

Zoogeography

Lesson 12

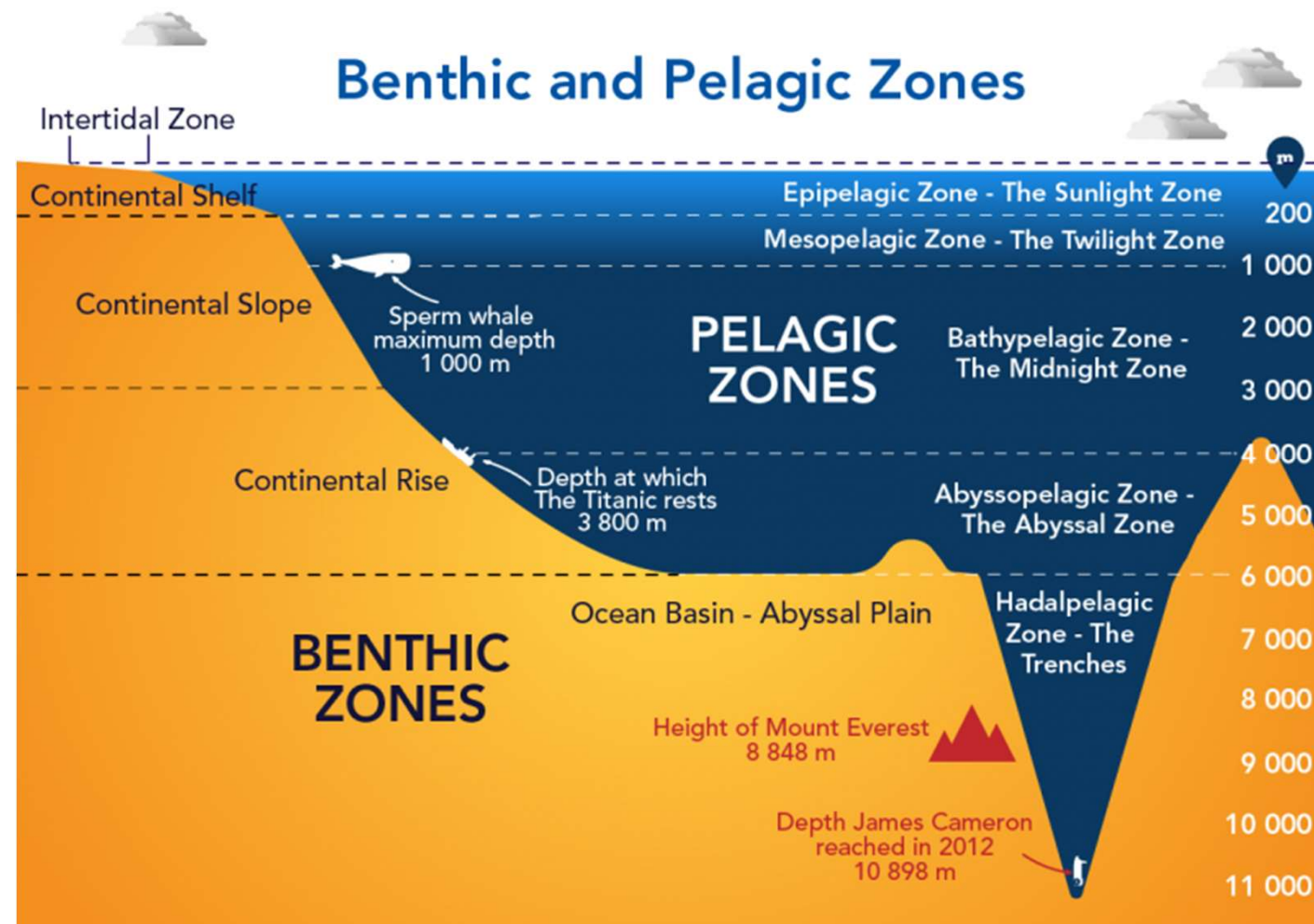


20th-21st November
2023

ID paper	Title and references	Student
1	New developments in the field of genomic technologies and their relevance to conservation management. doi.org/10.1007/s10592-021-01415-5	
2	Life history, climate and biogeography interactively affect worldwide genetic diversity of plant and animal populations. https://www.nature.com/articles/s41467-021-20958-2	
3	Animal invaders threaten protected areas worldwide. doi.org/10.1038/s41467-020-16719-2	
4	Urbanization and agricultural intensification destabilize animal communities differently than diversity loss. doi.org/10.1038/s41467-020-16240-6	
5	Low level of anthropization linked to harsh vertebrate biodiversity declines in Amazonia. doi.org/10.1038/s41467-022-30842-2	
6	Factors shaping the abundance and diversity of the gut archaeome across the animal kingdom. doi.org/10.1038/s41467-022-31038-4	
7	A 2-million-year-old ecosystem in Greenland uncovered by environmental DNA. doi.org/10.1038/s41586-022-05453-y	
8	High-resolution maps show that rubber causes substantial deforestation. https://doi.org/10.1038/s41586-023-06642-z	
9	Extensive global wetland loss over the past three centuries. https://doi.org/10.1038/s41586-022-05572-6	

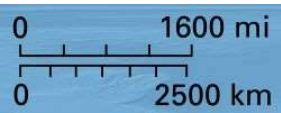
Patterns in the Oceans

- 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 continent and the oceans.

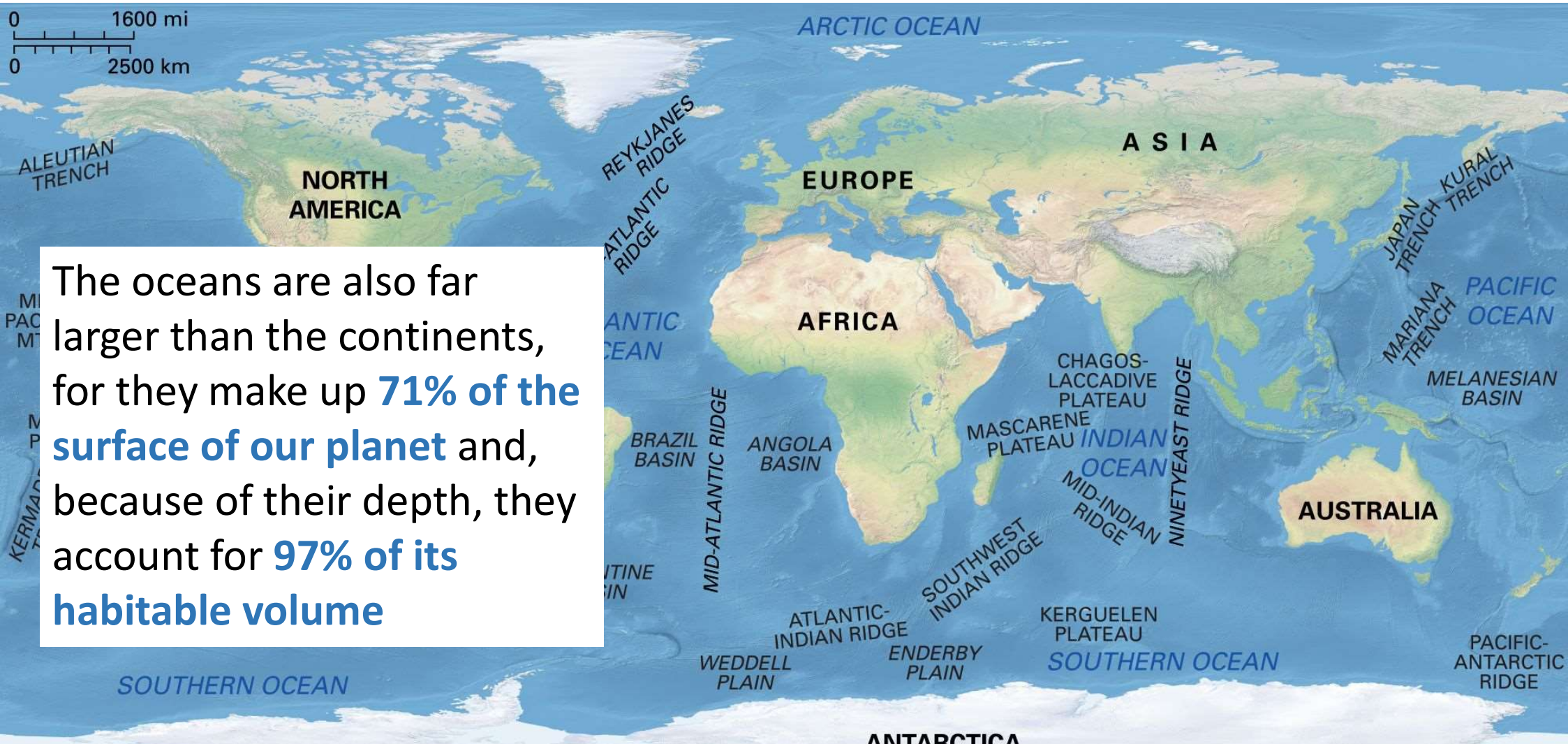


The understanding of oceans biogeography is limited by:

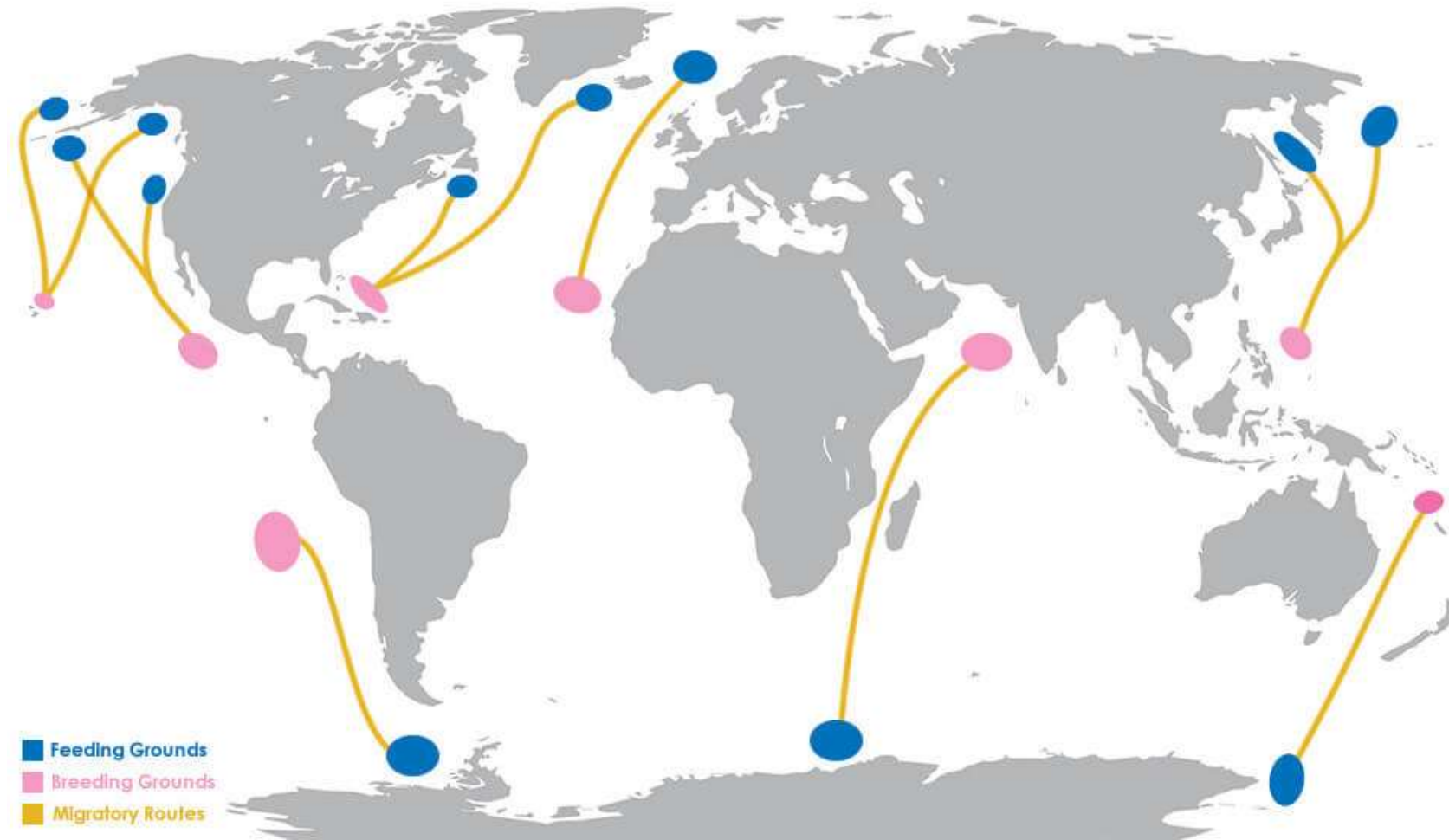
- We are air-breathing creatures: **difficulties to survey and sample** huge area of oceans.
- Unlike terrestrial species, marine species often cannot be distinguished by differences in **morphology**, so their taxonomy has to be based on more subtle genetic comparison.
- More difficult to **recognize 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**

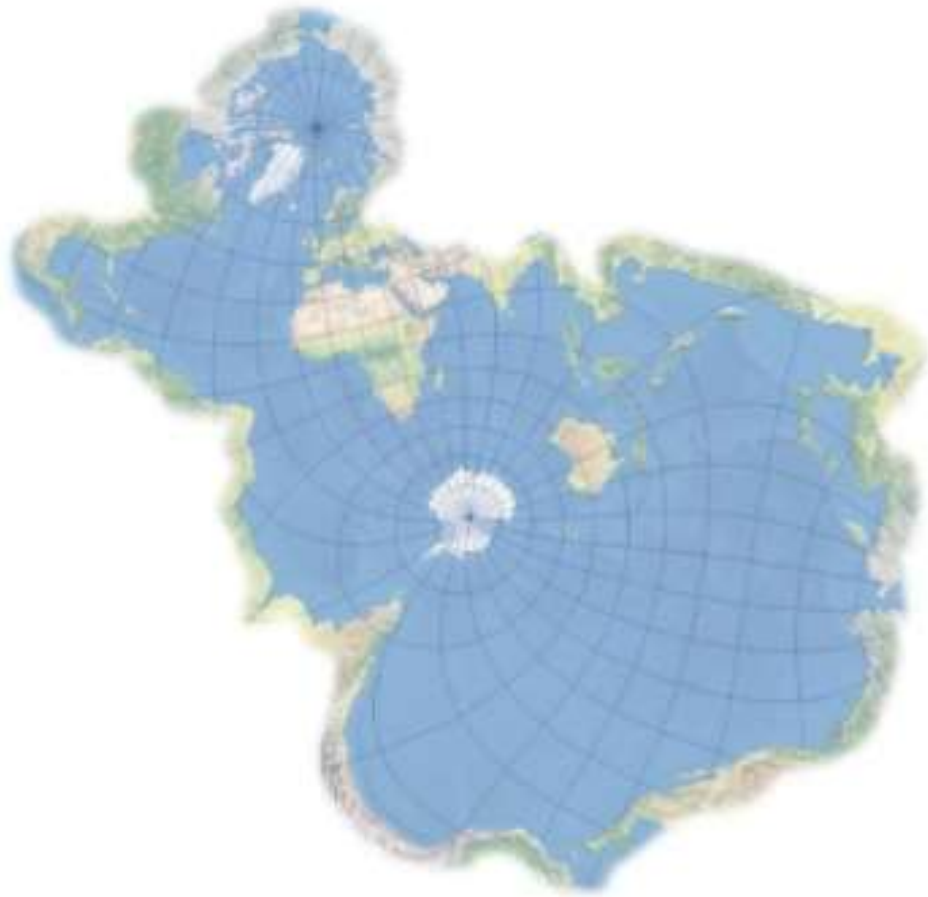


Migratory Routes of the Humpback Whale



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 km²**,
- is derived from cores totalling only about **500 m²**,
- 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.

- 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 plankton species



The rise of the Isthmus of Panama and the closing of the Central American Seaway



Surface waters flowed from the Pacific into the Atlantic 10 million years ago via an ocean gateway called the Central American Seaway, and both oceans had the same salinity.



About 5 million years ago, the North American, South American, and Caribbean Plates converged. The rise of the Isthmus of Panama restricted water exchange between the Atlantic and Pacific, and their salinities diverged. The isthmus diverted waters that once flowed through the Seaway. The Gulf Stream began to intensify.



Today, evaporation in the tropical Atlantic and Caribbean leaves behind saltier ocean waters and puts fresh water vapor into the atmosphere. Trade Winds carry the water vapor westward across the low-lying isthmus, depositing fresh water into the Pacific through rainfall. As a result, the Atlantic is saltier than the Pacific.

Jack Cook, WHOI Graphic Services

- Lack of physical barriers
- Lower productivity

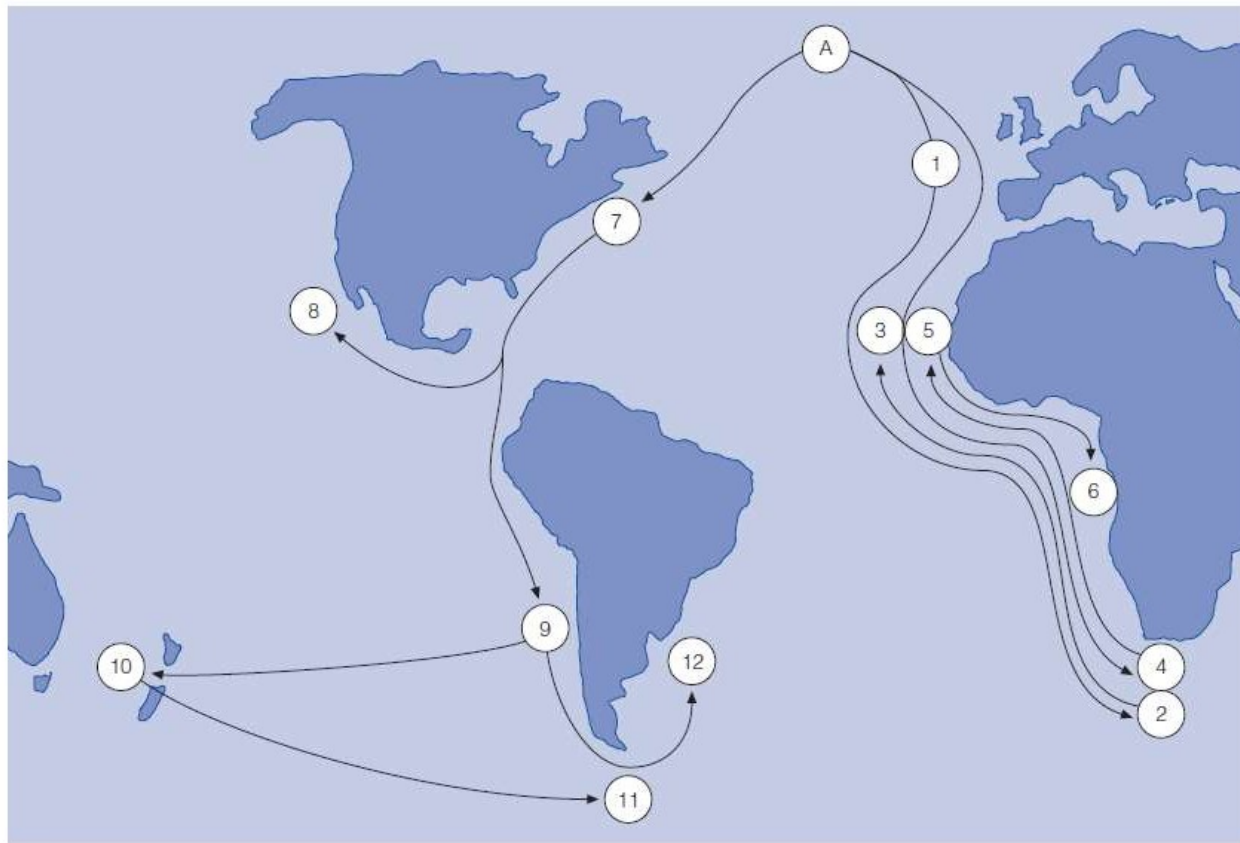


- Less opportunity for evolutionary diversification



3 million yrs ago

The case of the hake *Merluccius*



(a)

The case of the hake *Merluccius*

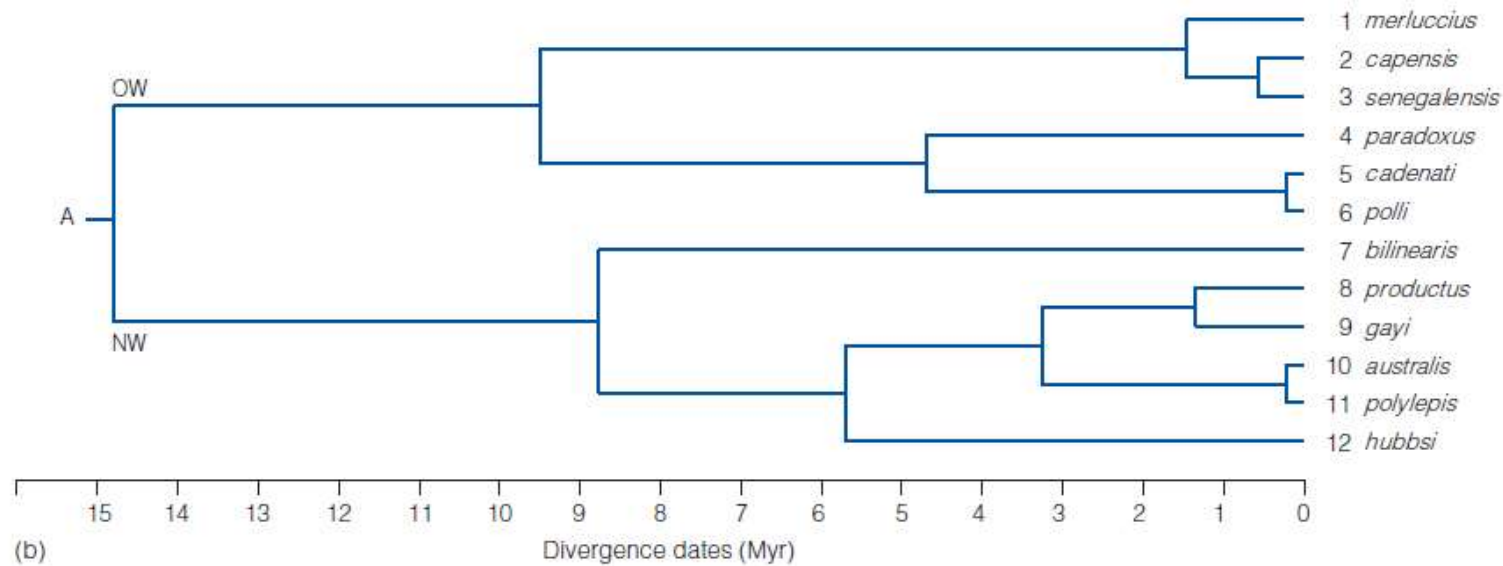
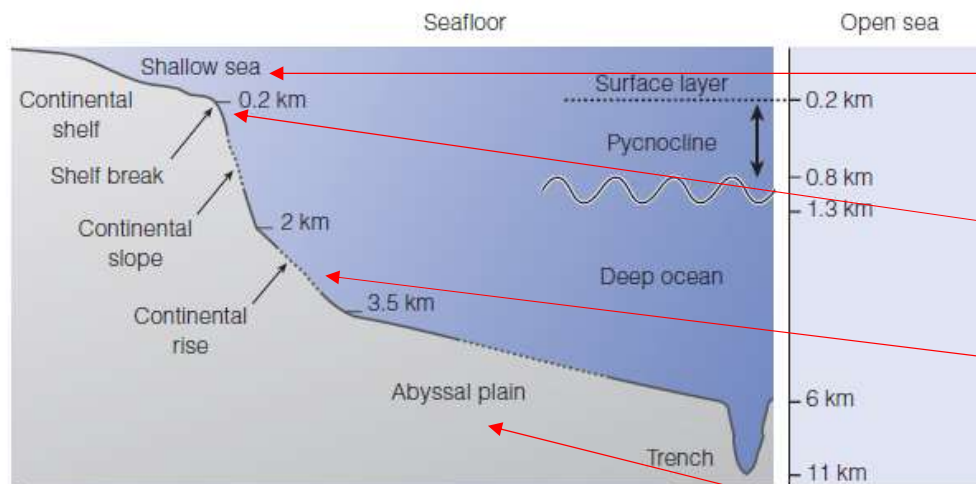
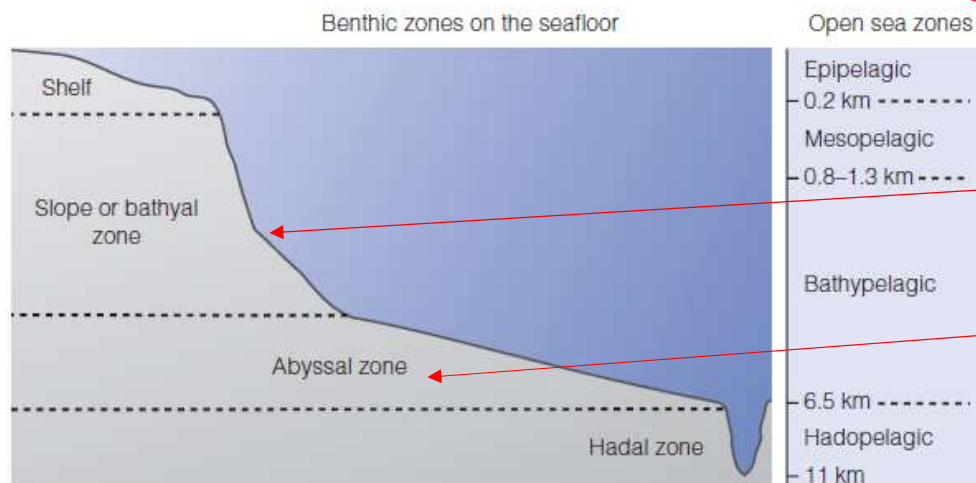


Figure 9.1 The dispersal of 12 species of hake, *Merluccius*, as suggested by fossil and molecular data. (a) Map showing distributions and dispersal. The numbers refer to the individual species shown in the cladogram of phylogenetic relationships (b), which also shows the dates of divergence between 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].



(a)



(b)

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 m, here the slight gradient of the seafloor increases sharply

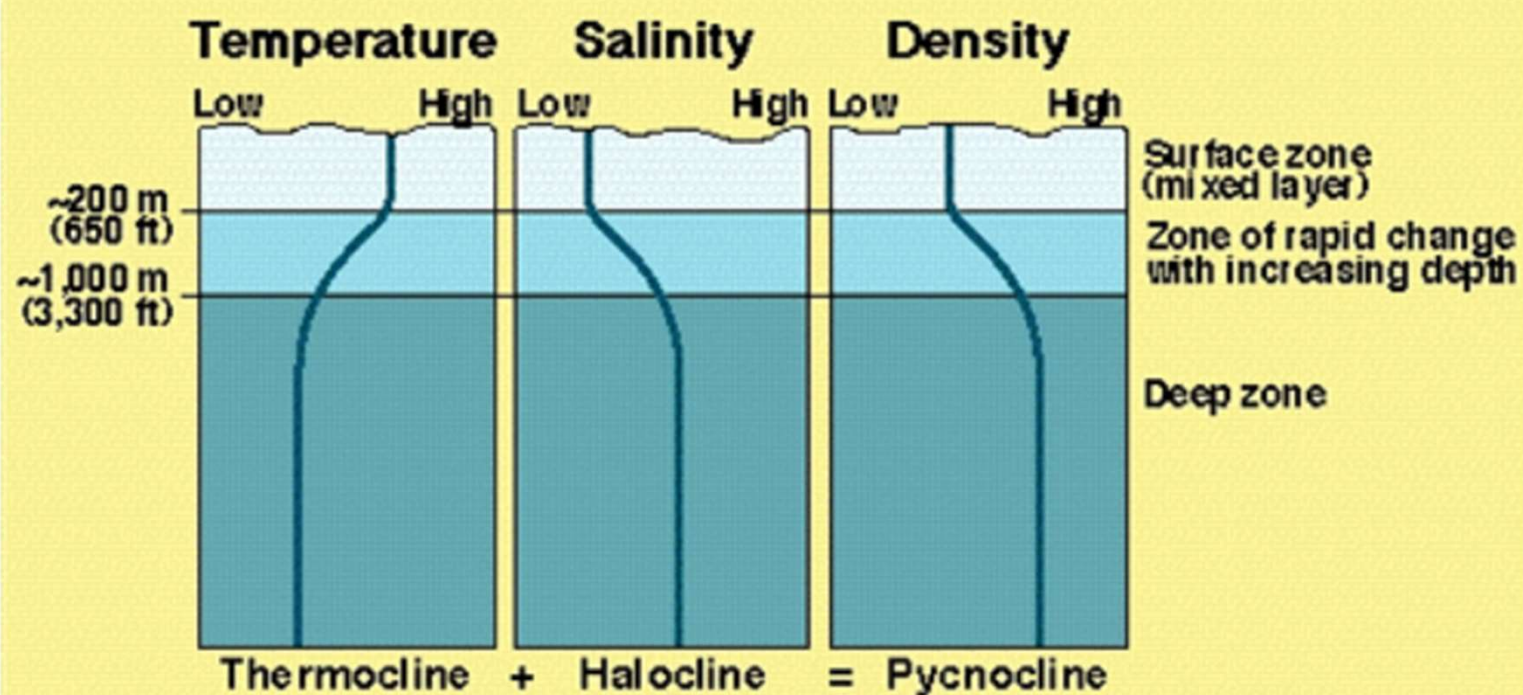
spill down over the edge of the continental slope and onto the adjacent margin of the abyssal plain to form a wedge known as the **continental rise**.

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

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

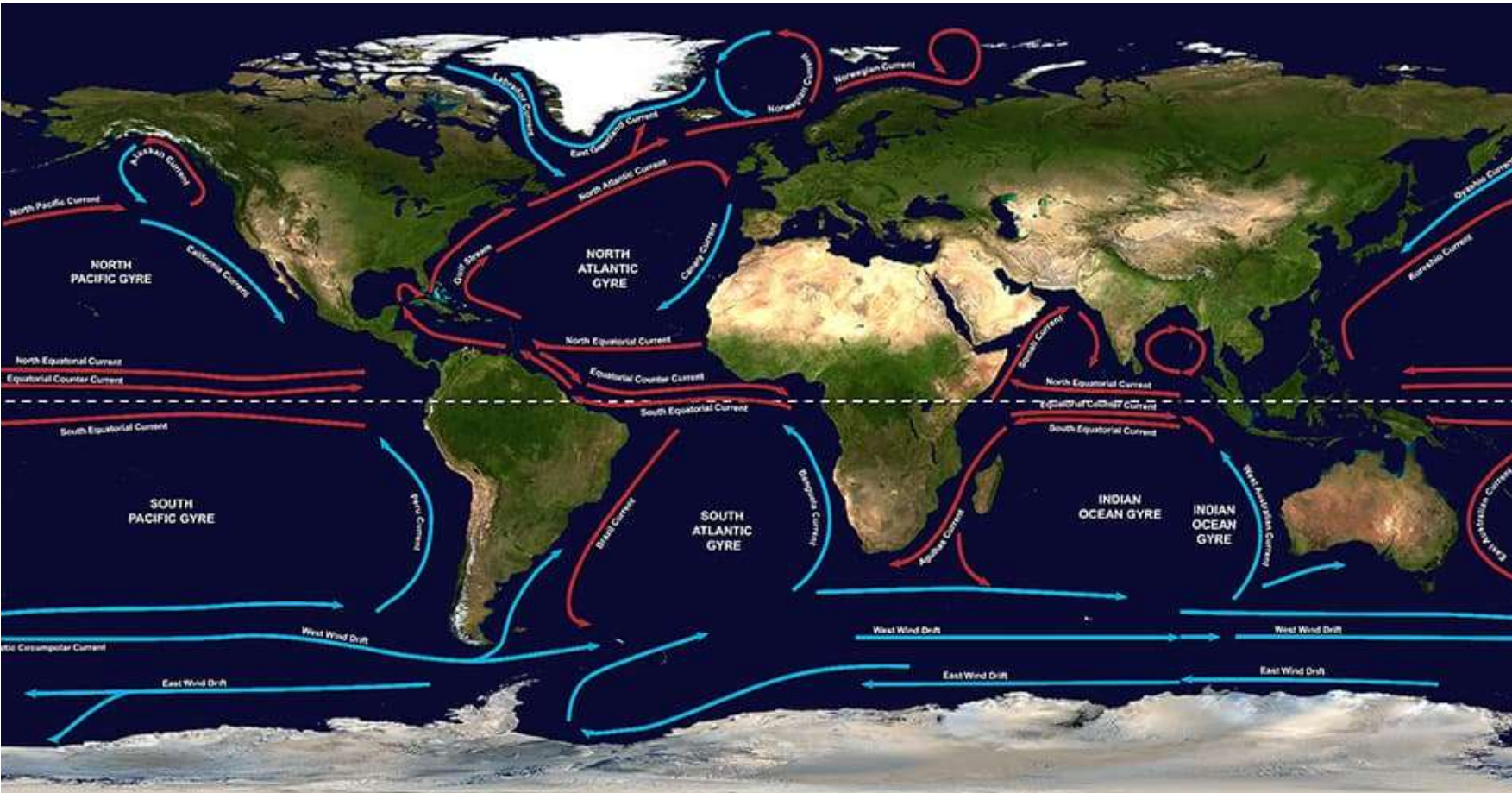
At an average depth of 4 km, the abyssal plain covers 94% of the area of the oceans and 64% of the surface of the world, and is therefore the most extensive of all environments.

Formation of the Pycnocline



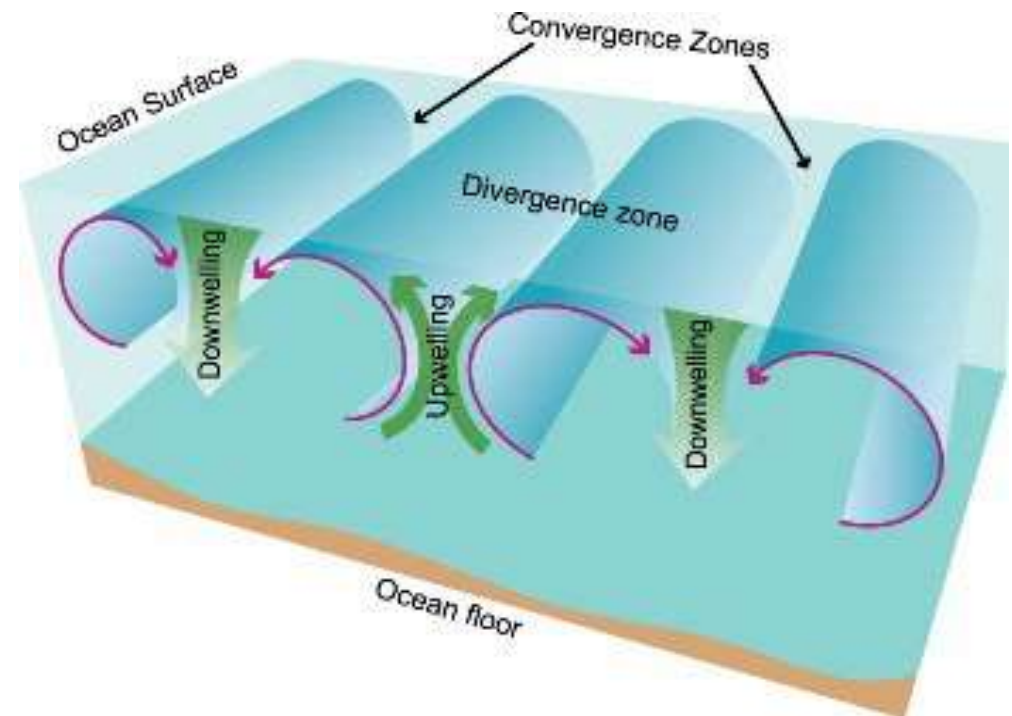
Dynamics of the Ocean Basins

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

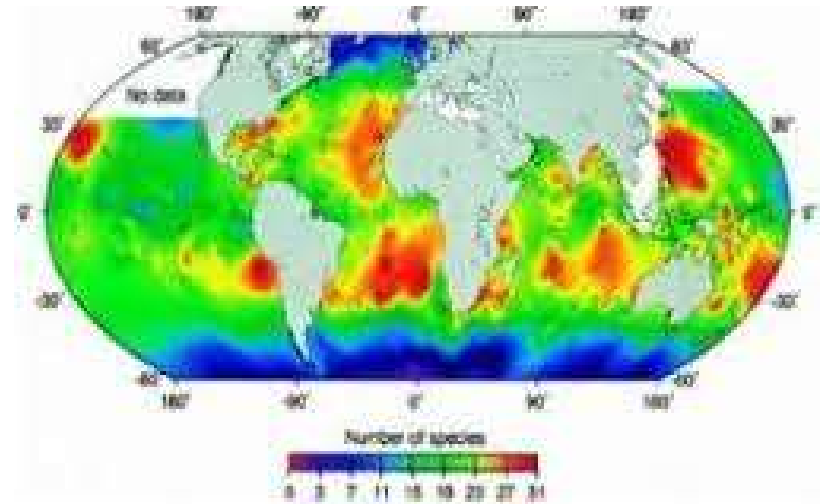
- Upwelling – vertical flow of cold, dense water to the surface; occurs in area where horizontal currents diverge
- Downwelling – vertical flow of warm, less dense water toward the ocean bottom; occurs in areas where horizontal currents converge



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.

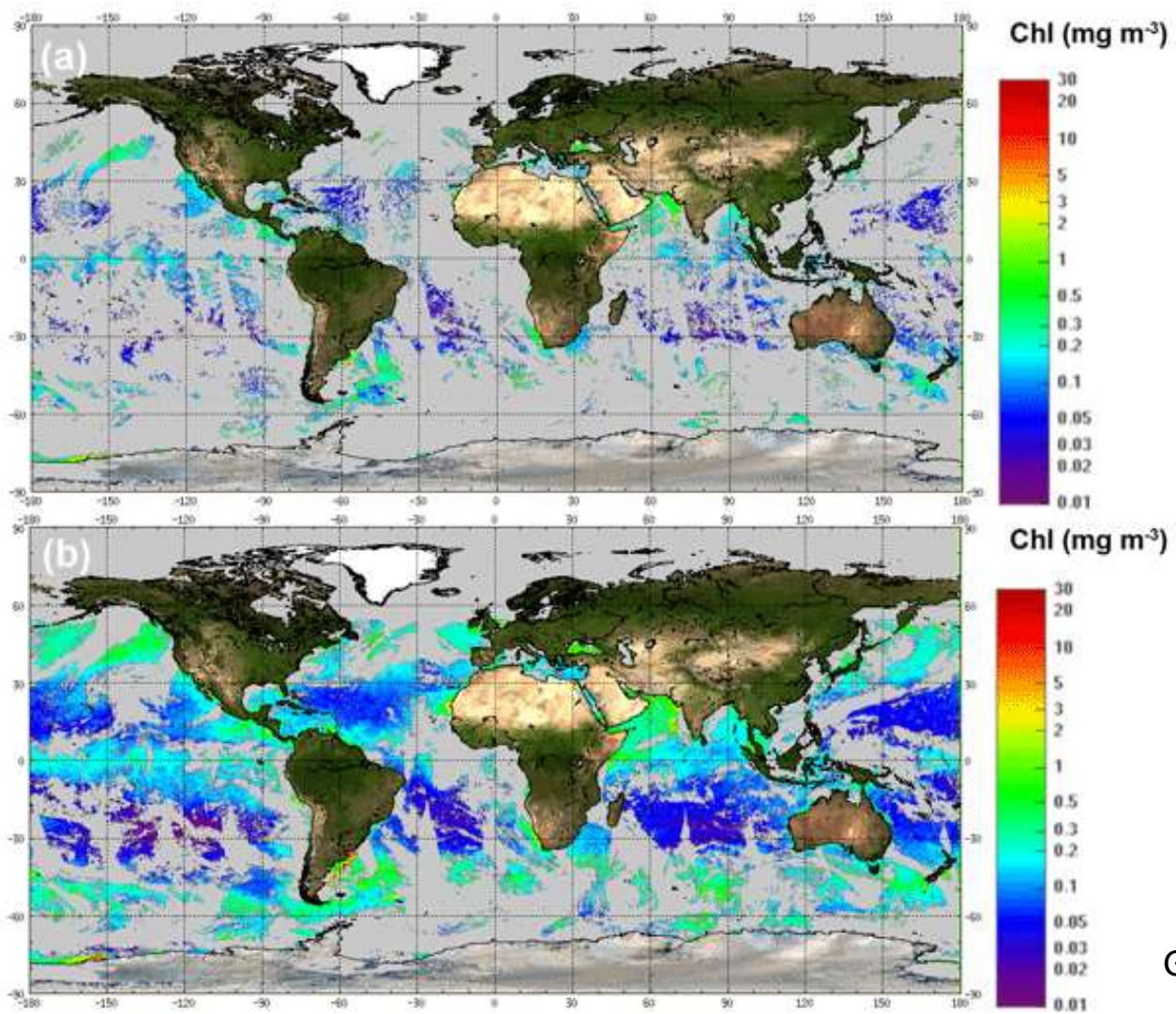


Species richness of planktonic foraminifera, illustrating maximal species richness in subtropical latitudes, with lower levels in equatorial regions. From Rutherford et al. 1999

- 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 thickness and depth of the pycnocline.

Patterns of Life in the Surface Waters

- The circulation patterns of the ocean waters, both horizontally and vertically, also create patterns in the concentration of such major nutrients as nitrate, phosphate and silicate.
- Although the patterns of movement in the oceans have long been known, it is only since satellite observations became available that it has been possible to monitor the annual changes in the patterns of the life that lies within them.
- Although upwelling areas account for only 0.1% of the ocean surface, these areas provide 50% of the world's fisheries catch.



Garnesson et al., 2019

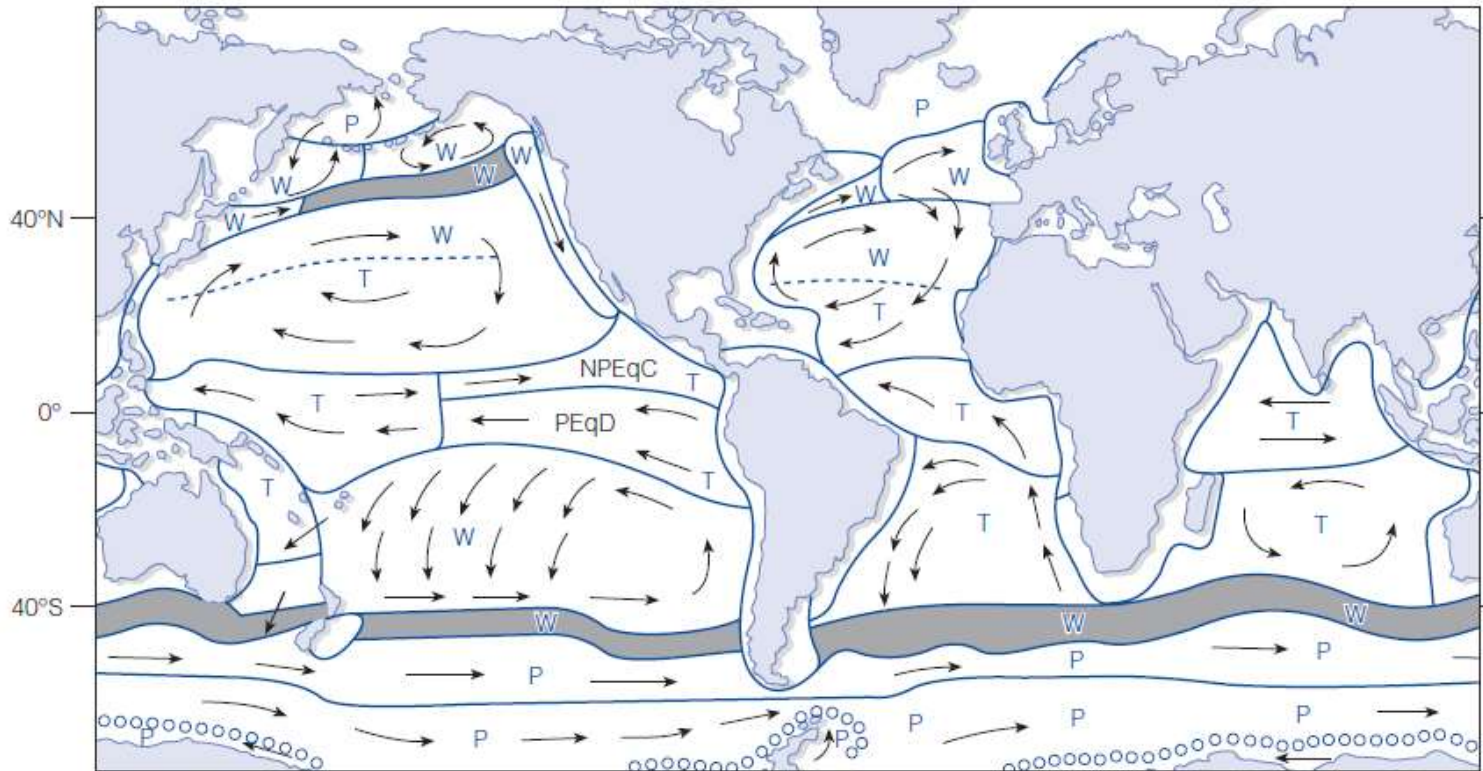
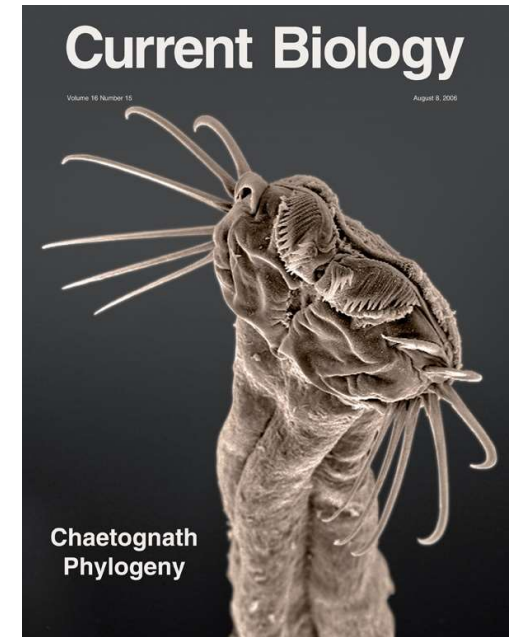


Figure 9.5 The oceanic biogeographical biomes and provinces. Letters in blue (P, T, W) indicate provinces that are placed in the Polar, Trade Winds or Westerly Winds Biomes, respectively. NPEqC, North Pacific Equatorial Counter-Current Province; PEqD, Pacific Equatorial Divergence. The North Pacific 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 pallasii

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

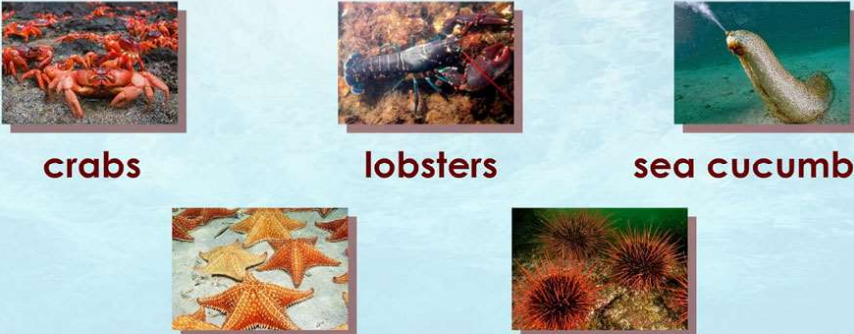
the two populations of fish feed in different locations: the intermediate hosts of the parasites of the Tomales Bay population are whales, which lie offshore, while those of the San Francisco Bay population are seals, marine birds and sharks, which are found closer inshore.

...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.

Detritivore Examples

Marine Detritivores



The image displays five examples of marine detritivores, each with a corresponding photograph and label. The examples are arranged in two rows. The top row includes crabs, lobsters, and sea cucumbers. The bottom row includes sea stars and urchins. The background of the slide is a light blue gradient with a subtle pattern of water ripples.

- crabs
- lobsters
- sea cucumbers
- sea stars
- urchins

