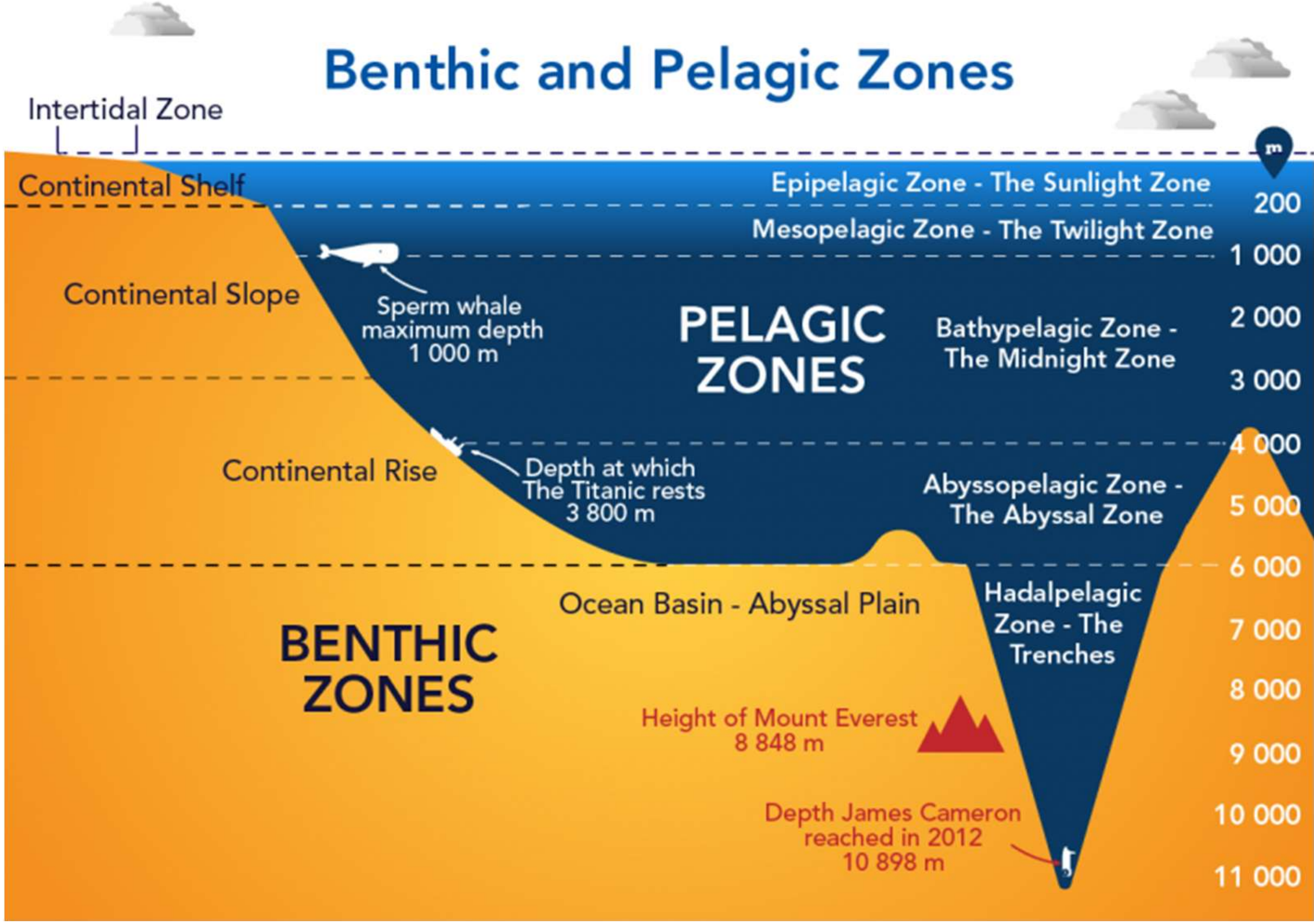
Zoogeography

Lesson 14

Patterns in the Oceans

- The vast volume of the open oceans.
- The floor of the deep ocean far from the light of the surface.
- The far richer life of the shallow seas around the continet and the oceans.

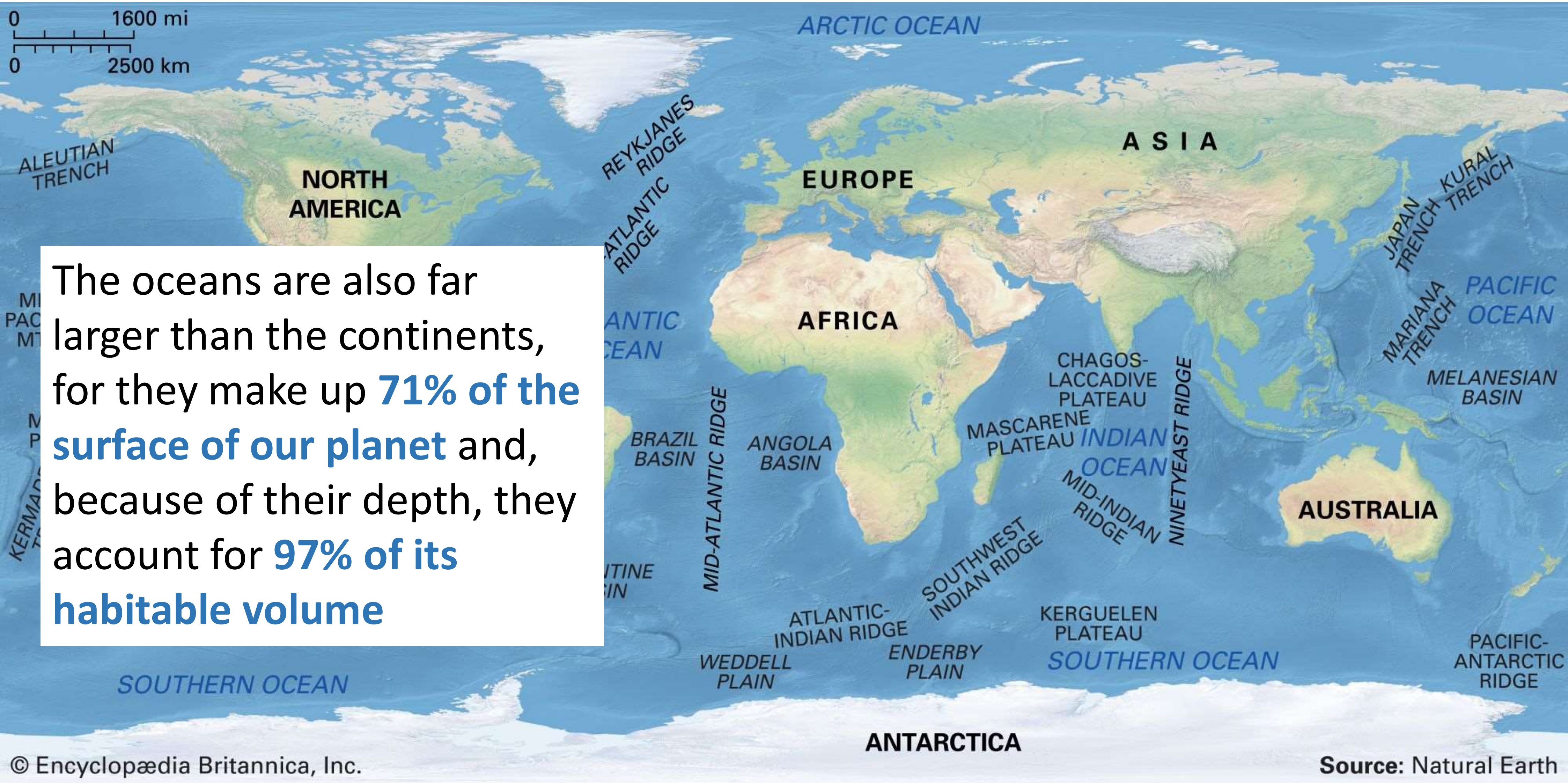


The understanding of oceans biogeography is limited by:

- We are air-breathing creatures: difficulties to survey and sample huge area of oceans.

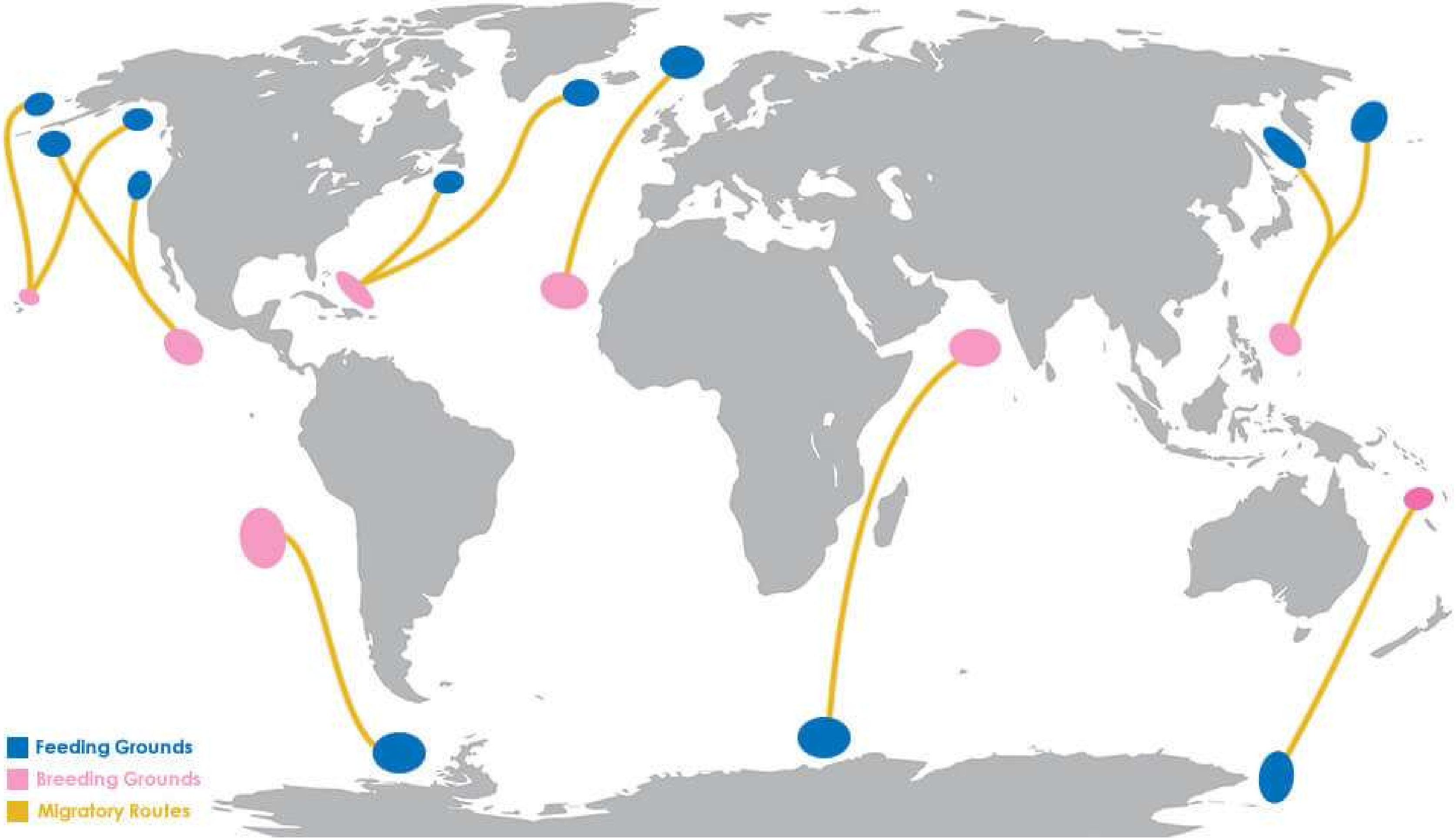
- Unlike terrestrial species, marine species often cannot be distinguished by differences in morphology, so their taxonomy has to be based on more subtle genetic comparison.

- More difficult to recognize the barriers that lie between the areas of distribution of marine species.



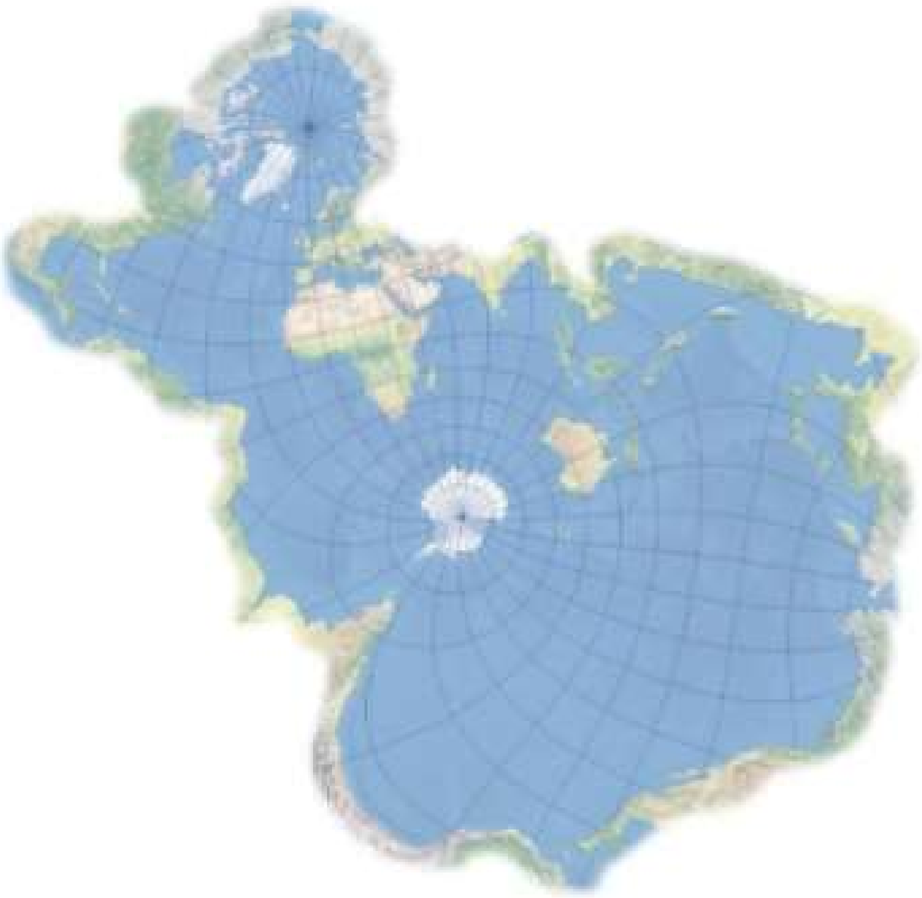
The oceans are also far larger than the continents, for they make up **71% of the surface of our planet** and, because of their depth, they account for **97% of its habitable volume**

Migratory Routes of the Humpback Whale



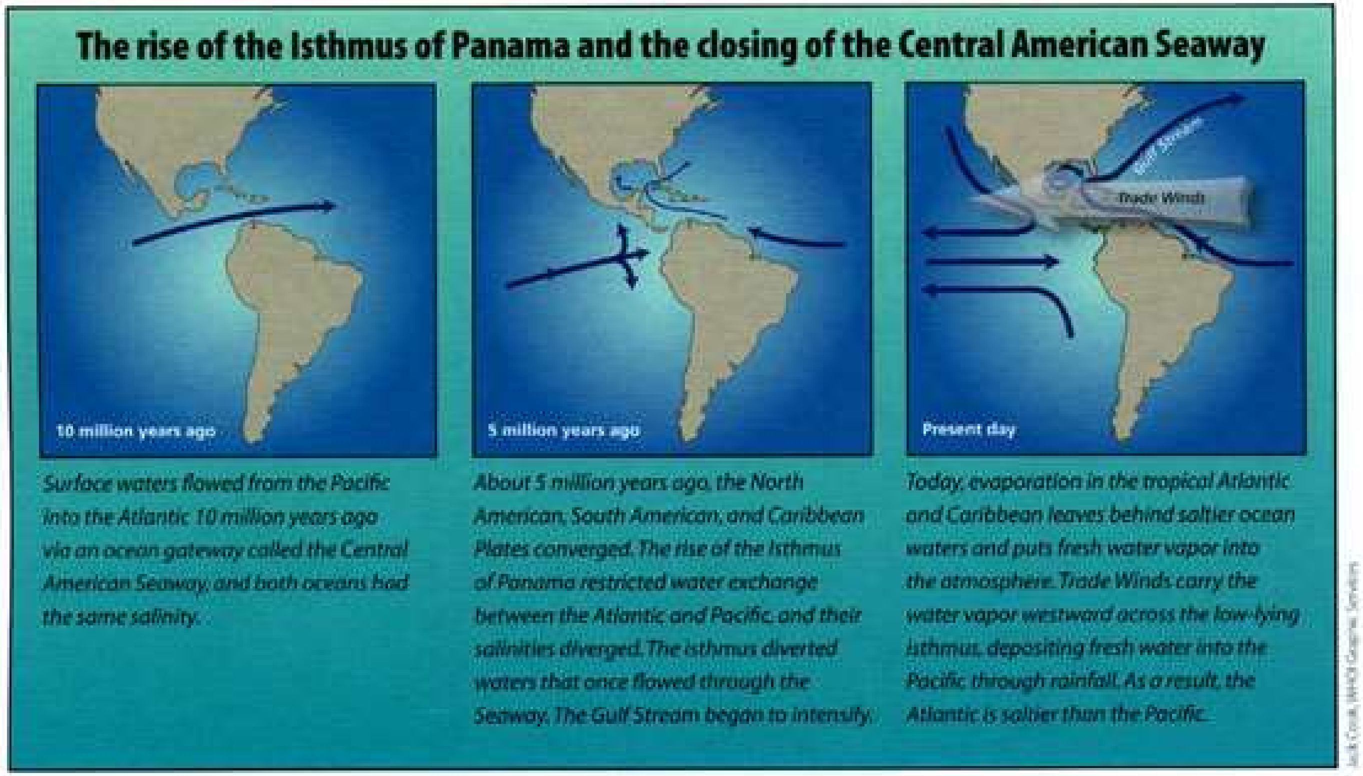
Over 90% of the marine environment's living space is pelagic (the three-dimensional layer from the water's surface through to the deepest trenches or bathypelagic zones).

World map according to fish



Although pelagic areas may seem like a boundary-less continuum, water chemistry, salinity, depth/pressure, currents and variations in primary productivity create different regions within these systems with distinct biotas and geographies.

- Our knowledge of the fauna of the deep ocean seabed, which covers an area of 270 million km^2,
- is derived from cores totalling only about 500 m^2,
- together with the areas sampled from dragging a number of trawls and deep sea sleds over the bottom!
- But our analysis of the life in the sea may well be blinkered by a far more fundamental error: the nature and **recognition** of species in the aquatic environment.



3 million yrs ago

- Lack of physical barriers
- Lower productivity

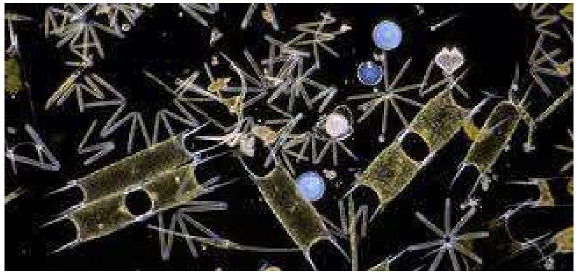
- Less opportunity for evolutionary diversification

- 210 000 species of marine organisms have been described so far

- 1,8 million species from the land

- 250 000 land plant species

- Only 3500-4500 phytoplankton species



The case of the hake *Merluccius*

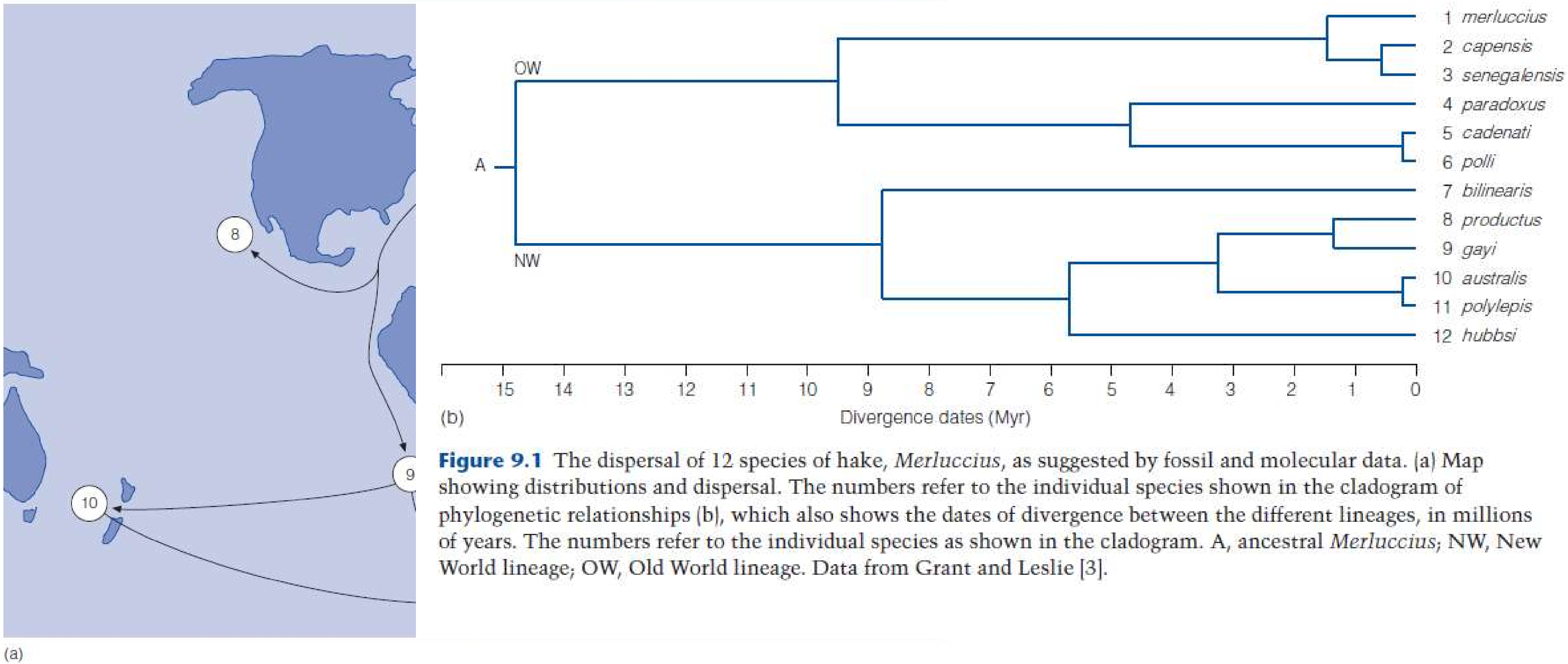


Figure 9.1 The dispersal of 12 species of hake, *Merluccius*, as suggested by fossil and molecular data. (a) Map showing distributions and dispersal. The numbers refer to the individual species shown in the cladogram of phylogenetic relationships (b), which also shows the dates of divergence between the different lineages, in millions of years. The numbers refer to the individual species as shown in the cladogram. A, ancestral *Merluccius*; NW, New World lineage; OW, Old World lineage. Data from Grant and Leslie [3].

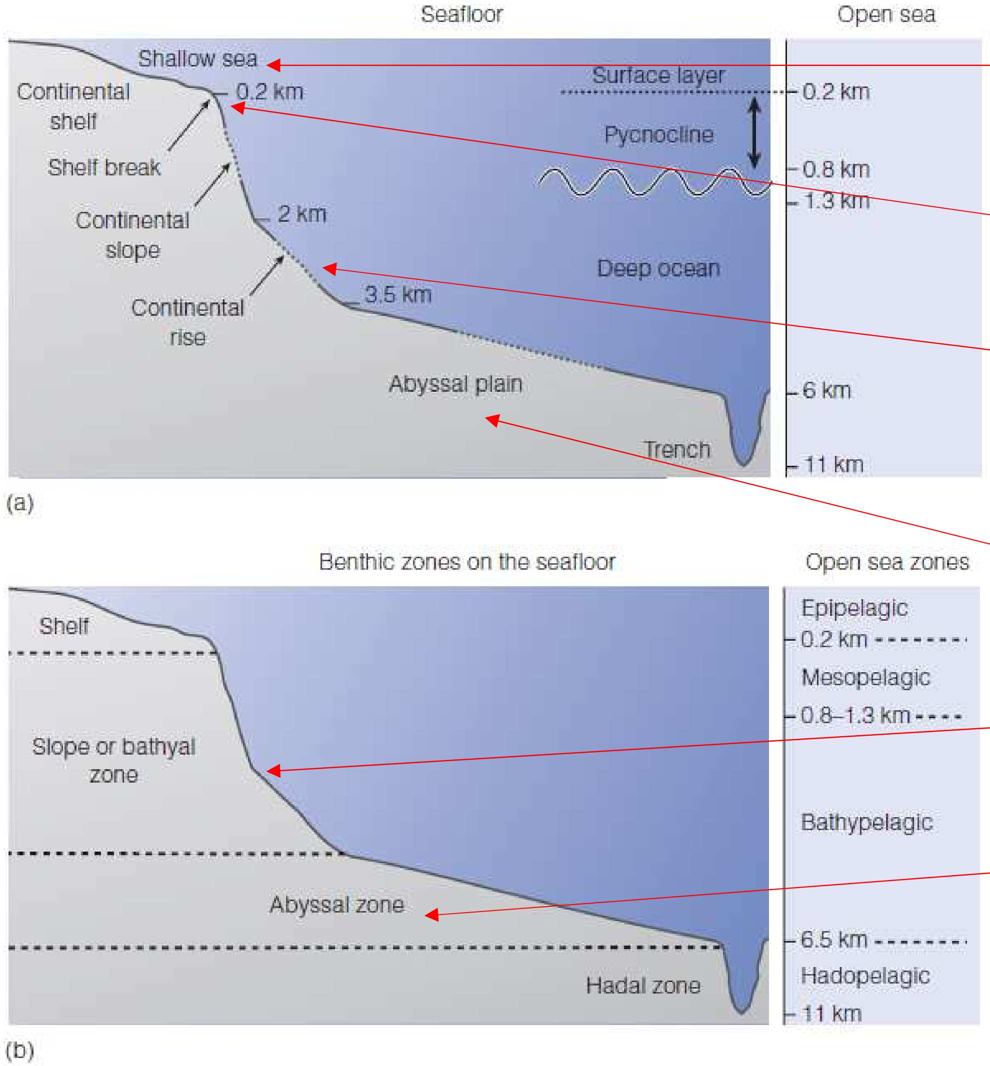


Figure 9.2 (a) Diagram of the vertical divisions of the seafloor and of the open sea. (b) Life zones on the seafloor and in the open sea.

Epicontinental seas varies according to how much of it has gone to form ice sheets and glaciers on the continents.

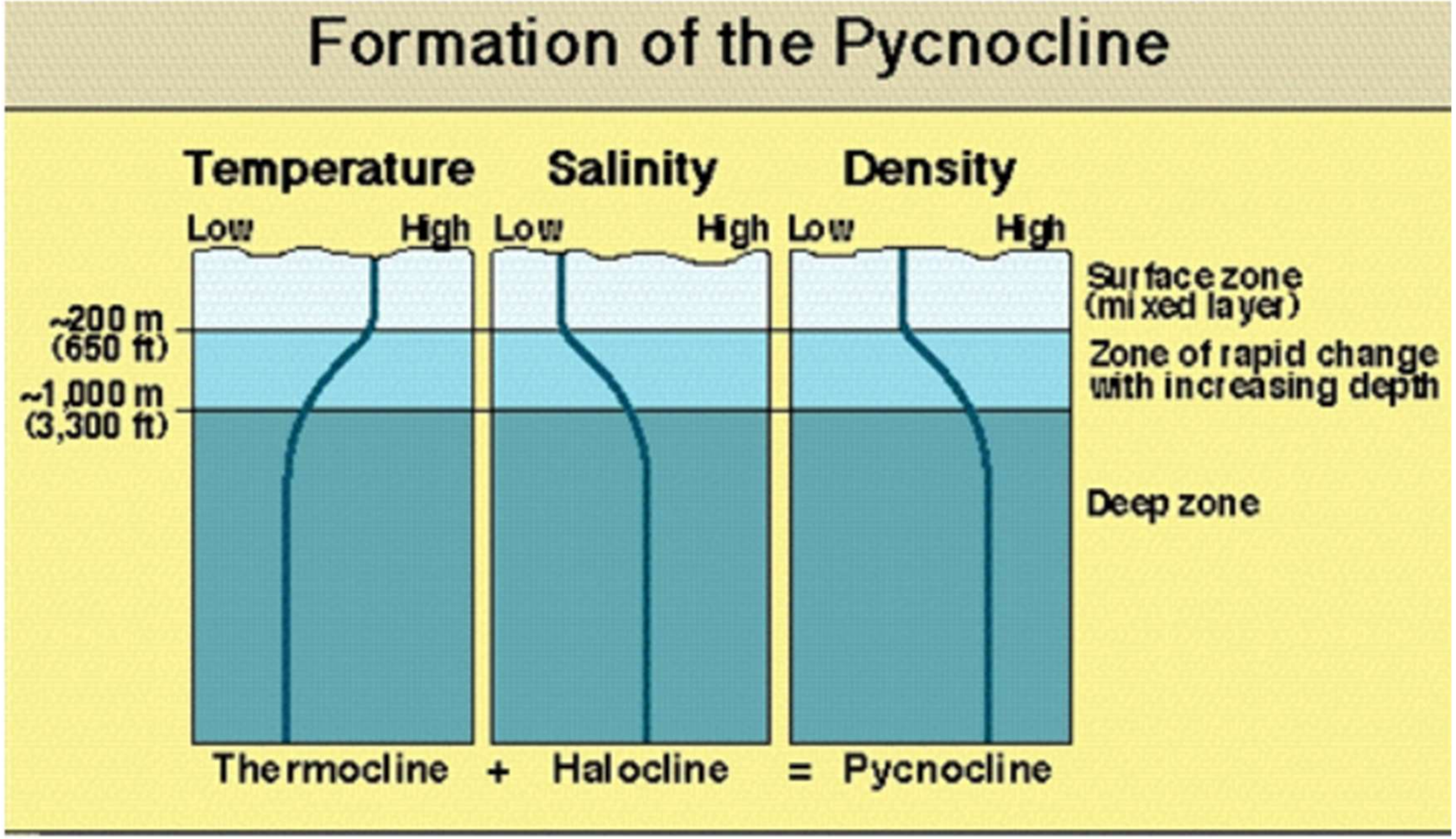
Average depth of 135 mt, here the slight gradient of the seafloor increases sharply

spill down over the edge of the continental slope and onto the adjacent margin of the abyssal plain to form a wedge known as the **continental rise**.

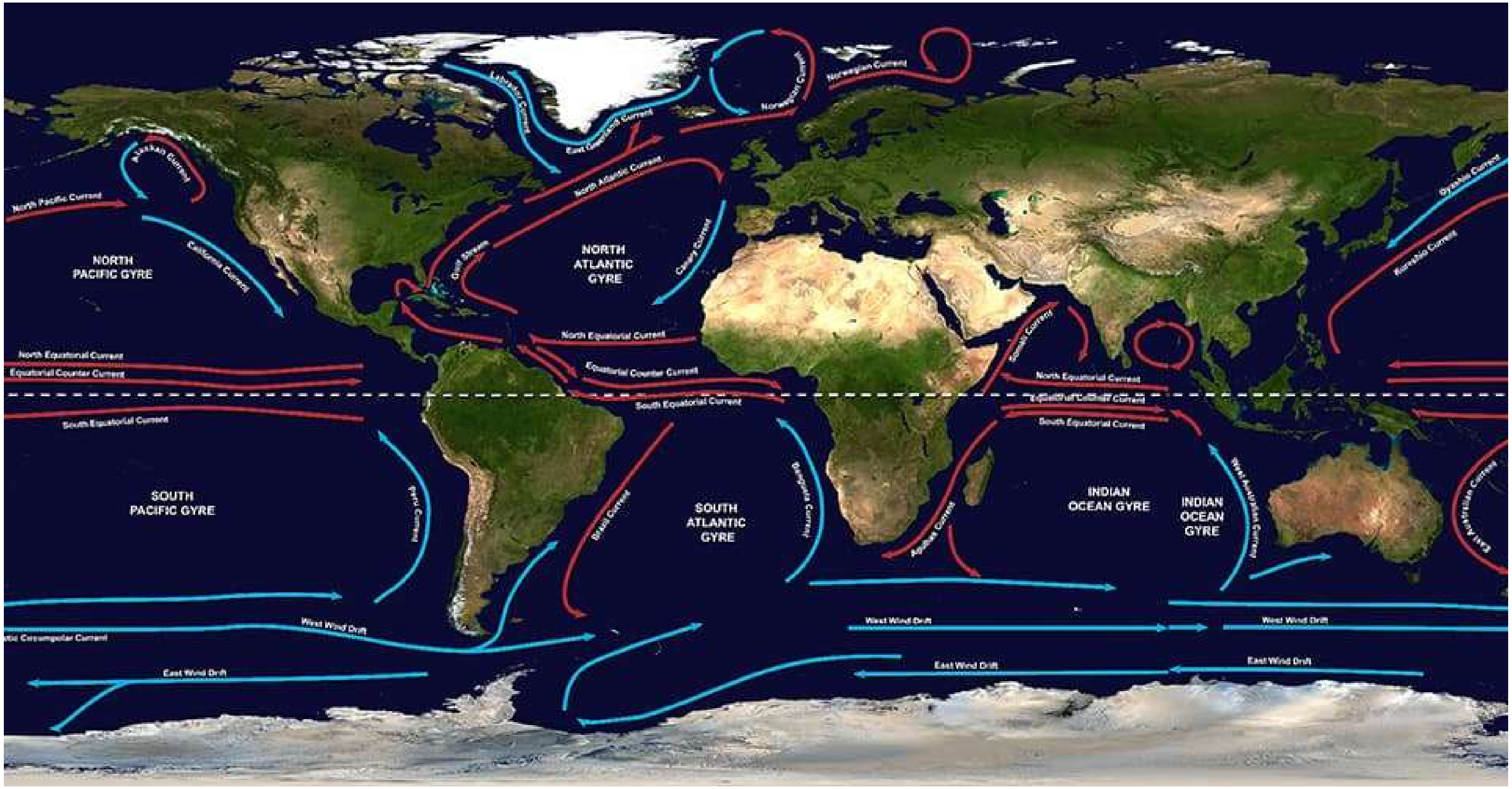
Depths of 3500-6500 m. Sediments cover all of these ocean floors.

The continental slope and continental rise together form the **bathyal** depth **zone**

At an average depth of 4 km, the abyssal plain covers 94% of the area of the oceans and 64% of the surface of the world, and is therefore the most extensive of all environments.


Formation of the Pycnocline
Temperature
Salinity
Density
Low
High
Low
High
Low
High
~200 m
(650 ft)
~1,000 m
(3,300 ft)
Surface zone
(mixed layer)
Zone of rapid change
with increasing depth
Deep zone
Thermocline + Halocline = Pycnocline

Dynamics of the Ocean Basins

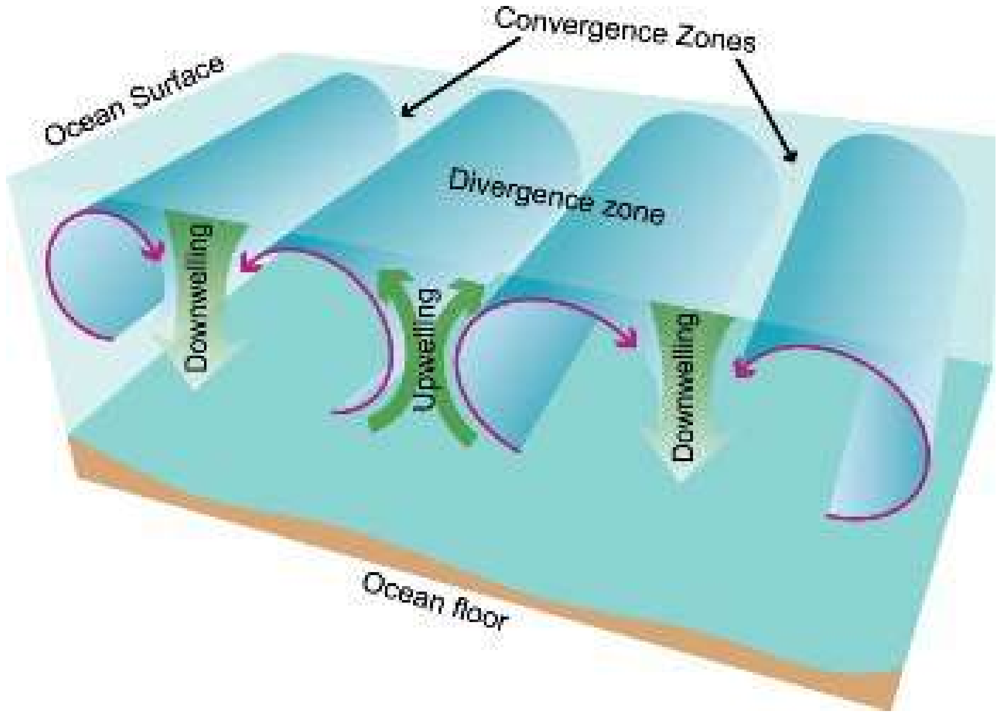


Their rotation is caused by wind patterns, which themselves result from the uneven distribution of solar energy on the surface of the Earth, as well as from the eastward rotation of the Earth due to the action of the Coriolis force

Vertical movement

- Upwelling – vertical flow of cold, dense water to the surface; occurs in area where horizontal currents diverge

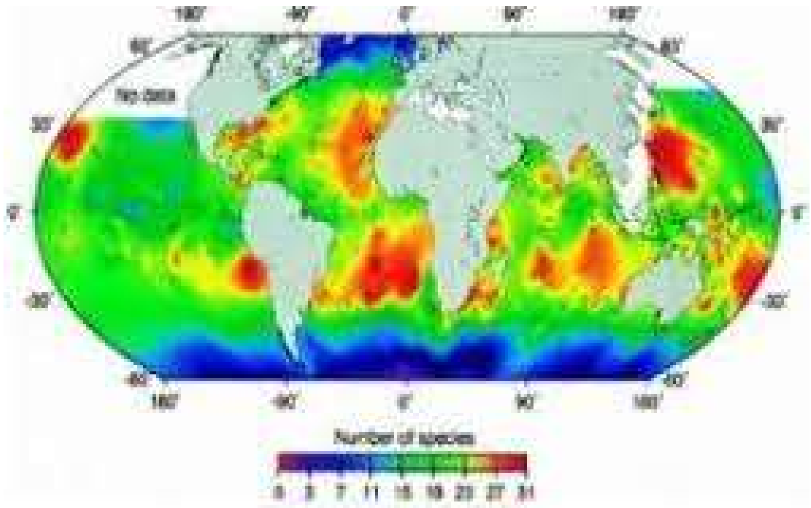
- Downwelling – vertical flow of warm, less dense water toward the ocean bottom; occurs in areas where horizontal currents converge



Plankton map

- the importance of seasurface temperature.

Satellite measurements of this temperature show that it accounts for nearly 90% of all the geographical variation in the density of the type of plankton known as foraminifera in the Atlantic.

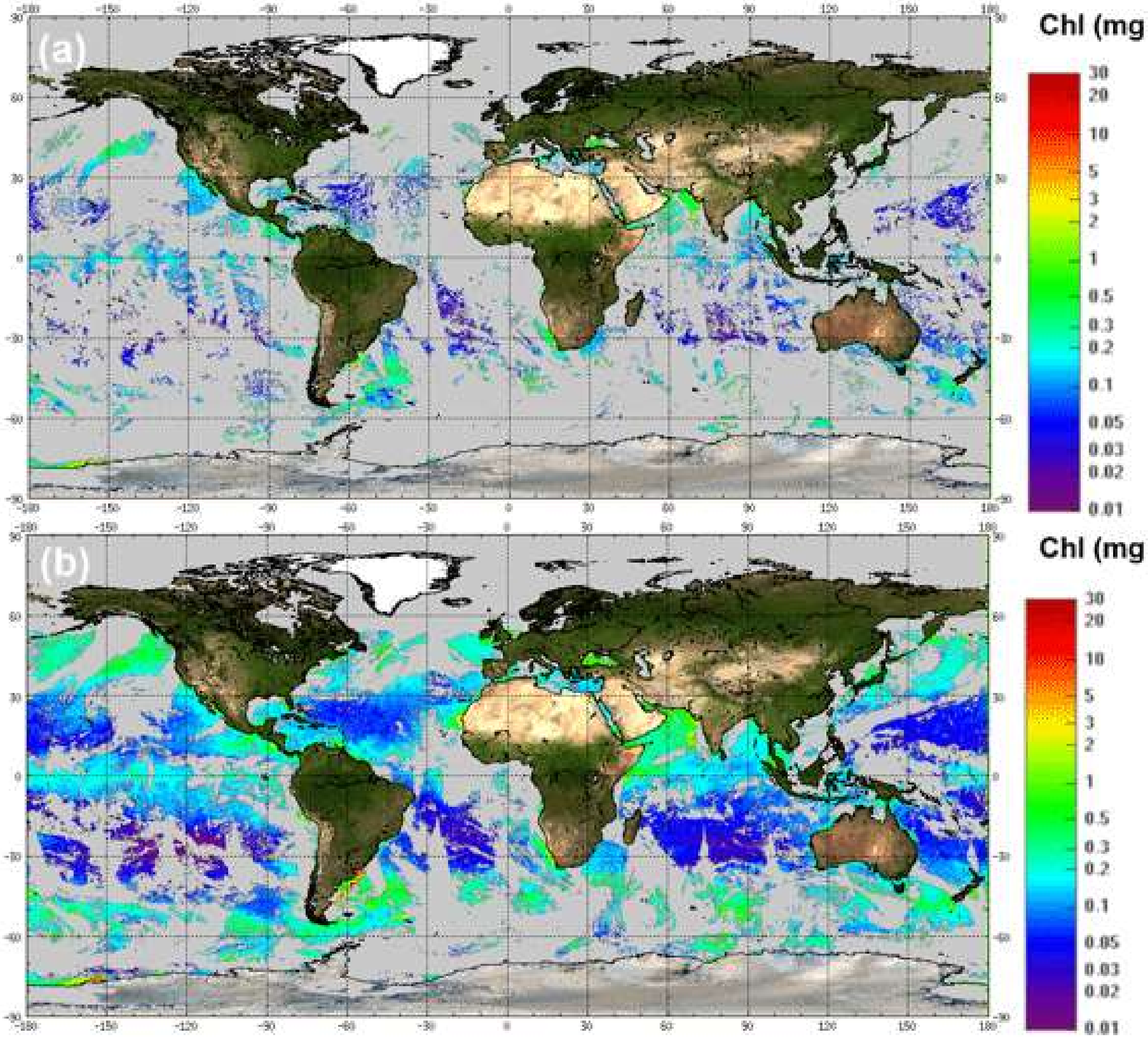


Species richness of planktonic foraminifers, illustrating maximal species richness in subtropical latitudes, with lower levels in equatorial regions. From Rutherford et al. 1999

- The results of this study also show that the diversity of planktonic foraminifera does not simply diminish from the equator to the poles, but instead peaks at middle latitudes in all oceans, it may be determined by the <u>thickness and depth of the pycnocline</u>.

Patte rs

- The ci ntally and vertica h major nutrients as nitr
- Althou ng been known, it is on t it has been possib the life that lies within
- Althou ean surface, these areas



Garnesson et al., 2019

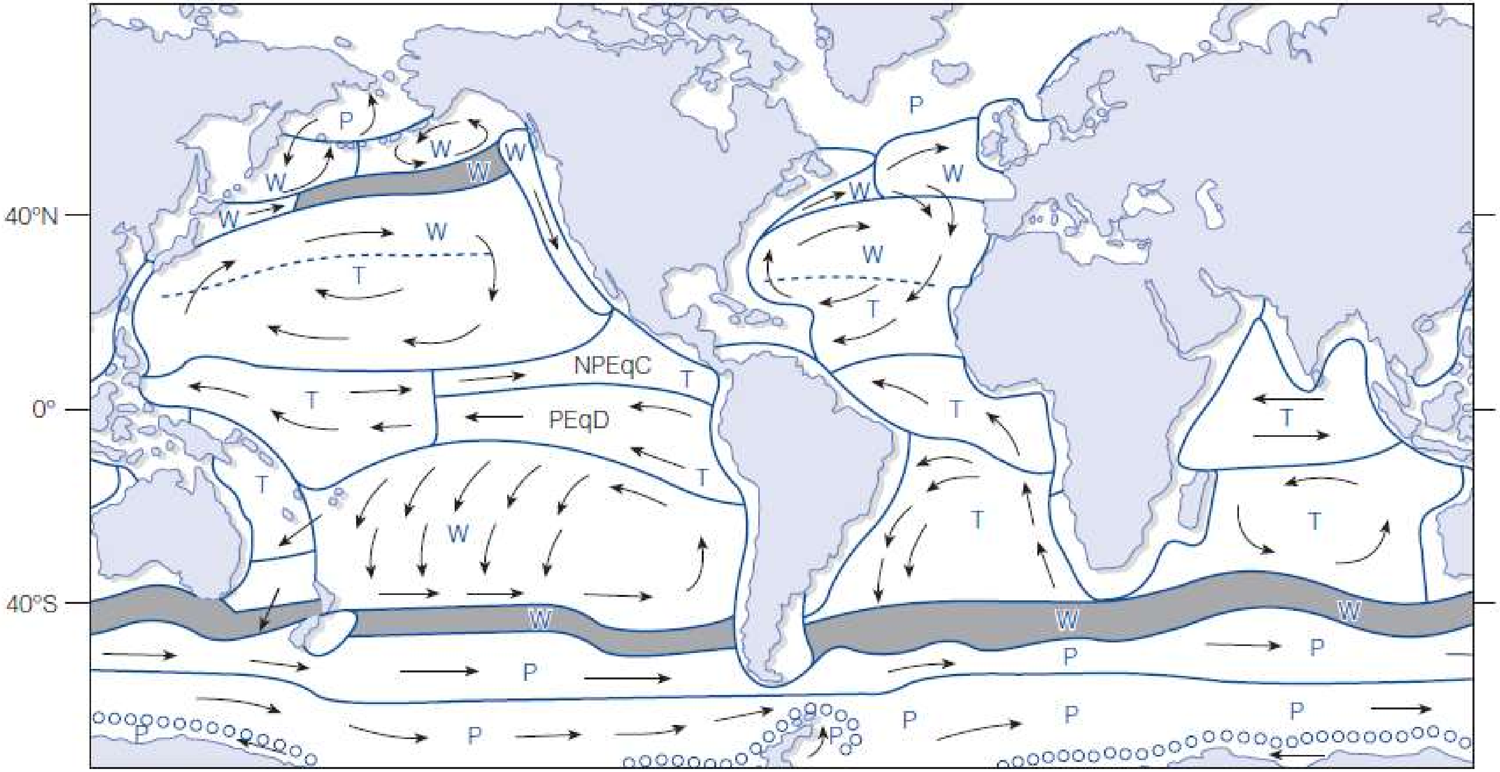
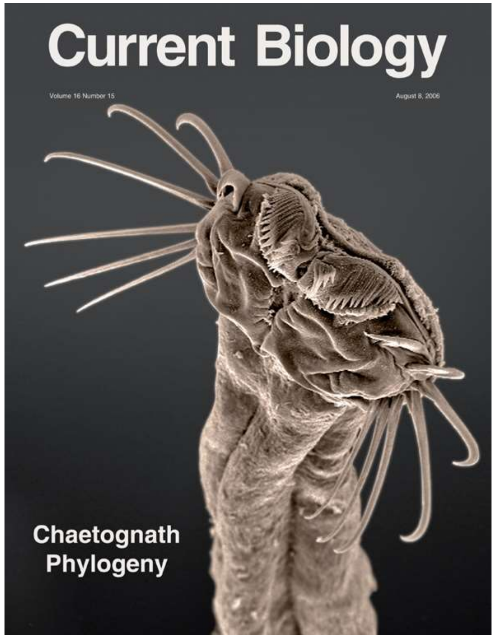


Figure 9.5 The oceanic biogeographical biomes and provinces. Letters in blue (P, T, W) indicate provinces that are placed in the Polar, Trade Winds or Westerly Winds Biomes, respectively. NPEqC, North Pacific Equatorial Counter-Current Province; PEqD, Pacific Equatorial Divergence. The North Pacific Polar Front Convergence and Southern Subtropical Convergence are shown as a dark tint. The Antarctic Divergence is shown as a line of small circles. From Longhurst [10]. (Reproduced with permission of Elsevier.)

Invisible barriers in the Oceans

The mesopelagic fish *Nominostomias*, which had been thought to contain only eight species, is now known to have over 100.



sea urchin *Diadema*, whose species range throughout the world, has shown that their morphology is an extremely unreliable guide to their species structure.

It has even been stated that the morphological differences are so slight that specimens
cannot usually be identified without knowing where they were collected!

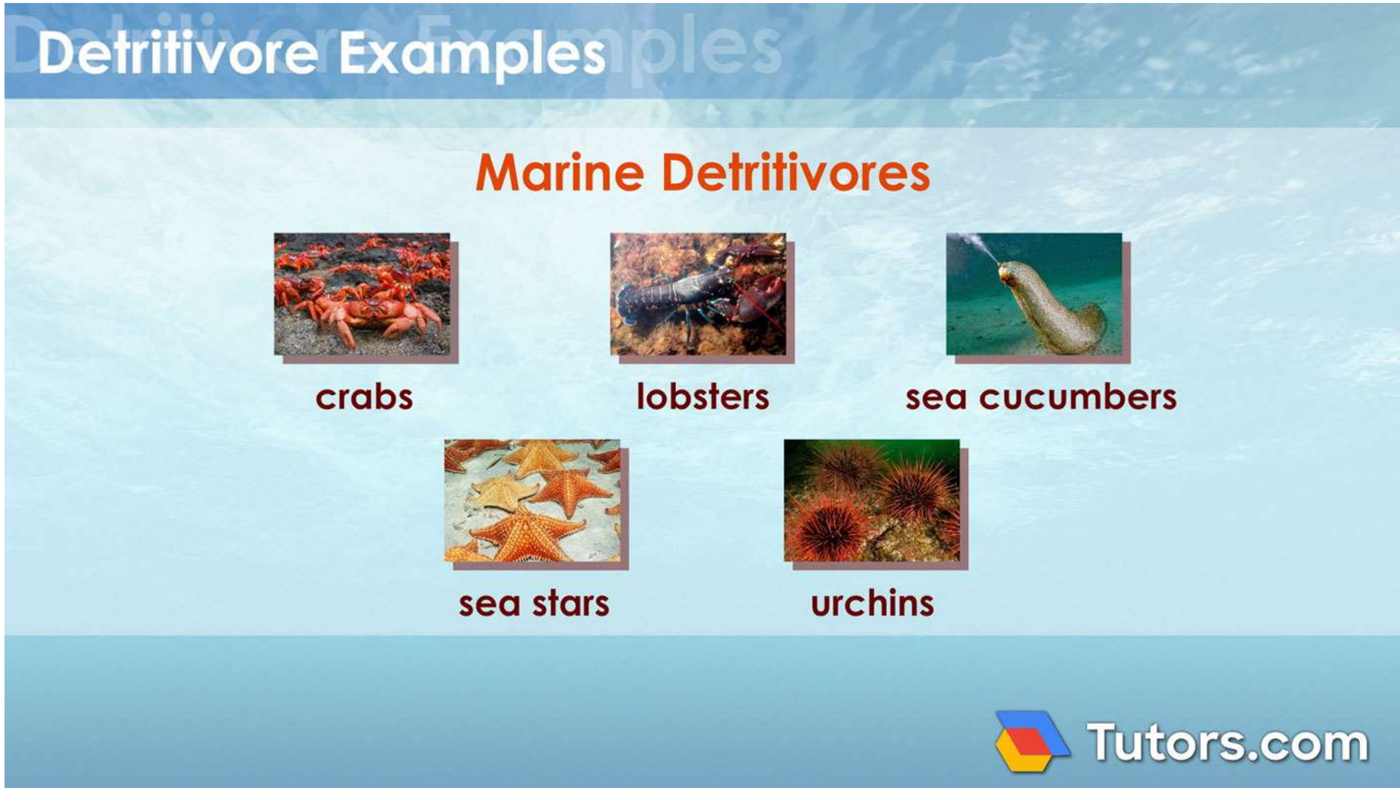
Clupea harengus pallasi

along the Pacific coast mainly spawn in one of two locations:
San Francisco Bay, or Tomales Bay 50 km further north.

the two populations of fish feed in different locations: the intermediate hosts of the parasites of the Tomales Bay population are whales, which lie offshore, while those of the San Francisco Bay population are seals, marine birds and sharks, which are found closer inshore.

…not only sun

Because there is no primary production in the lightless deep sea, its economy is based on the organic particles that settle on the bottom, and the fauna that lives on or in the seafloor is dominated by **detritivores**. Therefore, it may well be that a greater range in particle size provides a greater range of niches for the bathyal benthic fauna.



- The potential efficacy of larval dispersal is shown by the fact that species of benthic invertebrate along the western coasts of the Atlantic are more widely distributed if they have planktonic larvae than if they do not

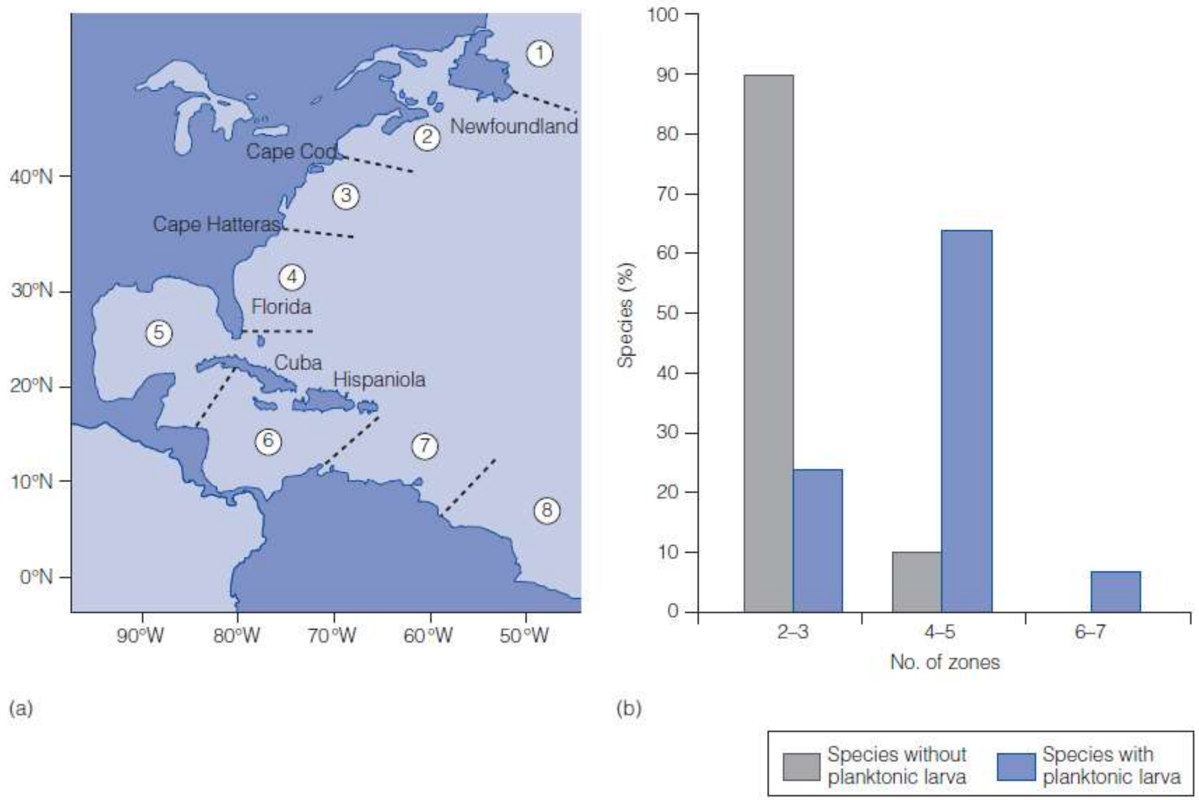


Figure 9.8 (a) Biogeographical zones down the western coasts of the Atlantic. (b) The number of invertebrate benthic species that occupy these zones, with or without planktonic larvae. Adapted from Scheltema [63].

- long-lived larvae will need to feed during the days of dispersal, so it is not surprising to find that such larvae are more common in low latitudes, where the phytoplankton season is long, than in high latitudes, in which it is shorter

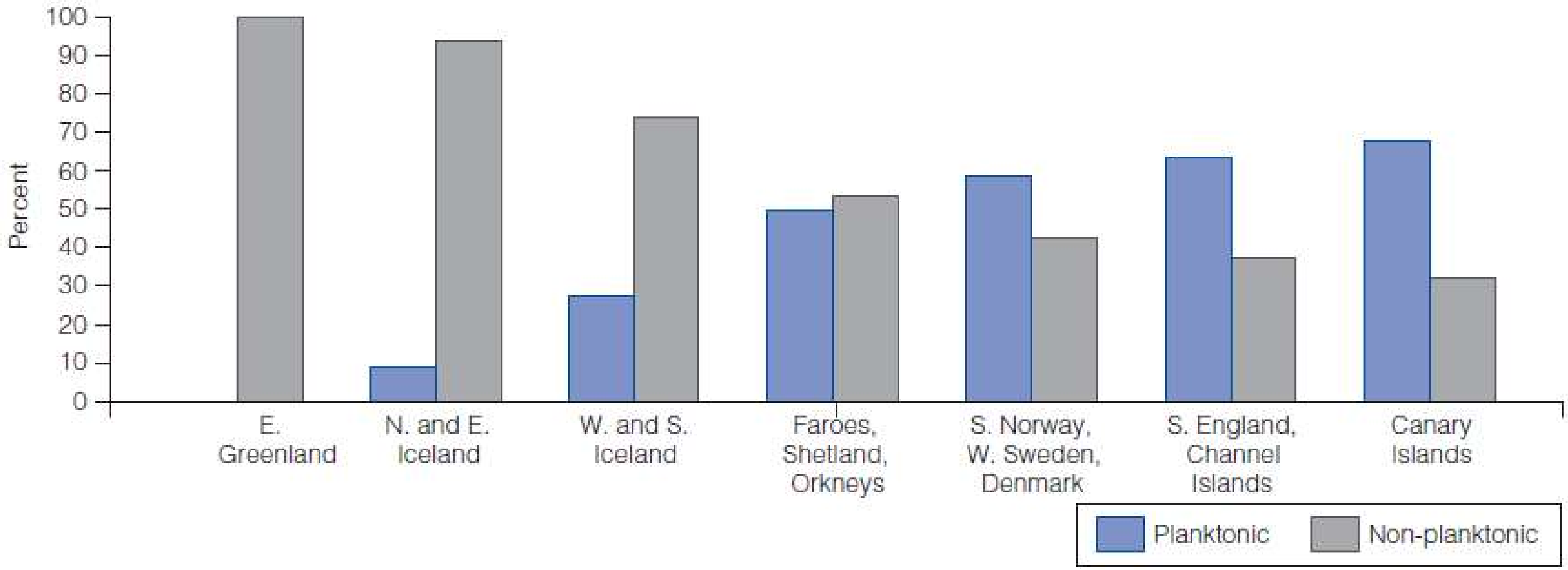


Figure 9.9 The percentage of gastropod species that either have, or do not have, planktonic larvae, at different latitudes. Adapted from Thorson [64].

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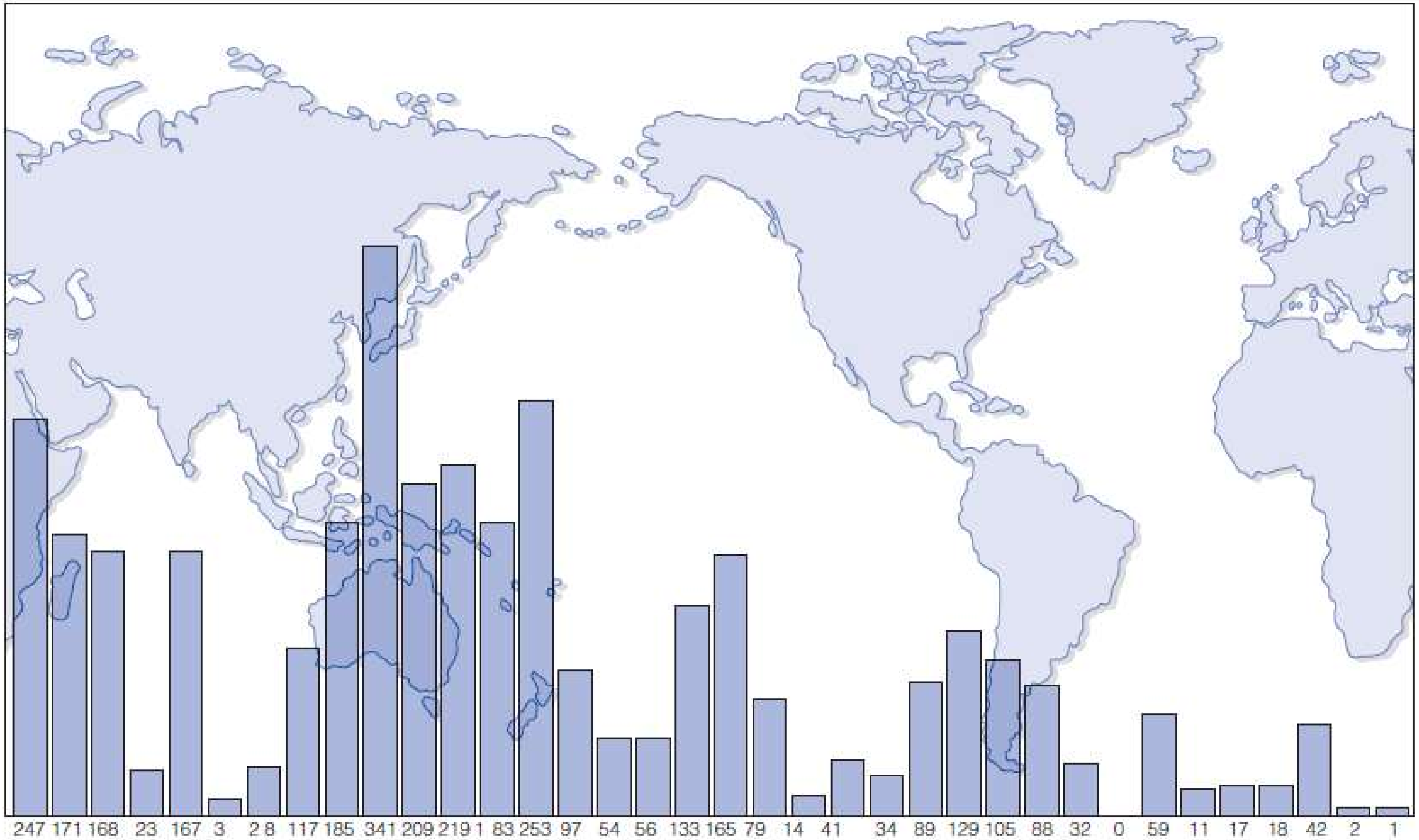
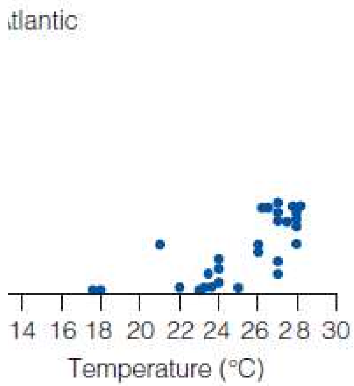


Figure 9.13 Longitudinal gradients in fish species richness. The columns represent the total number of fish species (from a sample of 799 species) that occur in each 10°-wide band of longitude. Note how the diversity increases in the latitudes that include the West Indies and Caribbean, where there are many coral reefs. Adapted from McAllister *et al.*



it mean annual sea-surface
From Rosen [65].

Reef hotspots location during time

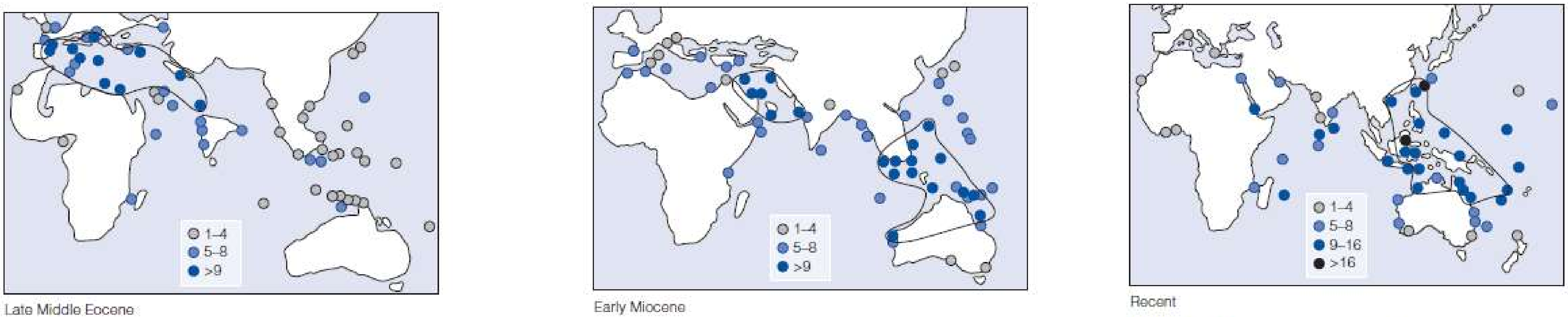


Figure 9.15 The locations of reef hotspots at three different periods of time. From Bellwood *et al.* [57]. (Reproduced with permission of Cambridge University Press.)