2023 ASSESSMENT REPORT

ESS315118 ENVIRONMENTAL SCIENCE

General Comment

The written exam was well received by candidates and teachers. Most candidates felt the exam paper was accessible and allowed ample scope for them to demonstrate their knowledge. Teachers appreciated the varying range of complexity in questions from those that assessed basic understanding through to questions that required greater analysis of interrelated concepts, as is the nature of Environmental Science.

In most cases, candidates provided very good answers. Where candidates performed poorly it was mostly due to inadequate or incorrect detail in their response. Candidates are advised to carefully read the questions, seek out exactly what is being asked of them and make connections to the course content they have covered during the year. This should provide scope for all candidates to attempt all questions.

Candidates are reminded to consider the command words (i.e., list, describe, explain) and highlight them during the reading time. Generally, answer 'explain' with the most amount of detail and as a rule of thumb, write in all the space provided.

Candidates can expect questions that have non-routine contexts, these are questions that use geographic areas or scenarios that are not covered in the course content. Candidates should read these questions carefully and identify exactly what is being asked and align this with content they have been taught and construct their response accordingly.

Candidates are reminded that the Information Sheet be used as a reference to assist them in constructing their responses. Responses that are written word-for-word from the sheet reveal little understanding of the required knowledge, and often yield little if any credit. Candidates should use the information and apply it to the question. It is also advisable for future candidates to equip themselves with an approved English dictionary, this may prove to be an invaluable asset if terms used in the question challenge their understanding of what is being asked.

Written Exam

The following section specifically comments on candidates' performance. Markers have offered suggested answers to each question, followed by specific comment on aspects such as how the question was assessed, where candidates gained or lost marks, where they had difficulty in interpreting the question, or where candidates failed to comprehend what was required to successfully answer the question. The suggested answers are by no means prescriptive. Candidates providing different but valid answers were rewarded accordingly as noted by the examiners.

Section A (Criterion 2)

Question 1

a) IV = Lead concentration (1) OR, amount of lead in water (1).

b) DV = Number of amphipods dead after 2 days (1) OR number of amphipods surviving after 2 days (1).

Lose ½ mark if 2 days is not included.

c) Hypothesis: Increasing lead concentration will decrease survival of amphipods OR Increase in the amount of lead will increase the number of dead amphipods OR Lead concentrations above a threshold level will kill amphipods. Other similar formulations of the hypothesis are also acceptable.

Mark allocation – 1 mark for causal relationship between IV and DV, 1 mark for identifying the direction of the response/threshold level of lead.

d) The experiment does have a control (1) which is tank 1 (½). A control is a treatment against which to compare experiment treatments (½) – in this case no lead (½).

Could argue that an appropriate control is the background level of lead in the environment (not provided in question) so control could be tank 2 or tank 3 if properly explained in answer for full marks. Simply stating lead as the control was not awarded any marks.

e) Any four of the following controlled variables (½ each): amount of water in each tank; temperature of water; source of amphipods; size/shape of tank; light environment of tank; colour of tank; other answers possible.

f) Reliability: there is only a single replicate of each tank (1) which means that results observed could be due to chance alone (½) e.g. comparing survival in tanks 1-3 (½) – need to have multiple replicates of each treatment (½) and use averages to increase reliability (½).

OR

Validity: treatment levels are unevenly spaced (1), from 0.02 mg/L in tank 3 to 0.10 mg/L in tank 4 (½). Without intermediate treatment levels it is not possible to determine whether response is linear (½) or if there is a threshold lethal level for lead (½) – would need to have more treatment levels between 0.02 and 0.10 mg/L to determine this (½).

Other possible answers might mention difference between response in laboratory to actual field conditions for which partial marks could be given but question does explicitly state "this experiment". References to ethics and other species was not awarded any marks.

Comments

Overall, this question was well answered, with many candidates getting full marks or close to full marks.

a) This question was well answered.

b) Mostly well answered; however, many candidates failed to add the time frame of 2 days and were only awarded ½ marks.

c) Many candidates had slightly incorrect DV carried over from b); however, this did not affect their ability to achieve full marks if the hypothesis had the key aspects outlined in the answer key.

d) Only satisfactorily completed as many candidates failed to explain what a control was or link to the control in the experiment given.

e) Well answered, most candidates achieved full marks as there were many possible answers.

f) Many candidates failed to refer explicitly to limits of the experiment, which reduced available marks.

Question 2

a) This type of long-term monitoring is used to determine changes/trends (½) in populations of long-lived animals (½) or those of commercial/ecological importance (½) to inform management decisions (½).

No marks were awarded for describing spotlight surveys, and only partial marks were awarded for descriptions of population properties.

b) All sampling methods have biases/assumptions (½) which affect the results (½). If the sampling method is changed, then results may change irrespective of any real changes in the number of animals (1). This will result in inaccurate/invalid interpretations of population trends (½).

c) Any two of the following (1 each): spotlights have a limited range and animals closer to the vehicle will be easier to spot; darker-coloured animals will be more difficult to spot than lighter-coloured animals; vehicle noise and/or light may scare some animals away; spotlighting will have different efficiencies in different habitats (i.e. easier in grassland than forest); some observers may be better/worse at spotting animals. Many other answers possible.

Emigration and immigration were awarded ½ marks as it was unlikely to have a large impact on the survey technique. Seasonal variation was also awarded ½ as this was not explicitly mentioned in the stimulus. Answers that merely stated the road was a poor area to complete a total count received ½ marks as the survey was intended as an estimate of density. Candidates that focussed on the length of the road received no marks.

d) There is a general decrease in the number of brushtail possums (1) from approximately 45/km2 in 2002 to 38/km2 in 2020 (½). However, the numbers are quite variable from year-to-year (½) with particularly high numbers of 65/km2 in 2005 and low numbers of 23/km2 in 2010 (½).

Need to provide data with some units from the graph to gain full marks. References to the carrying capacity were not awarded credit.

e) Any of the following (1 each): network of wildlife/trail cameras across Tasmania; mark-recapture studies (includes individual photo ID methods); citizen science style surveys and remote sensing were also awarded full credit if provided with some explanation.

Comments

a) Poorly answered. Many candidates failed to describe the purpose of baseline data and instead focussed on describing transect/spotlight/mammal sampling.

b) Poorly answered. Most candidates failed to connect variations between methods causing variables in data that cannot be compared over time.

c) Satisfactorily completed. Most candidates managed to name at least one limitation, but many answers confused estimates and proxy measures with total counts, which was not the intent of the original survey.

d) Satisfactorily completed. Most candidates could describe the trend, but many failed to refer to specific data from the stimulus.

e) Satisfactorily completed. Many candidates lost marks by not including some detail about their method e.g. remote sensing as a standalone answer was not awarded any marks.

Question 3

a) Hypothesis is framed as a question rather than a statement relating IV and DV (1). Hypothesis includes two separate IVs (and two DVs) (1).

Half marks were awarded about specificity of species and the identification of two IVs or DVs but not both.

b) Tomato plants will grow taller in lower light levels (or vice versa) OR Tomato plants/leaves will be greener in higher light levels (or vice versa).

1 mark for causal relationship, ½ for extracting one IV and one DV from question and ½ for direction. Partial marks were awarded for writing an appropriate hypothesis with both IVs and DVs.

c) Answer needs to include mention in each category for full marks. Will depend on hypothesis chosen on part b).

IV = light levels (measured in lux or photosynthetically active radiation [PAR] photon flux) OR temperature (°C). (1)

½ for IV, ½ for units, ½ for measurement techniques or clear groupings of treatments.

DV = colour of leaves (colour scale) or height of tomato plant (mm). (1)

Controlled variables = source of tomato plant (cultivar), initial size/age of plant, watering frequency, soil in pots, size of pots, temperature/light levels (only if not in hypothesis) etc. (½ per variable up to max of 2)

Replication: 3-10 tomato plants placed in identical environments except for changes in IV. (1)

Experimental treatment: replicate tomato plants placed in identical environments except for changes in IV. Could be temperature-controlled cabinets/rooms or light environments of specific light intensity. Grow plants for specified period sufficient to see differences (e.g. 14 – 60 days). (up to 2 marks)

Data collection: Measure height in mm at (e.g.) 14, 30 days using a ruler or compare colour of leaves against a standard colour chart. (1)

Comments

Overall, this question was poorly answered as most candidates misinterpreted the question to create a hypothesis a) and design an experiment c) that incorporates both IVs and DVs.

a) Mostly well answered.

b) Poorly answered. Many candidates misinterpreted the question to rewrite the hypothesis for the existing experiment which included two IVs and DVs.

c) Satisfactorily answered. Most candidates achieved partial marks in this question and there were many opportunities to gain credit in their answers. Full marks were possible even if the hypothesis from b) was incorrect; however, the inclusion of two IVs made it difficult to create a valid experiment. Some common errors that candidates made included:

- using seeds instead of plants
- not separating temperature variables when using sunlight as an IV
- small sample sizes (<3)
- not using accurate measurements and units for IV and DV. Note – plant 'health' was not awarded any credit.

Question 4

a) A baseline study provides a measure of conditions before any impact (½) against which changes can be assessed (½).

b) i) Any the following (½ for biotic, ½ for abiotic). Biotic: number of tree species, height of canopy, density of trees, number of understory species, density of understory etc. No marks were awarded for generic answers such as 'animal species' or 'vegetation'. Abiotic: light level, soil depth, pH, nutrient levels, soil compaction, rainfall etc. Many possible answers for each.

ii) Method needs to be appropriate for variable. E.g. quadrat or transect for number of species. (1) mark for appropriate method and (1) mark for description.

Comments

a) This question was not answered well by the majority of candidates. Most achieved partial marks, as some reference to comparisons or changes were required for full marks.

b) i) Poorly answered. Most candidates failed to name a clear biotic variable that was measurable.

ii) Poorly answered. Few candidates could describe any clear measurement methods for their chosen variable. Explanation of how they would measure/compare across time was required for full marks.

Question 5

a) Any two of the following (½ each): animals do not die during study, animals do not reproduce during study, animals do not move out of or into study area (all three reasons in category of closed population), discs are not lost/damaged, marked animals are equally likely to be caught/observed as unmarked, marked animals are not affected by marking, animals not territorial.

b) Any of the following (1): more efficient/less time-consuming than full count, allows population estimate where direct counting is impossible (*e.g.* whales), accuracy doesn't depend on measuring amount of suitable habitat.

c) Catch and mark animals (½), return and catch animals (½), count number marked and number unmarked (½), use (Peterson) estimator from proportion of marked animals to estimate population size (1): where N1 is initial number caught, N2 is recaptured number, M is number marked individuals in recapture (1 mark if equation provided).

Comments

Overall, this question was very poorly answered with many candidates leaving it blank and more than 30% of mark allocations were less than 1 mark out of a potential 4.

a) Many candidates misinterpreted numbers on the shells as the number in a total count and therefore missed key assumptions except for the mark falling off. Death of snails with no explanation was not awarded any marks.

b) Poorly answered. Many candidates misinterpreted numbers on the shells as the number in a total count and described measuring age/sex of individuals which was not awarded credit. Increased accuracy was awarded partial marks if explained correctly.

c) Poorly answered. Many candidates understood the steps required but not underpinning principles. Some clear explanation of the mathematics/ratio/proportional relationship between the marked and unmarked groups was required for full marks.

Section B (Criterion 5)

Question 6

a) Arrows represent flow of energy (1) and matter (½).

b)

i. Producer: Plant (½)
ii. Organism in third trophic level: shredders, fungi-feeding nematodes or protozoa (½)
iii. Decomposer: bacteria, fungi (½)
iv. Tertiary consumer: predatory arthropod or predatory nematode (½).

c) Any two of the following (1 each): Increase in the number of predatory nematodes as their only predator has decreased, decrease in the number of birds/animals as their prey numbers have decreased. Increase in the number of shredders – although picture shows an arthropod, this is not explicitly stated. Could also get diverse answers about decrease in number of root-feeding nematodes, fungi, bacteria if shredders increase in number or increase if shredders decrease.

d) Food chains are a simplified way of representing relationships between organisms (½), implying that organisms only eat one type of food (½). However, organisms interact with many other species (½), can feed or be eaten across multiple trophic levels (1). Food webs more accurately represent all the relationships in an ecosystem (½).

e) Organisms require energy to survive (½) which they obtain from their food (½). Most energy is used for maintenance (½). No energy transformation is 100% efficient (2nd law of thermodynamics) (½). Thus, the amount of available energy decreases at each trophic level, 10% rule (½) so there is simply not enough energy flux to sustain beyond a particular trophic level (½).

Comments

a) Mostly well answered.

b) Mostly well answered, some candidates confused tertiary consumers and the third trophic level.

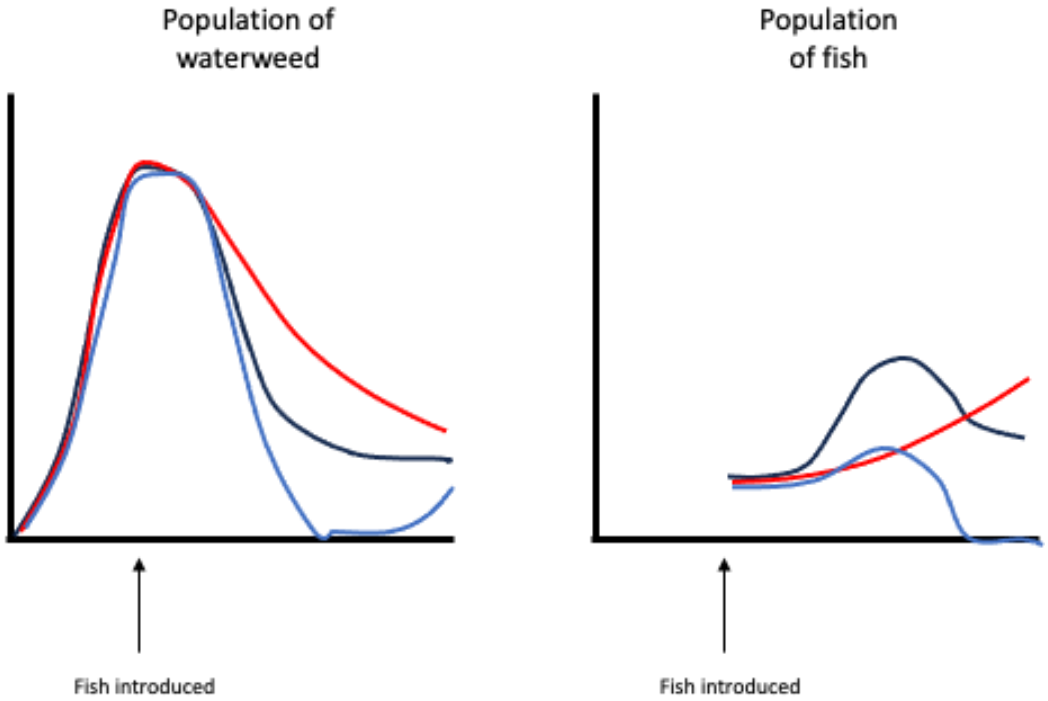
c) Mostly well answered, some candidates gave examples of a predator and a prey species that are affected by the reduction of predatory arthropods. Some candidates did not realise that the caterpillar is not part of the soil food web shown.

d) Mostly well answered, many candidates lost marks by omitting that species can be eaten across multiple trophic levels.

e) Mostly well done, some candidates did not explain why some species have no predators.

Question 7

a) Graphs should look similar to one of the following (black = most likely):



Mark allocation. Waterweed – one mark for approximately 'S' curve before fish, then one mark for approximate similar fall to carrying capacity. Fish – one mark for similar shape to above, ½ for only starting at arrow, ½ for smaller population size than waterweed.

Some possible variations: waterweed drops to near zero and fish die out completely; fish numbers still increasing at end of two years because reproduction rate relatively slow (shown by different colours).

b) Carrying capacity is the approximately stable population (½) where the number of fish can be maintained by the production of waterweed (1).

c) Negative feedback is where change in a system occurs in the opposite direction to the stimulus (½). Initially when a predatory fish is introduced, there is lots of resource (herbivorous fish) (½), which it will feed upon (½). Depending on reproductive rate the numbers of predatory fish may increase (½). The population of herbivorous fish will decrease (½) causing the population of predatory fish to decrease (½). A predator-prey cycle will be established (½) whereupon the numbers of both will fluctuate asynchronously (½) around each one's carrying capacity (½), mediated by the amount of resource (waterweed) available for the herbivorous fish (½).

Comments

a) Poorly answered as many candidates started the waterweed population at 100% and started the fish population at 0%.

b) Well done. Most candidates applied the term carrying capacity correctly to the dam example.

c) While satisfactorily attempted, most candidates did not explain the concept of "negative feedback".

Question 8

a) Ammonia (1)

b) Denitification (1)

c) Plants cannot directly absorb NO_2 (nitrite). They can only absorb NO_3 (nitrate) (1).

d) Bacteria are involved in many processes in the nitrogen cycle (½). Antibiotic use could decrease decomposition, nitrification or nitrogen fixation (1) leading to a build-up of dead organic matter, reduced nitrogen in the soil or reduced fixation (1).

Possible to get full marks by discussing only one of the three processes if explained fully.

Comments

a) Mostly well done.

b) Satisfactorily answered. Some candidates quoted the information sheet incorrectly.

c) Mostly well done. Many candidates knew that plants cannot directly take up nitrites.

d) Poorly attempted. Many candidates did not make the connection between antibiotics and bacteria.

Question 9

a) Generalist: Little forest bat, Louse fly, Ring-tailed possum or Sugar glider (½)

Specialist: Musk lorikeet or Swift parrot (½).

b) Most obvious example is Musk lorikeet and Swift parrot; however, Sugar glider and Little forest bat do share insects as a resource.

Interspecific competition is where two species use the same resource (½), in this case nectar for the Swift parrot and Musk lorikeet (½). For both species to persist, there will have to be some niche separation (½) *e.g.* they feed on nectar from different species of tree, different times or day or year (1).

c) Parasitism (Louse fly on any of the other species) (1), predation (Sugar glider on Swift parrot or Musk lorikeet chicks or Little forest bat on Louse fly) (1), possibly commensalism (sugar glider lives in hollow created by Ring-tail possums).

d) Fewer insects available in winter so they cannot gain enough energy (1).

Comments

a) Well done.

b) Reasonably well done, most candidates missed out on full marks by not mentioning that two species never occupy the same niche.

c) Poorly answered. Most candidates did not describe an interspecific relationship other than competition referred to in part b).

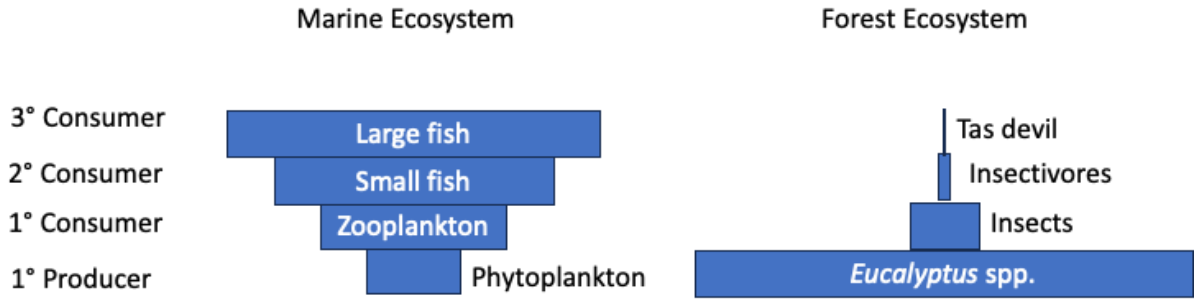
d) Mostly well done.

Question 10

a) Sun/sunlight/photosynthetically active radiation (PAR) from sun or similar (1).

b) Primary producer (½) uses photosynthesis (½) to create glucose from carbon dioxide and water (½) which is then converted into a variety of other molecules (e.g. cellulose, starch) for storage (½).

c) Diagrams similar to the following:



(Note that scales are different for the two ecosystems – not really possible to fit on same scale). Marking scheme for each ecosystem – ½ for correct orientation (producer at bottom), 1 mark for relative sizes correct, ½ for correct labels.

d) Biomass does not represent productivity/flow of energy (½). Both ecosystems produce biomass through photosynthesis (½). However, phytoplankton grows rapidly and produces biomass but it is eaten almost as soon as it is produced (½). *Eucalyptus* lays down much of its productivity in structural material (lignin/cellulose) (½) which is not eaten and accumulates (½). Energy flux through both systems is similar (probably greater in marine) but variation in rate of consumption (½).

Comments

a) Mostly well done. Some candidates incorrectly stated producers and not the sun as the ultimate source of energy.

b) Mostly well done. Most students missed full marks by not stating where the energy is stored in either of the chosen ecosystems.

c) Mostly well done. Some candidates did not adhere to the convention of using approximate scale of data provided to construct pyramids.

d) Poorly answered. Most candidates were unfamiliar with the concept of energy flux.

Section C (Criterion 6)

Question 11

a) South-east Australia (could say Vic/NSW but this level of detail not necessary) or circled on diagram (1).

If candidates indicated the whole SE area of Australia or only the NW coast of Australia, then they only received ½ mark.

b) Displaying changes at a decade scale shows the long-term patterns (½), removing the effects of shorter time-scale changes such as ENSO (½) or anomalous years (outliers) (½). This is

important for showing overall/average warming patterns (½). However, it doesn't show extreme events or seasonal differences (½) which may be biologically important (½) if organisms are living near their physiological limit (½).

c) Any two of the following (1 mark each). Abiotic: changes in weather patterns due to warmer waters such as intensity of sea breeze or frequency of storms; changes in currents due to density of water; changes in oxygen saturation. Biotic: colonisation of warmer water species (*e.g.* long-spined sea urchin, yellow-tailed kingfish); survival and reproduction of warmer water species over winter; loss of cold-adapted species (such as giant kelp); disruption of seasonal mating patterns dependent on temperature cues. Many other answers possible.

d) El Niño is caused by increased SST in the central and eastern Pacific causing weakening of east-west trade winds (½) leading to reduced rainfall, warmer temperatures and other changes in eastern Australia (½). La Niña is the reverse situation (½). Thus, warmer waters in the Pacific in general would be expected to increase the intensity (½) of El Niño events and decrease the intensity of La Niña (½). However, warmer waters off Australia might decrease the temperature gradient and reverse some of these effects (½).

Comments

a) This part was very straightforward with the majority of candidates identifying the correct area. A significant number of candidates were too broad in their answer, identifying larger areas in the two greatest categories of warming rather than just the top category.

b) Almost all candidates obtained marks on this section by identifying the smoothing effect of using longer time scales to show trends and the elimination of seasonal data or ENSO. However, only three achieved full marks by considering possible problems caused by averaging such as those provided in the solutions (e.g. missing extreme events which may have major biological effects).

c) This question was poorly answered with few candidates gaining both marks. Many candidates provided generic responses about the effects of SST without any reference to Tasmania – about 50% suggested that coral bleaching would occur as a biotic change. Others were confused at the difference between biotic and abiotic changes, although this generally didn't affect their mark allocation as either type of change was acceptable. Very few candidates provided a Tasmanian-specific example; so marks were given for more generic responses.

d) Most candidates attained some marks in this part and could gain credit for connecting a change in intensity or frequency in ENSO events in a logical manner to the physical processes occurring due to warmer water (e.g. increased evaporation).

Question 12

a) A and D are only about 100 km apart in terms of north-south distance (½) so seasonal changes in day length will be very similar between the two locations (1) with longer nights in summer (½) and shorter nights in winter (½)

OR

Because locations are not very far apart in latitude (½) changes in the amount of solar radiation received will be very similar (1) with more solar radiation in summer (½) and less in winter (½).

Up to a total of one mark was given for providing information on similarities between locations without describing seasonal variation.

b) Although precipitation varies seasonally, it is highly dependent on local topography (½) and altitude (½). Location A would be expected to have different patterns of rainfall (½) and receive considerably more snow in winter (½) than location D. Salinity (½) or water stratification (½) at location D might be expected to change seasonally due to freshwater input from upstream (½) whereas location A would remain constant (½). Water levels (½) at location D would change daily due to tides (½) with amplitude varying monthly (½) whereas water levels at location A would change more slowly (½) due to freshwater input from the surrounding catchment (½).

   Up to a total of one mark was given for providing information on differences between locations without describing seasonal variation.

c) Location C would be the most challenging for aquatic organisms (1). Since it is in a tidal area, there will be daily changes in exposure to water and air for non-motile organisms (½), leaving organisms vulnerable to desiccation (½). For motile organisms, they will have to move with the tides (½). Location C also receives freshwater input from upstream and saltwater input from tides (½) so salinity will change unpredictably (½), leading to difficulties in osmoregulation (½).

   If a different location was chosen as the most challenging, follow-on marks were awarded up to a total of 2½. *E.g.* Location D would be most challenging due to urbanization (½), pollution from industries such as heavy metal extraction (½), noise pollution (½), interactions with vessels (½) or sewage discharge (½). Location A would be most challenging due to lower temperatures (½) or ice formation in winter (½).

Comments

In general, this question was poorly answered, with the marking scheme adjusted in parts a) and b) to give credit for similarities and differences without considering seasonal variation.

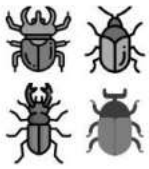
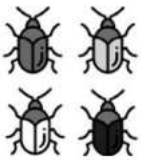
a) A number of candidates were confused about the changes in abiotic factors across geographic locations – e.g. stating that the higher altitude location would be warmer as it was closer to the sun. Many candidates only addressed similarities at one point in time rather than describing seasonal cycles.

b) Similarly, most candidates identified abiotic differences between the locations, but many failed to identify seasonal changes.

c) Most candidates gained some marks for identifying challenges to aquatic organisms due to their location – about half recognised that daily changes in salinity and exposure due to tides would be the most physiologically challenging at location C. Lack of detail about the mechanisms responsible restricted marks for many candidates. Some candidates misinterpreted aquatic organisms as purely marine organisms.

Question 13

a)

Example	Type of Biodiversity	Definition
	Species (½)	The number and relative abundance of different species in an ecosystem.
	Genetic (½)	The number and relative abundance of different gene variants in a species (½)
	Ecosystem	The variety of different habitats, communities and ecological processes (½)

b) Habitat loss or degradation may lead to smaller populations of organisms (½) which will contain less genetic variation through simple probability (1), causing "genetic bottlenecks" (½). In addition, populations may be isolated from other populations (½), leading to reduced gene exchange (1) and/or inbreeding depression (1). Fewer species will reduce overall species numbers (½), so less total genetic diversity (½).

Comments

a) This part was relatively straightforward with support for correct answers on the information sheet. The majority of candidates received at least 1 mark for this part, with many getting full marks.

b) This part was poorly answered with many candidates only considering the number of species present and not intraspecific genetic variation related to population size. A considerable number of students described the process of evolution to a changed environment without considering overall genetic variation.

Question 14

a) Fallow deer have no natural predators (½) and an abundant food supply (½) in Tasmania, they have similar conditions in Tasmania to Europe (½) and they are successful breeders (½). They have taken over a previously unoccupied niche (½) and this is a broad niche (½) as they have adapted very well to a range of conditions, resources and habitats in Tasmania.

b) Any of the following: remove bark from young trees, overgrazing plants and stopping forest regeneration (½), browsing on particular plant species, reducing population (½), which may lead or exacerbate endangered species (½), creating open spaces in vegetation for invasion by non-

native species (½), reducing vegetation available for food for native browsing species (½), reducing cover and degrading habitat, thus making them more vulnerable for predation (½), altering habitat through soil erosion (½) and trampling of vegetation from their hooves (½).

c) Fallow deer could be controlled by direct removal (e.g. aerial or ground shooting) (½). This is effective (½) and has the benefit of not harming any other species (½) but resource and time intensive (½), with risks to other humans in the bush (½) and ethical implications (½) for the deer if they are not killed with the first shot (½).

OR

Fallow deer could be controlled by poisoning (½). Difficult to find a suitable poison that does not affect native animals (½). Baiting is very resource-intensive (½), unlikely to work across all habitats (½) and likely causes animal suffering (½). A great deal of research is needed before a suitable bait is approved adding to its cost (½) and this makes it unhelpful to reduce deer numbers this year (½).

Other answers were possible. Marks were allocated as ½ for naming an appropriate technique and 1½ for discussion of both advantages and disadvantages.

Comments

a) Most candidates performed well in this question although no marks were awarded for candidates that stated fallow deer are an 'introduced species' as this was clearly stated in the question. Many candidates also stated that fallow deer have bred rapidly and have many young throughout the year; both points are incorrect. Fallow deer have only one fawn each year (twins are very rare) and only breed in the spring. The deer have however been successful breeders (½) because of the lack of predators and abundant resources.

b) This part was mostly answered successfully; however, both plants and animals were needed to be mentioned for full marks. Often native animals were omitted thus a maximum of 1½ marks could only be awarded.

c) The command word 'Evaluate' was ignored by almost all candidates thus full marks were rare. Evaluate is given on the front page of the information sheet as, 'assess the limitations and implications'. Unfortunately, most candidates commented on only the benefits of their chosen control method without considering any limitations. A large number of candidates suggested that a predator should be brought to Tasmania. This was disappointing as candidates should know that wolves, coyotes, or dingoes should not be introduced to Tasmania.

Question 15

a) CO_2 levels remained relatively constant (½) with small fluctuations (½) at approximately 280ppm (½) from year 0 to year 1600 (½), at which time there was a small dip to 270ppm (½). From 1800-2000 levels rose exponentially (½) to approximately 380ppm (½).

If no gas levels were mentioned, then candidates could achieve a maximum of 1½ marks.

b) Methane concentration in Year 0 is 700 ppb (½) (725 or 750ppb also accepted) and in the year 2000 was 1250 ppb (½) (1200ppb was also accepted but 1300 ppb was not). Change is the difference between these values 1250-725ppn (½) or 500 ppb (½) (525 and 550 were also accepted).

If units were missing or incorrect a ½ mark was removed.

c) Main method for reconstructing past GHG levels comes from ice cores (½). Ice traps bubbles of air (½) which can be extracted and levels of oxygen isotopes (½) and GHGs give the temperature and GHG levels of the ancient air (½). Age of the ice core layer is done by counting annual layers, carbon dating, chemical analysis or mathematical models (½). Proxy measurements (½) include using coral growth, sediment cores from the ocean floor, pollen analysis or tree rings (½) which are related to GHG gas concentrations in mathematical models (½) based on current relationships between these variables and GHGs (½).

d) GHGs increase mean global temperature (½). Short-wavelength solar radiation passes through the atmosphere (½) and warms land and water (½). These warmer bodies re-radiate at longer wavelengths (½), infrared wavelengths (½) of heat (½) which are reflected back by GHGs (½) and trapped in lower layers of the troposphere (½).

e)

i. Sea levels will rise (½) because of thermal expansion (½) and melting of ice caps on land (½). Stating melting of sea ice or icebergs as a consequence achieved no marks as this does not alter sea level.

ii. Timing of seasonal biological events will change (½) and often will become mismatched (½). Bud burst and spring flowering will occur earlier (½) and animals may migrate (½) and hibernate at different times and locations.

Comments

a) Most candidates performed well in this question.

b) Very few candidates achieved full marks because the different vertical scales were confusing. Using highlighters for each line and its matching scale, is recommended during the 15-minute reading time.

c) Most candidates performed well in this question.

d) This question was very poorly answered. Most candidates mentioned the ozone hole and became very confused. The greenhouse effect occurs in the troposphere more than 10 km below the ozone hole which is found within the ozone layer in the stratosphere.

e)

i. Most candidates performed well in this question.

ii. This was a difficult question for many candidates. No marks were awarded if the 'biological events' were not clear. No marks were awarded for El Nino or La Nina or other abiotic changes; unless they were clearly related to biotic events.

Section D (Criterion 7)

Question 16

a) Any three ecosystem services from the following provisioning, regulating, cultural or supporting services (½ for naming, ½ for description): water purification through removal of nutrients/pollutants; flood mitigation through water storage and controlled releases; improvement of air quality through removal of pollutants and adding oxygen to the atmosphere; nutrient recycling through bacteria & fungi; local climate control through heat absorption and release, shade etc; supporting soil formation, carbon and water cycling; food from animals or plants; timber or fibre from trees and plants; drinking water from storage; recreation in forest or water body; mental/physical wellbeing through nature; cultural significance to indigenous peoples; educational importance. Others answers possible.

b) Cultural services include spiritual & religious values, physical & mental wellbeing, and opportunities for recreation (½ for outlining this and another 1½ for explanation). Construction of a road could directly destroy cultural artifacts/sacred places (½), disrupt enjoyment of the habitat and serenity through noise or pollution (½) and it may reduce the intrinsic aesthetic value of the habitat (½).

Comments

a) This question was answered well by the majority of candidates. However, many candidates listed services directly from the information sheet and provided no description – ½ mark per service was the maximum awarded in this case. Some candidates listed "food", "air", "sunlight" but did not state the service and were awarded ½ marks only for each of these. Some simply stated "provisioning", "regulating" and "cultural" and again were awarded ½ mark for each.

b) This question was generally well answered, but some candidates lost marks for failing to explain what "cultural services" mean (only a maximum of 1½ marks awarded in this case) or did not explain how cultural services specifically may be impacted if a road was built, and instead discussed general impacts on the ecosystem such as "scaring wildlife" or "increased pollution". No marks were awarded for these answers.

Question 17

a) Any four of the following (½ mark each): methods of transport and distance travelled; size of housing and construction materials used; diet type, food wastage and food miles; agricultural techniques (*e.g.* farming meat); mining practices; deforestation; energy usage; population size; generation and types of wastes; water consumption; use/misuse of resources. Other answers possible.

b) Bangladesh has the smallest footprint. (1 mark)

c) Any two of the following (1 mark): different size of populations; different levels of source, type and amount of consumption of food; different levels of energy usage and types of energy used for transport, heating/cooling; different amount of disposal income available; countries GDP.

d) ½ for identifying plausible method, 1½ for full description. Many answers possible.

Example: Decrease consumption of meat (½). Meat rearing requires high levels of food (½), water (½) and energy input (½). Eating a plant-based diet will reduce the amount of these inputs as the metabolic costs of the animal are eliminated (½).

OR

Increase energy efficiency of homes (½). Providing insulation (½) will reduce the amount of energy needed to heat or cool the home (½), as will appropriate design for the climate conditions (½) e.g. large overhanging eaves in hot climates or double-glazed windows in colder climates (½).

Comments

a) Many candidates chose to copy the information provided in the information sheet (page 10) to answer this question and named four factors from the list. Only one mark out of two was given in this case. More information was needed than stating "food", "water", "housing" and "transport"; for example, "type of food eaten-less red meat", or "amount of water used", "material used in houses or size of house" and "mode of transport or distance driven in a car". Some candidates named "fossil fuels" or "pollution" as factors without any context, such as "burning of fossil fuels" or "amount and type of pollution generated by households, cars etc". Overall, the question was done well by most candidates.

b) This question was answered very well, but a few candidates chose to name two countries (Bangladesh and the Solomon Islands) from the table and were awarded no marks.

c) This part was answered well by most candidates with "population size", and "the country's GDP" most commonly suggested as two reasons. For the full 2 marks, each of these reasons needed some information to apply to how it can contribute to variations in Earth Overshoot Day, such as "with a higher population living in a smaller area, each person will contribute more waste, use more water, use more building materials etc".

d) This was answered well with most candidates able to describe one method of reducing a country's ecological footprint. For two full marks, a detailed description of one method was needed-most candidates discussed dietary changes, reducing food and clothing waste, better education and ride /walk or take public transport to reduce GHG's. Some candidates chose to discuss more than one method in less detail and were marked on their first response only with 1 mark awarded, as the question asked to describe **one** way to reduce ecological footprint for 2 marks.

Question 18

a) Superphosphate in **soil**: is a pollutant.

Superphosphate in **water**: is a pollutant.

It is man-made and causes harm in each environment.

b)

Property	Answer
Point Source	NO
Biodegradable	YES
Persistent	NO
Biomagnification	NO

c) High levels of phosphate in waterways will cause eutrophication (½). Phosphate is often the limiting factor for algal growth (½), so additional phosphate stimulates increased production of single-celled algal (and sometimes aquatic macrophytes) (½). When these organisms die, they are decomposed by micro-organisms such as bacteria (½) which consume dissolved oxygen (½). The resulting anoxic water (½) will result in the death of multi-celled organisms such as fish and frogs (½).

d) Similarities: both are spread over entire crop (½) and are transported by precipitation run-off into waterways (½). Both cause harm to organisms and the environment.

Differences: neonicotinoids (NN's) do not cause eutrophication in the waterways (½). NN's cause direct mortality to arthropods (½) on the crop. NN's are taken up by aquatic invertebrates and killed (½) and also bioaccumulate (½) in their predators, meaning that levels increase going up the trophic levels (½).

Comments

a) The first part of this question was answered incorrectly by nearly all candidates, stating that superphosphate in the soil is a contaminant rather than a pollutant, giving them only ½ mark out of 1 for this question. The second part of the question (are superphosphates a pollutant or contaminant in water) was answered correctly by most candidates. Some candidates wrote "yes" and "no" for each part which was awarded no marks.

b) With identifying the properties of phosphate in the waterway, most candidates correctly answered "NO" to it being point source, but the remaining properties (biodegradable, persistent, biomagnification) had a mixture of correct and incorrect answers, with being persistent and biomagnifying the most incorrectly answered. Very few candidates gained the full 2 marks for this question.

c) For 3 marks, candidates needed to give a full explanation of the process of eutrophication, explaining how it occurs and the effects on the abiotic and then biotic components of the waterway, including higher order consumers. A very common incorrect answer was a detailed

discussion about phosphates entering into the bodies of organisms and biomagnifying up the food chain. This was after these candidates said "NO" to phosphates biomagnifying in the first part of the question.

d) This question proved difficult for most candidates, and not many achieved the full 3 marks. One similarity and two differences were needed. Common incorrect similarities that were named were that neonicotinoids and superphosphate both biomagnify, or both biodegrade. Many struggled to discuss two differences or did not identify which was the difference and which was the similarity, or which compound they were actually referring to.

Question 19

a) Prior to 1978, there were no reported commercial catches of Orange Roughy (½). From 1978-1990 catches increased in an approximately linear form (½), peaking at 90,000 tons in 1991 (½) due to increased fishing efforts and improved technology (½). Orange Roughy are long-lived, and this catch was unsustainable – fish were taken at a faster rate than could be replaced in the population (1). This is shown by the sharp decline to 45,000 tons in 1993 (½) and thereafter, a slower decline to 12-13,00 tons in 2009 (½).

b) Any two of the following (1 mark each): decrease fishing effort by limiting numbers of commercial boats or limiting number of fish/tonnes of fish caught; change size of nets used or size of mesh in the nets to catch less fish, or to capture only larger mature fish; enforce open and closed seasons to avoid fishing during spawning periods or enforce bans on taking of vulnerable species (whether total ban or a temporary ban); introduce size limits on species to allow for larger more mature fish to be taken; return females with eggs/roe back to the ocean; ban or reduce the use of unselective fishing gear such as long lines and beam trawlers; use more conservation modelling of maximum sustainable yield (MSY), or set targets below MSY's; provide more marine conservation or protected areas. Other answers possible.

Comments

a) This question was answered relatively well by most candidates. However, marks were lost for not using the data on the graph - such as no reference made to production amounts in specific years (only 1½ marks were awarded if no data was used) and not explaining **why** changes in production amounts occurred prior to 1990 and after 1990 (1 mark lost for no explanation). Some candidates gave vague answers such as "numbers quickly increased and then slowly decreased".

b) This part of the question was answered well, with most candidates being able to outline two strategies to make wild capture fisheries more sustainable. If answers were brief such as "enforce fines" or "catch limits" only ½ was awarded to each of these and if more than two were listed, only the first two were marked and awarded ½ each. Some candidates mistakenly referred to strategies to make aquaculture more sustainable and received no marks.

Question 20

a) ½ mark for identifying the advantage/disadvantage and 1½ marks for the explanation.

Advantages: Energy supply can be produced by renewable sources (½). Electricity to charge the batteries (½) can be made by renewable sources such as solar or wind (½) without the reliance on fossil fuels and the greenhouse gas (GHG) emissions produced from burning these (½)

OR

Air pollution can be greatly reduced (½) as electric vehicles do not emit nitrous oxides, CO, O_3 (½) or other pollutants, produced by combustion (½) of fossil fuels (½)

OR

Large numbers of electric vehicles represent a distributed electricity storage solution (½). As each vehicle stores a considerable amount of electricity (½), large numbers of vehicles can supply power back to the grid locally (½) if there are problems with supply (½).

Disadvantages: Large amount of infrastructure (½). Both the production of electricity (½) and its distribution/charging (½) requires large amounts of concrete, steel, rare earth metals etc. (½) which themselves need energy for production and mining (½).

OR

Manufacturing electric vehicles (EV) can increase GHG emissions (½). Construction materials such as steel used in EV's (½) all have emissions associated with production (½) - large amounts of EV's may increase overall emissions unless renewable energy sources are used in their production (½).

b) Any two of the following (1 mark each); increased public mass transport such as trains and buses (including electrical versions); increase home working to decrease commuting; encourage recreation and vacations closer to where people live rather than overseas trips: reduce air travel or switch to renewable fuel *e.g.* hydrogen. Other answers possible.

Comments

a) This question was answered well by the majority of candidates, but many candidates did not provide enough detail to gain the full 4 marks. Most were able to give one advantage and one disadvantage for ½ mark each but lacked information to explain these. For example, an advantage commonly stated was "reduces GHG's so cleaner for the environment", and a disadvantage "uses rare earth minerals which damage the environment" but an explanation on how GHG"s are reduced and how rare earth minerals damage the environment was not given. Only 2 marks out or 4 were awarded for such answers. Only a few mentioned the disadvantage of electricity used to charge EV's comes from burning fossil fuels such as coal (unless you live in Tasmania).

b) This question was well answered by many candidates, but a large number misinterpreted the question to read "suggest two other ways using **EV's** help reduce environmental impacts" and so answered "make no noise" or "can charge at home so don't have to drive to find a charging station". These responses were awarded no marks as the question clearly asked for two **other** ways the environmental impacts of transport can be reduced. If candidates gave brief answers like "carpooling" or "public transport" ½ mark for each was awarded only.

Question 21

Candidates needed to discuss at least one advantage and one disadvantage for the full marks.

Recirculating aquaculture systems may require considerably more infrastructure (filters, sterilizers, pipes, tanks versus sea cages) to produce the same biomass of fish (1) making this business more expensive to set up initially. Thus, the running-costs of production are likely to be higher, perhaps making fish protein unaffordable (1). However, all pollution (e.g. excess nutrients/faeces) is contained within the system (1) and can be used for other purposes rather than lost (such as agricultural fertiliser)

(1). Fish cannot escape and impact on wild populations (predation, competition) (1) nor pass on parasites and diseases (1). Water is recirculated and oxygen pumped into it, so fish remain in clean, oxygenated water (1).

Comments

This question was answered well by candidates, as the diagram was helpful for information and most achieved the full 4 marks. However, there were some candidates who discussed the advantages of land-based systems and the disadvantages of the marine aquacultural industry and were awarded 2 out of 4 only. As the question asked to evaluate, positive and negative arguments of land-based aquaculture were needed (at least one of each). The discussion also needed to compare these advantages and disadvantages to marine aquaculture. Some students added their own personal opinions about marine based aquaculture, which were not awarded credit.

Section E (Criterion 8)

Question 22

a) Legal protection may directly protect a species which is exploited by humans e.g. for food, garden plants, souvenirs etc. by deterring or limiting collection (1). Additionally, it may place an onus on landholders or the government to consider the impact on the endangered species of any proposed development (1).

b) Require at least one advantage and one disadvantage for each species for full marks.

Graveside leek orchid: Advantages – can cover entire habitat where species is currently found (1), easy and cheap to implement (1). Disadvantages – protected areas will not mitigate risks from any other threats such as climate change or disease (1), need to liaise & negotiate with private landowners (1).

Swift parrot: Advantages – will maintain ecosystem integrity and protect breeding populations (1). Disadvantages – Swift parrots nest in different locations each year, so network of protected areas will have to be enormous to cover all possible nesting sites (1), does not mitigate risks from other threats such as predation by Sugar gliders (1), does not mitigate risks during migration or periods where parrots are not in Tasmania (1), potential conflicts with other land-use such as forestry (1).

A disadvantage for both species is the fact that a protected area only supports the species whilst it's within the area (1). If the Orchid or Parrot are outside the region they will not be legally protected. Could use legislation instead to protect the species. (1)

Comments

a) Most candidates gained at least one mark on this question; however, many responses simply stated a reason without giving an explanation.

b) Very few candidates addressed both species and did not give an advantage and disadvantage for each. Many candidates simply wrote general statements about conservation areas and only gained part marks.

Question 23

a) Water allocation/amount of water/water released into Murray-Darling (M-D) or similar (1).

b) Can be argued that it is a Tragedy of the Commons (TotC) or not – both possible answers require consideration of issues of water extraction and management.

Environmental conditions in the Coroong is not a TotC (1). While water is removed from the river system by human activities (1), this abstraction is controlled and not a 'free-for-all' (1). Allocations are set by government authorities (1) and environmental conditions in the Coorong may simply be a result of the fluctuating water environment of Australia (1).

OR

Environmental conditions in the Coorong is a TotC (1). Too much water is taken out of the river system (1) compared to natural flow conditions (1). While there is allocation of water, this is not shared equitably (1) and there is no incentive to not use full allocation (1).

c) Full-cost pricing is where the end users pay for loss of environmental or ecological values (1). In this case, crops grown in areas irrigated by water from the M-D would have a higher cost (1) to restore degraded systems (1) or reduce total demand (1). User pays principle applied, in which more water use equates to higher costs (1).

d) Alternative strategies could include: government incentives (cash, land etc.) (1) to move farming communities out of food production and restore natural vegetation (1) OR creation of National Parks/other forms of protected areas (1) as alternative livelihoods for local human population (1) OR construction of large amounts of water storage and transfer infrastructure (1) in order to move water around during periods of low rainfall and sustain river flows. Improvements in irrigation technology such as drip systems or soil moisture monitoring (1) Other answers possible.

Comments

a) Most candidates gained the full mark for this question.

b) This was not answered well, with only a few candidates gaining full marks. Many responses missed the fact that water is managed within this region by the Murray-Darling Basin Authority and therefore the commons does not have free, unmanaged access.

c) Generally answered well by candidates. Many responses clearly linked full-cost pricing to the scenario and gave examples.

d) Most candidates performed well in this question.

Question 24

a)

Principle	Example
Intergenerational equity	Coffee growing will result in diminished land productivity (½), lack of future access to rainforest resources (½) and pollution from waste material (½)
Intragenerational equity	Only a few landowners benefit from money generated by coffee (½), while other people who might have used the land for hunting or gathering now have no access to resources (½).
Conservation of Biodiversity	Many species have been replaced by a monoculture = direct loss of biodiversity (½), together with any species (insects, vertebrates) dependent on the cleared species (½).
Pricing of Environmental Values	Cost of coffee produced does not reflect the loss of ecosystem services (½) and biodiversity (½).

b) Many answers possible – must relate to example in part a). Examples include:

- Intergenerational equity – profits from growing coffee invested in a future fund (1) used to provide benefits to subsequent generations – education, housing etc. (1)
- Intragenerational equity – establishment of co-operatives to produce coffee (1) where profits are provided to all community members. (1)
- Conservation of biodiversity – use understory growing model (shade coffee) (1) where minimal tree clearing is used and coffee is grown in conjunction with other species. (1)
- Pricing of environmental values – use full-cost pricing (1) and sustainability certification/auditing to ensure environmental values are retained. (1)

Comments

a) Most candidates gained marks for the first three principles. Responses for the last principle often missed the link between price of coffee and the environment.

b) Candidates generally gave good suggestions as to how the coffee could be grown in a more sustainable manner and received at least part marks.

Question 25

a) Global plastic production has increased exponentially (½) from 0 in 1950 to over 450 million tonnes in 2019 (½), with small dips in 1975 and 2009-10 (½).

b) Many different strategies – need at least two for full marks with a description, not just statement. E.g. Increased recycling (½) where used plastic is collected and reused (½), reduction in use of plastic materials (½) for packaging, manufacture etc. (½), replacement of plastics (½) with other materials such as corn starch (½).

Comments

a) Most candidates performed well in this question.

b) This question was answered well with many candidates gaining the full 3 marks.

Question 26

a) A social licence to operate (SLO) is acceptance by the community of stakeholders of the desirability and necessity of a proposed development (1).

b) Any four of the following (½ each): local farmers, residents within view of the wind farm, bird conservationists/ornithologists, local business owners, local council, state government, tourism operators.

c) Need to include at least one biotic and one abiotic factor for full marks.

Abiotic. Contamination of soil with pollutants from construction (1), contamination of marine waters with pollutants from construction (1), disruption of local microclimate through changed wind speed or direction (1).

Biotic. Interactions with bird species including death by striking turbines (1), disruption of bird migration routes or loss of feeding habitat (1), loss of habitat for species due to the construction footprint of wind turbines.

Other answers possible.

d) Any three of the following:

- Cost-benefit analysis (½) – how much would local and state communities benefit from construction of the wind farm versus the costs of environment degradation (½)
- Societal benefit (½) – how much employment would result (½) and would profits be distributed or retained by few (½)
- Impact on visual or other aesthetic amenity (½) – how many stakeholders would be affected and their views on the wind turbines (½)
- Necessity of project (½) – is the project needed by Tasmania/Australia to meet climate change commitments? (½)
- Longevity of the project (½) – will the project provide benefits in the longer-term or only the short-term? (½)
- Logistics/feasibility study (½) and construction process e.g. Foundations and powerlines (½)

Many other answers possible.

Comments

a) Most candidates performed well in this question.

b) Most candidates performed well in this question and clearly identified 4 relevant stakeholders.

c) Very few candidates gained full marks in this question. Many responses did not consider factors that were relevant for the environmental impact of the project, and instead discussed what would make the project effective such as amount or speed of wind. Many candidates did include migratory birds for a biotic factor and were awarded marks for that answer.

d) Very few candidates gained full marks in this question. A significant number of responses simply wrote out considerations that would be found in an Environmental Impact Assessment or an Environmental Management Plan and copied directly from the information sheet.