LESSON 2

A PORTRAIT OF THE OCEAN PLANET

Elements of Ocean Literacy

1 A sketch of major features
2 Some lessons from the seashore
3 Winds and currents
4 Life in the sea
5 Chemistry and fertility of the sea
6 Ocean and climate through time

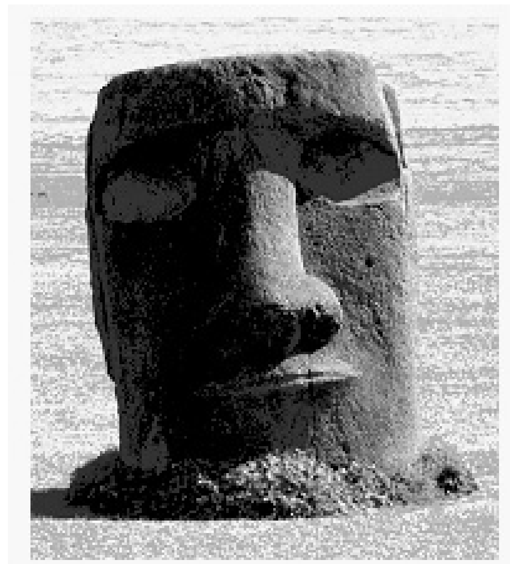


Fig. 2.01. Polynesian stone head made of basaltic rock derived from volcanic eruption.

Earth literacy has at least one big benefit: a sense of delight at living on this very special planet.

Also, clearly, Earth literacy is useful when trying to follow discussions about human impacts on the planet and what to do about it. (1) Knowledge of the ocean is crucial to Earth literacy. Ocean literacy starts with the knowledge that the ocean covers 70% of the planet's surface and is typically 2.5 miles (4 km) deep, with the bulk of the water being very cold, and in the dark. It includes knowing why fishing is good in some parts of the sea and bad in others.

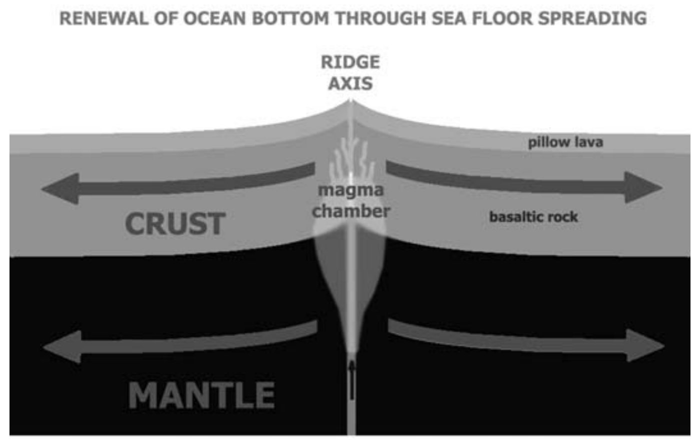
The ocean contains over ninety-nine percent of life's habitat space. On a high taxonomic level (class to phylum) animal diversity in the sea greatly exceeds that on land. In other words, there are many more fundamentally different animals in the sea than on land. As the main reservoir for water, the ocean is at the center of all water-governed processes. Water is the lifeblood of the planet; it is the main limiting factor for the growth of land plants and all the organisms dependent on them. Water vapor in the air powers the climate processes that govern our environment. Frozen water in high latitudes and in the high mountains helps maintain the temperature gradients responsible for the wind patterns and for the geographic patterns of living things. Our home planet is an oasis for life in space because of the abundance of water.

The ocean basins are made of basaltic rock that is geologically young, while the continents are made of granitic rocks that include extremely ancient types.

Notes and references

1. Literacy: *Literate* and *literacy* refer to the ability to read, hence learning. In analogy, *Earth literacy* implies command over a basic vocabulary of the Earth sciences and knowledge of the major concepts expressed in that vocabulary. Illiteracy is readily recognized; it expresses itself, for example, in an inability to explain why there are seasons.

Images



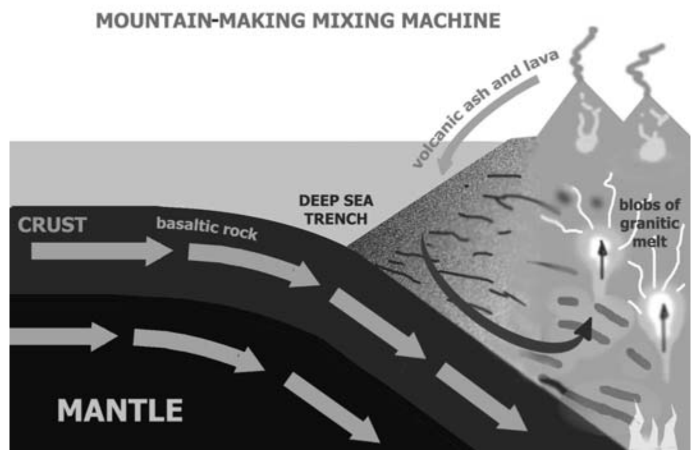


Fig. 2.02. Seafloor is being made and destroyed all the time: at the Mid-Ocean Ridge, there is seafloor spreading (upper graph), and in the zones marked by deep-sea trenches, there is subduction and associated mountain building (lower graph).

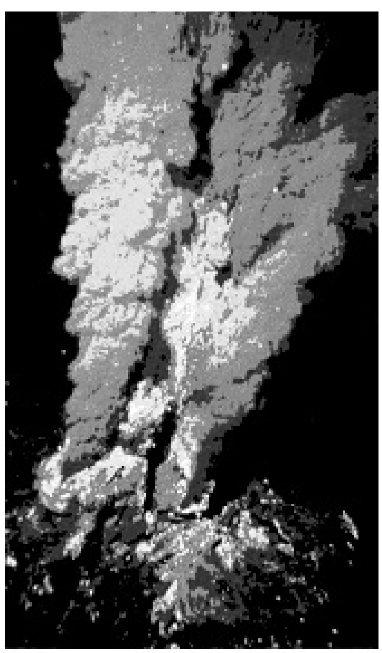


Fig. 2.03. Hot vent in the eastern Pacific. The interior plumbing of the vents is the site of chemical reaction between basalt and seawater.

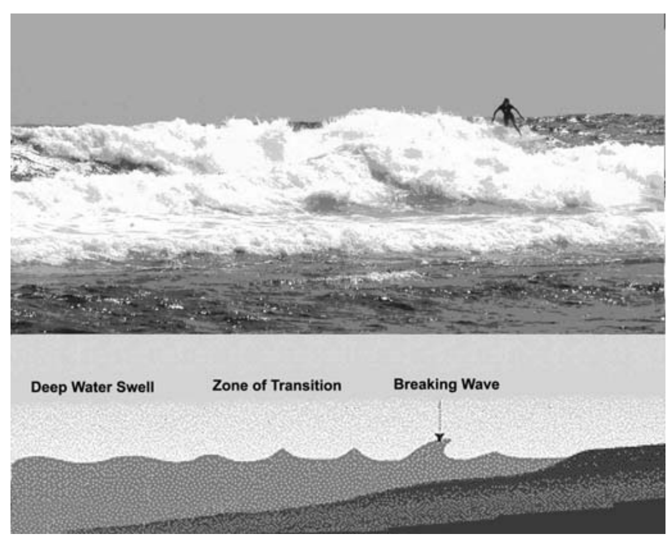


Fig. 2.04. Waves breaking at the shore. (Hawaii)

Fig. 2.05. Common sights along the shores of California: brown pelicans (upper panel) and cormorants (lower panel).

Fig. 2.06. Gas float of elkhorn kelp along with small floats of giant kelp. (La Jolla beach)

Fig. 2.07. West Coast versus East Coast shorescape: land rising, land sinking. (N. California vs. Long Island, N.Y.)

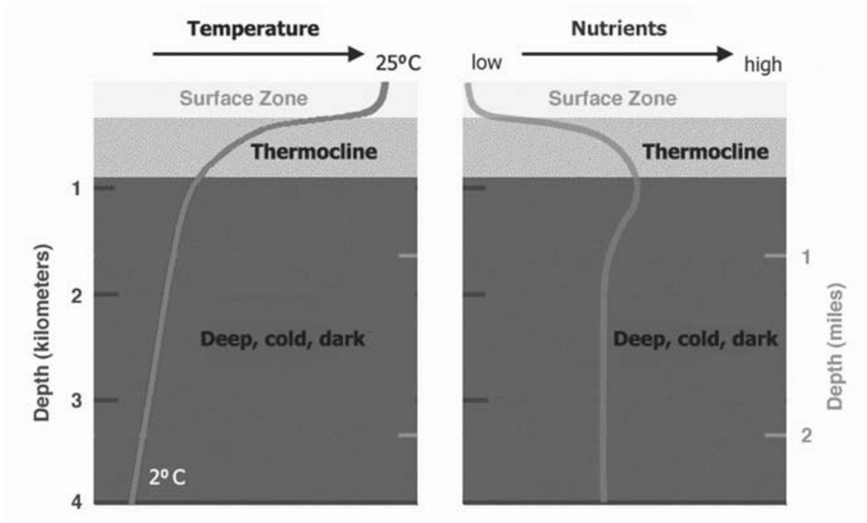


Fig. 2.08. Vertical structure of the ocean, in low to temperate latitudes, and the associated pattern of nutrient abundance.

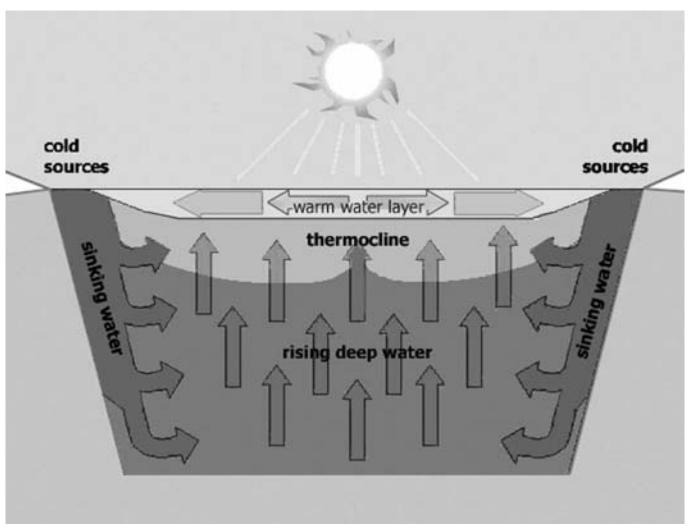


Fig. 2.09. Why deep water is cold. Elementary representation of the nature of deep circulation.

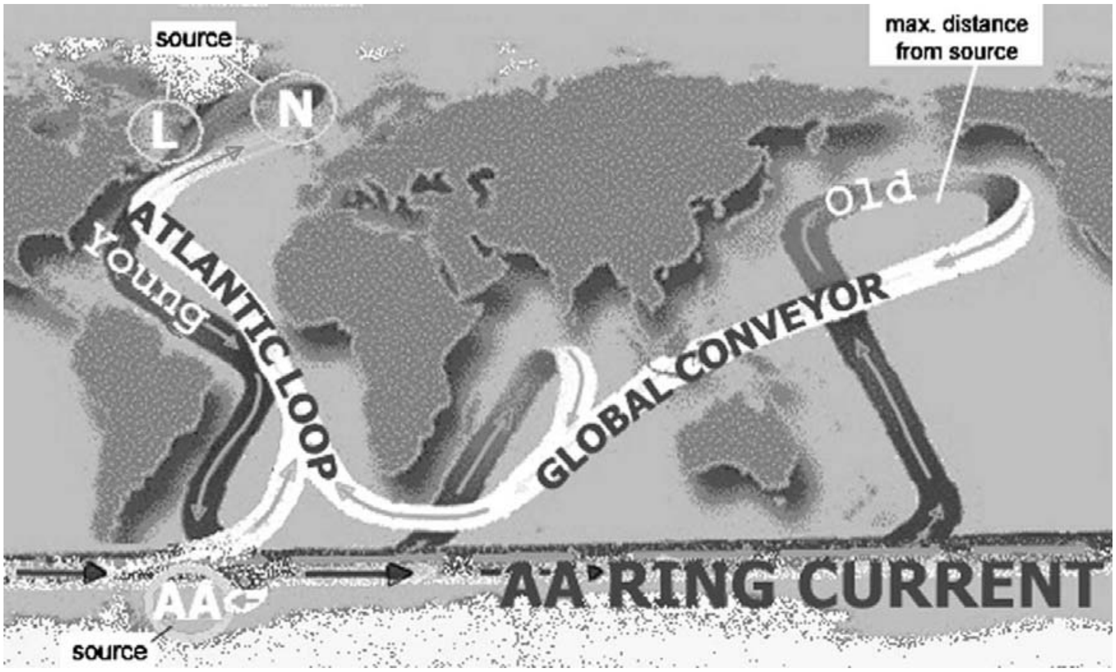


Fig. 2.10. How the basins exchange water. The main connection is the Great Ring Current moving around the Antarctic Continent (AA). The deepwater sources are at the cold ends of the Atlantic basin. The loop current (“Global Conveyor”) determines how much warm upper water gets into the North Atlantic, providing a heat subsidy. L, Labrador Sea; N, Nordic Sea; AA, Antarctic Weddell Sea. Young, oxygen-rich deep water; Old, oxygen-poor deep water. The AA Ring Current is mixed to great depth.

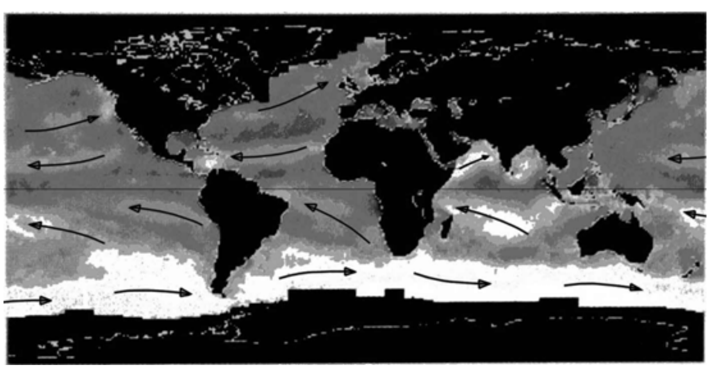


Fig. 2.11. The global wind field as seen from space. Areas with strong winds shown white. Note that the winds are stronger in the southern hemisphere than in the northern one, overall. The strongest winds blow around Antarctica with its great ice cap.

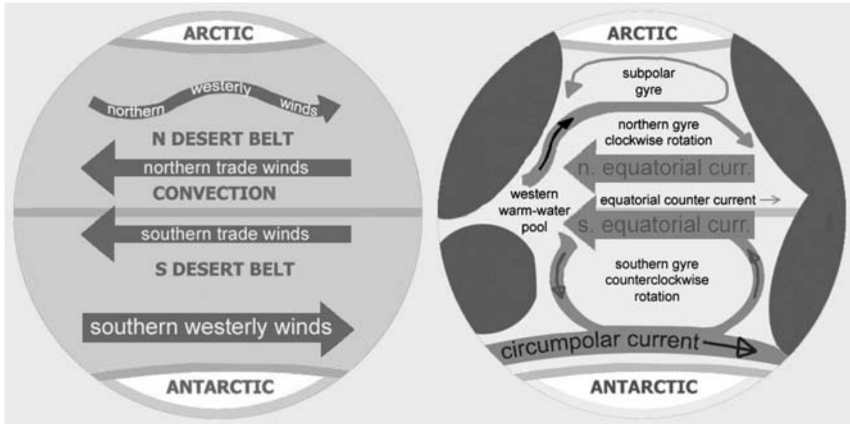


Fig. 2.12. Zonal winds of Planet Earth (left panel) and the currents they generate (right panel).

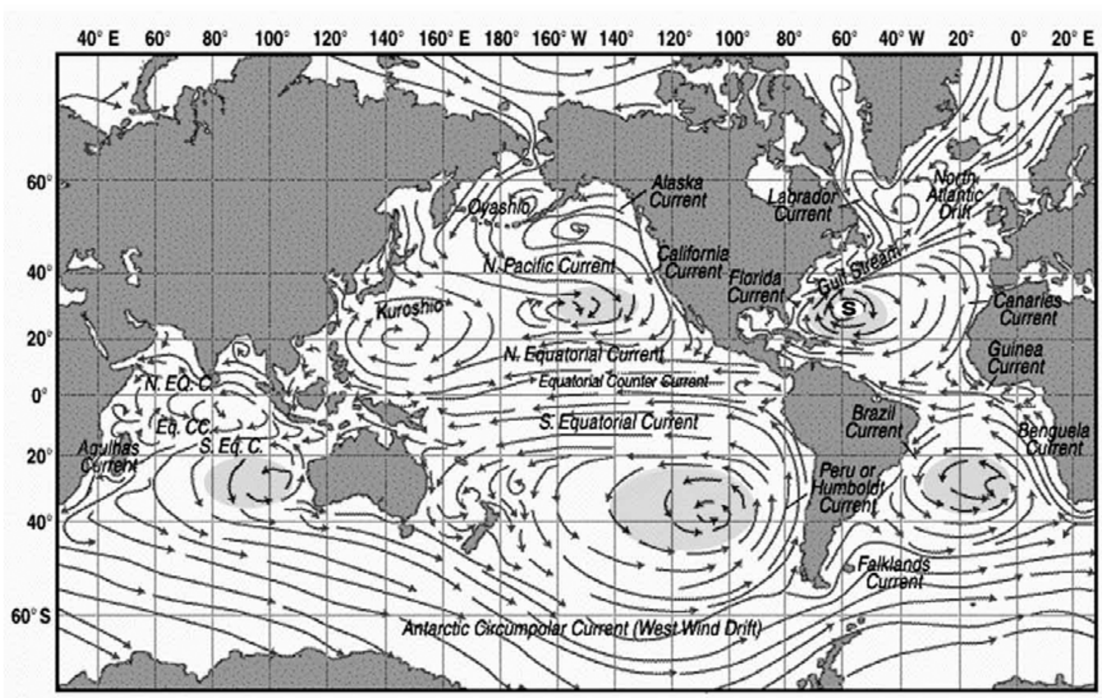


Fig. 2.13. Surface currents of the world ocean. Note the prominence of the central gyres (darkened for identification). S, Sargasso Sea (the center of the subtropical gyre in the North Atlantic).

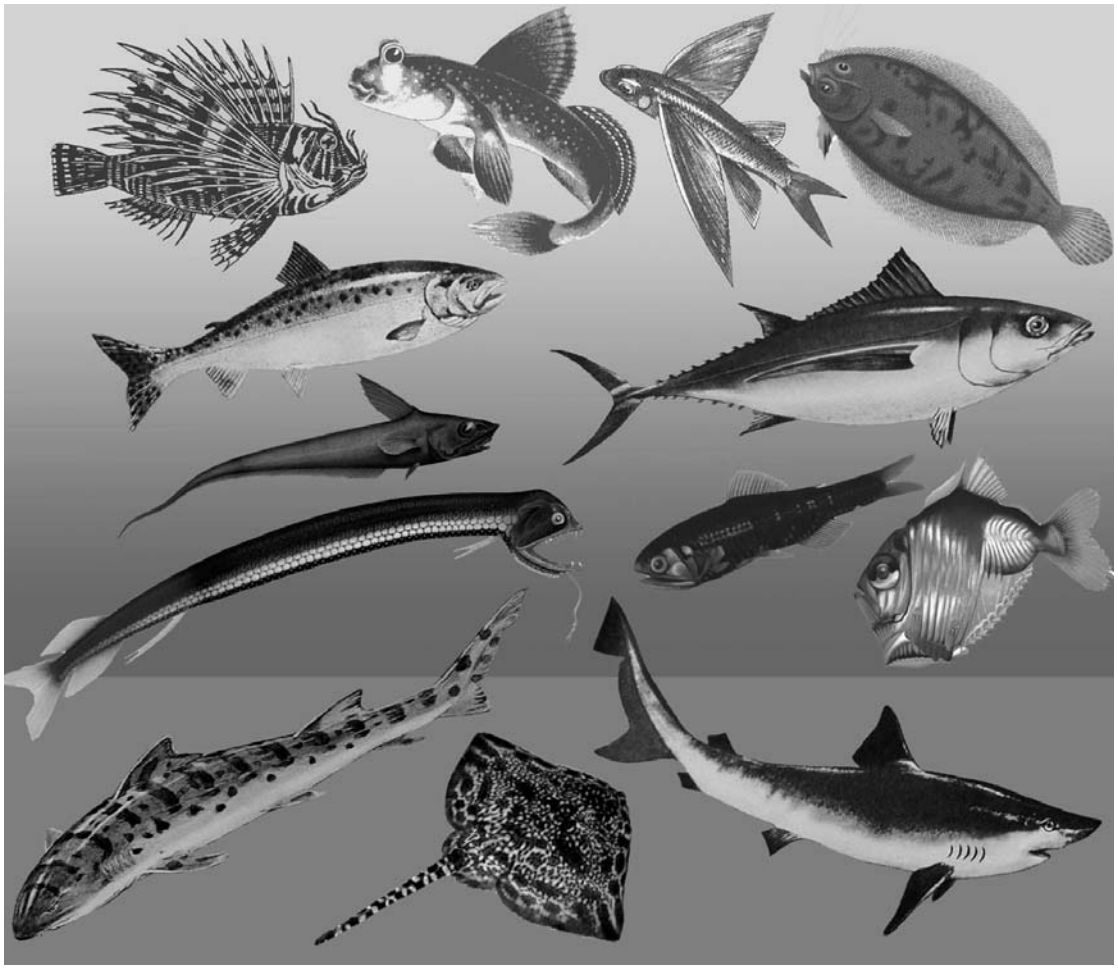


Fig. 2.14. Common fishes in the sea. Upper panel: Ray-finned bony fishes (lionfish, mudskipper, flying fish, flatfish, salmon, rattail, tuna, deepwater fishes), showing a wide range of adaptations (poison points, tree climbing, gliding in air, probing mud, pursuit hunting, ambush). Lower panel: Cartilaginous fishes (leopard shark, ray, pelagic shark). Rays are shark-like fishes adapted to life in contact with the bottom.

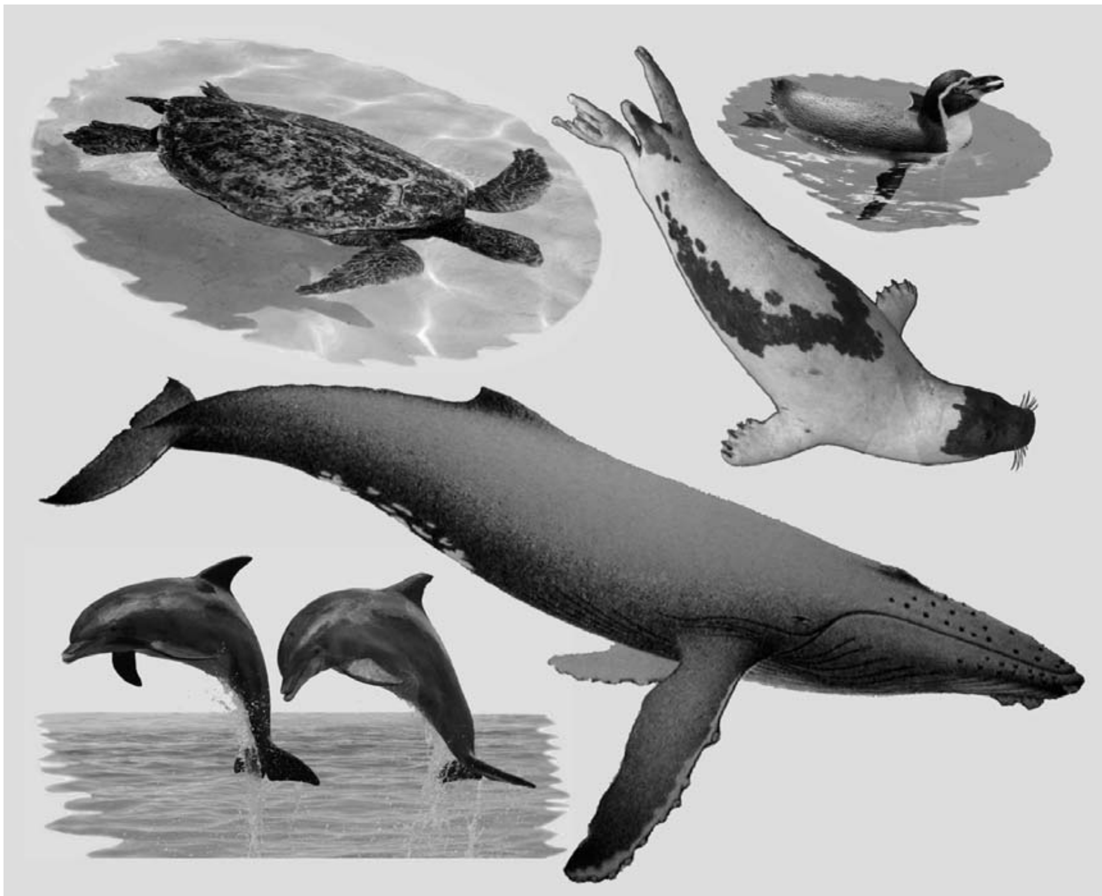


Fig. 2.15. Formerly terrestrial vertebrates that have gone marine: sea turtle, penguin, seal, humpback whale (baleen whale) and dolphins (toothed whales). Not to scale.

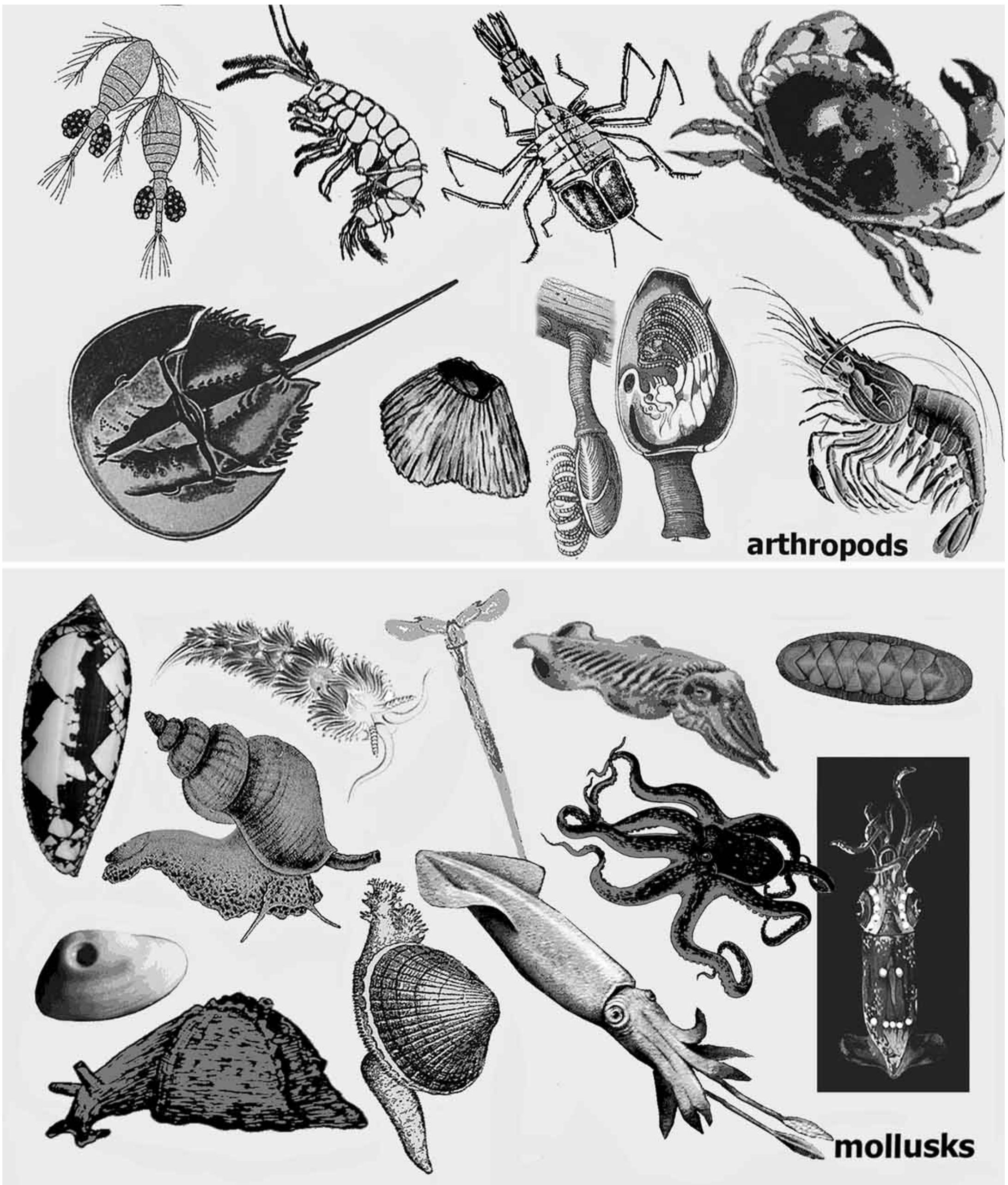


Fig. 2.16. Common marine representatives of the two giant phyla arthropoda and mollusca. Upper panel: two copepods, two amphipods, crab, horseshoe crab, barnacles, shrimp. Lower panel: snail shell, nudibranch, pteropod, cuttlefish, chiton, snail, octopus, deep-sea squid, clam shell (drilled), sea hare, cockle, squid.

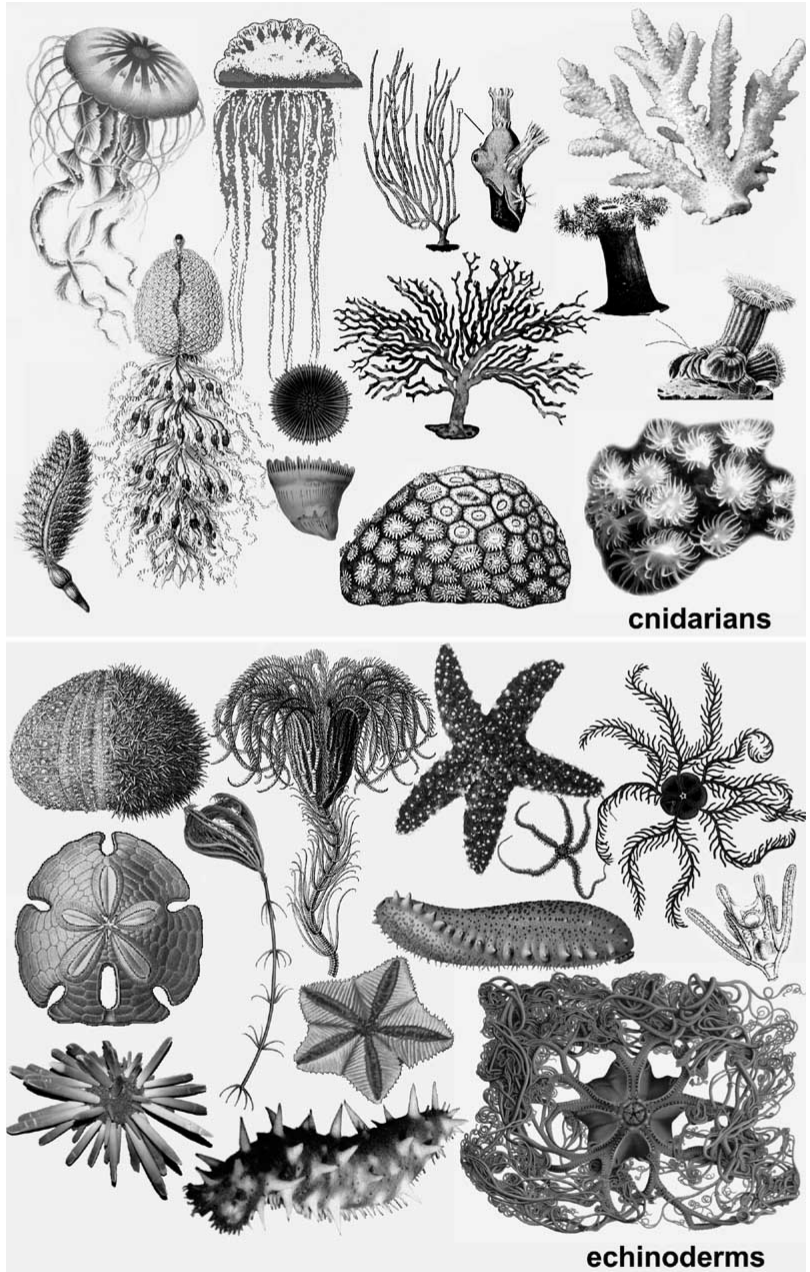


Fig. 2.17. Animals with stinging cells (cnidaria) and sea stars and kin (echinodermata). Upper panel: jellyfish, siphonophore, gorgonian, sea anemones (one on hermit crab), branched stone coral, sea pen, siphonophore, deep-sea solitary coral, gorgonian and massive stone coral, anemone colony. Lower panel: sea urchin, sea lily, sea star, brittle stars (2, and larva), sea urchin, sea lily, sea star, sea cucumber, sea urchin (pencil spines), sea cucumber (spiny), basket star.

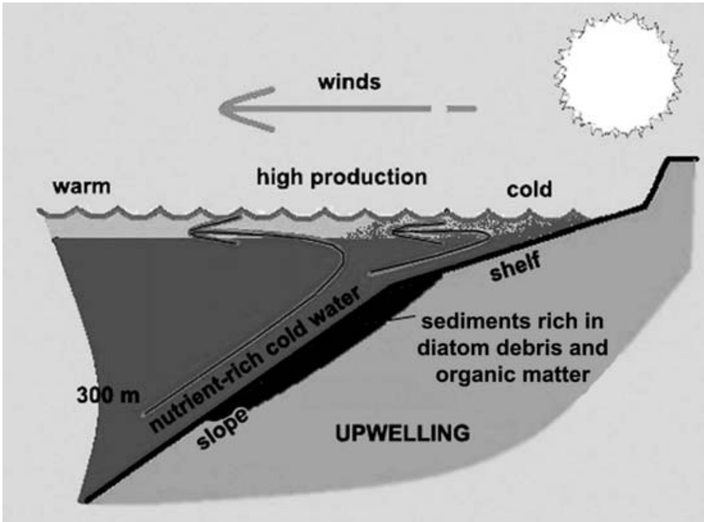


Fig. 2.18. Upwelling of cold water brings nutrients to the sunlit zone, stimulating production of tiny algae.

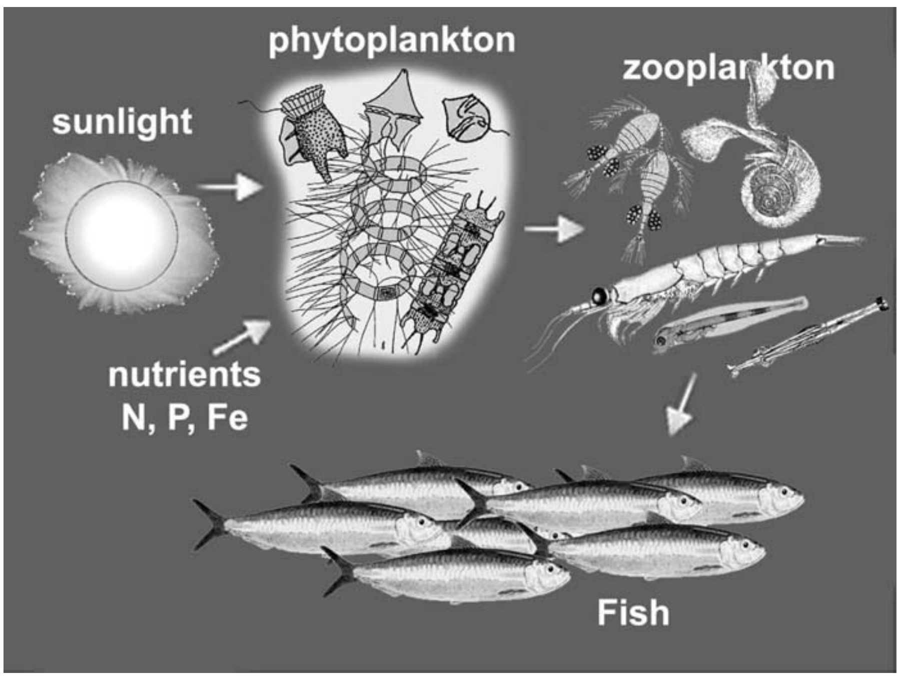


Fig. 2.19. The short food chain of upwelling regions, which supports herring-like fish, which in turn feed mammals and birds. Arrows indicate the flow of energy and matter. Phytoplankton: dinoflagellates (top three) and diatoms (bottom two). Zooplankton: copepods (2), wing-foot snail, krill, fish larva, arrow worm.

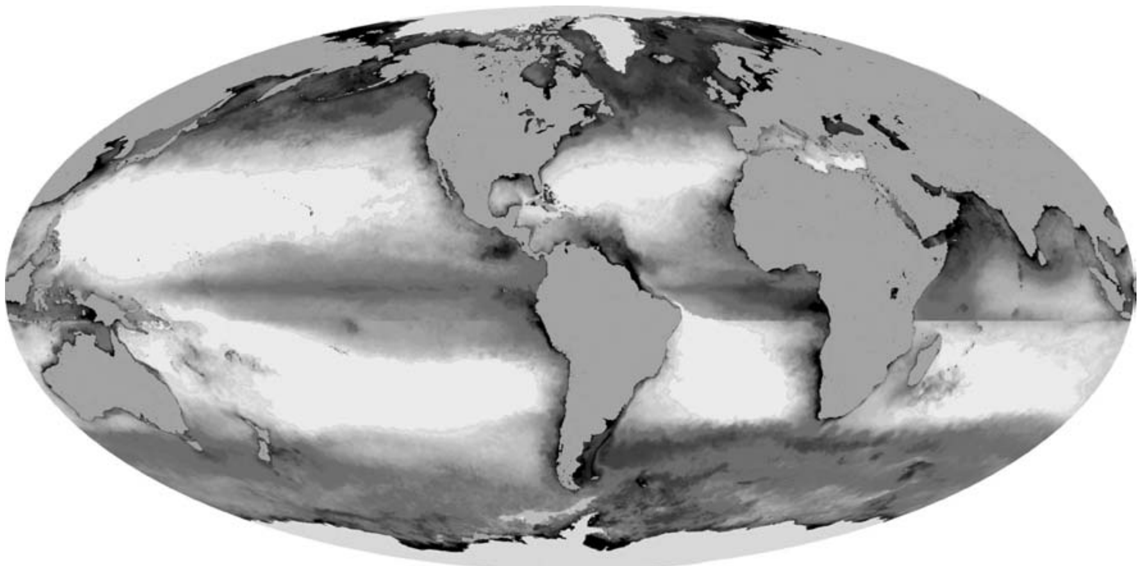


Fig. 2.20. Global patterns of productivity from chlorophyll distribution, based on satellite color surveys. Dark regions: high phytoplankton concentrations. Shown are northern and southern hemisphere during their respective productive season (spring and summer). (The equatorial zone is combined with the northern hemisphere).

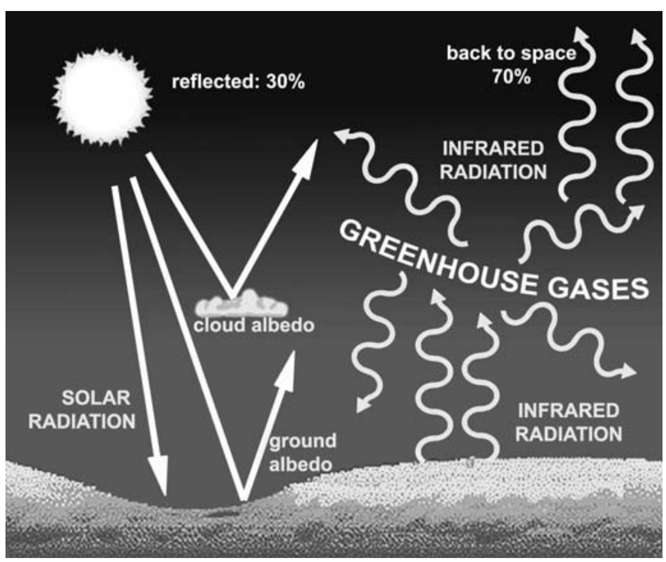


Fig. 2.21. Radiation balance of Earth. Greenhouse gases: water vapor, carbon dioxide.

Fig. 2.22. Coastal landscapes in high latitudes: fjords carved by glacial ice. Left: Ushuaia, Patagonia (Argentina); right: Bergen (Norway).

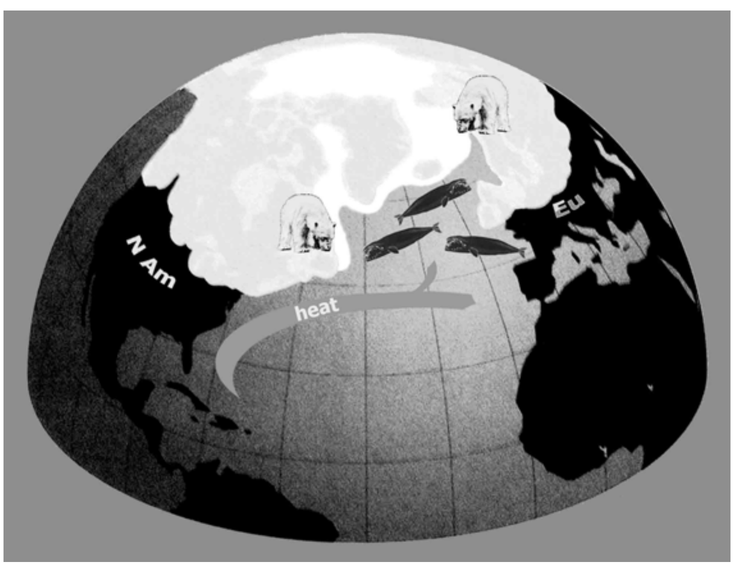


Fig. 2.23. Maximum ice extent on land and in the sea on the northern hemisphere during glacial periods. Note the east-west asymmetry of ice margins across the North Atlantic.

Fig. 2.24. Earth.

Figure sources (where based on sources in the literature, on the web or in museum exhibits: figures are considerably modified and adapted for present purposes, using Adobe Photoshop; drawings and photographs by the author are marked “orig.”):
1. Bishop Museum, Honolulu (orig.); 2. orig.; 3. Alvin photo, Woods Hole Oceanographic Institution; 4. upper: orig.; lower: NOAA; 5, orig.; 6, orig.; 7, orig.; 8, JPL NASA; 9, orig.; 10, NASA, with additions; 11, Kuenzi 2002, Wittheit; 12, orig.; 13, NOAA; 14, Brehms Tierleben (see Ch. 1 for reference), SIO Explorations, H. Murayama (see Ch. 1 for reference), Expedition Reports of Albert I Prince of Monaco, L.A. Natural History Museum, Bergen Aquarium; 15, Sea Life Park Oahu, Zoological Museum Hamburg (origs.); 16, Sverdrup et al. (1942), Galathea Report, E. Haeckel (see Ch. 1 for reference), NOAA, Brehm’s Tierleben, Hardy, and other sources; 17, E. Haeckel, Brehm’s Tierleben, L.A. Natural History Museum (orig.), Expedition Report Albert I Prince of Monaco, Aquarium of the Pacific (Long Beach) (orig.), SIO Explorations, and other sources; 18, orig.; 19, Sverdrup et al. (1942), CalCOFI reports, H. Murayama; 20, NASA SeaWIFS; 21, NOAA; 22, orig.; 23, base: J. and K. Imbrie, polar bear: F. Nansen; 24, NASA. **References**: NOAA, National Oceanic and Atmospheric Administration, U.S. Department of Commerce; JPL NASA, Jet Propulsion Laboratory, U.S. National Aeronautics and Space Administration; JPL NASA image given by K. Kuenzi in Hempel, G., and F. Hinrichsen (eds.) 2002. *Der Ozean – Lebensraum und Klimasteuerung. Jahrbuch 2001/2002 der Wittheit zu Bremen.* Verlag Hausschild GmbH, Bremen, 147pp.; Albert I, Prince of Monaco, ca 1900, *Résultats des Campagnes Scientifiques accomplies sur son yacht* (numerous volumes) Imprimerie de Monaco; H.U. Sverdrup, M.W. Johnson, R.H. Fleming, 1942. *The Oceans, Their Physics, Chemistry, and General Biology*. Prentice-Hall, Englewood Cliffs, N.J., 1087pp.; Poul Winther (1953) in A.F. Bruun, S. Greve, H. Mielche and R. Spärck, 1956. *The Galathea Deep Sea Expedition 1950-1952, Described by the Members of the Expedition.* Macmillan, New York, 296pp. (First publ. in Danish, in 1953.); A. Hardy, 1959. *The Open Sea: Its Natural History*. Collins Clear-Type Press, London, 322 pp.; SIO Explorations, “Explorations” (1995-2007) is a publication of the SIO office for public relations; CalCOFI, California Cooperative Fisheries Investigations, Atlas series published by SIO; J. Imbrie and K.P. Imbrie, 1979, *Ice Ages, Solving the Mystery*. Enslow, Hillside, N.J., 224pp.