The desert pupfish (*Cyprinodon macularius*) is a species of fish found in shallow waters of desert pools and streams of northern Mexico. Desert pupfish can survive in environments of extreme salt, high temperature and low oxygen. Individual pupfish differ in the temperature extremes they can withstand.

4a) Before 1980, pupfish population sizes in the Sonoran Desert were stable. Between 1980 and 2010, the habitat of these pupfish was reduced by 25% because less water was available. The population size over the same time period dropped by 75%. The pupfish population and habitat area remained stable after 2010.

i) What happened to the density of the pupfish between 1980–2010? **Briefly** justify your answer. (**2 marks**)

Density would have decreased (1 mark), since the reduction in number of individuals is much greater than the reduction in habitat area (1 mark).

ii) What happened to the carrying capacity of the pupfish's habitat between 1980–2010? **Briefly** justify your answer. (**2 marks**)

Carrying capacity would have decreased as well (1 mark), since the number of individuals that can be supported by an equivalent habitat area is much lower after water reduction (1 mark).

Many populations of desert pupfish live in permanent pools that are sometimes connected by streams. During years with average rainfall, the streams connecting the pools dry up, causing the pools to differ in salinity and temperature (Fig. 4a). During years of above average rainfall, about once every decade, pools are connected by streams and individuals migrate among pools (Fig. 4b).

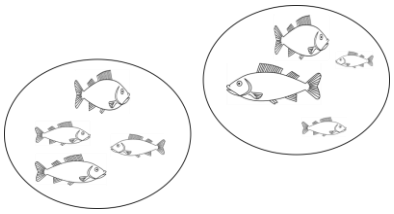

Fig. 4a: Pools separated during average rainfall

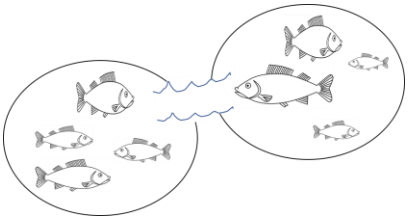

Fig. 4b: Pools connected during above-average rainfall

The closest relative of desert pupfish is the Devils Hole pupfish (*Cyprinodon diabolis*), a species native to Devils Hole, an isolated cave pool in Nevada, U.S.A. Both species originated from a common ancestor species ("CAS") of pupfish which entered western North America at the end of the last ice age. Outline a hypothetical step-by-step scenario for how this common ancestor "CAS" evolved into the two different modern pupfish species. Be sure to include appropriate evolutionary mechanisms in your answer, and be specific to this situation as described in the introductory parts of the question. (**3 marks**)

The two populations would have to have become genetically isolated due to reduced gene flow (1 mark)
1 mark for an evolutionary mechanism (mutation, selection, drift) that caused evolutionary divergence of the two populations
1 mark for being specific to this situation.

For example (other answers are possible)

1) *Once connected by rivers and streams, increased temperature and decreased water levels isolated populations of the Common Ancestor Species into separate pools and river systems with no gene flow between them.*
2) *Over time independent mutations, genetic drift and adaptations to water systems with different salinity and oxygen levels caused the two populations to genetically diverge.(Both populations evolving independently).*
3) *The two populations being sufficiently different genetically and morphologically that they even if their pools were connected by new streams, they would be reproductively isolated. (I would expect a specific Prezygotic or Postzygotic barrier to be mentioned).*