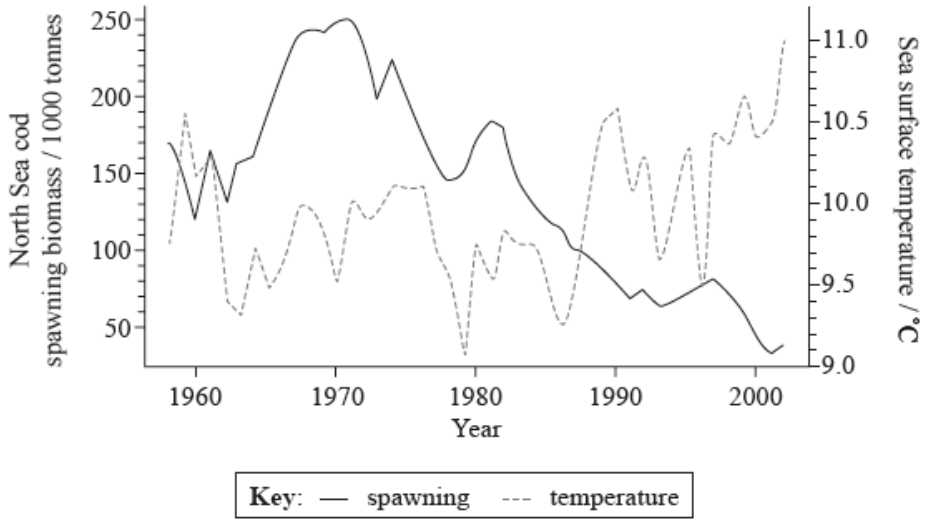
HL Paper 3

Reproduction in fish is called spawning. The males and females in a population that are mature enough to reproduce are the spawning stock. In order to provide better fisheries management and conservation decisions, there is a need to investigate the relationship between spawning stock and environmental conditions. The graph shows the North Sea cod spawning biomass and sea surface temperatures.



[Source: adapted from EM Olsen, *et al.*, (2011), *Proceedings of the Royal Society B*, **278** (1705), pp. 504–510. Figs 1 (a) and 1 (b).]

a.i. State the sea surface temperature when the North Sea cod spawning biomass was the highest, giving the units. [1]

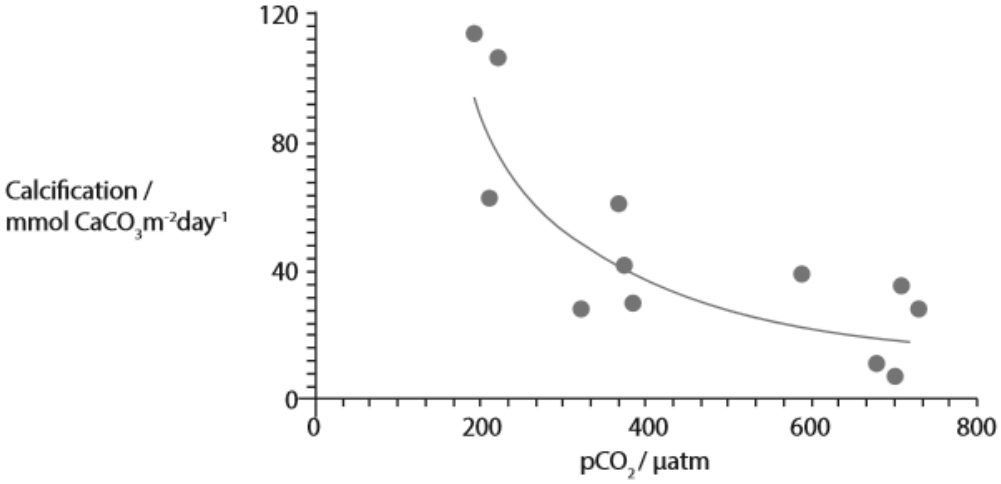
a.ii. State the North Sea cod spawning biomass when the sea surface temperature was the lowest, giving the units. [1]

b. Outline the trends in North Sea cod spawning biomass between 1960 and 2000. [2]

c. Evaluate the evidence provided by the data, for the prediction that North Sea cod will become extinct if sea temperatures continue to rise. [3]

d. Suggest **one** factor, other than sea surface temperature, that might influence the North Sea Cod spawning [1]

Increasing carbon dioxide concentration in the atmosphere leads to acidification of the ocean. This in turn reduces the amount of dissolved calcium carbonate. A study was undertaken to investigate the effect of increasing the concentration of atmospheric carbon dioxide on the calcification rate of marine organisms. Calcification is the uptake of calcium into the bodies and shells of marine organisms. The study was undertaken inside Biosphere-2, a large-scale closed mesocosm. The graph shows the results of the data collection.



[Source: © International Baccalaureate Organization 2016]

a. State the relationship between atmospheric carbon dioxide and calcification rates. [1]

b. Suggest **one** advantage of using a mesocosm in this experiment. [1]

c. Outline **one** way in which reef-building corals are affected by increasing atmospheric carbon dioxide. [2]

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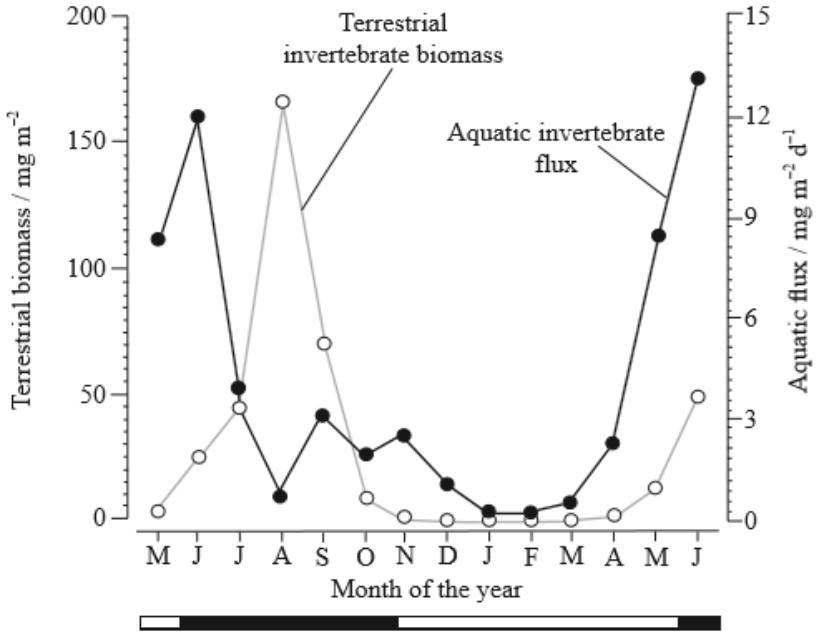
a. One of the distinguishing features of the Archaea is that they are capable of inhabiting extreme environments such as extreme temperatures or anoxic conditions. Outline other extreme environments inhabited by the Archaea. [2]

b. Describe how methane can be made from biomass. [3]

The graph below shows the monthly mean values of terrestrial invertebrates from May 1997 to June 1998 in the northern hemisphere. The light line shows the biomass of invertebrates which are prey to forest birds (terrestrial invertebrate biomass). The darker line shows the invertebrates which lived in the stream and have moved to the forest (aquatic invertebrate flux or movement). The black bars on the horizontal line at the bottom show periods when trees have leaves and the white bars show periods of defoliation.



S. Nakano and M. Murakami, 'Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs'. *PNAS*, 98 (1) pp. 166-170. Figure 1C. Copyright (2001) National Academy of Sciences, U.S.A.

a. State the mean terrestrial invertebrate biomass measured in August. [1]

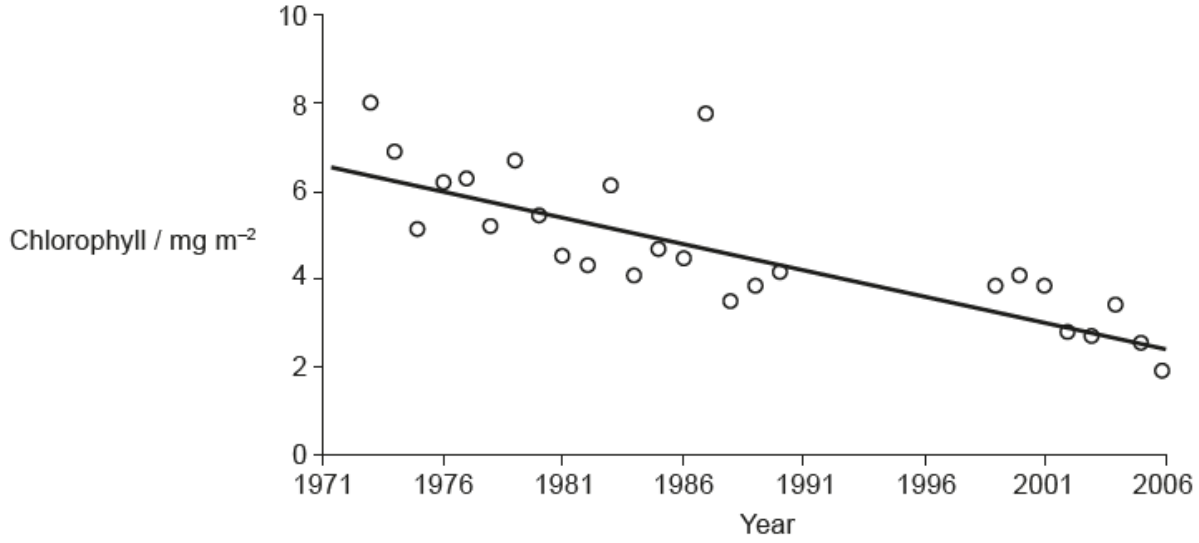
b. Describe the trend in the aquatic invertebrate flux. [2]

c. Suggest the relationship between defoliation and the amount of terrestrial invertebrates in the forest. [2]

d. Suggest a possible explanation for the pattern in aquatic invertebrate flux to the forest seen between the months of June and December. [2]

e. Allochthonous organisms are those which have migrated from one place to another, such as the aquatic invertebrates in this study. Suggest **one** effect of allochthonous invertebrates in this environment. [1]

Mean annual chlorophyll concentration was measured in surface water of Narragansett Bay along the Atlantic coast of the USA, from 1971 to 2006. Field data of chlorophyll concentrations are shown below.

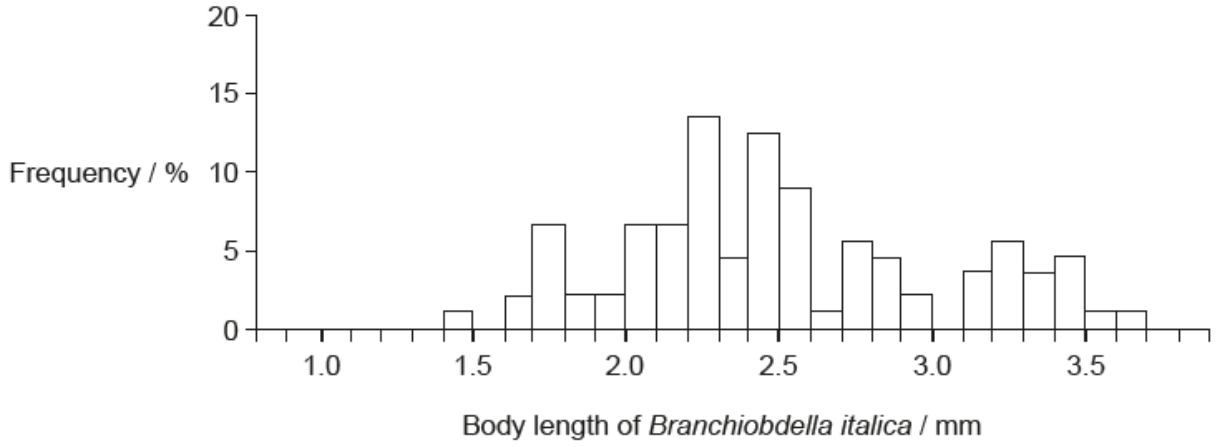


[Source: Reprinted by permission from Macmillan Publishers Ltd: *Nature*, Vol. 448, R. W. Fulweiler, S. W. Nixon, B. A. Buckley and S. L. Granger, Reversal of the net dinitrogen flux in coastal marine sediments, copyright (2007)]

a. Suggest a hypothesis for the trend in the graph. [2]

b. Mesocosm experiments using water from Narragansett Bay were completed in the laboratory during a six month period. Discuss advantages and limitations of carrying out mesocosm investigations. [3]

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]

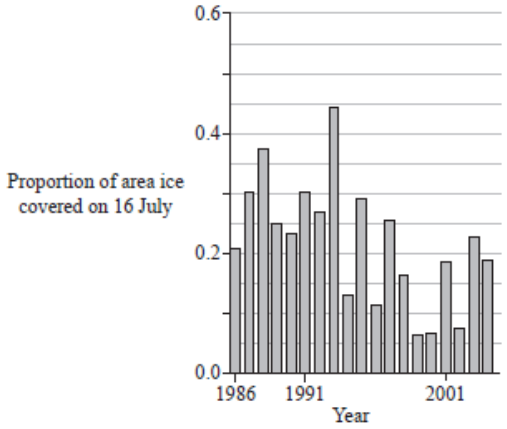
b. The relationship between *A. pallipes* and *B. italica* is mutualistic. [1]

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]

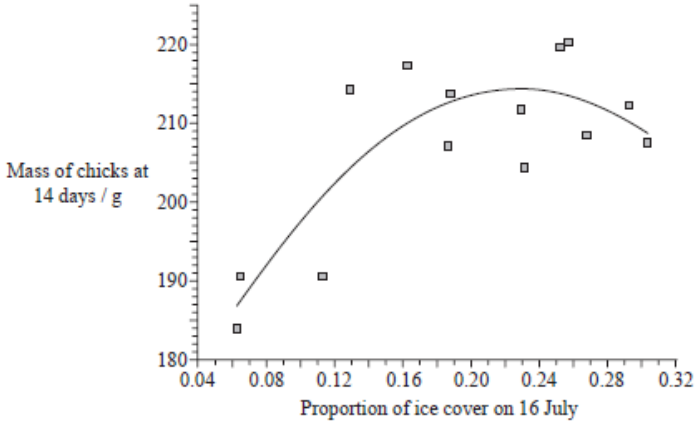
A colony of a marine diving bird, Brunnich's guillemot (*Uria lomvia*), lives on the southern limits of the Arctic on Coats Island. Brunnich's guillemots feed principally on Arctic cod (*Arctogadus glacialis*) which are characteristic of Arctic waters.

The graph shows the changes in ice cover on Coats Island over a period of 19 years.



[Source: A Gaston, et al., "Climate change, ice conditions and reproduction in an Arctic nesting marine bird: Brunnich's guillemot (Uria lomvia L.)", *Journal of Animal Ecology*, Volume 74, number 5, pages 832-841. © John Wiley & Sons, Inc. Reproduced with permission.]

At Coats Island, chick mass at 14 days was measured in most years between 1988 and 2002. The scattergraph below shows the results, plotted against proportion of ice cover.



[Source: A Gaston, et al., "Climate change, ice conditions and reproduction in an Arctic nesting marine bird: Brunnich's guillemot (Uria lomvia L.)", *Journal of Animal Ecology*, Volume 74, number 5, pages 832-841. © John Wiley & Sons, Inc. Reproduced with permission.]

a(i). Outline the changes in ice cover shown in the data above. [2]

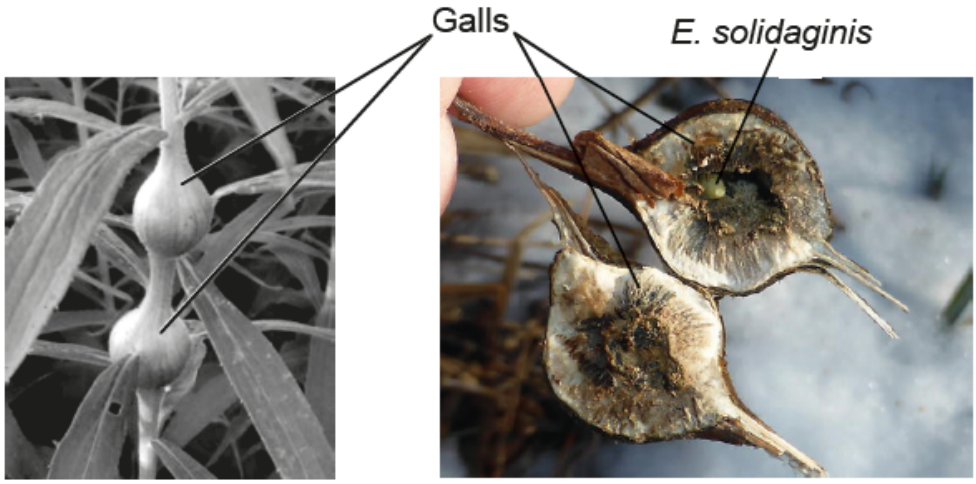
a(ii). Suggest **one** reason for the changes in ice cover. [1]

b(i). Outline the relationship between ice cover and the mass of 14-day-old chicks on Coats Island. [2]

b(ii). Suggest reasons for the relationship. [2]

c. Predict, with a reason, the change in the mass of chicks in the years ahead. [1]

The larval stage of the fly *Eurosta solidaginis* develops in the plant *Solidago altissima*. The larva secretes a chemical which causes plant tissue to grow around it forming a swelling called a gall. The gall provides the developing insect with protection from predators.



[Source: https://nhgardensolutions.files.wordpress.com]

[Source: Masumi Palhof]

The *E. solidaginis* fly is preyed upon by the parasitic wasp *Eurytoma gigantea*. The graph shows the relationship between gall diameter and the percentage of flies that avoid predation by *E. gigantea*.

a. In order to form galls, the insects choose a location where cell division occurs at a high rate. State the term for a region of rapid cell division within a plant. [1]

b. Describe the relationship between gall diameter and percentage survival of *E. solidaginis*. [2]

c. Explain the concept of directional selection with respect to this example. [2]
