

**Lecture 4: Adaptations for particular habitats**

I. Introduction

A. Objectives

1. Appreciate extremity of selection pressures in certain aquatic environments
2. Recognize adaptations, often convergent, exhibited by fishes living in these environments

B. Some definitions

1. Benthic
2. Pelagic
3. Littoral

II. The deep sea

A. Phylogeographic patterns

B. Regions

1. Depth zones
2. Light/production zones

C. Selection pressures and adaptations

1. Water pressure

- a. Relationship to depth
- b. Consequences for fish
- c. Three types of adaptations

2. Temperature

- a. Relationship to depth
- b. Vertical migrations

3. Space

- a. Some numbers – it's a bathypelagic world

b. Sexual dimorphism

4. Light

a. The twilight zone and the dark zone

b. Bioluminescence – fireflies of the deep

c. Eye adaptations

5. Food

a. Three adaptations for obtaining scarce food

b. Three strategies for conserving energy

III. The open ocean

A. The diverse and important epipelagic zone

B. Upwelling (more later)

C. Selection pressures and adaptations

1. Patchiness of food supply

a. Keep moving – 6 adaptations that help

b. Eat a variety of foods and do it quickly

2. Variation in spawning success

a. The cyclonic strategy

b. The anticyclonic strategy

c. Larval drift

d. American and European eels

3. Lack of structure – flotsam

D. Convergence with lake fishes

IV. Polar regions

A. Similarities and differences between the two poles

B. Welcome to the Antarctic!

1. Radiation of the notothenioids

2. Adaptations for the cold

3. Other adaptations

C. Welcome to the Arctic!

1. Convergence with Antarctic fishes

2. Greater range and flux of temperature

3. Freshwater fauna

V. Deserts and other habitats that periodically dry up

A. Definition

B. Other consequences of dewatering

C. Drought-adapted versus non-adapted species

D. Three common adaptations

1. Diapause

2. Accessory respiratory structures

3. Estivation

E. Endemism in the North American southwest

1. Ancestral marine origins of different strategies

2. Habitats and segregation by body size

3. Tough critters

4. Body morphology

VI. Caves

A. Nature and origin of caves

B. Phylogeography of cave-dwellers

C. Adaptations for cave life

1. Physiological

2. Life history

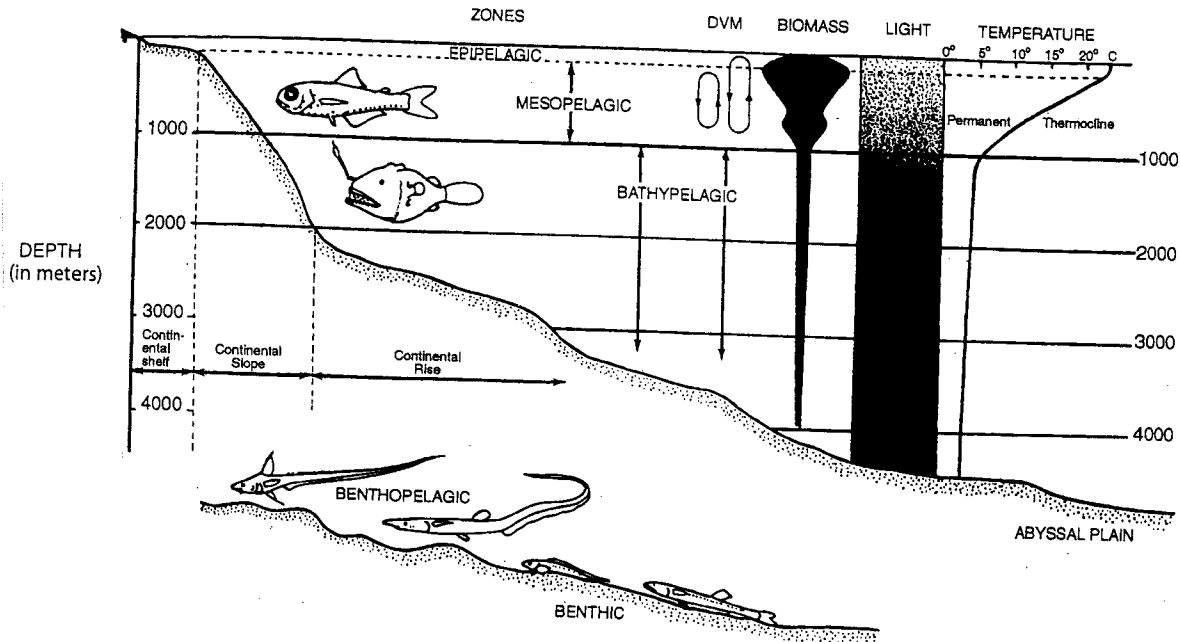
3. Food

D. Pre-existing tendencies of cave-dwelling lineages

E. Convergence with deep-sea fish

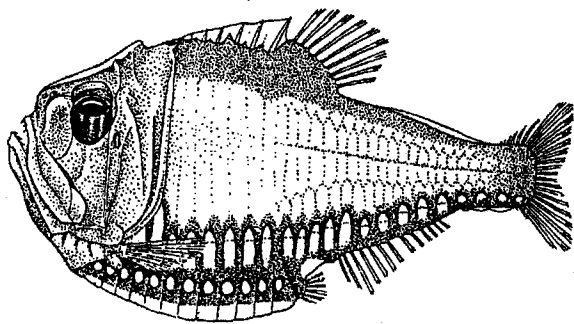
VII. Conclusions

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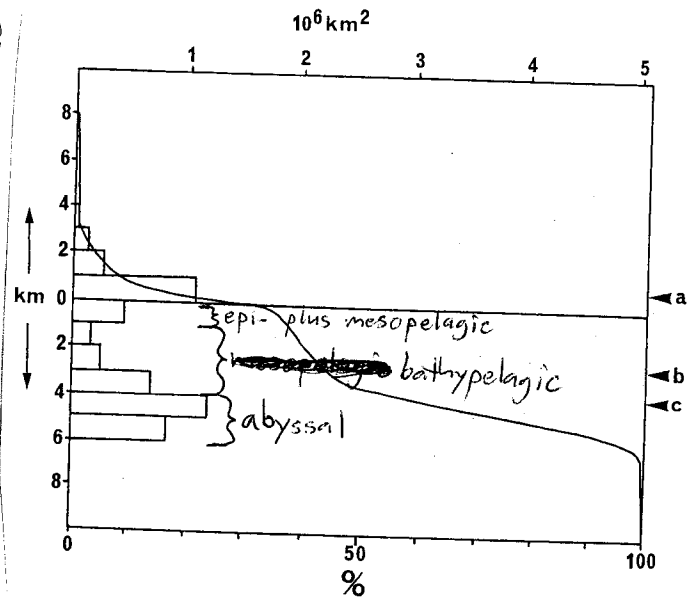


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Hatchetfish (photophores)

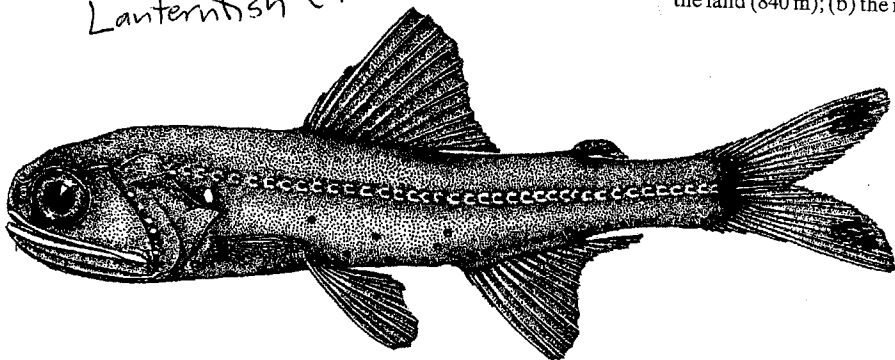


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Lanternfish (eyes)



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Anglerfish (lure)

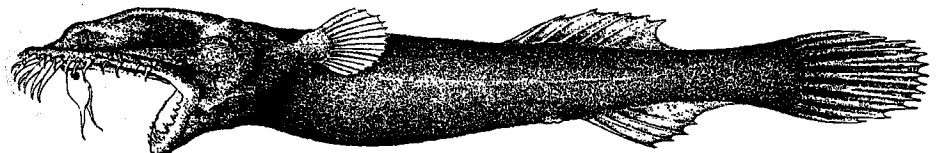


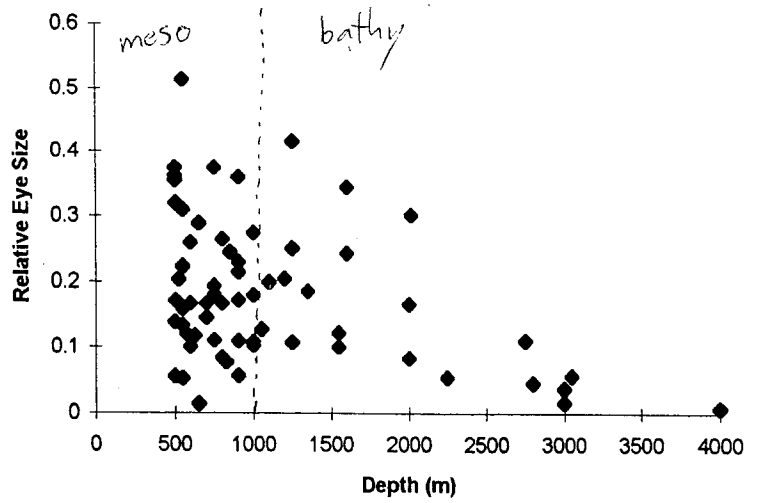
Fig. 1. Hypsographic curve of the world, showing areas in  $10^6 \text{ km}^2$  (upper axis), and percentages of the Earth's surface covered by land [with a range of elevations (km)] and by oceans [with a range of various bathymetric depths (lower axis)]. (a) The mean elevation of the land (840 m); (b) the mean sphere depth (2440 m); (c) the mean depth of the ocean (3800 m).

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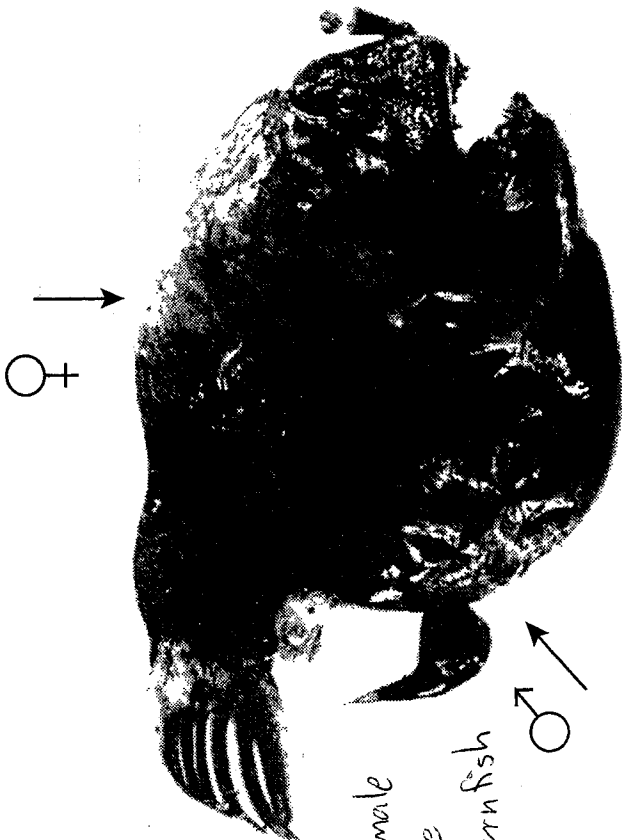
**Table II**  
Specific Gravities of Various Lipids  
Accumulated in Fishes

Lipid	Density (kg liter <sup>-1</sup> )
Triacylglycerol <sup>a</sup>	0.93
Alkyl diacylglycerol <sup>a</sup>	0.91
Wax ester <sup>a</sup>	0.86
Squalene	0.86
Cholesterol	1.065
Pristane	0.78

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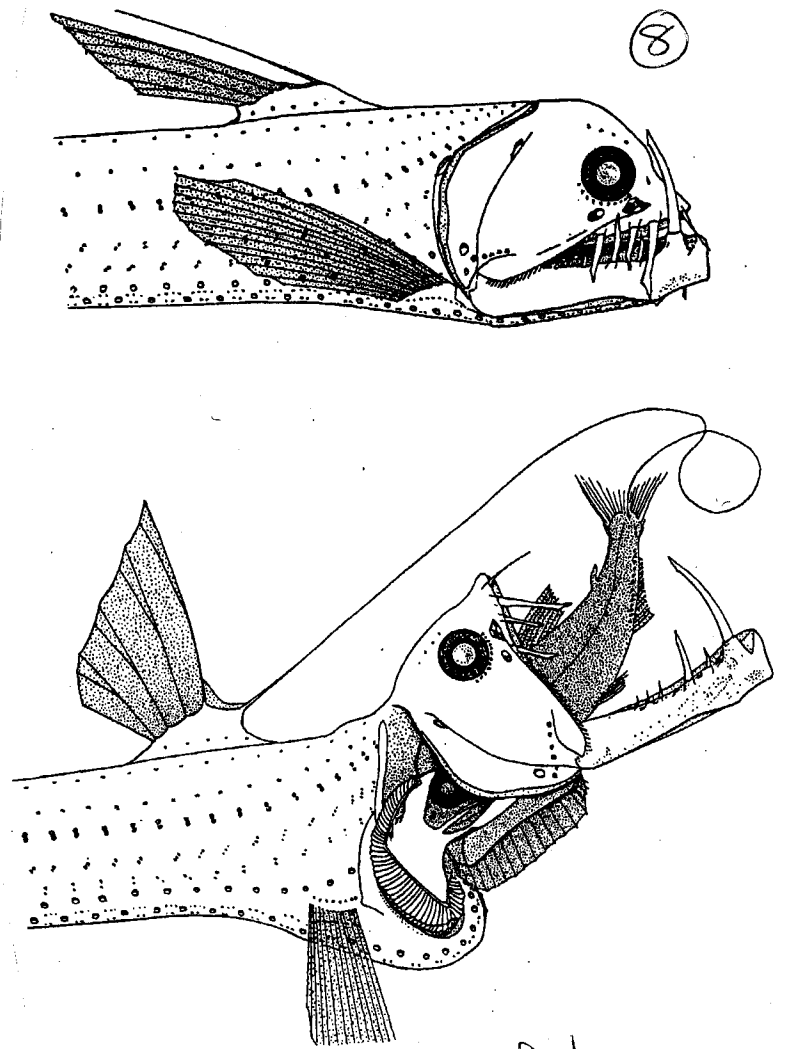
**Fig. 1.** Relative eye size as a function of depth of occurrence for fish, with a median depth range of greater than 500 m. Relative eye size is taken here as horizontal eye diameter divided by head length. [Data measured from illustrations in Paulin *et al.* (1989).] Each data point represents the illustrated representative species for one family and is plotted at the median depth range given for that family.



Parasitic male  
on a large  
female lantern fish

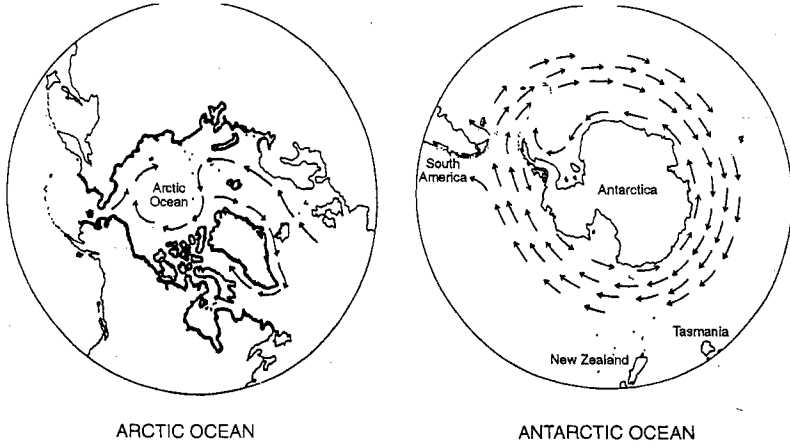
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viperfish

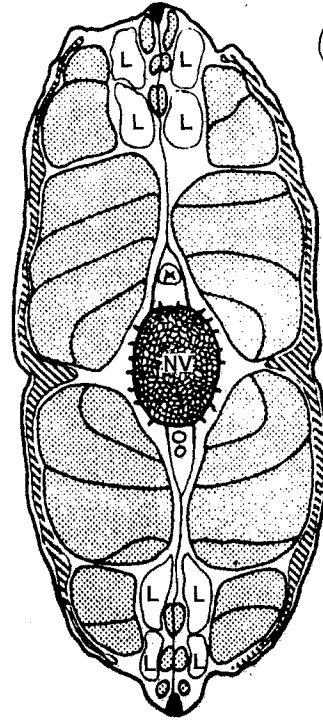
**FIGURE 17.5.** North and south polar regions. General oceanic circulation patterns are shown by arrows. The Arctic Ocean centers on the North Pole; the southern limits of the region are indicated by the dark continental borders. The Southern Ocean surrounds Antarctica.



ARCTIC OCEAN

ANTARCTIC OCEAN

(11)

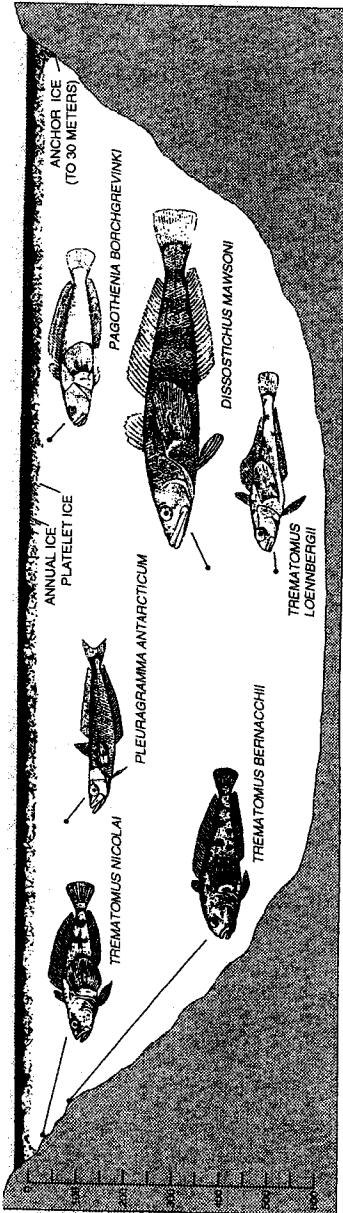


0.5 cm

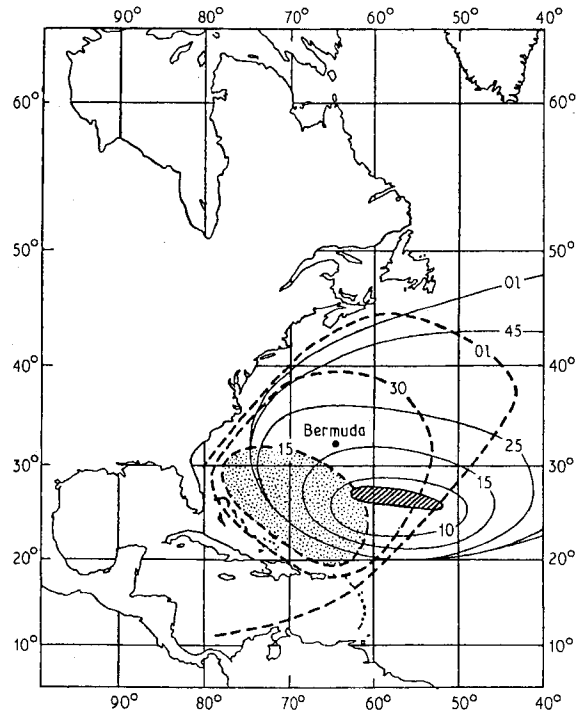
Low-density lipid sacs (L) in cross-section of the cod icefish

(10)

**FIGURE 17.6.** Body form and habitat types of common antarctic nototheniid fishes. The dots show the preferred depths and habitats.



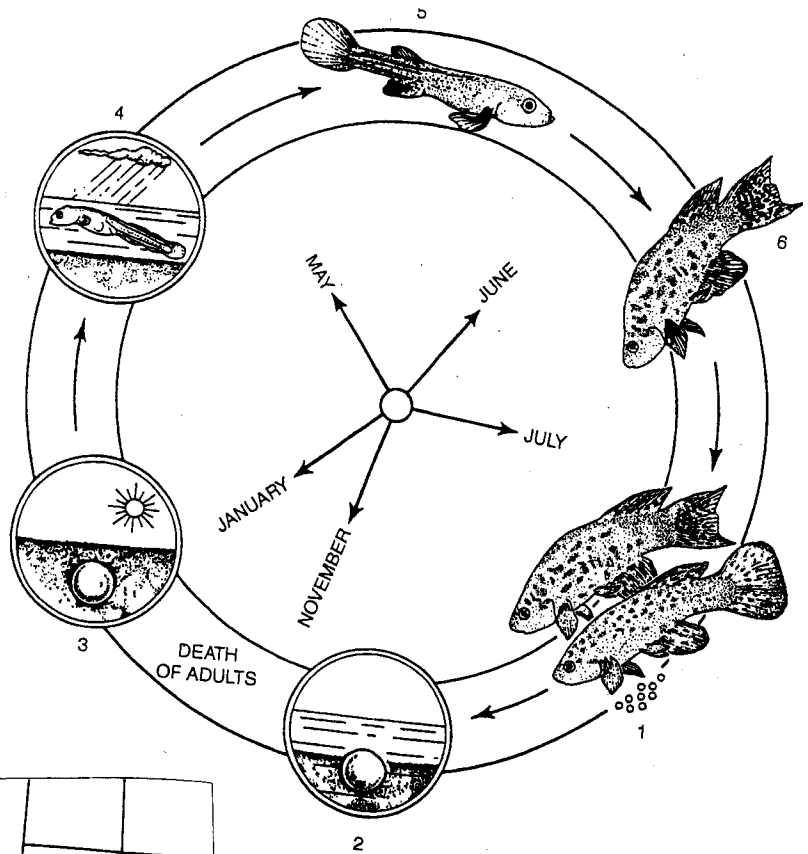
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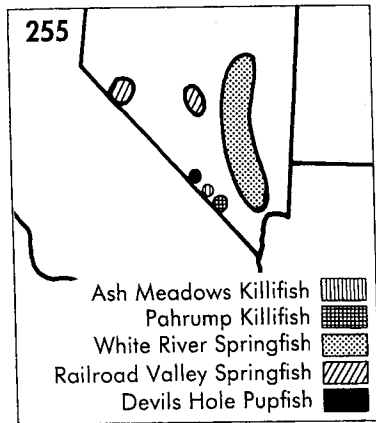
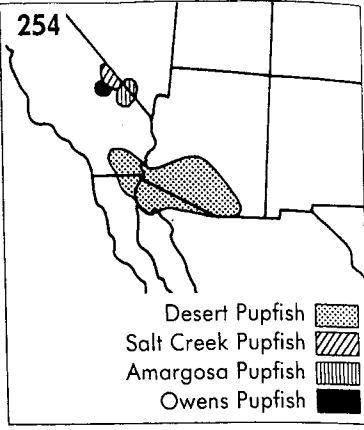
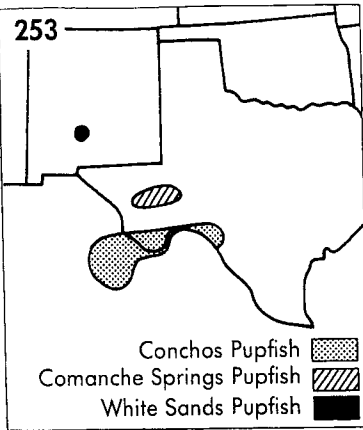
Limits of occurrence of *Anguilla* larvae of various sizes (10, 15, 25 and 45 mm). Continuous lines indicate the areas of occurrence of the European eel (*A. anguilla*), discontinuous lines of the American eel (*A. rostrata*). For the American eel the outer boundary line (ol) indicates the absolute limits of distribution of the larvae. Five to seven millimetre long larvae, i.e. relatively recently hatched European eel larvae, were caught within the hatched area, and thus the spawning grounds are thought to lie within this region (after Tåning, 1938).

Life-cycle of the Venezuelan pupfish

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15



Some desert fishes of NA

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FIGURE 17.8. An amblyopsid cavefish, *Typhlichthys subterraneus*, about 6 cm long. Note regressed eyes and the development of sensory canals and pores on the head and body, and even on the tail.

