OCEAN LIFE

Composition of Sea Water

Seawater is Salty

The salt comes from:

- Chemical weathering of rocks
- Outgassing from volcanic eruptions

Seawater becomes less salty when diluted with fresh water.

These processes add fresh water to the sea and dilute the salinity.

- Precipitation
- Runoff from land
- Icebergs melting
- Sea ice melting

Seawater becomes saltier when fresh water is removed.

These processes remove fresh water from the sea and increase the salinity:

- Evaporation (salt does not evaporate)
- Formation of sea ice

Salinity varies from about 3.3% to 3.8% in the oceans.

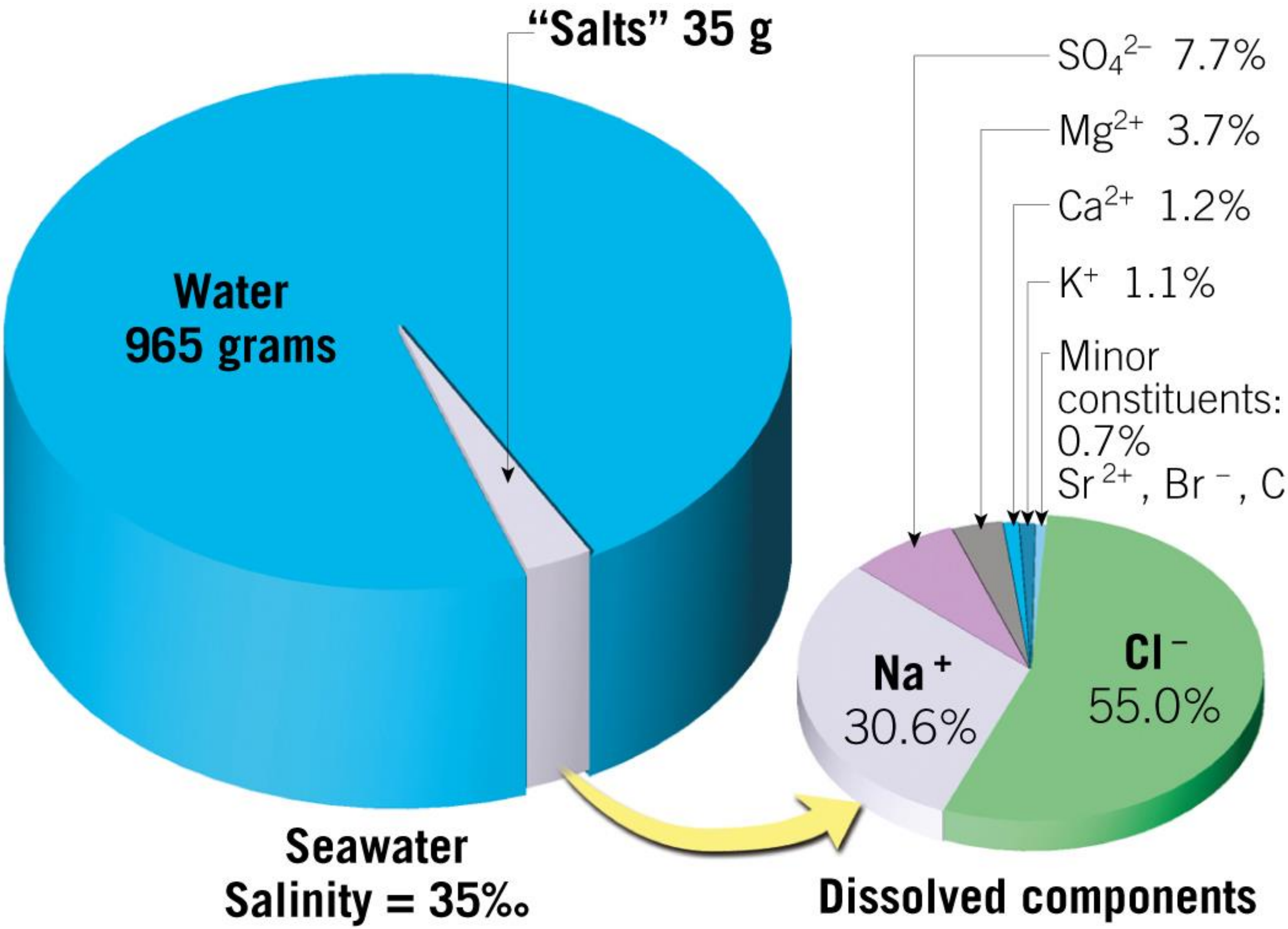
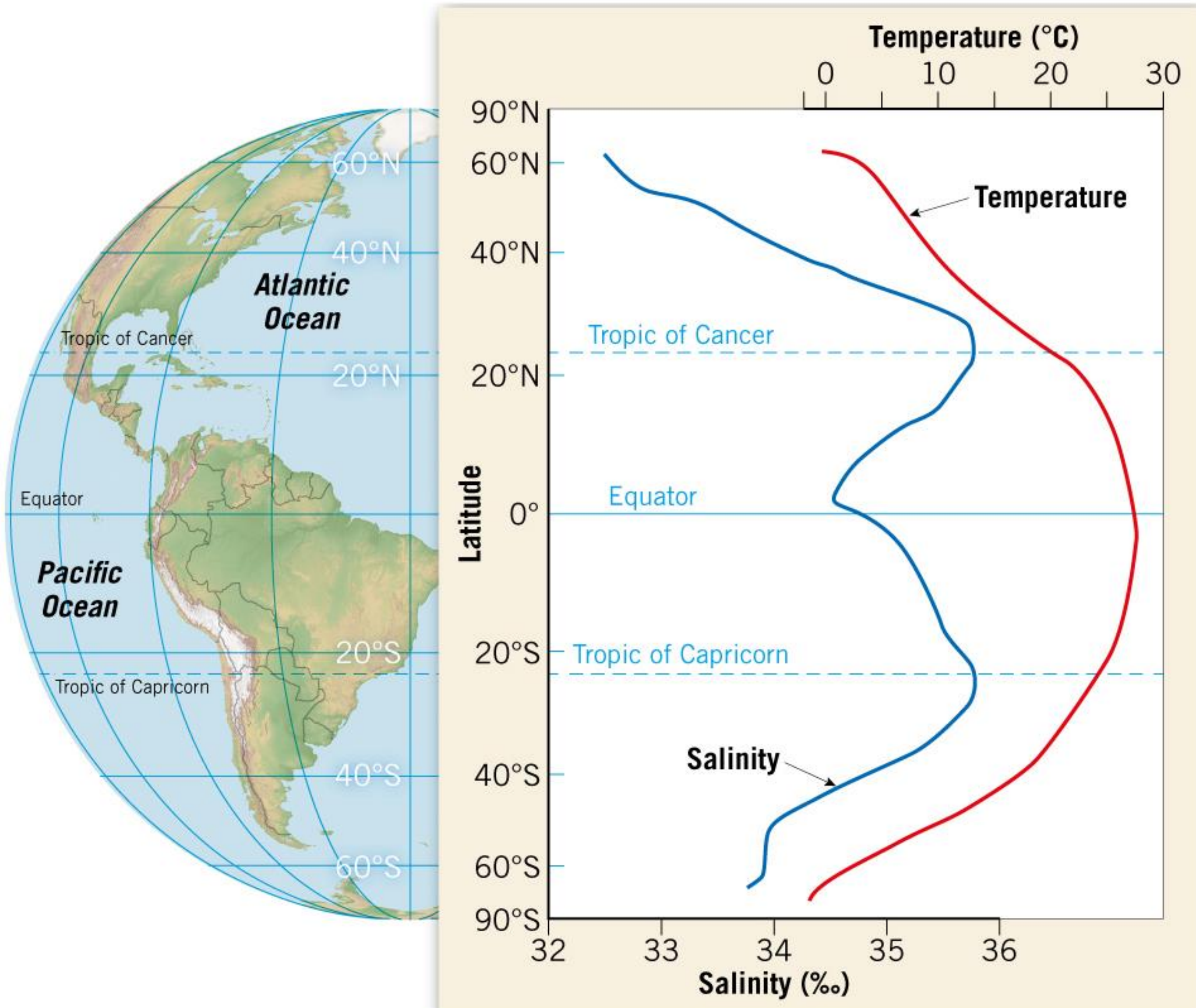


Table 14.1 Recipe for Artificial Seawater

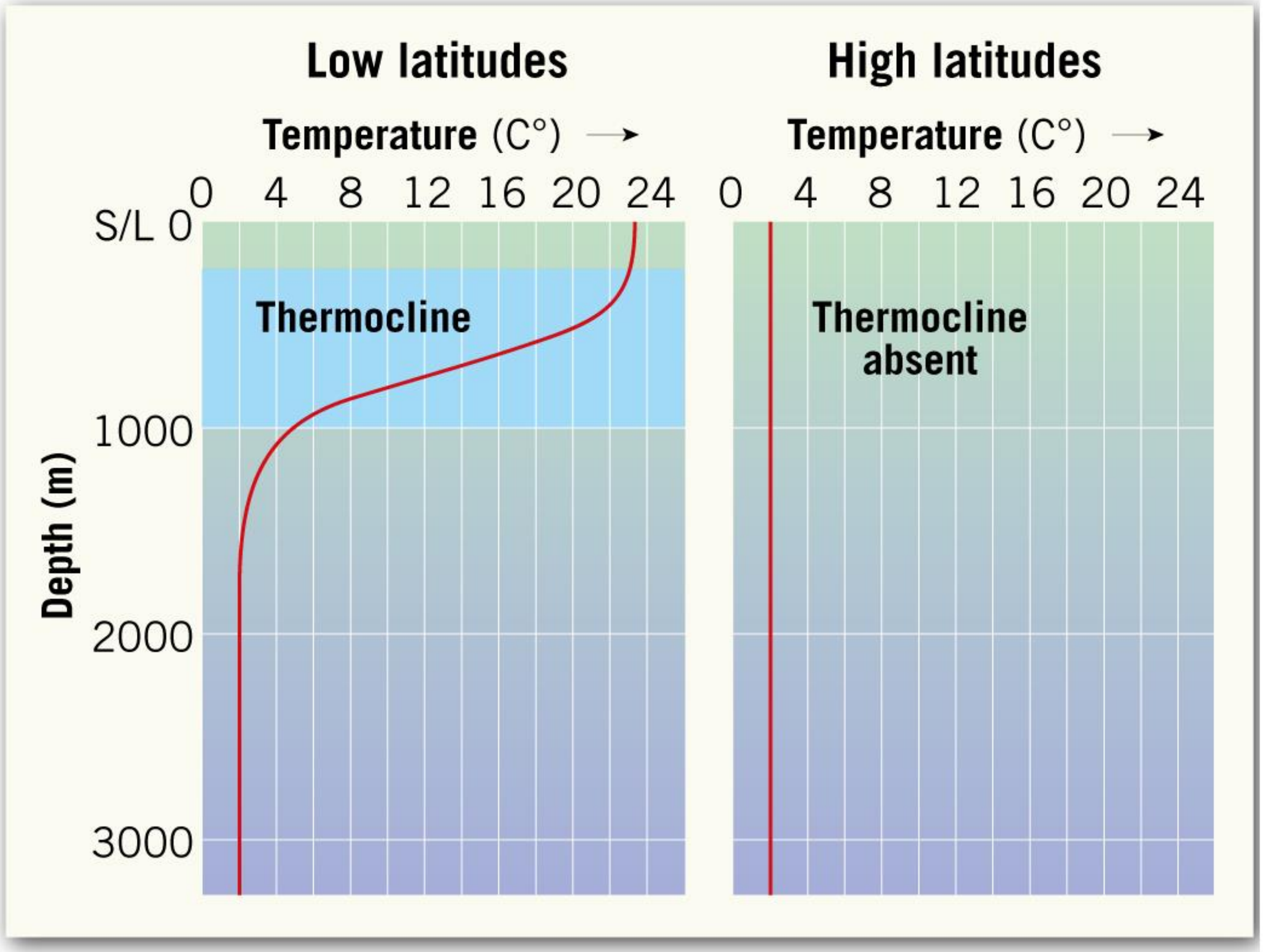
To Make Seawater, Combine:	Amount (grams)
Sodium chloride ($NaCl$)	23.48
Magnesium chloride ($MgCl_2$)	4.98
Sodium sulfate (Na_2SO_4)	3.92
Calcium chloride ($CaCl_2$)	1.10
Potassium chloride (KCl)	0.66
Sodium bicarbonate ($NaHCO_3$)	0.192
Potassium bromide (KBr)	0.096
Hydrogen borate (H_3BO_3)	0.026
Strontium chloride ($SrCl_2$)	0.024
Sodium fluoride (NaF)	0.003

Then Add: Pure water (H_2O) to form 1000 grams of solution.

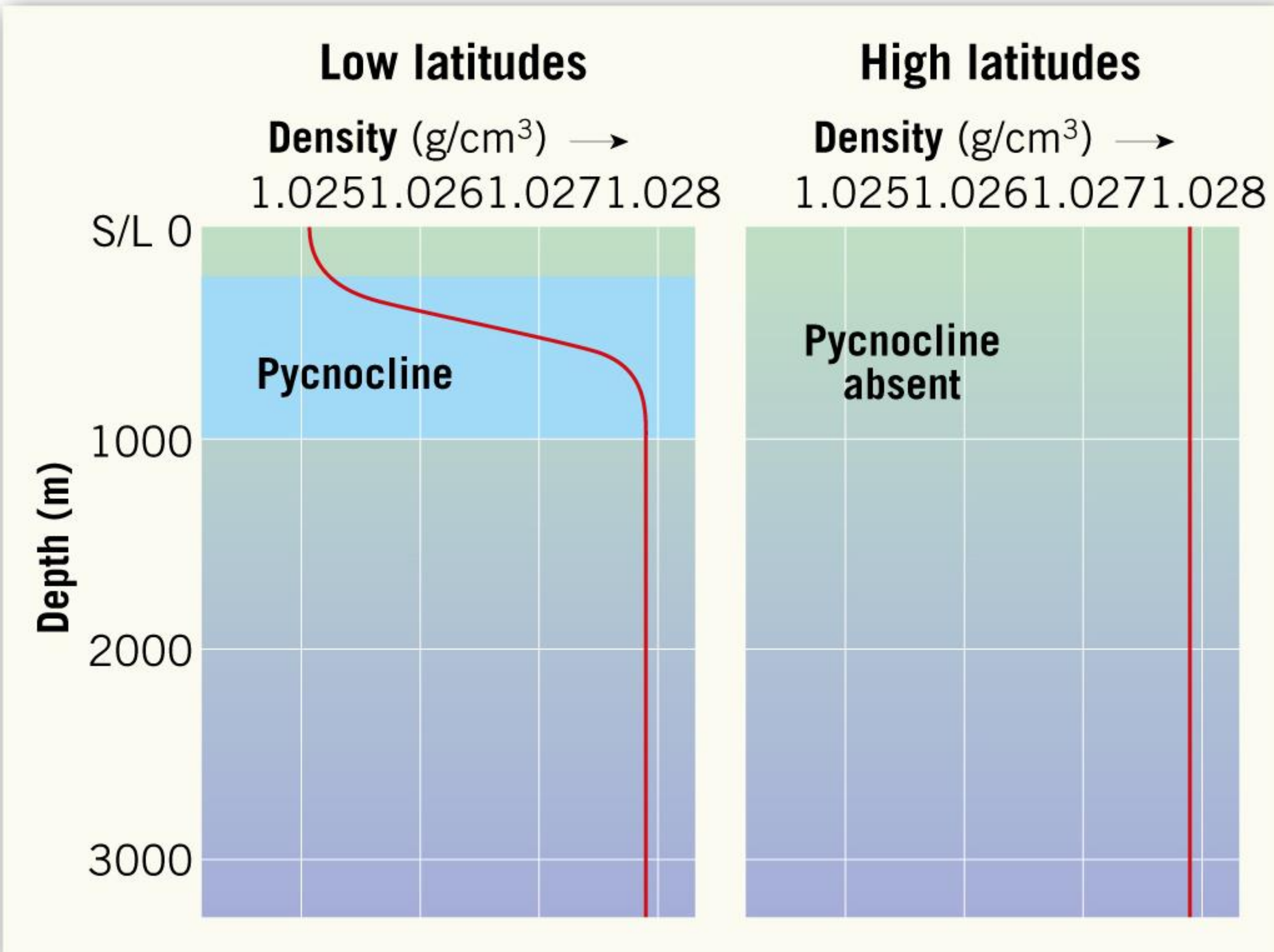
Salinity Depends on Latitude



Temperature (°C)
0
10
20
30
90°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
90°S
Latitude
Temperature
Tropic of Cancer
Equator
Tropic of Capricorn
Salinity
32
33
34
35
36
Salinity (‰)
Atlantic Ocean
Pacific Ocean
Tropic of Cancer
Equator
Tropic of Capricorn
60°N
40°N
20°N
20°S
40°S
60°S



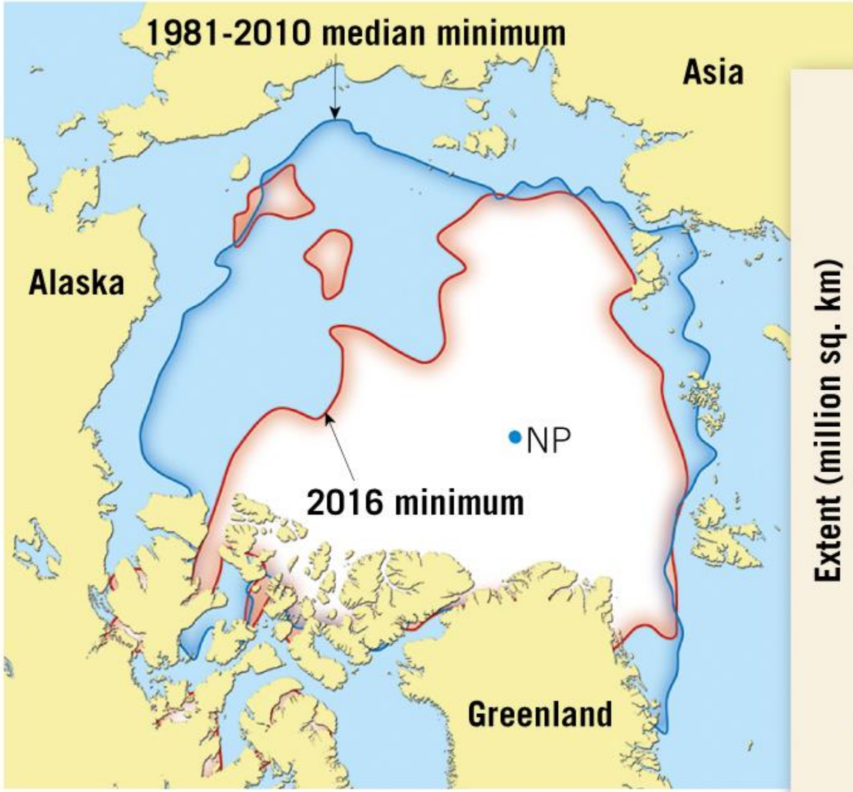
Low latitudes
High latitudes
Temperature (C°)
0 4 8 12 16 20 24
Temperature (C°)
0 4 8 12 16 20 24
S/L 0
1000
2000
3000
Depth (m)
Thermocline
Thermocline absent



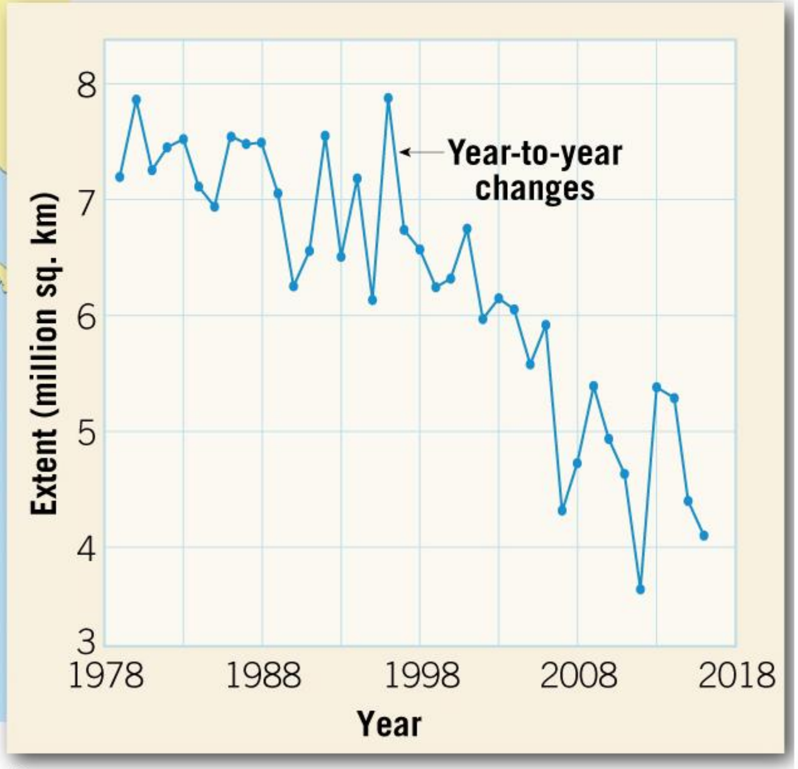
Low latitudes
High latitudes
Density (g/cm3) →
1.025
1.026
1.027
1.028
Density (g/cm3) →
1.025
1.026
1.027
1.028
S/L 0
1000
2000
3000
Depth (m)
Pycnocline
Pycnocline absent

Sea Ice in the Arctic

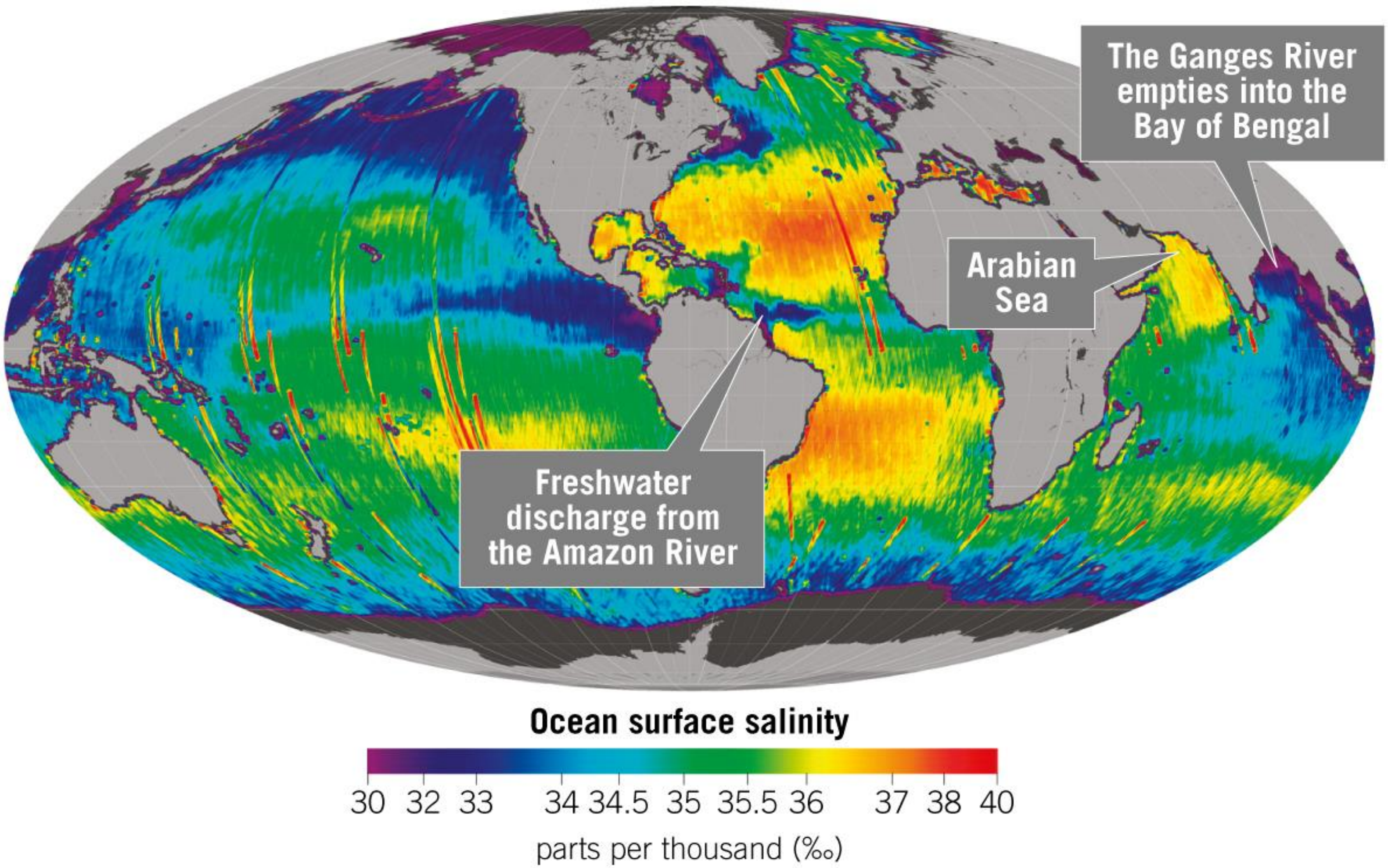
Changes in Sea Ice Around the North Pole



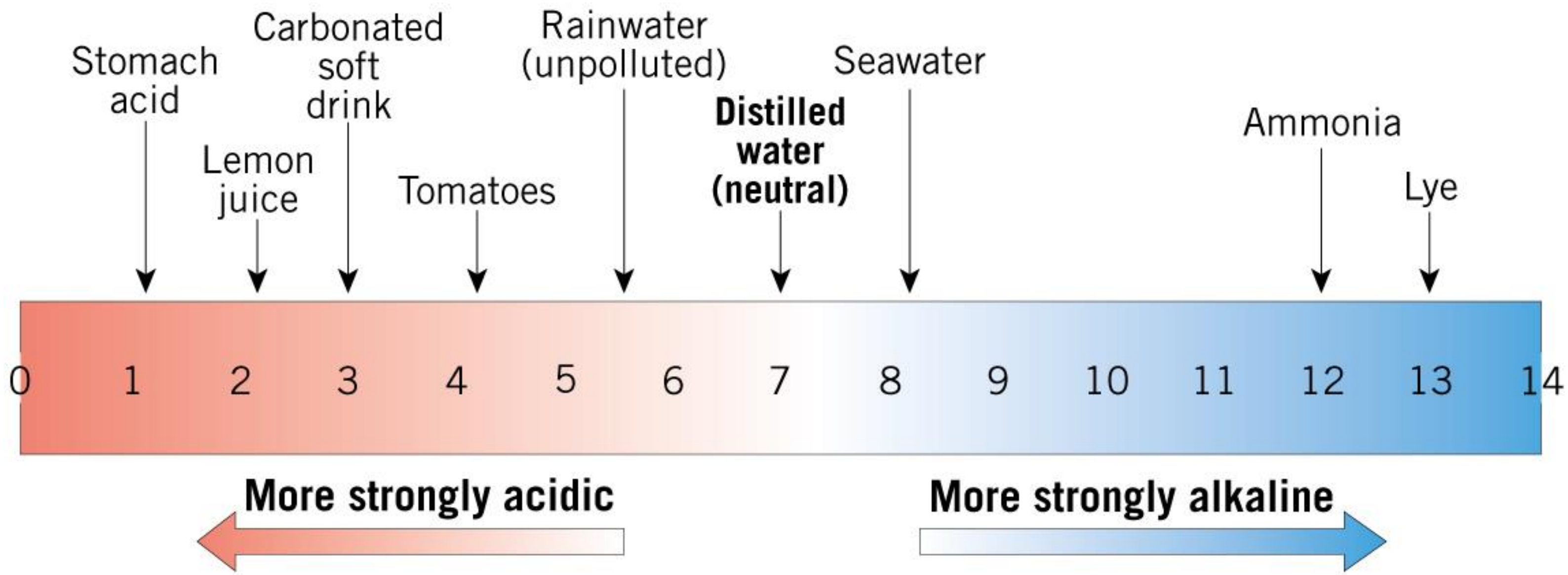
A.

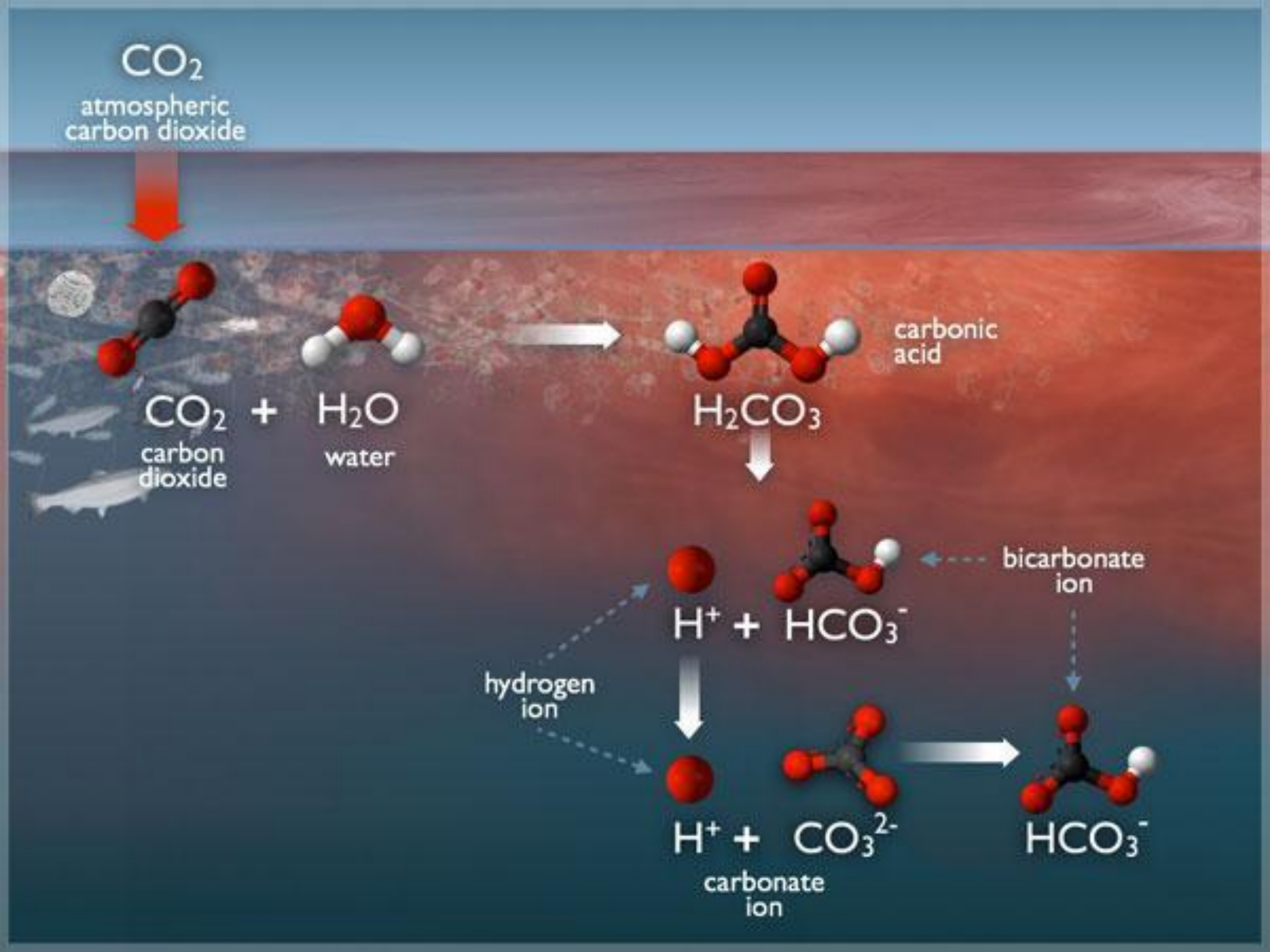


B.

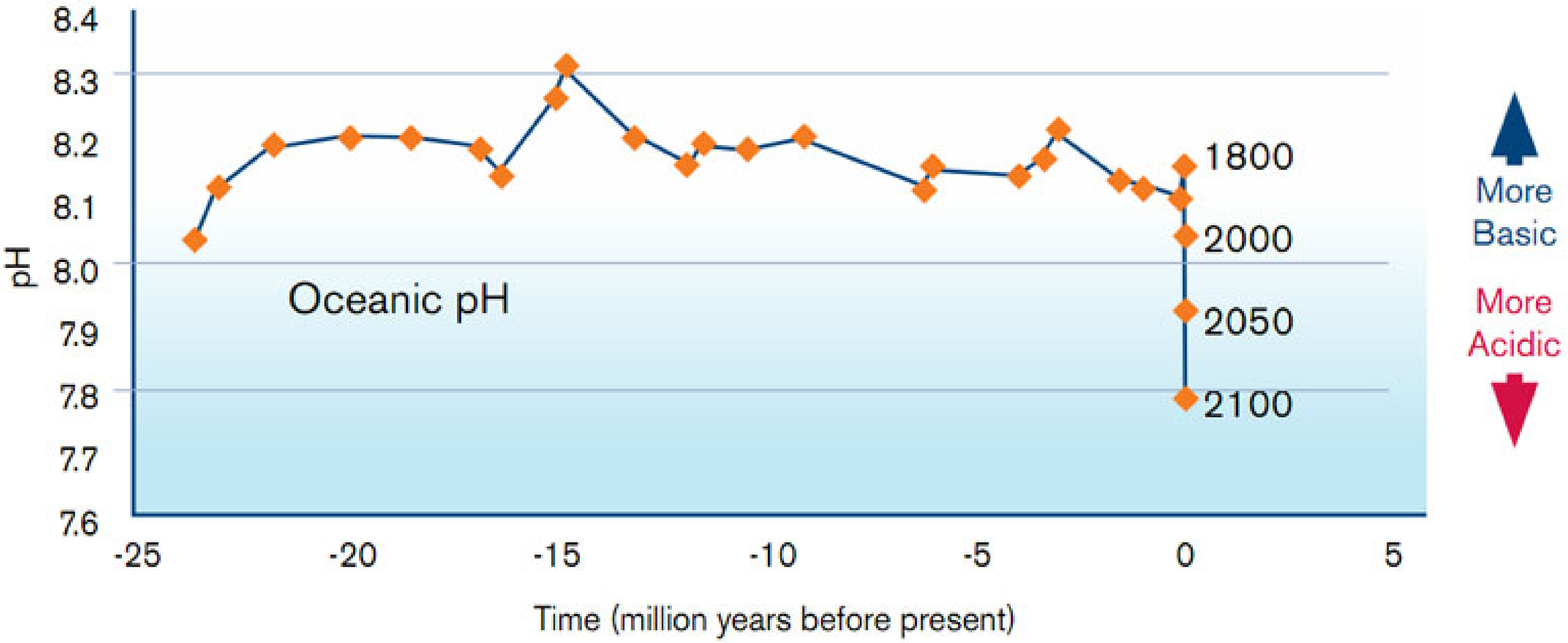

The Ganges River empties into the Bay of Bengal
Arabian Sea
Freshwater discharge from the Amazon River
Ocean surface salinity
30 32 33 34 34.5 35 35.5 36 37 38 40
parts per thousand (‰)

Carbon Dioxide and the Sea


Stomach acid
Lemon juice
Carbonated soft drink
Tomatoes
Rainwater (unpolluted)
Distilled water (neutral)
Seawater
Ammonia
Lye
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
More strongly acidic
More strongly alkaline

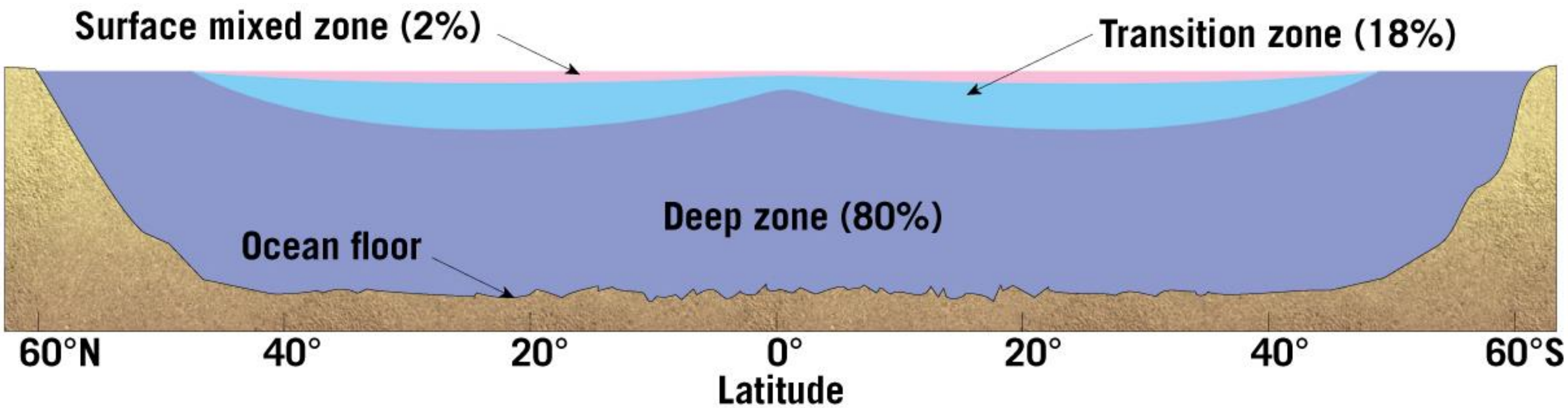


CO_2
atmospheric
carbon dioxide
CO_2 + H_2O
carbon
dioxide
water
H_2CO_3
carbonic
acid
H^+ + HCO_3^-
bicarbonate
ion
hydrogen
ion
H^+ + CO_3^{2-}
carbonate
ion
HCO_3^-


8.4
8.3
8.2
8.1
8.0
7.9
7.8
7.7
7.6
pH
Oceanic pH
1800
2000
2050
2100
More
Basic
More
Acidic
-25
-20
-15
-10
-5
0
5
Time (million years before present)

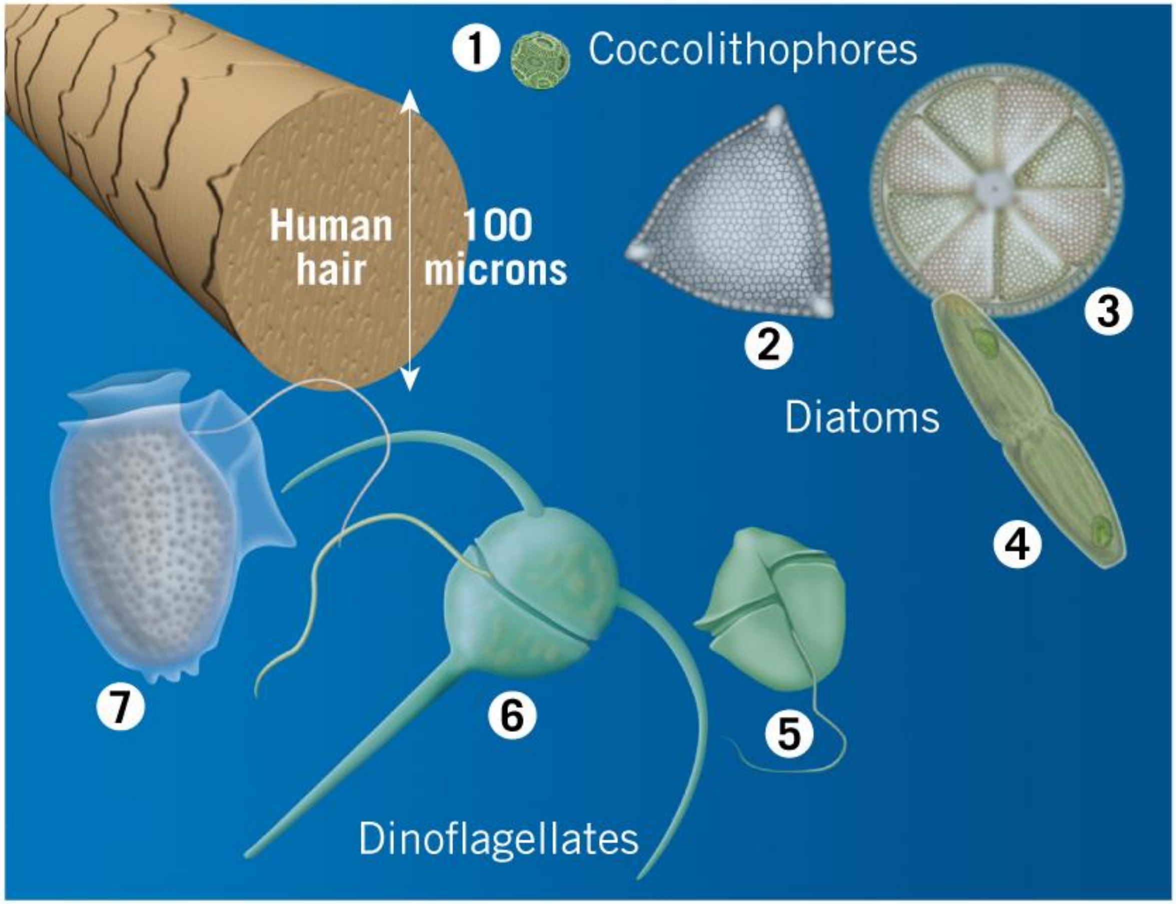
If all the ice melted…
(5000 years in the future)

Ocean Life

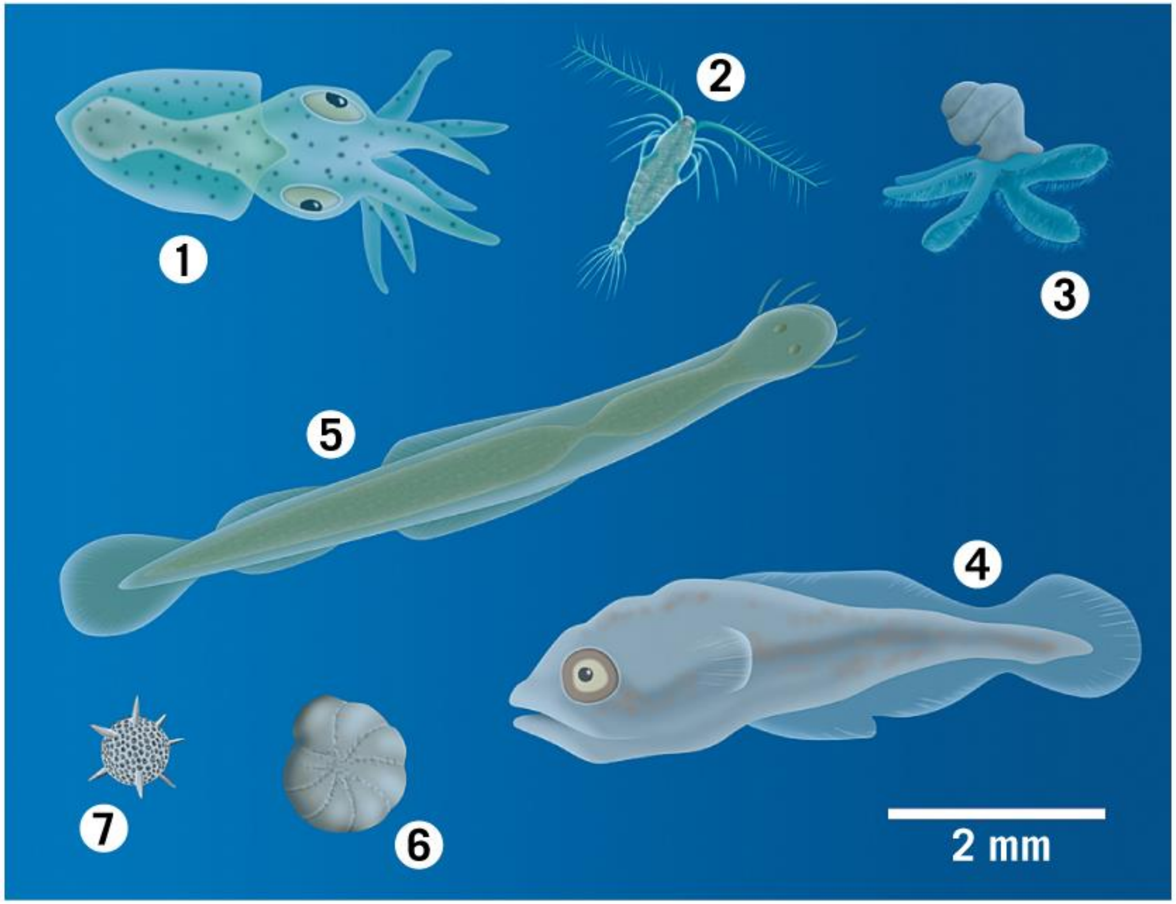


Surface mixed zone (2%)
Transition zone (18%)
Deep zone (80%)
Ocean floor
60°N
40°
20°
0°
20°
40°
60°S
Latitude

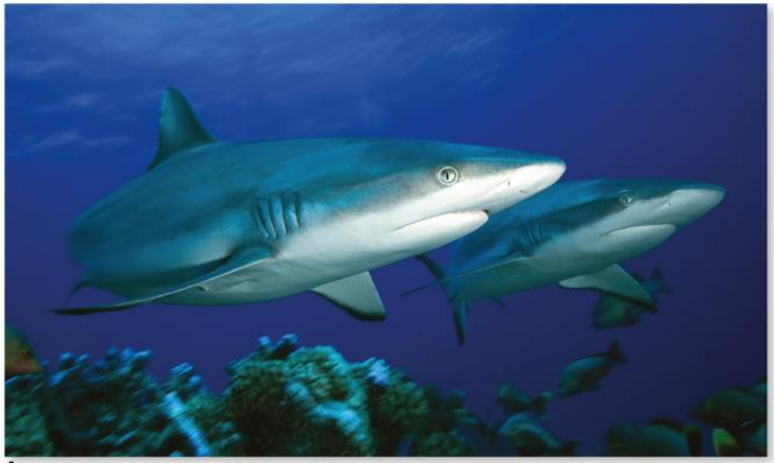
Phytoplankton:
(1) Coccolithophores; (2–4) Diatoms; (5–7) Dinoflagellates.



Zooplankton:
(1) Squid larva; (2) Copepod; (3) Snail larva; (4) Fish larva; (5) Arrowworm; (6) Foraminifers; (7) Radiolarian.



Nekton



A.

B.

C.

D.

A. Gray reef shark, Bikini Atoll

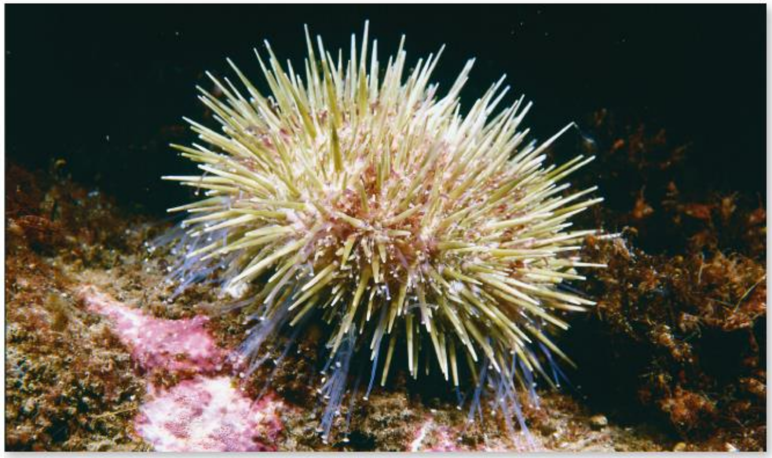
B. California market squid

C. School of Grunts, Florida Keys

D. Pygmy killer whales in shallow surface waters along the Kona Coast, Big Island, Hawaii.

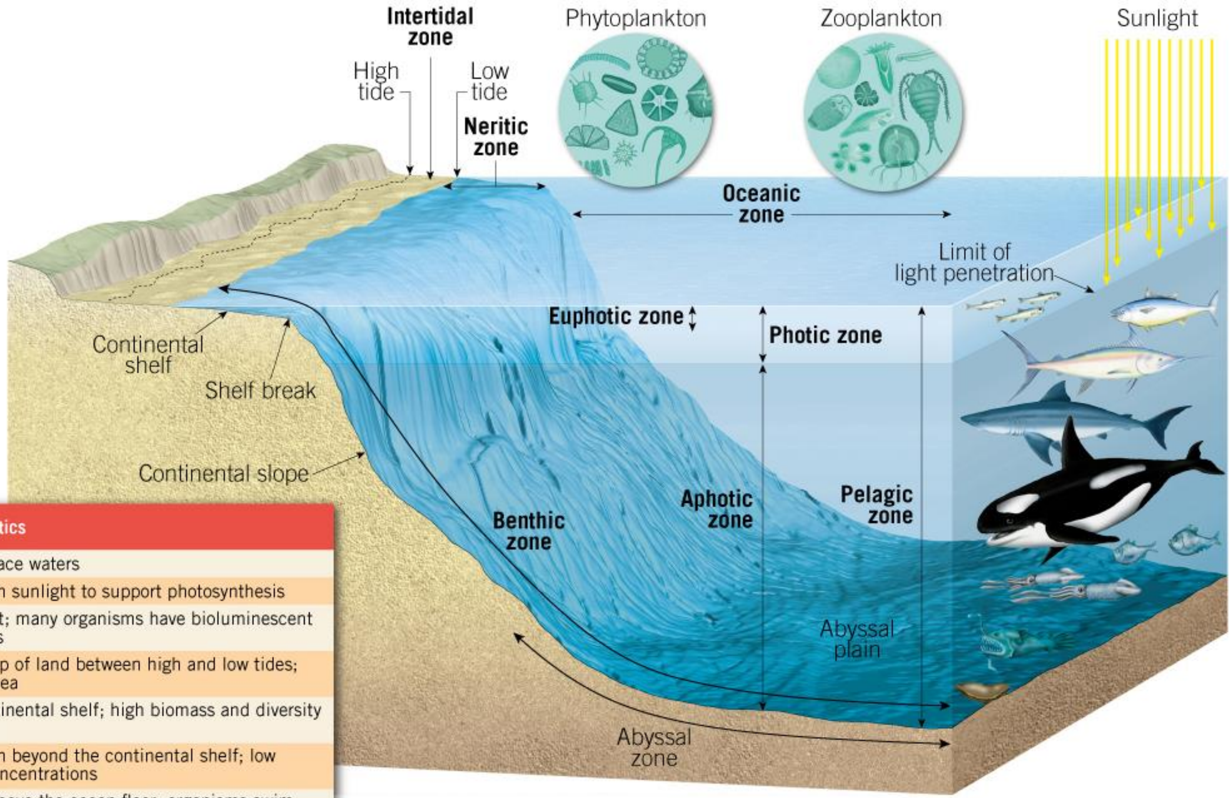
Benthos


A. B.




C. D.

A. Sea Star B. Yellow tube sponge C. Green sea urchin D. Coral crab



Basis	Marine Life Zone	Subdivision	Characteristics
Available sunlight	Photic		Sunlit surface waters
		Euphotic	Has enough sunlight to support photosynthesis
	Aphotic		No sunlight; many organisms have bioluminescent capabilities
Distance from shore	Intertidal		Narrow strip of land between high and low tides; dynamic area
	Neritic		Above continental shelf; high biomass and diversity of species
	Oceanic		Open ocean beyond the continental shelf; low nutrient concentrations
Depth	Pelagic		All water above the ocean floor; organisms swim or float
	Benthic		Bottom of ocean; organisms attach to, burrow into, or crawl on seafloor
		Abyssal	Deep-sea bottom; dark,cold, high pressure; sparse life

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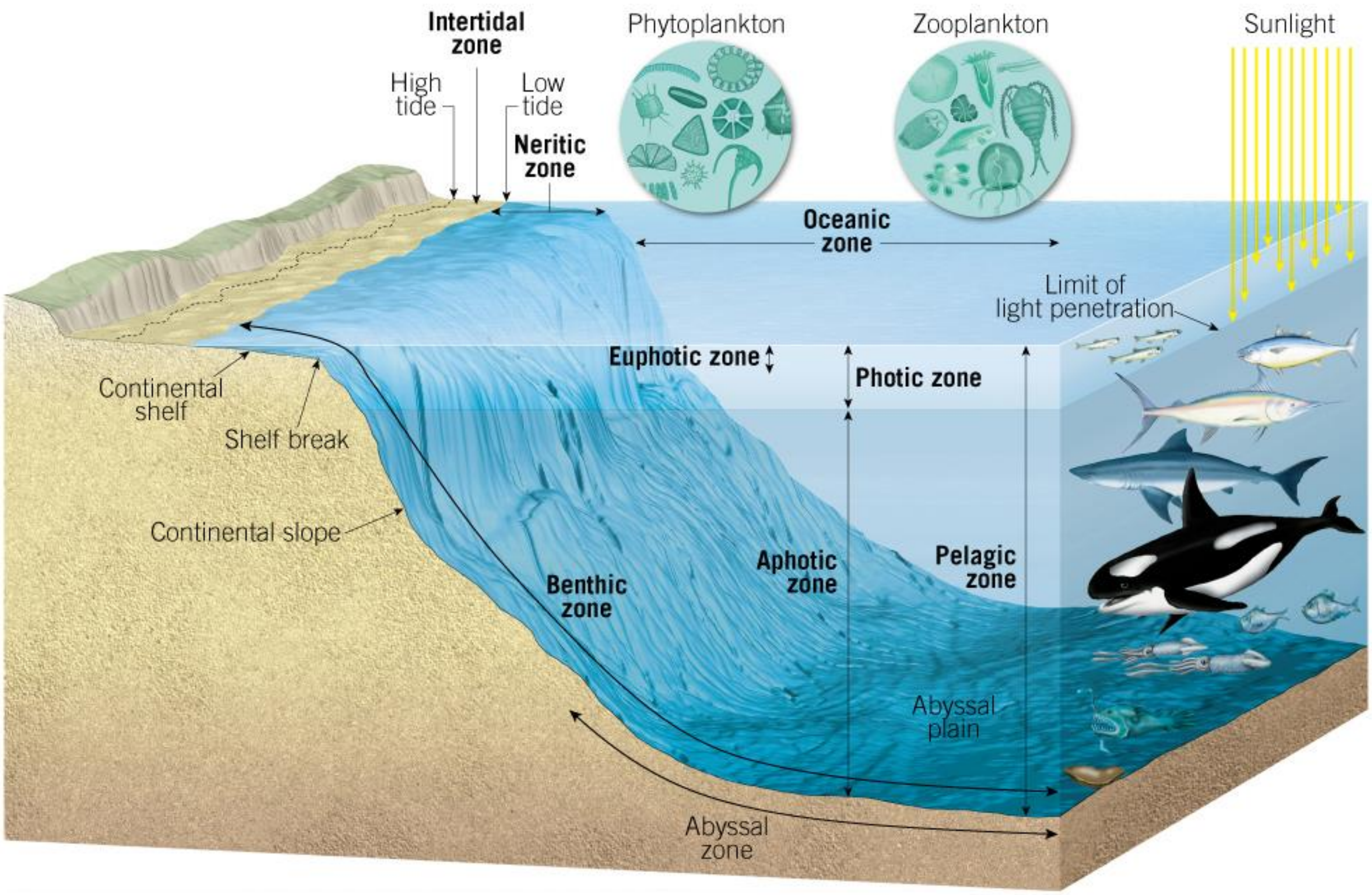
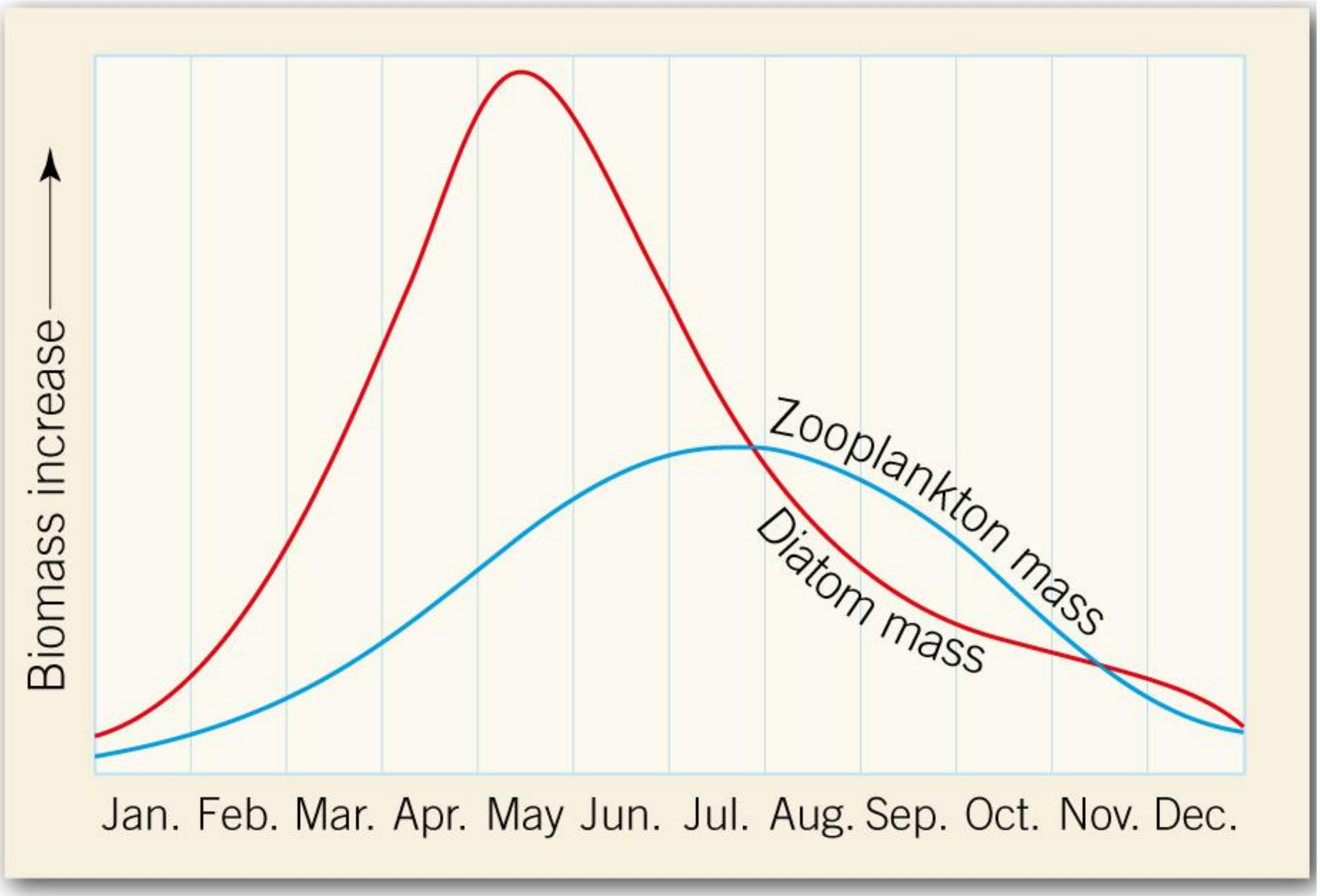
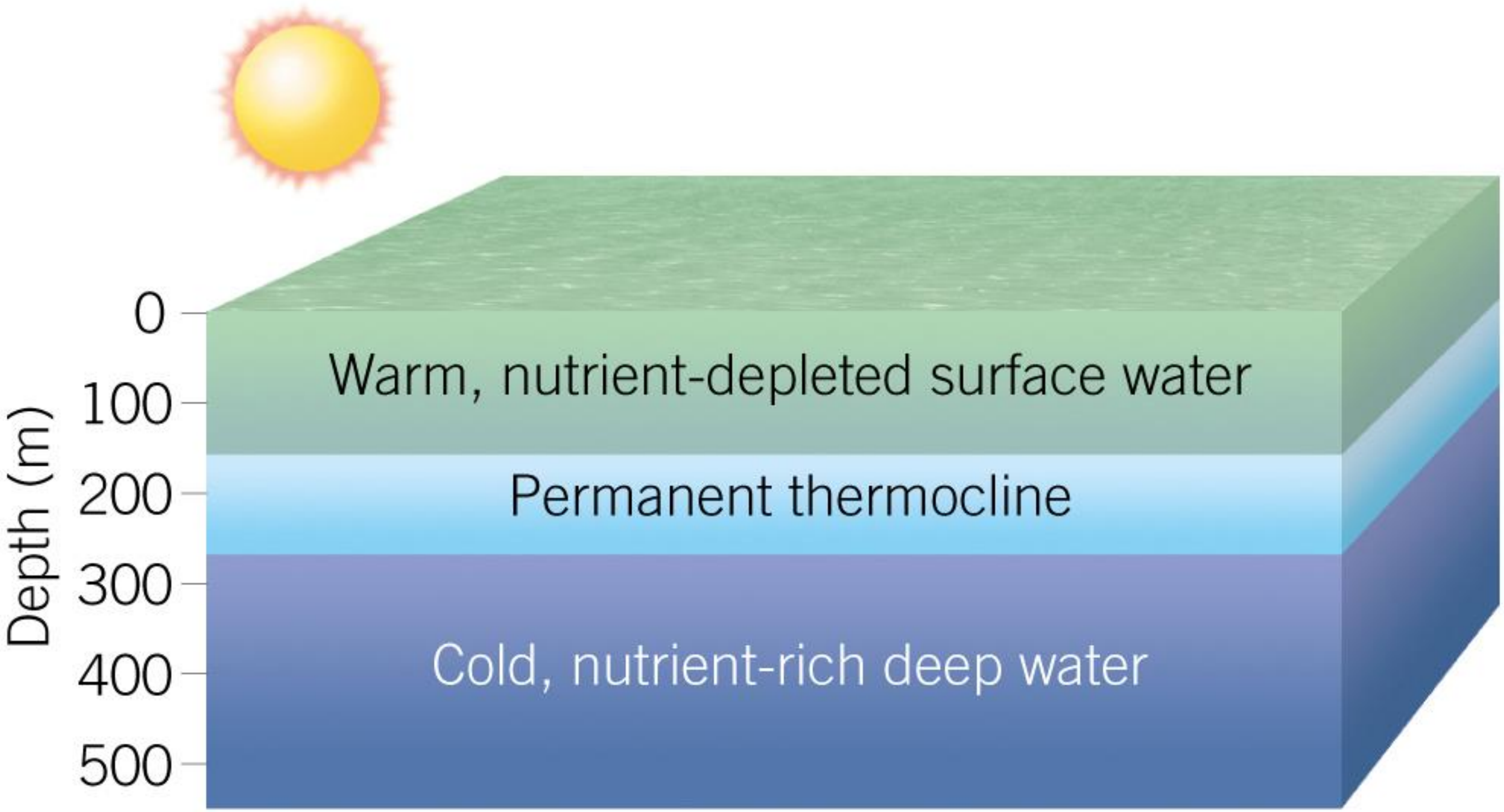
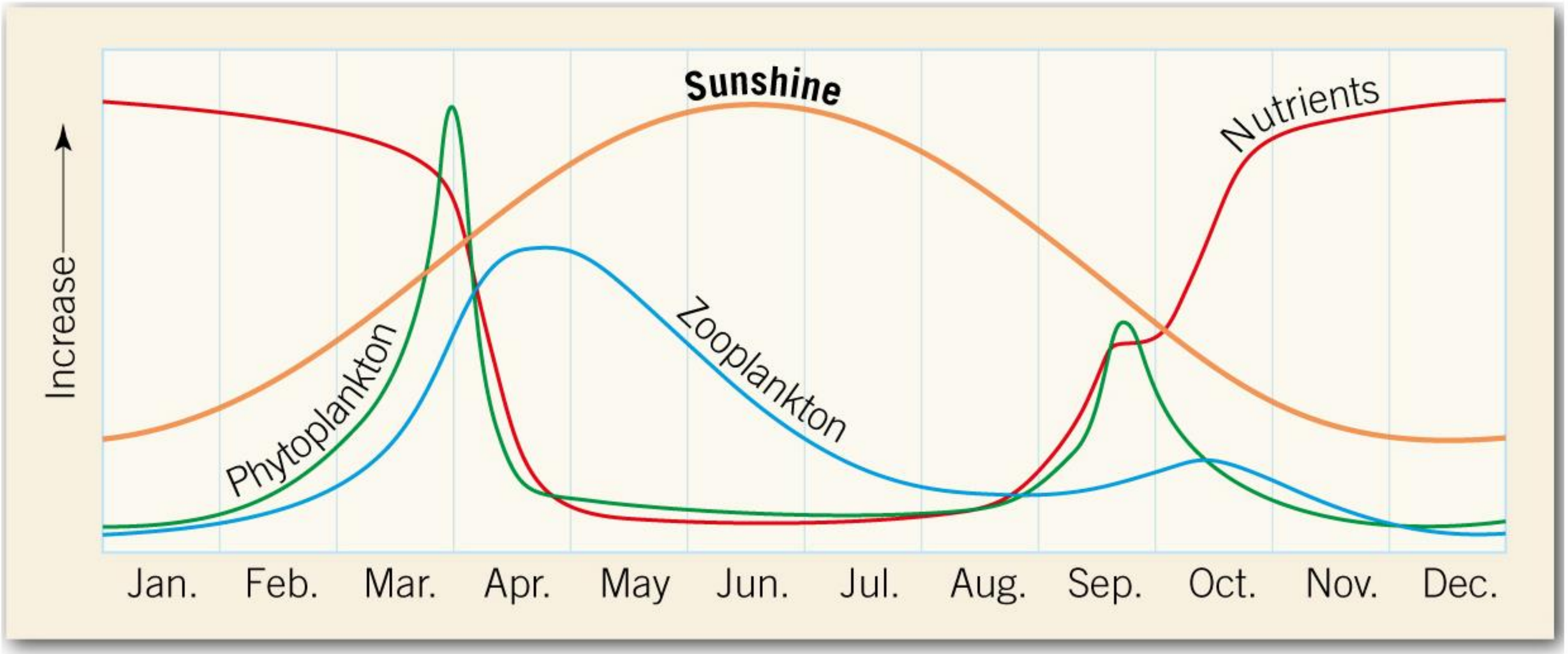
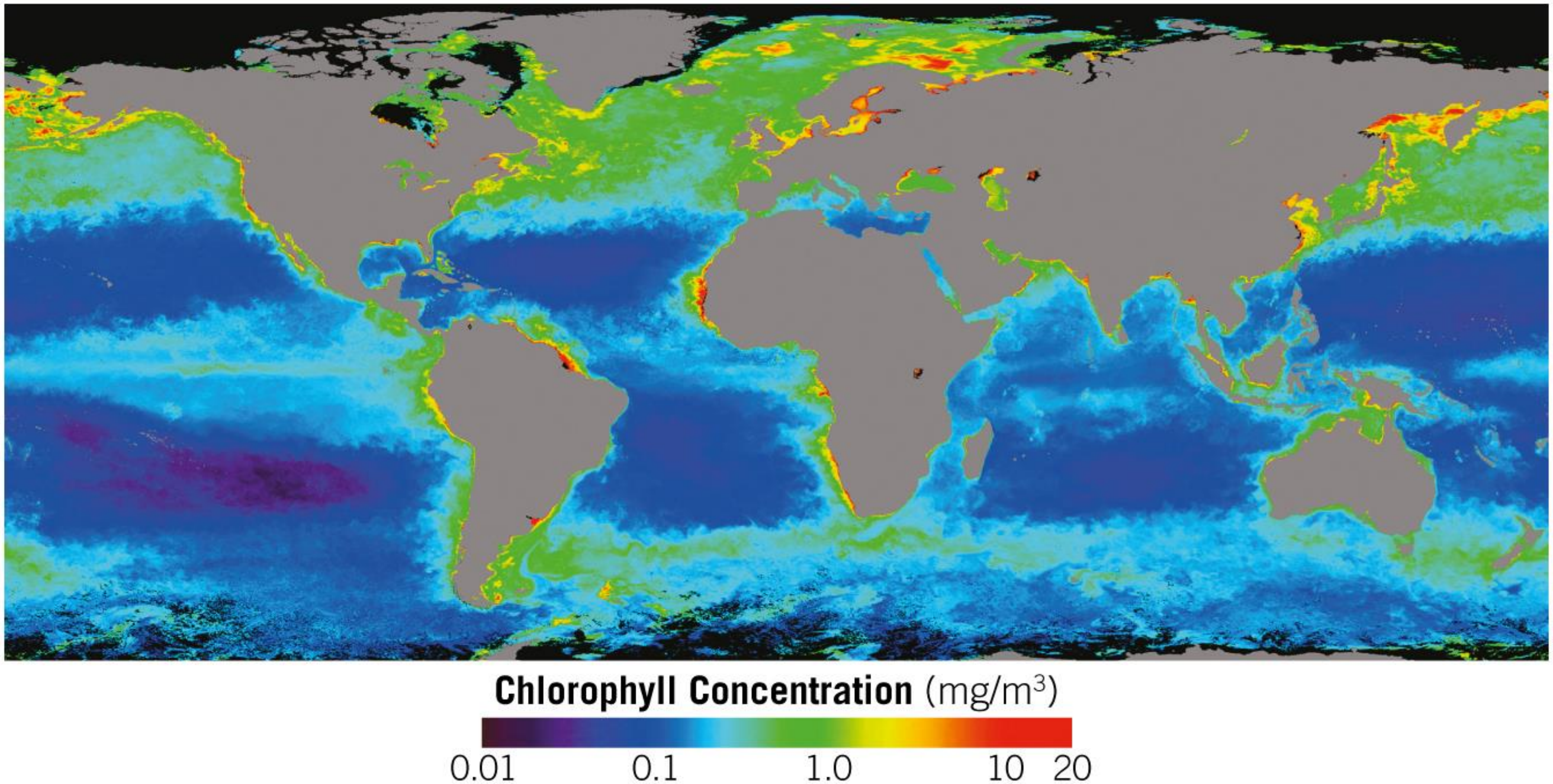
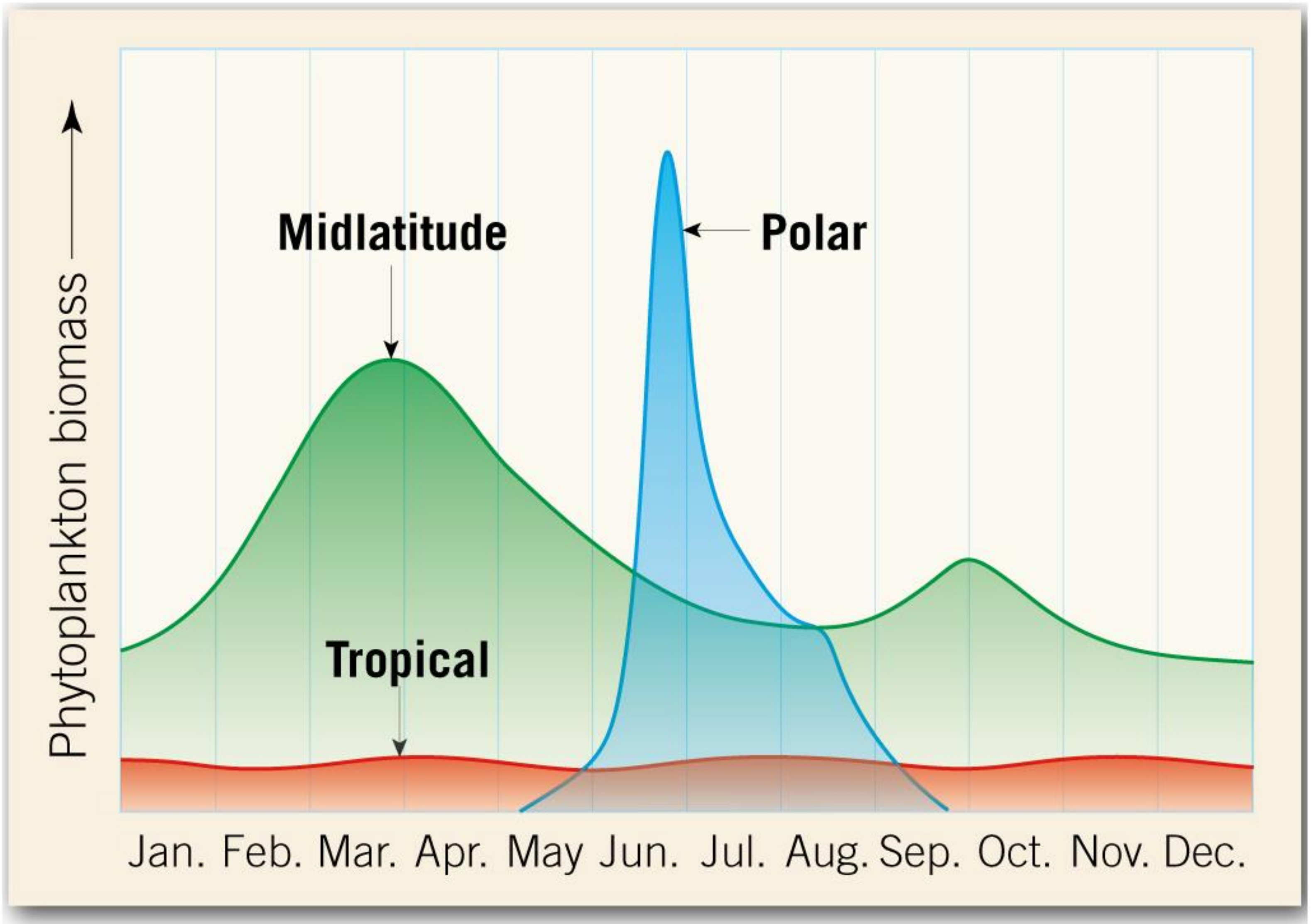

Intertidal zone
High tide
Low tide
Neritic zone
Phytoplankton
Zooplankton
Sunlight
Oceanic zone
Limit of light penetration
Continental shelf
Shelf break
Euphotic zone
Photic zone
Continental slope
Benthic zone
Aphotic zone
Pelagic zone
Abyssal plain
Abyssal zone

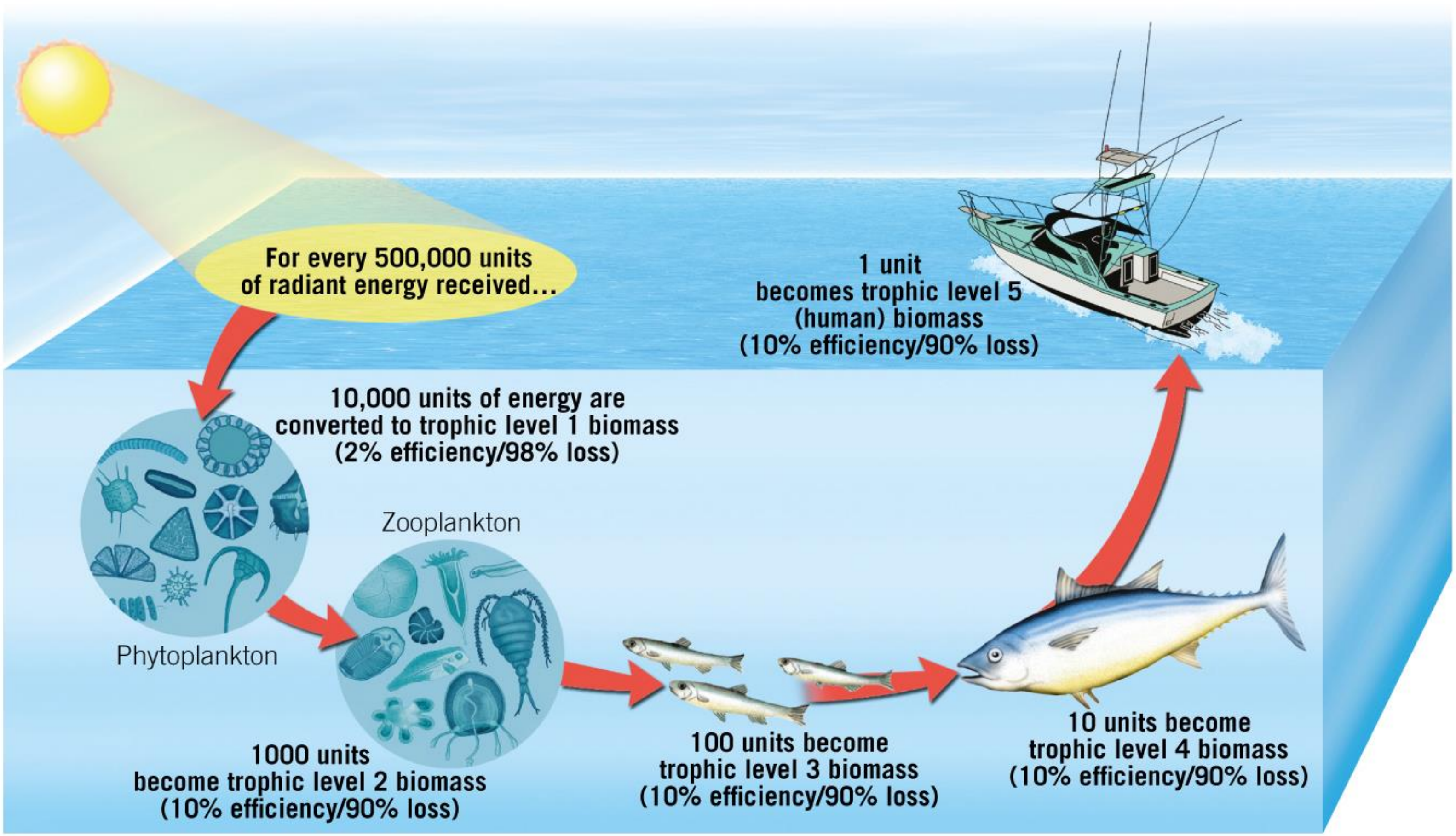

Biomass increase
Zooplankton mass
Diatom mass
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.

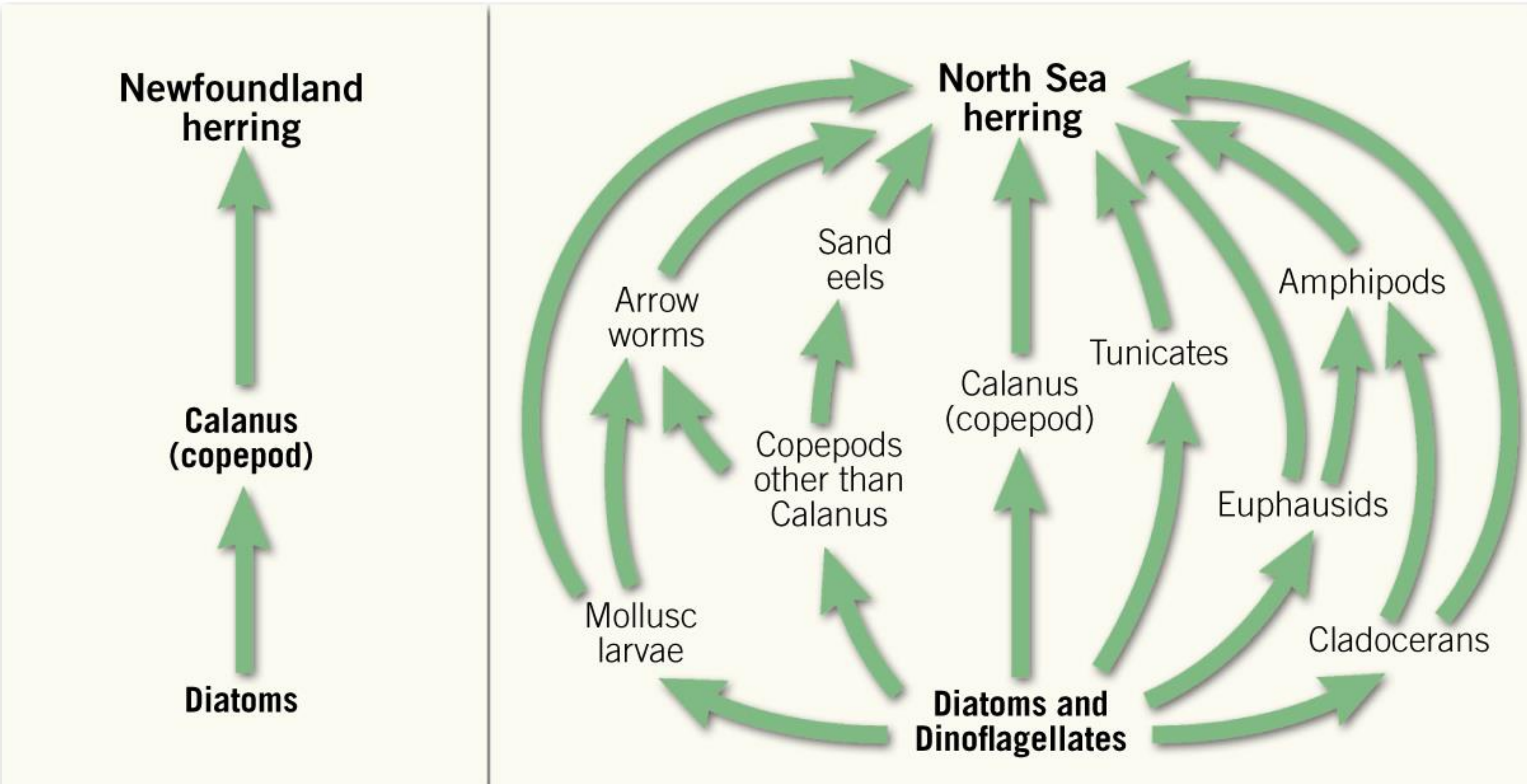

0
100
200
300
400
500
Depth (m)
Warm, nutrient-depleted surface water
Permanent thermocline
Cold, nutrient-rich deep water


Sunshine
Nutrients
Phytoplankton
Zooplankton
Increase
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.


Chlorophyll Concentration (mg/m³)
0.01
0.1
1.0
10
20


Phytoplankton biomass
Midlatitude
Polar
Tropical
Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. Dec.


For every 500,000 units
of radiant energy received...
10,000 units of energy are
converted to trophic level 1 biomass
(2% efficiency/98% loss)
Phytoplankton
Zooplankton
1000 units
become trophic level 2 biomass
(10% efficiency/90% loss)
100 units become
trophic level 3 biomass
(10% efficiency/90% loss)
10 units become
trophic level 4 biomass
(10% efficiency/90% loss)
1 unit
becomes trophic level 5
(human) biomass
(10% efficiency/90% loss)



A. Three-level food chain of Newfoundland herring

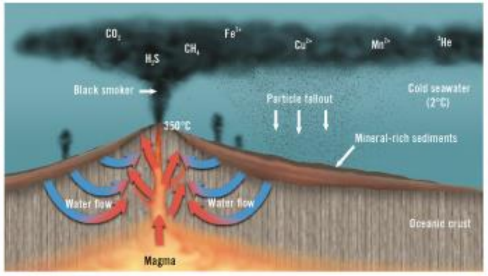
B. Food web of North Sea herring containing many food chains

GEOGRAPHICS 14.1

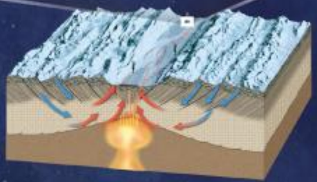
Deep-Sea Hydrothermal Vents

Deep-sea hydrothermal vents are openings in the oceanic crust from which geothermally heated water rises. They are found mainly along the oceanic ridge system where tectonic plates rift apart, resulting in the production of new seafloor by upwelling magma.

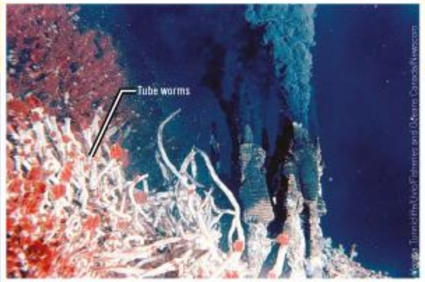
When these hot, mineral-rich fluids reach the seafloor their temperatures can exceed 350 °C, but because of the extremely high pressures exerted by the water column above, they do not boil. When this hydrothermal fluid comes into contact with the much colder seawater, mineral matter rapidly precipitates to form shimmering smoke-like clouds called "***black smokers.***" The particles that compose the black smokers eventually settle out of the seawater. These deposits may contain economically significant amounts of iron, copper, zinc, lead, and occasionally silver and gold.



At oceanic ridges, cold seawater circulates hundreds of meters down into the highly fractured basaltic crust, where it is heated by magmatic sources. Along the way, the hot water strips metals and other elements such as sulfur from surrounding rock. This heated fluid eventually becomes hot and buoyant enough to rise along conduits and fractures toward the surface.



Some minerals immediately solidify and contribute to the formation of spectacular chimney-like structures, which can be as tall as a 15-story building, and are appropriately given names like ***Godzilla*** and ***Inferno***.



Hydrothermal vents are remarkable for the unique types of marine life they support. In these extreme environments, completely devoid of light, microorganisms utilize mineral-rich hydrothermal fluids to perform chemosynthesis—the conversion of carbon into organic compounds without sunlight for energy. The microbial communities, in turn, support larger, more complex animals such as fish, crabs, mussels, clams, and perhaps the most conspicuous creatures, tube worms, which can be up to 3 meters (10 feet) long. With their white chitinous tubes and bright red plumes, tube worms rely entirely on bacteria growing in their trophosome, an internal organ designed for harvesting bacteria. The symbiotic bacteria rely on tube worms to provide them with a suitable habitat and, in return, they use chemosynthesis to provide carbon-based nutrients to the tube worms.

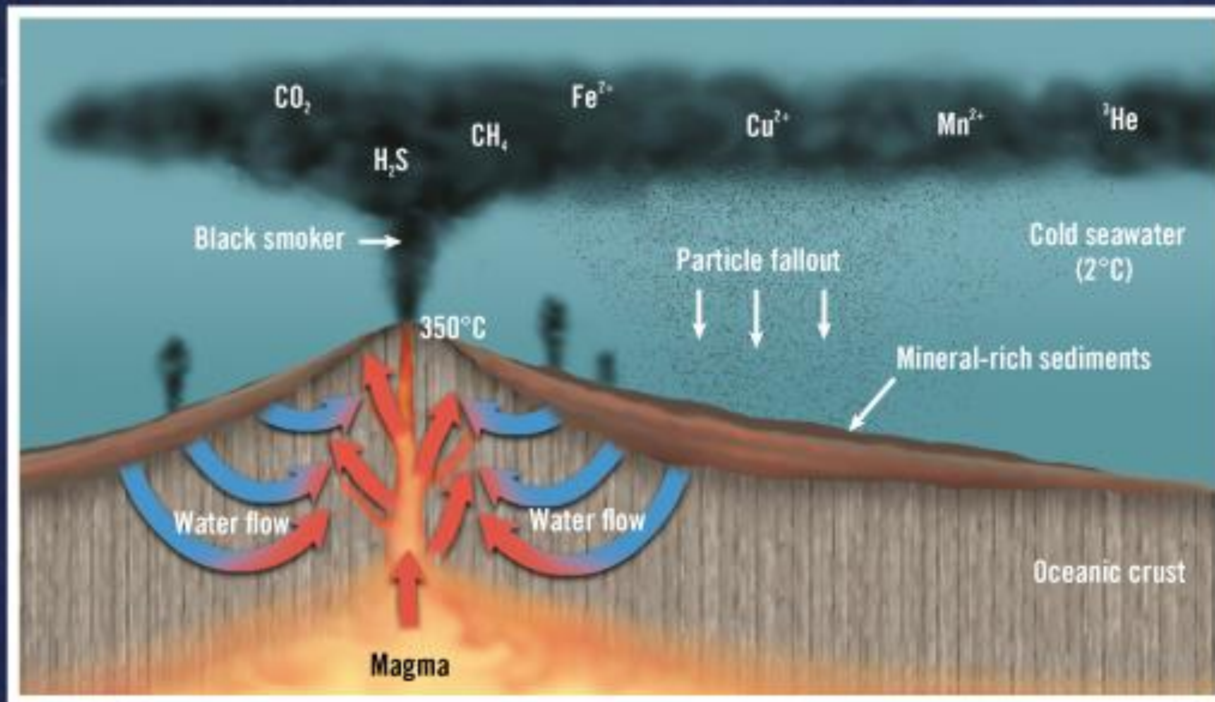
Question:
Where are hydrothermal vents found? ?

Most hydrothermal vents are found around the oceanic ridge system including some small spreading centers such as the Juan de Fuca Ridge and Galapagos Rift, as well as in the back arc basins that lie behind subduction zones.

GLOBAL DISTRIBUTION OF HYDROTHERMAL VENT FIELDS

Data from Woods Hole Oceanographic Institution

When these hot, mineral-rich fluids reach the seafloor their temperatures can exceed 350 °C, but because of the extremely high pressures exerted by the water column above, they do not boil. When this hydrothermal fluid comes into contact with the much colder seawater, mineral matter rapidly precipitates to form shimmering smoke-like clouds called "*black smokers.*" The particles that compose the black smokers eventually settle out of the seawater. These deposits may contain economically significant amounts of iron, copper, zinc, lead, and occasionally silver and gold.



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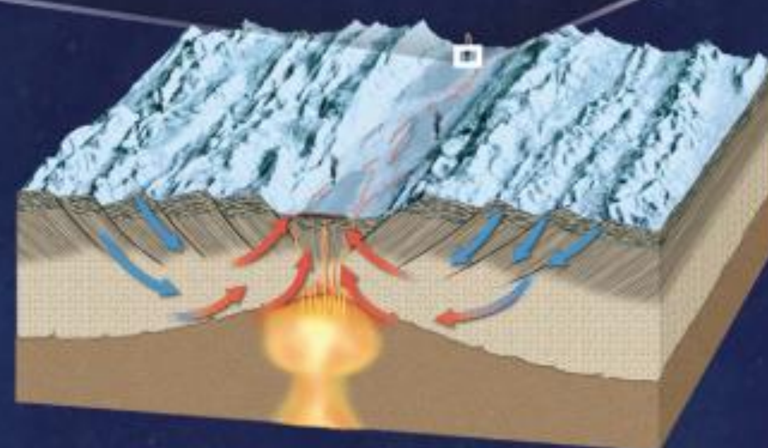

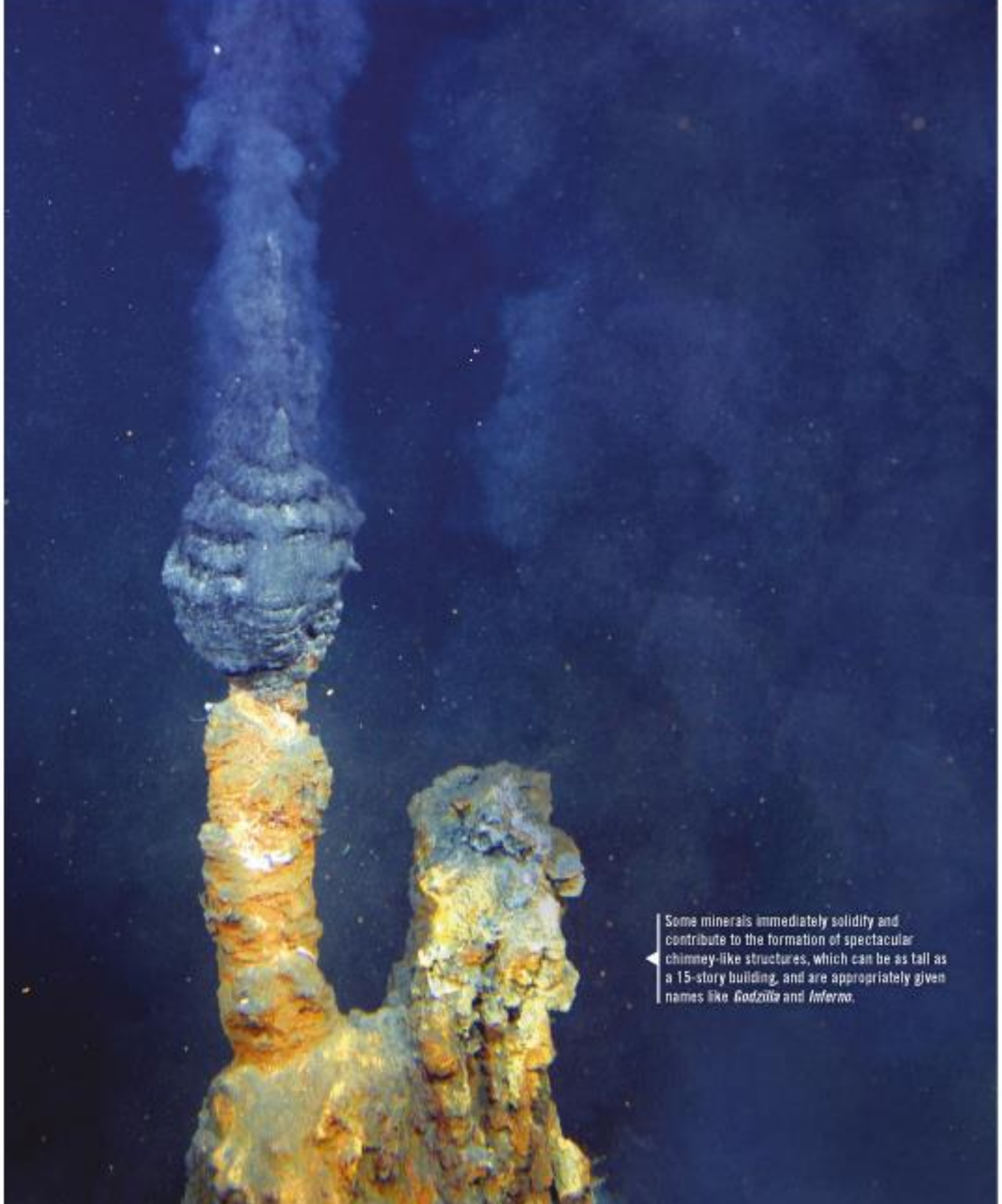

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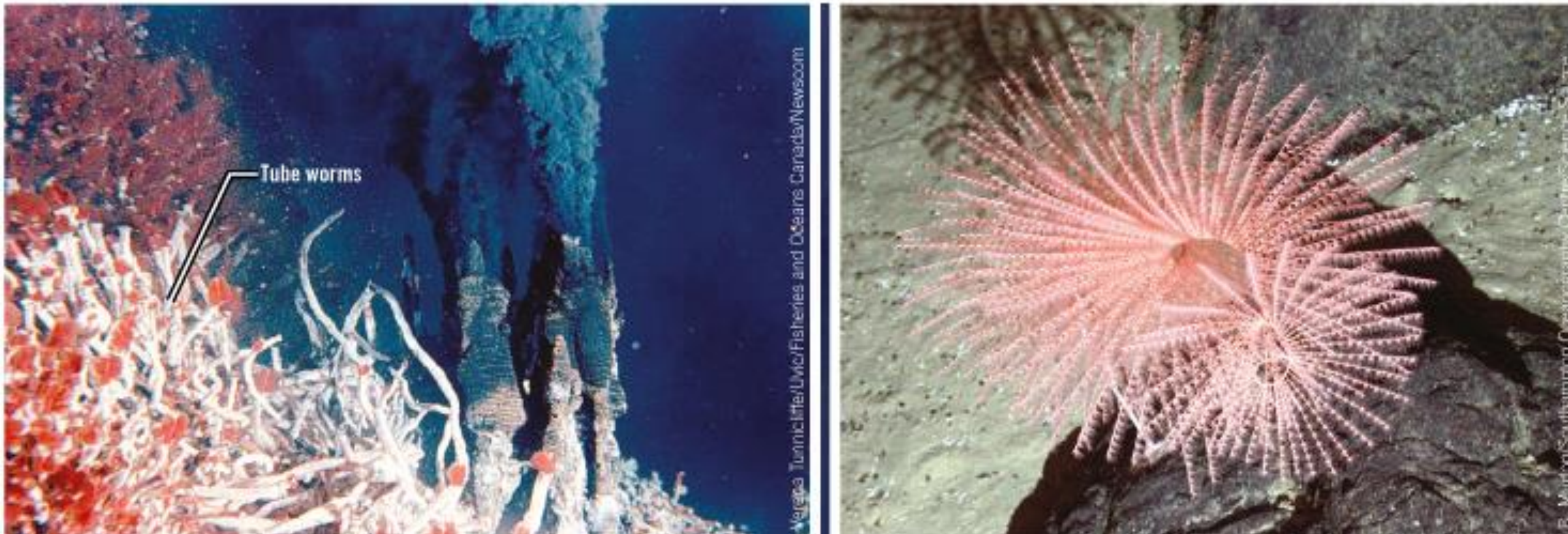

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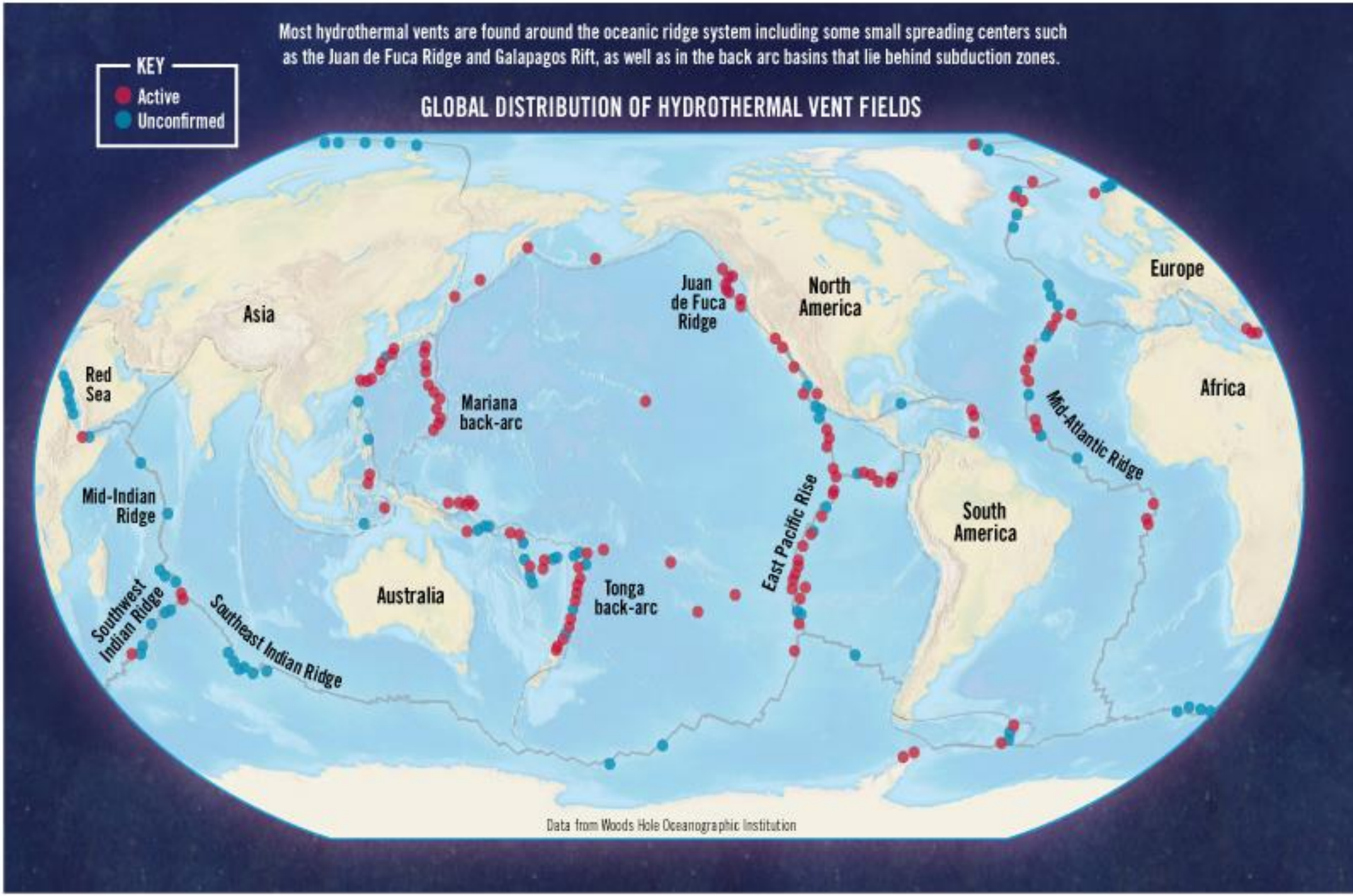
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KEY
Active
Unconfirmed
GLOBAL DISTRIBUTION OF HYDROTHERMAL VENT FIELDS
Asia
Red Sea
Mid-Indian Ridge
Southwest Indian Ridge
Southeast Indian Ridge
Australia
Mariana back-arc
Tonga back-arc
Juan de Fuca Ridge
North America
East Pacific Rise
South America
Mid-Atlantic Ridge
Europe
Africa
Data from Woods Hole Oceanographic Institution