Past-paper walk-through

Ecological Tolerance ▪ 2.4

eXercise

Questions in this set

- 2024 Set 1 Q1
- 2023 Set 1 Q2

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

2024 Set 1 ▪ Q1

Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

[Diagram: a cross-section of a stream divided into five vertical zones (A through E) labeled left to right, with "Direction of Streamflow" arrow pointing right along the bottom axis. The y-axis (unlabeled numerically) ranges from "Low" at the bottom to "High" at the top, showing two curves: a solid line for "Dissolved oxygen" and a

Question 1

dashed line for "Biological oxygen demand". Common fish/macroinvertebrate species listed above each zone:

- Zone A: adult fish; mayfly, stone fly, and caddis fly larvae
- Zone B: blackfly and midge larvae
- Zone C: sludge worms; midge and mosquito larvae
- Zone D: adult fish; blackfly and midge larvae
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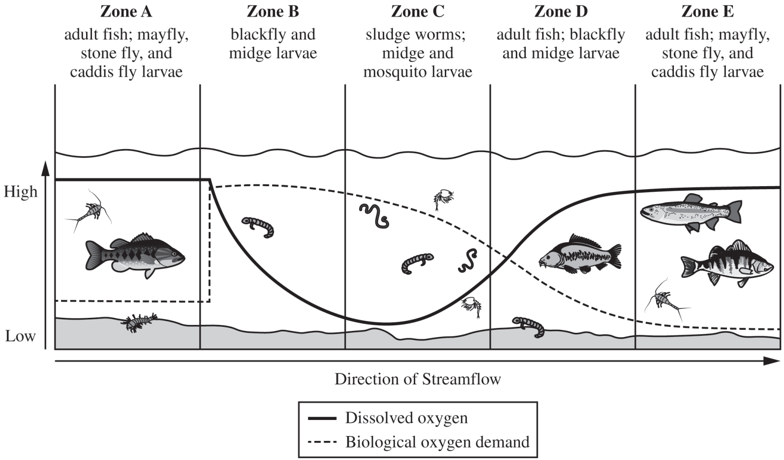
Question 1

Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen.

Question 1



Zone A
adult fish; mayfly, stone fly, and caddis fly larvae
Zone B
blackfly and midge larvae
Zone C
sludge worms; midge and mosquito larvae
Zone D
adult fish; blackfly and midge larvae
Zone E
adult fish; mayfly, stone fly, and caddis fly larvae
High
Low
Direction of Streamflow
Dissolved oxygen
Biological oxygen demand

Question 1

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Question 1

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Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.

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Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

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(d) Identify the dependent variable in the researchers' investigation.

Question 1

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(e) Identify a testable hypothesis for the researchers' investigation.

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(f) Describe the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

Question 1

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(g) Explain how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

Question 1

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(h) Describe the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.

Question 1

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(i) Identify an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.

Question 1

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(j) Explain how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

Solution 1

(a)

Mark scheme

- Zone C has the lowest level of dissolved oxygen (based on the diagram).

Solution 1

(b)

Mark scheme

- Biological oxygen demand (BOD) and dissolved oxygen (DO) are inversely related: as BOD increases, DO decreases (equivalently, as DO increases, BOD decreases).

Solution 1

(c)

Mark scheme

- Zone B is where point-source water pollution is most likely discharged into the stream (based on the diagram).

Solution 1

(d)

Mark scheme

- The dependent variable is the number of macroinvertebrate species (macroinvertebrate diversity / macroinvertebrate species richness) — the researchers measured this in response to dissolved oxygen level.

Solution 1

(e)

Mark scheme

- A testable hypothesis relates dissolved oxygen level to macroinvertebrate species number, e.g.: 'As dissolved oxygen levels increase, the number of macroinvertebrate species increases' (or the inverse: as DO decreases, species number increases; or a general statement of a direct/inverse relationship between DO and macroinvertebrate species number). A null hypothesis of no relationship is also acceptable.

Solution 1

(f)

Mark scheme

- Zone A was chosen as the control because it is upstream from the pollution/organic waste source, so it is not affected by (not impacted by) the discharge — its dissolved oxygen levels reflect conditions unaffected by the pollution, giving a baseline for comparison.

Solution 1

(g)

Mark scheme

- Collecting data in winter could alter the results because: (1) cold water holds more dissolved oxygen, which could increase the number of species; or (2) colder temperatures may fall below the tolerance range of some organisms, decreasing the number of species; or (3) lower light levels in winter reduce plant photosynthesis, which lowers dissolved oxygen and could decrease the number of species.

Solution 1

(h)

Mark scheme

- Raw sewage introduces nutrients (and/or organic matter) that increase the bacteria population (more food source), and/or raw sewage directly contains bacteria that increases the bacteria population size in the stream.

Solution 1

(i)

Mark scheme

- Any abiotic factor other than dissolved oxygen and organic pollution that affects bacteria population size, e.g.: temperature, pH, light/sunlight, turbidity/sediment, salinity, or nitrate/phosphate concentration.

Solution 1

(j)

Mark scheme

- Persistent organic pollutants (POPs) bioaccumulate/biomagnify in the tissues of organisms at higher trophic levels because those organisms consume prey that have already accumulated the pollutants, so pollutant concentration increases up the food web (often concentrating in fatty tissue); this can cause effects such as neurological toxicity in top predators.

Question 2

2023 Set 1 ▪ Q2

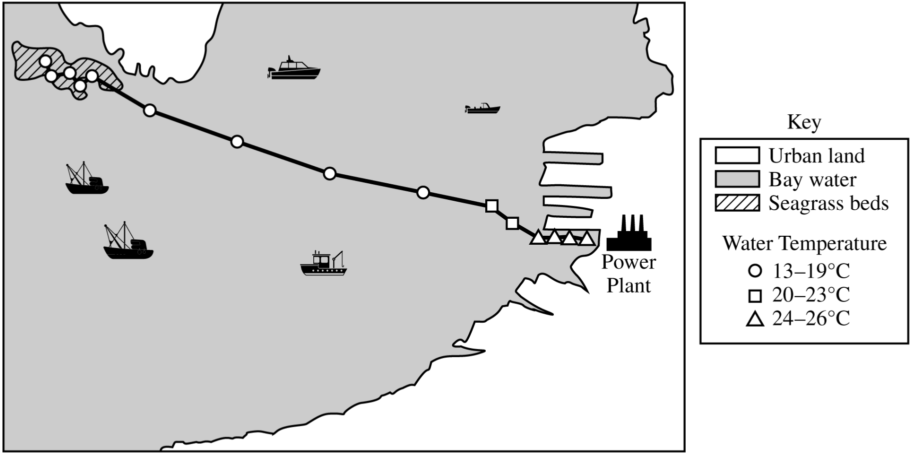
The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below $20°\text{C}$ for extended periods of time.
Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period
[Map diagram of a bay/river channel showing a coastline with urban land at upper left near a cluster of small circles (13-19°C markers) close to shore, and hatched "Seagrass beds" also near that shore. A black line with a series of point markers runs from the seagrass-bed/urban-land area near the top-left, diagonally down and to the right across open bay water, passing several boats (fishing boats and small craft scattered across

Question 2

the bay), and ending at the lower right near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles (13-19°C) for most of the track's length across the open bay, changing to open squares (20-23°C) near the shore closer to the power plant, and open triangles (24-26°C) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = 13-19°C, square = 20-23°C, triangle = 24-26°C.]

(a) Based on the information in the diagram, identify the temperature range of the water through which the majority of the adult manatee's daily movement occurs.

Question 2


Power
Plant
Key
Urban land
Bay water
Seagrass beds
Water Temperature
13–19°C
20–23°C
24–26°C

Question 2

2023 Set 1 ▪ Q2

The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below $20°$C for extended periods of time.

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Question 2

near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles (13-19°C) for most of the track's length across the open bay, changing to open squares (20-23°C) near the shore closer to the power plant, and open triangles (24-26°C) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = 13-19°C, square = 20-23°C, triangle = 24-26°C.]

(b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, identify a characteristic of the power plant waste water that would attract the manatees.

Question 2

2023 Set 1 ▪ Q2

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(c) Based on the information in the diagram, describe a potential negative impact of the waste water released by the power plant on other aquatic species.

Question 2

2023 Set 1 ▪ Q2

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(d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.

(d)(i) Describe a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.

(d)(ii) Describe the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

Question 2

2023 Set 1 ▪ Q2

The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below $20°$C for extended periods of time.
Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period
[Map diagram of a bay/river channel showing a coastline with urban land at upper left near a cluster of small circles (13-19°C markers) close to shore, and hatched "Seagrass beds" also near that shore. A black line with a series of point markers runs from the seagrass-bed/urban-land area near the top-left, diagonally down and to the right across open bay water, passing several boats (fishing boats and small craft scattered across the bay), and ending at the lower right

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near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles (13-19°C) for most of the track's length across the open bay, changing to open squares (20-23°C) near the shore closer to the power plant, and open triangles (24-26°C) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = 13-19°C, square = 20-23°C, triangle = 24-26°C.]

(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(e)(i) Propose a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(e)(ii) Justify the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

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(f) Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

Describe how summertime weather conditions can increase the frequency of photochemical smog.

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(g) Identify one ecological problem that results from exposure to photochemical smog.

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(h) A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

Describe a potential disadvantage of using hydrogen fuel cells to power automobiles.

Solution 2

(a)

Mark scheme

- 13-19 degrees C, based on the temperature range through which the majority of adult manatee daily movement occurs in the diagram.

Solution 2

(b)

Mark scheme

- The waste water is warm (approximately 24-26 degrees C), which is why manatees are attracted to it in winter.

Solution 2

(c)

Mark scheme

- Any one of: warming of the water near the outfall reduces the dissolved oxygen available for aquatic organisms to use/breathe; the warming could impact the survival/health of species with a range of tolerance for the original (lower) water temperature; or the warming could alter/affect the timing of reproductive cycles for aquatic species.

Solution 2

(d)

Mark scheme

- This line is introductory/context text (seagrass decline and the 2021 manatee mortality spike) setting up parts (d)(i) and (d)(ii) below; it carries no points of its own – see 2di and 2dii.

Solution 2

(d)(i)

Mark scheme

- Any one of: manatees are herbivores/eat seagrass, so they would have less food and could starve; they require a lot of energy to survive, so a reduced food supply threatens them; they inhabit warm water, so they would need to travel farther to colder waters to find remaining seagrass/food; or they have a low reproductive/maturation rate, so they would take longer to recover from the loss of their food source.

Solution 2

(d)(ii)

Mark scheme

- Less energy flows to/is available for organisms at higher trophic levels, because less energy from the Sun is captured/stored by producers (seagrass) once seagrass is significantly lost.

Solution 2

(e)

Mark scheme

- This line is introductory/context text (nutrient and sediment runoff causing seagrass decline) setting up parts (e)(i) and (e)(ii) below; it carries no points of its own – see 2ei and 2eii.

Solution 2

(e)(i)

Mark scheme

- Any one solution: replace existing pavement with permeable pavement; add vegetation (e.g., a riparian buffer) where it will intercept runoff; reduce fertilizer use in the area; install barriers/construct fences where they will intercept runoff; or improve wastewater treatment plants in the area.

Solution 2

(e)(ii)

Mark scheme

- Any one additional advantage (not related to manatees): reduces eutrophication; increases biodiversity/species richness; improves water clarity; increases ecotourism; reduces the cost of water treatment; or increases profits for commercial fishermen.

Solution 2

(f)

Mark scheme

- Any one of: sunlight is more intense/there is more sunlight in summer, so more primary pollutants (nitrogen oxides/NOx) react in sunlight; summertime temperatures are warmer than other seasons, and chemical reactions occur more quickly at warmer temperatures; or trees release more VOCs in summer, leading to more reactions that form photochemical smog.

Solution 2

(g)

Mark scheme

- Any one ecological problem: causes respiratory problems/eye irritation in animals; reduces photosynthesis; slows/inhibits/stunts plant growth; or increases the susceptibility of plants to pests and disease.

Solution 2

(h)

Mark scheme

- Any one disadvantage: high cost to manufacture hydrogen-fuel-cell automobiles; obtaining hydrogen requires a lot of energy and may consume more energy than the hydrogen fuel can produce; hydrogen is explosive/flammable (may catch fire); there is a lack of infrastructure (such as fueling stations) for hydrogen fuel; or hydrogen must be obtained by separating it from natural gas or water (often using fossil fuels).