MARINE SCIENCE

Paper 9693/11
AS Structured Questions

Key messages

Many candidates were able to answer in clear scientific terms, providing detailed answers and showing a good overall understanding of the specification content. Others needed to carefully consider their word choices to ensure they used scientific and technical vocabulary where they could.

Candidates need to ensure they have a clear understanding of command words to help them when answering problems, and to ensure that they are aware of the mark allocation for each question. This will guide them to the amount of detail required for each question part.

For mathematical calculations, candidates need to understand significant figures, including which digit is significant when rounding numbers. Candidates should also aim to lay out their calculations clearly, showing each step in a logical progression as credit is usually available for partially correct answers.

General comments

Most candidates attempted all parts of the paper, with many answers showing that candidates had worked hard to develop their knowledge and understanding of the specification content. In some questions, such as **3(b)(i),** candidates needed to read the question more carefully to be clear about what was being asked.

Areas that candidates generally performed well in were understanding why surface waters are high in oxygen in **Question 7a**, and knowing the carbon cycle within the ocean from **Question 6b**, but some candidates needed a better understanding of the role of carbon dioxide in this process.

Areas which were more challenging included the understanding of carbon dating of coral reefs from **Question 2**, and the formation of abyssal plains from **Question 5(b)(i)**.

Candidates who continue their answer to a question elsewhere on the question paper should always make it clear where the rest of their answer is.

Comments on Specific questions

Section A

Question 1

(a) Both **(i)** and **(ii)** were answered well, but some candidates gave chemosynthesis for **(ii)**.

(b) (i) The majority of candidates answered both parts correctly, although some selected shark as being on the fourth trophic level

(ii) Many candidates referred to organisms rather than animals and often gave vague answers.

(c) Many candidates gained at least partial credit here, but many referred to the nematode as feeding on the tuna, which implied a predator – prey relationship rather than parasitic. Some candidates also described a fall in tuna population affecting food availability for the sharks, rather than the growth of the tuna being compromised by the presence of parasites reducing their body mass, or the nematodes being passed onto the sharks, which would in itself not affect the energy transfer efficiency.

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Question 2

(a) Some candidates clearly understood that it was the ratio between carbon-12 and carbon-14 that was important. Many candidates however found this question challenging with answers ranging from named elements to carbon containing chemicals, such as carbonates, to named isotopes, from carbon-6 to carbon-18.

(b) (i) Many candidates were able to accurately read from the graph to give a value in the correct range, of 8500 – 9000.

(ii) This calculation proved challenging for many candidates. A significant number attempted to calculate a percentage change, and many attempted to calculate the age of the second sample only through dividing 12 by 11 400. Candidates who carried out the subtraction first sometimes inverted the final division required. Some candidates who did not use a calculator simplified the fraction as far as they could, and then presented their answer in terms of years/m (of growth).

(iii) The strongest candidates recognised that the growth rate shown by the analysis is likely to be less than the actual growth rate, and that erosion of the reef may have occurred to reduce the width of each band. Other candidates instead stated that the growth conditions would have been more favourable to increase growth.

Question 3

(a) The majority of candidates were able to identify the term correctly as the thermocline, but a few named it as the halocline.

(b) (i) Candidates needed to be more precise in their use of language when comparing trends. Although many could identify the start temperatures as different (25 °C – 15 °C), some did not make it clear they were describing the surface waters, or the region as a whole. Some who recognised that the thermocline started at a shallower depth in the temperate region had difficulty expressing themselves clearly, sometimes mentioning “lower depths” for both deep water and shallow water. The strongest candidates gave stated depths or ranges for the thermocline, and compared those. Some candidates identified the difference in temperature change between the tropical and temperate, or the idea that the water below the thermocline reached the same temperature. Weaker candidates often made vague statements such as “it is warmer in the tropical region as it is closer to the equator”, answering **(ii)** in this question.

(ii) The most common correct answers referred to more sunlight exposure or heat from the increased light in the tropical region. Turbulence increasing or the angle of the light being lower were rarely mentioned. Many candidates focused their answer linking the two regions to their distance from the equator giving no scientific explanation why this would affect the surface temperatures. Many candidates stated the common misconception that the equator is closer to the Sun and is therefore warmer.

(c) This question was challenging for many candidates. Some candidates stated that the polar regions received little or less light (intensity), and related that to the cool surface temperatures. A few also correctly stated that that there would be a similar temperature in the water at lower depths, but some stated there was no change in temperature.

Question 4

(a) (i) Many candidates gave a good explanation of the causes of currents, or the difference between water flow in the northern and southern hemispheres, but had difficulty in trying to clearly express what a current is. They needed to be more precise in describing the water movement as continuous and directional.

(ii) Most candidates related upwelling to movement of nutrients and mentioned cool water and a significant number mentioned from the deep ocean and to the surface waters. Candidates needed to be precise in their word choice, as some stated “cold, nutrient filled water will flow upwards” or “cold, nutrient filled water rises”, which was not sufficient for credit, as the water may only be rising a metre or two.

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(b) This data set caused many candidates to draw more than one version before choosing their correct version. Pyramids of biomass, energy or numbers should be drawn using closed horizontal bars, not a sub-divided pyramid shape. While many candidates completed rectangular bars, they often did not pay attention to the detail that they wrote into them. Many candidates added the name labels in the correct order, and often added in the quantities shown on the diagram. However, many did not stop to consider that the phytoplankton number was less than the krill number, and so did not gain credit for this. When candidates drew a subdivided pyramid, some realised the numbers were not as expected, and many then swapped the positions of the krill and the phytoplankton in the order, so then the numbers were correct, but the labelling order was not. Candidates need to be encouraged to look carefully at the information presented to them before starting a question.

Question 5

(a) (i) Many candidates knew these features and named them accurately but the most common error was naming the mid-Oceanic ridge as a hydrothermal vent.

(ii) This was generally answered well, with the most common incorrect answer being divergent.

(b) (i) While sea floor spreading and divergent plates were often quoted correctly, few candidates were able to express the idea of magma rising or that this then cools and solidifies to form new rock or crust. The role of sediments in the formation of a flat abyssal plain was explained well by some candidates.

(ii) Although many candidates clearly knew of evidence for the theory of plate tectonics, the majority found it difficult to choose a relevant piece of evidence for the theory of abyssal plain formation. A few candidates correctly referred to the relative age of rock moving away from the mid ocean ridge. Although more tried to explain the idea of magnetic banding on the ocean floor, many of these omitted the idea of the magnetism being recorded in the rocks of the ocean floor.

(iii) Many candidates were able to express the meaning of the term clearly, with many understanding that consistent evidence is required, not just a single piece of evidence. Some candidates focused on lack of proof and that it was not a law.

(c) This topic was well understood and candidates were usually able to describe conditions at hydrothermal vents. A few candidates needed to be clear there is no light there, and to understand that whilst the water surrounding the vent can be very cold, the water coming from the vent can be very hot. A small number of candidates were not clear that acidic conditions relate to a low pH.

Question 6

(a) Most candidates gained at least partial credit for this question, with the strongest gained full credit. The idea of calcium being an essential constituent in bone, skeletons, shells and teeth was well known. A few candidates cited nitrogen as being used in the form of nitrates for growth of an organism, which suggested that many candidates knew that nitrates are taken in by marine producers, but not that these inorganic molecules are turned into organic molecules of amino acids, proteins, DNA/RNA, which is the form it is passed along the food chain.

(b) Many candidates gained full credit for this question. There was a good understanding of the carbon cycle, but candidates did not always make it clear that carbon can exist as carbon dioxide, and just referred to carbon throughout their answer, when some aspects of their answer should have referenced carbon dioxide. The most common correct answers involved photosynthesis being carried out by producers who sank to the sea bed when they died and decayed, before being returned to the surface waters by upwelling. Some candidates put too much emphasis on the movement into and out of the ocean (e.g. atmospheric dissolution, run-off, harvesting) which missed the point of the question about cycling in the ocean.

Question 7

(a) This topic was generally well understood, with most candidates giving creditworthy answers here. Many candidates focused on either the idea of photosynthesis, or atmospheric dissolution but did not include both to obtain full credit. Some candidates used the term productivity instead of

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photosynthesis, suggesting they were not clear in their understanding of the two terms. A number of candidates also incorrectly stated that warmer water held more oxygen.

(b) (i) and **(ii)** Most candidates were able to read the information from the table and graph to obtain credit.

(c) Many candidates described the conditions at one or other depths, or the difference between the two depths, but did not explain the impact this may have on a fish travelling between the two regions. Very few candidates noticed that the fish would have to pass through the oxygen minimum zone and this may kill the fish. Many candidates stated "'the fish is used to living at 800 m", but did not go on to explain any of the reasons the fish may not survive for long at the surface. Candidates then needed to emphasise that the light, water temperature and oxygen level would be too high for these fish to survive in the surface waters. Pressure differences were rarely mentioned. Some candidates felt the fish needed to remain where it was in in order to carry out chemosynthesis.

Question 8

(a) (i) Candidates generally performed well on this calculation. The most common error made was a rounding error, either when they had incorrectly rounded 0.084449 to 0.085, or rounded 0.91555 to 0.915. Both of these errors resulted in an incorrect final answer, but where candidates had laid out their answer clearly, it was possible to see where their error had occurred, and credit was given for the work they had completed correctly.

(ii) Many candidates often used one word to answer this question. A qualifying statement to emphasise the point was required. For example, "deforestation" alone was insufficient and candidates needed to support this by describing the use of the wood as fuel, or clearing the land for growing crops.

(b) Most candidates correctly identified parasitism here.

Question 9

(a) Some candidates gave good accounts of conditions needed to form a tropical cyclone without explaining why moving on land would cause the storm to weaken. Candidates needed to explain their ideas precisely using scientific language, and in some detail. Comments such as buildings or mountains blocking or reducing the cyclone were a good start but answers needed more scientific reasoning, with a reference to the impact these masses would have on the energy of the cyclone. Many candidates realised that water was a key factor, but they needed to qualify this in some way to show an understanding of the water as a source of energy for the cyclone.

(b) This was a demanding question as it required linked impact and effect. Many candidates were able to discuss some of the consequences of a cyclone, e.g. larger waves/increased turbidity/air exposure, but they then needed to describe the effect of these impacts. For example, increased turbidity would reduce light reaching the polyps which was needed for photosynthesis.

(c) Most candidates were able to provide at least some information on the effects of hurricanes on human coastal communities, but a few missed the reference to human communities. There were some excellent, wide-ranging descriptions of the effects of a hurricane, with some of the strongest candidates also able to point out that there could be long-term benefits from the hurricane, e.g. flooding could improve fertility and increase crop production. Weaker candidates often simply stated that cyclones affected infrastructure or habitats, without saying how they were affected.

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Paper 9693/12
AS Structured Questions

Key messages

- Candidates should read the instructions for each question with care. Answers to questions asking for use of data should include or manipulate appropriately selected data and include any necessary units.
- Some questions may not have answer lines because candidates are asked to answer elsewhere on the paper, such as on a figure. Candidates should take care not to miss these questions.

General comments

Some questions were answered well by all candidates. Others were more challenging and required descriptions or explanations. Most candidates attempted the majority of questions and had no difficulty with the space and time allowed.

Comments on specific questions

Question 1

(a) Many candidates could give one feature of water coming of out hydrothermal vents, but few could give two features. Often, the idea given in the question of high temperature was given.

(b) (i) Candidates found it challenging to define the term ecosystem. Many excellent descriptions of community were seen, but were incorrect for this question. Some referred to abiotic and biotic factors. References to “abiotic living things” were seen fairly often.

(ii) Many candidates answered well and gave the answer of a lack of light. This could be described in a number of alternative ways, such as being in the aphotic zone. Responses that suggested any light is present, such as low light, were not sufficient for credit to be awarded.

(c) Many candidates identified that this would be a divergent plate boundary and therefore gained partial credit. A common error was for candidates to describe underwater volcano formation rather than hydrothermal vents.

(d) The question required an example of mutualism and succession at a hydrothermal vent. Examples that do not occur at a hydrothermal vent could not gain credit. For mutualism, the bacteria involved needed to be clearly chemosynthetic. For succession, confusion was seen as to whether *Tevnia* follows *Riftia* or vice versa. Suggestions that *Tevnia* turns into *Riftia* were not creditworthy.

(e) Many candidates could give a clear explanation of why hydrothermal vents have low biodiversity.

Question 2

(a) Most candidates answered this correctly.

(b) (i) Many candidates could recall the Darwin-Dana-Daly theory of atoll formation, and often gained partial credit for this. It was more challenging to gain full credit for applying their knowledge to explain how the information given provides evidence for the theory.

(ii) Excellent, clear descriptions of radiocarbon dating were frequently seen.

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Question 3

(a) (i) The majority of candidates could add tuna to the food web with appropriate arrows. Weaker responses had arrows in the incorrect direction, or missing arrows.

(ii) Candidates frequently gave clear definitions of the term ecological niche. Many went on to give examples. These were not required for credit. Reponses that did not gain full credit often referred to the role of an organism in the food web, rather than in an ecosystem.

(iii) Candidates could clearly express how the figure showed that sharks occupy a general ecological niche.

(b) (i) Most candidates could use the term parasitism. The most common incorrect answer was mutualism.

(ii) The strongest candidates answered this question correctly. Many other candidates could not use the information given to realise the nematodes are not gaining energy from the mackerel, but from the undigested food that the mackerel has eaten

(iii) Only stronger candidates could suggest why nematodes are not normally included in food webs.

(c) (i) Candidates could give many reasons why energy consumed by the mackerel population is not all passed to the shark population. The full range of points on the mark scheme were seen.

(ii) Clear and appropriately labelled pyramids of energy were frequently seen. There were only a few incorrect pyramids of energy that were triangular rather than the correct bars.

Question 4

(a) (i) The strongest responses gave clear comparisons of the data and manipulated data to support these comparisons. No credit was available for simply reading the values from the graph.

(ii) Some candidates only gained partial credit for calculating the reduction in the height of the wave, rather than continuing their calculation to give the height of the wave.

(iii) Strong candidates applied their knowledge to demonstrate an understanding of how environmental factors influence the formation of different ecological communities.

(iv) The two ideas expected here were that if wave height is reduced, the energy of the waves is decreased, and the wave will travel less distance inland.

(v) Candidates could answer in terms of effects on human communities, or the communities on the coral reef. The full range of answers on the mark scheme were seen.

(b) (i) This was well answered, either in terms of smoke or ash from a forest fire blocking light, or changes to the pH of the water.

(ii) Few candidates gave the biological uses of nitrogen or phosphorus in their responses. Full credit was most often gained for a clear explanation of how algal blooms can lead to coral death.

Question 5

(a) Most candidates could describe that the Moon has more effect than the Sun on the tides because it is closer to Earth.

(b) (i) Most candidates could identify one location on the figure that would be experiencing a high tide.

(ii) Many candidates misinterpreted this question, assuming it was asking for an explanation of spring and neap tides. There appeared to be a common misconception regarding high tides compared with spring tides. Few candidates gave a full explanation, accounting for the inertia causing a high tide on the opposite side of Earth from the Moon, or the changing location of a high tide as the Earth spins on its axis.

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(iii) Most candidates could identify that the Sun would need to be on the left-hand side of the figure to cause the largest possible tidal range.

(c) (i) Strong candidates performed well on this question. The most frequent correct responses referred to the narrow bay, or the narrowing shape.

(ii) Some candidates incorrectly presumed that this was a question about spring and neap tides, failing to realise that these are accounted for in the expected tides at any location. References to wind were sufficient for credit, but if a direction was stated this had to be a wind direction that would increase the height of the tide in this location. References to air pressure were insufficient, because only low air pressure would increase the height of the high tide.

Question 6

(a) (i) Frequently, correct arrows were seen. Care needed to be taken not to exaggerate the up or down movement of these plates.

(ii) Most candidates could name the type of tectonic plate boundary.

(iii) Most candidates could identify the feature as a trench.

(iv) Explanations of why volcanoes occur near this plate boundary were often too vague for full credit.

(b) (i) Isostasy was not well known by many candidates.

(ii) This was a challenging question for some candidates. The strongest answers referred to the figures given for density.

Question 7

(a) The majority of candidates could describe three advantages of shoaling behaviour.

(b) (i) Some candidates found it difficult to evaluate this data. Descriptions or explanations of the data were frequent, rather than evaluations.

(ii) Candidates could approach this question in many different ways and the full range of responses shown on the mark scheme were seen.

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Paper 9693/13
AS Structured Questions

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Paper 9693/21
AS Data-Handling and Free-Response

Key messages

Candidates should read the questions carefully and consider what the question is about. They should select appropriate information to answer the questions and try to avoid including irrelevant or vague descriptions.

Candidates should manipulate data presented in tables or graphically, for example subtracting, dividing, multipling or adding numbers, rather than quoting figures directly to support a trend in the data.

The quality of graph drawing was generally of a good standard. Candidates should be reminded that axes should be labelled correctly and they should not use non-linear scales when working out the size of the graph axes. The plots must take up at least 50% of the graph paper provided. Candidates need to be careful when plotting points. They should not use very large dots or crosses which go beyond the +/– half a square plotting tollerance.

General comment

A high standard of scientific knowledge and understanding was displayed by many candidates. Overall candidates tended to score equally on ***Section A*** and ***Section B***, showing that many candidates were able to apply their knowledge of principles and concepts in a logical, deductive manner. Most candidates attempted every question. Weaker candidates sometimes did not answer the question as it had been set or gave a vague answer with very little scientific detail.

Comments on specific questions

Section A

Question 1

(a) Most candidates attempted the question. The most common correct answers were predation, death of the limpet and wave action/currents. Many candidates stated the distance moved by the limpet or the time taken for the limpet to return were difficult to control when they were the independent and dependent variables. A number of candidates gave the temperature or the tides as an answer, but these could not be credited without further qualification.

(b) (i) This question was generally well answered. Many candidates showed working out and gave the correct answer.

(ii) The strongest candidates gained full credit on this question. A common error was using an inappropriate linear vertical scale starting at 0, making the graph too small. A significant number of candidates chose a difficult scale, for example 6.125 or 7.35 per small square to go up in, which made both plotting and reading the plots very difficult. Candidates who chose such difficult scales frequently made plotting mistakes. Candidates are strongly encouraged to use scales which are easy to plot and interpret. Extrapolation is to be discouraged. Some candidates plotted the number returning not percentage returning.

(iii) Very few candidates used the data provided to demonstrate the overall changes in percentage returning to their home scars. A small proportion of candidates recognised the value at 20 cm to be an outlier, and only referred to an increase between 20 and 30 cm without recognising that all the values except 20 cm supported the general downwards trend. Very few candidates mentioned

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repeats or sample size having an effect on the validity of the conclusion. Stronger candidates manipulated the data well in this question.

(c) "Predation" and "preventing being washed off" were the most commonly seen correct answer. Many candidates referred to the limpet being safe/protected. Food availability was a common incorrect answer. A correct answer seen very rarely was the ability of the limpet to get a better attachment to rocks on the home scar.

Question 2

(a) (i) The majority of candidates knew it was an El Niño event. Incorrect answers included, global warming/climate change, monsoon, red tide and sea surface variation.

(ii) Many candidates recognised that the catch would decrease and explained why. They usually gave "stop upwelling" as the correct answer, but did not always relate it to productivity. Common misconceptions were that the anchoveta migrated to cooler water or that the catch would increase due to increased productivity in warmer water. A few candidates did not discuss catch size, but population size which was incorrect.

(b) (i) A minority of candidates described clearly how to calculate the mean by adding the variation and dividing it by the relevant number, usually three. Some candidates described calculating a mean over the seven years and gave details of the equipment used to measure the temperature, misinterpreting the question.

(ii) Most candidates were able to select two correct years.

Section B

Question 3

(a) (i) Many candidates were knowledgeable about the meaning of the term ecological niche. Incorrect answers included the role in a community or environment and the use of job for role.

(ii) Many candidates gave extremely detailed answers, understanding that a narrow ecological niche was associated with high biodiversity and a high degree of competition. Coral reef was the example given by many candidates for a marine habitat and butterfly fish for the marine organism.

(b) (i) Many candidates answered this question very well. They included the two main processes, photosynthesis and chemosynthesis in their answers. There was also a good understanding of each process and the way producers convert inorganic compounds into organic compounds making energy available. However, there were some examples of incorrect terminology, for example "making energy" or "creating energy" and referring to ''sun'' rather than sunlight when describing photosynthesis. Some candidates described energy transfer from one trophic level to the next and predator/consumers, which were not required.

(ii) Overall this question was well answered. The most common responses to how heat is lost were, respiration/heat, egestion/faeces, urine/excretion and "not all parts of the organism were eaten". A few candidates accurately used the term nektonic to describe movement. Most errors included using the term waste in general terms, and using non-scientific words for faeces and urine. Also detritus and dead organisms were discussed without reference to decomposition/decay.

Question 4

(a) Many candidates produced good responses to this question. There was a general understanding that tsunamis originate from events at plate boundaries, but the explanations were rarely specific enough to gain full credit. A number of candidates incorrectly referred to divergent plate boundaries. Many candidates had the idea of the plates becoming stuck but did not go on to describe the pressure or tension build up. They described "slippage" without "sudden", "energy release" without "large amount", "earthquakes" without "underwater" and gave a general statement that this leads to a tsunami without "large displacement of water" or a description of the wavelength/depth.

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(b) For the majority of candidates the Darwin-Dana-Daly theory of atoll formation was clearly understood. They produced many excellent accounts with the correct sequence of events. Some candidates mixed up the timings, particularly at which point the island begins to sink. A few candidates incorrectly described barrier reefs as being formed before fringing reefs. There was also some confusion over when, where and how a lagoon is formed. Subduction was used by a few candidates incorrectly for subside/sink.

(c) Many candidates scored some credit for the factors affecting the tidal range but few could correctly describe the effects. Answers were often not specific enough. For example, wind without qualifying their answer in terms of strength or direction or pressure without air/atmosphere. Many candidates explained the role of the Sun and Moon and the formation of neap and spring tides, even though the question stated “describe other factors which affect the tidal range”. Many candidates found this question difficult and incorrectly described the effect of temperature, density, depth of water, area of water, Coriolis effect, evaporation and precipitation on tidal range.

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Paper 9693/22
AS Data-Handling and Free-Response

Key messages

- Candidates should be familiar with what is required by different command words used on the paper, such as the difference between 'describe', 'explain', 'discuss' and 'suggest'. They should also always look at the number of marks available for each question part to help them decide how much detail to include in their answer.
- If asked for named examples of ecosystems or organisms within their answers, candidates must ensure that these come from the marine environment.
- Candidates should be careful with respect to their language relating to energy, avoiding incorrect science such as "more energy is produced".

General comments

Candidates found some aspects of *Section A* more difficult than *Section B*, particularly **Questions 2(b)(i)** and **2(c)(ii)** where they had to use the patterns in the data to support their answers. Candidates must ensure that they study the data presented carefully to ensure they are specifically answering what the question has asked about. Candidates need to read the question carefully to correctly identify which part(s) of the data set they are to comment on. This includes looking carefully at any key present if there are multiple lines or bars on a graph. If using data from a graph to support their answer, candidates should aim to manipulate the data (and include the unit), rather than just quote figures extracted from the data. For example, calculating how much a variable has increased or decreased.

Comments on specific questions

Section A

Question 1

(a) A number of candidates were unable to define this term accurately. Some candidates simply referred to "an organism that eats another organism", which does not exclude other types of consumer such as herbivores. Other candidates referred to "an animal that eats another animal", but this was also insufficient for full credit as it did not convey the idea of an animal hunting/catching its prey.

(b) (i) Many candidates answered this question well. However, some candidates had not looked carefully at the information provided. For example, some had not read the key correctly and consequently described the wrong data (i.e. the changes in COTS rather than coral), or did not describe data from the correct years.

(ii) The command word for this question was 'explain', but many candidates simply described the relationship e.g. "as coral cover increases, COTS per tow increases". This was insufficient unless it suggested that, or explained how, one caused the other. To gain full credit candidates needed to explain two elements of the relationship, but this could include reference to the lag time between the population changes.

(c) (i) The question tells candidates that the number of reef fish had declined by 95%, so descriptions of a decline in reef fish populations were insufficient unless they suggested that some species would be

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eradicated/become extinct. Only a minority of candidates suggested that this would then impact on other species populations (including the lionfish themselves) or reduce biodiversity.

(ii) This question was answered well by most candidates, who seemed to easily interpret what the graph was showing. Some candidates only commented on one line from the graph e.g. "the results support the hypothesis as when lionfish are controlled by spear fishing the number of small reef fish increased'", and so could not gain full credit.

Question 2

(a) Most candidates knew that productivity was related to the production of new biomass, but some descriptions did not convey that it is the rate of production.

(b) (i) Many excellent bar graphs were seen. It was not difficult to come up with a suitable scale for the *y* axis that allowed for at least 50% of the space to be filled, but some candidates did not then read their own scale correctly and plotted bars at incorrect heights, most frequently when each small square on the *y* axis was 0.5% (and plotted as if they were 1%). Some candidates did not leave a space between the bars for each treatment, or reversed the labels on their key.

(ii) This question proved challenging for some candidates as although the pattern was straight forward, articulating it proved more difficult. However, strong candidates managed to answer this very well.

(iii) Only the strongest candidates answered this question correctly. Many candidates suggested that with increased populations of producers, more energy was available to transfer, without reference to why the efficiency would be greater. Only a small number of candidates realised that due to the increased density of food, the energy expended finding food would be reduced, i.e. the feeding efficiency was increased.

Section B

Question 3

(a) A range of answers were seen for this question. Many candidates were able to describe that particular gases would be released into the atmosphere, dissolve in water and be added to the oceans via precipitation and run-off. Many were able to describe the change in pH/acidity associated with this. Fewer candidates were able to describe the direct addition of mineral ions through tectonic activity on the sea bed. One of the most common errors was not referring to minerals added as ions, e.g. magnesium and sulfur being added.

(b) This question was answered well with many candidates gaining full credit. When describing the effect of evaporation, it was important that candidates conveyed that water is being lost from the ocean and the salt left behind. Some candidates stated that sea water was lost or made no reference to this at all. Similarly, it is clearest to say that precipitation adds fresh water.

(c) Most candidates were able to gain at least partial credit on this question but few gained full credit. The higher oxygen concentration in the surface layer then reducing with depth was often well described. Many candidates made reference to the oxygen minimum layer, but only a few of these were able to fully explain the relative rates of photosynthesis and respiration that cause this. Fewer candidates were clear about the expected increase at greater depth. Some correctly explained that oxygen becomes more soluble at lower temperatures and greater pressure, but others were confused and stated the opposite. Some candidates had the right idea but used less scientific language, such as how much oxygen the water "can hold/carry" rather than describing solubility. Some used incorrect terminology such as describing the "solubility of the water".

Question 4

(a) A minority of candidates correctly described the relative effect of the underlying processes i.e. sedimentation exceeding erosion. Many were able to describe the unstable nature of the shore and the potential impact of wave action. A number of candidates discussed other aspects of sandy shores, such as a lack of biodiversity and the adaptations of organisms living there, showing some good knowledge but not answering the question.

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(b) Many candidates were able to write a significant amount for this question, but the quality of answers varied greatly. Most were able to describe some of the factors that would affect the distribution of organisms, such as wave action, air exposure during low tide and the changing environmental conditions such as temperature and salinity. However the explanations of how these factors affected the distribution were often lacking the correct detail. Zonation was mentioned by some candidates, but often without an explanation of what this meant or the causes of it. One of the most common misconceptions seen was that rocky shores have high levels of erosion. Candidates needed to be aware that a high level of wave action does not necessarily mean a high level of erosion; this depends on the type of rock on the shore.

(c) This question was answered well by many candidates. Most were able to describe the idea of reducing interspecific competition between the many species present, but not all conveyed the idea that each species has/is adapted to utilising a specific food source. Some candidates neglected to give examples, or gave incorrect examples from inappropriate ecosystems, including some from terrestrial rather than marine ecosystems.

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Paper 9693/23
AS Data-Handling and Free-Response

Key messages

- Candidates should be familiar with what is required by different command words used on the paper, such as the difference between 'describe', 'explain', 'discuss' and 'suggest'. They should also always look at the number of marks available for each question part to help them decide how much detail to include in their answer.
- If asked for named examples of ecosystems or organisms within their answers, candidates must ensure that these come from the marine environment.
- Candidates should be careful with respect to their language relating to energy, avoiding incorrect science such as "more energy is produced".

General comments

Candidates found some aspects of *Section A* more difficult than *Section B*, particularly **Questions 2(b)(i)** and **2(c)(ii)** where they had to use the patterns in the data to support their answers. Candidates must ensure that they study the data presented carefully to ensure they are specifically answering what the question has asked about. Candidates need to read the question carefully to correctly identify which part(s) of the data set they are to comment on. This includes looking carefully at any key present if there are multiple lines or bars on a graph. If using data from a graph to support their answer, candidates should aim to manipulate the data (and include the unit), rather than just quote figures extracted from the data. For example, calculating how much a variable has increased or decreased.

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Paper 9693/03
A2 Structured Questions

Key messages

- Candidates should read and process information in the question carefully before attempting their answers.
- Candidates should consider the command word, the number of answer lines and mark allocation for each question.
- Most candidates used terminology carefully, but some candidates used imprecise language e.g. 'nutrients' for food, 'juves' for juveniles and arrows up or down to represent an increase or decrease in populations.

General comments

There were some very strong candidates this year and overall the standard was good. Stronger candidates showed a thorough understanding of the syllabus and were able to process the information provided, while other candidates often gave generalised answers that gained partial or no credit. **Question 3** on prawn fishing in India was generally answered well, especially **(a)** and **(b)**. Candidates also had a strong knowledge of the negative effects of removing mangrove forests for **Question 6(b)(i)**. By contrast, more demanding topics such as the role of pigments in red algae in **Question 1(b)**, gill adaptations in tuna and grouper in **Question 2(b)**, and assessing two different sites for an aquaculture business for **Question 4(a)** were less well understood.

Comments on specific questions

Question 1

(a) (i) Candidates were asked to 'state and explain', so answers had to address both parts to gain full credit. Stronger candidates linked clear or shallow water with increased light availability for photosynthesis. Answers stating that tropical waters were suitable for growth were not quite enough as this needed to be linked to suitable or optimum temperature. Sheltered bays providing protection from predators was a common incorrect answer.

(ii) Full or partial credit was gained by most candidates, usually for the seaweed providing a habitat or food for consumers. If protection or shelter was stated, this needed to be stated as "from predators". There were only a few references to seaweed providing oxygen. Weaker candidates used the term nutrients instead of food.

(b) The majority of candidates were able to gain at least partial credit, usually for stating a named pigment in red algae. Some candidates had not read the question carefully enough and gave answers describing how red algae were adapted to live at depths of 35 m. Other candidates confused light wavelengths with pigments and there was a common misconception that red pigments absorb red light.

(c) This question asked about the social impacts on the community if tourism spread to the island. There were some excellent answers, but many candidates answered in terms of economic benefits or the effect of increasing tourism on the environment and were unable to gain credit.

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Question 2

(a) (i) This was a straightforward question linking the stages in the life cycle of grouper to their habitat, but full credit was rarely awarded. Some candidates confused grouper with salmon, while others had adult grouper spawning in deep water reefs as well as offshore. Some answers were incomplete e.g. “fertilisation occurs offshore” or “juveniles live in seagrass beds and estuaries”. Other answers used imprecise language e.g. newborn, young fish. Few references were made to females being able to change into males or that juveniles develop inshore to avoid competition with adults.

(ii) This question was generally well answered, with most candidates gaining some credit, usually for external fertilisation. Some candidates gave very general answers e.g. “they both have four stages in the life cycle” or “the life cycle takes place in the ocean”.

(iii) The idea of egg or larval wastage was a common answer and some candidates went into detail about the lack of parental care, but could only gain one mark. Fewer candidates made reference to the fact that eggs and fish were all in one place which would be known to fishermen and predators alike. A few candidates could not gain credit as they referred to general fishing for juveniles, for example “there were too few left to mature into adults”. There were few references to grouper taking many years to reach sexual maturity.

(b) This question was about gill adaptation and produced some excellent answers. Many candidates managed to gain partial credit for linking the demand for oxygen with the speed of the fish. However, often answers were only a comparison of pumped ventilation in grouper with ram ventilation in tuna and did not relate to gill structure at all. Answers which merely copied information from the table without reference to oxygen uptake or needs could not be credited. Terms such as respiration and breathing were often misused.

Question 3

(a) (i) Most candidates could state that benthic trawling was the method used to catch prawns. Incorrect responses included purse-seine fishing and dredging.

(ii) Some candidates described bycatch rather than answering the question. There were few references to mesh size or to the fact that there was a large number of organisms on the sea floor.

(iii) Most candidates gained at least partial credit, usually for stating that the bycatch was already dead or injured. There were fewer references to the destruction of habitats or that bycatch was released too far from their original habitat.

(b) There were many good answers referring to increased recruitment and reproduction and a number of candidates were familiar with the spill over effect. Some candidates had not read the question carefully enough and did not note that it stated that all commercial fishing was banned. They described quotas and closed seasons as ways of improving stocks. Others simply stated that “prawns won’t be caught” or used imprecise language, referring to thriving instead of stating that they had more food.

(c) The majority of candidates recognised that they had to give the pros and cons of each method. There was some confusion as to what satellites do, and many candidates thought that they were the same as sonar and could locate shoals of fish or prawns. Very few made the point that the technology would not show whether a boat was fishing or not. Inspection of catch was better understood, but some responses were more focussed on cost, training enough inspectors, enforcement and sanctions which could not gain credit.

Question 4

(a) (i) Most candidates had not processed the information given in the question that “seabass live in the sea and in estuaries”. Consequently, many answers for **(i)** and **(ii)** focussed on salinity changes and could not be credited. Credit was usually awarded for strong tidal flow causing damage to sea cages. Closeness to town and pollution was often mentioned, but answers were often vague about the nature of the pollutant.

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(ii) Candidates were asked to discuss the suitability of site B. Many answers focussed on the advantages and few mentioned any disadvantages. Some candidates used vague terms or gave incomplete answers e.g. the river water providing nutrients instead of food, or providing oxygen, but this needed to be linked to respiration. Others mentioned the high levels of silt, but this was not linked to damaging fish gills.

(b) (i) To gain credit, candidates were required to state and explain. Most answers focussed on answering one part or the other only. Some answers were again too vague, e.g. "farmed fish can harm or cause problems for wild fish", "waste can cause pollution". There was a misunderstanding by some candidates who thought that aquaculture meant fishing. Other candidates missed the fact that the effects had to be on the marine environment and gave answers that referred to jobs or the price of fish.

(ii) Stronger candidates were able to make sensible suggestions, giving enough detail about food sources, disease control or minimising the effects on the environment. Weaker candidates merely copied the information provided, or gave answers that lacked specificity or were about enforcement rather than advice or education.

Question 5

(a) Full credit was common, usually for "wind" and "temperature". Frequently seen incorrect answers included "upwelling", "warm/cold water" and references to the Sun, Moon and gravity.

(b) There were a few excellent and precise answers from candidates who had read and processed the information provided. In some cases responses were too vague, referring to affecting the temperature or failing to mention warm anywhere in the answer. Many candidates thought that the mackerel were passively moved by the current.

(c) Most candidates gained at least partial credit, usually for correctly stating that puffins competed with the mackerel for sand eels. Some candidates had not processed the information provided, did not mention mackerel at all and gave answers stating that sand eel numbers were reduced due to overfishing or due to pollution such as plastics.

(d) (i) Almost all candidates could name carbon dioxide as the main contributor to global warming. Incorrect answers included carbon monoxide, methane and carbon.

(ii) Partial credit was gained for stating that the temperature fluctuated, but many candidates could not expand on this point. Figures were sometimes quoted from the graph, but to gain credit there needed to be manipulation of figures. Some candidates misread the question and gave reasons why global warming was occurring. Several quoted the industrial revolution and fossil fuel burning since 1880, even in the absence of this evidence from the graph and went on to say that the temperature had constantly risen.

Question 6

(a) Although there were some strong answers to this question, some candidates struggled to express themselves clearly. There were some vague answers about people wanting different things about something, which could not be understood. Other candidates used the same wording as the question e.g. "conflict about something" or "different interests in something" which could not be credited.

(b) (i) Many candidates had a good understanding of the importance of mangroves and gained full credit. However, some candidates referred to shelter or homes instead of using the term habitat.

(ii) Stronger candidates correctly stated that application 1 would provide more homes to cater for an increase in population and that application 2 would increase the economy through tourism.

Question 7

(a) (i) The majority of candidates could use the information provided to state that farmed salmon contained more omega-3 than wild salmon.

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(ii) A number of candidates did not state that anchovies and sardines had the highest levels of omega-3, and instead only referred to them having high levels of omega-3. Only a few candidates mentioned that cod and tuna are high value species for human consumption.

(iii) To gain credit, a direct reference to the context of the question and the relationship between fishing and recruitment was required. Most answers were too vague e.g. “numbers of fish are decreasing”.

(b) Most candidates could state that omega-3 levels had decreased but to gain further credit there needed to be some manipulation of figures rather than just quoting figures from the table.

(c) (i) There was a wide range of answers for this question. The strongest candidates were able to give complete answers. Many managed to refer to a length/part/section of DNA but then did not go on to suggest proteins or characteristics. Incorrect reference to a strand of DNA was common. Weaker candidates mentioned phenotypes, genotypes and material passed on from parents to offspring.

(ii) Stronger candidates gained full credit. The most common error was to state growth gene, usually instead of promoter. Typical errors included DNA, RNA, genotype and phenotype.

(iii) Few candidates gained full credit, but partial credit, usually for “people do not want to buy it” was common. References to possible long-term effects on health or lack of research were rare. Many answers were too vague to gain credit e.g. “people are scared or sceptical of GM food”.

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Paper 9693/04
A2 Data-Handling and Free-Response

Key messages

In general the standard of answers was very good. Many candidates showed a detailed knowledge and understanding of all topic areas of the specification. Some candidates underestimated the level of depth required to answer A Level questions. Drawing conclusions from unfamiliar data was a challenge for some candidates. To improve, candidates should:

- understand the meaning of all command words
- ensure that answers have sufficient detail and that it is of an A Level standard
- identify patterns and trends in data series
- give explanations that are fully supported by data provided in questions
- check mathematical calculations carefully.

General comments

There were many excellent answers and the factual knowledge of many candidates was strong. Most candidates performed better on the free-response questions in ***Section B*** rather than data-handling questions in ***Section A***. Many candidates wrote very detailed, accurate accounts of osmoregulation, the effects of desalination plants, artificial reefs and the release of cultured stocks, and ecotourism. Weaker candidates often underestimated the level of detail required at A Level, and wrote vague answers with little scientific vocabulary. Some candidates found data-handling questions challenging.

Comments on specific questions

Section A

Question 1

(a) This question required candidates to explain why fishing intensity was higher around a marine reserve. Most candidates were able to correctly identify that the marine reserve would act as an area where fish could breed. Many went on to explain that fish would then migrate away from the area and so more fish could be caught in the regions close to the reserve. A few candidates thought that the fish would be harder to catch around the area and so would require more fishing effort there.

(b) (i) This question required candidates to recognise the change in grouper egg density within and outside the marine reserve. Most candidates were able to correctly state that the grouper egg density decreased with distance from the reserve. Only stronger candidates were able to identify that points were highly scattered and/or the points furthest from the reserve showed an increase in egg density. Candidates needed to examine data carefully to identify all subtleties.

(ii) This question required candidates to calculate the gradient of the line of best fit. A significant number of candidates were able to carry out the calculation correctly. Some candidates only calculated the decrease in egg density and did not divide by the distance.

(c) This was a challenging question and strong candidates were able to answer it well. Candidates were required to review the data critically and suggest whether it could be used to show that the marine reserve was beneficial for fish stocks. For full credit, candidates had to discuss supporting and opposing evidence. Many candidates recognised that egg density was high inside the reserve,

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but fewer went on to discuss **Fig. 1.2** in detail. Most candidates only focused their answers on how the data showed that the reserve was beneficial for fish stocks. Strong candidates explored how the data did not suggest that the reserve is helping fish stocks. A few candidates noted that there was no control experiment, no repeats or that other factors could be affecting the fish distributions. When answering 'discuss' questions, candidates are reminded to explore all aspects of data or information.

Question 2

(a) Most candidates were able to recognise that the lids on the tubes were used to prevent oxygen entering or leaving the solutions. Some candidates gave vague answers that referred to substances that may enter the solution or thought that water would evaporate. Candidates should always try to give precise answers and, if appropriate, name substances such as oxygen rather than referring to air.

(b) (i) This question required candidates to calculate a percentage change, which proved challenging for some candidates. Common mistakes included dividing by the BOD in August and dividing the August BOD by the January BOD.

(ii) This question required candidates to examine the effect of both fertiliser use and rainfall on the biological oxygen demand of water. At this level, candidates are expected to be able to process the effects of two different variables. Some excellent answers were seen that described the effects of fertiliser and rainfall on BOD, and then went on to give good, reasoned explanations of eutrophication. Some candidates suggested that algae consume large amounts of oxygen due to photosynthesis. Weaker candidates often simply gave a description of the effect of fertiliser and/or rainfall on the BOD and did not link it to an explanation. It is important that candidates fully understand the definitions of each command word: 'explain' requires candidates to give reasons for an observation rather than just describing it.

Section B

Question 3

(a) Most candidates understood that euryhaline organisms are tolerant of a range of salinities with only a minority confusing them with organisms that can only survive in a narrow range of salinities. A significant number confused osmoconformers with osmoregulators and others simply restated the question, for example, "osmoconformers conform to the water salinity". Some candidates implied that osmoconformers actively pump ions to keep their salinity the same as surrounding water.

(b) This question required candidates to explain how marine bony fish osmoregulate. Some outstandingly detailed answers were seen that fully explained the difficulties that marine organisms face when in water of high salinity, and how ion pumps are used to osmoregulate. Most candidates understood that sea water would have higher salinity than the body fluids, but only stronger candidates gave full, detailed explanations of the osmoregulatory process. Some candidates discussed fresh water organisms, and a few suggested that water would enter the organisms by osmosis when in sea water. A significant number of candidates confused ventilation with osmoregulation and so wrote detailed accounts of pump and ram ventilation methods.

(c) This question required candidates to discuss the effects of desalination plants on marine ecology. Many responses had a high level of detail, with many candidates discussing several consequences thoroughly. Most candidates recognised that desalination plants release brine back into the sea, that organisms can be sucked in, that toxins are released and that the turbidity of water can increase. A number of candidates thought that desalination plants are marine plants that remove salts from saltwater. Candidates should ensure that they are familiar with all the key terms in the syllabus.

Question 4

(a) Many candidates understood the role that conservation plays in protecting species or habitats and a significant number went on to explain how it prevents extinctions. Some candidates gave very vague answers that just referred to the protection of animals or organisms or stated that "conservation is the conserving of organisms". Candidates should try to avoid using words that are found in the question when giving definitions.

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(b) This question required candidates to compare the advantages and disadvantages of artificial reefs and the release of cultured stocks. Most candidates gained some credit on this question with many gaining full credit. Some excellent comparisons were seen that fully explored advantages and disadvantages of each method. A few candidates restricted their answers to only one of the two methods, and others did not compare the methods, instead giving descriptions. The most common correct answers were: recognising the risks of disease and lack of adaptation to the wild when using cultured stocks and explaining the role of artificial reefs as habitats, ecosystems and the risk of toxins leaking out.

(c) This question required candidates to explain how ecotourism can help to protect the marine environment. Several candidates discussed the generic role of ecotourism and did not relate it to the marine environment. Many excellent answers were seen that explored many benefits of ecotourism. Most candidates correctly described the role of ecotourism in education and raising funds for conservation. The most successful candidates gave a broad discussion of different effects of ecotourism rather than focusing on just one or two. Less successful candidates gave only one or two effects of ecotourism and kept repeating the same theme. On longer discursive essays, candidates should explore topics as fully as possible.

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