw on knowledge of core practicals. They test generic understanding of how to plan a practical investigation to generate valid results and conclusions. There is guidance in the question about what candidates should include in their answers. They should always ensure that they include the following:

- a hypothesis
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- how they will change the independent variable – this should have detail, for example, use of thermostatically controlled water baths. At least five different values should be given, and these should be stated
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- risks and how these are minimised, e.g., hydrochloric acid is an irritant so eye protection will be worn
- how any ethical issues are dealt with, e.g., indicator could cause environmental pollution so will not be released into the water.

Weaker responses to this question were characterised by:

- not stating the variables
- giving inadequate detail in the method
- using imprecise language, for example, referring to amounts rather than volumes or masses
- not stating the temperature used or simply giving hot and cold
- not suggesting the calculation of means
- using imprecise language, for example, “use safety glasses” when not linked to a risk or “plot a graph” rather than stating exactly what will be plotted.

**Question 4**

**(a) (i)** Most candidates were able to gain at least partial credit with stronger candidates often going on to gain full credit. Most recognised that carbonic acid is formed when carbon dioxide dissolves in water, but fewer went on to explain how it dissociates leading to an increase in $H^+$ ion concentration. Only stronger candidates described how $H^+$ ions reacting with carbonate ions reduces carbonate ion availability.

**(ii)** Most candidates were able to explain that increased ocean acidity would cause a weakening of the shells due to loss of calcium carbonate. Fewer went on to explain how weaker shells would lead to increased predation or damage.

**(b)** Many candidates found this question challenging but most gained at least partial credit and the very strongest gained full credit. Candidates were presented with data showing the rise of atmospheric carbon dioxide since 1958 and the change in ocean pH since 1988. Most recognised that there was a negative correlation in pH and carbon dioxide levels, and this would support the idea that fossil fuel use is leading to increased ocean acidification. However, stronger candidates explained that this is a correlation between carbon dioxide and acidity and that it does not show a direct causal effect of fossil fuels burning. Some candidates correctly suggested that other factors could be causing the changes in carbon dioxide levels and acidity. Some candidates also explored the data very thoroughly and described the fluctuations in pH and the extent to which they correlated with the atmospheric carbon dioxide fluctuations. Stronger candidates explored many aspects of the data rather than being restricted to one or two things.

**(c) (i)** Some candidates found this question challenging but most gained at least partial credit. The question presented candidates with data showing a positive correlation between the maximum pH of water around kelp and the maximum light intensity. Many candidates correctly recognised that increased rates of photosynthesis would lead to a reduction in carbon dioxide in the water, thus increasing the pH.

**(ii)** This question required candidates to consider whether encouraging the growth of kelp forests could be a solution to reducing ocean acidification. Stronger candidates gave reasons why the data both supported the idea and why there was insufficient evidence. Some candidates only focused on one aspect, for example, reasons why the kelp would reduce in the ocean and did not explore factors

such as that the data was only taken from summer months or the fact that kelp will not grow in all areas.

**(iii)** Drawing skills are a new feature of the syllabus. Candidates should always ensure that they:

- draw what they have been asked to draw without adding other details
- do not shade or have broken lines
- draw large diagrams.

Weaker answers were typically due to shading, having incorrect proportions, and/or missing features from the photograph. Some candidates drew additional organelles that were not present in the diagrams. Candidates should be encouraged to draw what they see rather than producing idealised diagrams.

**Question 5**

**(a)** The topic of invasive species and conservation is a new part of the syllabus. Many candidates had a vague idea of what defines an invasive species according to the IUCN but often gave answers that lacked detail. Many referred to alien species by simply stating that they are species that have been introduced into an area in which they are not usually present. Candidates should be careful to give precise, accurate definitions when asked.

**(b) (i)** This question presented candidates with a graph to show the changes in mean number of lionfish seen on an area of coral reef between 2004 and 2010. Error bars that represented standard deviation were shown. The question asked candidates to explain the changes in lionfish over the time period. A significant number of candidates only described the data and did not give reasons. Candidates need to be very careful to answer questions according to the command words given. The graph clearly had three phases to show how the population of lionfish remained low while they adjusted to the reef, increased due to abundant food and few predators and then levelled off/fell as competition for food increased.

**(ii)** Only stronger candidates gave explanations of the significance of the overlaps of error bars. The graph clearly shows overlapping error bars between 2007 and 2010 suggesting little difference between the mean values. It is also clear that there is no overlap between 2006 and 2007 suggesting that there is a large difference in mean values. Candidates should be encouraged to explain what the overlap of error bars means when presented with such data.

**(c)** This question presented candidates with the changes in populations different types of species on a coral reef after the arrival of lionfish. The question was answered well by most candidates who were able to recognise that lionfish reduce the prey species by consuming them and that this led to a small increase in non-prey species which may have more food. Most candidates were able to recognise that the lionfish were outcompeting other species by occupying their niches. Many also went on to explain how the consumption of prey species would lead to less consumption of algae.

**(d) (i)** The new syllabus has introduced statistical testing and three statistical tests are listed. This question required candidates to complete a chi-squared test. Most candidates were able to complete the test. However, a few candidates did not recognise that squaring a negative number results in a positive number.

**(ii)** Most candidates who had completed **(i)** were able to calculate the chi-squared value.

**(iii)** Most candidates were able to calculate the correct number of degrees of freedom and to use the correct row of the table. A few selected the wrong critical value, taking the critical value for 0.5 rather than 0.05. When interpreting statistical test results, candidates should state whether the null hypothesis is accepted or rejected and then go on to explain this in terms of probability of the difference being due to chance. Candidates should also make it clear what critical value they have selected.

**(iv)** This question was answered well with most candidates gaining at least partial credit. Most recognised that many species have wide geographical ranges that cross national boundaries. Some candidates also went on to explain how many areas of the High Seas have little regulation.

# MARINE SCIENCE

**Paper 9693/43**

**A Level Data-handling and investigative skills**

## Key messages

Candidates should:

- ensure that they know what each command word means
- give full depth and detail in answers
- use scientific language
- have the confidence to apply their knowledge to unfamiliar data
- use linear scales for graphs
- be familiar with the rules for drawings
- be familiar with the requirements for planning an investigation.

## General comments

The standard of responses was often very high. Topics new to the syllabus such as plastic pollution, chemosynthesis, and the increased depth and detail required for transport across membranes were well understood by many candidates. The quality of many graphs, detailed experimental plans, and drawing skills was high. Mathematical skills were generally good, but some candidates found the statistical test more difficult. Some candidates found aspects of data analysis challenging but many were prepared to answer questions confidently by applying their knowledge to unfamiliar situations.

## Comments on specific questions

### Question 1

**(a) (i)** This question required candidates to draw a graph with two different vertical axes. A small number of candidates did not recognise this and tried to produce a single combined vertical axis. However, most graphs were drawn to an excellent standard. Most candidates selected sensible linear scales, but a few used unusual increments. Candidates should try to select scales with increments such as 2s, 5s, 10s to reduce the risk of plotting errors. Nearly all candidates labelled axes and labelled the lines.

**(ii)** This question was answered well by many candidates and most recognised that the reduction in seagrass density near to the desalination plant correlated with the increased salinity of the water. Stronger candidates went on to explain that this could be due to water loss due to osmosis. A few candidates gave descriptions of the seagrass distribution rather than explanations. Candidates should be careful to give explanations rather than descriptions when required.

**(b)** Many candidates gave impressive answers to this question. The question required candidates to give an outline of osmoregulation by salmon in areas of high salinity. Most recognised that the water potential of the seawater would be higher than the water potential of the salmon body fluids leading to water loss by osmosis. Many candidates gave detailed answers with impressive use of vocabulary, clearly stating the roles of ion pumps in gills and the need for drinking of water to replace lost water.

**Question 2**

**(a)** This question investigated the concentration of mercury in the bodies of fish with different diets. Some candidates found the question demanding and did not recognise that the data showed the mercury concentration in the fish rather than in the food that the fish were eating. Stronger candidates recognised that fish from lower trophic levels had a lower concentration of mercury as mercury bioaccumulates and biomagnifies along food chains. Some recognised that fish that consume dead fish had the highest mercury concentration as these species would be at higher trophic levels and could be consuming fish that had died due to mercury poisoning. Some candidates gave impressive answers that used excellent, accurate terminology. Weaker candidates often did not recognise that the fish were obtaining mercury from their diets and sometimes thought that they were absorbing it directly from the water.

**(b) (i)** Most candidates were able to correctly calculate the mass of mercury found in 340 g of tuna and gave their answer to three significant figures. Mathematical skills were generally very strong across the paper.

**(ii)** Most candidates recognised that tuna are high trophic level predators and so consuming tuna would result in consuming large amounts of mercury. Many candidates also explained that the toxic nature of mercury would be particularly bad as it would harm a baby which has a lower mass than an adult.

**Question 3**

**(a) (i)** Most candidates were able to give the correct, balanced chemical symbol equation for respiration. A few weaker candidates were unable to give the correct formula for glucose or gave word equations.

**(ii)** Most candidates recognised that the experiment was carried out in the dark because light would cause zooxanthellae to photosynthesis and release oxygen. Stronger candidates went on to explain that this would mean that it would be impossible to see exactly how much oxygen had been removed from the water.

**(iii)** Stronger candidates were able to gain full credit for this question. Candidates had to use the graph to calculate the difference in oxygen after 15 minutes and then divide this by 15 minutes to get a rate. Credit was awarded for giving the correct unit. Weaker candidates often did not recognise that the mean rate is the gradient of the line.

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