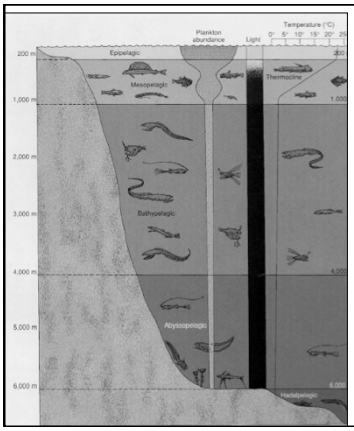
The Ocean Depths (Inner Space)

Includes the mesopelagic and deep sea zones

- 90% of the volume in the ocean
- 79% of the entire volume in the biosphere is at depths of more than 1000 m



Mesopelagic and Deep Sea Zones

Not enough light for PP

Life is less abundant & declines with depth (5-10 x fewer at 500m 100 x fewer at 4000)

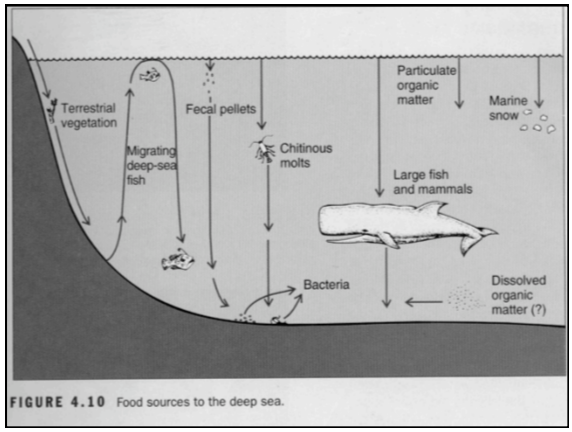


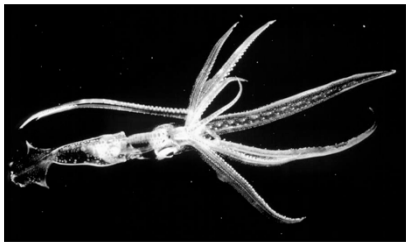
FIGURE 4.10 Food sources to the deep sea.

II. The animals of the Mesopelagic Zone (often called midwater animals)

Major groups of zooplankton are krill and copepods; several kinds of shrimp are also common

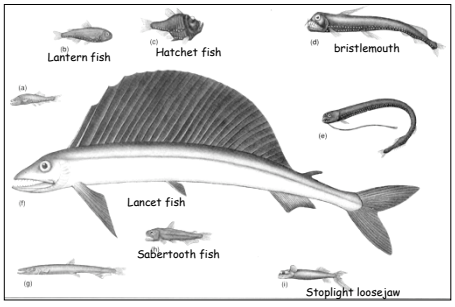
Arrow worms are important midwater predators

Mesopelagic squids are also common



Mesopelagic fishes are small (2-10 cm)

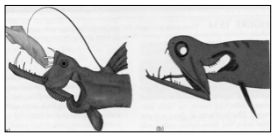
Bristle mouths and Lantern fishes make up > 90% of the fish in the mesopelagic zone



III. Adaptations to the Mesopelagic Zone

Adaptations to Life in the Mesopelagic

- Only about 20% of the food from the epipelagic makes it to the mesopelagic… fewer organisms , small size



Large mouth, generalist diet, long teeth to keep any prey from escaping.

Adaptations to Life in the Mesopelagic

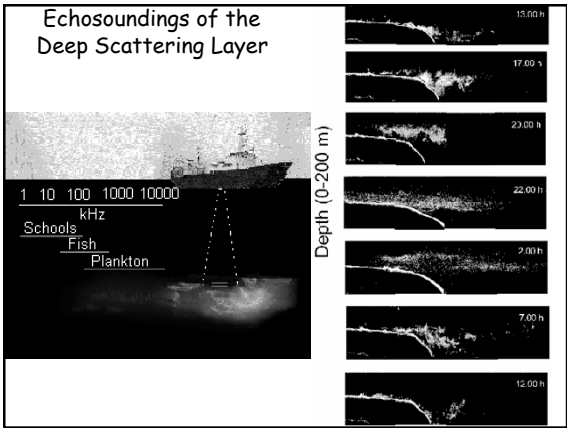
Migrators versus non Migrators

Non migrators are either detritivores who filter out fallout from the surface or sit and wait predators that feed in darkness

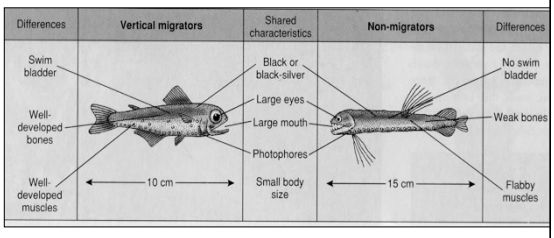
Most mesopelagic organisms undergo a vertical migration, moving to the epipelagic zone to feed at night.

Migrating organisms form the deep scattering layer, which can create a false sonar "bottom"

Echosoundings of the Deep Scattering Layer

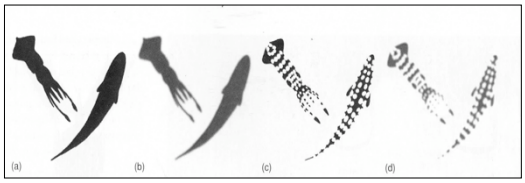


Vertical Migrators vs. Non Migrating Fishes



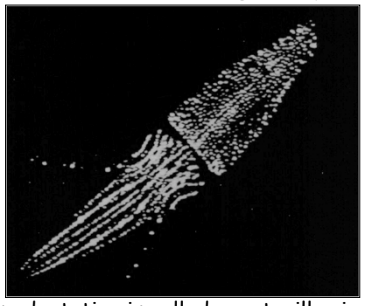
Adaptations to Life in the Mesopelagic

Predator avoidance Strategies
--Countershading, transparency
--Reduction of silhouette: bioluminescense



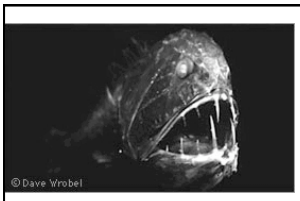
With surface light in the background, animals can create a detectable shadow; ventral photophores help animals blend with the background

Midwater Squid Showing Photophores



This adaptation is called counterillumination

IV. The Deep Sea: Perpetual Darkness



"fangtooth"

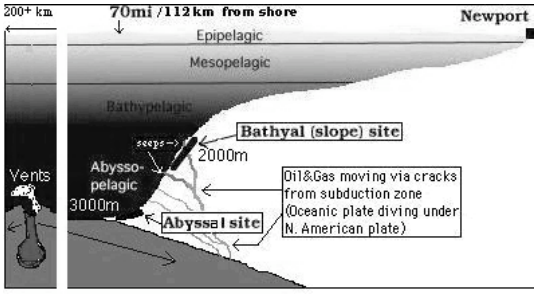
Angler fish

Angler fish video

General Characteristics

- No need for countershading or c-illumination colors generally drab or black
- Bioluminescense prevalent as a way of attracting prey or mates
- Only about 5% of the food at the surface falls to those depths; no vertical migrations; Adaptations to food shortage are accentuated
- Many deep sea fishes are hermaphrodites
- Pressure plays an important role

V. The Deep Ocean Floor: Hot Springs and Cold Seeps



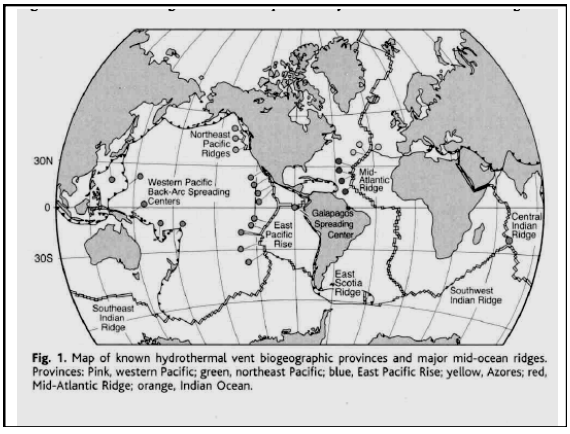
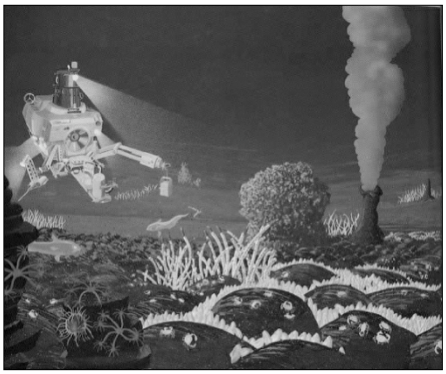


Fig. 1. Map of known hydrothermal vent biogeographic provinces and major mid-ocean ridges. Provinces: Pink, western Pacific; green, northeast Pacific; blue, East Pacific Rise; yellow, Azores; red, Mid-Atlantic Ridge; orange, Indian Ocean.

A living model of earliest life?



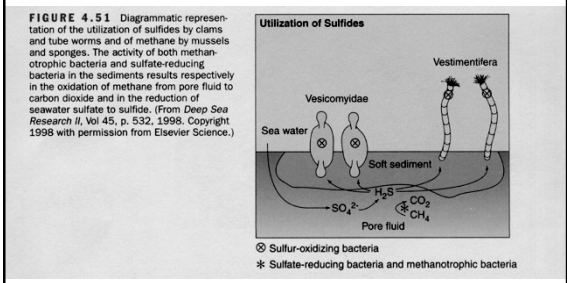


FIGURE 4.51 Diagrammatic representation of the utilization of sulfides by clams and tube worms and of methane by mussels and sponges. The activity of both methanotrophic bacteria and sulfate-reducing bacteria in the sediments results respectively in the oxidation of methane from pore fluid to carbon dioxide and in the reduction of seawater sulfate to sulfide. (From *Deep Sea Research II*, Vol 45, p. 532, 1998. Copyright 1998 with permission from Elsevier Science.)

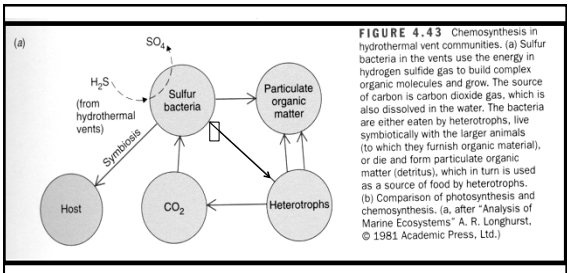


FIGURE 4.43 Chemosynthesis in hydrothermal vent communities. (a) Sulfur bacteria in the vents use the energy in hydrogen sulfide gas to build complex organic molecules and grow. The source of carbon is carbon dioxide gas, which is also dissolved in the water. The bacteria are either eaten by heterotrophs, live symbiotically with the larger animals (to which they furnish organic material), or die and form particulate organic matter (detritus), which in turn is used as a source of food by heterotrophs. (b) Comparison of photosynthesis and chemosynthesis. (a, after "Analysis of Marine Ecosystems" A. R. Longhurst, © 1981 Academic Press, Ltd.)

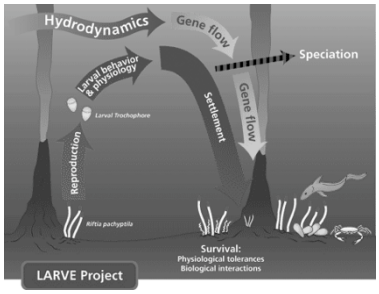
$$CO_2 + 4\ H_2S + O_2 \Rightarrow [CH_2O]_n + 4\ S + 3\ H_2O$$

Chemosynthesis by sulfur reducing bacteria

Dispersal and Recruitment in Vent Populations

- Vents are temporally and spatially patchy
- Most species found at vents are not found elsewhere
- Vent organisms have a widespread distribution
- How are vents habitats colonized and populations replenished?

Buoyant Plume Model - Advection Model

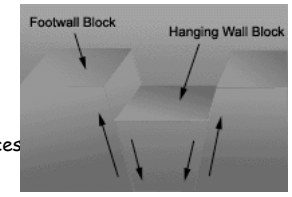


- Larval life ~ 30 d
- Mullineaux (1995) found vent larvae in vent plume near a sea mount
- "Megaplumes" may be especially important
- Plume advection of larvae may serve in initial colonization

http://www.whoi.edu/oceanus/viewImage.do?id=5133&aid=2420

Ocean Currents in the Mid-Atlantic Ridge

- The buoyant plumes carry larvae vertically
- At neutral density, the effluent layer is carried horizontally
- Local topography influences larval transport

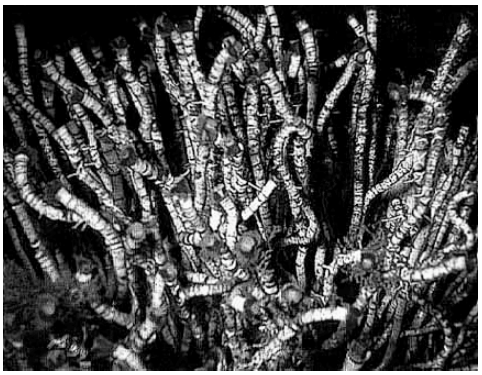


http://extremescience.net/keyterms/graben.gif

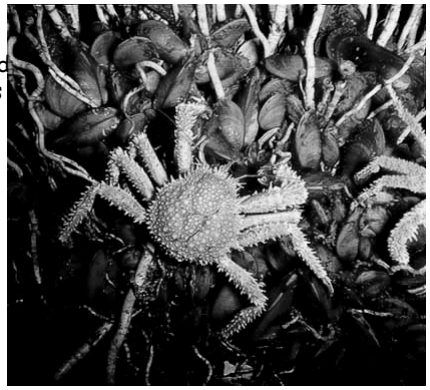
Cold Water Seeps

Along the continental margins, hydrogen sulfide and organic chemicals like methane seep out from the ocean floor

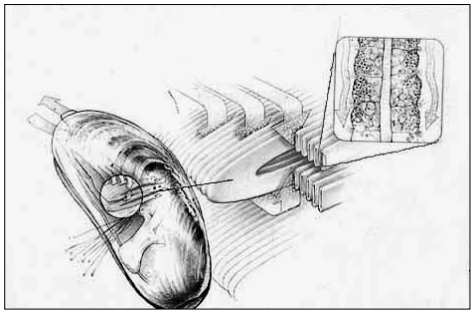
Note red tentacular crown



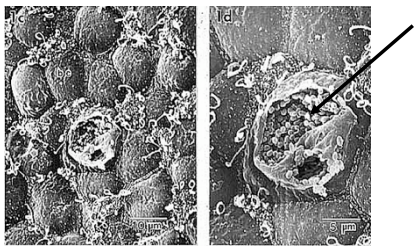
Mussels and also crabs abound



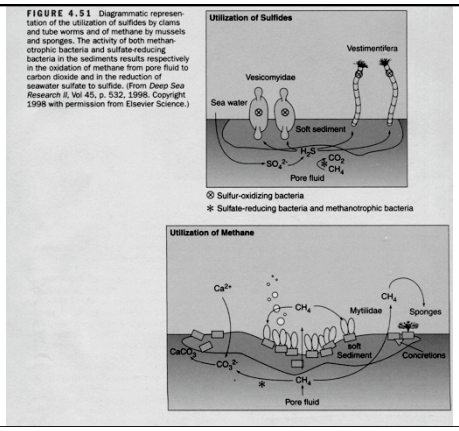
Studies of mussel anatomy show an unusually large gill



The gills of these mussels and other seep animals are laden with bacteria… which use methane to create energy



Methanotrophic bacteria of Mussels



Whale Falls

A sunken carcass provides a massive food fall for the normally organic-poor deep-sea floor. (i.e. 40 ton whale (2 million g C)

Provides an amount of carbon to one hectare that is equivalent to 100-200 yr fallout from the epipelagic zone

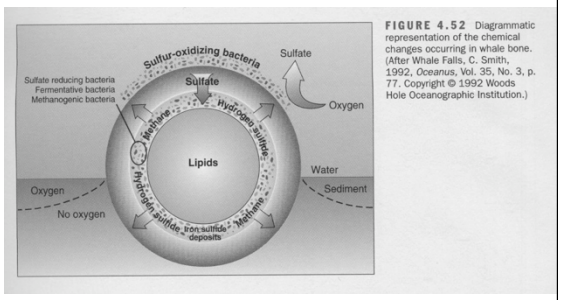


FIGURE 4.52 Diagrammatic representation of the chemical changes occurring in whale bone. (After Whale Falls, C. Smith, 1992, *Oceanus*, Vol. 35, No. 3, p. 77. Copyright © 1992 Woods Hole Oceanographic Institution.)