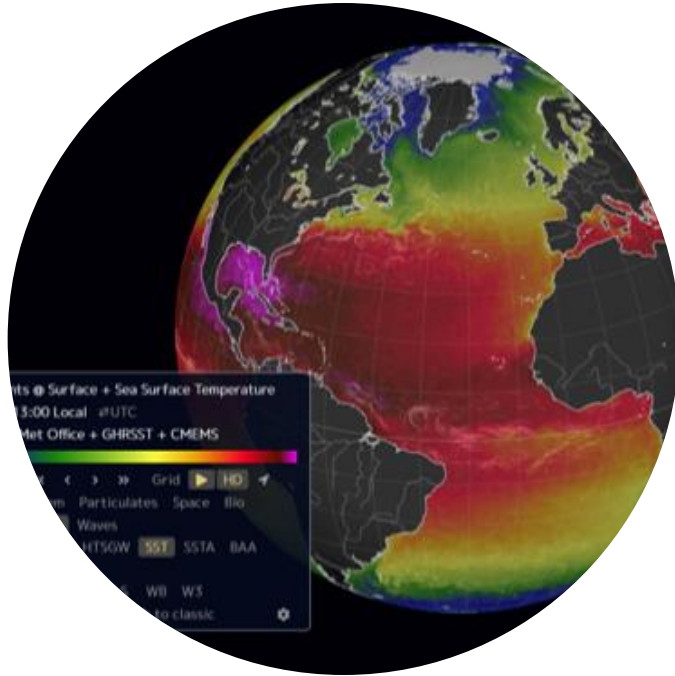


Abiotic Factors in Marine Environments



AIM



We will define and provide examples of abiotic factors for different marine and coastal ecosystems. Then we investigate the importance of these abiotic factors and physical processes within ecosystems.

[earth :: a global map of wind, weather, and ocean conditions \(nullschool.net\)](http://nullschool.net)



CONTENT

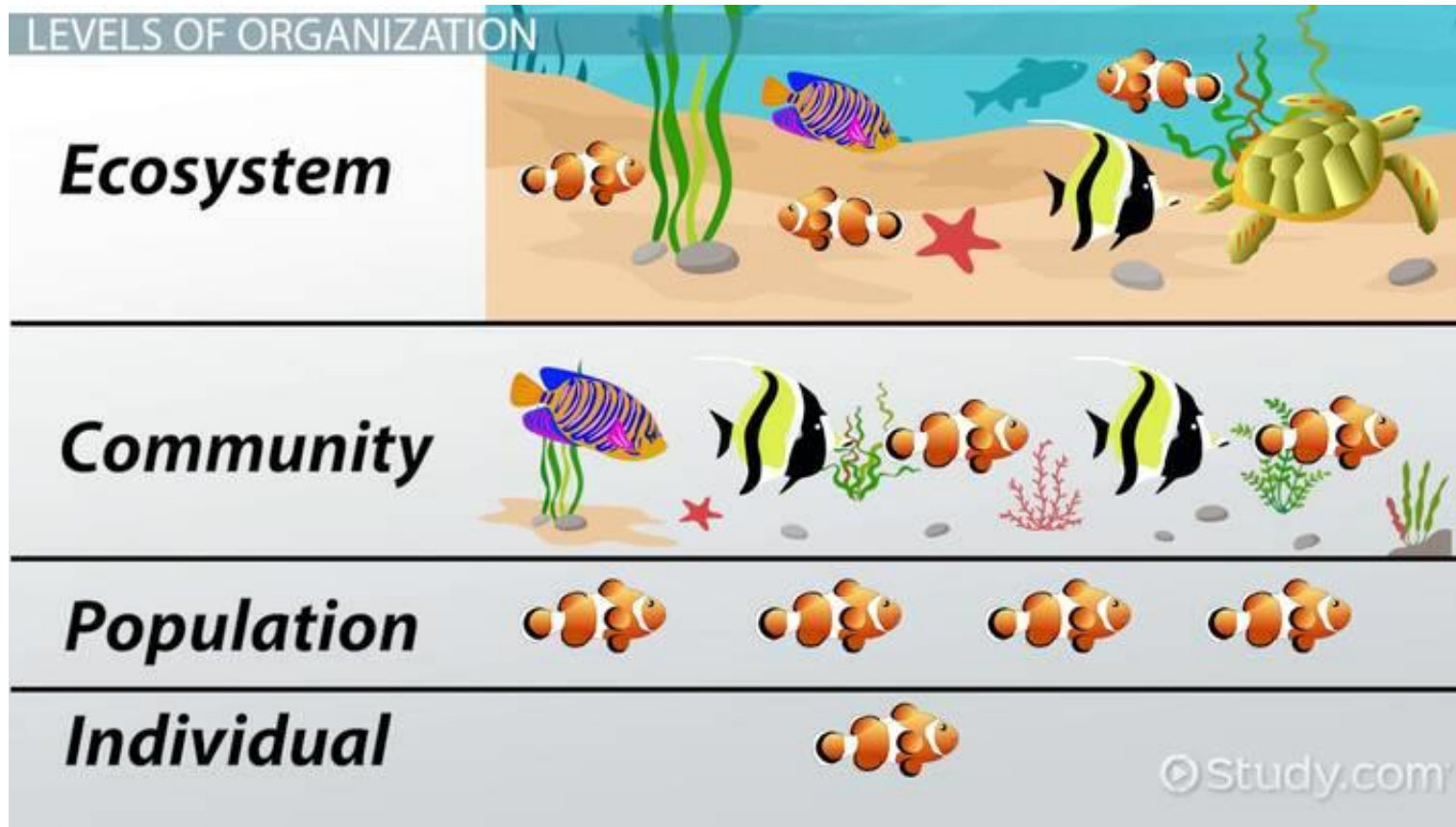
- 1) What do we know about ecosystems
- 2) What are abiotic factors
- 3) Pressure, salinity, temperature, density

BREAK

- 4) Light, physical ocean, chemistry
- 5) Abiotic Activity

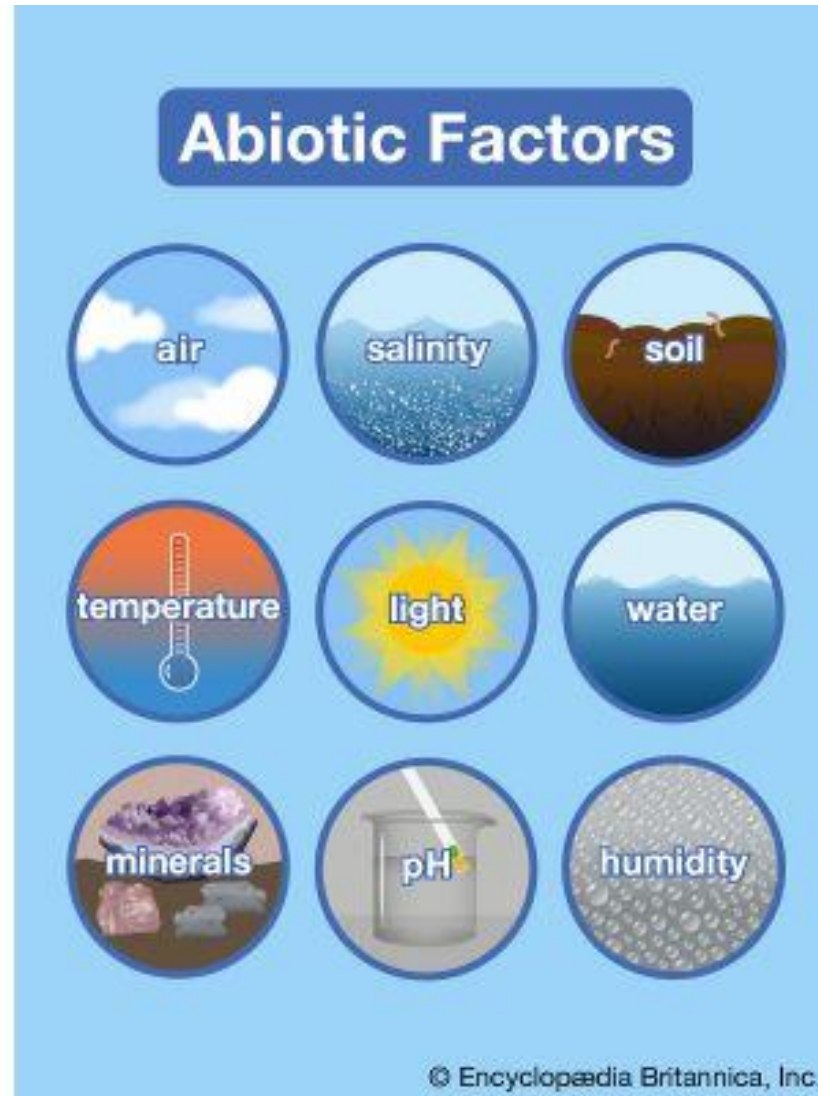
WHAT DO WE KNOW ABOUT ECOSYSTEMS?

ECOSYSTEMS



The root of the word ecology is the Greek word *oikos*, meaning “house”. Ecosystem literally means a “**system of houses**”.

WHAT ARE ABIOTIC FACTORS?



- Biotic = Living
- Abiotic = Non-living

ABIOTIC FACTORS

Temperature

Salinity

Light

Pressure

Currents

Tides

Nutrients

Oxygen

ABIOTIC FACTORS

Temperature

Salinity

Light

Pressure

Currents

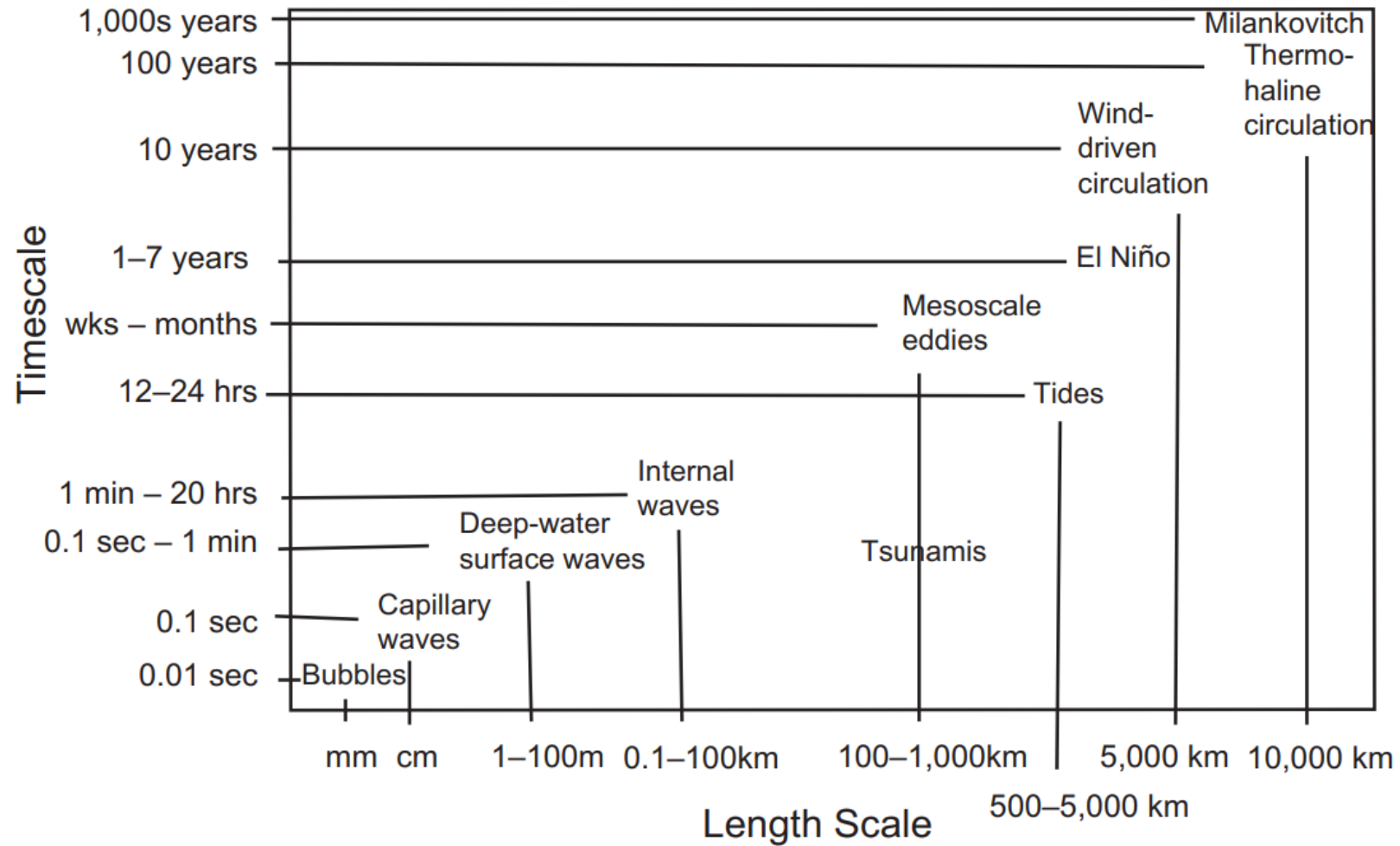
Tides

Nutrients

Oxygen

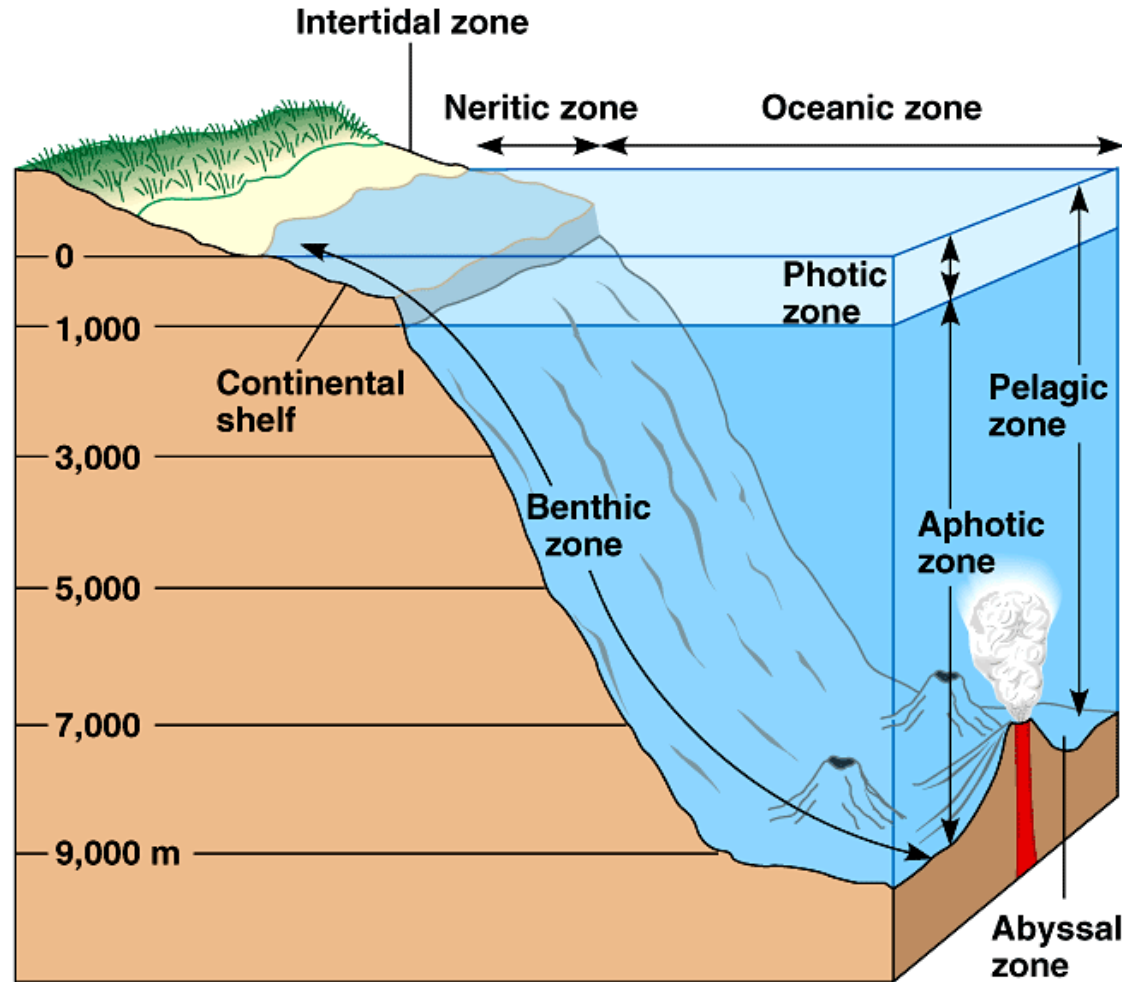
All these factors control where species are distributed in the oceans.

ABIOTIC FACTORS



Abiotic factors also controlled by physical oceanography phenomena across a range of scales(!)

DIFFERENCES BETWEEN LAND AND MARINE



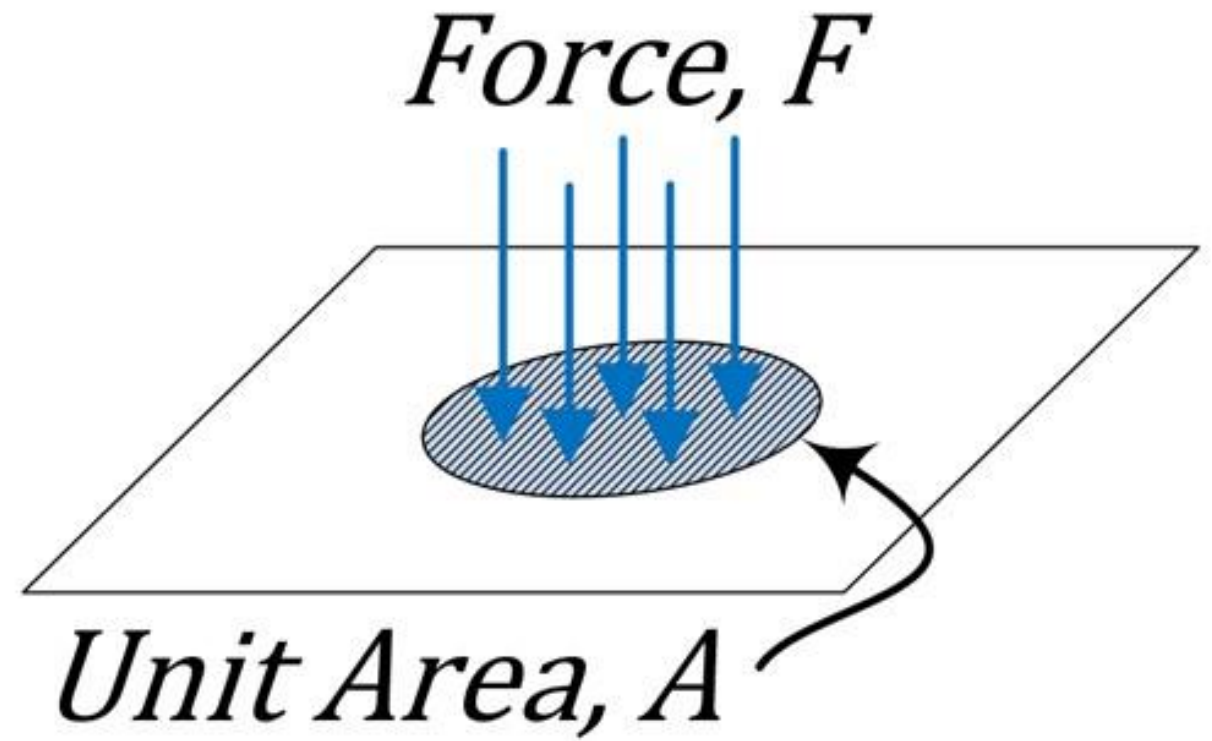
Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

- Abiotic factors are similar to those on land such as sunlight, temperature, and soil nutrients.
- However, since the ocean is water, pH and salinity are also considered important abiotic factors that influence and sustain healthy and productive organisms.
- Oceans function just like land ecosystems, but they have far more area and depth.

PRESSURE

When we talk about pressure in the ocean, we are referring to **hydrostatic pressure**, which is a result of the weight of the water column pressing down on an object due to gravity.

At the surface we experience one atmosphere of pressure (**1 atm = 101.3 kPa**) due to the weight of the atmosphere above us.



Pressure in the ocean zones:

[6.1 Pressure – Introduction to Oceanography \(pressbooks.pub\)](http://pressbooks.pub)

PRESSURE

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Pressure Units

	Pascal	Bar	Pounds per square inch	Standard atmosphere	Technical atmosphere
1 Pa	XX	0.00001	0.000145	0.0000099	0.0000102
1 bar	100000	XX	14.5	0.987	1.020
1 psi	6895	0.0689	XX	0.0680	0.0703
1 atm	101330	1.013	14.7	XX	1.033
1 at	98670	0.981	14.2	0.968	XX

[What is Bar – Unit of Pressure - Definition \(thermal-engineering.org\)](http://thermal-engineering.org)

Pressure in the ocean zones:

[6.1 Pressure – Introduction to Oceanography \(pressbooks.pub\)](http://pressbooks.pub)

PRESSURE

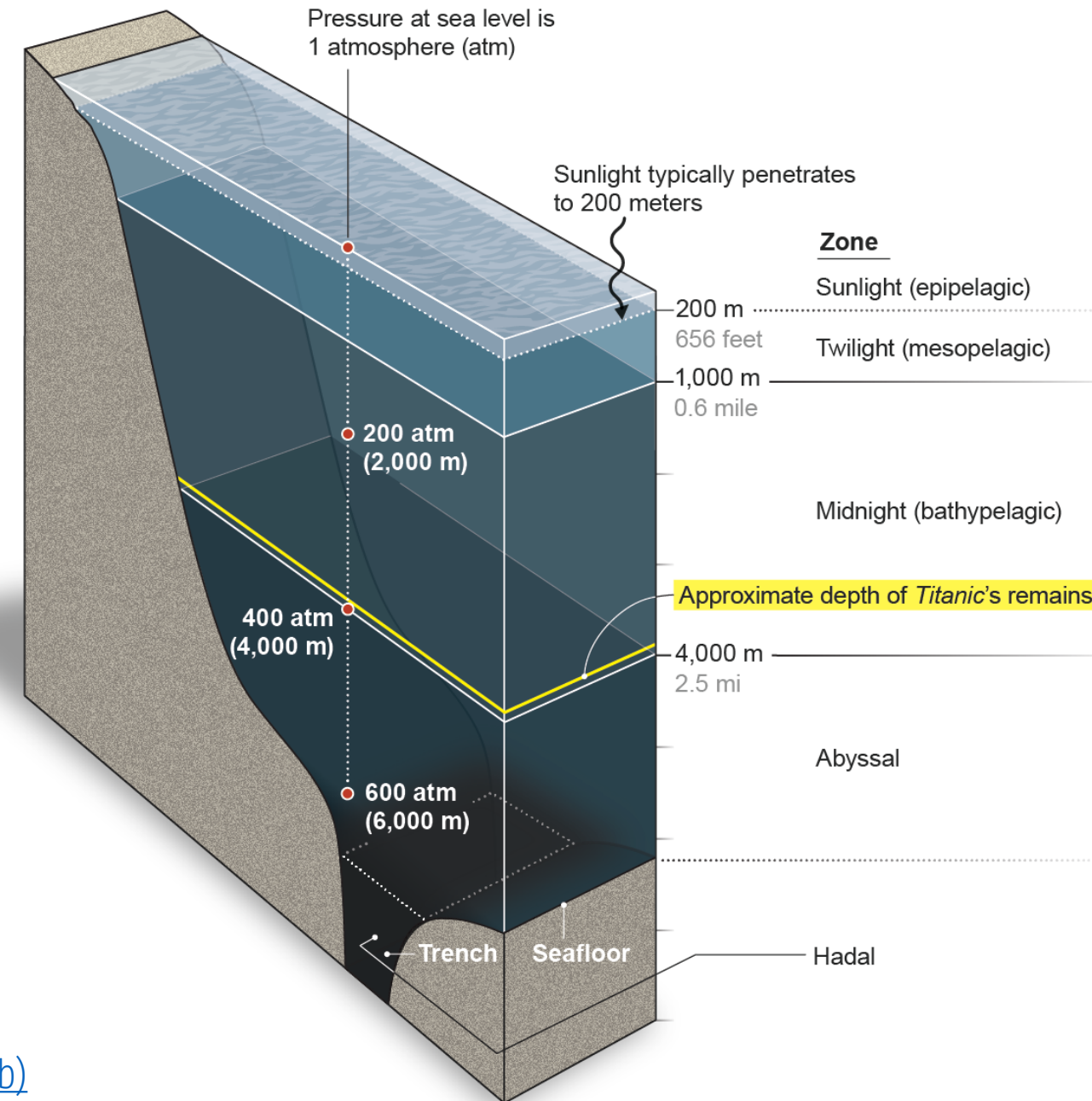
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PRESSURE

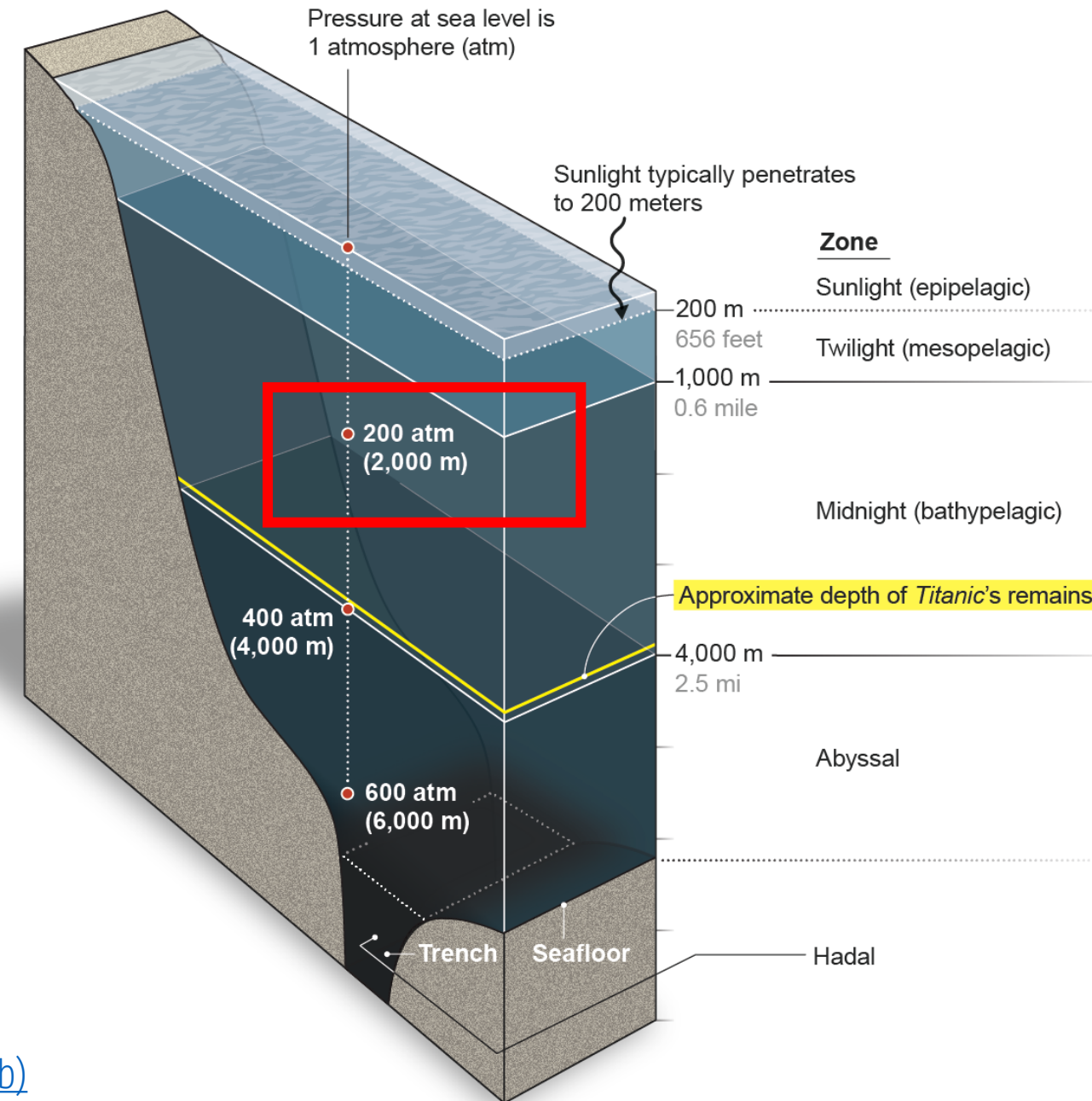
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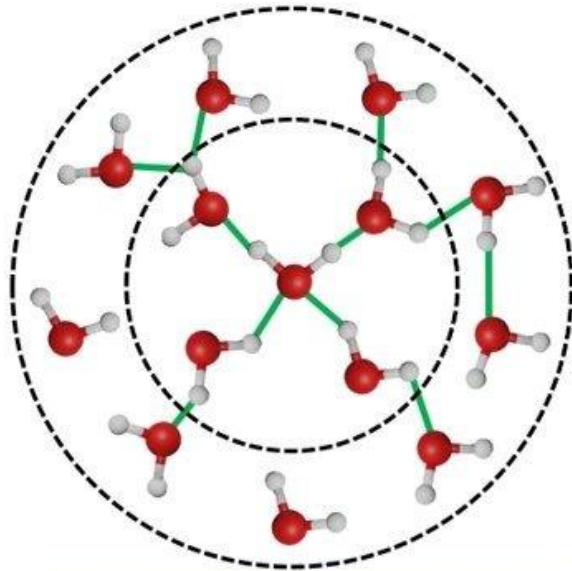
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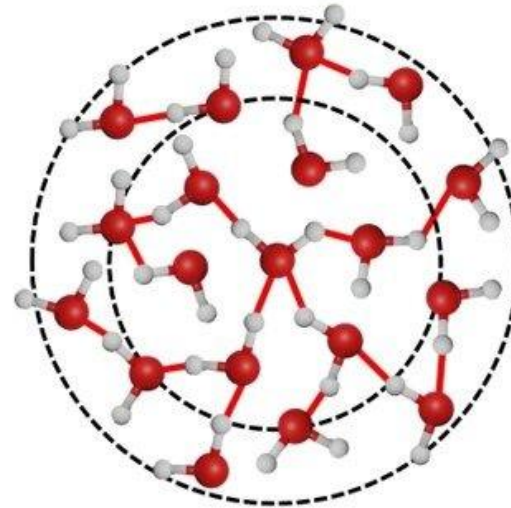
[6.1 Pressure – Introduction to Oceanography \(pressbooks.pub\)](http://pressbooks.pub)



PRESSURE AND WATER

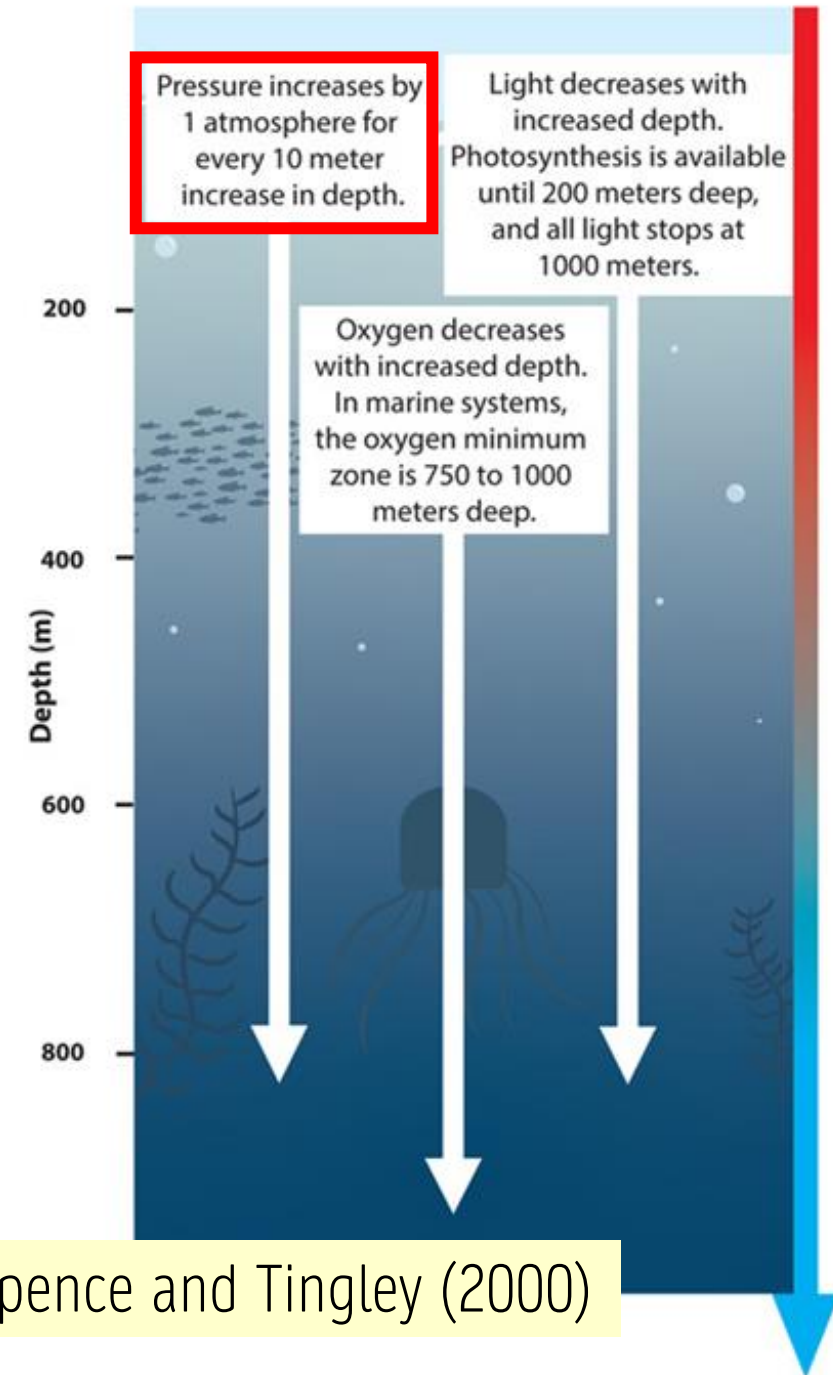


Water at ambient pressure
Open tetrahedral structure –
strong hydrogen bonds



Water at high pressure
Compressed structure –
weakened hydrogen bonds

[Chemical in cells of marine organisms enables them to survive high pressures found in deep oceans \(phys.org\)](http://phys.org)



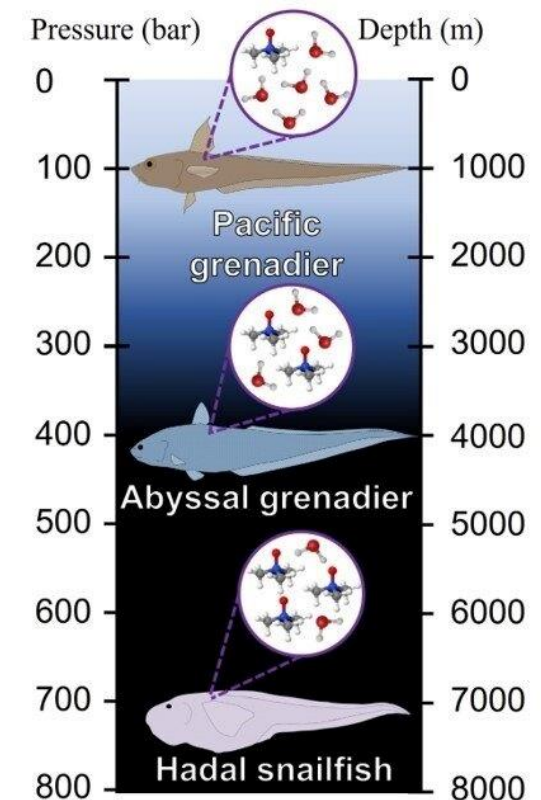
PRESSURE AND WATER

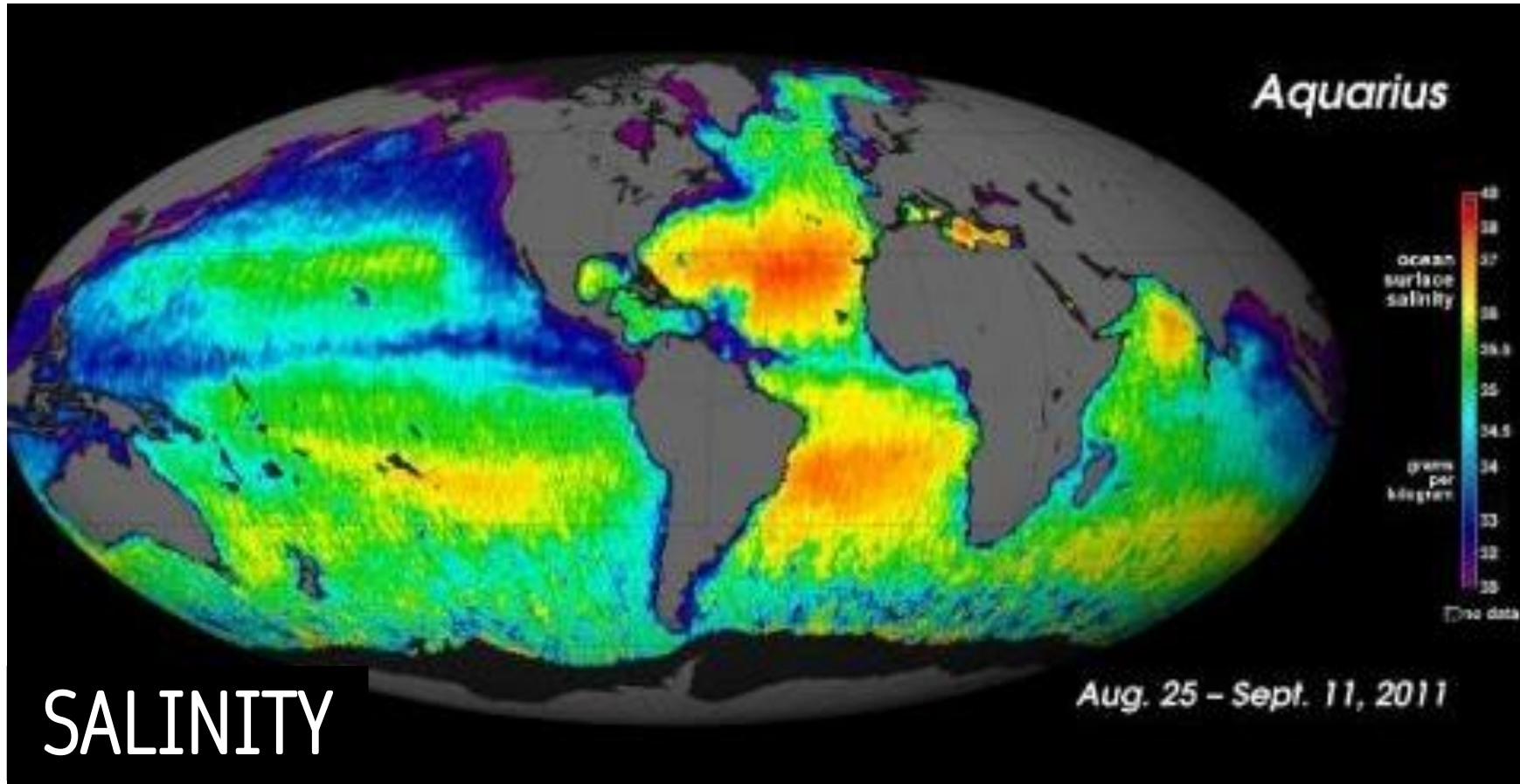


Everyone has smelled it that's ever been to a fish market. TMAO is what gives aquatic species their fishy scent.

[Chemical in cells of marine organisms enables them to survive high pressures found in deep oceans \(phys.org\)](https://phys.org)

- The molecule found in cells that produces the protective effect against high external pressure is called **TMAO—trimethylamine N-oxide**.

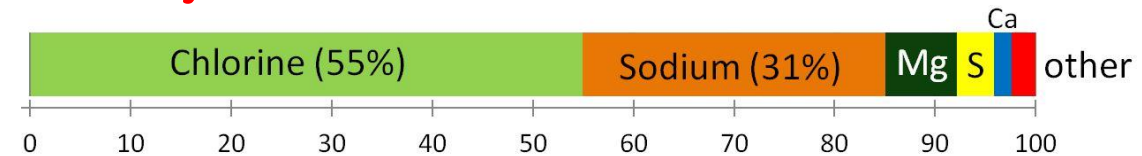




https://youtu.be/5xQP_B18vMw

Salinity from Space: NASA's Aquarius (2011-2015) measuring changes in salinity, or salt concentration, in the surface of the oceans. Composite of the first two and a half weeks of data.

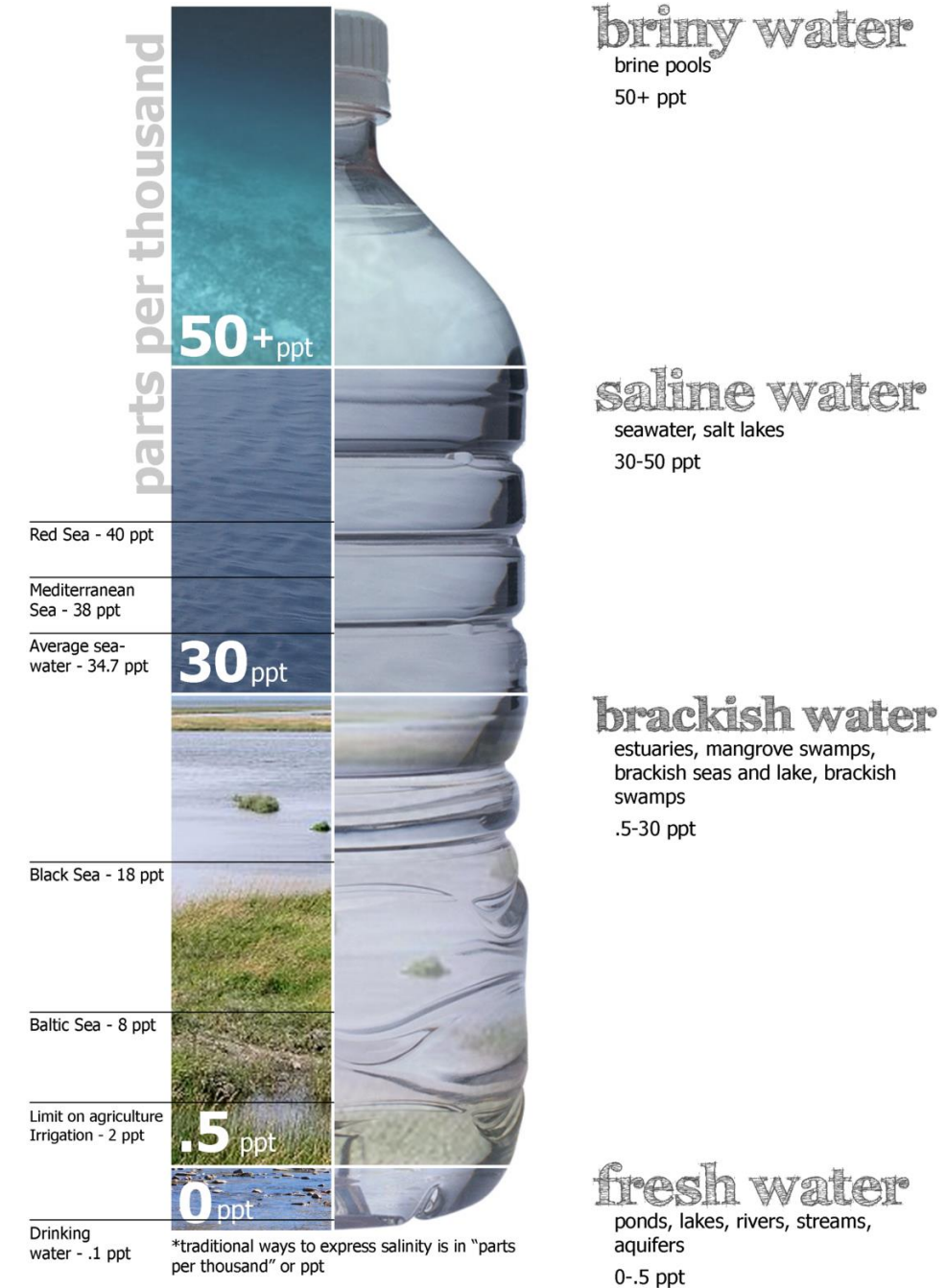
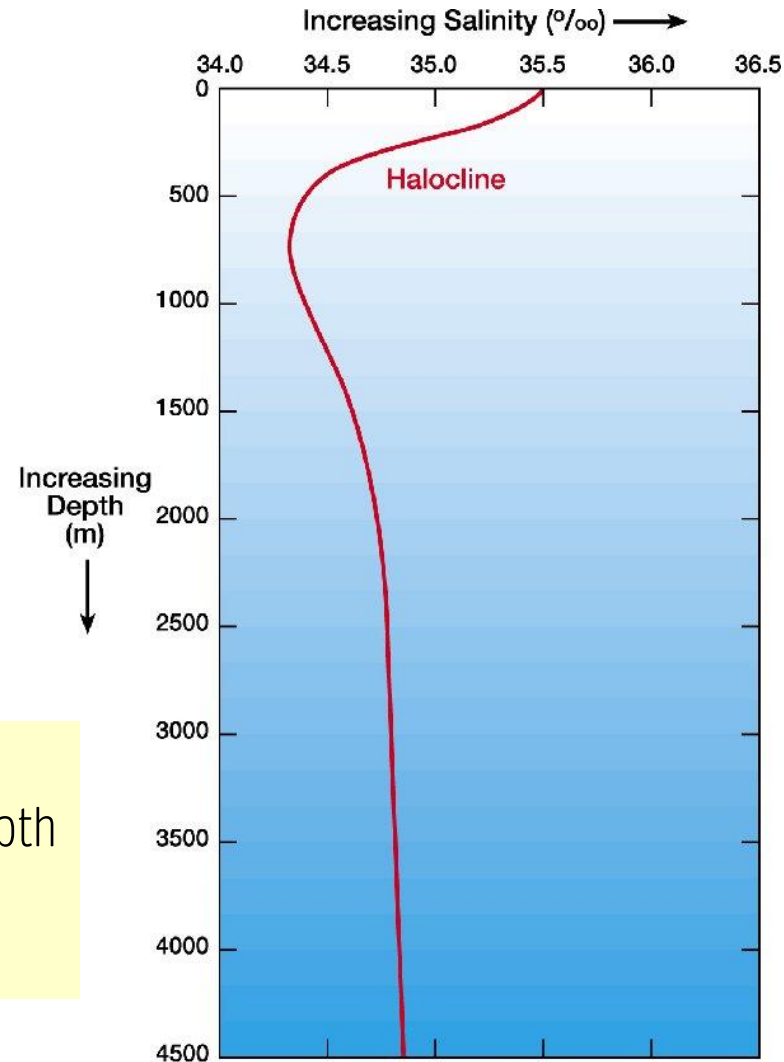
Salinity: Sodium chloride + friends



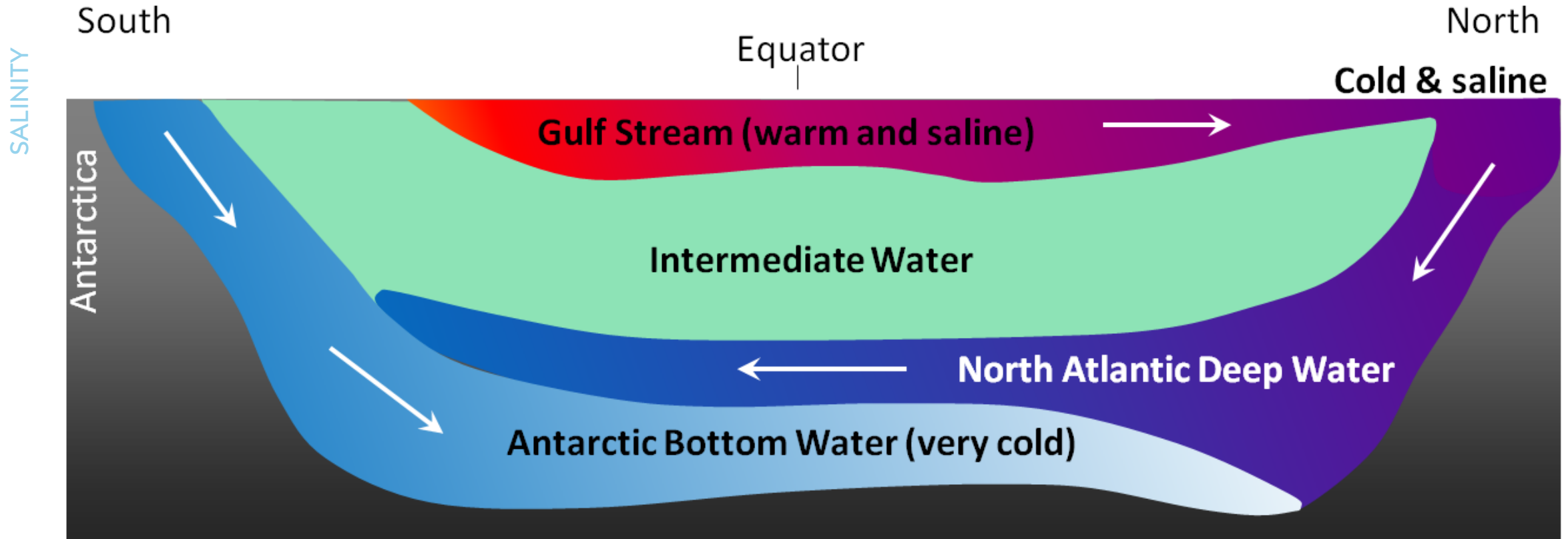
Salinity: Measure of all dissolved salts in water
Measured in parts per thousand (ppt) or practical salinity units (psu)

SALINITY

This graph show a generalized salinity depth profile for the South Atlantic Ocean.



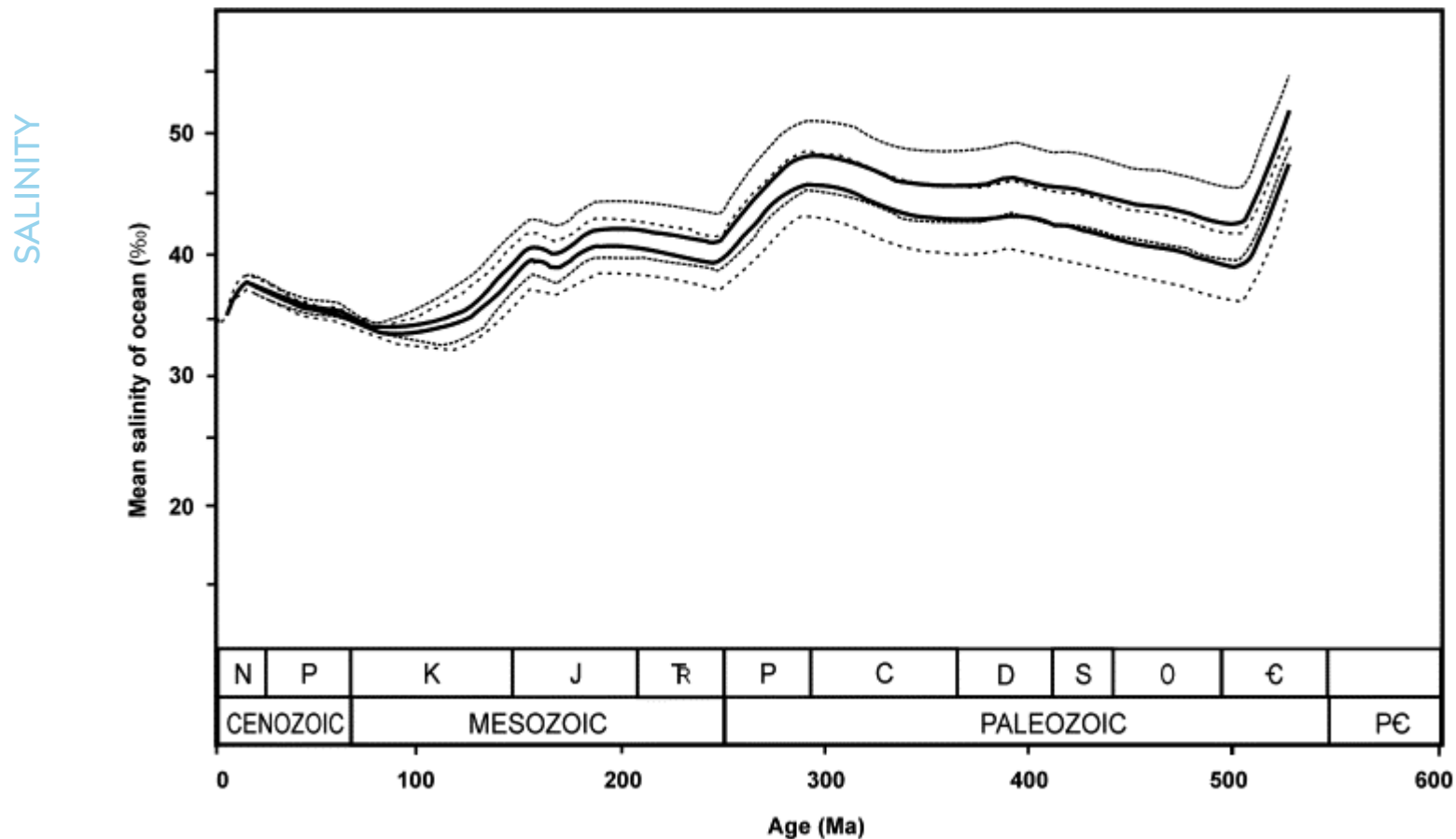
SALINITY – OCEAN CONVEYOR



A depiction of the vertical movement of water along a north-south cross-section through the Atlantic basin

SALINITY – OCEAN CONVEYOR

[18.4 Ocean Water – Physical Geology \(openstextbc.ca\)](https://openstextbc.ca/18.4-Ocean-Water-Physical-Geology/)



[How Do Ice Ages Happen?
Exploring Paleosalinity and
Thermohaline Circulation –
Aliosha Pittaka Bielenberg
\(alioshabielenberg.com\)](#)

Throughout Earth's history, certain processes have served to make the ocean salty. Weathering delivers minerals, including salt, into the ocean. Evaporation of ocean water and formation of sea ice both increase the salinity of the ocean. However, these "salinity raising" factors are continually counterbalanced by processes that decrease salinity such as the continuous input of fresh water from rivers, precipitation of rain and snow, and melting of ice.

SALINITY – OCEAN CONVEYOR

[18.4 Ocean Water – Physical Geology \(opentextbc.ca\)](https://opentextbc.ca/18.4-Ocean-Water-Physical-Geology/)

SALINITY



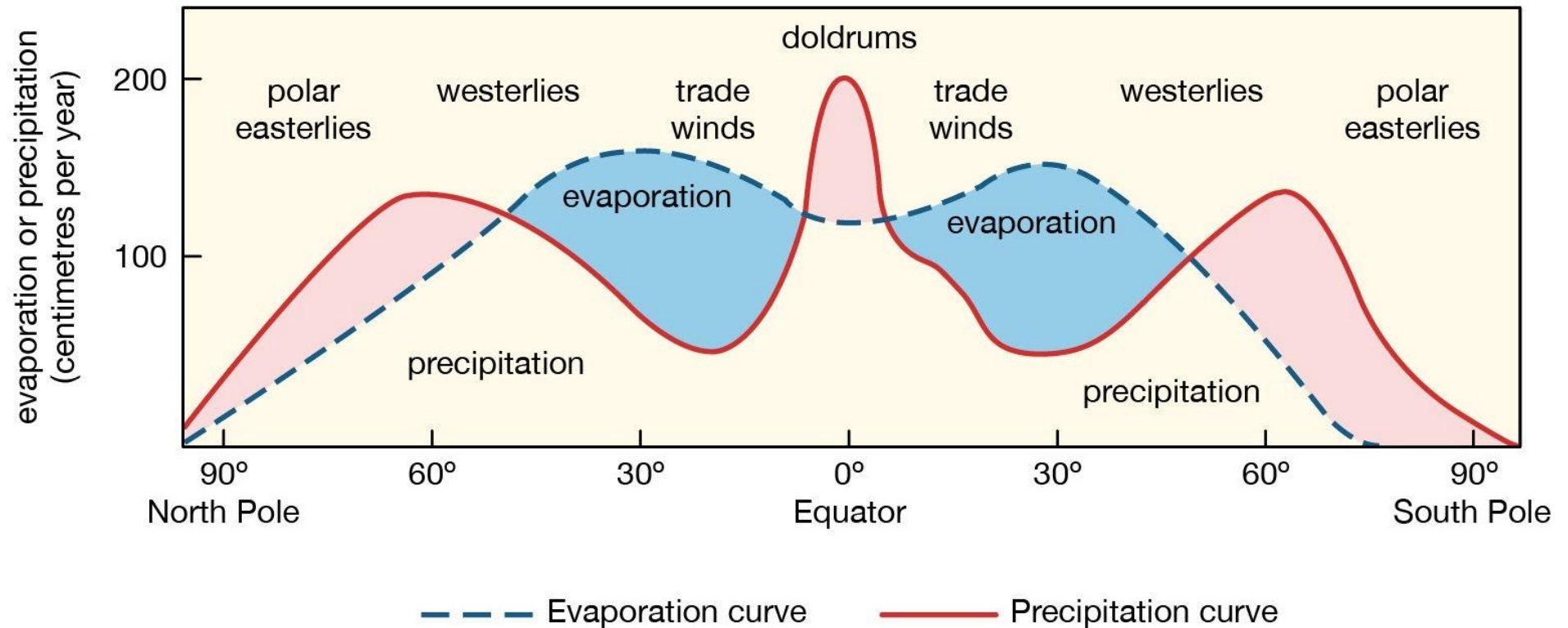
Artistic interpretation of the Mediterranean geography during its evaporative drawdown, after complete disconnection from the Atlantic. The rivers carved deep gorges in the exposed continental margins; The concentration of salt in the remaining water bodies led to rapid [precipitation](#) of the salt. The inset evokes the transit of mammals (e.g. camels and mice) from Africa to Iberia across the exposed [Gibraltar Strait](#).

SALINITY – OCEAN CONVEYOR

[Pacific Ocean - Temperature, Salinity, Depth | Britannica](#)

Latitudinal variation in precipitation and evaporation

SALINITY



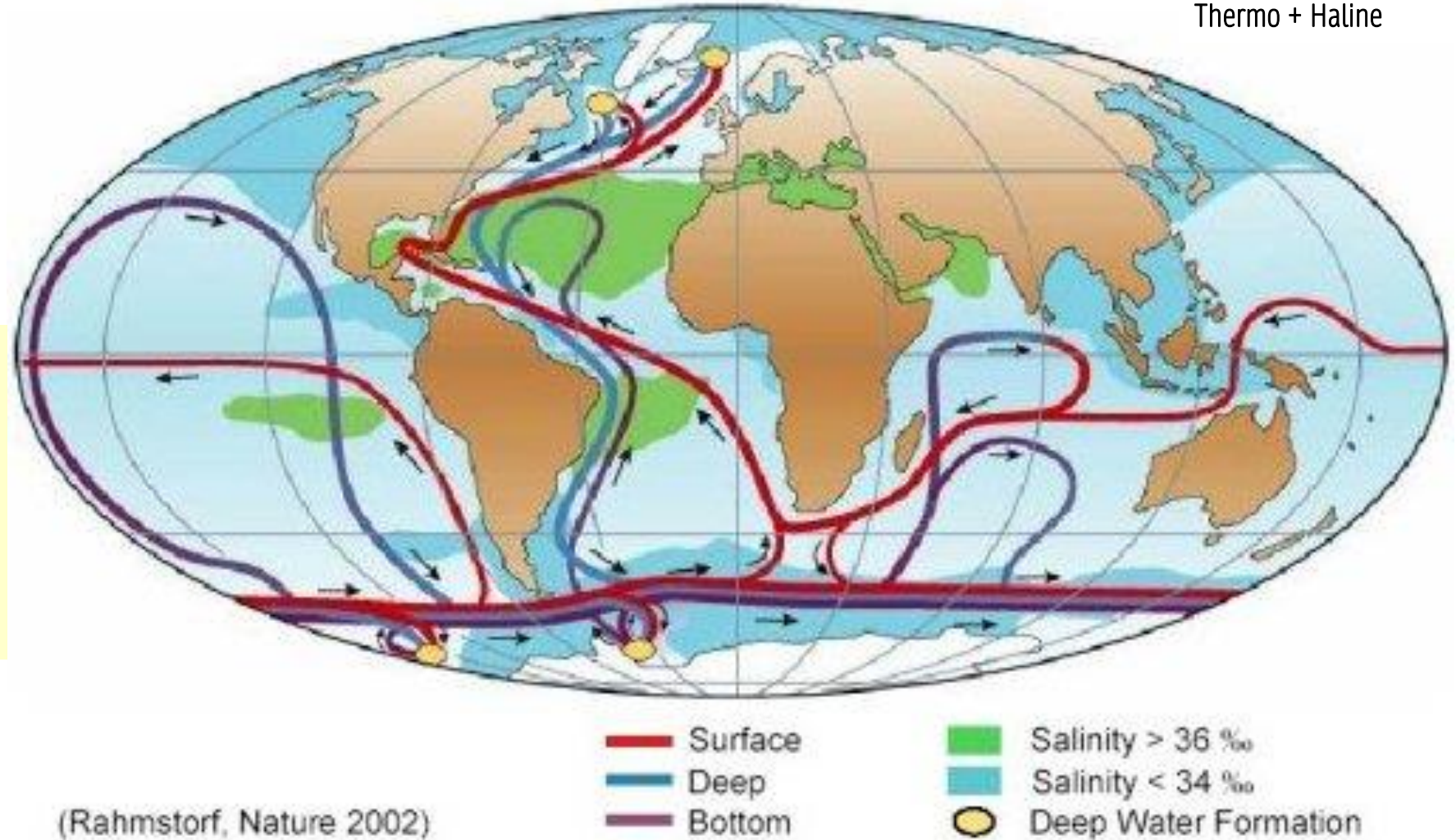
Latitudinal variation in precipitation and evaporation and its relationship to major wind belts and oceanic salinity.

SALINTY - THERMOHALINE

Thermo + Haline

SALINITY

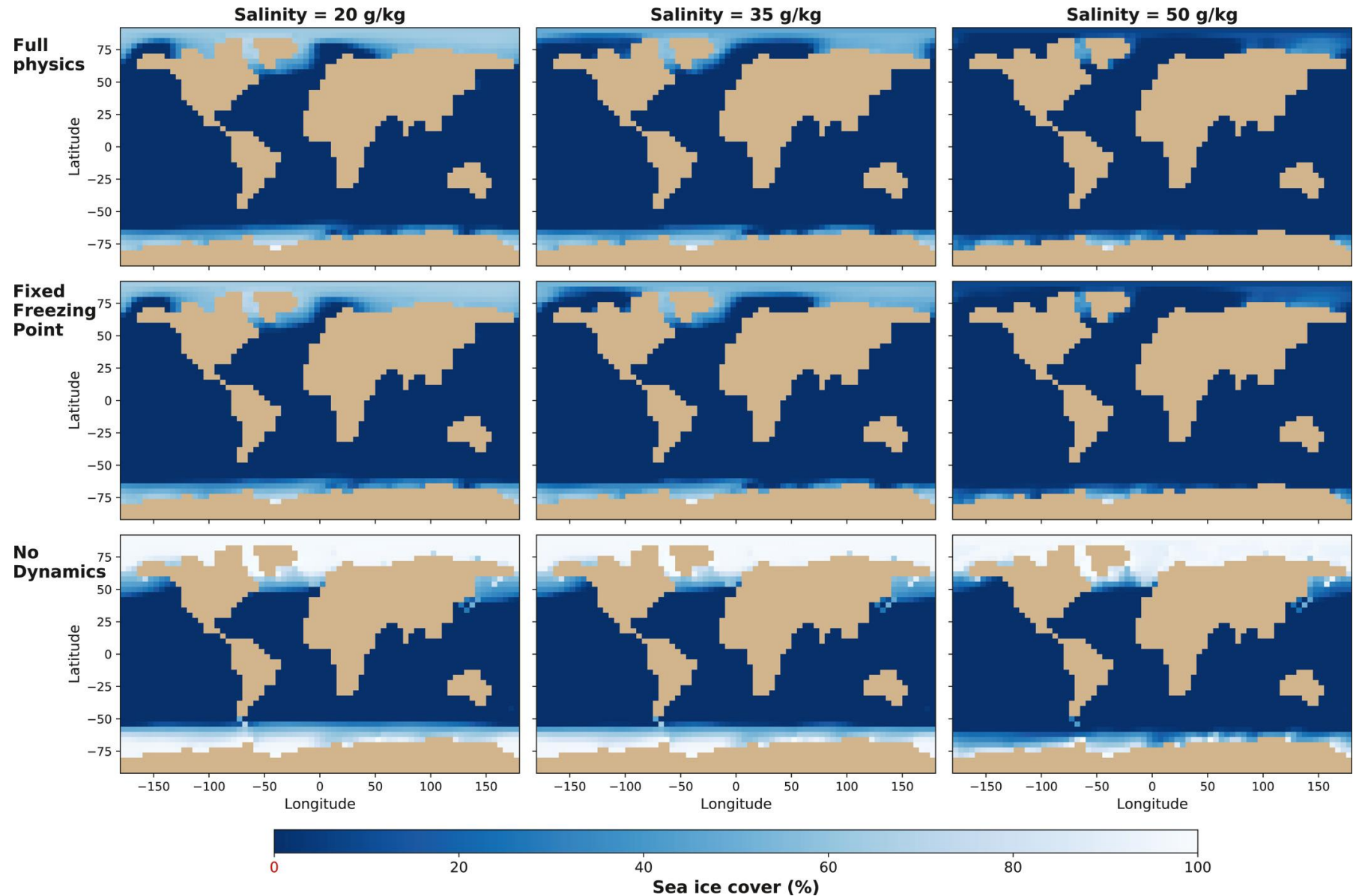
Surface currents are shown in red, deep waters in light blue and bottom waters in dark blue. The main deep water formation sites are shown in orange.



[Thermohaline Circulation - Fact Sheet by Stefan Rahmstorf \(pik-potsdam.de\)](#)

OCEAN SALINITY AND CLIMATE

CORAL REEFS

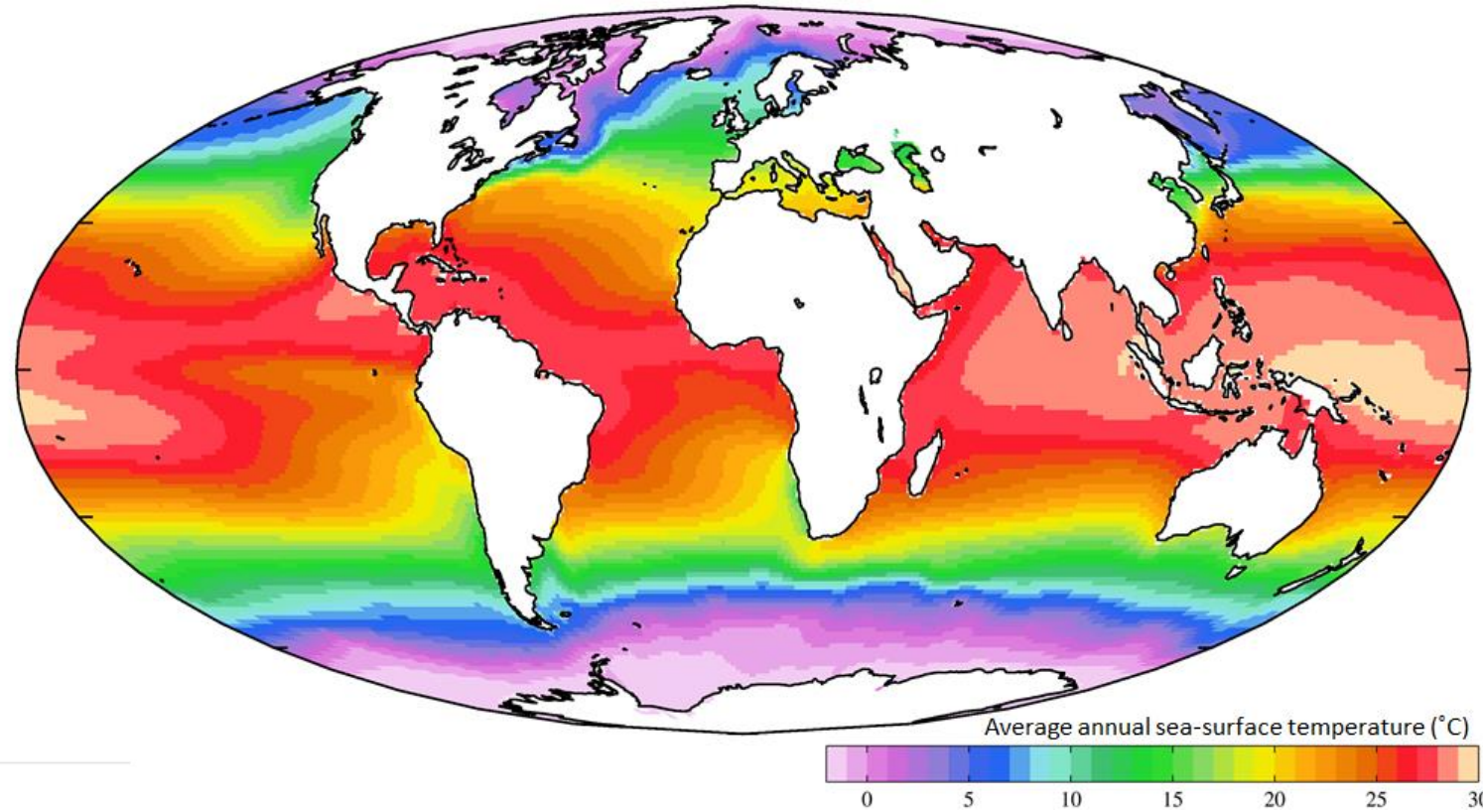


[The Effect of Ocean Salinity on Climate and Its Implications for Earth's Habitability - Olson - 2022 - Geophysical Research Letters - Wiley Online Library](#)

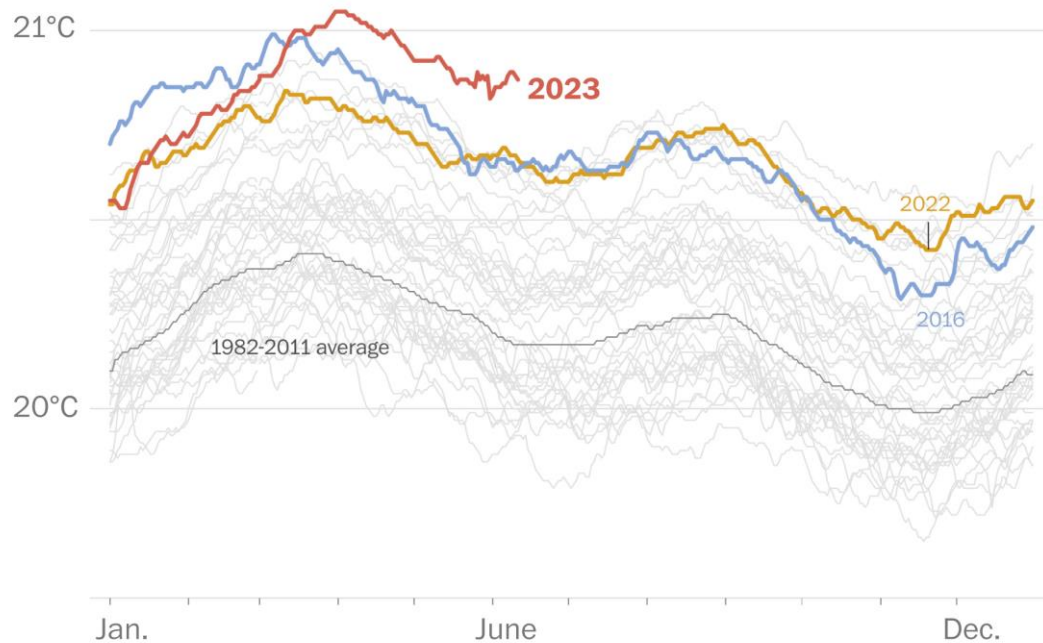
TEMPERATURE

TEMPERATURE

Temperature: A measure of the energy of molecular motion. Varies horizontally with changes in latitude and with changes in depth



Average daily ocean temperature



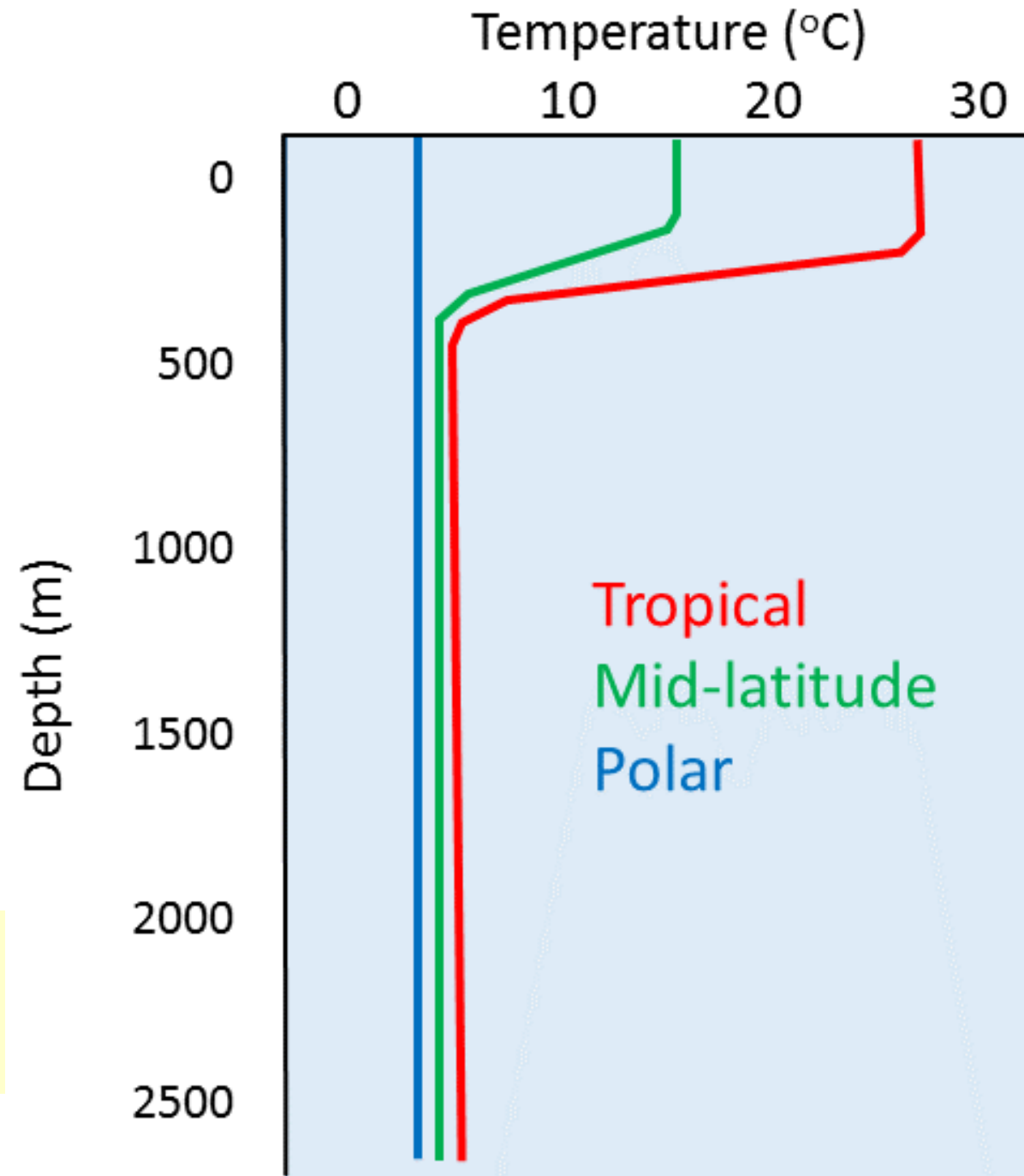
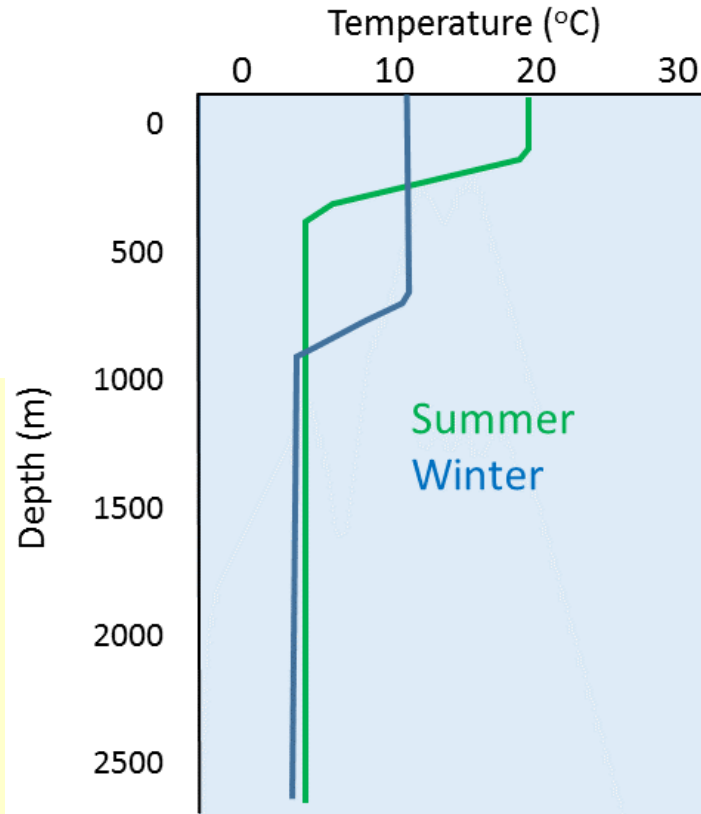
[Scientists are baffled why the oceans are warming so fast - The Washington Post](#)

TEMPERATURE

TEMPERATURE

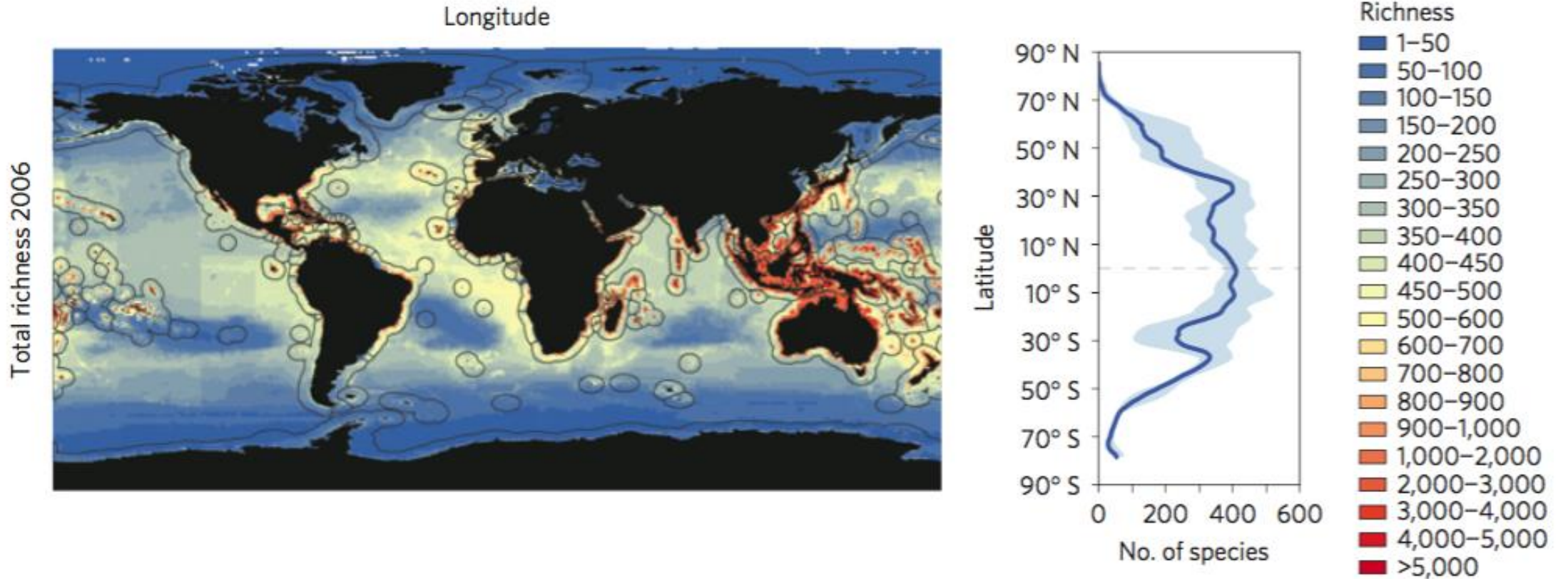
In temperate regions, the mixed layer is deeper and the thermocline less pronounced in the winter compared to the summer (PW).

Temperature affects chemical processes (such as precipitation of calcium carbonate which helps animals make their shells), physiological function and water density.



TEMPERATURE

TEMPERATURE

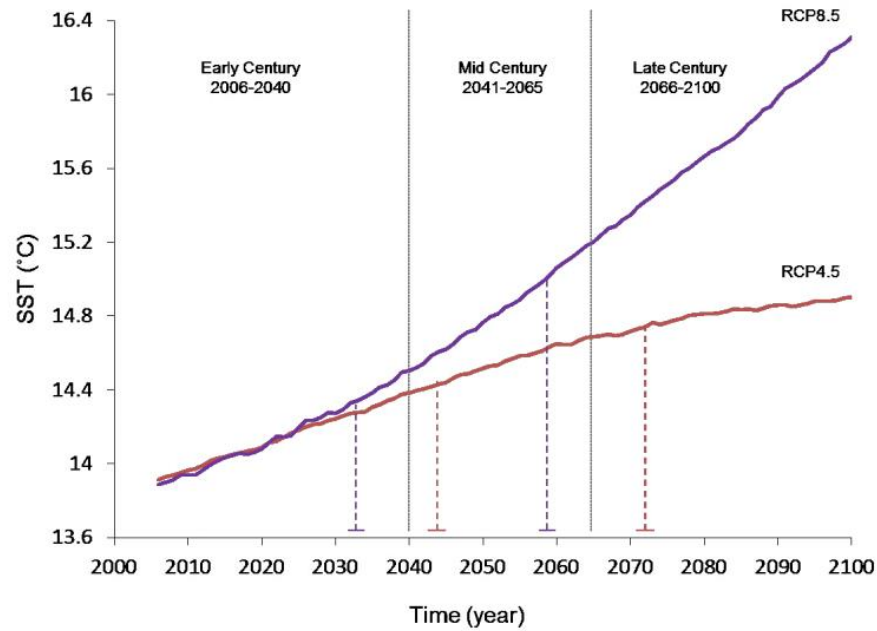


You can see from the areas shaded yellow or red that there tends to be a larger number of species in warmer, tropical waters than in cooler waters towards the poles.

[Warming tropical oceans could see 'widespread and intense' species loss, study warns - Carbon Brief](#)

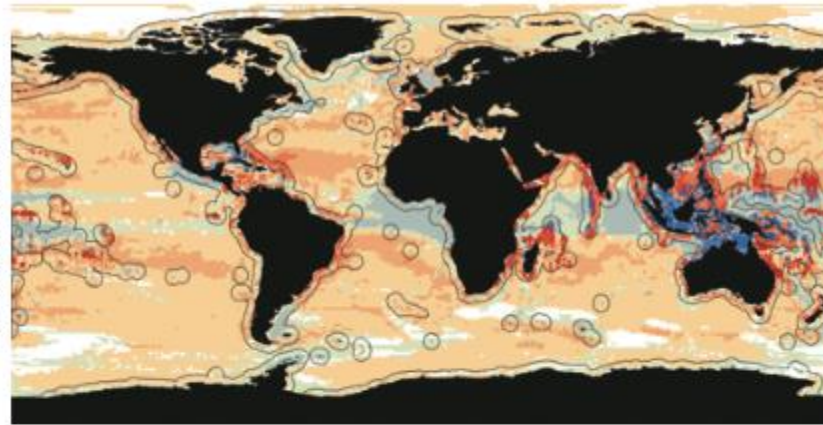
TEMPERATURE

TEMPERATURE

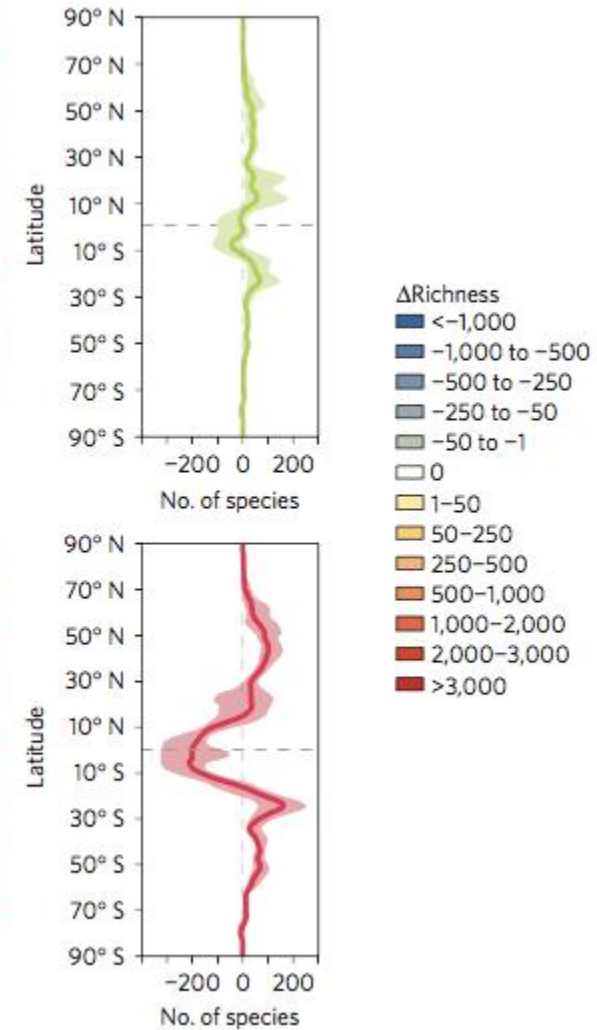
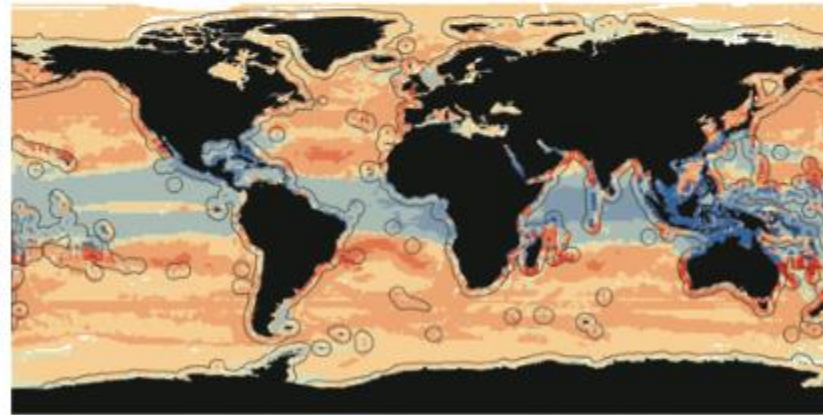


RCP – Representative Concentration Pathways

ΔN° RCP4.5 (2006–2100)



ΔN° RCP8.5 (2006–2100)



Future warming, widespread and intense species loss.

[Warming tropical oceans could see 'widespread and intense' species loss, study warns - Carbon Brief](#)

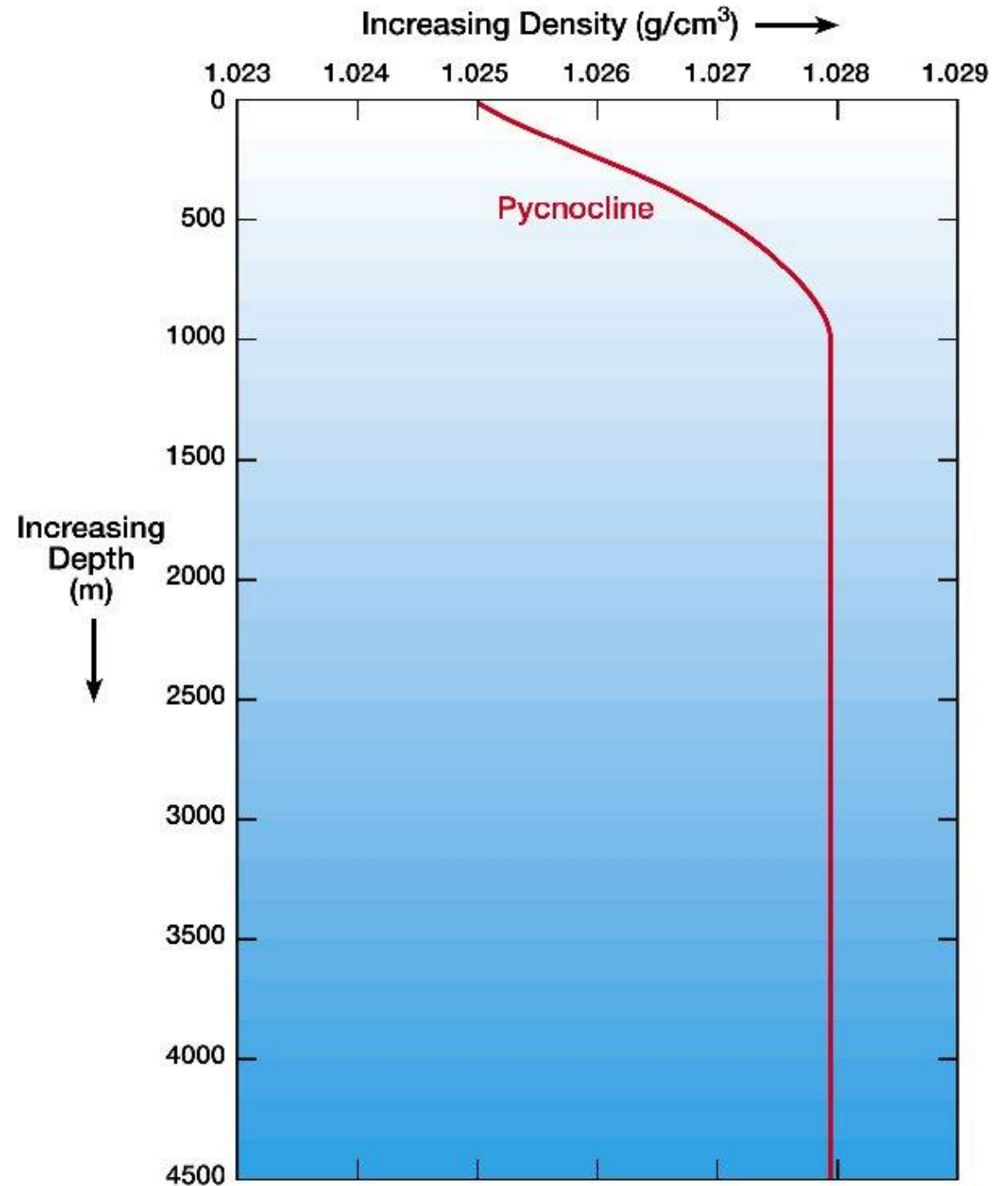
TIME FOR A BREAK – 5 MINS



DENSITY

DENSITY

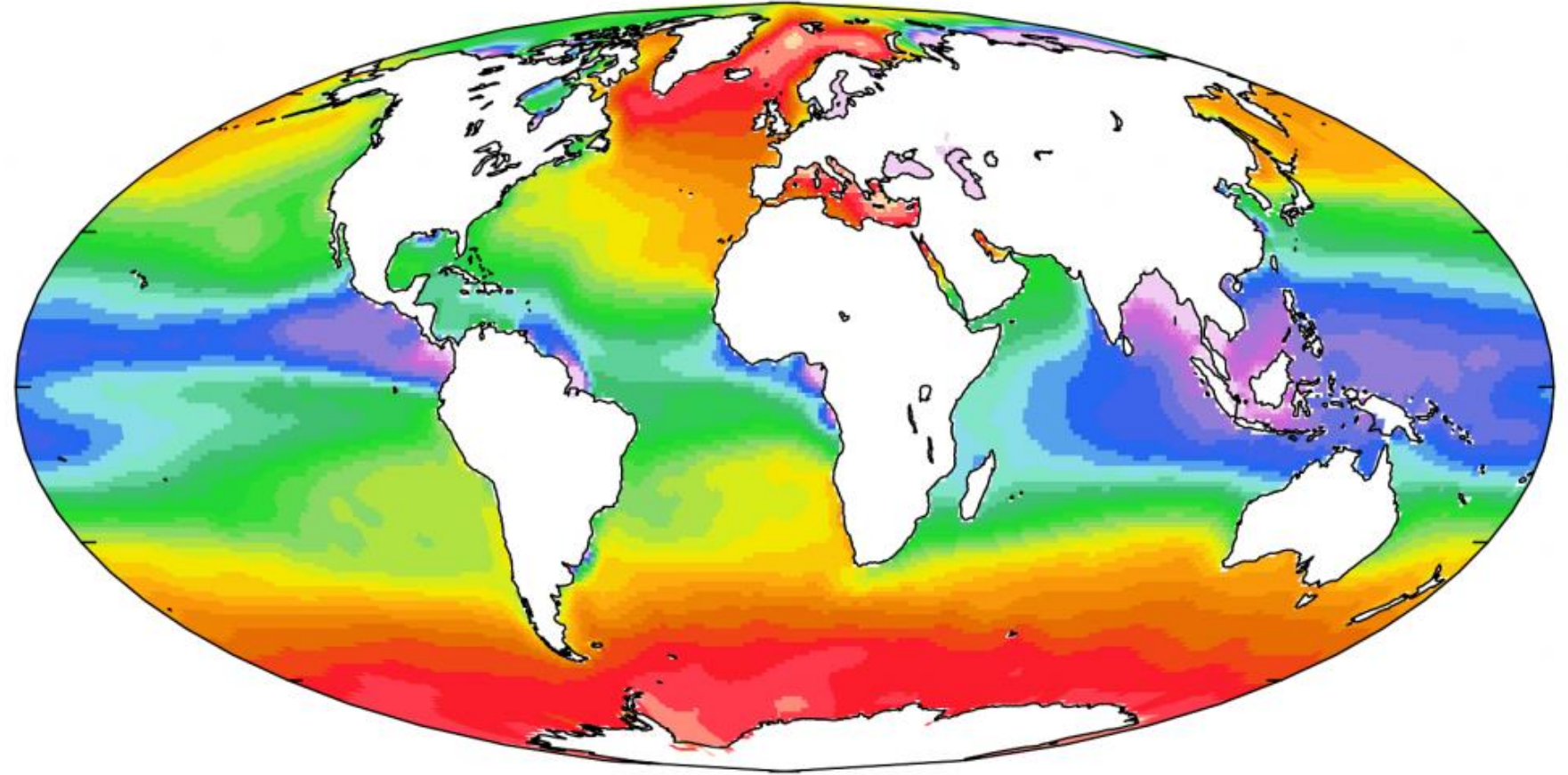
- Density refers to the amount of mass per unit volume, such as grams per cubic centimeter (g/cm^3).
- The density of fresh water is **1 g/cm^3** at 4 degrees C but the addition of salts and other dissolved substances increases surface seawater density to between **1.02 and 1.03 g/cm^3** .



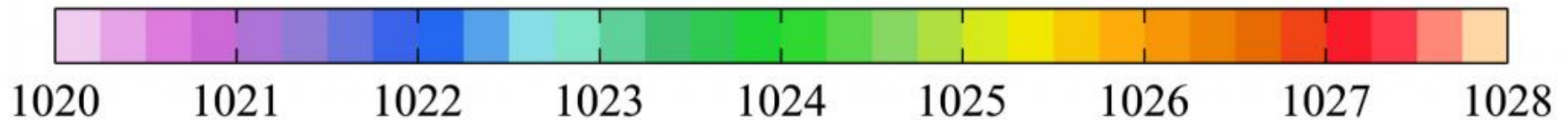
DENSITY

DENSITY

Question: What is controlling this density distribution?



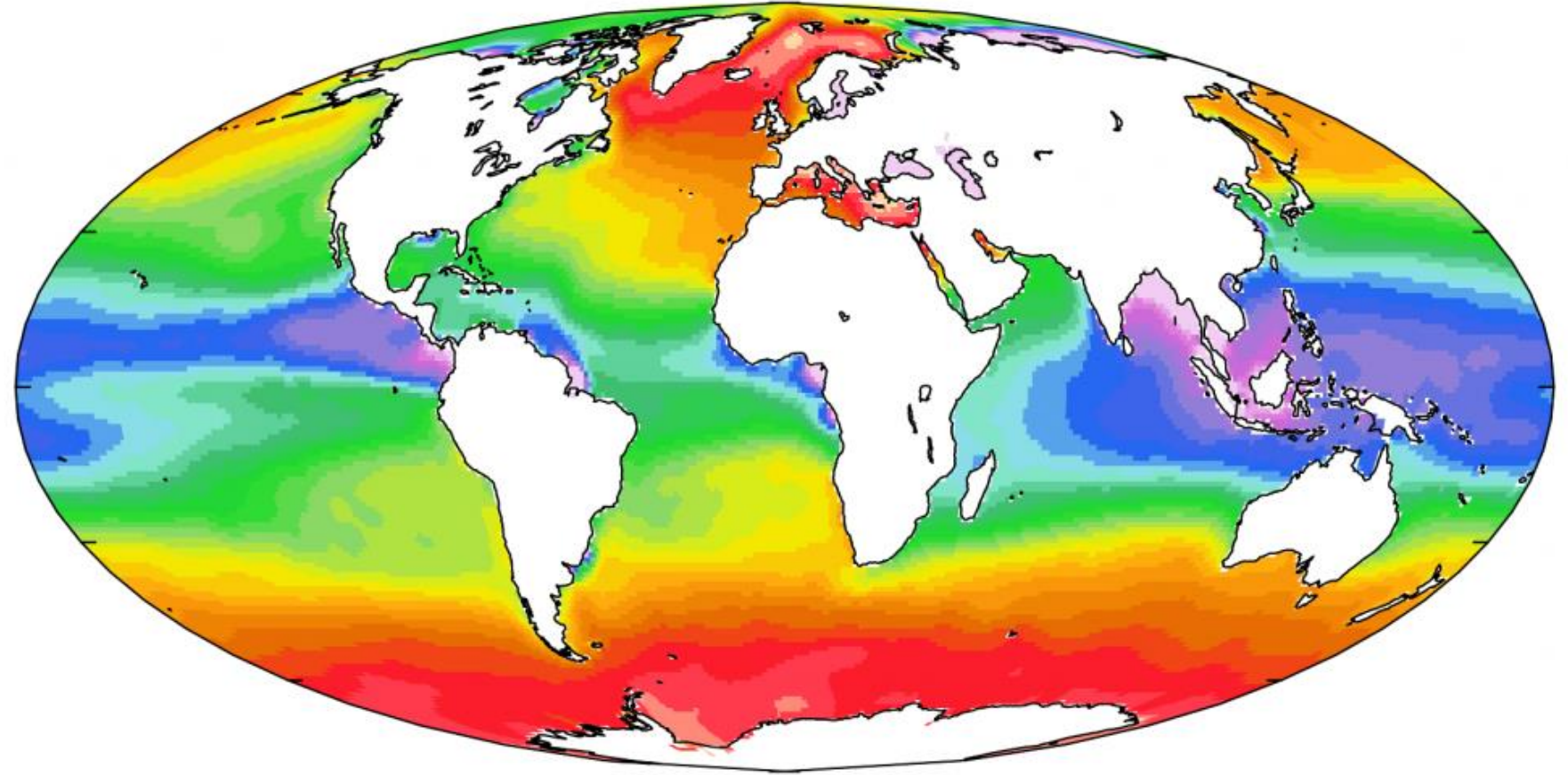
Sea-surface density [kg m^{-3}]



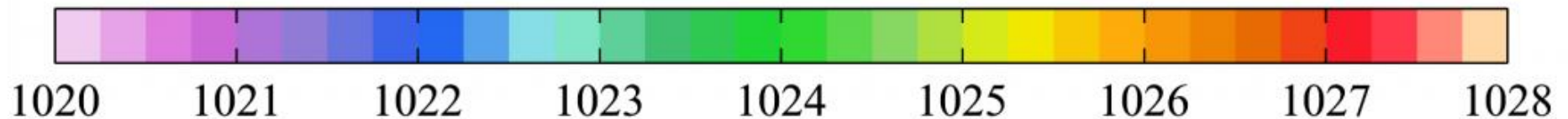
DENSITY

DENSITY

Temperature and salinity are the primary factors determining density, and of these, **temperature** has the greatest impact



Sea-surface density [kg m^{-3}]

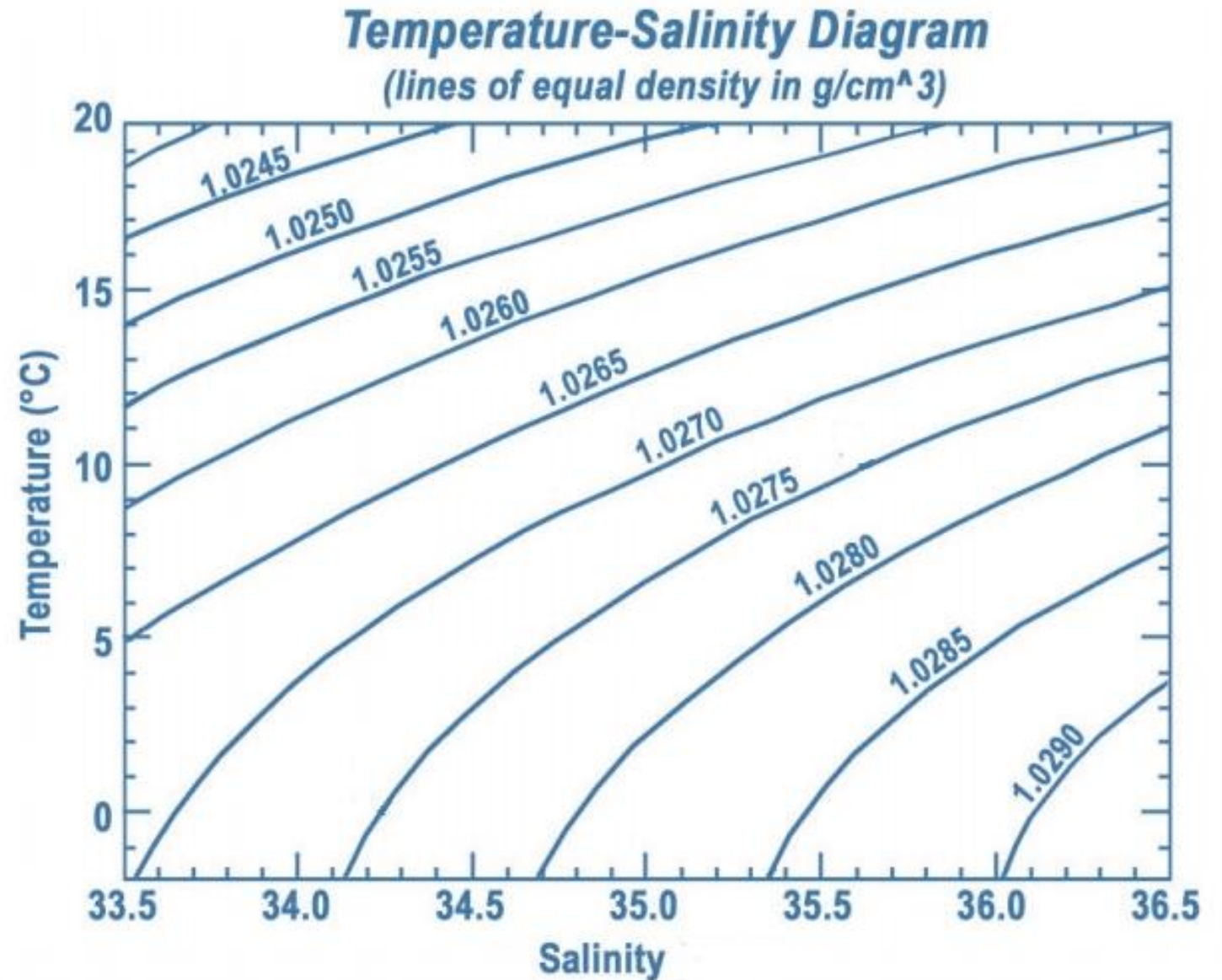


DENSITY

DENSITY

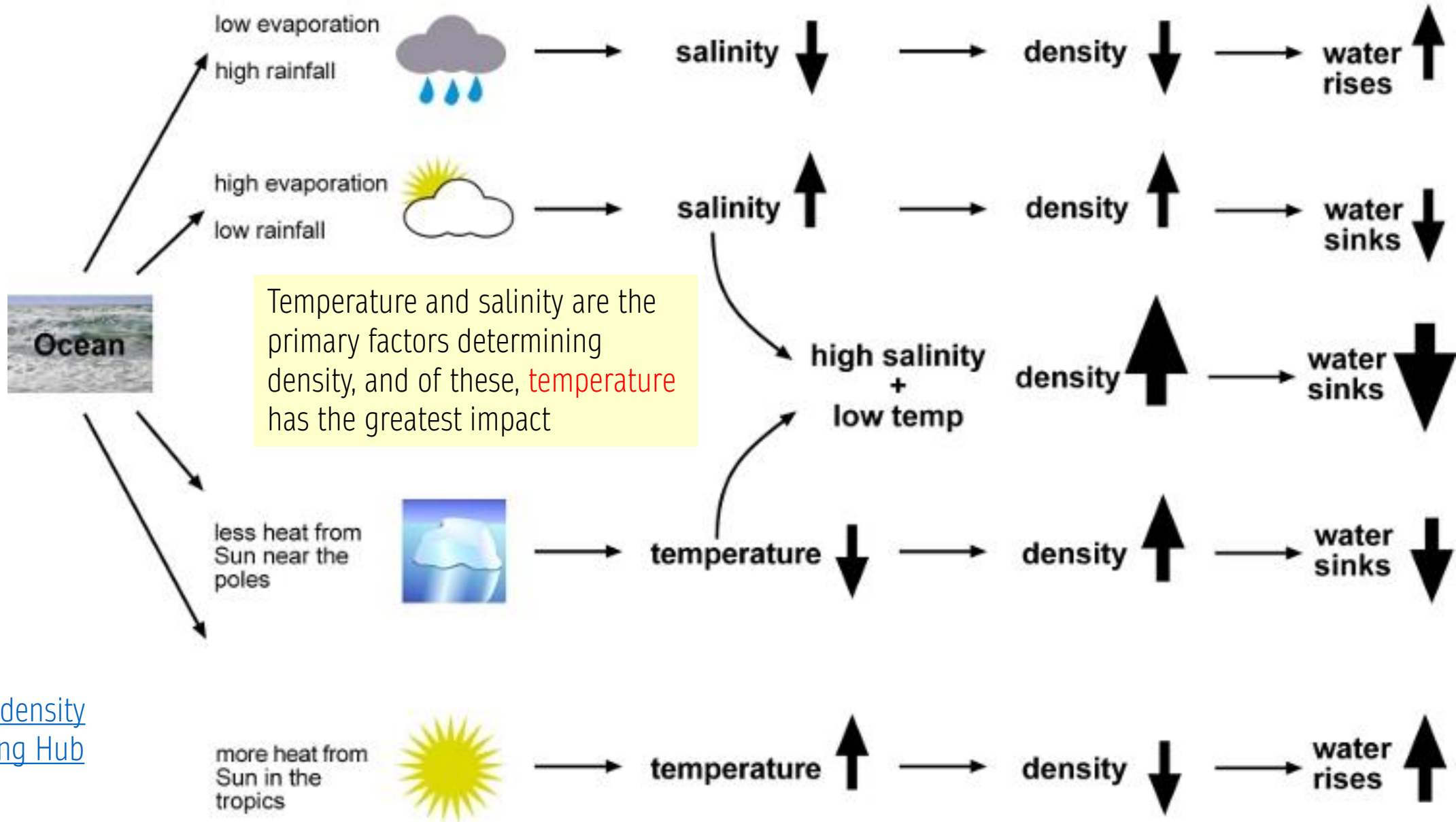
Temperature and salinity are the primary factors determining density, and of these, **temperature** has the greatest impact

[Seawater density - Coastal Wiki](#)



DENSITY

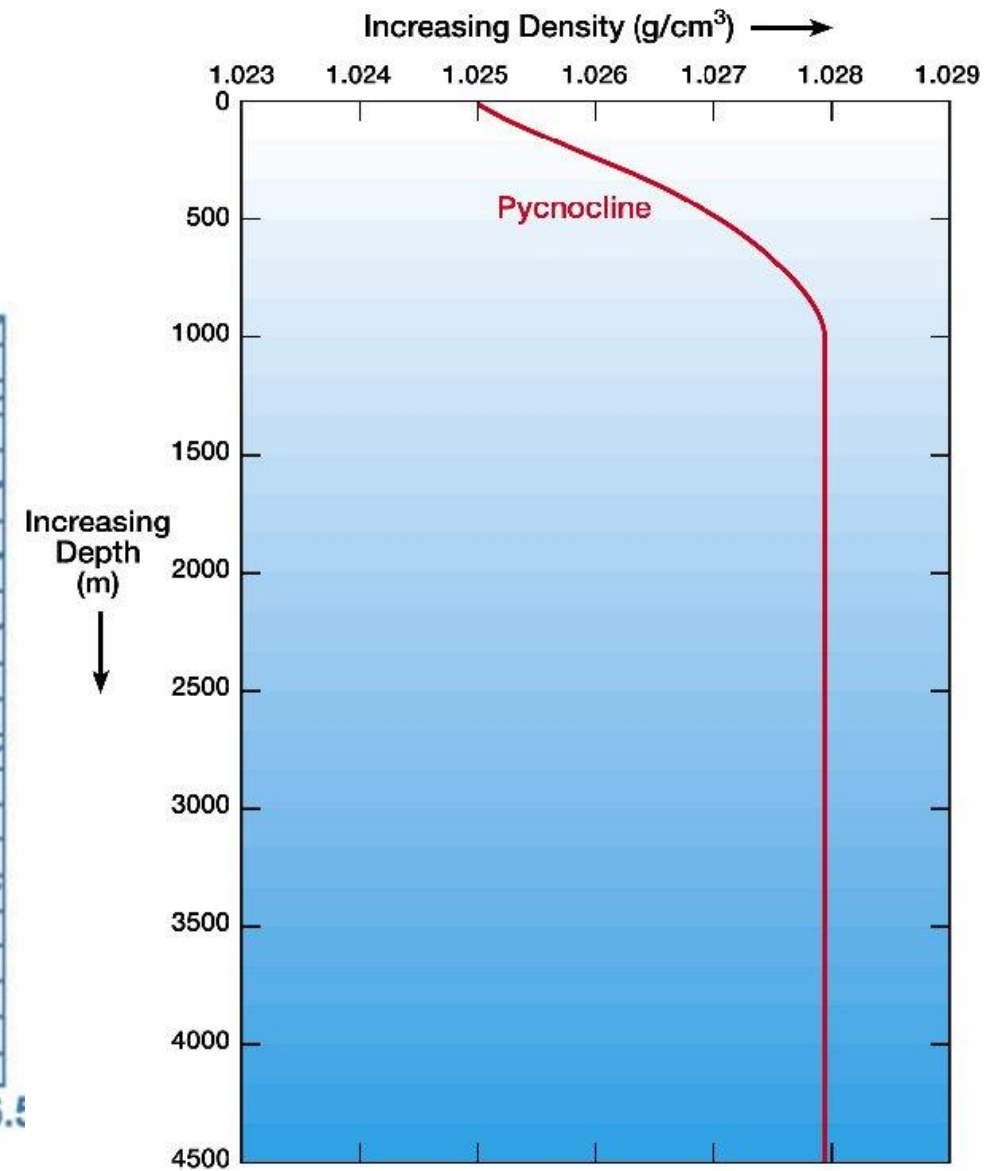
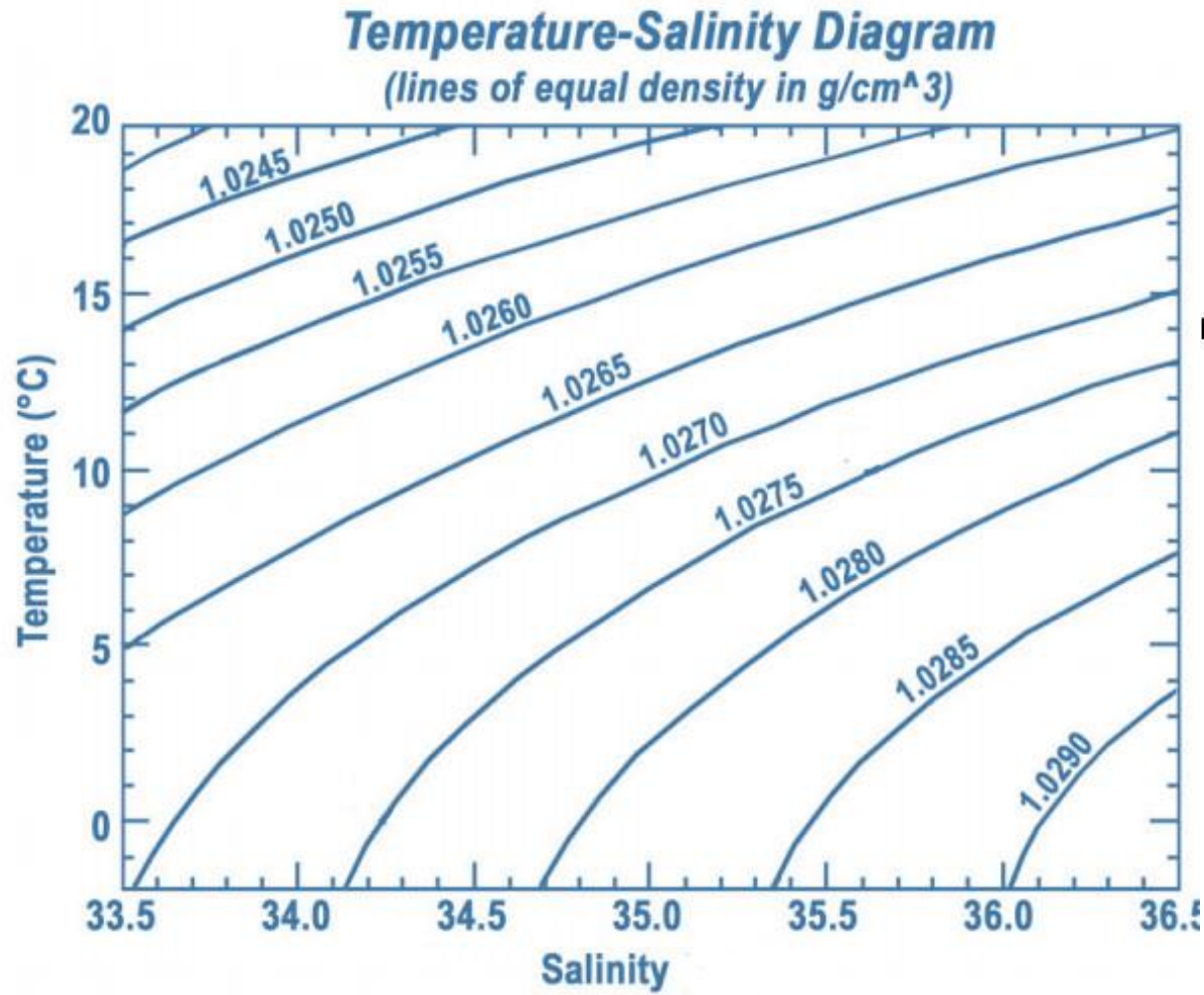
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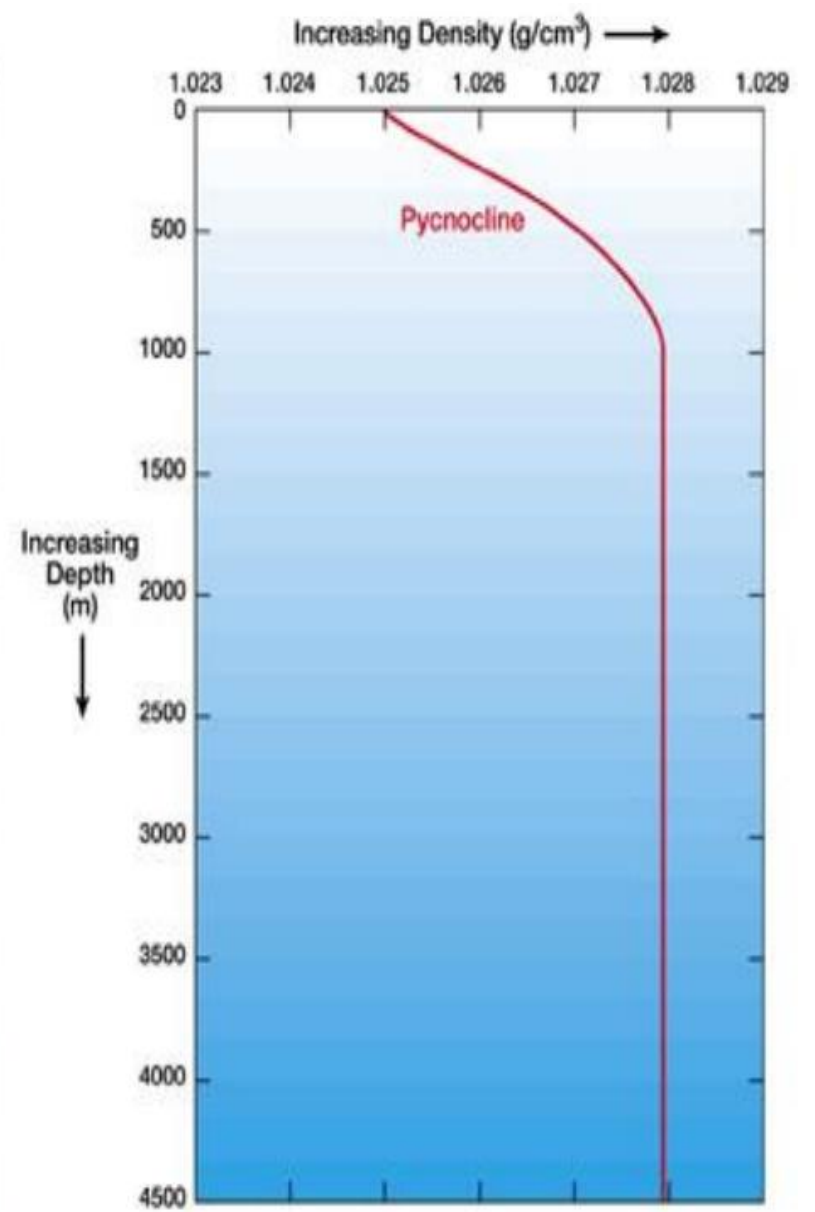
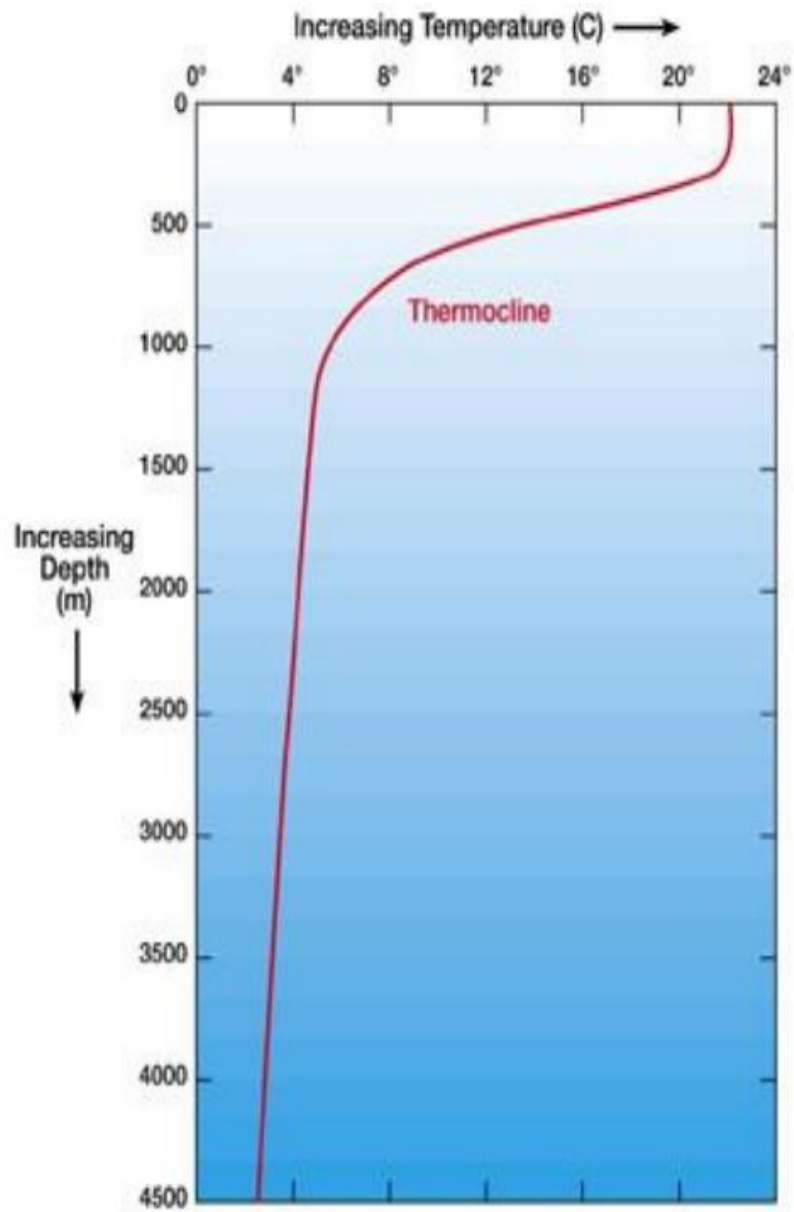
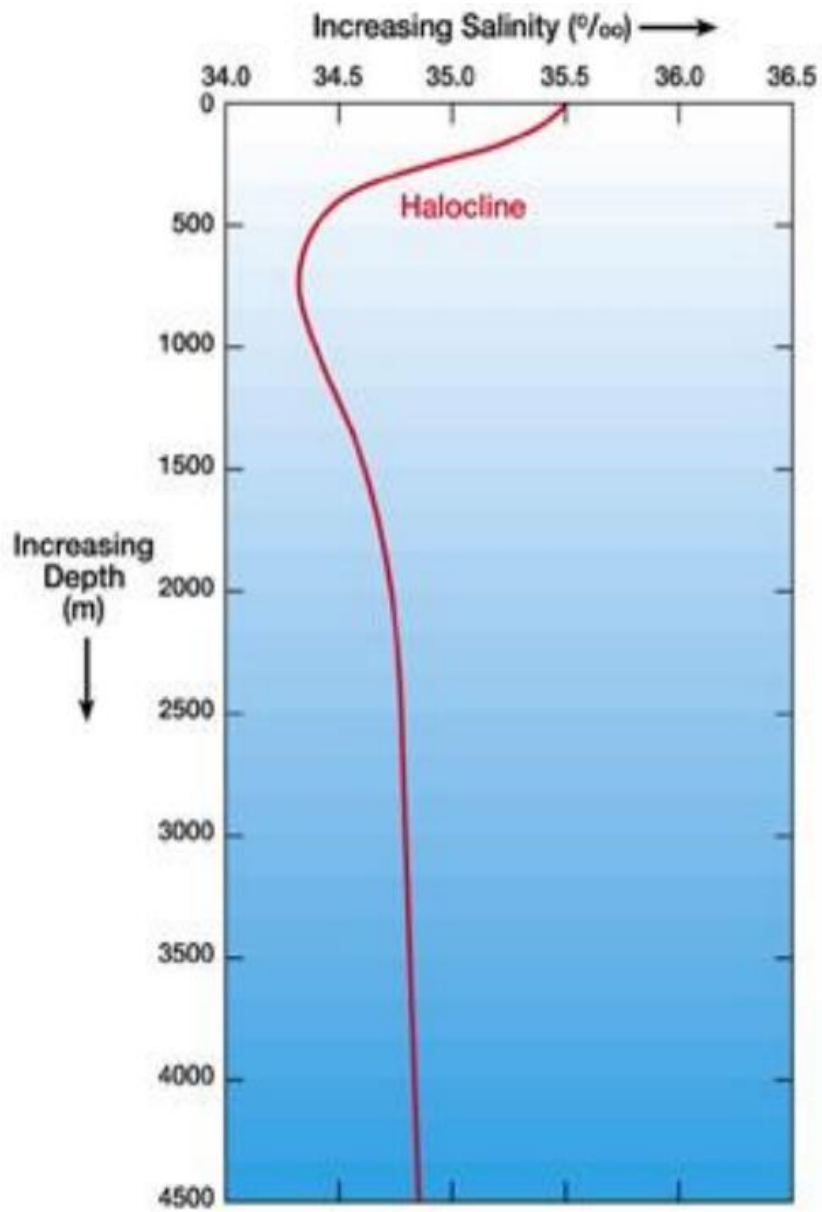


[Ocean salinity, temperature and density](#)
— Science Learning Hub

DENSITY

DENSITY

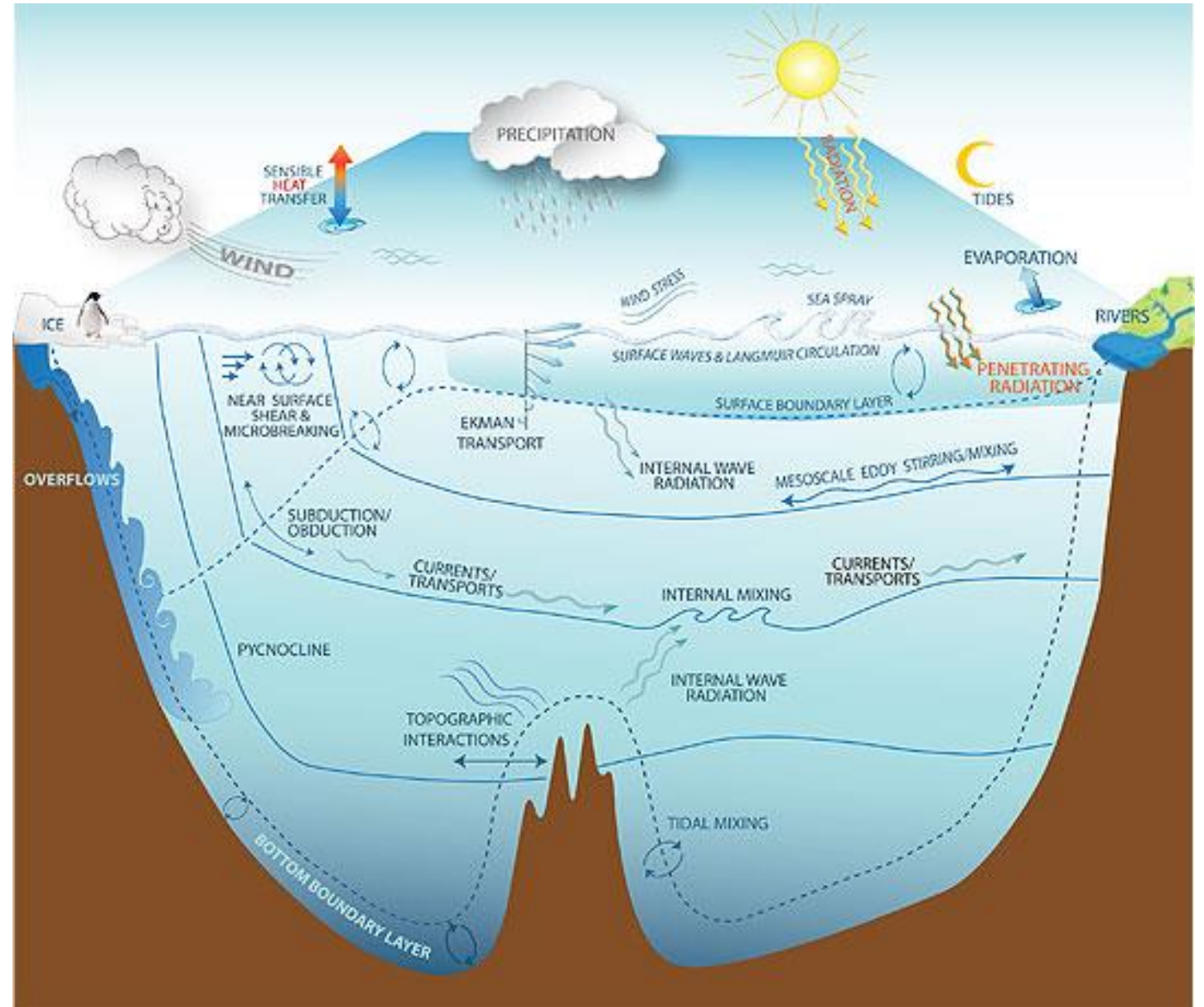




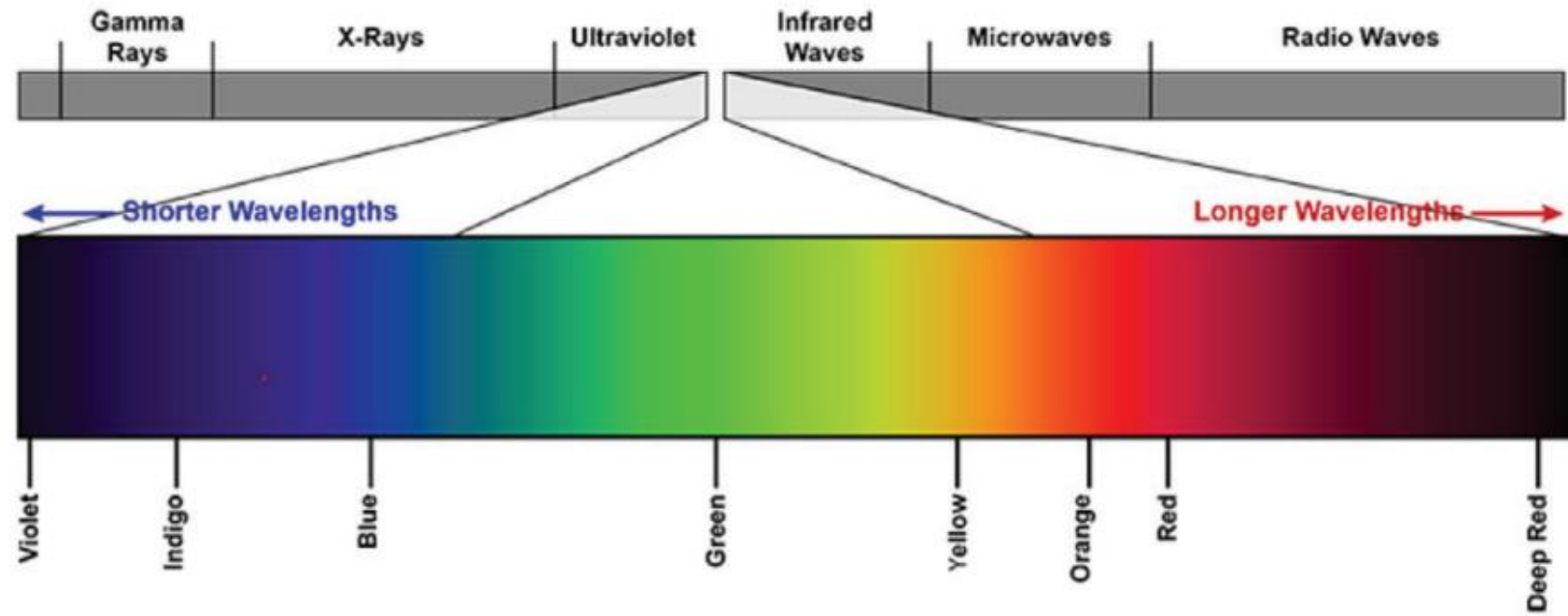
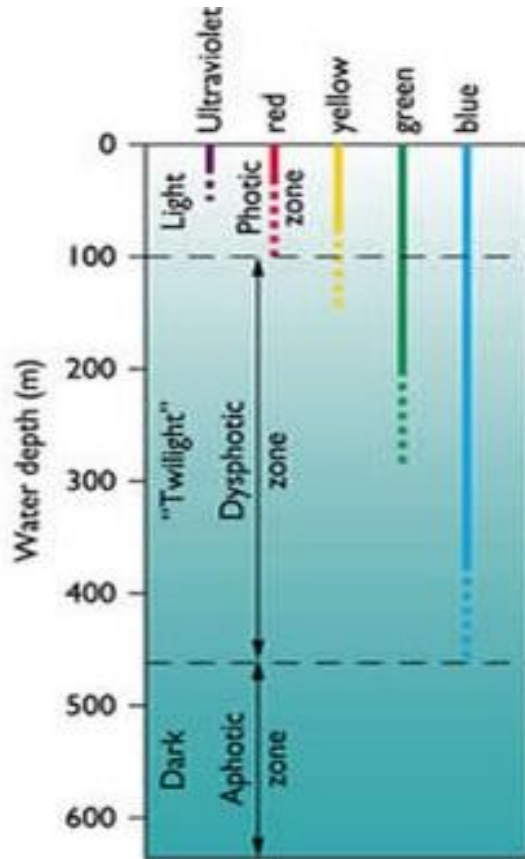
OCEAN MIXING AND COMPLEXITY

The **thermodynamic** properties of the ocean, such as temperature, salinity, and buoyancy, and dynamic properties, such as momentum, energy, and vorticity, are governed by numerous **hydrodynamic processes**.

[Ocean Mixing – Geophysical Fluid Dynamics Laboratory \(noaa.gov\)](https://www.noaa.gov/ocean-mixing-geophysical-fluid-dynamics-laboratory)

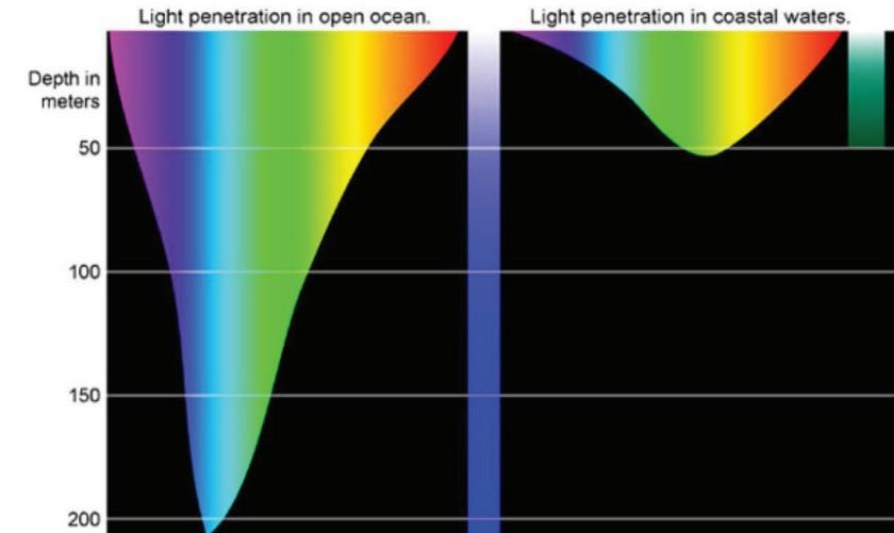


LIGHT



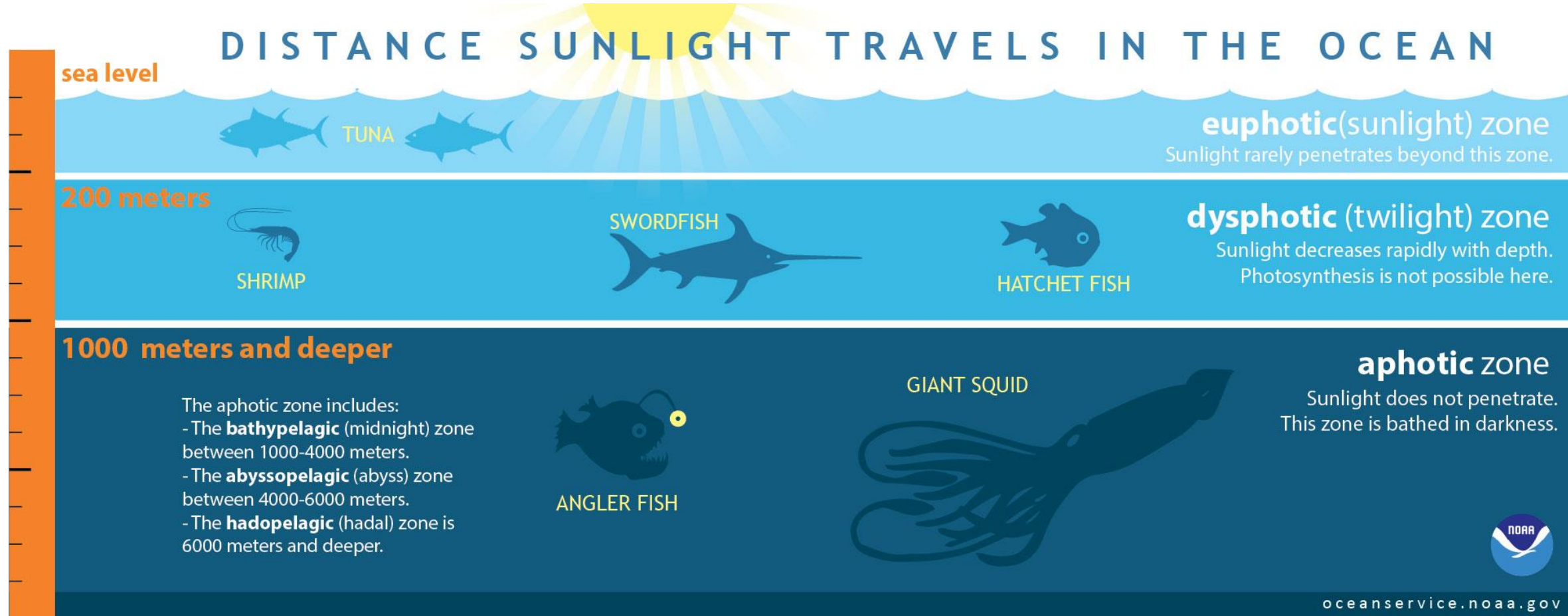
Visible light is only a small portion of the full electromagnetic spectrum.

A basic illustration of the depth at which different colors of light penetrate ocean waters. Water absorbs warm colors like reds and oranges (known as long wavelength light) and scatters the cooler colors (known as short wavelength light). Image courtesy of NOAA Ocean Exploration.



LIGHT

ABIOTIC FACTORS



oceanservice.noaa.gov

Photic
Aphotic

[How far does light travel in the ocean? \(noaa.gov\)](https://oceanservice.noaa.gov)

The ocean is divided into **three** zones based on depth and light level.

LIGHT

ABIOTIC FACTORS

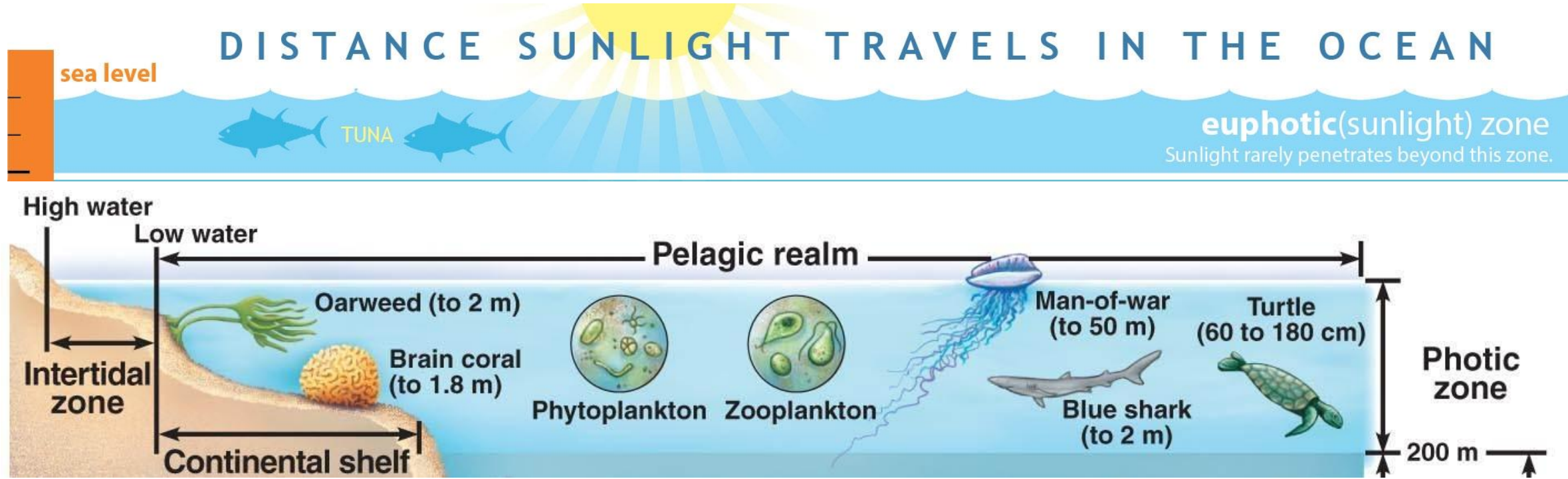


- Upper layer with maximum light and variable temperature.
- 0-200m variable
- 90% of all marine life
- Plants, marine mammals, sharks, turtles, jellyfish, tuna etc.

Photic
Aphotic

LIGHT

ABIOTIC FACTORS

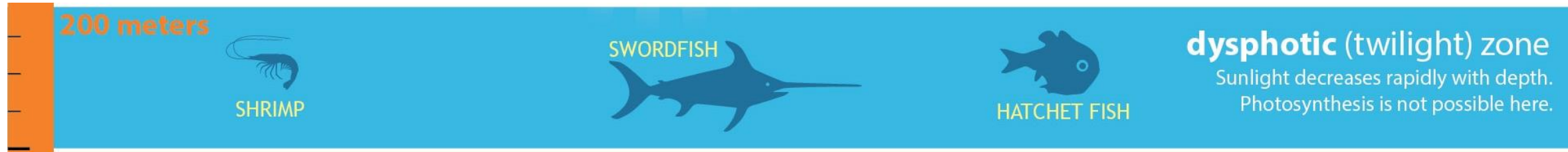


Photic
Aphotic

The abiotic factors that affect the photic zone are availability of light and depth of the photic zone, temperature, stratification, salinity, nutrients, and currents and tides.

LIGHT

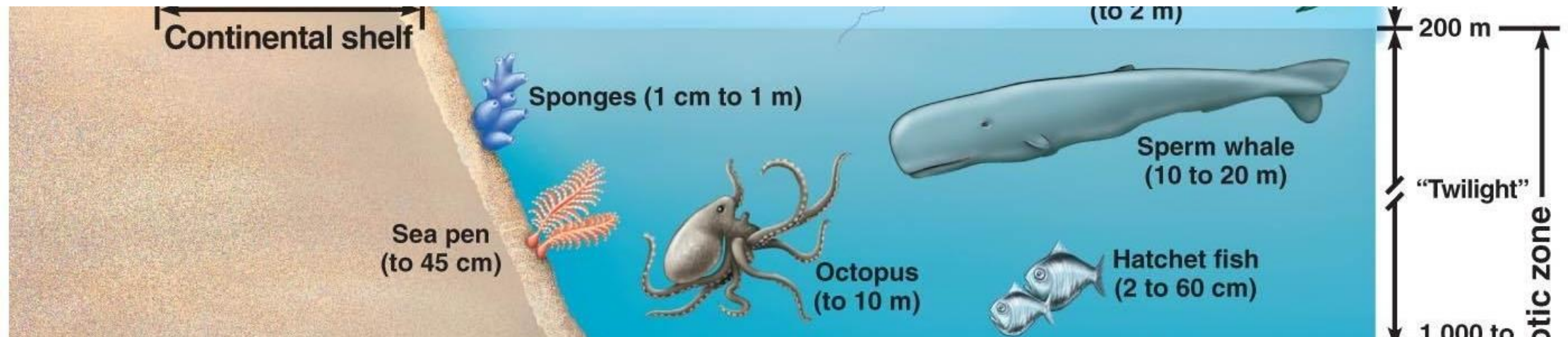
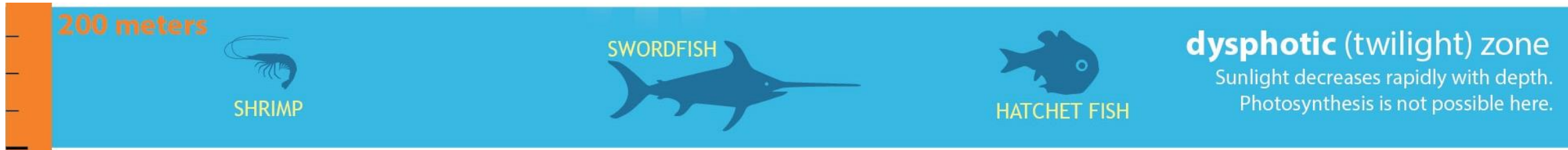
ABIOTIC FACTORS



- Twilight zone
- 200-1000m variable
- Adaptation to the cold
- No plants
- Thin bodies
- Red, black coloration
- Bioluminescence photophores

Photic
Aphotic

LIGHT



LIGHT

- 90% of the Ocean
- Extreme pressure
- Fewer organisms

1000 meters and deeper

The aphotic zone includes:

- The **bathypelagic** (midnight) zone between 1000-4000 meters.
- The **abyssopelagic** (abyss) zone between 4000-6000 meters.
- The **hadopelagic** (hadal) zone is 6000 meters and deeper.



ANGLER FISH



GIANT SQUID

aphotic zone

Sunlight does not penetrate.
This zone is bathed in darkness.



oceanservice.noaa.gov

Aphotic = also known
as the Midnight zone

[Why are so many deep-sea animals red in color?: Ocean Exploration Facts: NOAA Office of Ocean Exploration and Research](#)

LIGHT



1000 meters and deeper

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ANGLER FISH

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oceanservice.noaa.gov

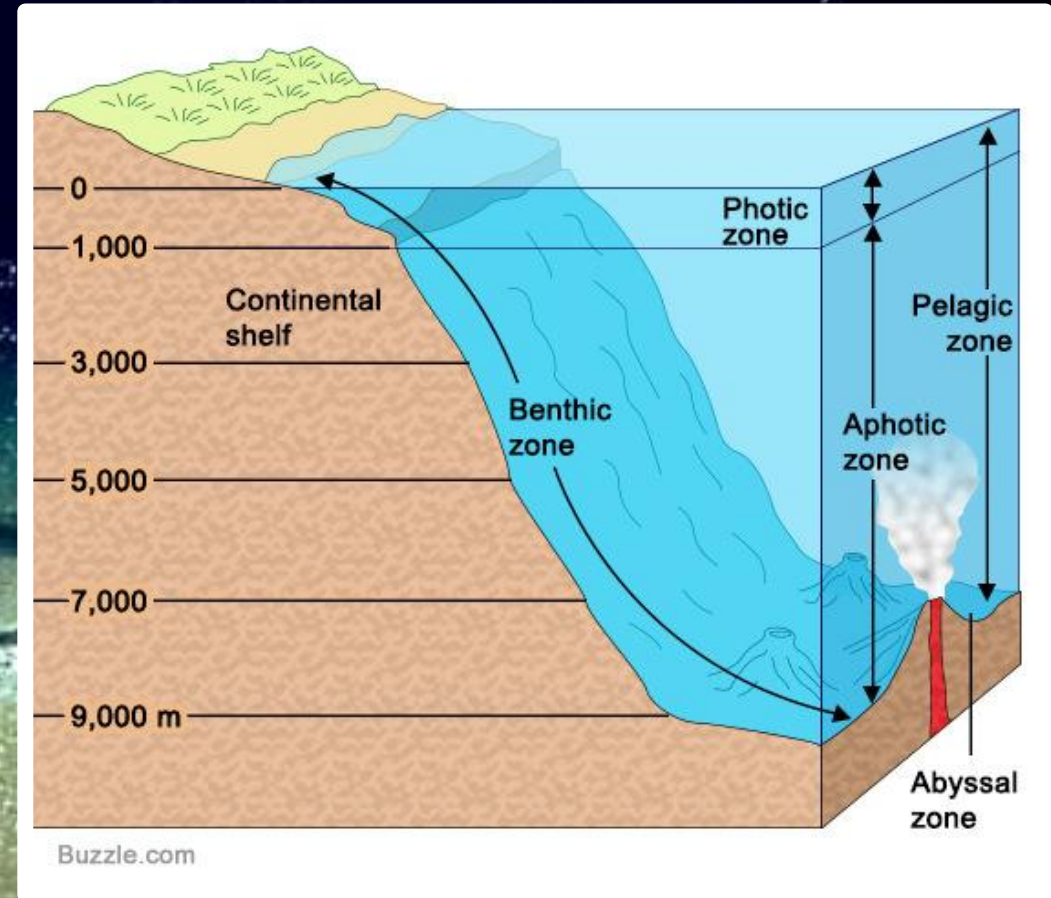
Aphotic = also known as the Midnight zone

[Why are so many deep-sea animals red in color?: Ocean Exploration Facts: NOAA Office of Ocean Exploration and Research](#)

DEEP OCEAN

[Deep Ocean/Benthic Zone - Angelena Mangieri \(weebly.com\)](#)

The Benthic/Abyssal zone is the portion of the ocean that is below depths of 4,000 meters. It covers about 300,000,000 square kilometers out of the 510,000,000 square kilometers of entire Earth. This makes up 60% of the global surface and 83% of the areas of the oceans and seas.



Aphotic = also known as the Midnight zone

DEEP OCEAN

[Deep Ocean/Benthic Zone - Angelena Mangieri \(weebly.com\)](#)



Aphotic = also known as the Midnight zone

As you travel from the surface of the ocean downward to the seafloor, water pressure increases by one atmosphere (or 14 pounds per square inch) for every 10 meters (32.8 feet) of depth. This means, for example, at 100 meters (328 feet), you would experience one atmosphere of air pressure and 10 atmospheres of water pressure, for a total of 11 atmospheres. Travel to 1,000 meters (3,280 feet) below the ocean's surface and most organisms with gas-filled spaces (e.g., lungs) would be crushed by the pressures that other deep-sea life experience

DEEP OCEAN

Strange but true: How deep sea creatures survive hostile habitats | The Straits Times

What conditions exist for life in the deep ocean? : Ocean Exploration Facts: NOAA Office of Ocean Exploration and Research

Aphotic = also known as the Midnight zone

Adapting to life in the deep

Many strange creatures were discovered in the depths of the Indian Ocean by Singapore and Indonesian scientists during a deep sea biodiversity expedition in southern Java in 2018. Their physical attributes, though unconventional, are what help them thrive in hostile environments.



ABOUT THE EXPEDITION:

- A 14-day voyage in 2018.
- Scientists sailed anti-clockwise towards Cilacap in southern Java and back, covering a total distance of 2,200km.



- The expedition team comprised 31 researchers and support staff.
- Samples collected from 63 stations, at depths averaging 800m, with the deepest depth reached at 2,100m.
- More than 12,000 creatures collected.

THE DEEP SEA IS A HOSTILE ENVIRONMENT:

It is dark and cold

- Sunlight does not penetrate beyond 200m. Without any source of heat, the waters are cold, with temperatures at the bottom dipping well below 10 deg C, even in the tropics.

Food is scarce

- With no light, there are no plants or photosynthetic phytoplankton. This means there are no herbivorous marine creatures, which are often prey for other animals. Most are therefore scavengers or predators.

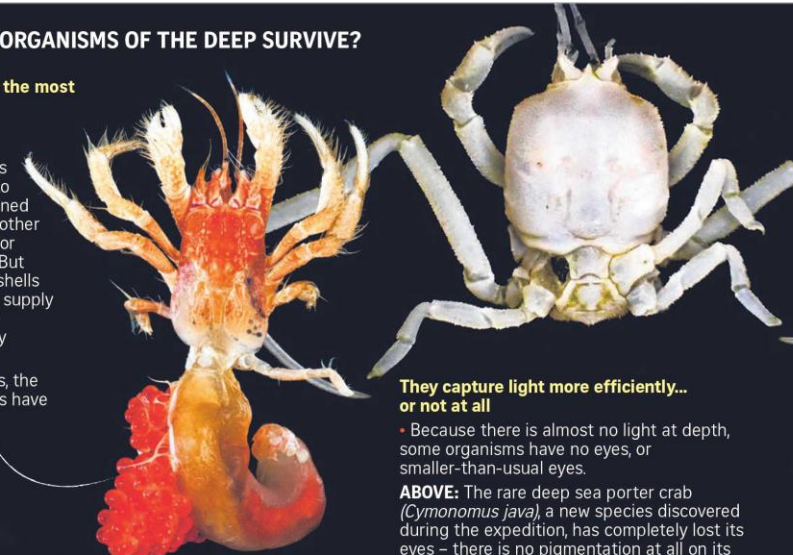
Pressure is high

- The deeper the seabed, the higher the pressure. Every 10m of water exerts a pressure equivalent to the atmospheric pressure experienced by an organism at the surface. This means that at 200m, organisms have to deal with pressure that is 21 times that felt by land-dwelling organisms.

HOW DO ORGANISMS OF THE DEEP SURVIVE?

They make the most of things

- On the seashore, hermit crabs are known to use abandoned shells from other organisms for protection. But since such shells are in short supply in the deep oceans, they improvise.
- Sometimes, the hermit crabs have no shell.



They capture light more efficiently... or not at all

- Because there is almost no light at depth, some organisms have no eyes, or smaller-than-usual eyes.

ABOVE: The rare deep sea porter crab (*Cymonomus java*), a new species discovered during the expedition, has completely lost its eyes - there is no pigmentation at all on its eyestalk. It relies on its long legs and feelers to search the deep for food.

They search for food more efficiently

- Larger mouths help organisms catch any prey that may swim by.



Fangtooth

- Good things come to those that wait. The tripod fish is known to lie in wait for prey on the seabed, propped up by its tail and fins.

- Other creatures have developed long feelers that can help them make their way around in the dark and detect prey.



Chlorophthalmus corniger

- But other organisms have adapted by having larger eyes that can capture any incoming reflection.



Juvenile glass eel

Monochromatic life, with pops of red

- In the dark depths of the ocean, many creatures are usually black, white or translucent.

- The only pops of colour are red. Red light does not penetrate to such depths, which helps the organisms to camouflage themselves.



RIGHT: Rahayu's deep sea lobster (*Nephropsis rahayuuae*), named after Indonesian scientist Dwi Listyo Rahayu, is a spectacular orange and red.

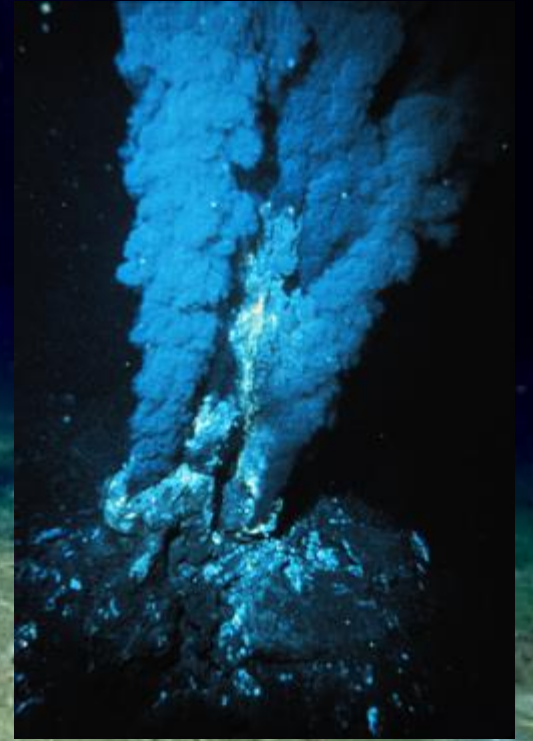
Sources: NATIONAL UNIVERSITY OF SINGAPORE, SOUTH JAVA DEEP SEA BIODIVERSITY EXPEDITION (SJADES)

PHOTOS: SJADES STRAITS TIMES GRAPHICS

DEEP OCEAN

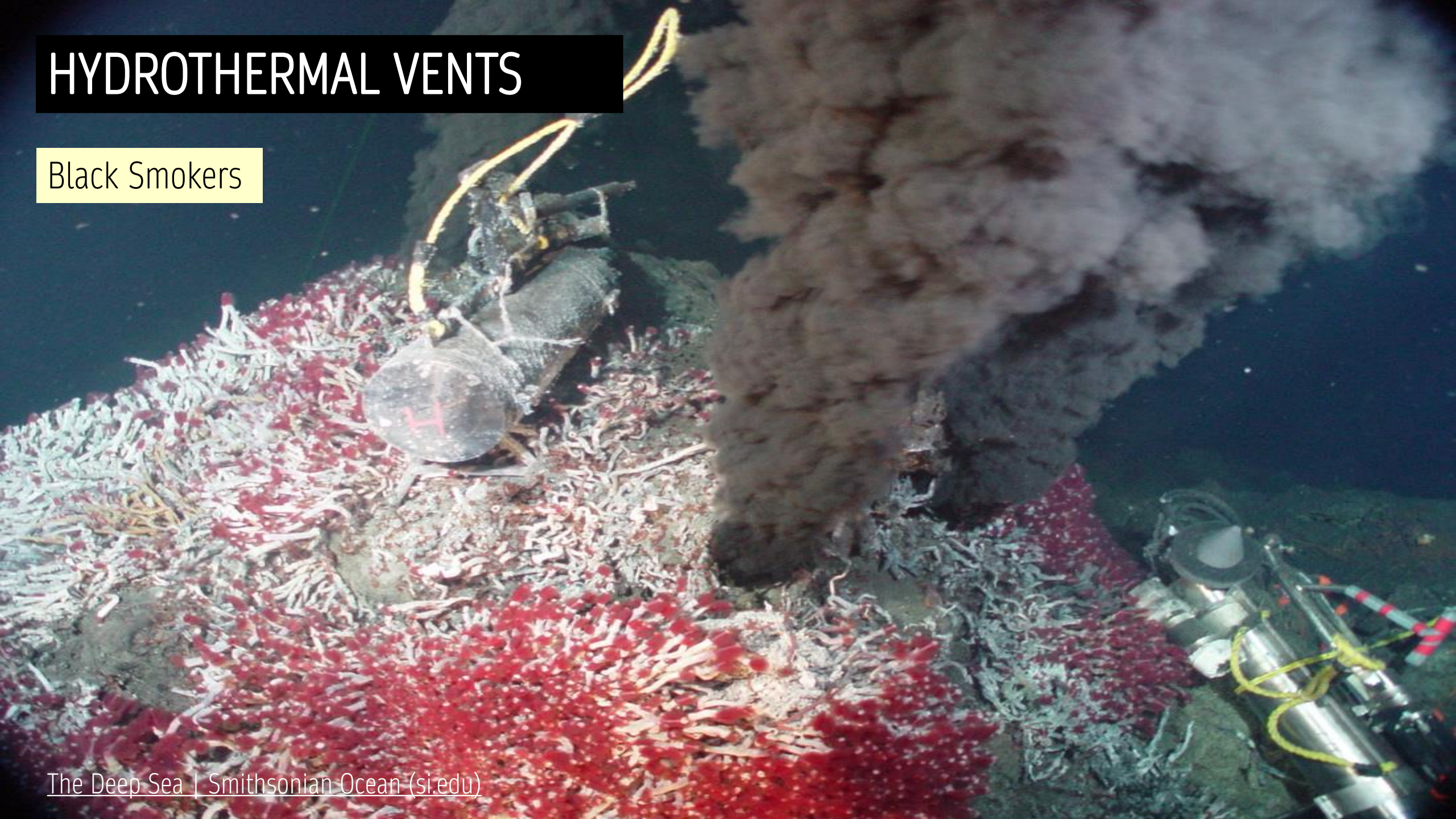
[Deep Ocean/Benthic Zone - Angelena Mangieri \(weebly.com\)](#)

Carbon Cycle – CO₂ is very important in the deep ocean. many organisms thrive off of hydrothermal vents. The vents send out heated water which creates currents of debris. The organisms use a process called **chemosynthesis**, which is the conversion of one or more carbon molecules and nutrients into organic matter through oxidation, to create food.



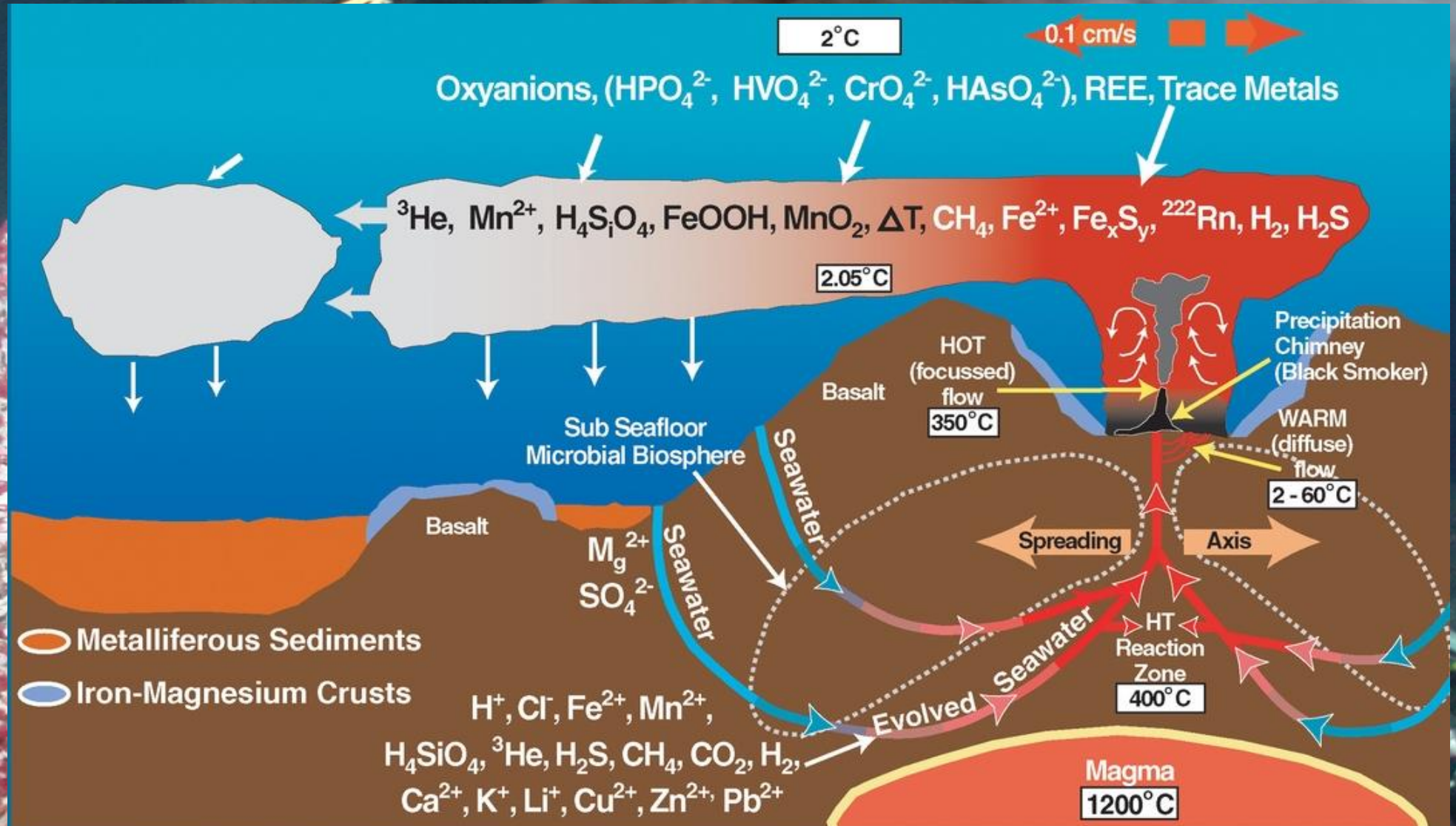
HYDROTHERMAL VENTS

Black Smokers



HYDROTHERMAL VENTS

Black Smokers



HYDROTHERMAL VENTS

Colour – indicator of what chemicals the vents are comprised of

HYDROTHERMAL VENTS

Colour – indicator of what chemicals the vents are comprised of

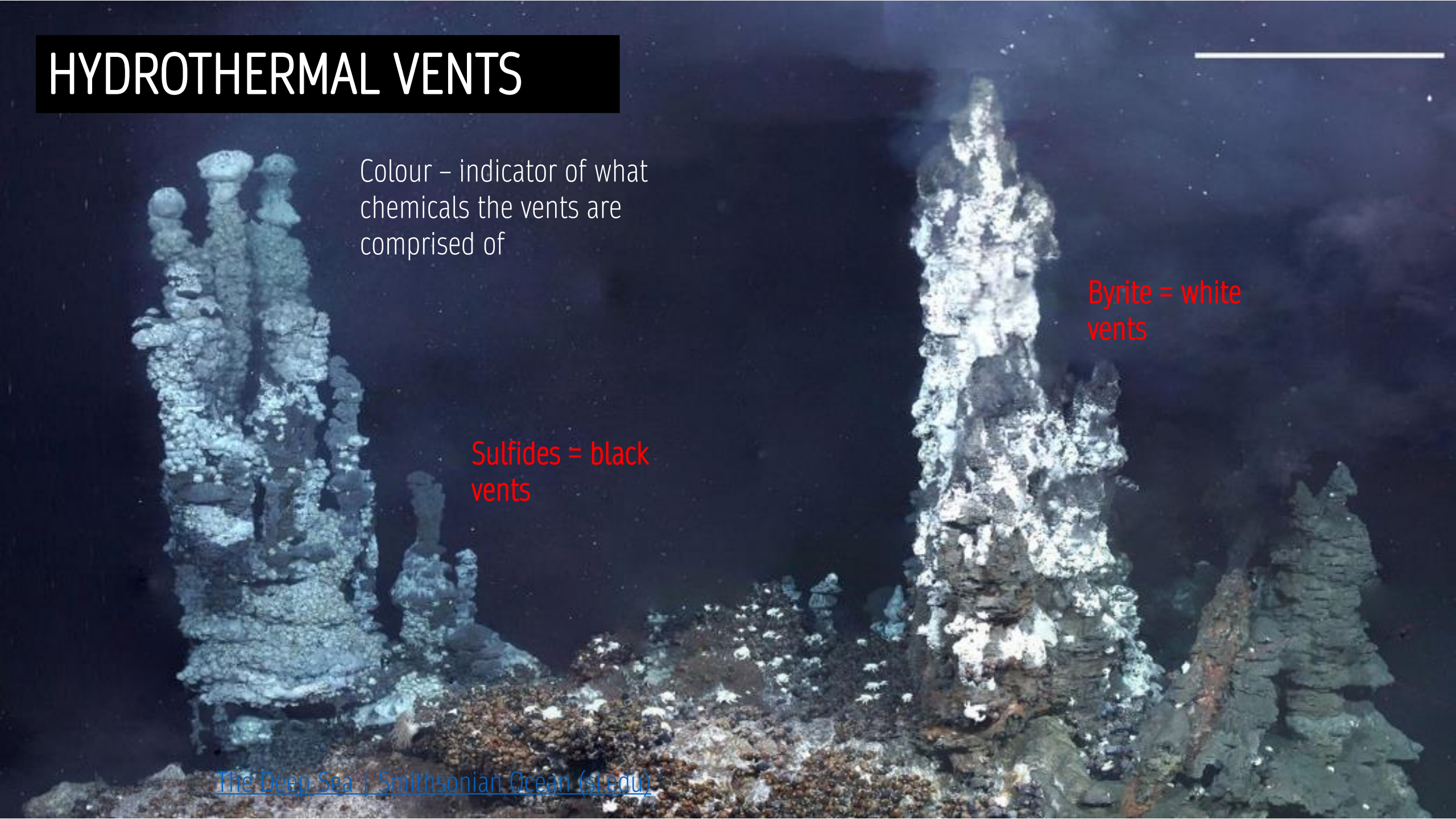
Sulfides = black vents

HYDROTHERMAL VENTS

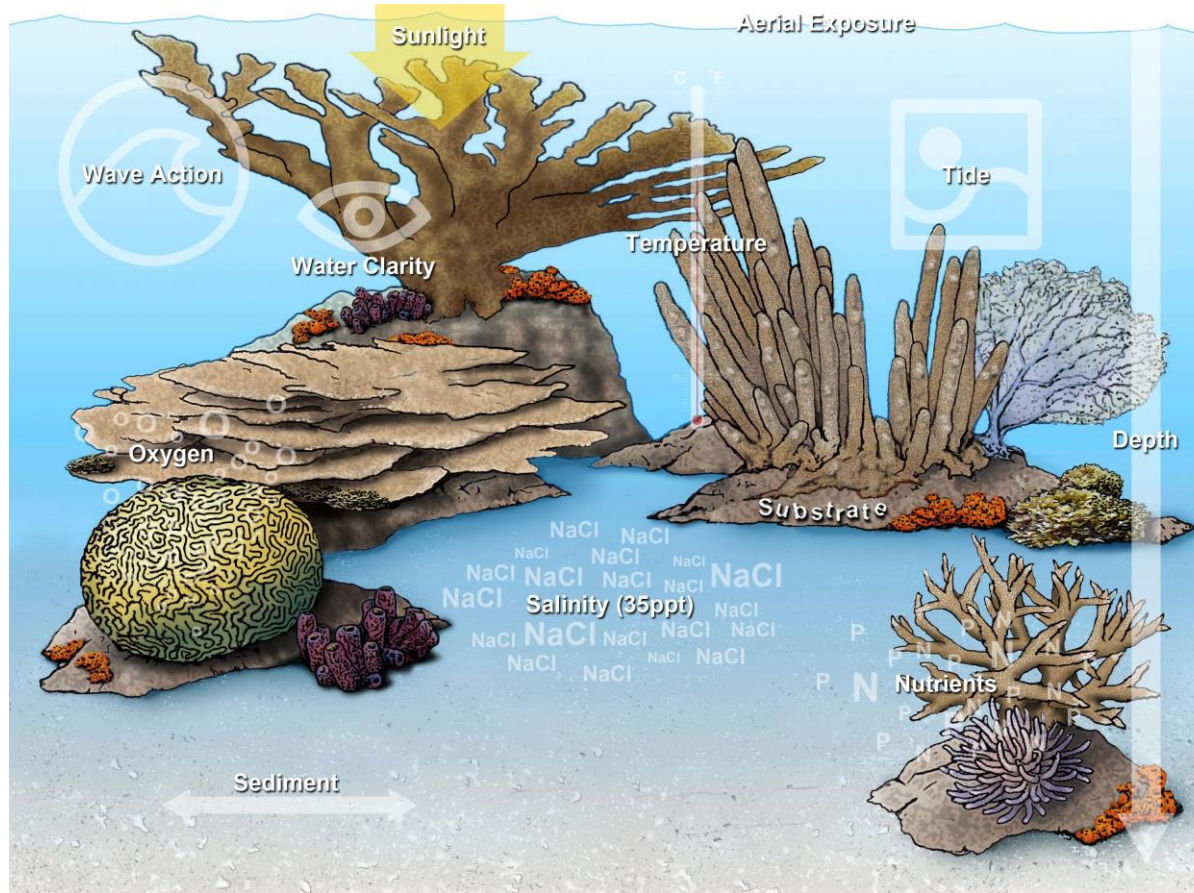
Colour – indicator of what chemicals the vents are comprised of

Sulfides = black vents

Byrite = white vents



LIGHT



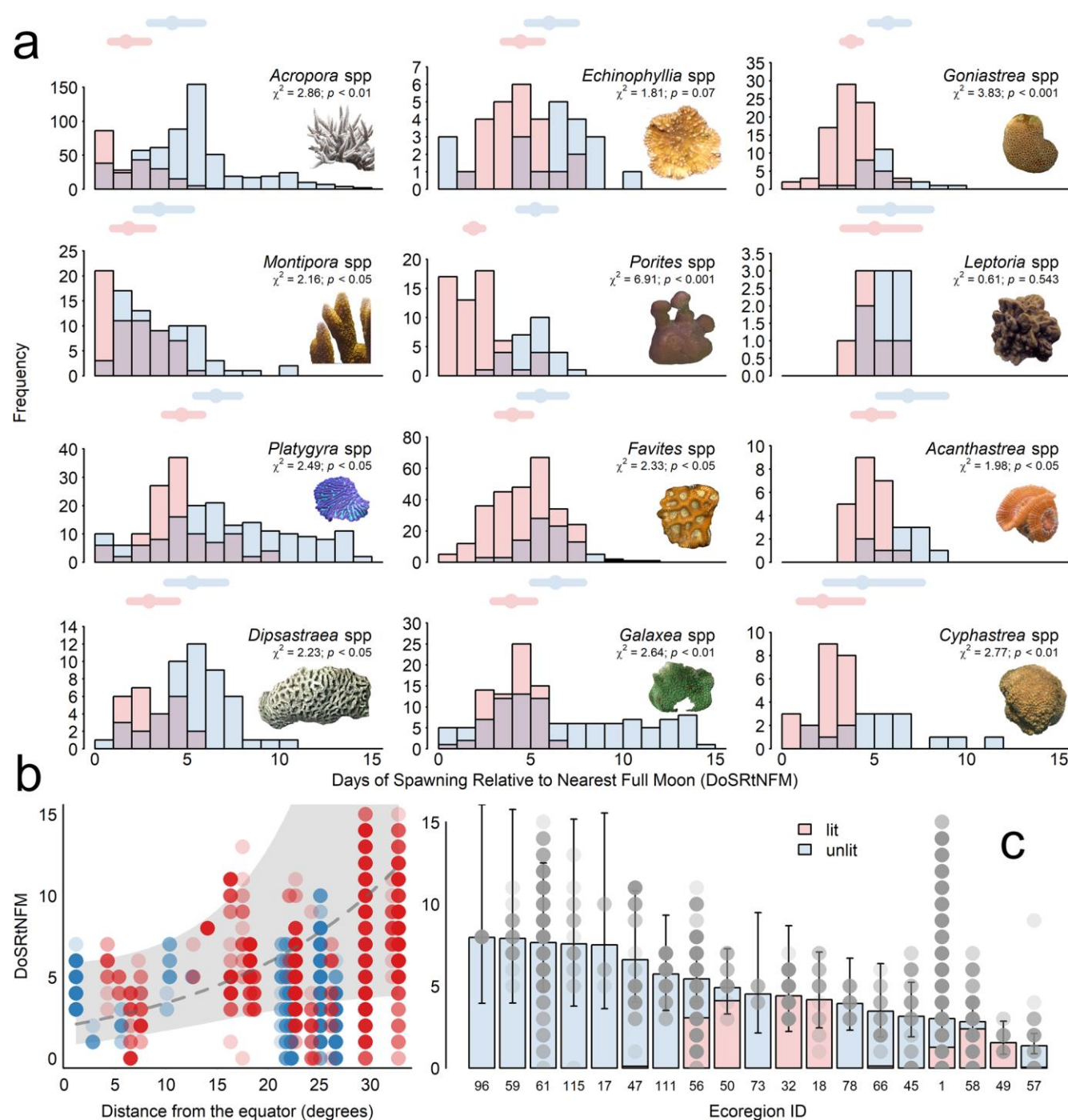
- Corals depend on lunar illumination cues to synchronize their biological rhythm.
- Moonlight governs their physiology and behavior and reproduction.
- It's all too easy for artificial wavelengths to mimic that orb's light.

Photic
Aphotic

WHAT ABOUT ARTIFICIAL LIGHT?

Underwater ALAN disrupts the timing of broadcast spawning by scleractinian corals (Davies et al, 2023). Frequency histograms of the days spawning is observed relative to full moon (zero on the x-axis) in corals exposed to underwater light pollution (pink) and not exposed (blue).

Research shows several species have lost their reproductive synchrony.



WHAT ABOUT ARTIFICIAL LIGHT?

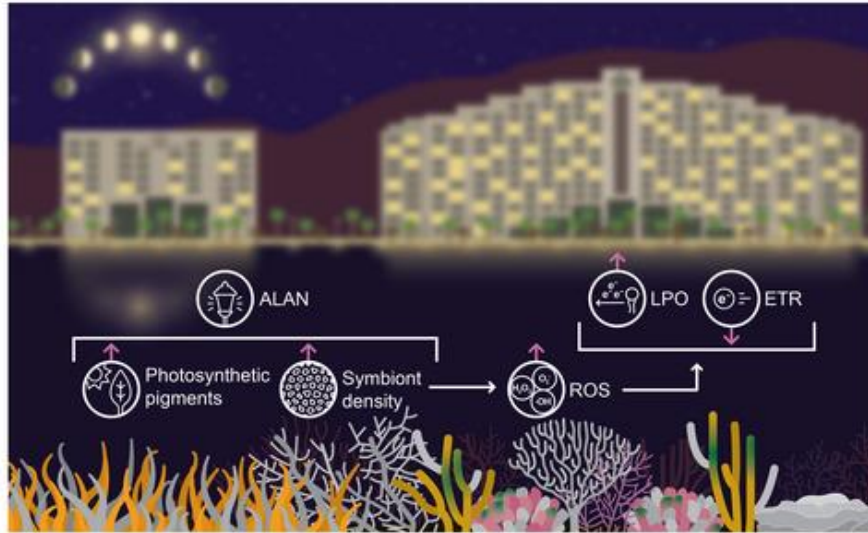


- The impacts were significant.
- Changes in environmental conditions, such as artificial light may also cause damage in less visible ways.
- Corals that reproduce by broadcast spawning are particularly vulnerable because their reproductive phenology is governed by environmental cues

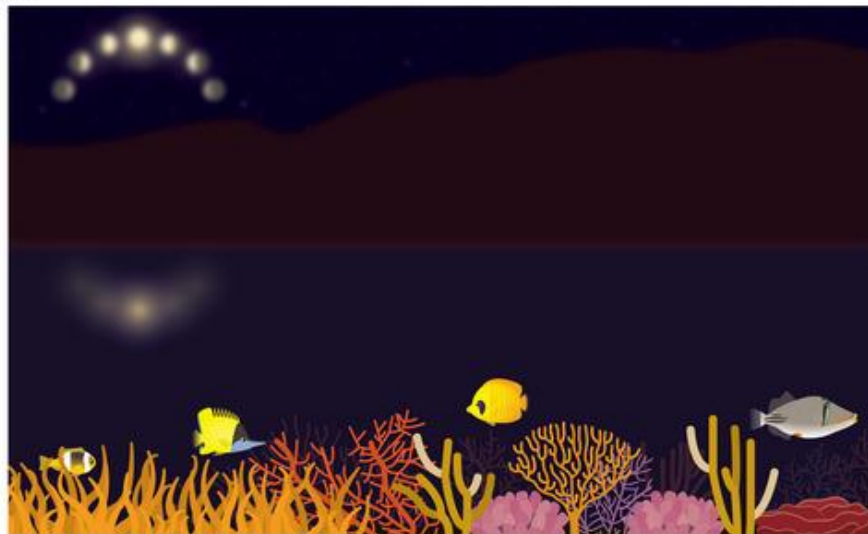
Artificial “sky glow” can now be detected along 22% of the world’s shorelines

WHAT ABOUT ARTIFICIAL LIGHT?

(a)



(b)



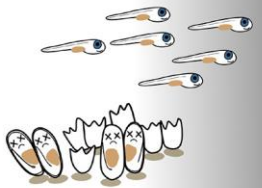
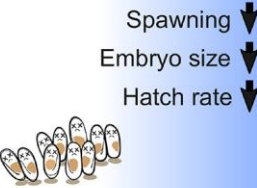
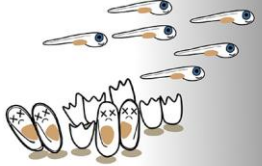
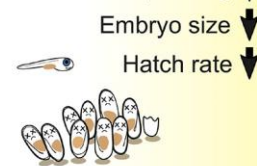
- Corals exposed to artificial light had higher levels of free radicals, or chemically-reactive forms of oxygen that cause **damage to DNA, proteins, and cellular structures**.
- Algae populations living symbiotically inside the corals fluctuated abnormally. Their **rates of photosynthesis declined** (Ayalon, 2019).
- Synchrony breakdown reduces the probability of **successful fertilization**, leading to a dearth of new recruits, which may drive aging populations to extinction.

WHAT ABOUT ARTIFICIAL LIGHT?

ABIOTIC FACTORS

Eggs incubated in the presence of artificial light had a zero hatching success rate.

- Fobert et al (2021)

	Control 12L:12D	Impact 12L:12Dim L
Cool ALAN		
Warm ALAN		



- An increasing amount of artificial light at night in coral reefs, even at relatively low levels, masks natural cues that trigger clownfish eggs to hatch after dusk.

TIME FOR A BREAK – 5 MINS

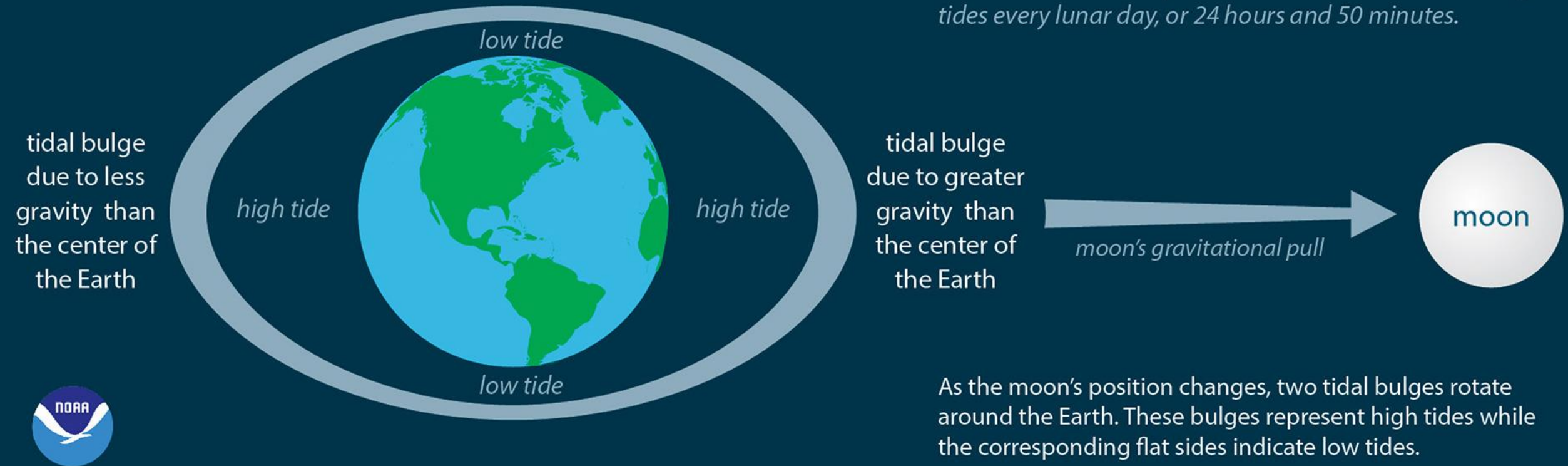


TIDES

Coastal areas experience two low tides and two high tides every lunar day, or 24 hours and 50 minutes.

FREQUENCY OF TIDES

Most coastal areas experience two low tides and two high tides every lunar day, or 24 hours and 50 minutes.



As the moon's position changes, two tidal bulges rotate around the Earth. These bulges represent high tides while the corresponding flat sides indicate low tides.



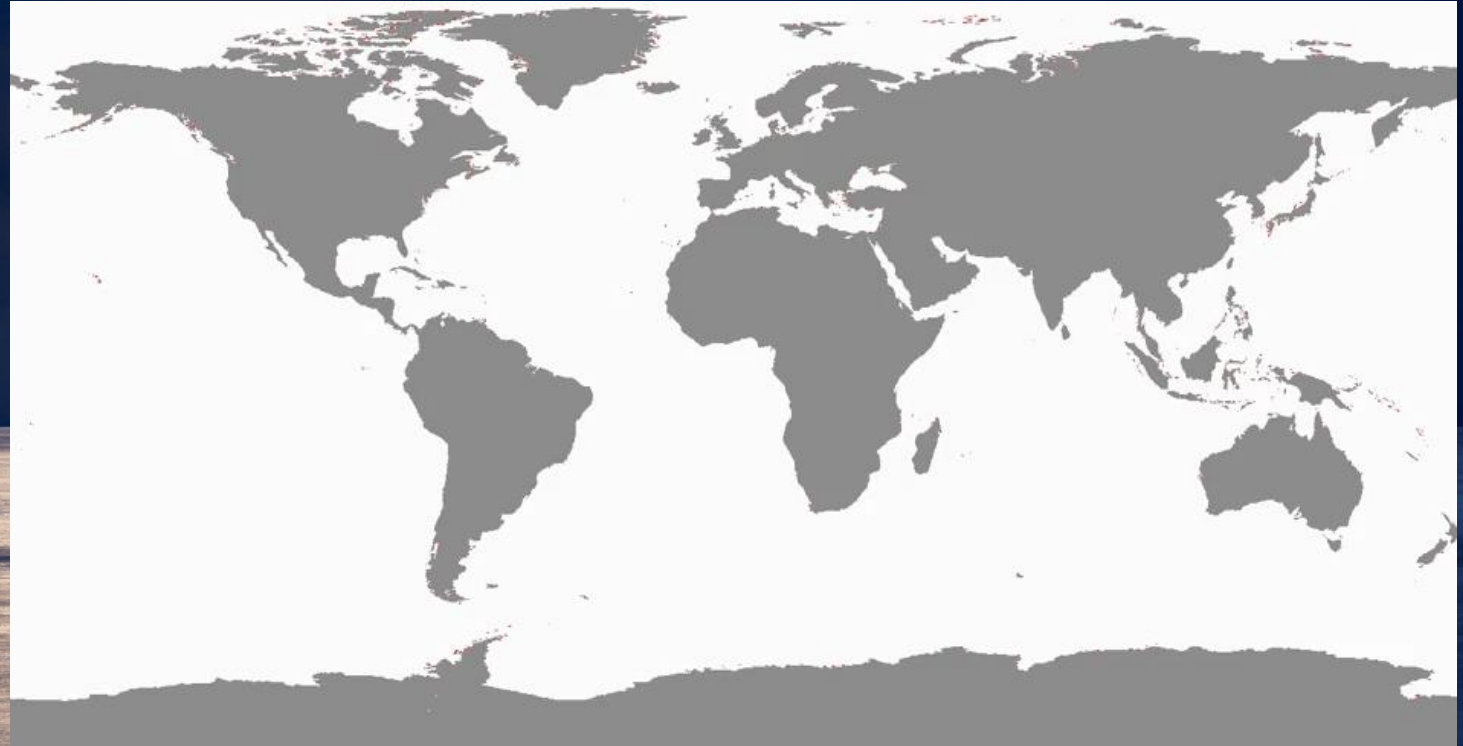
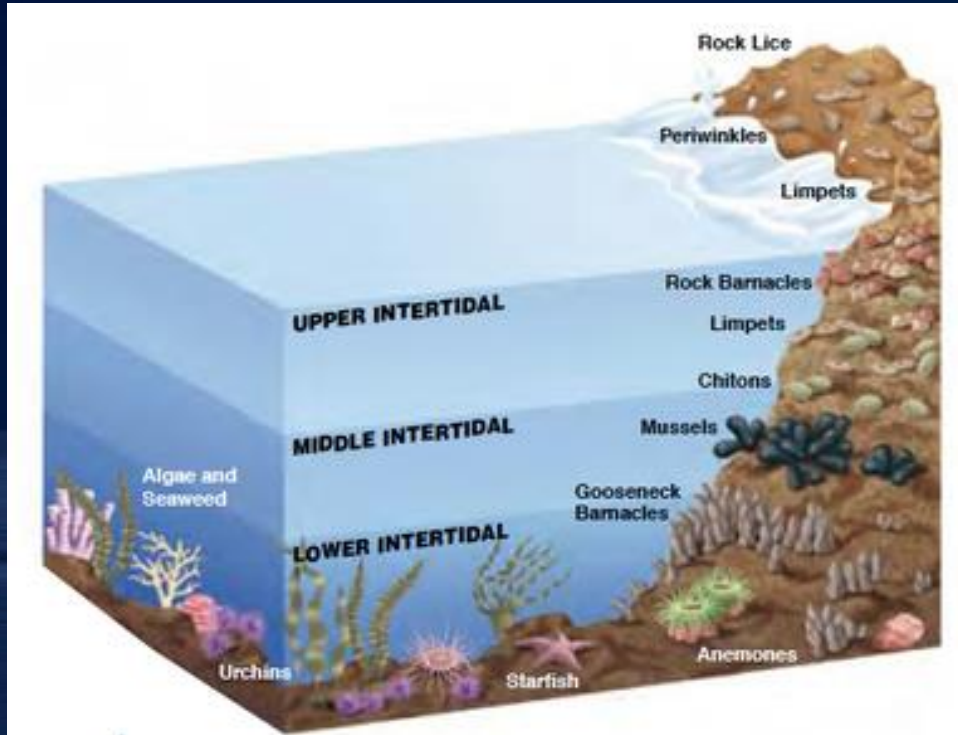
oceanservice.noaa.gov

[How frequent are tides? \(noaa.gov\)](https://oceanservice.noaa.gov)

TIDES

Amplification of tides is due to resonance with continental shelf, coastline configuration, narrow straits.

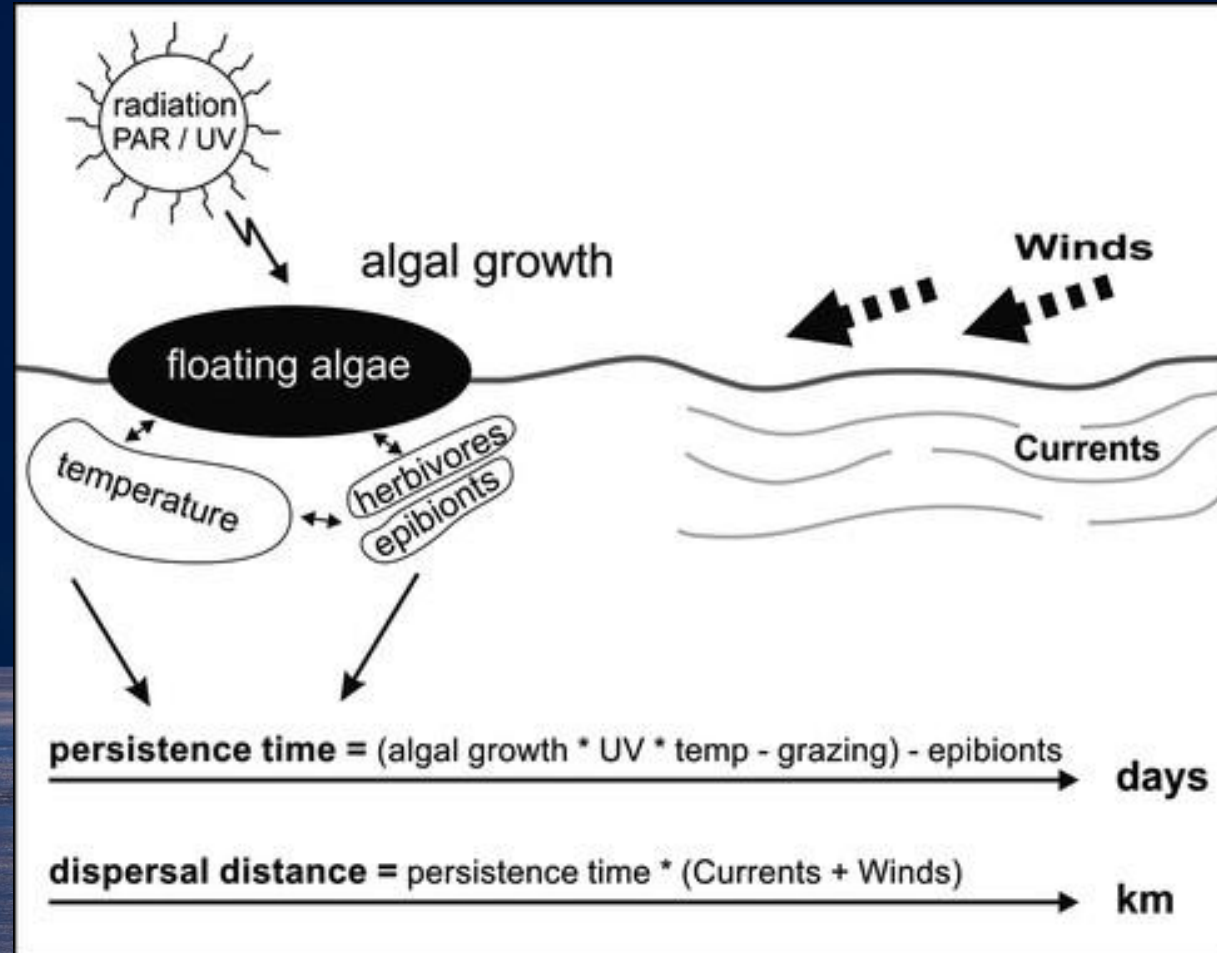
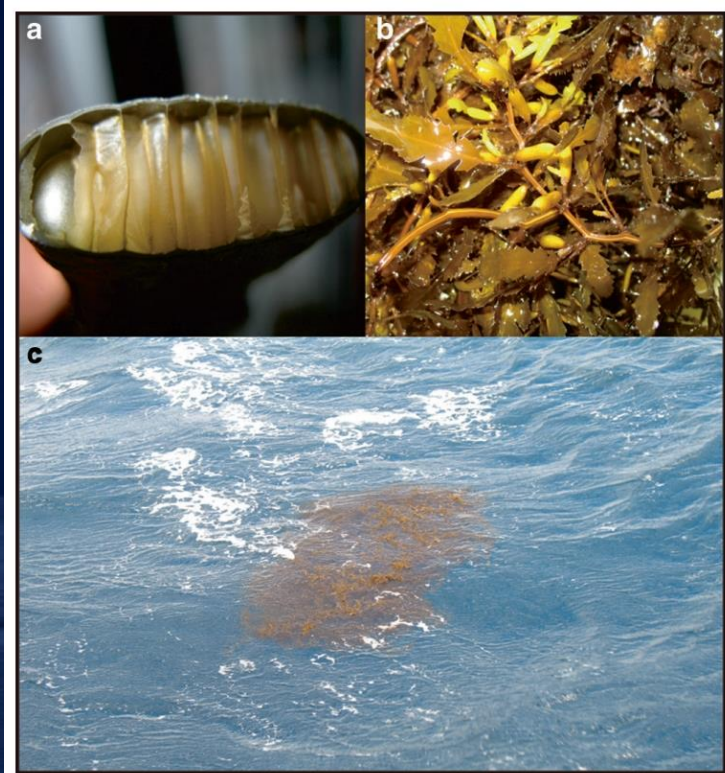
https://www.youtube.com/watch?v=tcGEjzt_4is



Simulation

[Intertidal Areas: The Intertidal Zone - Introduction to Intertidal Areas \(weebly.com\)](#)

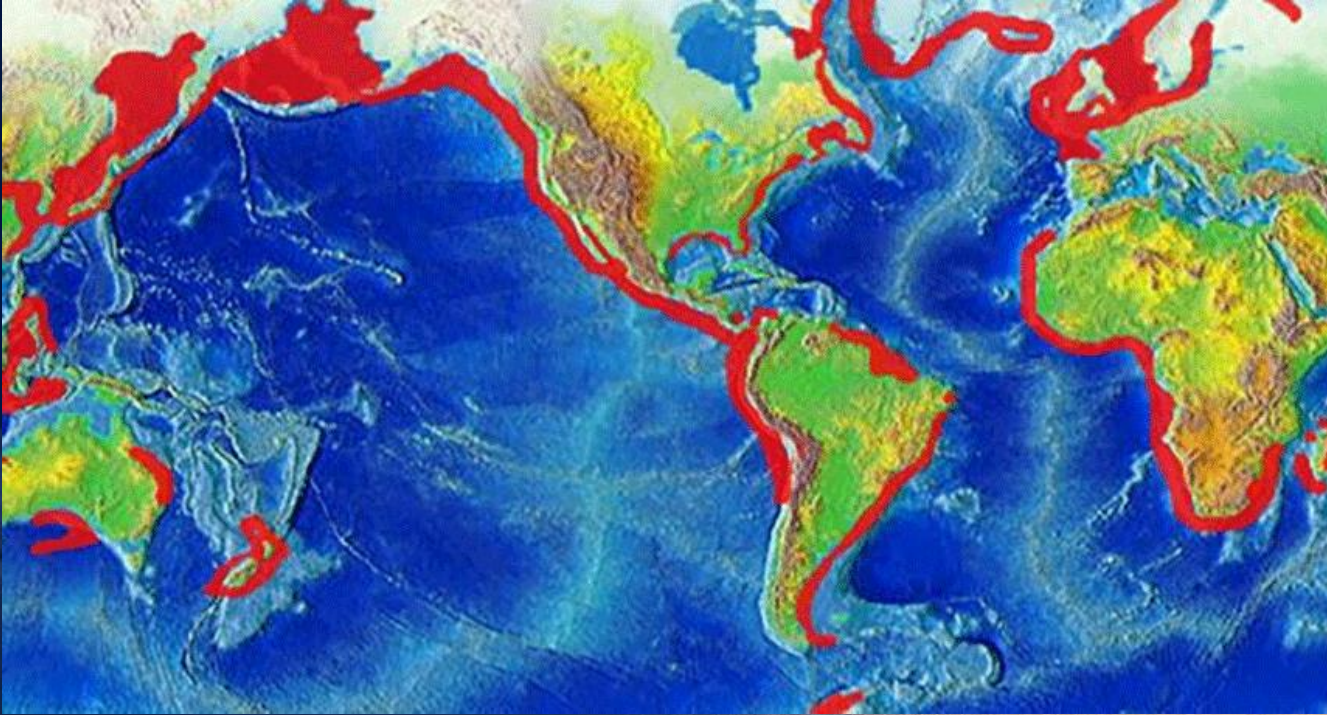
CURRENTS



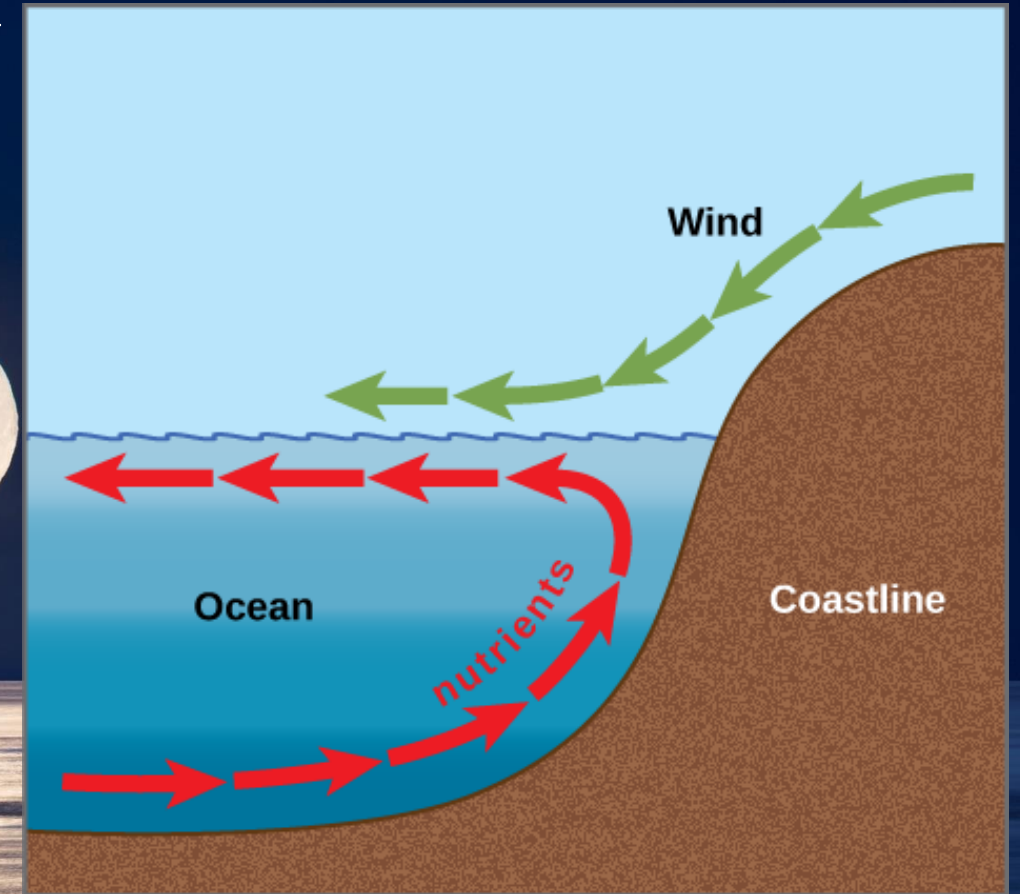
- Horizontal circulation in all the major ocean basins are known as gyres
- Large ones in the sub-Tropical Pacific and Atlantic Ocean
- Clockwise in Northern Hemisphere
- Driven by atmospheric circulation, Coriolis effect and coastal configuration

UPWELLING

Ocean Motion : Definition : Wind Driven
Surface Currents - Upwelling and
Downwelling



[Scientists Say: Upwelling \(snexplores.org\)](https://snexplores.org)



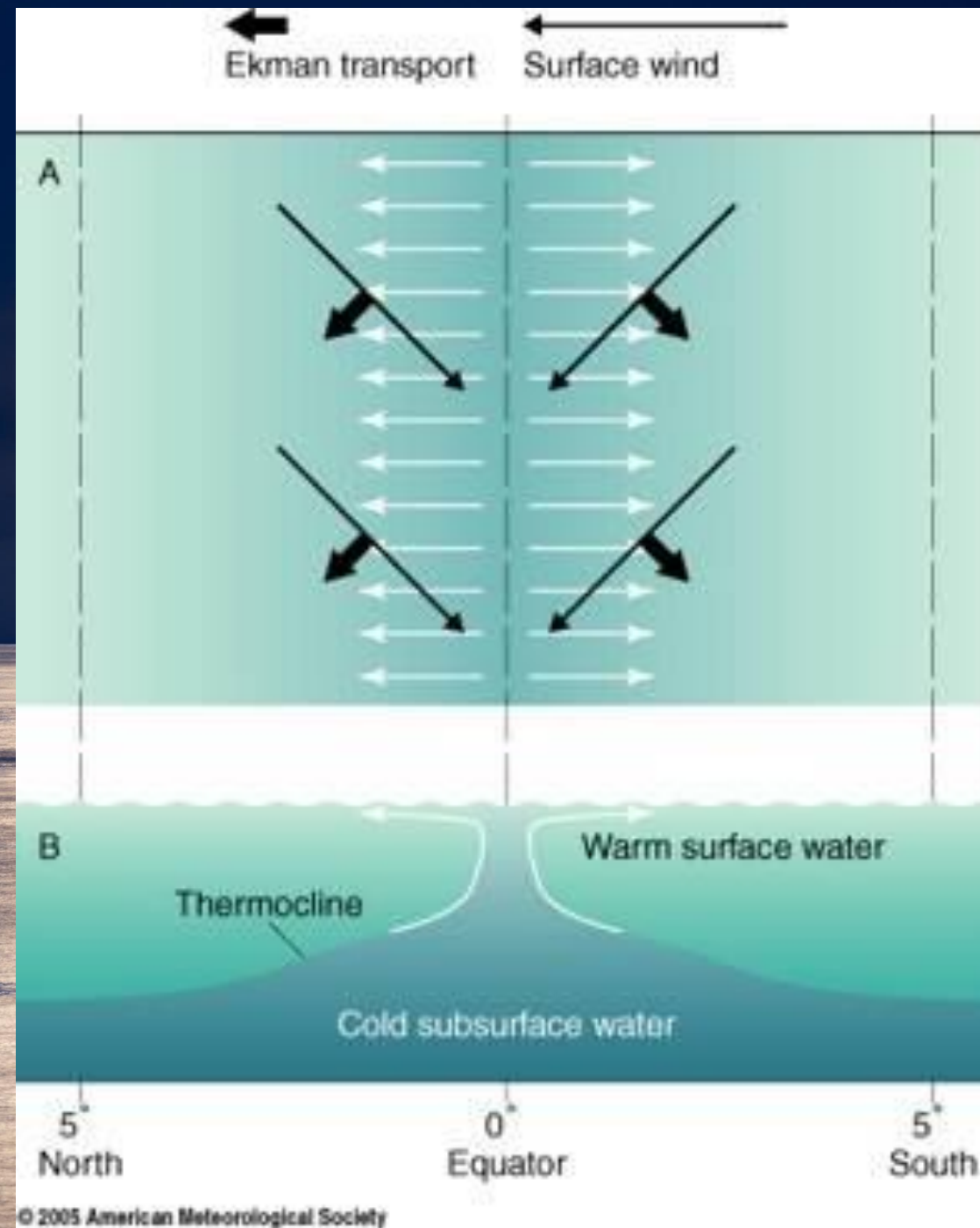
Ocean upwelling is an important process that recycles nutrients and energy in the ocean. As wind (green arrows) pushes offshore, it causes water from the ocean bottom (red arrows) to move to the surface, bringing up nutrients from the ocean depths.

UPWELLING

Equatorial upwelling. (A) In this plan view of the ocean from 5 degrees S to 5 degrees N, the **trade winds of the two hemispheres are shown to converge near the equator**. The consequent Ekman transport away from the equator gives rise to upwelling as shown in (B) a vertical cross section from 5 degrees S to 5 degrees N.

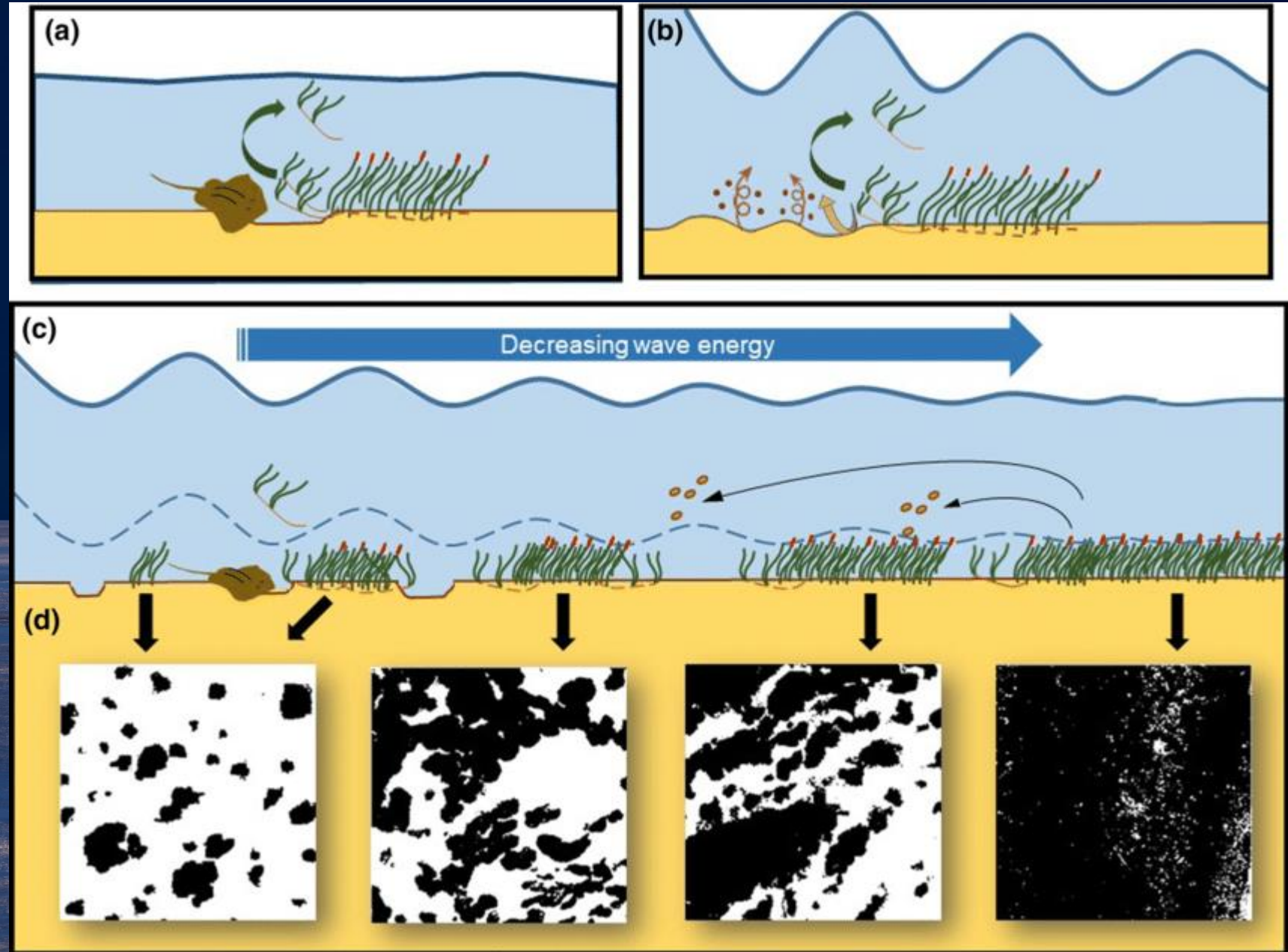
Ocean Motion : Definition : Wind Driven Surface Currents - Upwelling and Downwelling

Biotic and Abiotic Factors | Biology for Majors II (lumenlearning.com)



WAVES

- Constructive as well as destructive
- Coastlines are dynamic
- Cleansing, oxygenating and circulating nutrients
- Organism adaptation

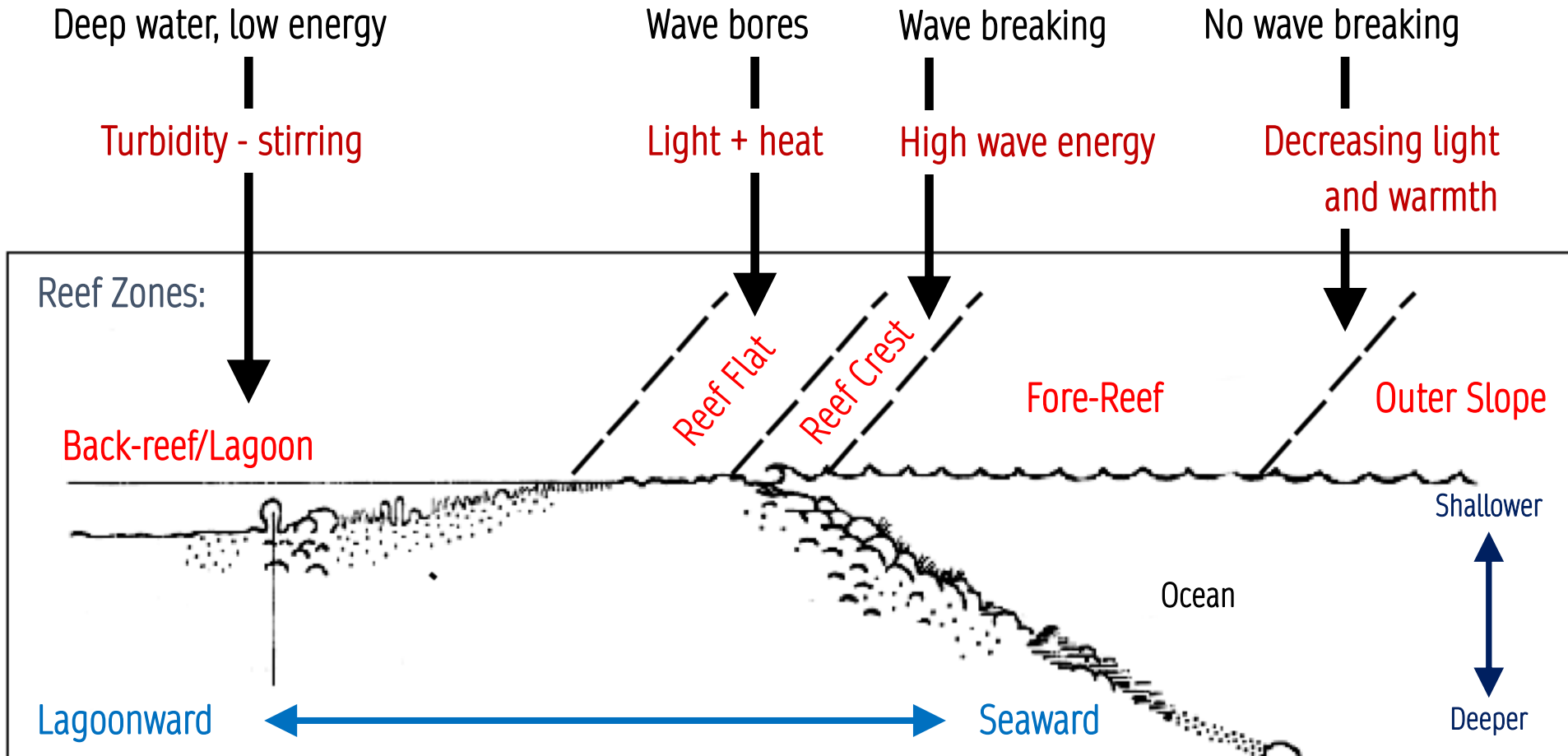


Coral morphology changes across a reef profile

Response to different stresses.

LAGOON

OCEAN



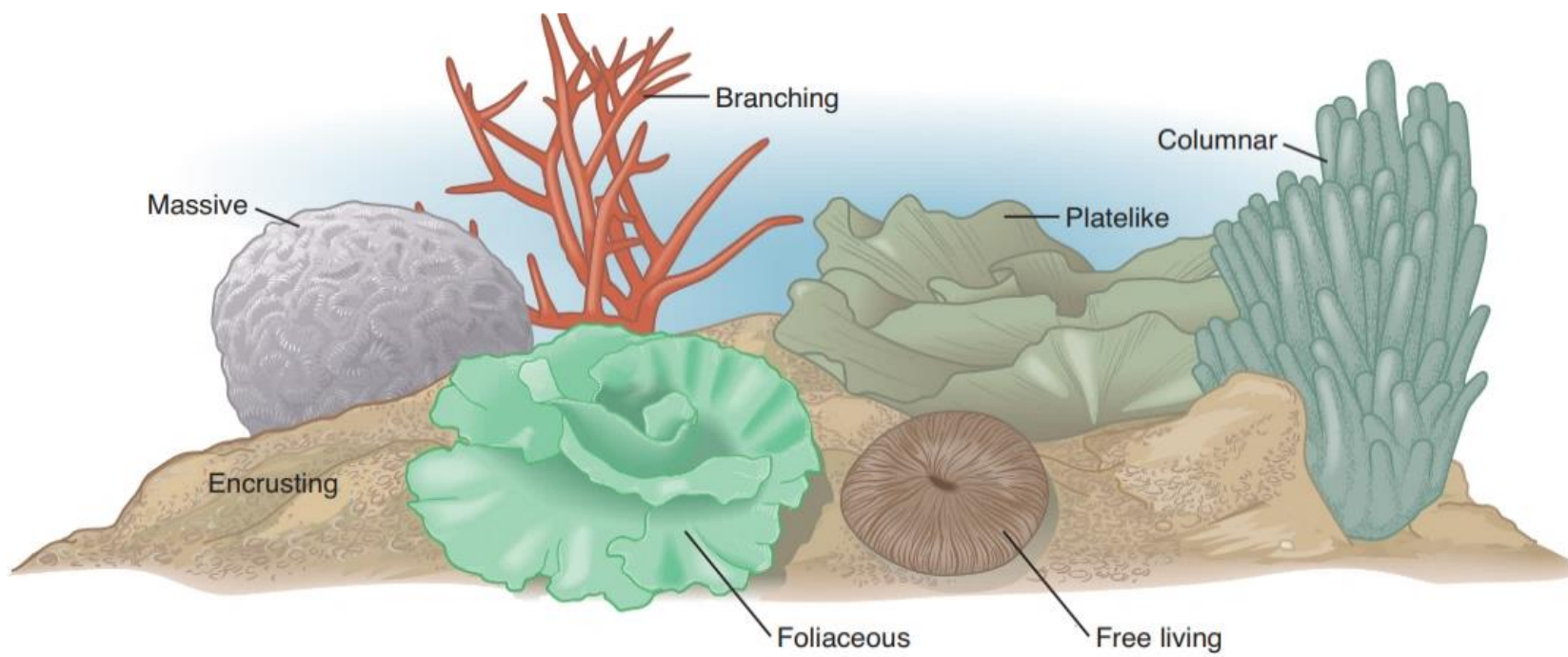
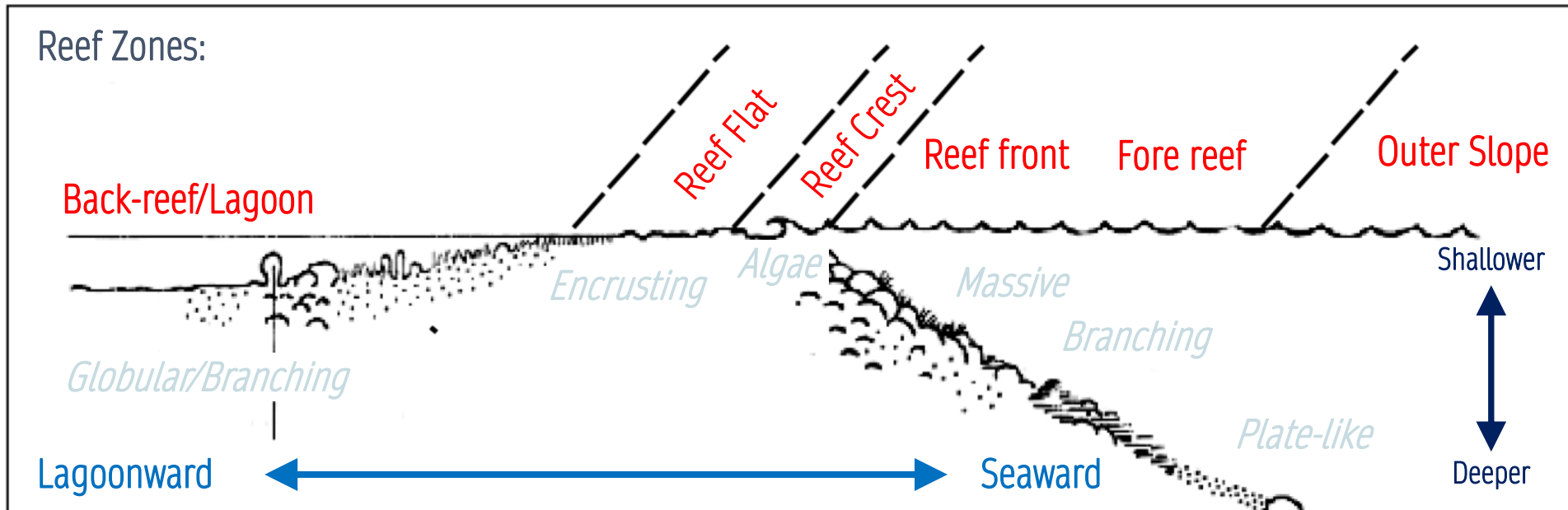
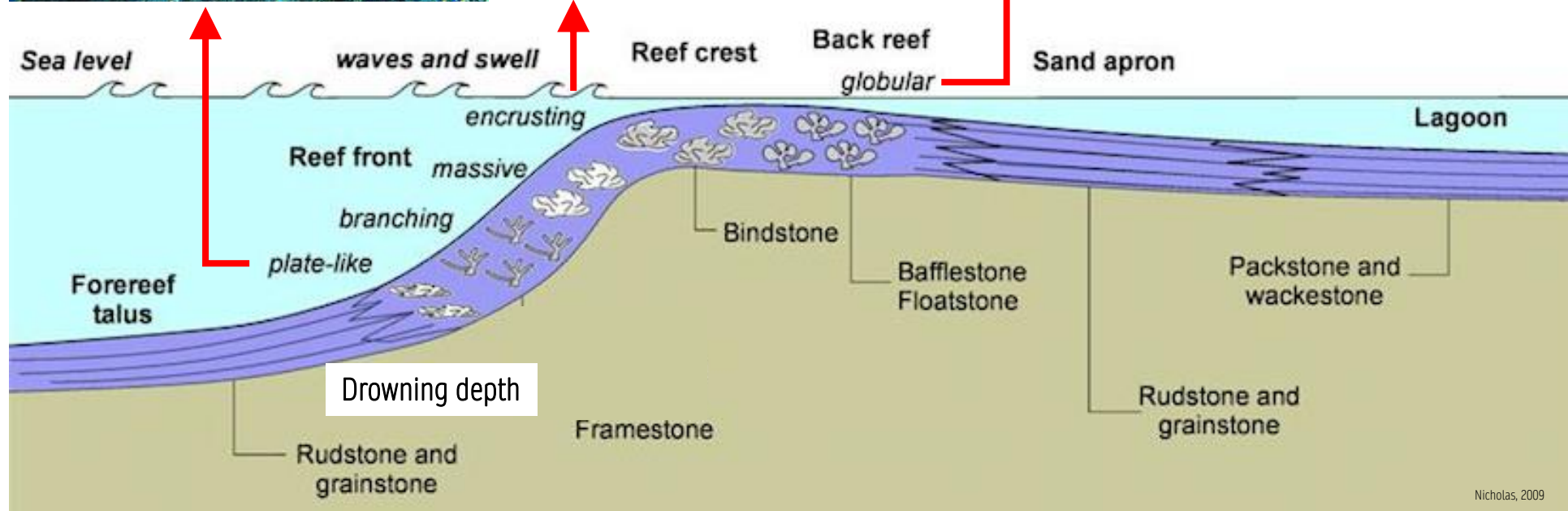
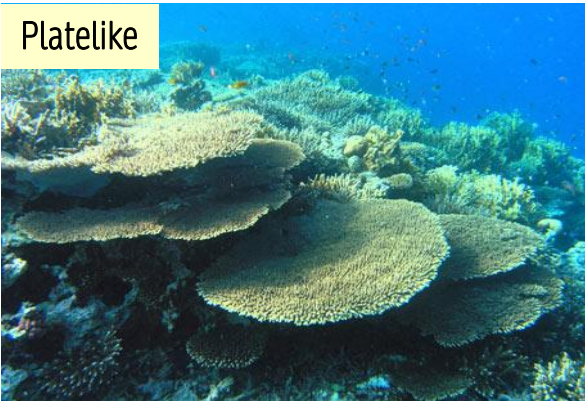
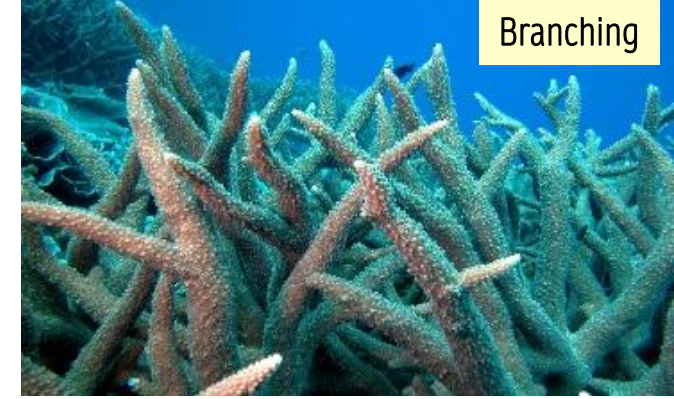


Figure 11.3 Corals exhibit a large variety of growth forms.

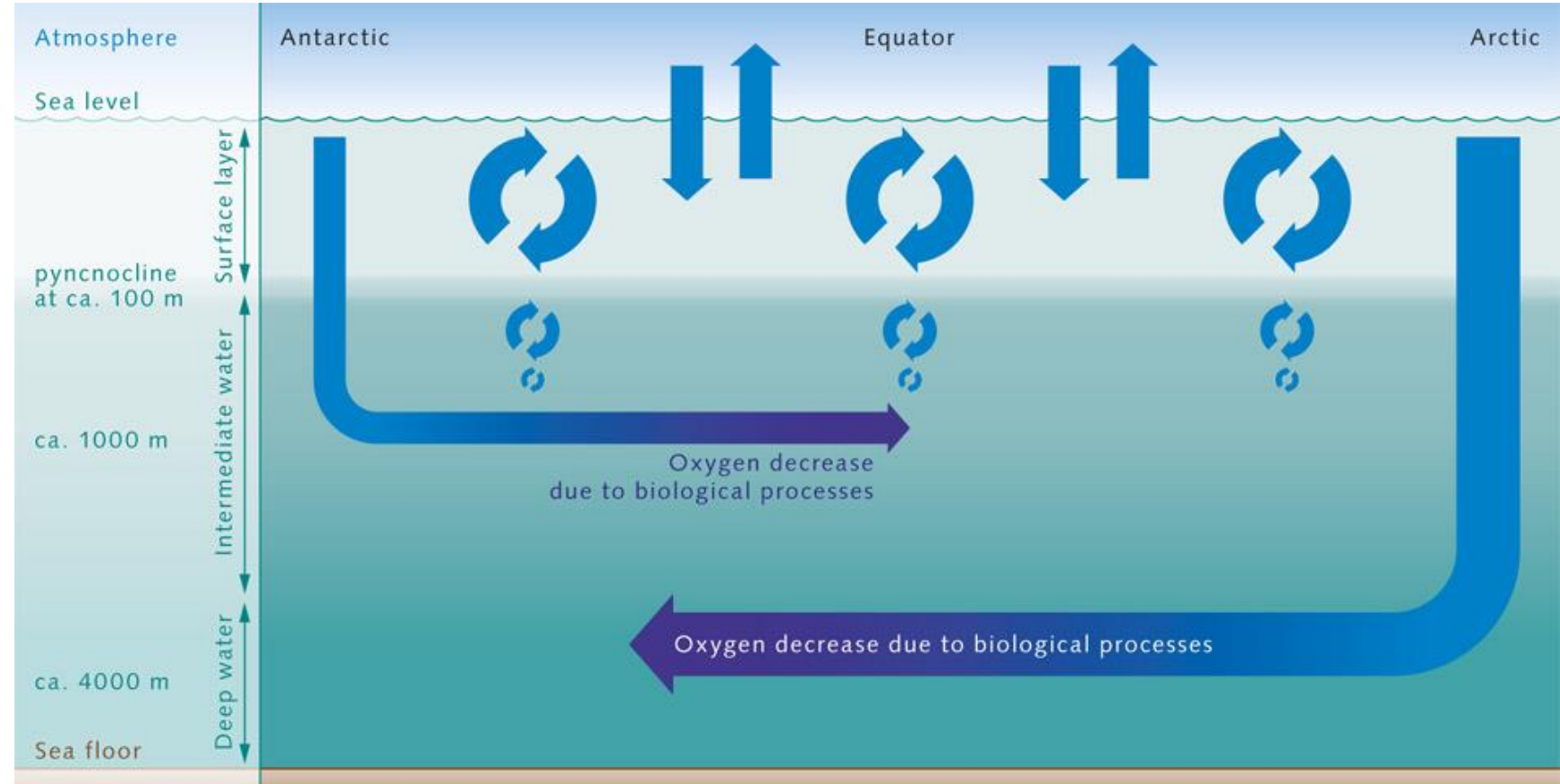




Dissolved Oxygen (DO)

Dissolved Oxygen (DO)

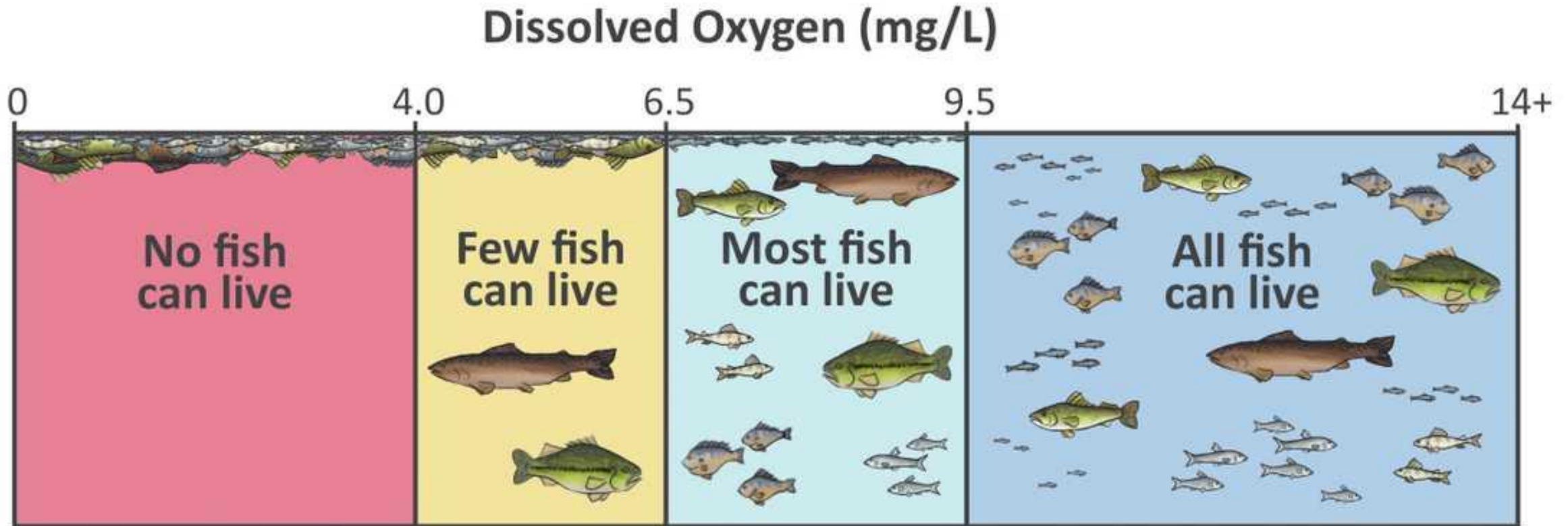
Oxygen from the atmosphere enters the near-surface waters of the ocean. This upper layer is well mixed, and is thus in chemical equilibrium with the atmosphere and rich in O_2 . It ends abruptly at the pycnocline, which acts like a barrier.



The oxygen rich water in the surface zone does not mix readily with deeper water layers.

Dissolved Oxygen (DO)

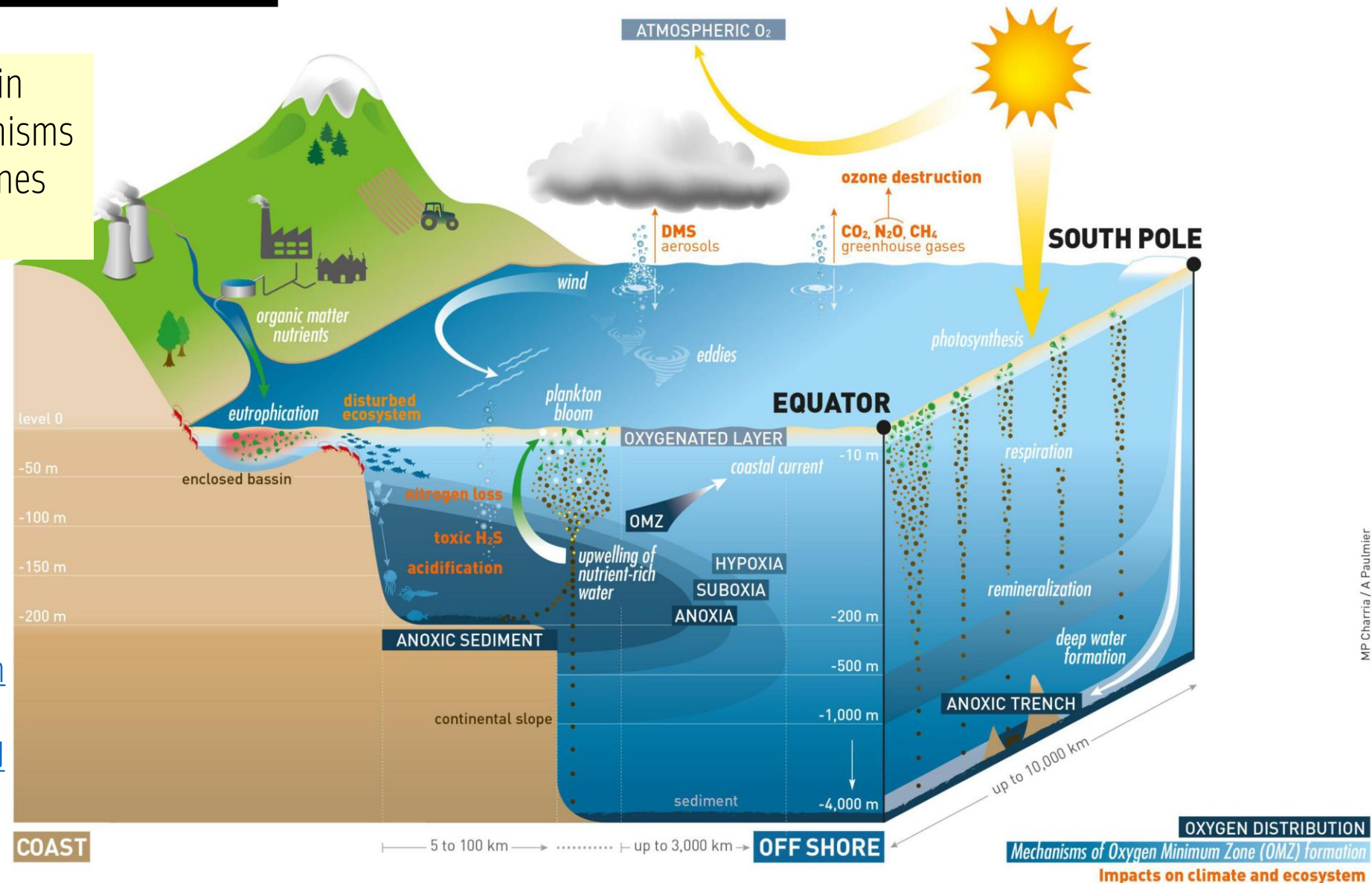
Dissolved Oxygen (DO) Measures of dissolved oxygen (DO) refer to the amount of oxygen contained in water, and define the living conditions for oxygen-requiring (aerobic) aquatic organisms.



Dissolved Oxygen (DO)

Dissolved Oxygen (DO) in the oceans and mechanisms of Oxygen Minimum Zones (OMZ).

OXYGEN IN THE OCEAN



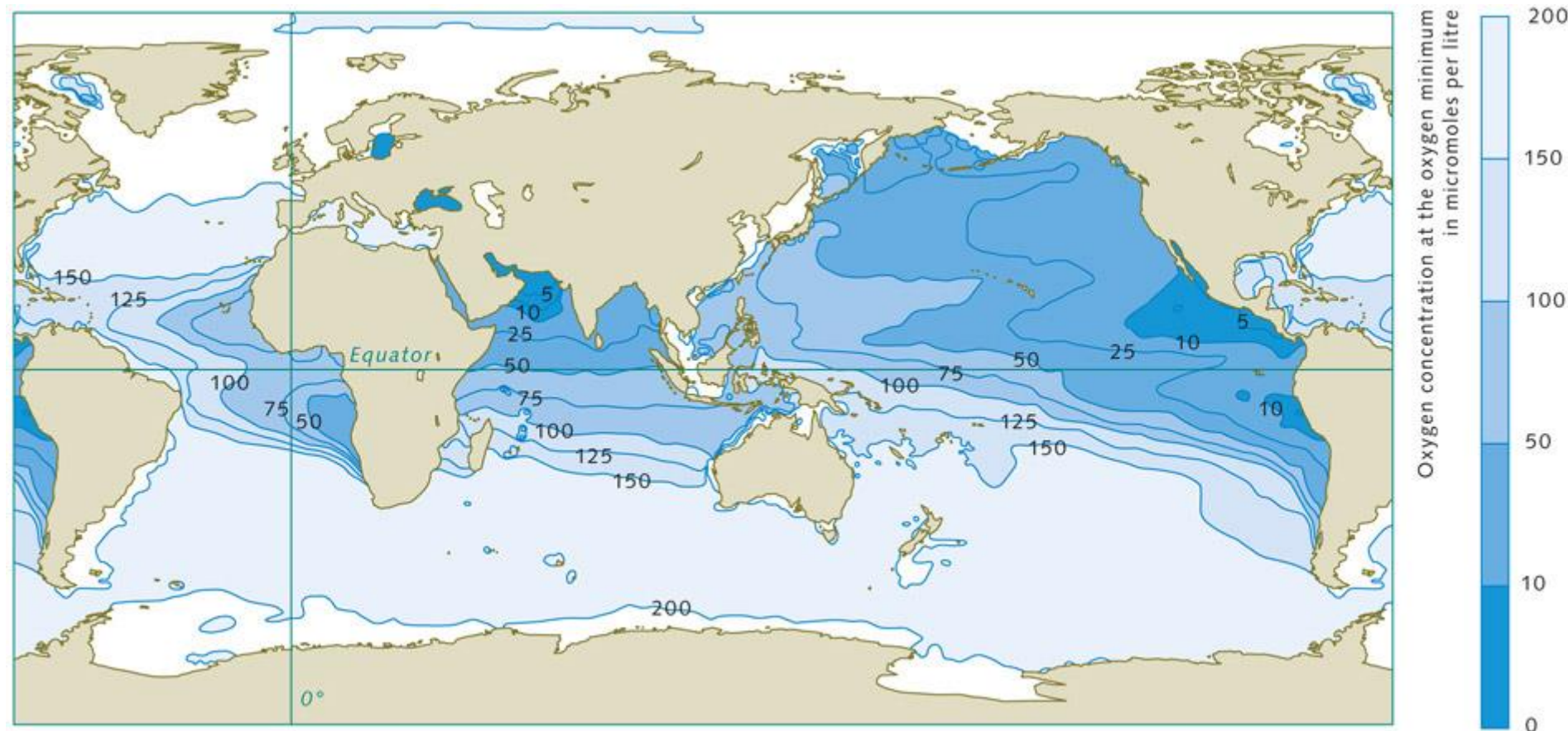
[Frontiers | A Global Ocean Oxygen Database and Atlas for Assessing and Predicting Deoxygenation and Ocean Health in the Open and Coastal Ocean \(frontiersin.org\)](https://frontiersin.org)

Oxygen Deficiency

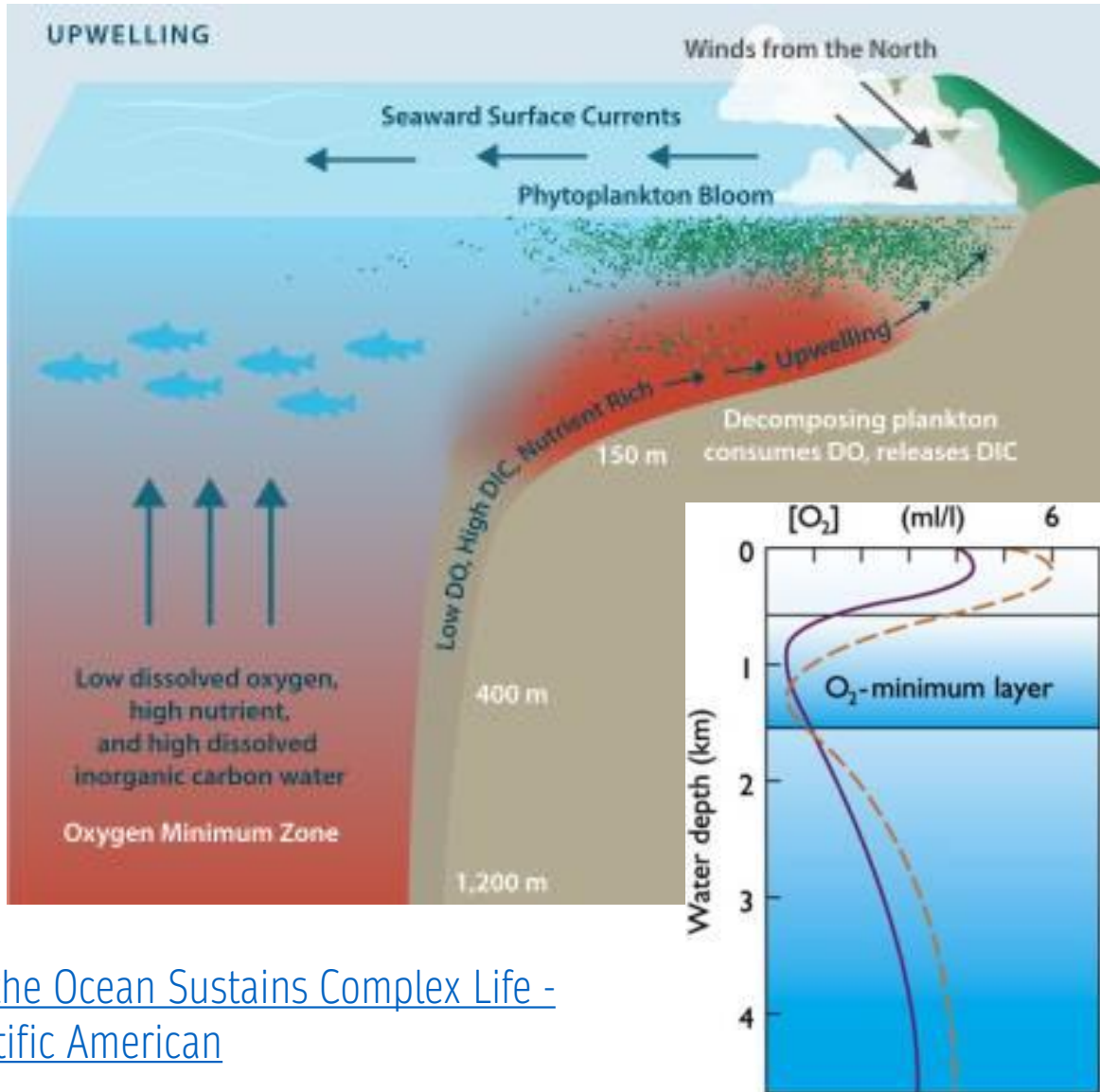
Marine regions with oxygen deficiencies are **completely natural** and are mainly located in the mid-latitudes on the west sides of the continents. There is very little mixing here of the warm surface waters with the cold deep waters, so not much oxygen penetrates to greater depths

In addition, high bioproductivity and the resulting large amounts of sinking biomass here lead to strong oxygen consumption at depth, - especially between 100 and 1000 metres

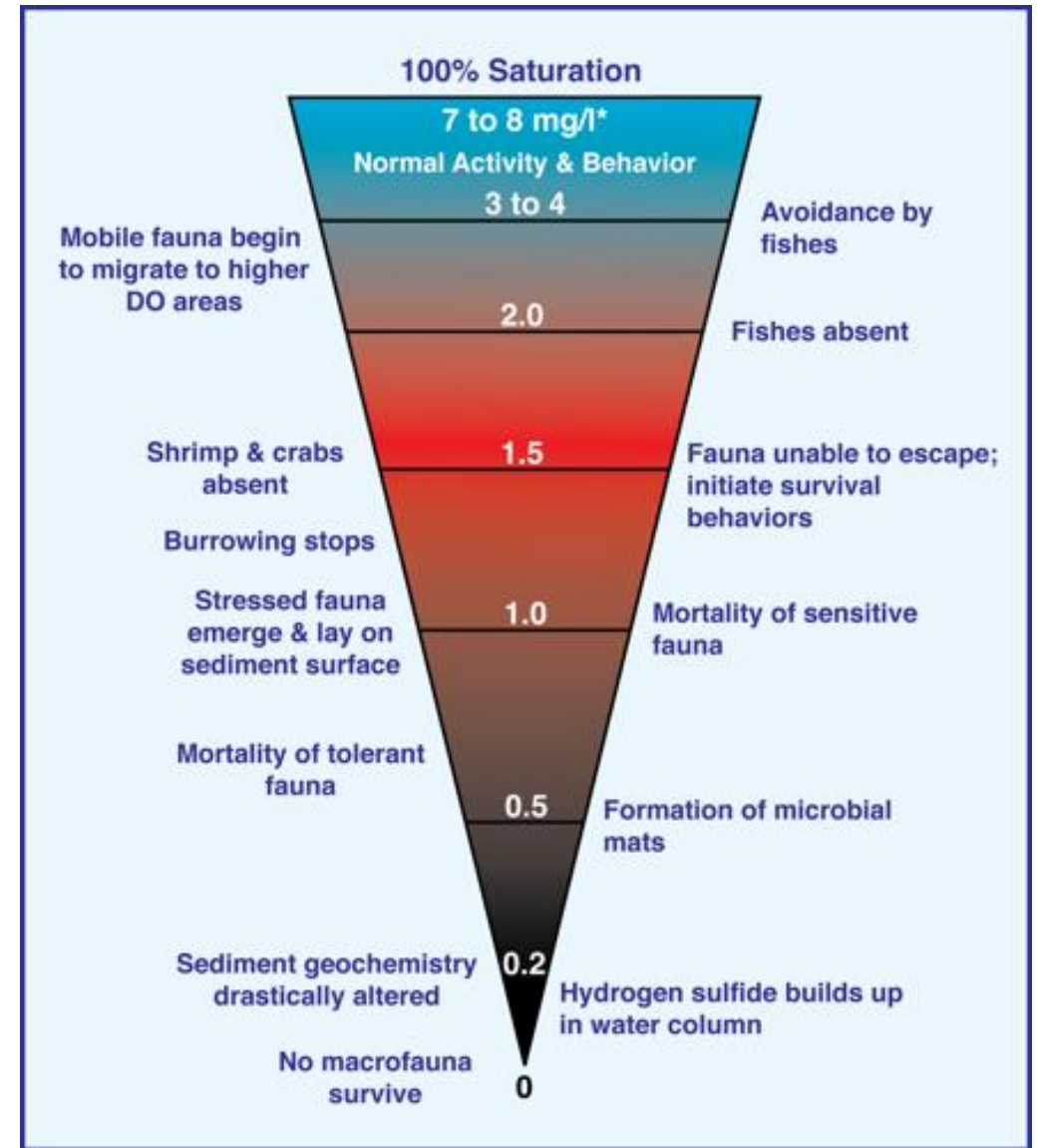
[Oxygen « World Ocean Review](#)



Dead Zones



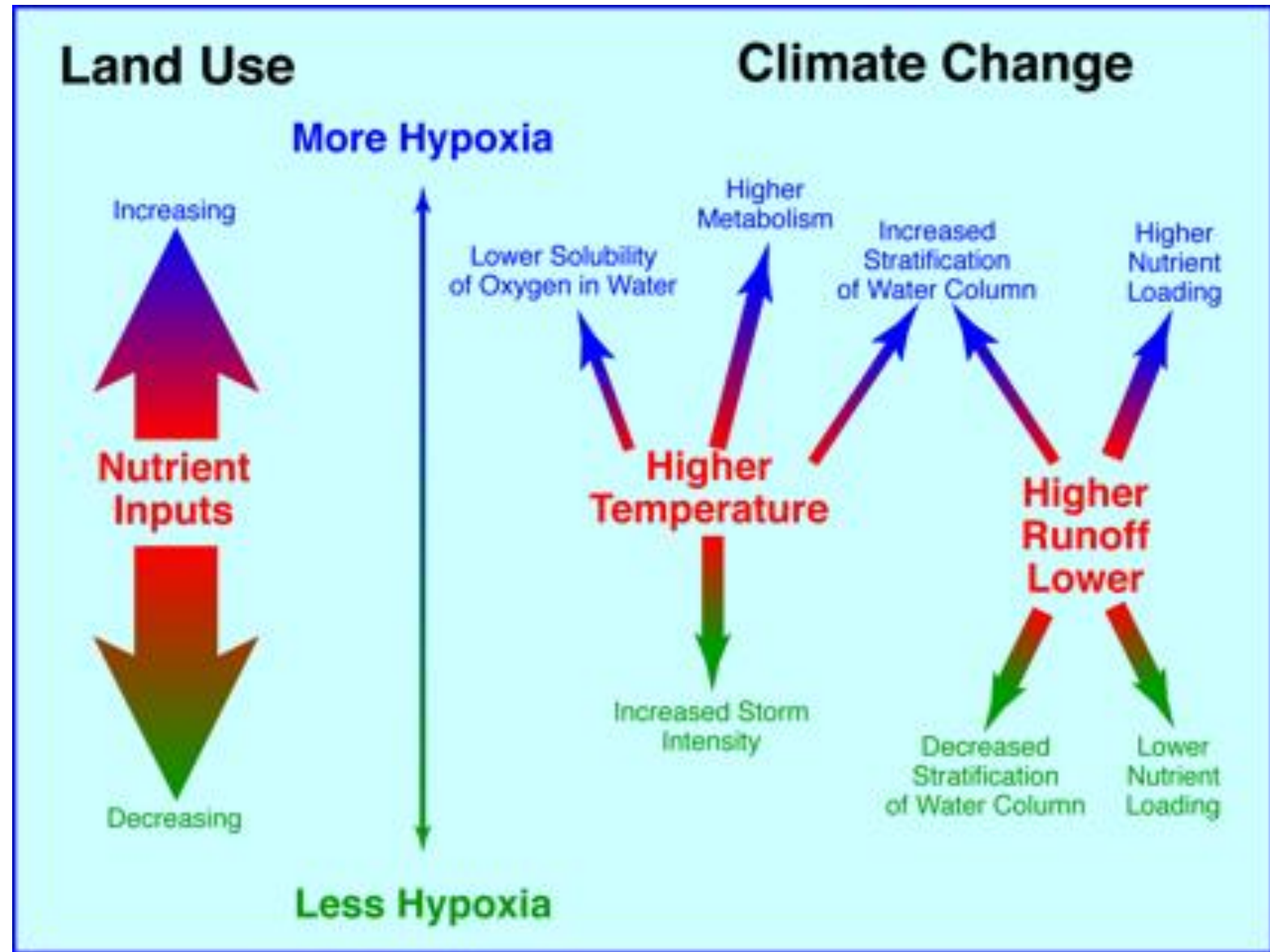
[How the Ocean Sustains Complex Life - Scientific American](#)



[Impacts | Virginia Institute of Marine Science \(vims.edu\)](#)

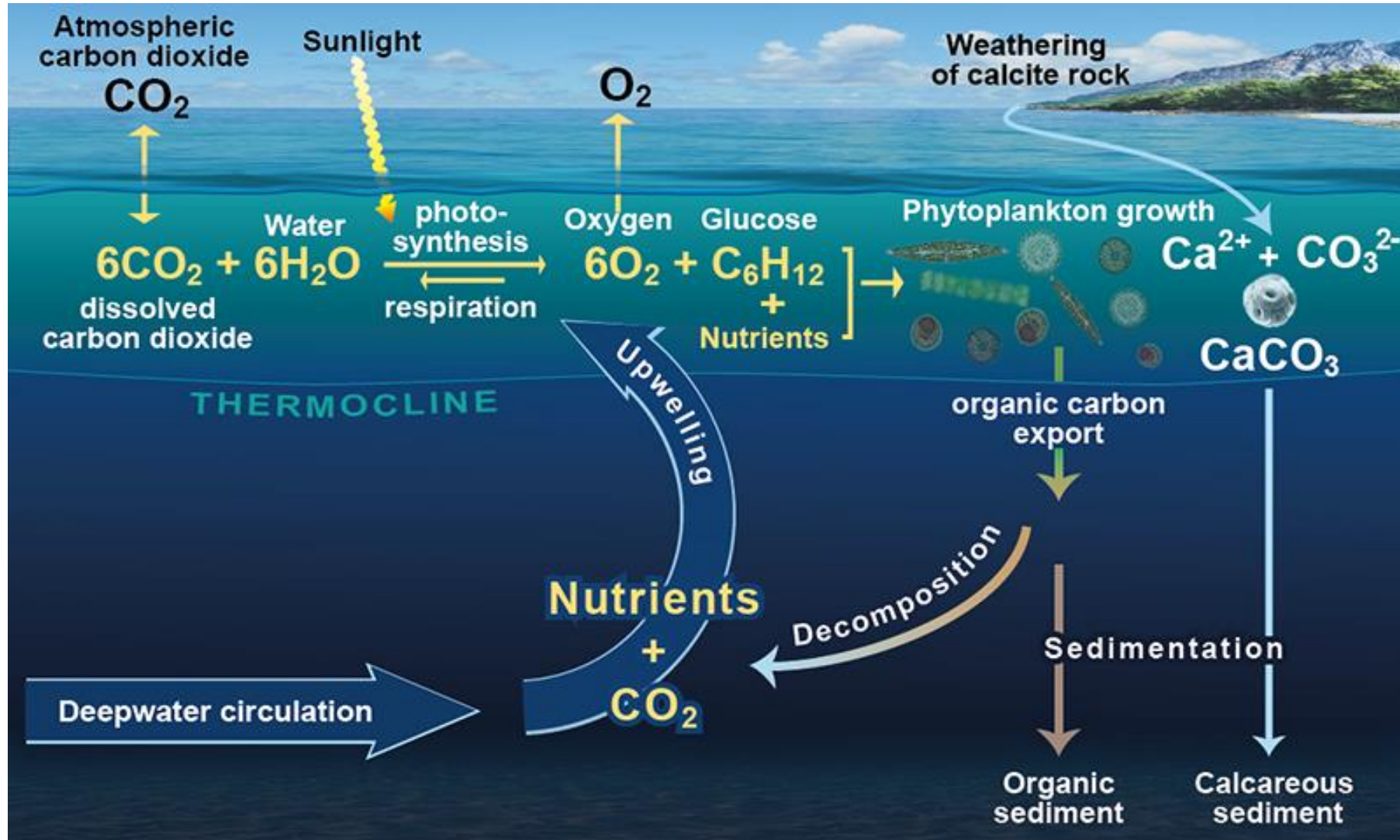
Oxygen Cycle and Climate Change

- Warmer waters hold less oxygen than cooler water, thus making it easier for dead zones to form
- Warmer waters will increase metabolism of marine creatures, thereby increasing their need for oxygen
- Warmer temperatures and increased runoff of freshwater will increase stratification of the water column, thus further promoting the formation of dead zones
- Increased runoff will also increase nutrient inputs into coastal waterbodies



[Dead Zones and Climate Change | Virginia Institute of Marine Science \(vims.edu\)](http://vims.edu)

Oxygen Cycle and Nutrients



pH

Measures concentration of hydrogen ions in solution

Scale 0-14

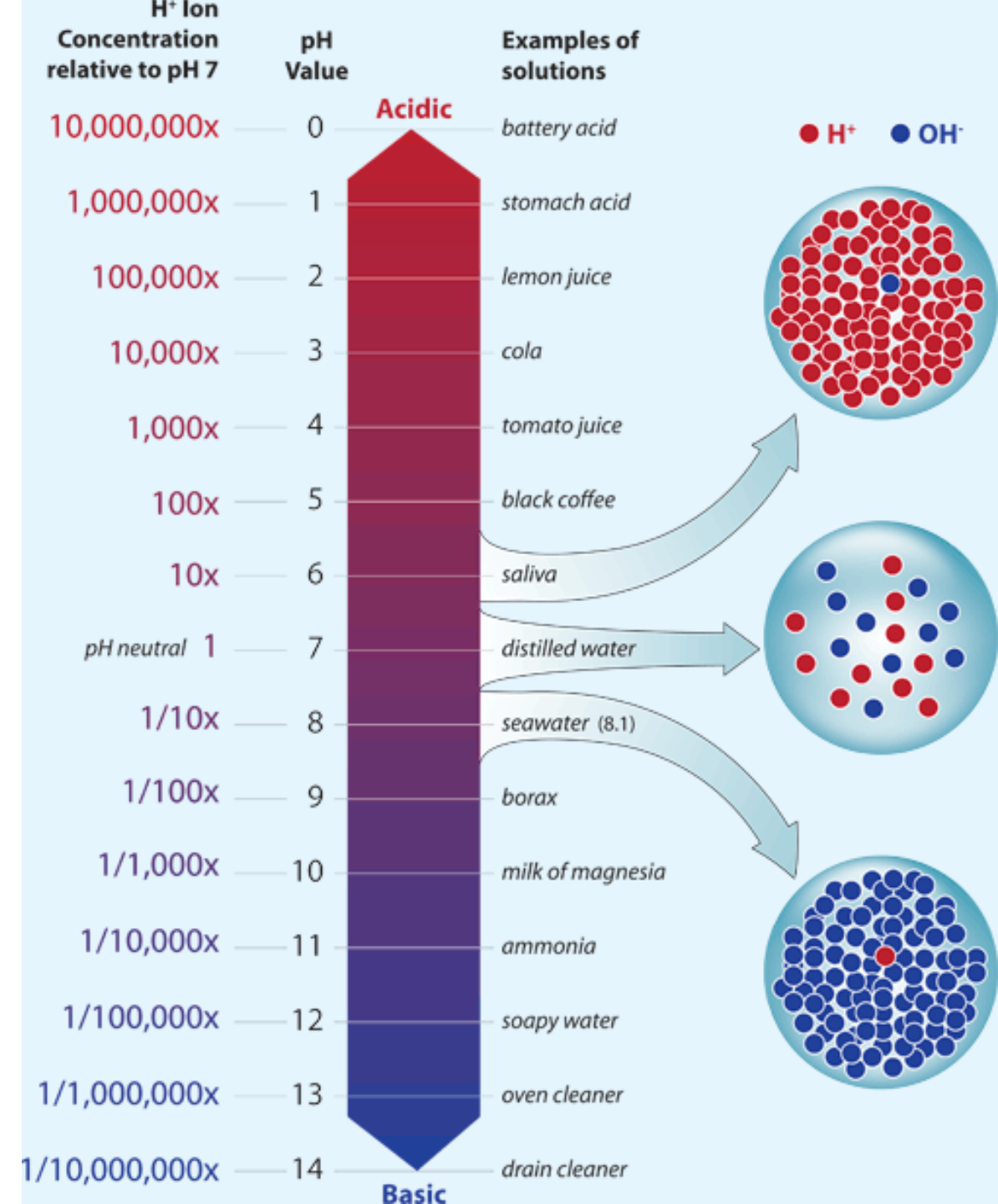
Logarithmic scale – each change of 1.0 represents a factor of 10.

pH 3.0 is ten times more acidic than pH 4.0

Average pH seawater is 8.2

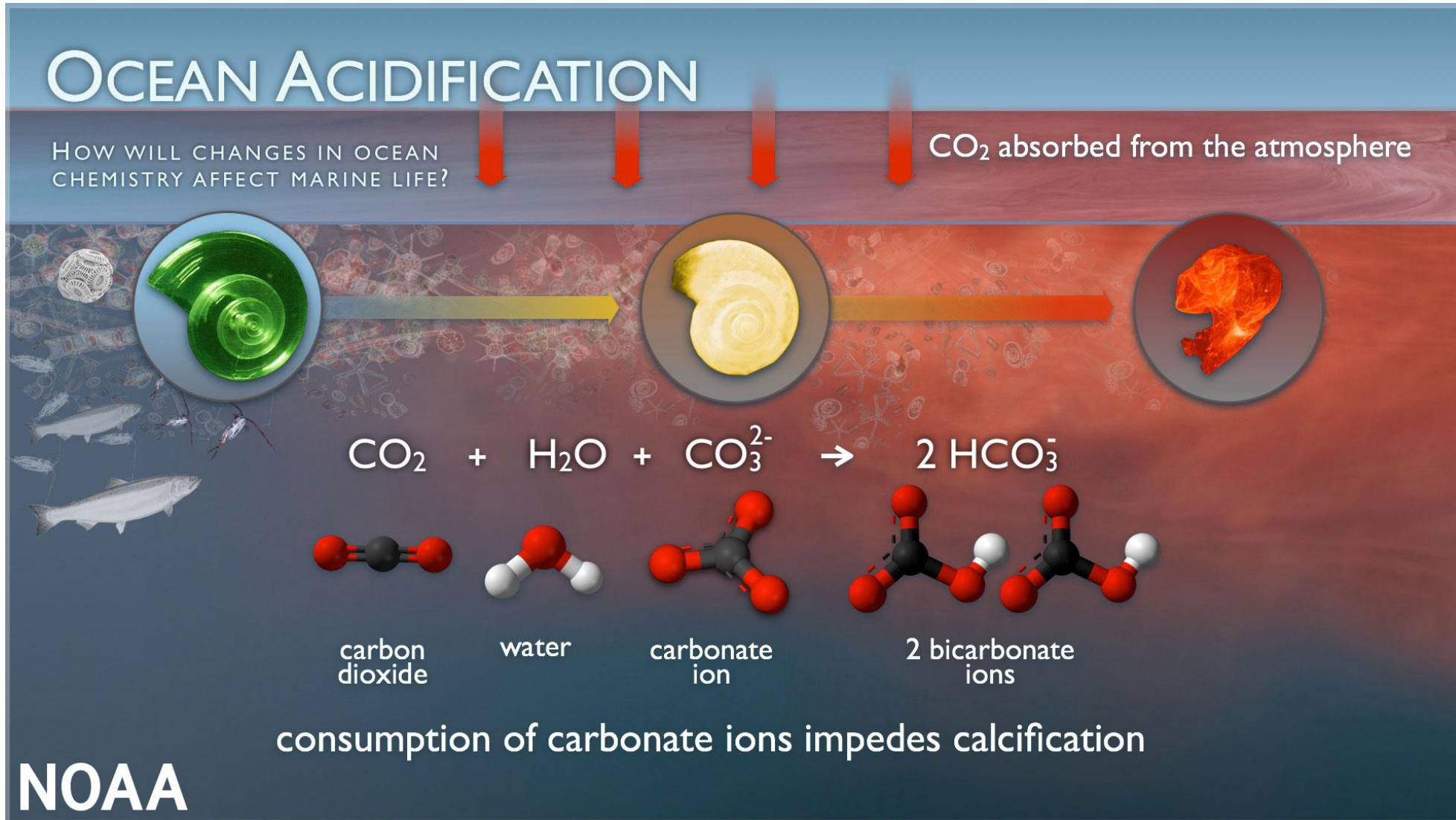
Seawater does not alter pH appreciably – natural buffer

pH above 9.0 or below 5.0 – survival rates fall



pH and Ocean Acidification

In the 200-plus years since the industrial revolution began, the pH of surface ocean waters has fallen by 0.1 pH units. This might not sound like much, but the pH scale is logarithmic, so this change represents approximately a **30 percent** increase in acidity.

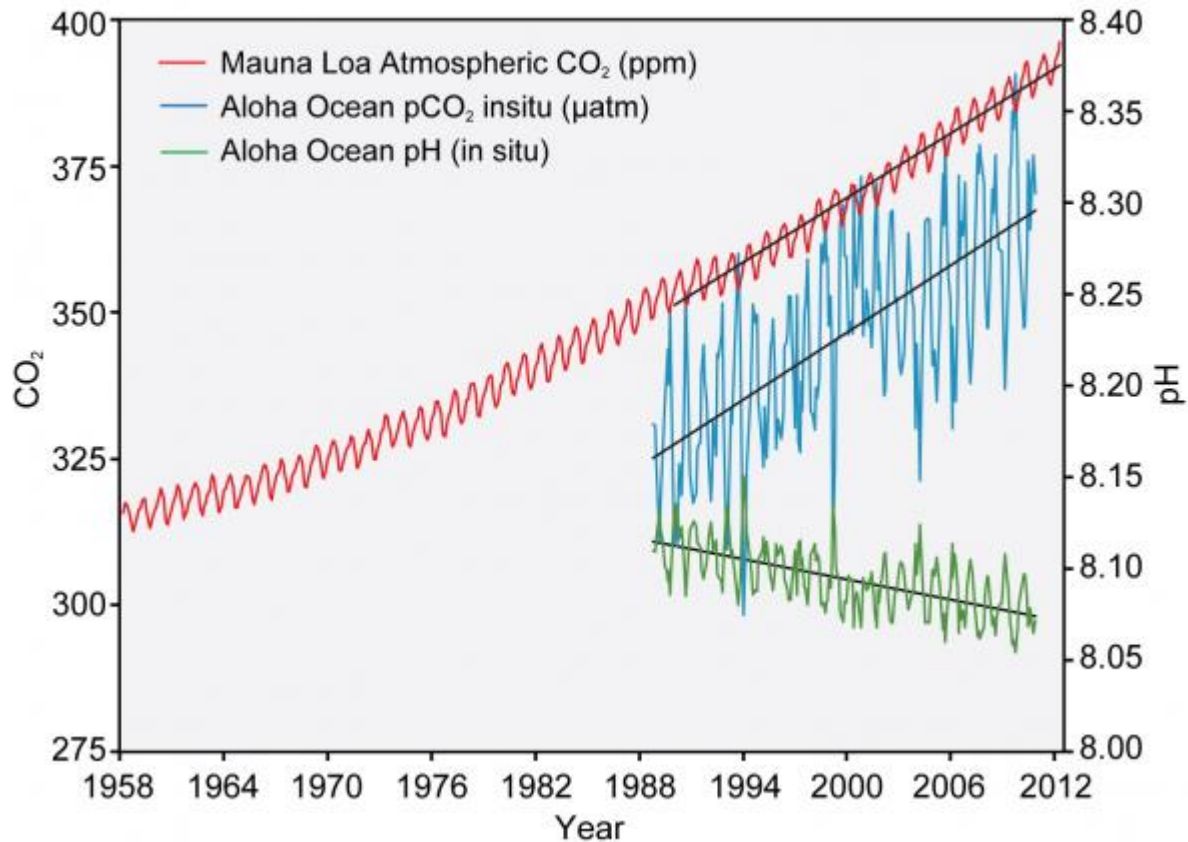


[Ocean acidification](https://www.noaa.gov/ocean/ocean-acidification)
[| National Oceanic and Atmospheric Administration](https://www.noaa.gov/ocean/ocean-acidification)
 [\(noaa.gov\)](https://www.noaa.gov/ocean/ocean-acidification)

pH and Ocean Acidification

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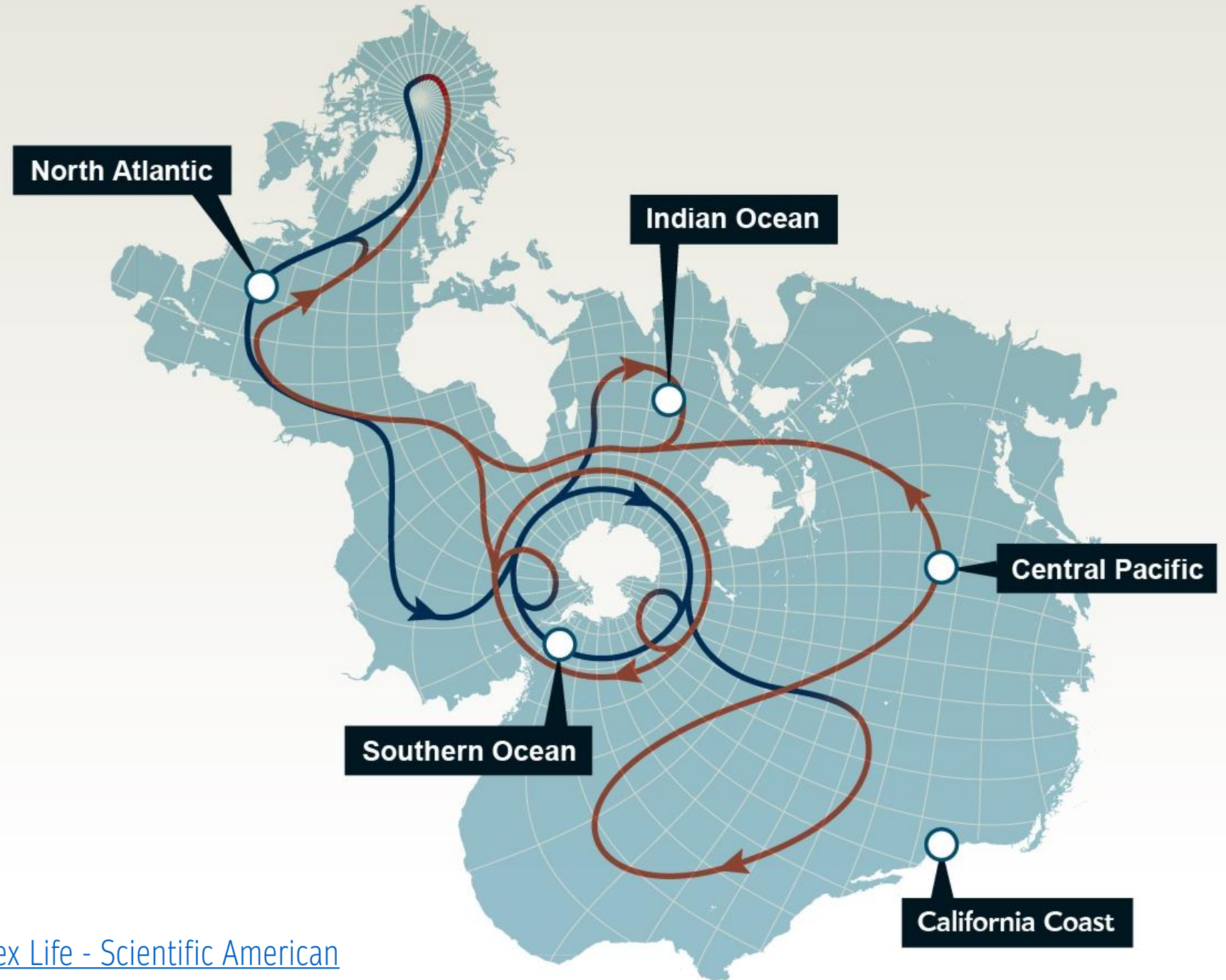
As Oceans Absorb CO₂, They Become More Acidic



[As Oceans Absorb CO₂, They Become More Acidic | GlobalChange.gov](http://GlobalChange.gov)

Abiotic Factors in Oceans

Interplay of many different gradients and abiotic factors



Abiotic Factors in Oceans

Interplay of many different gradients and abiotic factors

[How the Ocean Sustains Complex Life - Scientific American](#)

Salinity

Salinity, in practical salinity units (psu)

33.2 **Low** **High** 36.7

The North Atlantic is the saltiest ocean, particularly near the surface. Trade winds carry away evaporating moisture, and there are influxes of very salty water from the Mediterranean Sea and from the Arctic, where salt is left behind when water freezes.

Nitrogen

Each sphere indicates a measurement at that depth; more measurements have been made in the top few hundred meters of the water column.

● 42.7 micromoles per kilogram
● 0.04 $\mu\text{mol/kg}$

Surface water tends to be low in nitrogen because the element is consumed by the many photosynthesizing phytoplankton there. In the Southern Ocean, water that is more uniformly dense from top to bottom helps to distribute nitrogen evenly.

Temperature

0.5°C/32.9°F **Cold** **Hot** 26.1°C/79.0°F

Warm water reaches deeper in equatorial regions such as the Indian Ocean. The transition between warmer surface waters and colder deep waters happens at increasingly shallower depths toward the poles (Southern Ocean). On average, worldwide temperature in the top 700 meters has risen by about 0.8 degree Celsius since 1971.

Dissolved Oxygen

Each bubble represents a sample analyzed from a discrete depth.

○ 316 $\mu\text{mol/kg}$
○ 11 $\mu\text{mol/kg}$

Oxygen levels are high at the surface, where water mixes with air and photosynthesis is extensive. Low concentrations occur wherever bacteria consume too much oxygen as they decompose small creatures. Colder water, as in the Southern Ocean, can contain much more oxygen by volume. In the past 50 years oxygen levels worldwide have decreased an average of 2 percent, and levels in some tropical regions have dropped by up to 40 percent because of warming.

Light Penetration

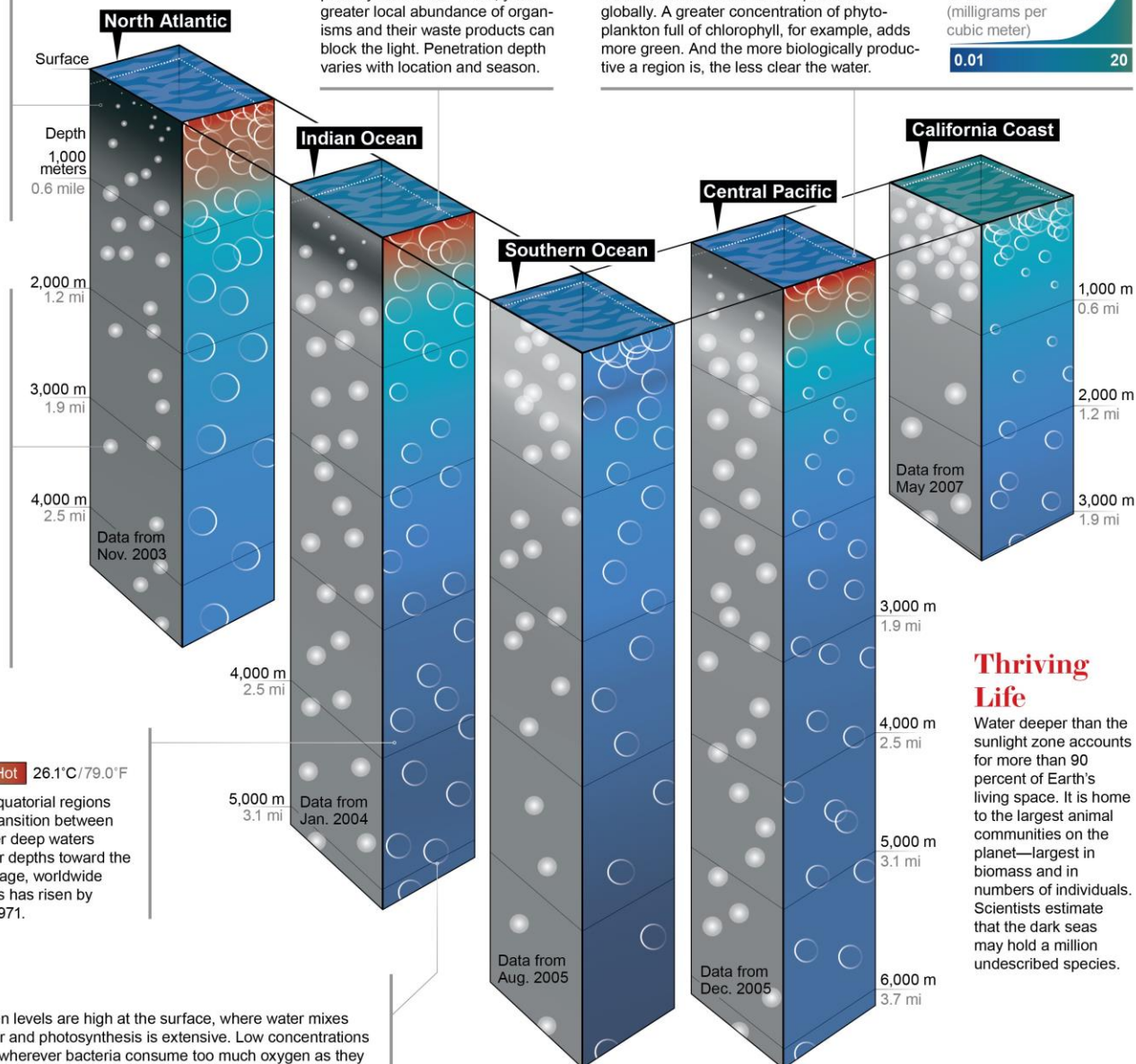
Sunlight determines how deep photosynthesis can occur, yet a greater local abundance of organisms and their waste products can block the light. Penetration depth varies with location and season.

Surface Color

"Aqua blue" is an appealing vision, but the ocean's surface color varies quite a bit globally. A greater concentration of phytoplankton full of chlorophyll, for example, adds more green. And the more biologically productive a region is, the less clear the water.

Surface Chlorophyll Concentration (milligrams per cubic meter)

0.01 **20**



Thriving Life

Water deeper than the sunlight zone accounts for more than 90 percent of Earth's living space. It is home to the largest animal communities on the planet—largest in biomass and in numbers of individuals. Scientists estimate that the dark seas may hold a million undescribed species.

Sources: World Ocean Atlas 2018, by Tim P. Boyer et al., NOAA National Centers for Environmental Information, <https://www.ncei.noaa.gov/archive/accession/NCEI-WOA18>. Accessed June 2022 (data plotted on columns); "Global Maps of Forel-Ule Index, Hue Angle and Secchi Disk Depth Derived from 21 Years of Monthly ESA Ocean Colour Climate Change Initiative Data," by Jaime Pitarich et al., in *Earth System Science Data*, Vol. 13; February 2021 (photoc zone reference); "A World of Chlorophyll," image created by Jesse Allen, NASA Earth Observatory, using data provided by SeaWiFS Project, NASA Goddard Space Flight Center and ORBIMAGE (sea-surface color reference).

Chlorophyll A

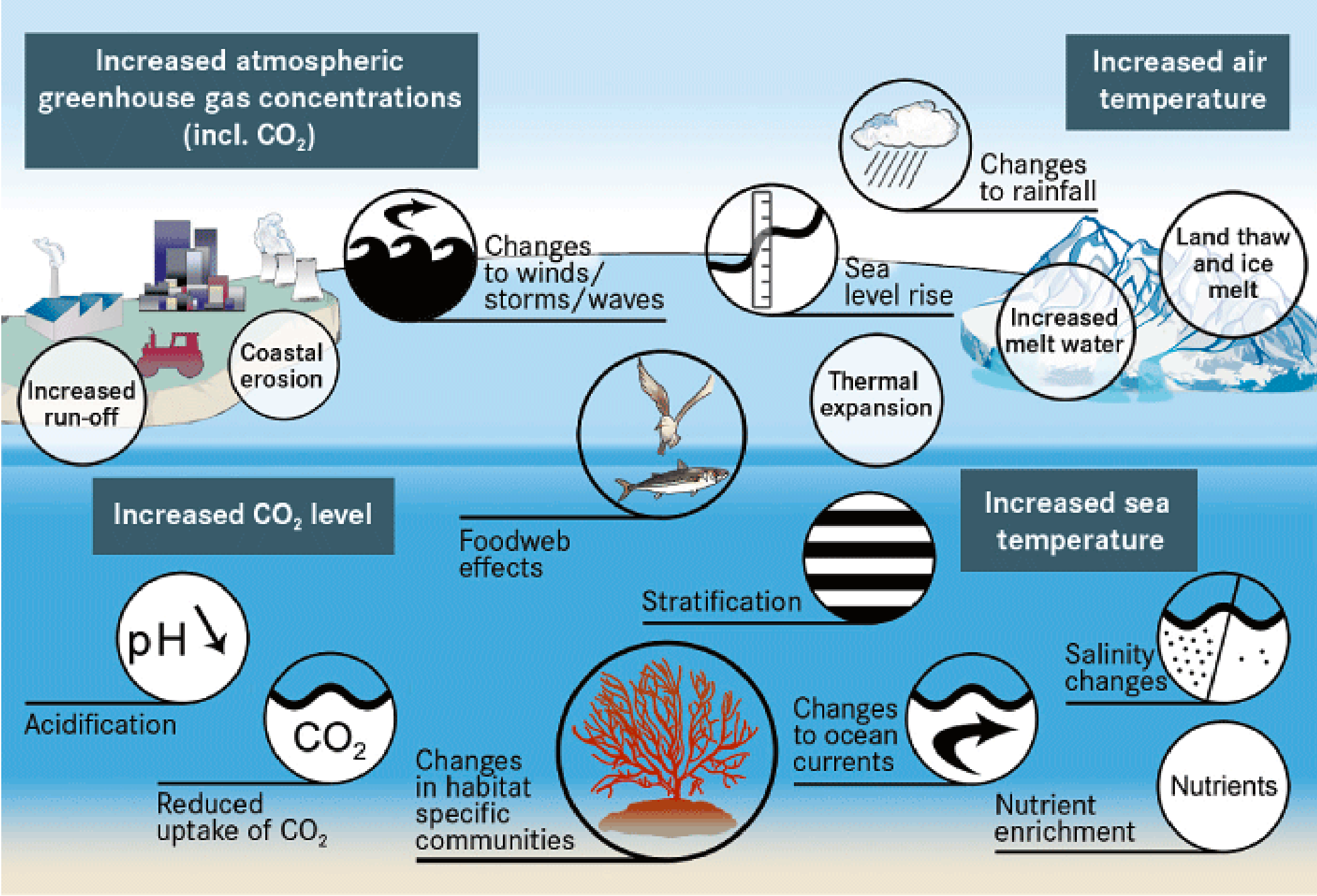


- Factors affecting growth:
- Sunlight
- Nutrient availability(nitrate & phosphate)
- Stratification
- Temperature
- Water quality

Used to measure relative abundance phytoplankton.

Concentrations generally highest just beneath surface waters rather than at the surface

CLIMATE CHANGE

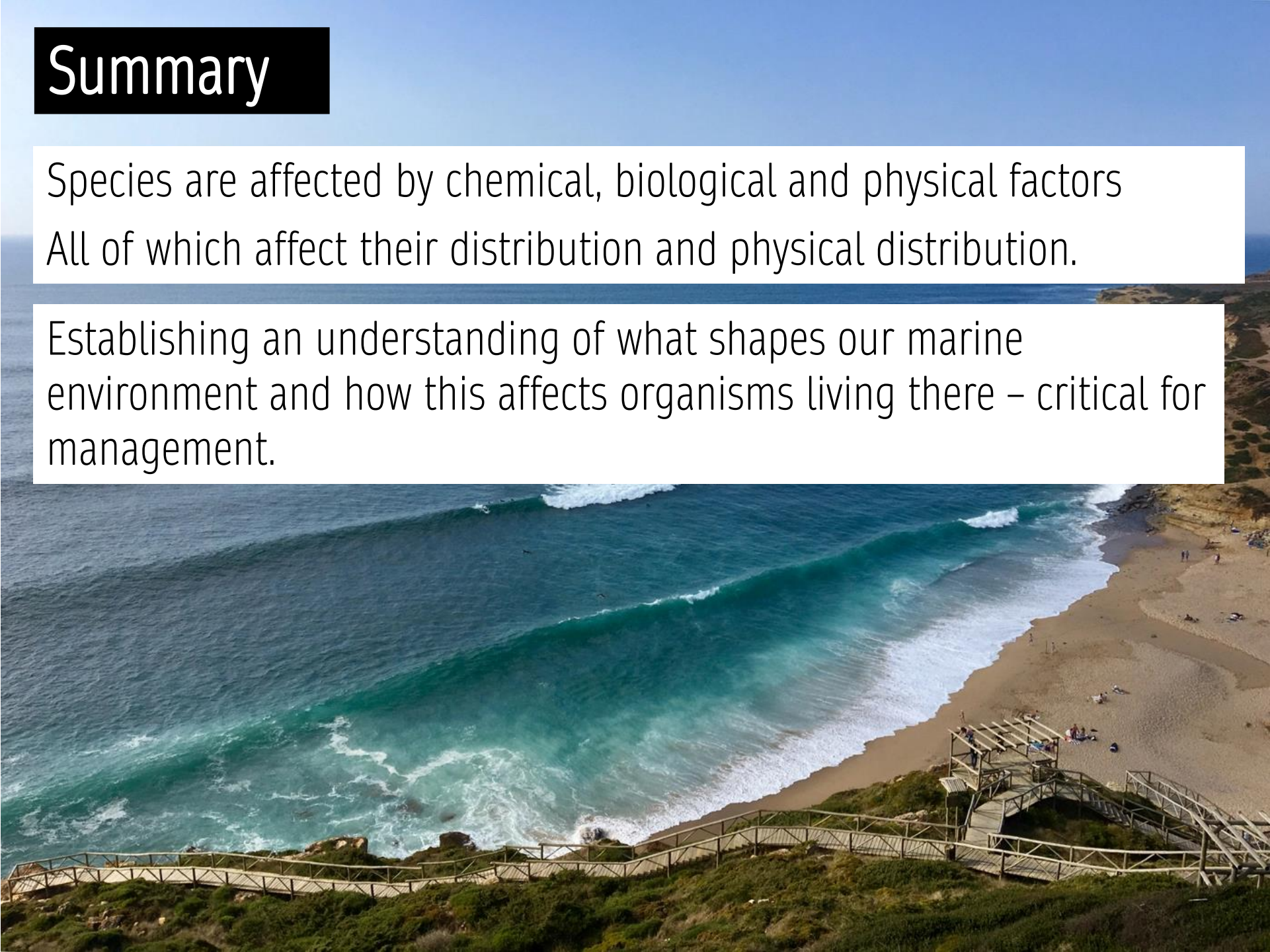


- Oceans - Climate change
(weebly.com)

Summary

Species are affected by chemical, biological and physical factors
All of which affect their distribution and physical distribution.

Establishing an understanding of what shapes our marine environment and how this affects organisms living there – critical for management.



TIME FOR A BREAK – 5 MINS



Previous exam questions...

- a) What major factors affect the ocean's productivity levels? (5) b) Using examples taken from previous El Nino events, identify and evaluate the main changes to our oceans as a result of higher sea surface temperatures (30) c) What evidence is there that marine species around the UK are being affected by changes to ocean circulation and temperature increases? (15) Discuss how climate change is affecting our oceans? You will be expected to consider the physical and biological impacts and provide detailed and credible statistics to emphasise your arguments. (100)