HL Paper 3

Discuss how crop plants obtain the phosphorus that they need to grow and whether the supply of phosphorus to crops is sustainable.

Discuss international measures that would promote the conservation of fish stocks.

a.i. Define fundamental niche. [1]

a.ii. Outline a reason for organisms seldom occupying their entire fundamental niche. [1]

b. Describe the relationship between *Zooxanthellae* and reef-building coral species. [2]

b. Define indicator species. [1]

c. Indicator species may be affected by biomagnification. Discuss biomagnification using a **named** example of a pollutant. [3]

e. Determine whether islands are open or closed ecosystems. [1]

Evaluate the methods used to estimate populations of marine organisms.

Forest fires are very common in the Amazon forest. A study was performed to see the relationship between forest fragmentation, fire and management

a. Describe **one** method that could have been used to estimate the population size of a given tree in a forest after fire damage had occurred. [3]

b. Outline how the edge effect can affect diversity in forests. [3]

c. The number of plants in two fields of approximately the same size was counted. [2]

Type of plant	Field 1	Field 2
Daisy (*Bellis perennis*)	307	18
Dandelion (*Taraxacum officinale*)	332	48
Buttercup (*Ranunculus repens*)	361	934
Total	1000	1000

Compare and contrast the richness and the evenness of the two fields.

Discuss the causes and consequences of eutrophication.

Outline **three** issues arising from the release of pollutants into the environment.

Most reef-building corals contain photosynthetic algae, called *Zooxanthellae*, that live in their cells. Coral bleaching can occur as a result of human-induced changes leading to the *Zooxanthellae* being ejected from the coral.

a. State the type of interaction that occurs between *Zooxanthellae* and reef-building corals. [1]

b. State the trophic level of *Zooxanthellae*. [1]

c. When coral is bleached, certain organisms become more common in the ecosystem such as the cnidarian *Gorgonia*, the echinoderm *Diadema*, other algae and certain sponges. State the term that is used for organisms whose presence provides evidence of the existence of a particular environmental condition. [1]

d. A coat of algae builds up on coral reefs as a consequence of eutrophication. Explain the relationship between eutrophication and algal growth. [2]

e. Explain how an excessive growth of algae on coral reefs can be controlled by top-down factors. [2]

Evaluate the use of indicator species in monitoring environmental changes.

Explain, with examples, the use of specific indicator species and biotic indices to detect changes in the environment.

a. State **two** bottom-up factors affecting algal blooms. [2]

1. .....

2. .....

b. Explain how top-down factors control algal blooms. [3]

a(i). Define *biomagnification*. [1]

a(ii). Outline a **named** example of biomagnification. [2]

a. Outline changes in species diversity during primary succession. [2]

b. Describe a method used to estimate the size of a mouse population. [3]

c. (i) Describe the environmental impact of a **named** invasive alien species. [2]

(ii) State an example of biological control of the invasive alien species named above.

a. Outline the diversity of Eubacteria according to cell wall structure. [2]

b. State the role of *Rhizobium* and *Nitrobacter* in the nitrogen cycle. [2]

Rhizobium: .....

Nitrobacter: .....

d. Explain the use of bacteria in bioremediation. [2]

a. Distinguish between *in situ* and *ex situ* conservation. [1]

b. The Atlantic cod is considered in many countries to be endangered due to overfishing. Describe two methods that could be used to estimate the cod population. [2]

d. Outline **one** reason for the extinction of a **named** animal species. [1]

Eight sub-species of tigers existed in 1950, but three of these former sub-species have now become extinct. Discuss the role of active management techniques to prevent the extinction of the remaining tiger species.

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b. Outline how habitat corridors can aid conservation of biodiversity in a nature reserve. [1]

c. Explain how living organisms can change the abiotic environment during primary succession. [3]

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a(i). State **two** nitrogen-fixing bacteria. [1]

a(ii). Outline the conditions that favour denitrification. [2]

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a. Earthworms are primary consumers that can be grown on household food waste such as fruit and salad leftovers. Outline their potential as an energy-containing food source for humans. [3]

b. State the units used in a pyramid of energy. [1]

Discuss the factors affecting population growth that can result in an exponential growth curve.

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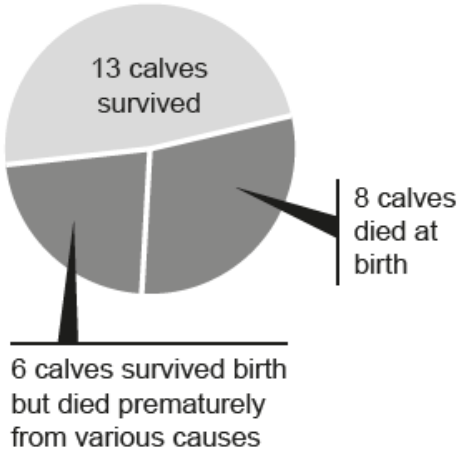
a. Zoos devote much effort to preserving and breeding elephants in captivity. Data for births resulting from artificial insemination in zoos in the United States from 1960 to 2012 are shown below. [1]



[Source: Association of Zoos and Aquariums, http://seattletimes.com]

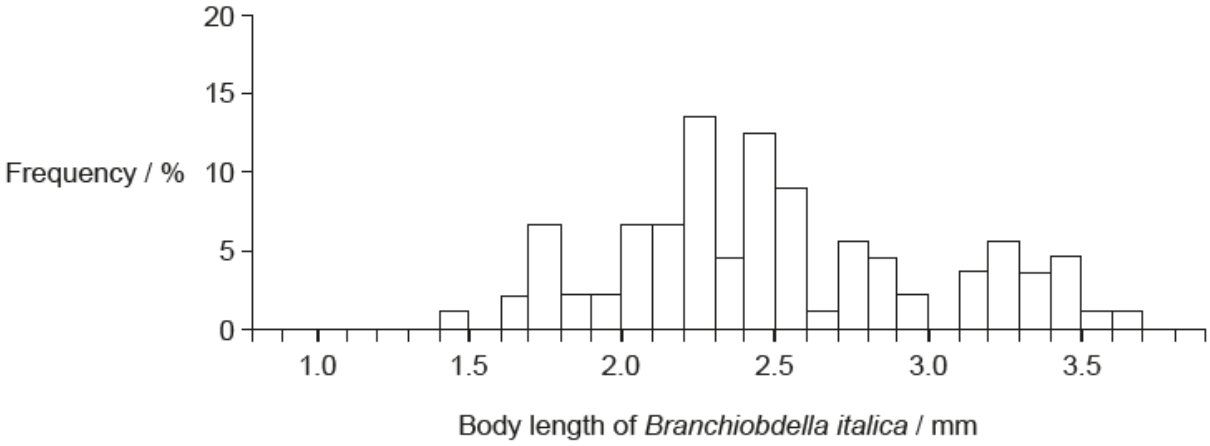
54% of successful artificial inseminations have resulted in miscarriages, stillborn births or premature deaths.

Evaluate the success rate of breeding elephants by artificial insemination using these data.

b. Discuss **two** advantages of *ex situ* conservation measures. [2]

c. State the **two** components needed to calculate the biodiversity of an area. [2]

The worm *Branchiobdella italica* lives on the external surface of the freshwater crayfish *Austropotamobius pallipes*. A study was carried out in a river in central Liguria, north-western Italy, of the range of sizes of *B. italica* found on adult *A. pallipes*.



[Source: M Mori, *et al.*, (2001), *Journal of Limnology*, 60(2), pages 208–210]

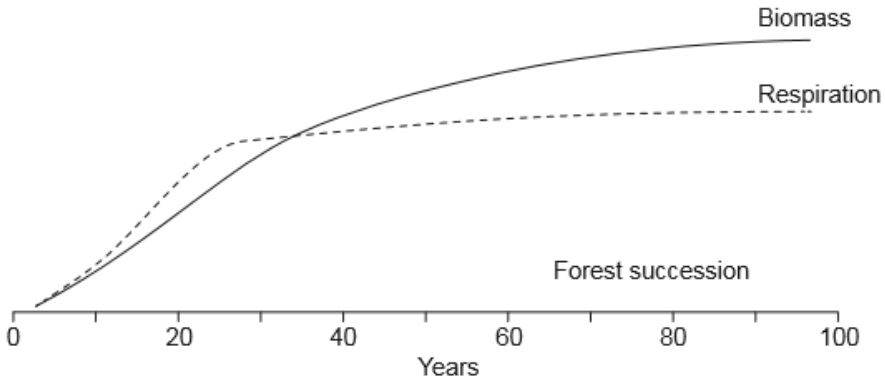
a. Describe the body length frequency of the *B. italica* worms collected in this study. [1]

b. The relationship between *A. pallipes* and *B. italica* is mutualistic. [1]

A. pallipes feeds on algae and another worm, *B. exodonta*, lives inside *A. pallipes* as a parasite. State the trophic level of *B. exodonta* in this food chain.

c. Distinguish between mutualism and parasitism, providing another example of mutualism and another example of parasitism. [2]

The graph is a model showing biomass and respiration levels in a field where farming stops at time zero and the abandoned land develops into forest.



[Source: From "The Strategy of Ecosystem Development" by Eugene P. Odum. *Science*, 18 Apr 1969: Vol. 164, Issue 3877, pp. 262-270. Reprinted with permission from AAAS.]

a. Describe the change in biomass over the 100 year period. [2]

b. Outline the evidence from the graph that the area had plentiful rainfall. [2]

c. Explain the changes in biomass. [2]

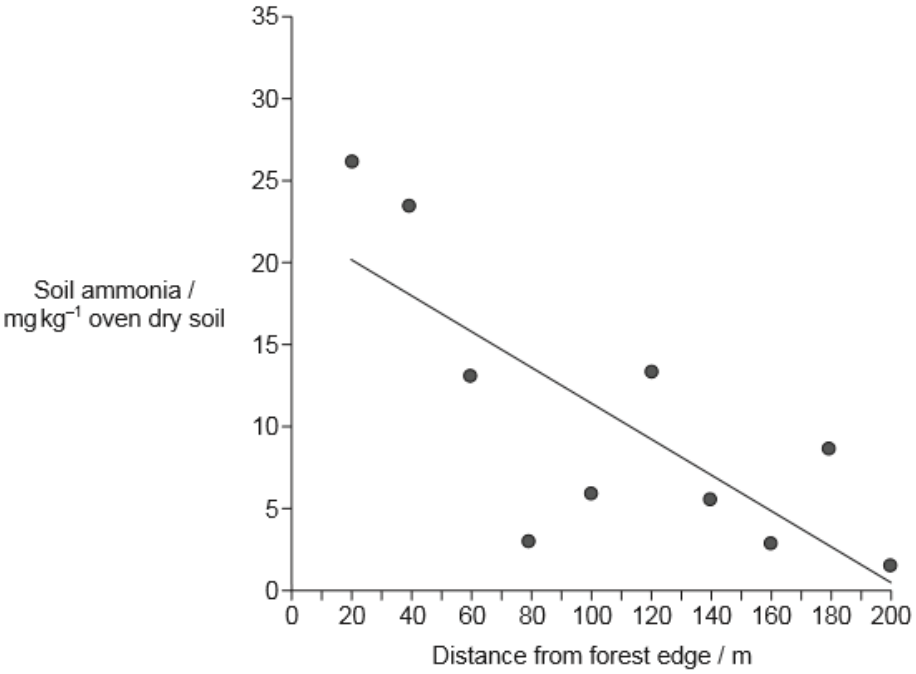
d. Explain why biomass continues to increase after the respiration levels plateau. [2]

Discuss the advantages of *in situ* conservation of endangered species, using examples.

Explain the causes and consequences of biomagnification with reference to a **named** example.

Discuss international measures that would promote the conservation of fish, including methods used to measure conservation of fish stocks.

Where high amounts of ammonium ions are present in agricultural areas, gaseous ammonia can be released into the atmosphere. This ammonia can dissolve and be carried across distances and then be deposited through precipitation. In a study of the effects of deposition of ammonium in a forest, soil samples were taken starting at the forest edge next to an open field and moving toward the centre of the forest.



[Source: "Spatial variations of nitrogen deposition and its effect on forest biochemical processes", M. A. Sutton *et al*. Crown Copyright, courtesy Forestry Commission, licensed under the Open Government Licence. http://www.forestry.gov.uk/fr/INFD-75PJ9E#sutton2001 (accessed May 2016).]

a. Outline the procedure that was most likely used by the researchers to decide where to take the samples. [2]

b. List **two** sources of the ammonium in the forest soils apart from deposition in rainfall. [2]

c. Suggest **one** reason for ammonium levels in the interior of the forest being lower than the soil ammonium close to the edge. [1]

. Discuss how international efforts can contribute to the conservation of fish stocks. [6]

c. Outline the biogeographical features of nature reserves that promote the conservation of diversity. [3]

Discuss, using **three** examples, how alien species have impacted ecosystems.

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a. Define the term *biomagnification*. [1]

b (ii) Define the term *biomass*. [1]

c. Describe **one** technique used to estimate the population size of mice. [2]

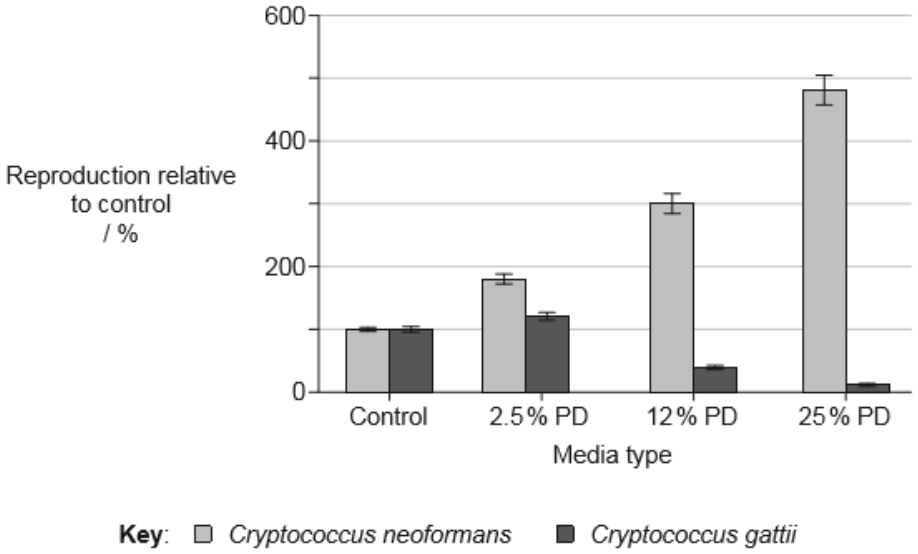
Discuss the role of *ex situ* conservation of endangered species.

b. Define *indicator species.* [1]

c. Outline, with a **named** example, biological control of invasive species. [2]

Outline the consequences of the edge effect for small nature reserves.

Cryptococcus neoformans and the closely related species *Cryptococcus gattii* are human fungal pathogens. The reproduction of these yeast species on increasing concentrations of pigeon droppings (PD) was examined to determine whether they occupy the same or different ecological niches. The results for reproduction are expressed as a percentage relative to the control.



[Source: adapted from K. Nielsen et al. (2007), "*Cryptococcus neoformans* Mates on Pigeon Guano: Implications for the Realized Ecological Niche and Globalization". *Eukaryotic Cell*, vol. 6, pp. 949–959, DOI: 10.1128/EC.00097-07. Amended with permission from American Society for Microbiology]

Suggest how this experiment shows that pigeon droppings represent a realized ecological niche for *C. neoformans* and a fundamental (but not a realized) niche for *C. gattii*.

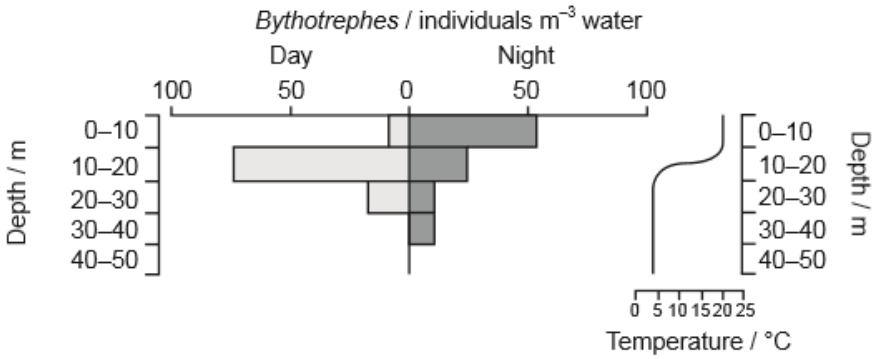
a. Distinguish between the use of a quadrat and a transect in gathering field data. [2]

b (i) State the change in species diversity and the change in production during primary succession. [1]

Species diversity: .....
Production: .....

b (i) State one difficulty in classifying organisms into trophic levels. [1]

During the 1980s, a tiny invasive crustacean *Bythotrephes cederstroemii* entered the eastern Great Lakes from Europe (probably via freshwater or mud in the ballast water of merchant ships) and eventually colonized Lake Michigan. *Bythotrephes* reproduces very quickly and eats common zooplankton, disrupting the food web by directly competing with small juvenile resident fish. *Bythotrephes* avoids predation by larger fish through the timing of its activities which have been investigated in offshore waters of Lake Michigan at various depths during the day and night.



[Source: Courtesy of Professor John T. Lehman, University of Michigan.]

a. State the depth range showing the most *Bythotrephes* during the night. [1]

b. Describe the distribution of *Bythotrephes* during the day. [2]

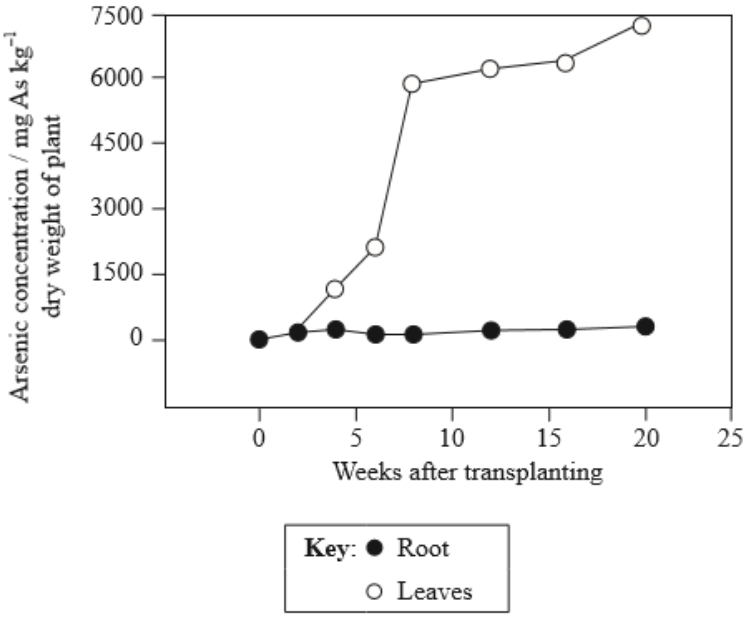
c. Deduce the responses of *Bythotrephes* to temperature and light. [2]

d. Explain the change in distribution of *Bythotrephes* between day and night in terms of its position in the lake food chain. [2]

Describe a **named** method for determining the size of fish populations and the challenges in conserving world fish stocks.

The element arsenic (As) is not needed for plant growth and development. The accumulation of arsenic in the Chinese brake fern (*Pteris vittata*) was studied. Young ferns with five or six leaves were transplanted to soil contaminated with arsenic and were grown for 20 weeks in a greenhouse.

The graph below shows the arsenic concentrations in leaves and roots of the Chinese brake fern during the 20 weeks after transplanting. Arsenic concentration is expressed as mg As kg^{-1} dry weight of plant.



[Source: C Tu, *et al.*, (2002), *Journal of Environmental Quality*, **31**, pages 1671–1675]

The table below shows the total amount of arsenic accumulated by the Chinese brake fern, expressed as a concentration in the plant tissue and as a percentage of the arsenic originally in the soil.

Time / weeks	Arsenic concentration in fern / mg As kg^{-1}	Percentage of original soil arsenic absorbed by fern
0	2	0.00
2	66	0.05
4	221	0.15
6	408	0.28
8	1300	0.88
12	5390	3.68
16	13 800	9.43
20	37 900	25.90

[Source: adapted from C Tu, *et al.*, (2002), *Journal of Environmental Quality*, **31**, pages 1671–1675]

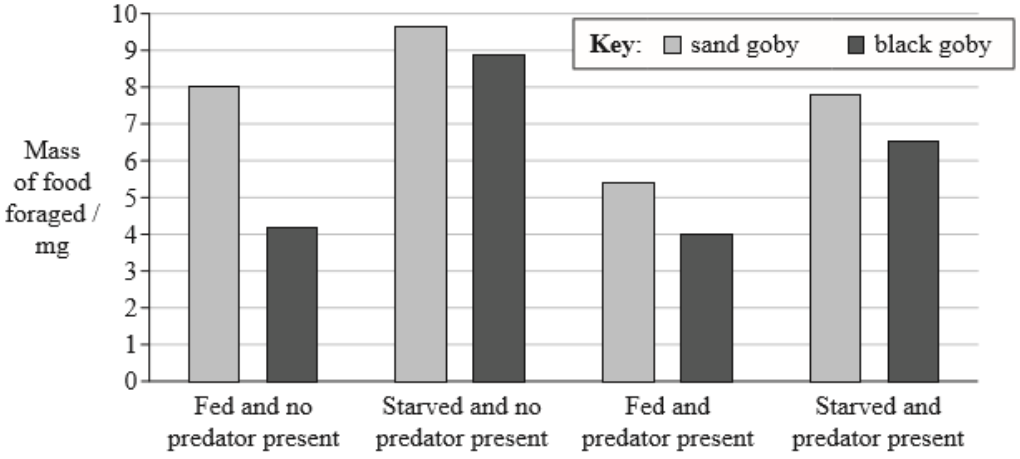
a. Using the data in the graph, describe the accumulation of arsenic in the Chinese brake fern. [3]

b (i) Assuming the mean rate of arsenic accumulation over the first 20 weeks continued, calculate how long it would take to remove all the arsenic from the soil. [1]

b (ii) Using the data in the table, discuss the potential of using Chinese brake fern to remove arsenic from contaminated soil. [2]

c. Suggest **one** possible consequence of arsenic accumulation in plants for other organisms in the community. [1]

Investigators studied the behaviour of two species of small fish, the sand goby (*Pomatoschistus minutus*) and the black goby (*Gobius niger*), while they foraged for mud shrimps. The amount of food foraged by the gobies was measured after they had been fed or after they had been starved. The measurements were repeated when a predator of the gobies was introduced to the tank where they were feeding.



[Source: "Conflicting demands in gobies: When to eat, reproduce, and avoid predators" by Carin Magnhagen, *Marine & Freshwater Behaviour & Physiology*, Oct 1, 1993, vol. 23, issue 1–4, pp. 79–90.]

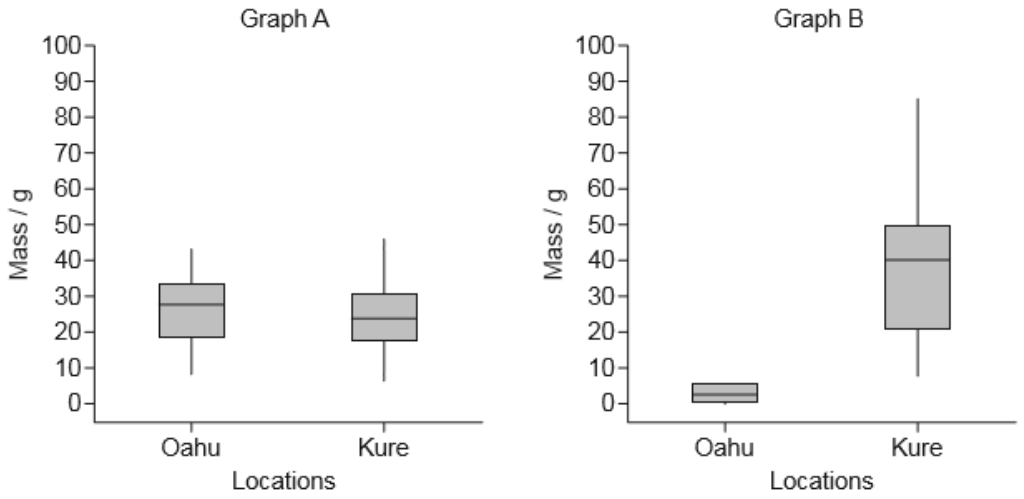
a. Calculate the decrease in mass of food foraged by fed sand gobies when a predator was introduced, giving the units. [1]

b. Compare the effect that starvation had on both species of goby when no predator was present. [2]

c (i) Describe the effect the predator had on the foraging of the gobies. [2]

c (ii) Suggest a reason for the effect of the predator. [1]

The Laysan Albatross (*Phoebastria immutabilis*) sometimes ingests plastic. A bolus is a pellet made of material that the albatross cannot digest, so brings it back up from its stomach to its mouth and then ejects the indigestible matter. Graph A indicates the mass of indigestible natural material, such as bones and octopus beaks, in the bolus of birds at two different locations. Graph B indicates the mass of plastic in the bolus at both locations.



[Source: Young LC, Vanderlip C, Duffy DC, Afanasyev V, Shaffer SA (2009) Bringing Home the Trash: Do Colony-Based Differences in Foraging Distribution Lead to Increased Plastic Ingestion in Laysan Albatrosses? *PLoS ONE* 4(10): e7623. doi:10.1371/journal.pone.0007623]

a. Suggest **one** reason for the Laysan Albatross ingesting indigestible plastic. [1]

b. Suggest a reason for the difference in ingested plastic in the diets of the Laysan Albatross in the **two** locations. [2]

c. Outline the origin of microplastic debris in the marine environment. [2]

d. Using microplastics as an example, outline the concept of biomagnification. [2]

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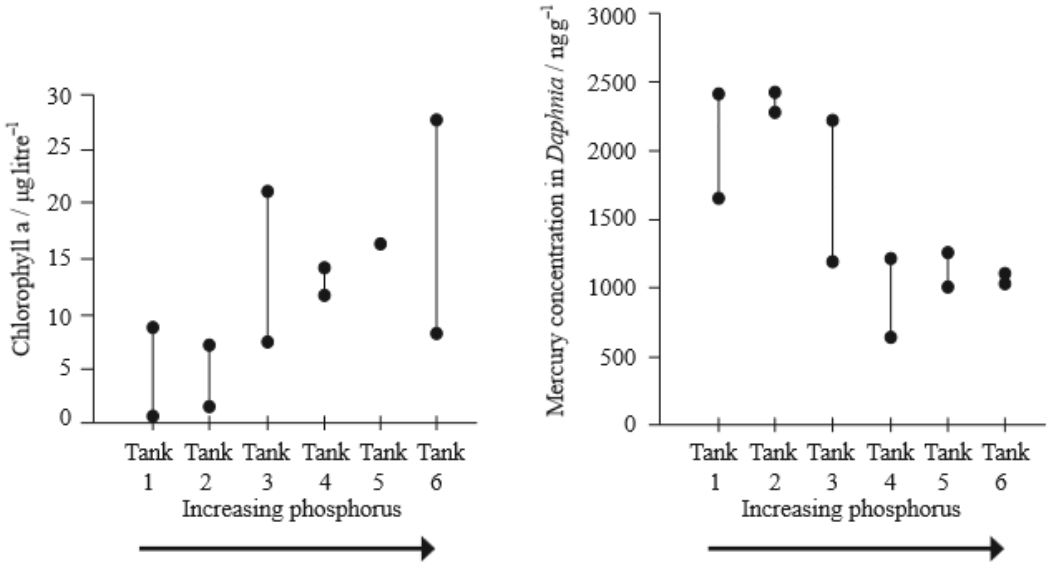
a. In a grassland ecosystem, the amount of energy captured by the photosynthetic organisms was 100 000 kJ m^{-2} yr^{-1}. Construct a pyramid of energy indicating the predicted energy levels for **four** trophic levels, including the producers. [3]

b. Define *biomass*. [1]

Mercury is a toxic substance and its biomagnification in aquatic food chains is a global concern. A study tested the effects of inorganic phosphorus levels on both algal growth and mercury accumulation by *Daphnia mendotae* feeding on the algae which absorb mercury from the water. *Daphnia* may subsequently be eaten by fish.

Experiments were performed in six different tanks with increasing phosphorus concentrations. The same amount of mercury was added to each tank. The quantity of algae, determined by measuring the amount of chlorophyll a, and the accumulation of mercury by *Daphnia* was measured in each tank. Chlorophyll a and mercury levels were measured twice at each of the six different phosphorus concentrations.



[Source: adapted from Paul C. Pickhardt, Carol L. Folt, Celia Y. Chen, Bjoern Klaue and Joel D. Blum (2002) 'Algal blooms reduce the uptake of toxic methylmercury in freshwater food webs'. PNAS, 99, pp. 4419–4423. Figures 2A and 3C]

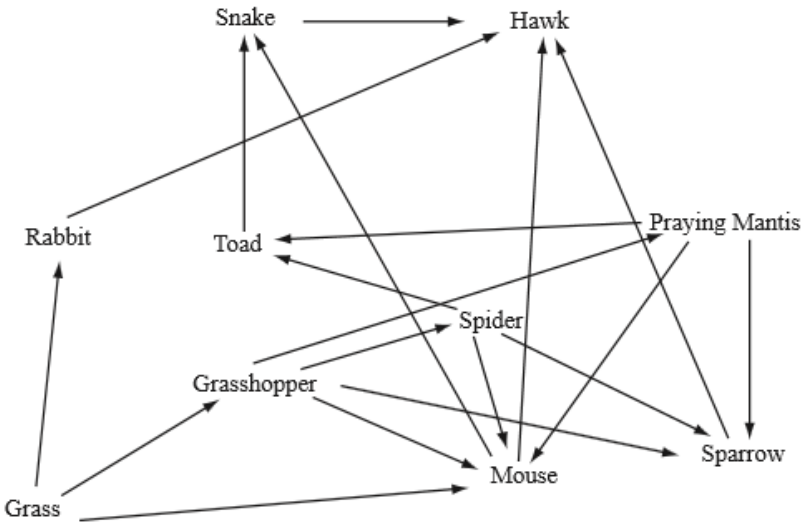
a (i) Deduce the tank in which the quantity of algae was highest. [1]

a (ii) Deduce the tank in which the level of mercury accumulation in *Daphnia* was lowest. [1]

b. Outline the relationship between phosphorus concentration in the water and the accumulation of mercury by *Daphnia*. [2]

c. Using the data, suggest reasons for the relationship between phosphorus concentration in the tanks and mercury concentration in *Daphnia*. [2]

The following figure represents a terrestrial food web.



a. Identify the trophic level of the toad. [1]

b. Outline a method that could be used to estimate the population of rabbits in this environment. [4]

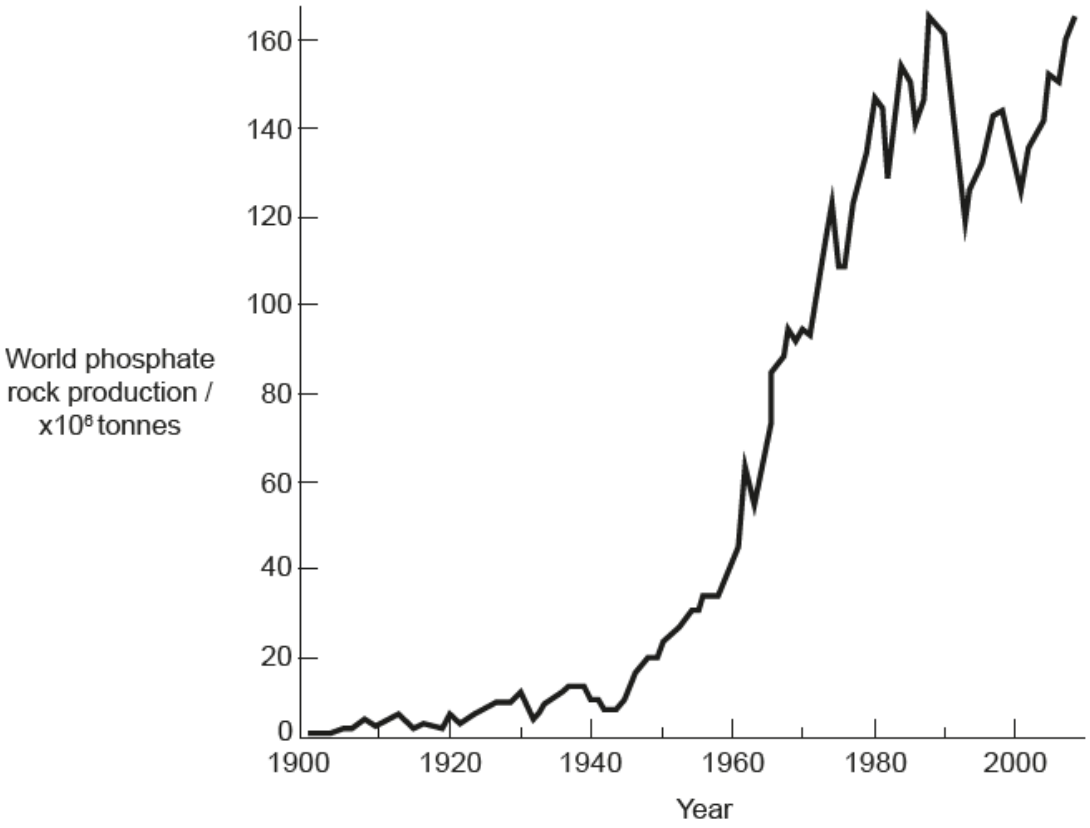
c. The Simpson diversity index is used to calculate the species richness in an ecosystem. [2]

Define the terms N and n in the formula above.

N =

n =

The predominant source of phosphorus is rock containing phosphate (phosphate rock). The graph below shows the world production between 1900 and 2009.



[Source: From the US Geological Survey, http://minerals.usgs.gov/ds/2005/140/#phosphate), redrawn by the IB]

a. Some scientists estimate that available phosphorus reserves in the Earth will be completely depleted within approximately 100 years. Discuss the implications of these estimates. [2]

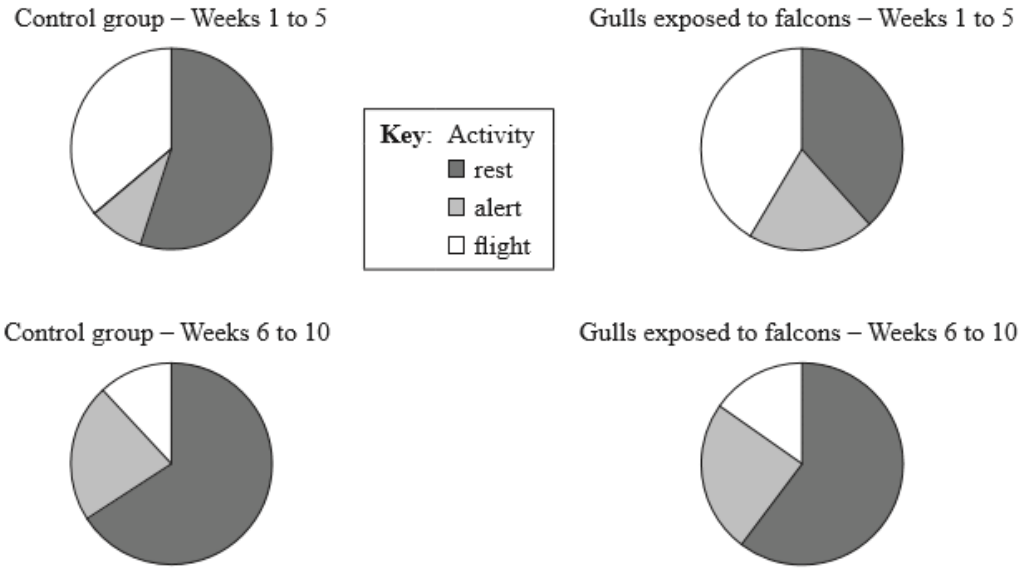
b. The percentage of phosphorus in an ecosystem that is recycled per year is in most cases very small, and far smaller than the percentage of nitrogen that is recycled. Suggest reasons for this difference. [2]

c. Nitrates (NO) are components of the nitrogen cycle. Outline the possible conversions of NO in the nitrogen cycle. [2]

In 2009, the town council of Dumfries in Scotland tested a project to prevent lesser black-backed gulls (*Larus fuscus*) from nesting in the town where they were causing problems. They released trained falcons into the town centre for 10 hours each day during a 10-week period when the gulls normally lay their eggs. Although the falcons are predators of the gulls, they did not kill the gulls during the study. The behaviour of the gulls was observed and the percentage time spent on three activities was recorded. The results were compared to a control group not exposed to falcons in another part of town.

- **Rest**: sitting on their nests, standing or preening their feathers
- **Alert**: remaining on the ground but disturbed and visibly agitated
- **Flight**: flying regardless of the cause

The pie charts show the results of the project.



[Source: © International Baccalaureate Organization 2013

a. State which activity decreased in weeks 1 to 5 as a result of exposure to the falcons. [1]

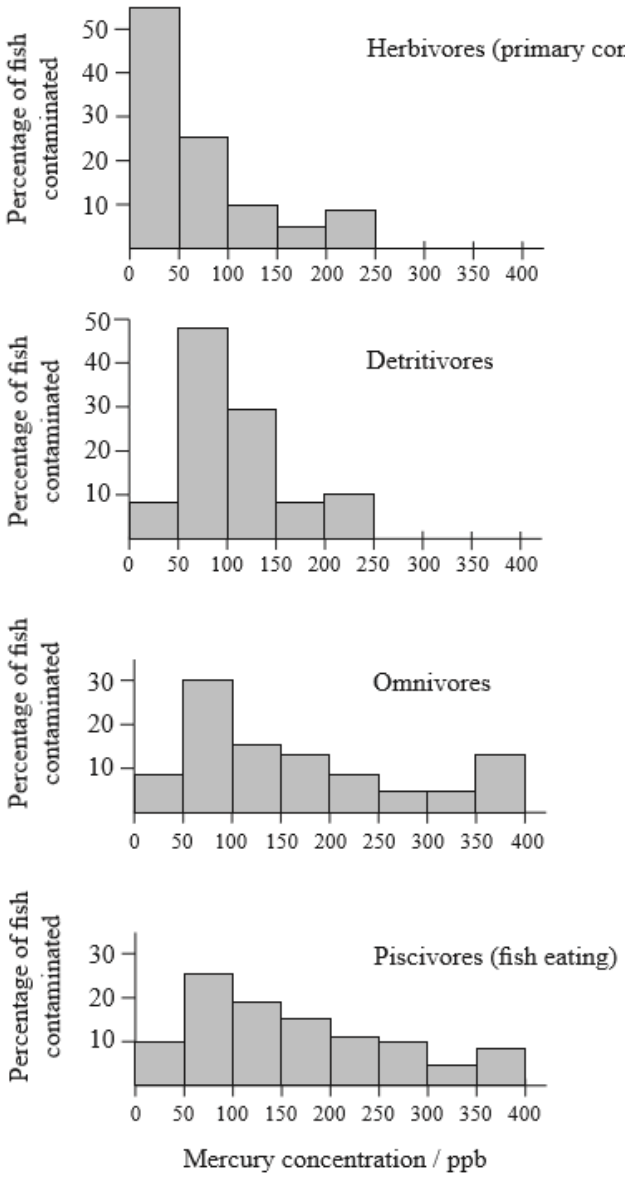
b. Estimate the total percentage of time the gulls exposed to falcons spent flying and at rest in weeks 6 to 10. [1]

.....%

c. Compare the behaviour of the gulls exposed to falcons with the control group over the period of study. [3]

d. Predict, using the data in the pie charts for weeks 1 to 5 and weeks 6 to 10, if the use of falcons will succeed in causing a long-term reduction in the number of gull nests in problem areas. [2]

Indigenous human populations living along riverbanks in the Amazon basin often rely heavily on fish as a major part of their diet. The data shown below come from a study that was carried out to investigate levels of mercury contamination in the Rio Negro basin in Brazil. Mercury concentration was measured in fish belonging to four different trophic levels and is shown in parts per billion (ppb).



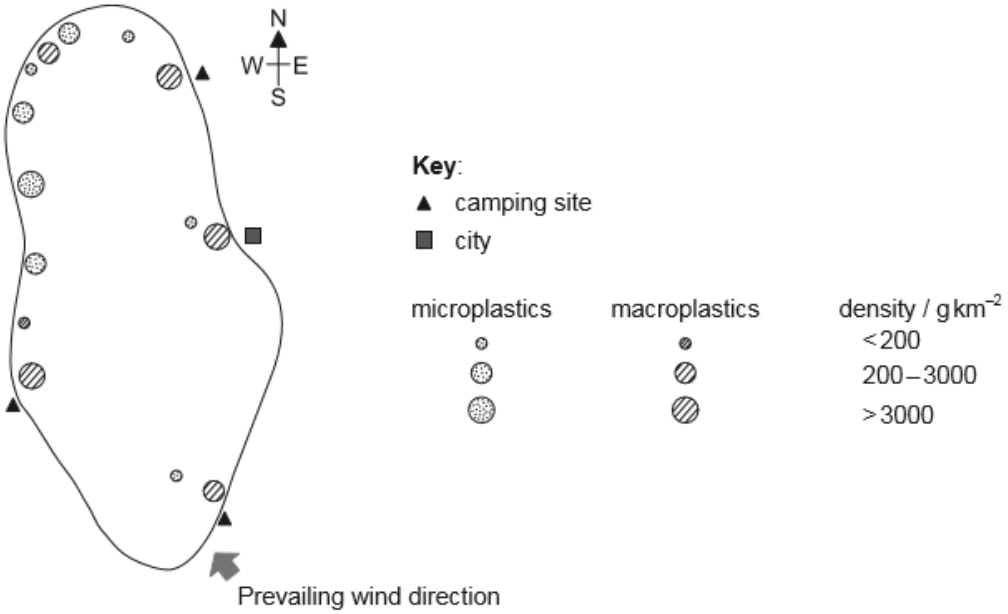
[Source: With kind permission from Springer Science+Business Media: *Archives of Environmental Contamination and Toxicology*, Mercury Biomagnification in a Tropical Black Water, Rio Negro, Brazil, 45, 2003, 235–246, A. C. Barbosa et al.]

a. State the trophic level of the fish that presents the least risk of mercury contamination for human consumers. [1]

b. Compare the levels of mercury found in herbivores (primary consumers) and detritivores. [2]

c. Explain the large range of mercury concentrations seen in the piscivores. [2]

The sketched map shows the density of microplastics and macroplastics found in a lake within a national park.



[Source: © International Baccalaureate Organization 2016]

a. Predict **one** example of macroplastic pollution that is likely to be found in this lake. [1]

b. State **two** possible effects on organisms of microplastic pollution. [2]

1. . . . . .

. . . . . .

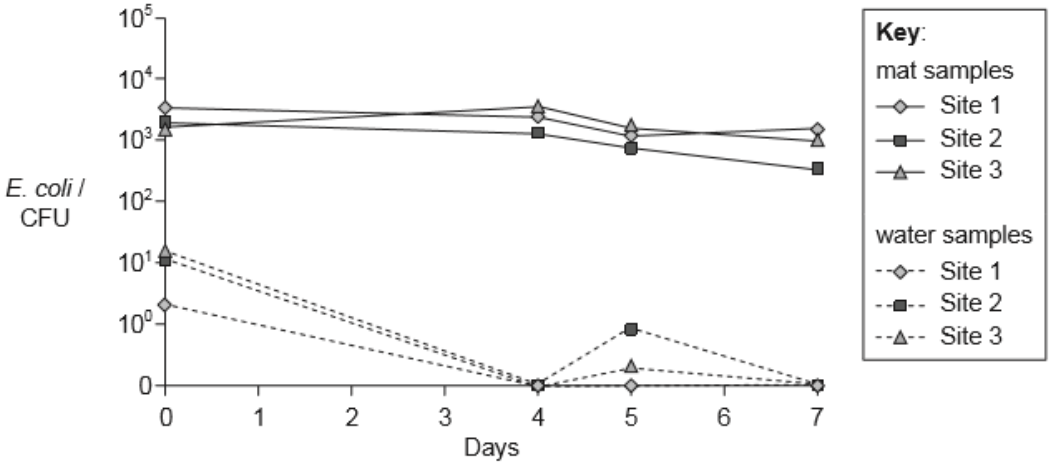
2. . . . . .

. . . . . .

c. Outline the effect of wind on the distribution of plastic pollution in this lake. [2]

d. Suggest changes in the management of the national park that could reduce the amount of macroplastic pollution. [3]

The filamentous green alga (*Cladophora*) forms mats along the shore of certain fresh water lakes. When the mats become stranded on beaches, they produce a bad odour from the action of decomposers. A study was undertaken on the abundance and persistence of fecal indicator bacterium *Escherichia coli* in the mats and in the water at three beach sites on one lake. The number of colonies (colony-forming unit or CFU) that grew from bacteria in a 100 gram sample of mat or water collected on day 0 at the three sites was measured on four days over an eight day period to test the survival of *E. coli.*



[Source: Adapted from O. Olapade *et al.* (2006) *Applied Environmental Microbiology*, **72** (3), pages 1932–1938. 'Microbial Communities and Fecal Indicator Bacteria Associated with Cladophora Mats on Beach Sites along Lake Michigan Shores'. Ola A. Olapade, Morgan M. Depas, Erika T. Jensen, and Sandra L. McLellan. Doi:10.1128/AEM.72.3.1932–1938.2006. Reproduced with permission from American Society for Microbiology.]

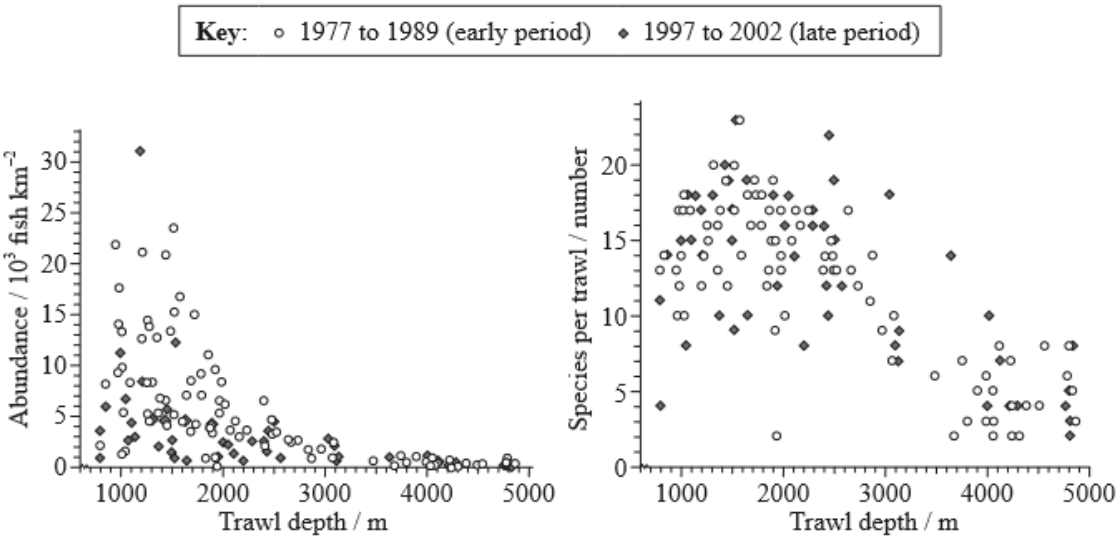
a. Identify the site with the lowest average CFU of *E. coli* in the water samples. [1]

b. Distinguish between the trends in the survival of *E. coli* on mat samples and in water samples over time. [2]

c. Scientists formerly related the population of *Cladophora* to changes in phosphorous levels in the lake. However, phosphorous quantities have decreased but *Cladophora* has recently increased along the shore. Suggest **two** reasons, other than phosphorous, for the change in population growth of *Cladophora* in the lake. [2]

d. Discuss the possible ecological relationships between *E. coli* and *Cladophora*. [2]

Knowledge of deep-water fish is important for fisheries and marine reserve management. Scientists analysed data from scientific trawls made from 1977 to 1989 (early period) and from 1997 to 2002 (late period). These were at depths from 800 m to 4800 m in the Porcupine Seabight and Porcupine Abyssal Plain area southwest of Ireland. The graphs represent the abundance of fish and the number of species for each of these trawls.



[Source: D.M. Bailey, M.A. Collins, J.D.M. Gordon, A.F. Zuur and I.G. Priede, 'Long-term changes in deep-water fish populations in the northeast Atlantic: a deeper reaching effect of fisheries?' *Proceedings of the Royal Society B* (2009), 276 (1664), pp. 1965–1969. By permission of the Royal Society.]

a . State the depth at which the maximum number of species per trawl were caught. [1]

b (i) Compare the abundance of fish between the early period (1977 to 1989) and the late period (1997 to 2002). [2]

b (ii) Suggest **one** reason for the difference in the abundance of fish at depths down to 2000 m between the early period and the late period. [1]

c. Discuss the evidence in these data for a decline in the biodiversity of fish between the early period and the late period. [2]

d. State **two** types of interactions that are most likely to occur among deep-water fish. [1]

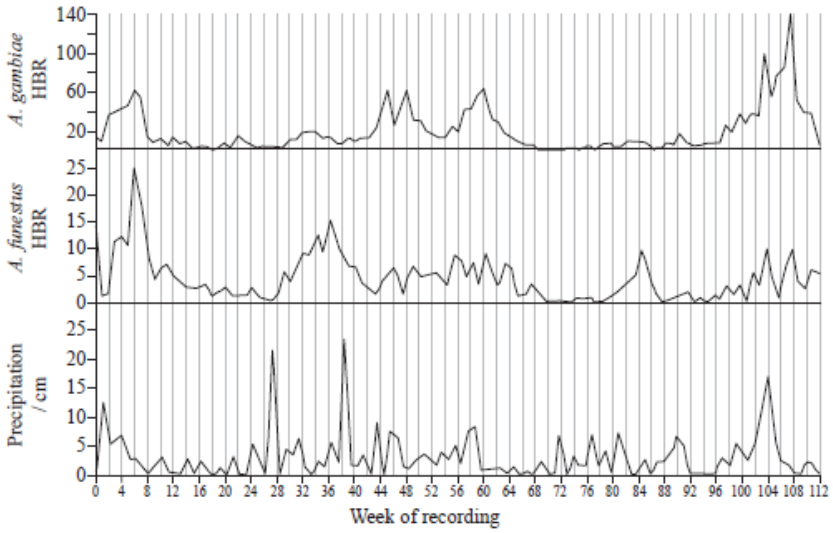
1. .....

2. .....

e. Outline the concept of maximum sustainable yield in the conservation of fish stocks. [2]

Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

a. State the week number when the highest human biting rate (HBR) is found for *A. gambiae*. [1]

b. Calculate the difference in peak HBR for *A. gambiae* and *A. funestus* for week 6. [1]

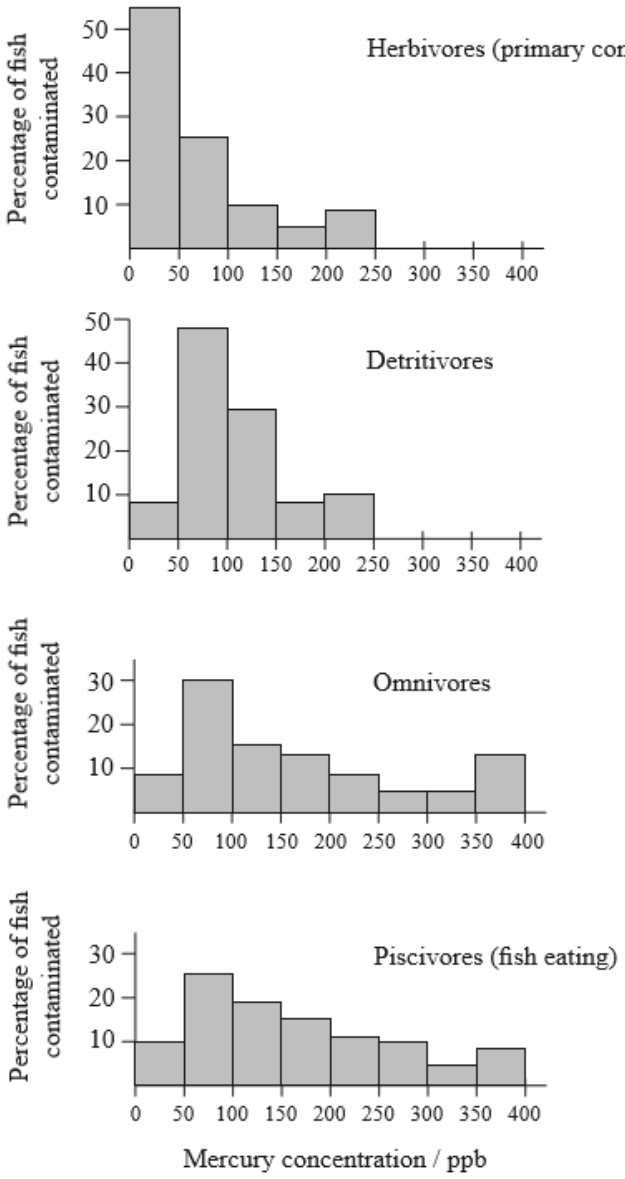
c. Evaluate the effect of increased precipitation on HBR for both species. [3]

d. Suggest how predictions of global climate changes, such as predictions of precipitation patterns, could be used to help control malaria. [1]

e. Suggest another factor which might affect the ecological distribution of mosquitoes. [1]

f. Suggest a biological control that might be introduced to reduce HBR. [1]

Indigenous human populations living along riverbanks in the Amazon basin often rely heavily on fish as a major part of their diet. The data shown below come from a study that was carried out to investigate levels of mercury contamination in the Rio Negro basin in Brazil. Mercury concentration was measured in fish belonging to four different trophic levels and is shown in parts per billion (ppb).

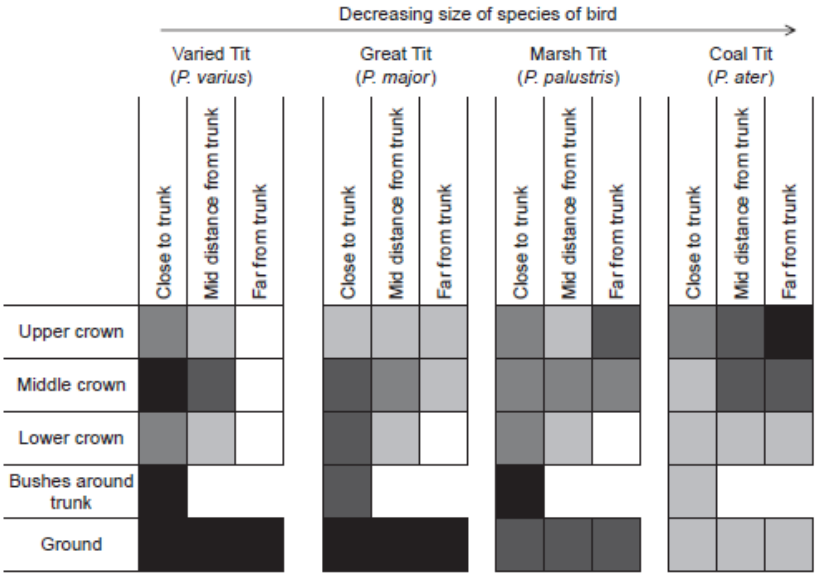


[Source: With kind permission from Springer Science+Business Media: *Archives of Environmental Contamination and Toxicology*, Mercury Biomagnification in a Tropical Black Water, Rio Negro, Brazil, 45, 2003, 235–246, A. C. Barbosa et al.]

Discuss how an understanding of biomagnification could help these human populations reduce their risk of mercury poisoning while maintaining their traditional diet.

In South Korea, flocks of birds of the tit family (*Paridae*) forage together on trees for food. Researchers observed four species of *Paridae* to determine whether they shared the same habitat in the trees and whether their position on the tree depended on their size. The leafy part of the tree (crown) was divided into nine sections, three according to height from the ground and three according to the distance from the tree trunk. Observations were also made of birds foraging in the bushes surrounding the trunk and on the ground below the tree.

The chart shows the relative use of each section of the habitat by the birds.



[Source: adapted from S Lee and PG Jablonski, (2006), *Polish Journal of Ecology*, **54**(3), pages 481–490]

a. State the relative use of the habitat by the Great Tit in the upper crown of the tree close to the trunk. [1]

b. Identify the section of habitat used least by the birds. [1]

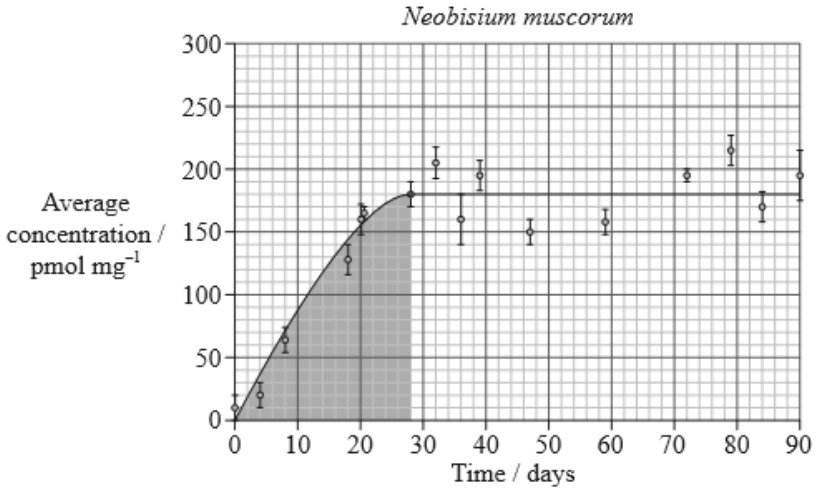
c. Compare how the Varied Tit and the Marsh Tit use the habitat in the upper crown of the tree. [2]

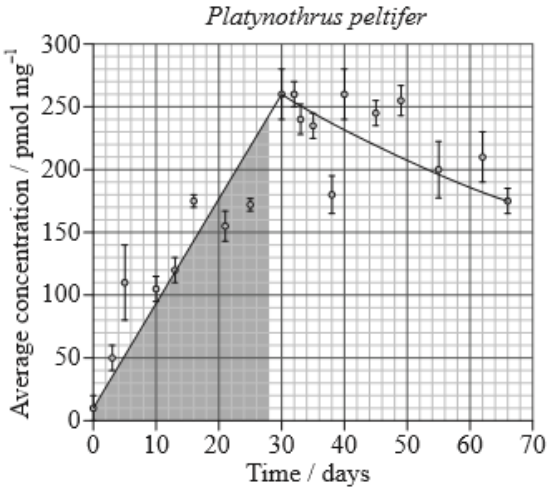
d. State how the distribution of birds changes with their size in the middle crown of the tree. [1]

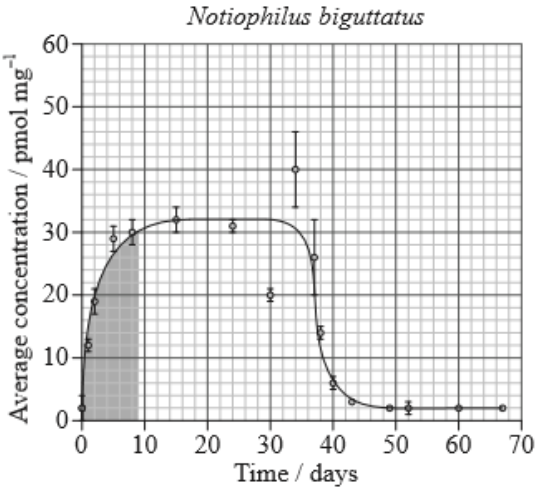
e. Suggest **one** reason why few Varied Tits were found far from trunk. [1]

f. Discuss whether the results for the Varied Tit and Coal Tit indicate competitive exclusion. [2]

Cadmium is a heavy metal that can be toxic to many species. In a study, the concentration of cadmium was examined in the tissues of three soil arthropods, *Neobisium muscorum*, *Platynothrus peltifer* and *Notiophilus biguttatus*. The shaded area of each graph indicates the time that the organisms were exposed to cadmium in their environment, while the unshaded area indicates the time when cadmium was not present in their environment.







JANSSEN, M.P.M., BRUINS, A., DE VRIES, T.H., & VAN STRAALEN, N.M. (1991) Comparison of cadmium kinetics in four soil arthropod species. *Arch. Environ. Contam.* Toxicol., 20: 305-312

a. Identify the highest average concentration of cadmium found in *P. peltifer*. [1]

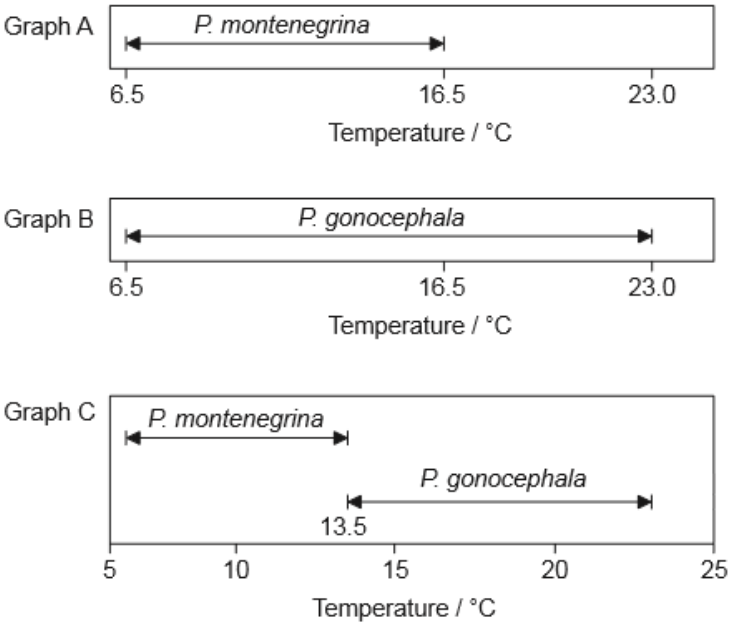
b. Determine, with a reason from the data, which species is unable to eliminate cadmium. [2]

c (i) State the species that accumulates the least cadmium. [1]

c (ii) Suggest, with observations from the data, a reason why the species stated in (c)(i) accumulates the least cadmium. [2]

d. Describe the possible effects of the presence of cadmium in food chains involving these arthropods. [2]

The figure shows the distribution of two species of freshwater flatworms, *Planaria gonocephala* and *Planaria montenegrina*, over a range of stream temperatures. Graph A and graph B show the distributions when each species is separate from the other. Graph C shows the distribution when they are found living together.



[Source: R. J. Putman (1994) *Community Ecology*, page 63. © Kluwer Academic Publishers Boston. Used with permission.]

a. Using graph A and graph B, compare and contrast the temperature ranges of the two species when they are found separately. [2]

b. Explain, with respect to the example of *P. montenegrina*, what is meant by realized niche. [2]

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a. State **one** example of a bacterium that forms aggregates. [1]

c. Outline the process of nitrogen fixation by a **named** free-living bacterium. [2]

d. The image shows part of a sewage treatment plant. [3]

[Source: http://purewatergazette.net]

Outline the role of bacteria in trickling filter bed treatment of sewage.

Distinguish between tropical rainforest and taiga in terms of nutrient stores, nutrient flows and climate. Gersmehl diagrams can be used to support your answer.

In 1988 a fire destroyed large portions of forest in Yellowstone National Park, USA. Photograph A was taken soon after the fire and photograph B one year later. The photographs are of the same area.

Photograph A

[Source: http://commons.wikimedia.org/wiki/File:Grass_growing_after_fire.jpg, created by National Park service employee.]

Photograph B

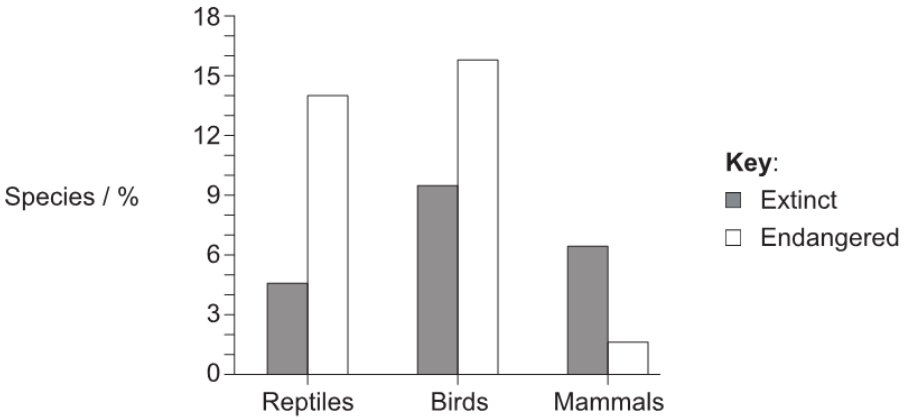
[Source: http://commons.wikimedia.org/wiki/File:Flowers_Yellowstone_1989.jpg, created by National Park service employee.]

a. Identify, with a reason, the type of succession that has taken place. [1]

c. Outline a method that could be used to sample the plant population shown in photograph B. [2]

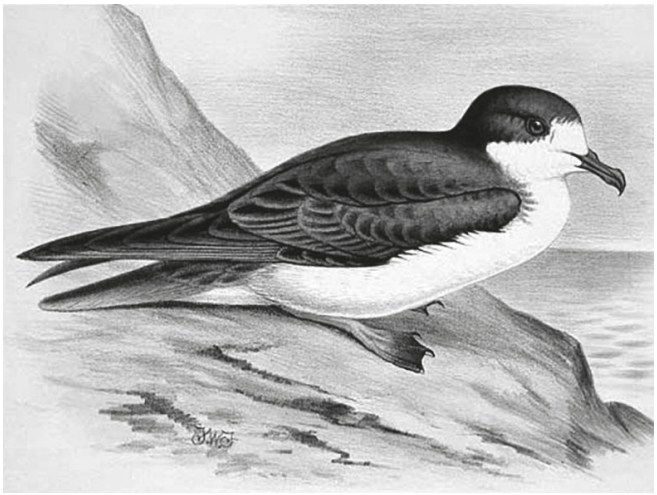
d. Yellowstone National Park was the first national park in the world and is a designated biosphere reserve site. Outline the biogeographical features of nature reserves that promote conservation of diversity. [3]

To assess the impact of introduced cats (*Felis silvestris*) that prey on native species, a study was carried out on 120 islands around the world. The graph shows the impact of *F. silvestris* on reptiles, birds and mammals.



[Source: A global review of the impacts of invasive cats on island endangered vertebrates, F. M. Medina et al. (2011) Global Change Biology, 17, pp. 3503–3510. Reproduced with permission from John Wiley and Sons.]

The ‘Ua‘u petrel (*Pterodroma sandwichensis*) is considered to be an indicator species in the Hawaiian Islands.



[Source: https://commons.wikimedia.org/wiki/File:Oestrelata_phaeopygia_AvesHawaiienses00Wils_0382.jpg]

a.i. Identify how the pattern in mammals is different from reptiles and birds. [1]

a.ii. Describe how invasive species such as *F. silvestris* can have a significant impact on native species. [2]

a.iii Suggest a method to limit the impact of *F. silvestris* on native species. [1]

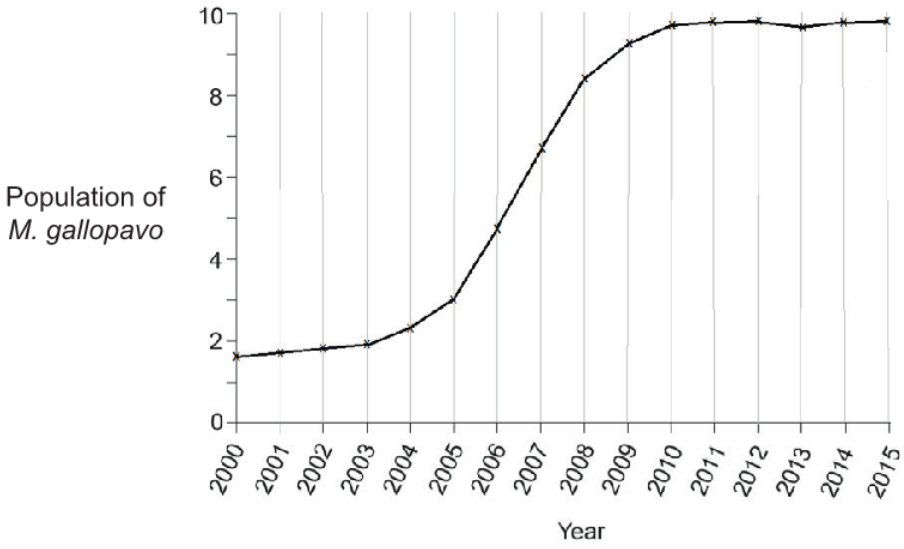
b.i. State the role of an indicator species. [1]

b.ii Identify possible approaches to maintain the population of *P. sandwichensis*. [2]

Wild turkeys (*Meleagris gallopavo*) once inhabited most forested areas of North America. As an important food source for early European settlers, the population of *M. gallopavo* seriously decreased. Due to recent conservation efforts, population numbers are increasing.

[Source: https://commons.wikimedia.org/wiki/File:A_wild_turkey_in_Middleboro,_Massachusetts.jpg] (https://commons.wikimedia.org/wiki/File:A_wild_turkey_in_Middleboro,_Massachusetts.jpg])

The curve shows a population of M. gallopavo from 2000 to 2015 in Ohio in the mid-western USA.



a.i. State the range of years when exponential growth of the *M. gallopavo* population occurred. [1]

a.ii. Suggest factors that could account for the growth curve of the *M. gallopavo* population. [2]

b. State how the population of *M. gallopavo* may have been determined. [1]

c. Hunting of *M. gallopavo* is currently regulated. Predict what would happen if the hunting regulations were removed. [2]