

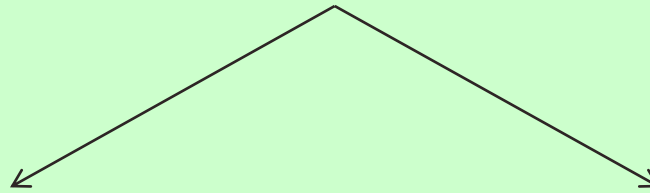
Coastal & Marine Science

Chris House

Rhian Jenkins

Module Structure

▲ *Format split:* **Marine & Coastal Science**



Chris: *Coastal Processes/Policy*

Rhian: *Marine Ecology*

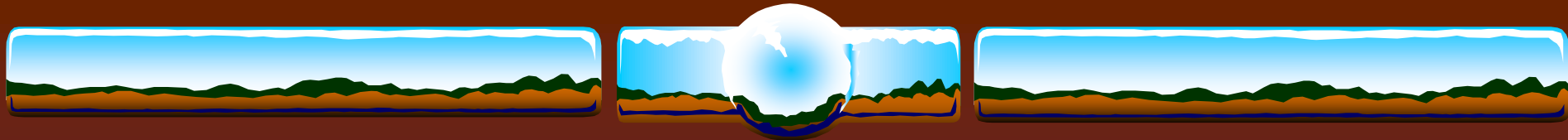
- ▲ *Assignment – Scenic Assessment of local beaches - management*
- ▲ *Exam – 2 hours in January*

Coastal & Marine Science

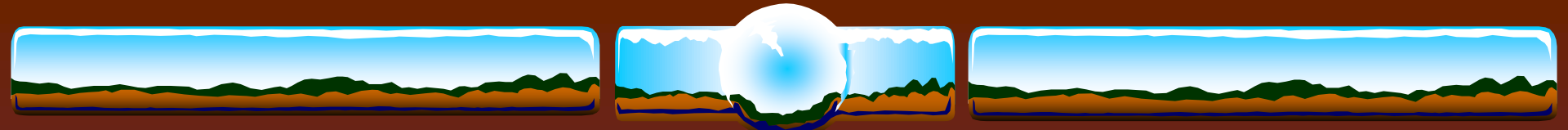
❖ Module Content:

- ❖ Physical and Biological Parameters and communities
- ❖ Climate change
- ❖ Methods of fishing and problem of over-harvesting
- ❖ Flags of Convenience and pirate fishing
- ❖ Marine pollution
- ❖ Identifying cetaceans – methods of research and data collection; Behavioural analyses
- ❖ Beach assessment techniques
- ❖ Coastal defences
- ❖ Physical Processes
- ❖ Marine policy & Protection (MPAs)





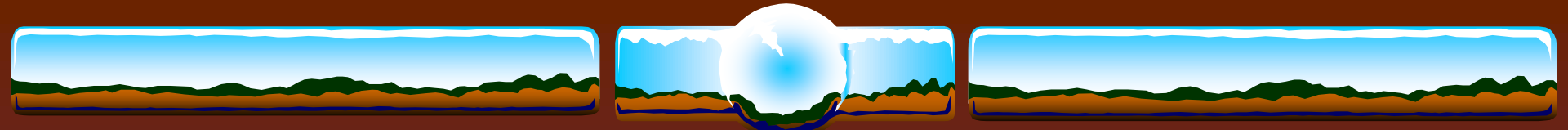
Week No	Date	Theme	Tutor
1	29/09/20	Introduction to module & intro to assignment	REJ
2	05/10/20	Abiotic Factors cont'd	REJ
3	12/10/20	IPCC Climate & Oceans Report (Assignment Workshop)	CH
4	19/10/20	Physical Processes	CH
5	26/10/20	Marine Pollution: Oil and Litter	REJ
6	02/11/20	Physical Processes cont'd	CH
7	09/11/20	Global Fisheries and Cetacean Science	REJ
8	16/11/20	Coastal Defences	CH
9	23/11/20	Climate Change Impacts: Biotic	REJ
10	30/11/20	Marine Protection Areas and Management	REJ
11	07/12/20	Coastal Zone Management and its Application	CH



Physical, Chemical and Biological Factors Affecting the Oceans

- ❖ Introduction – the Marine Environment
- ❖ Physical / Chemical Factors
 - ❖ Salinity
 - ❖ Light and Pressure
 - ❖ Temperature
 - ❖ Dissolved Oxygen
 - ❖ Density and pH
 - ❖ Chlorophyll a
 - ❖ Waves/currents/upwelling/tides





Physical, Chemical and Biological Factors Affecting the Oceans

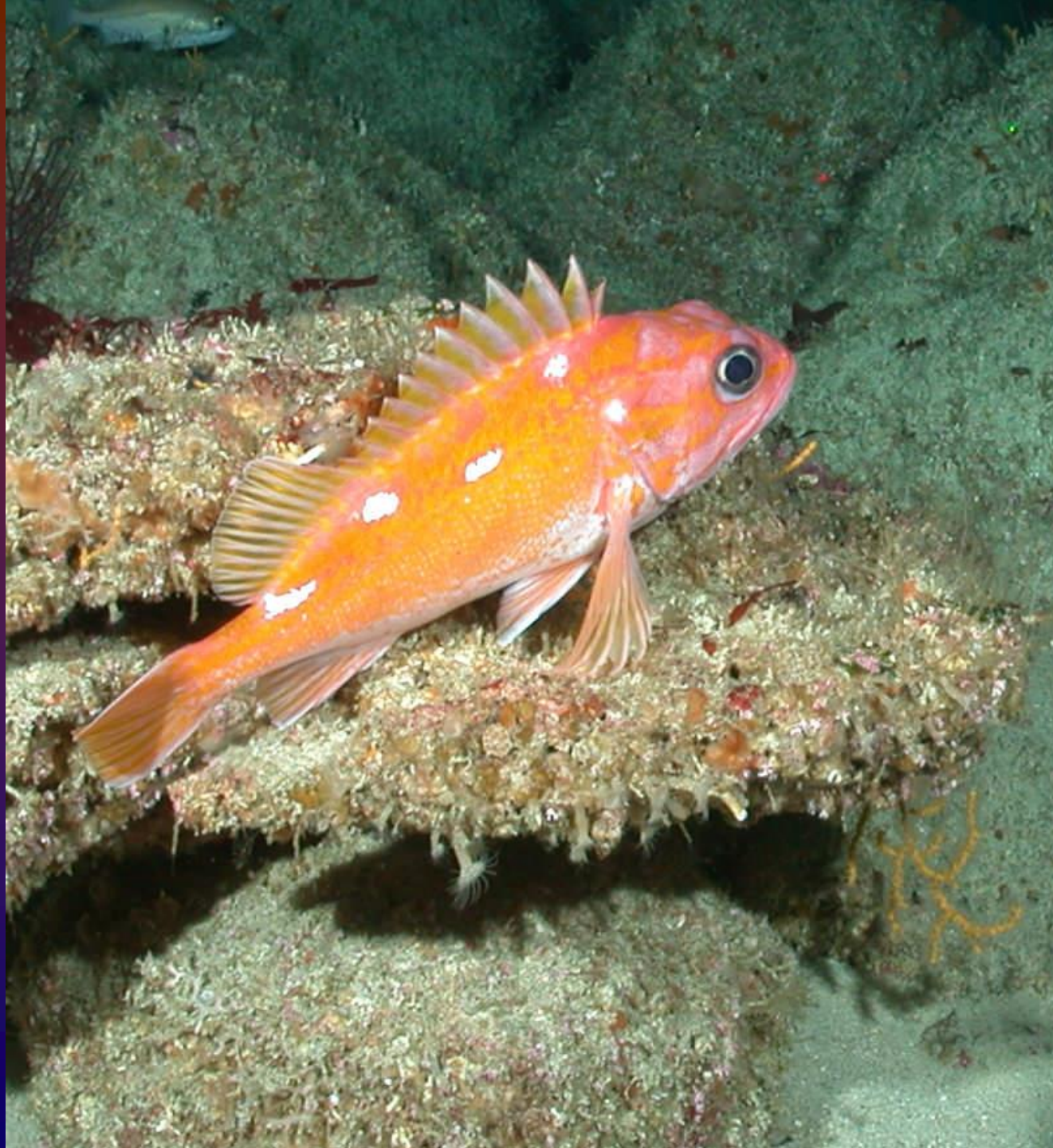
- ❖ **Introduction – the Marine Environment - terminology**
 - ❖ **What barriers are there to distribution of species in the ocean?**
 - ❖ **Why do species exist where they do?**
- 



Introduction

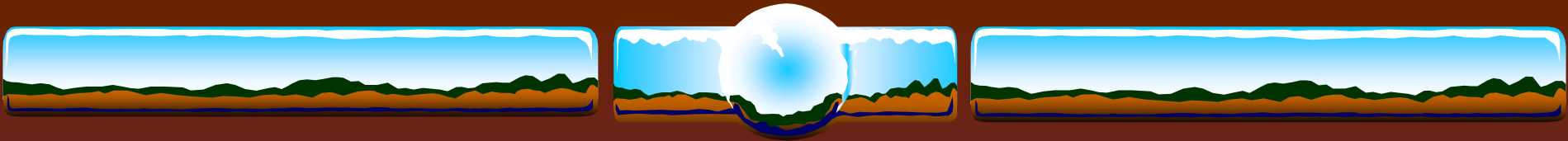


- ❖ 70% of the world is covered by water and 97% of water lies in the oceans and seas
- ❖ 80% Southern Hemisphere; 60% Northern Hemisphere
- ❖ Local and global climate influences
- ❖ Pacific Ocean – largest and covers a third of the earth
- ❖ Deepest part – Mariana Trench
- ❖ Variety of marine habitats exist – sandy beaches to rocky shores to protected estuaries to open ocean





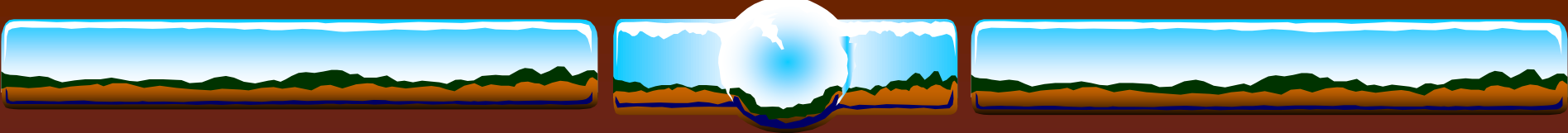
New species of worm discovered off New Zealand



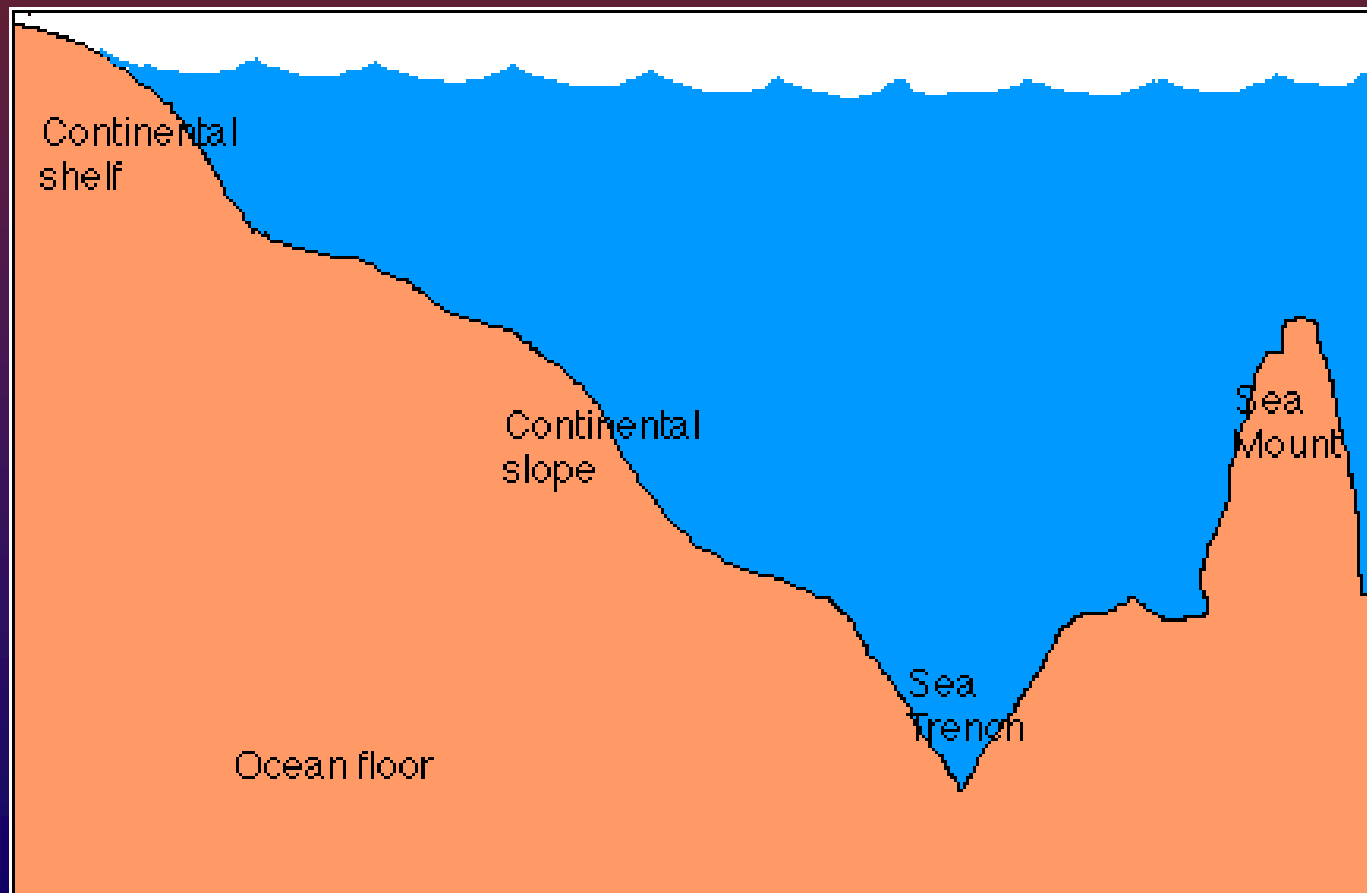
Newly discovered coral
forest off Bermuda in
2018 – Oxford
University

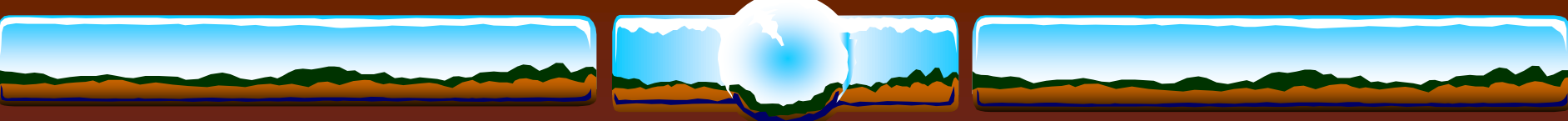
New species sea fan and
coral





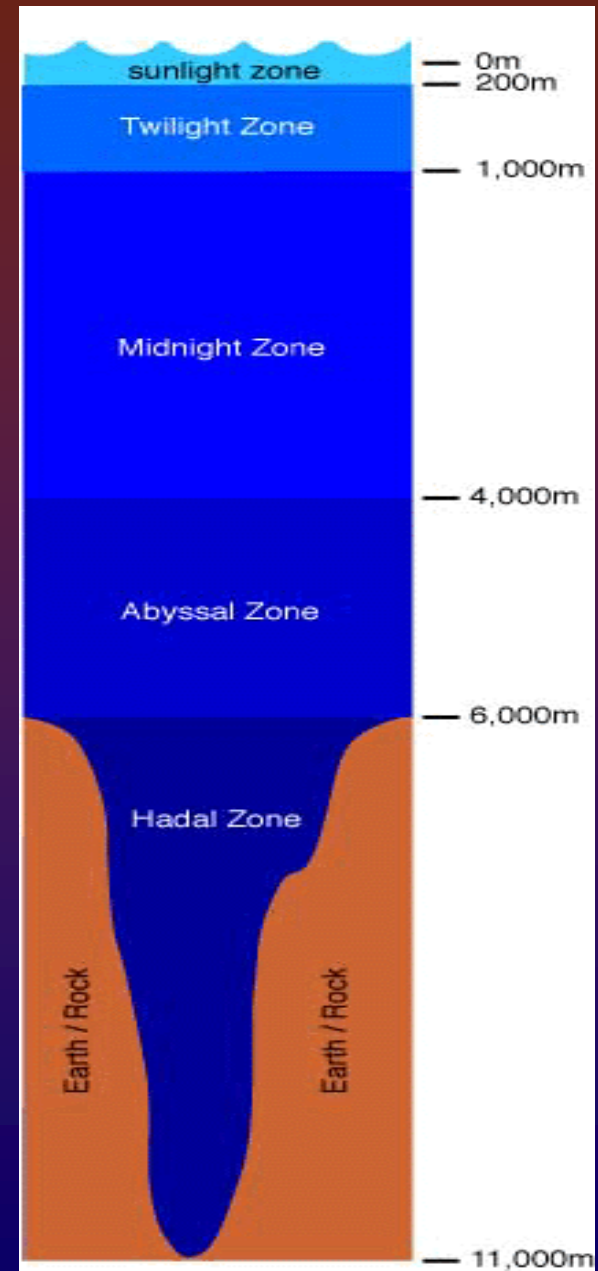
Habitable zones

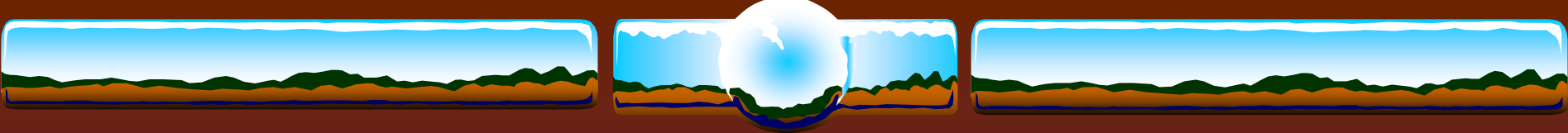




Introduction

- ❖ Ocean categorised according to depth:
 - ❖ Euphotic or Photic, Epipelagic or sunlight – upper layer with maximum light and variable temperature
 - ❖ Mesopelagic or Twilight – middle layer with a constant temperature
 - ❖ Bathypelagic or Midnight – with minimal light
 - ❖ Abyssal – pitch black, near freezing and extreme pressure
 - ❖ Hadal – waters found in deepest trenches
- ❖ Biomass varies with zonation

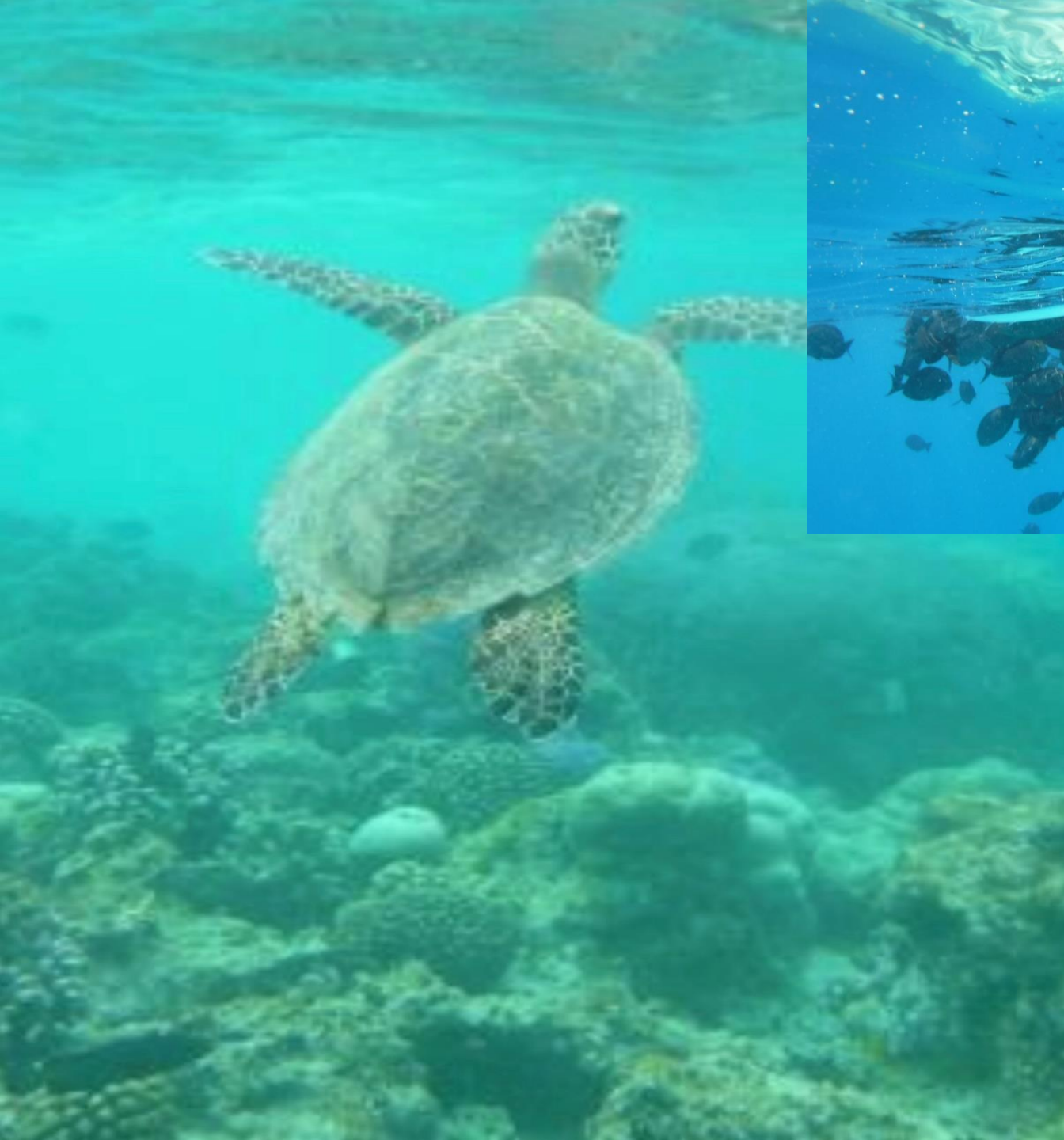




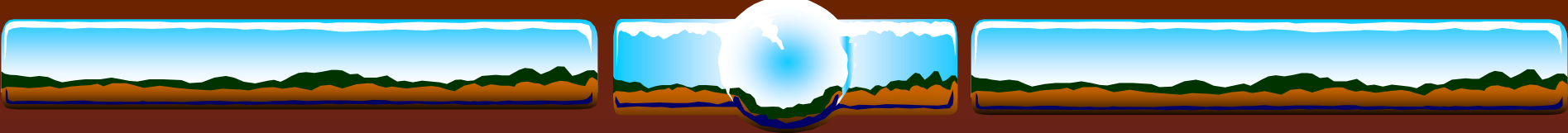
Ocean Zones – Sunlight/Euphotic

- ❖ 0-200m variable
- ❖ 90% all marine life
- ❖ Sunlit Zone
 - ❖ Plants , marine mammals
 - ❖ Sharks, turtles
 - ❖ Jellyfish, tuna
- ❖ Counter-shading

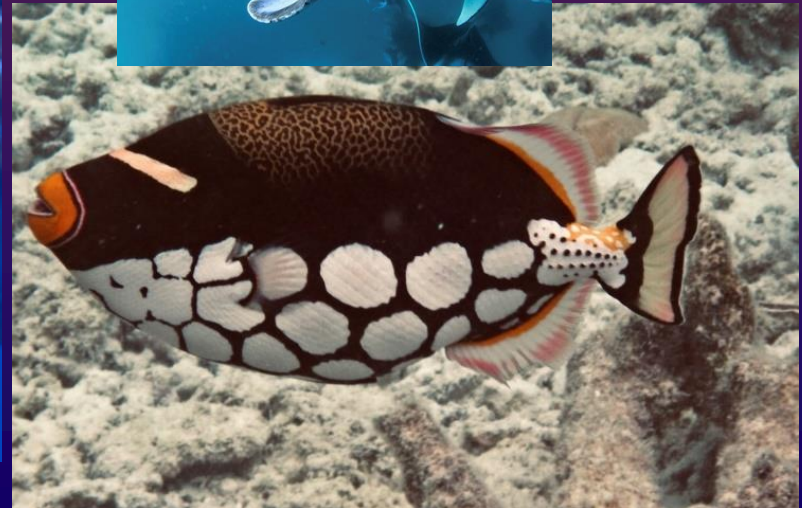




Camouflage
and safety in
numbers!

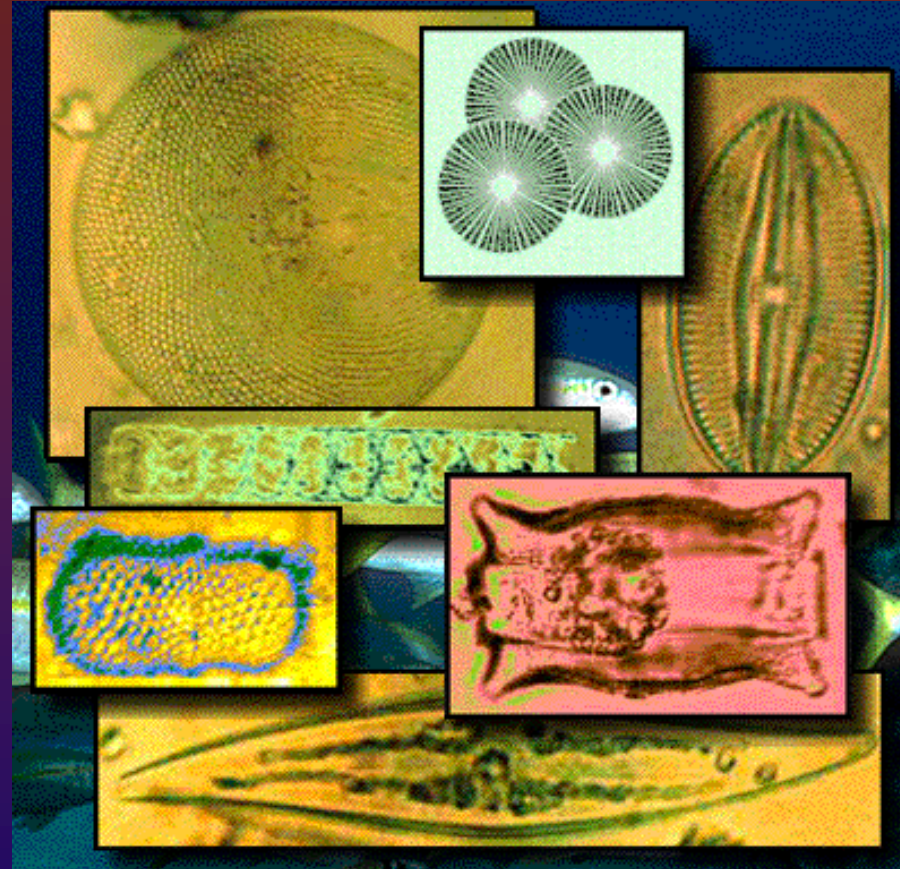


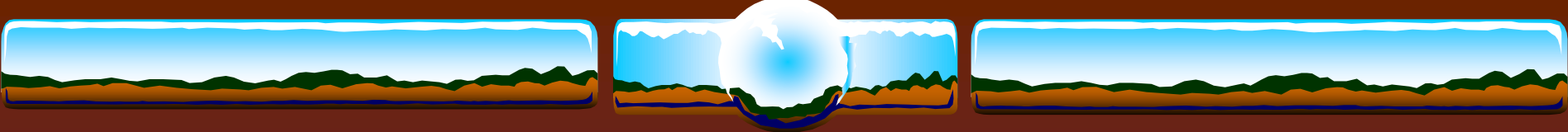
Biodiversity in the euphotic zone



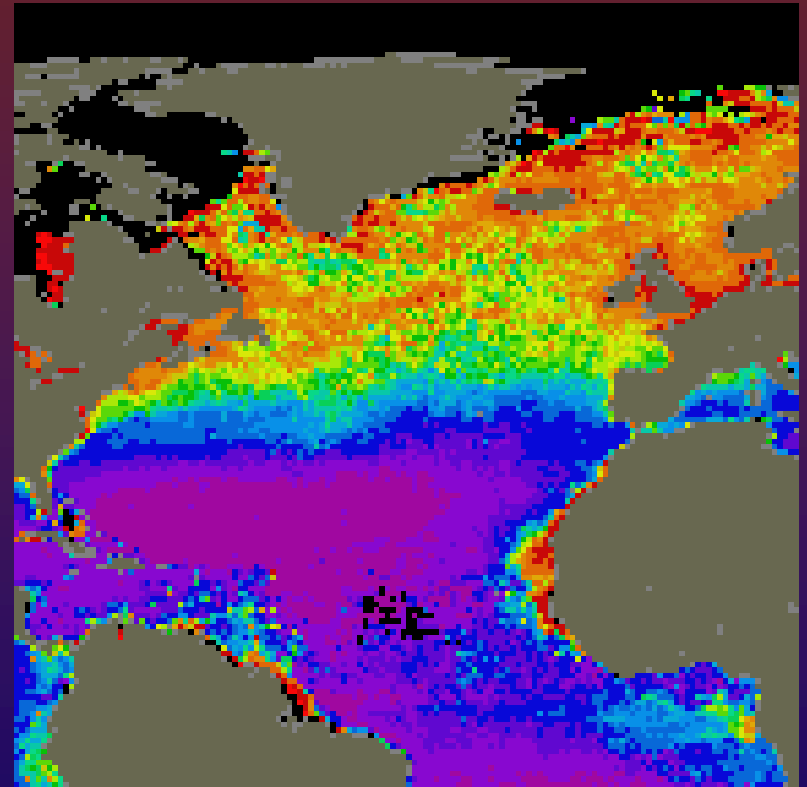
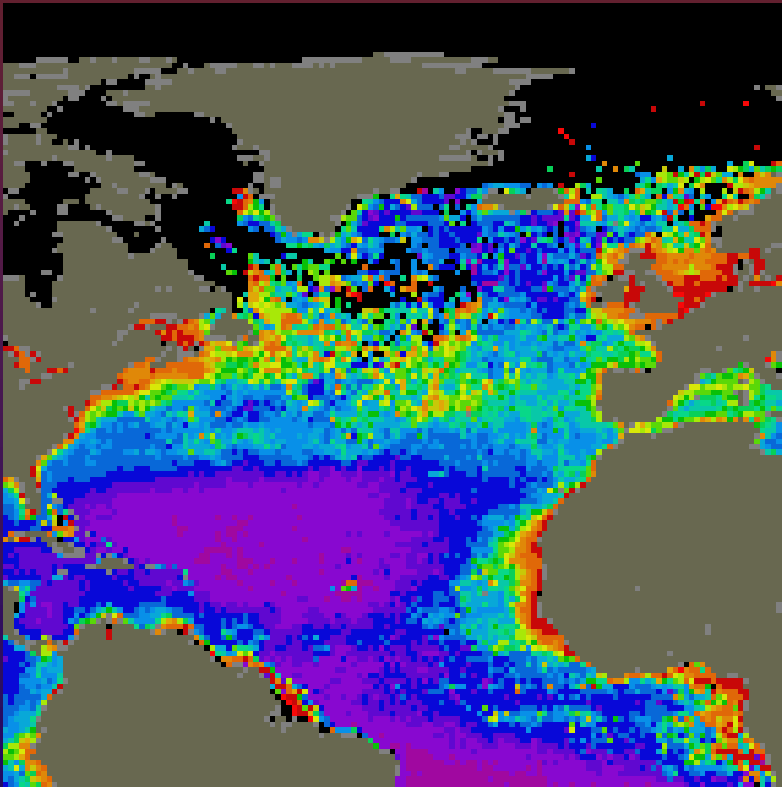
Phytoplankton

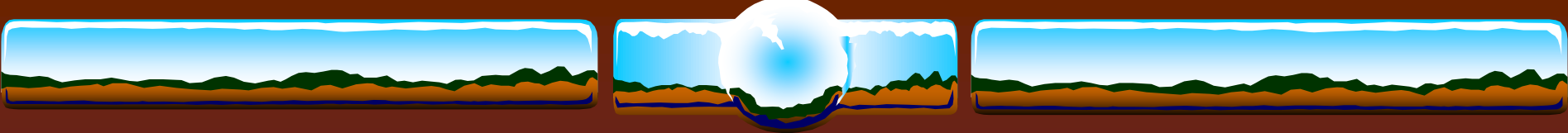
- ❖ Surface layer
- ❖ Free floating
- ❖ Microscopic
- ❖ Basis of food chain
- ❖ Cyanobacteria





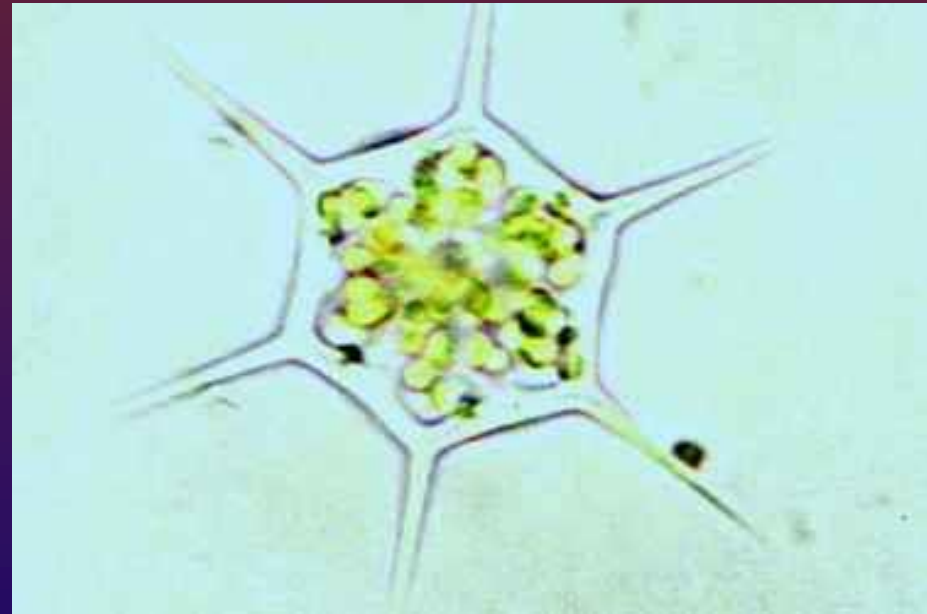
Plants - phytoplankton blooms



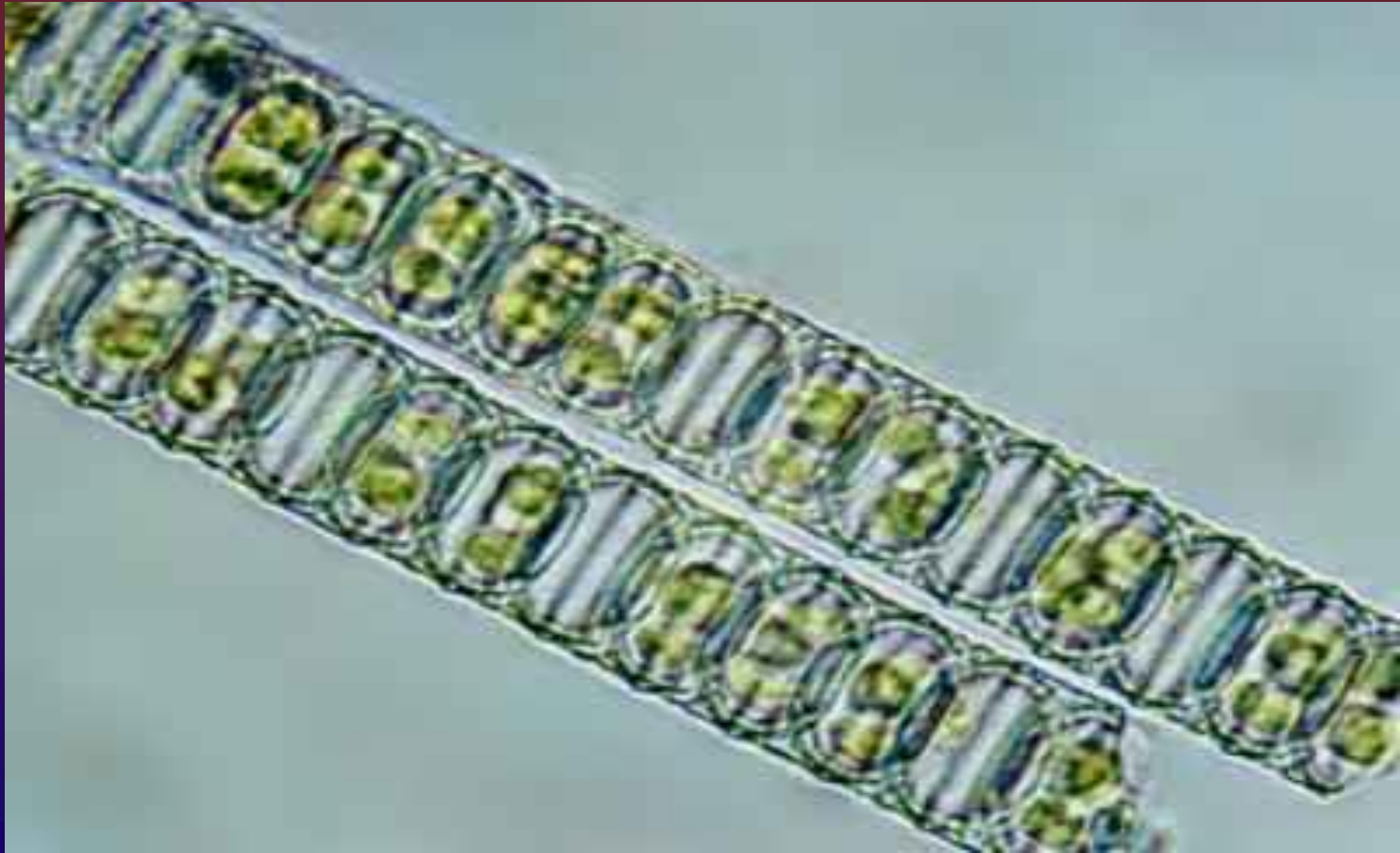


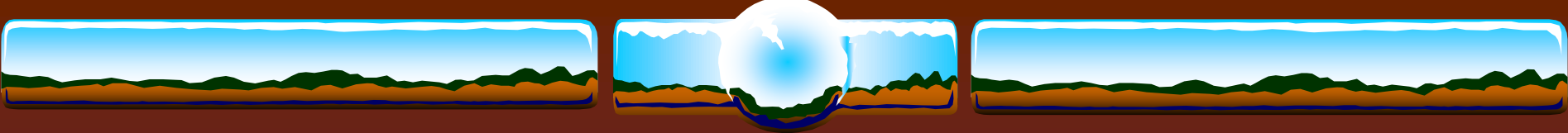
Diatoms

- ❖ Spines and projections
- ❖ Increases drag and slows down sinking
- ❖ Spreads organisms weight over a large surface area
- ❖ Parachute or skis



Diatom chain





Dinoflagellate *Noctiluca scintillans*

- ❖ Empty cavities make a cell more buoyant
- ❖ Neutral buoyancy (same density as seawater) will not sink
- ❖ Most plankton cells are denser than seawater

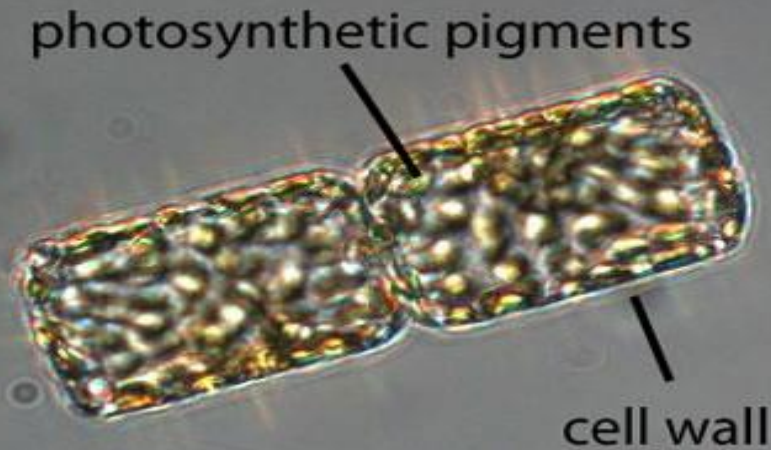


Dinoflagellate *Peridinium* spp

- ❖ Thin appendages – swim weakly
- ❖ Swimming prevents cell sinking to deep
- ❖ Cannot move easily against currents

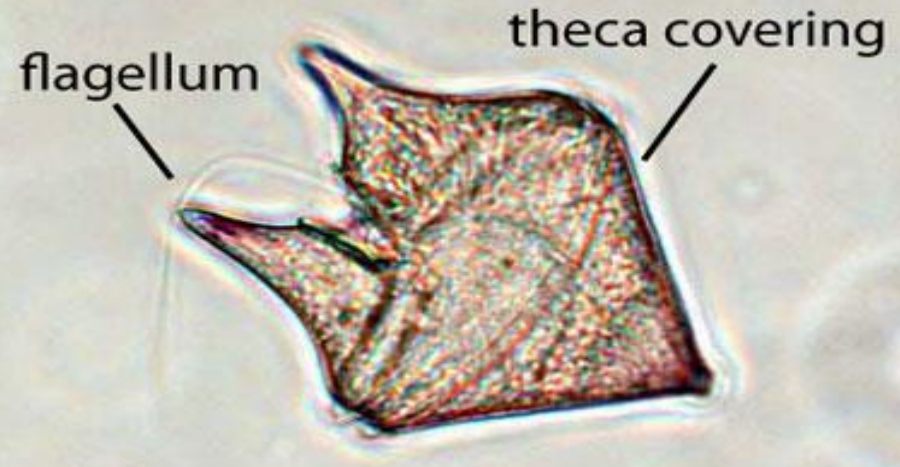






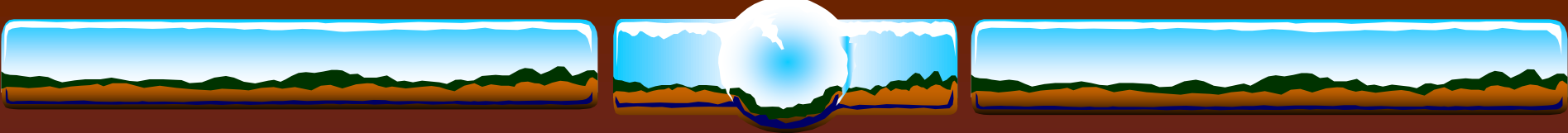
Diatoms

- Eukaryotic single-celled algae
- They are most like plants in their ability to meet their nutritional needs through photosynthesis
- The presence of chlorophyll and pigments, give them a golden colour and enables light energy from the sun to be harvested
- Cells are encased in transparent glass-like (silica).
- Cells may form chains or colonies.
- Up to 100,000 species of diatoms have been recorded world-wide



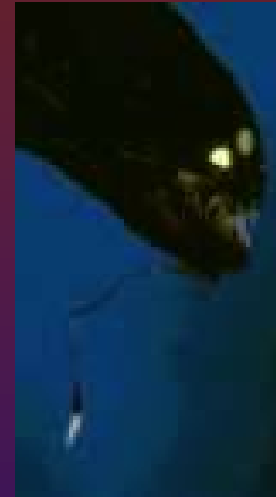
Dinoflagellates

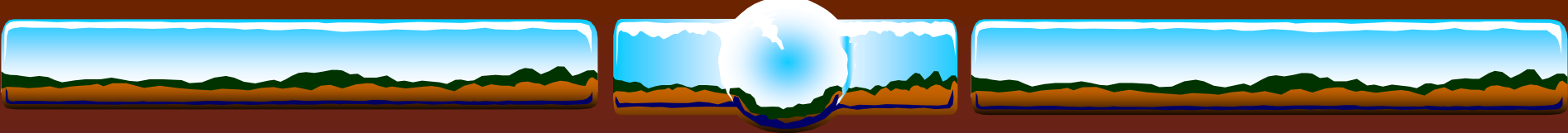
- Eukaryotic single-celled algae
- Many have two flagella, which allow the cells to have limited mobility
- Cells are covered by a theca (sheath) that can be smooth or ornamented
- Some species are able to migrate vertically through the water column
- Nearly half of known species are capable of photosynthesis and contain light-harvesting pigments (autotrophs)
- Of the 2000 known species, about 60 are able to produce complex toxins



Twilight Zone

- ❖ 200-1000m variable
- ❖ Adaptation to the cold
- ❖ Increase in water pressure
- ❖ Reduction in light availability
- ❖ No plants – octopus, squid, hatchet fish
- ❖ Thin bodies
- ❖ Red, black coloration
- ❖ Bioluminescence - photophores





Deep Ocean Angler Fish *Linophryne arborifera*



© 2005 P. Batson; ExploretheAbyss.com

Viper Fish *Chauliodus sloani*

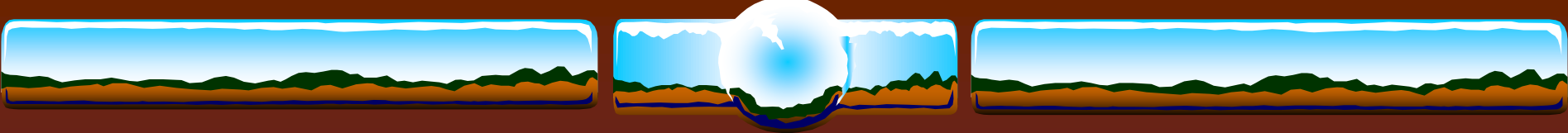


© 2005 P. Batson; ExploretheAbyss.com

Gulper eel *Eurypharynx pelecanooides*





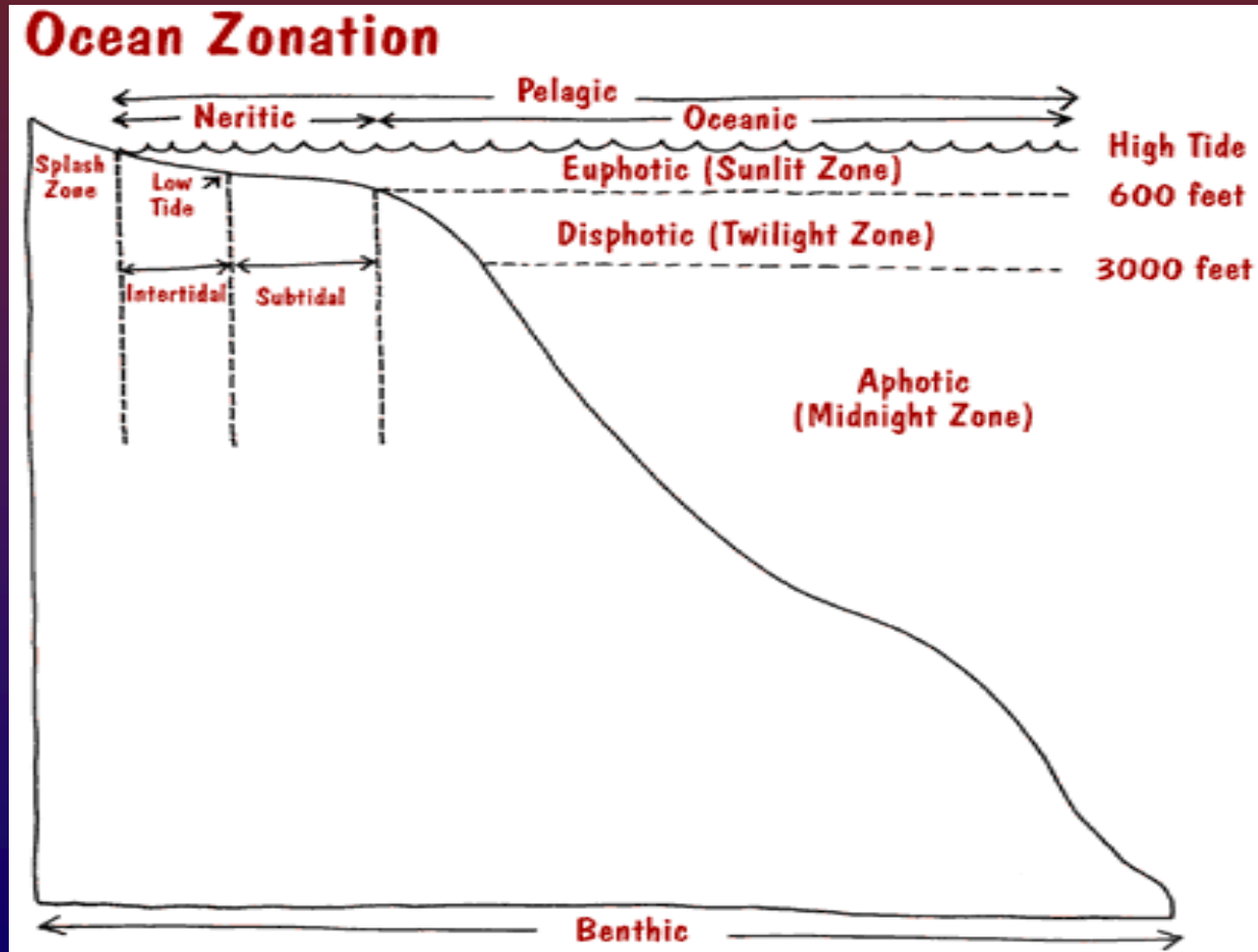


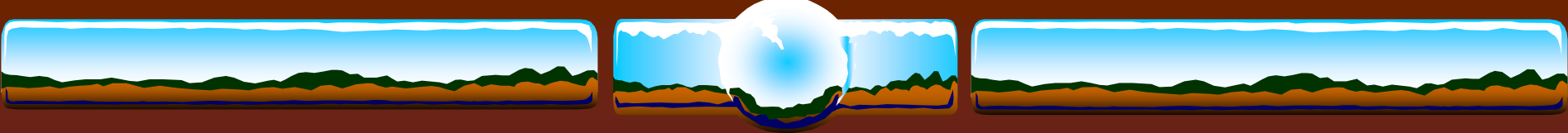
Midnight Zone and Abyssal

- ❖ 90% ocean
- ❖ Very cold and completely dark
- ❖ Extreme pressure
- ❖ Fewer organisms – bacteria utilising H_2S
- ❖ Some animals have no eyes



Ocean Zones

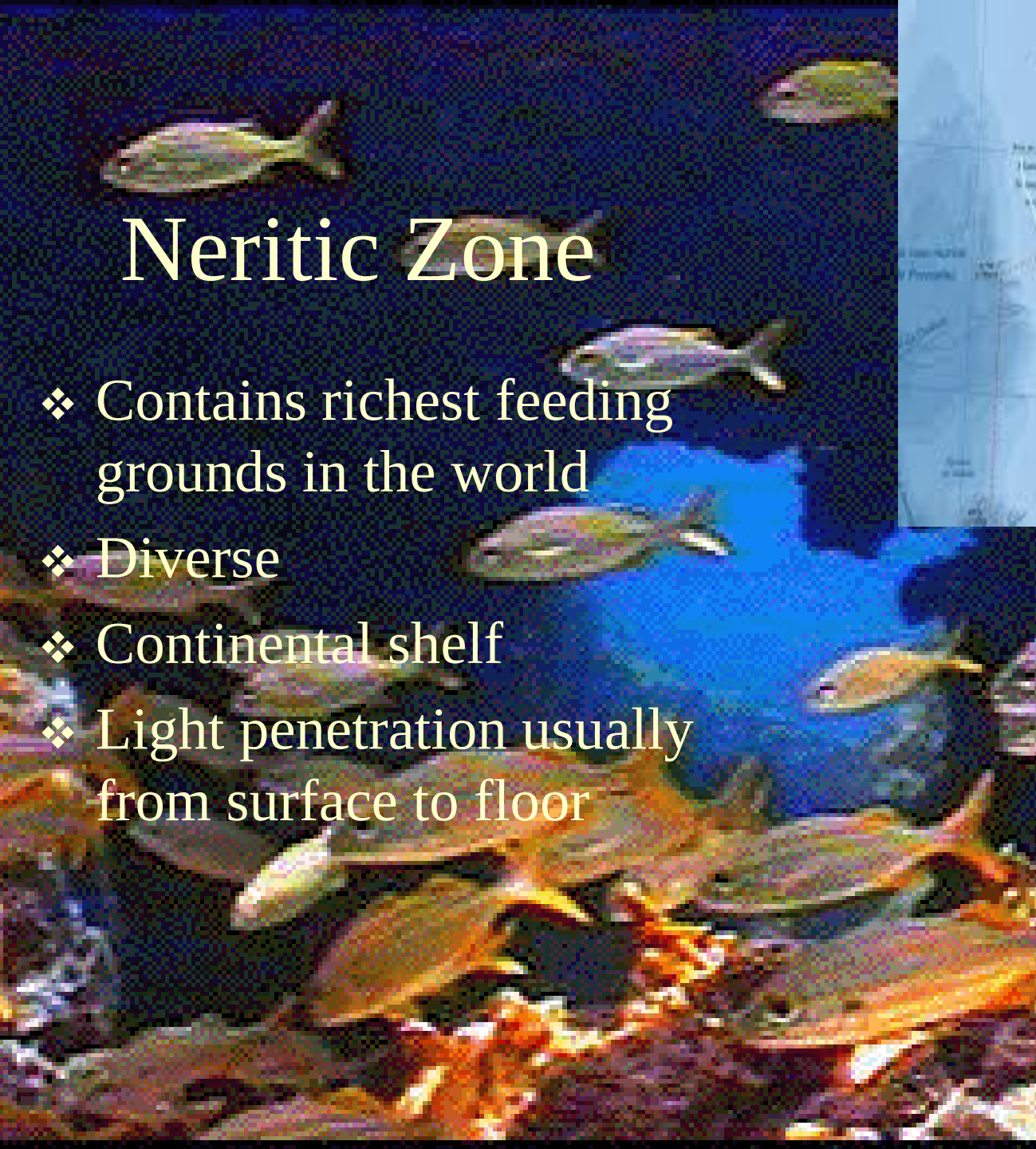




Littoral Zone

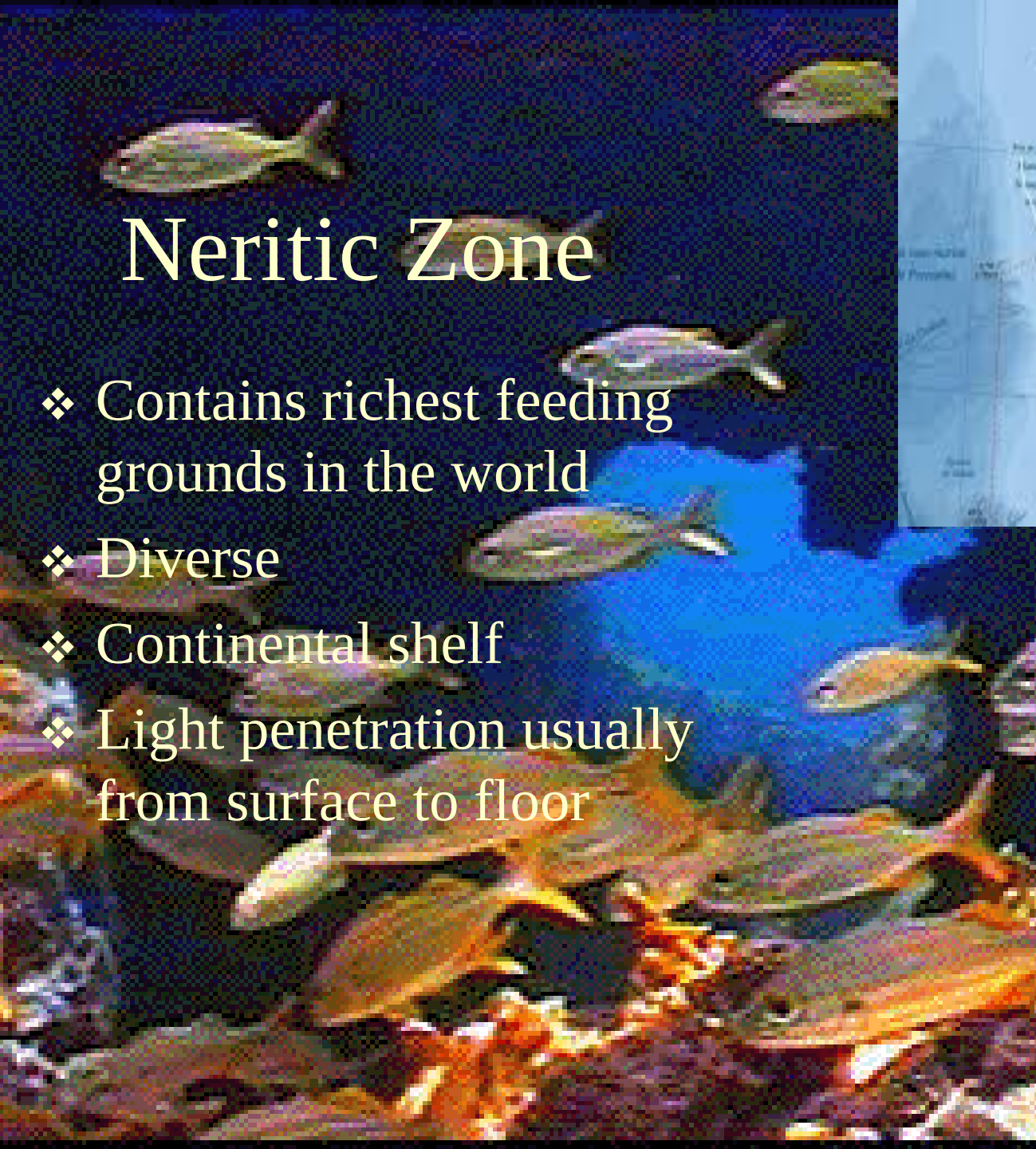


- ❖ Boundary between land and sea
- ❖ Exposed for sometimes 75% of each day – covered only during high tide
- ❖ Gets its name from *Littorina Littorea* (Common Periwinkle)

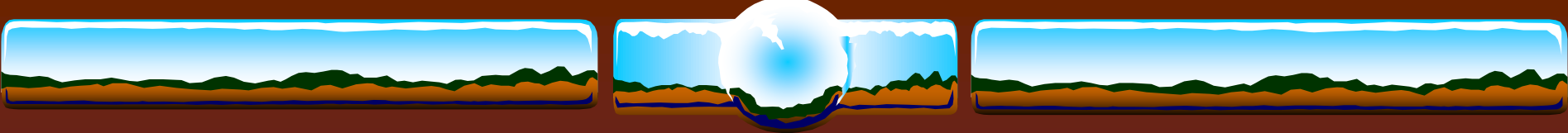


Neritic Zone

- ❖ Contains richest feeding grounds in the world
- ❖ Diverse
- ❖ Continental shelf
- ❖ Light penetration usually from surface to floor

- 
- # Neritic Zone
- ❖ Contains richest feeding grounds in the world
 - ❖ Diverse
 - ❖ Continental shelf
 - ❖ Light penetration usually from surface to floor

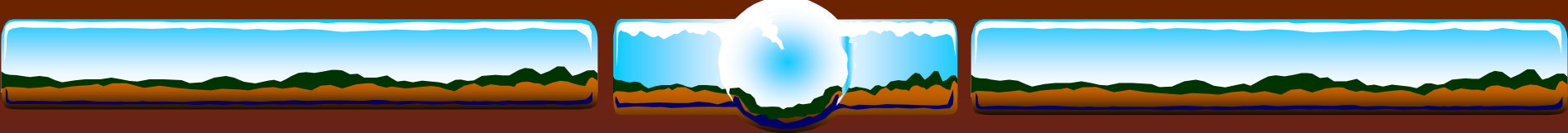




Oceanic

- ❖ Biogeographical zones
 - ❖ Polar 0-4°C
 - ❖ Cold temperate 5-9°C
 - ❖ Warm temperate 10-19°C
 - ❖ Tropical >20°C
- ❖ Cooler waters highly productive





Benthic Zone

- ❖ Ocean bed
- ❖ Less diverse but not just microscopic bacteria!
- ❖ Biological activity – decomposition
- ❖ Material is mainly rocky or shallow sediment





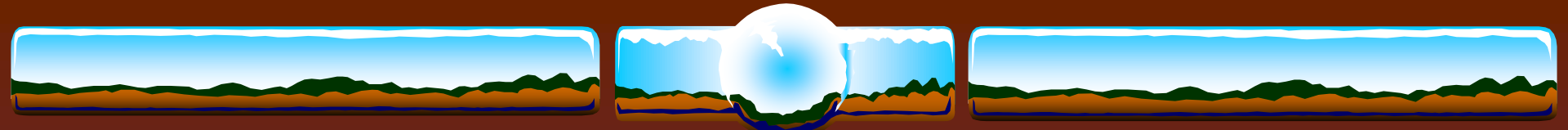
Marine Environment

- ❖ Species are affected by chemical, biological and physical factors, all of which affect their distribution and physical attributes
- ❖ Establishing an understanding of what shapes our marine environment and how this affects the organisms living there – critical for management!
- ❖ Take a look at Planet Earth: Deep Oceans and make a note of the extraordinary adaptations of deep water organisms

Watch the following documentary from National Geographic: The Incredible Glowing Creature of the Deep Sea: Bioluminescent Sea Life

- Consider the ways in which marine species communicate, identify and protect themselves in an aphotic environment

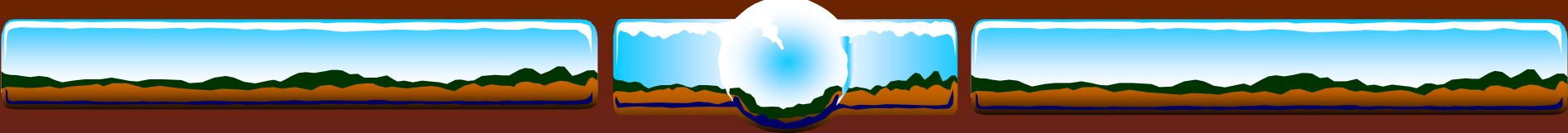




Physical, Chemical and Biological Factors Affecting the Oceans

- ❖ Introduction – the Marine Environment
- ❖ Physical / Chemical Factors
 - ❖ Salinity
 - ❖ Light and Pressure
 - ❖ Temperature
 - ❖ Dissolved Oxygen
 - ❖ Density and pH
 - ❖ Chlorophyll a
 - ❖ Waves/currents/upwelling/tides

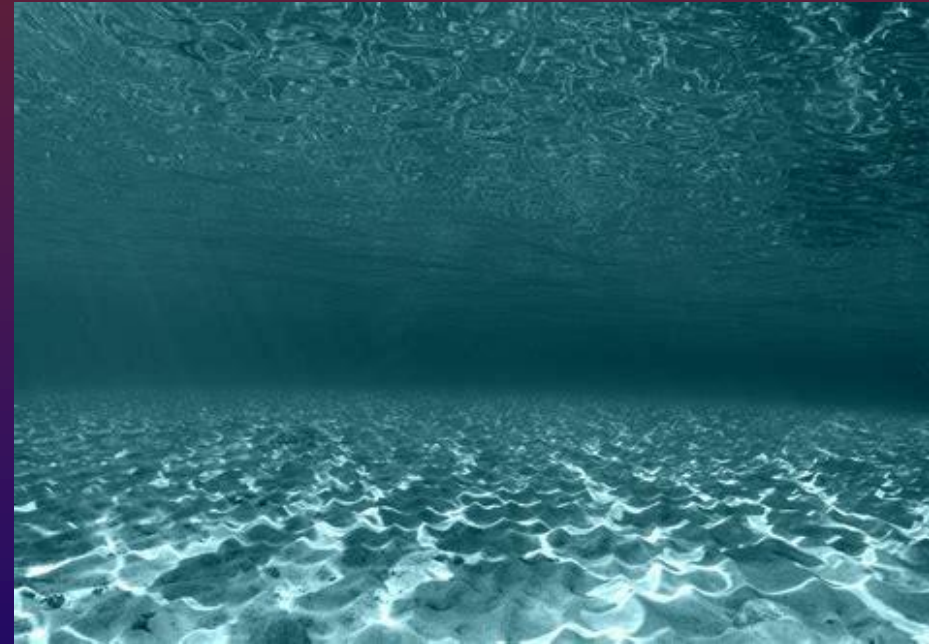




Physical (abiotic) Factors

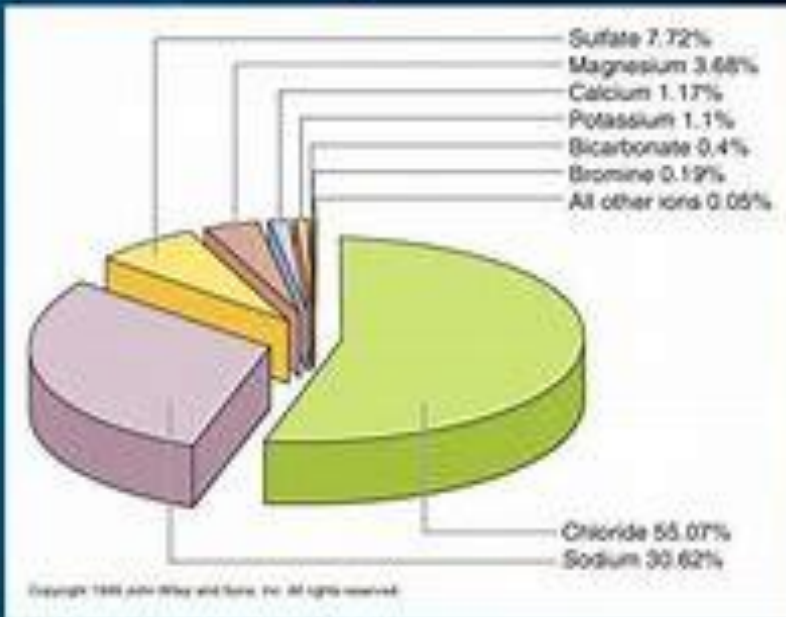
1. Salinity

- ❖ Measure of all dissolved salts in water
- ❖ Parts per thousand (ppt) or psu (practical salinity units)
- ❖ Average ocean salinity is 35ppt
- ❖ In river systems - 0.5ppt
- ❖ Variation throughout the water column:
 - ❖ Lower in coastal areas where there are river inputs – dilution
 - ❖ Increases in Tropics due to evaporation



Salinity

Chemical Composition of Seawater

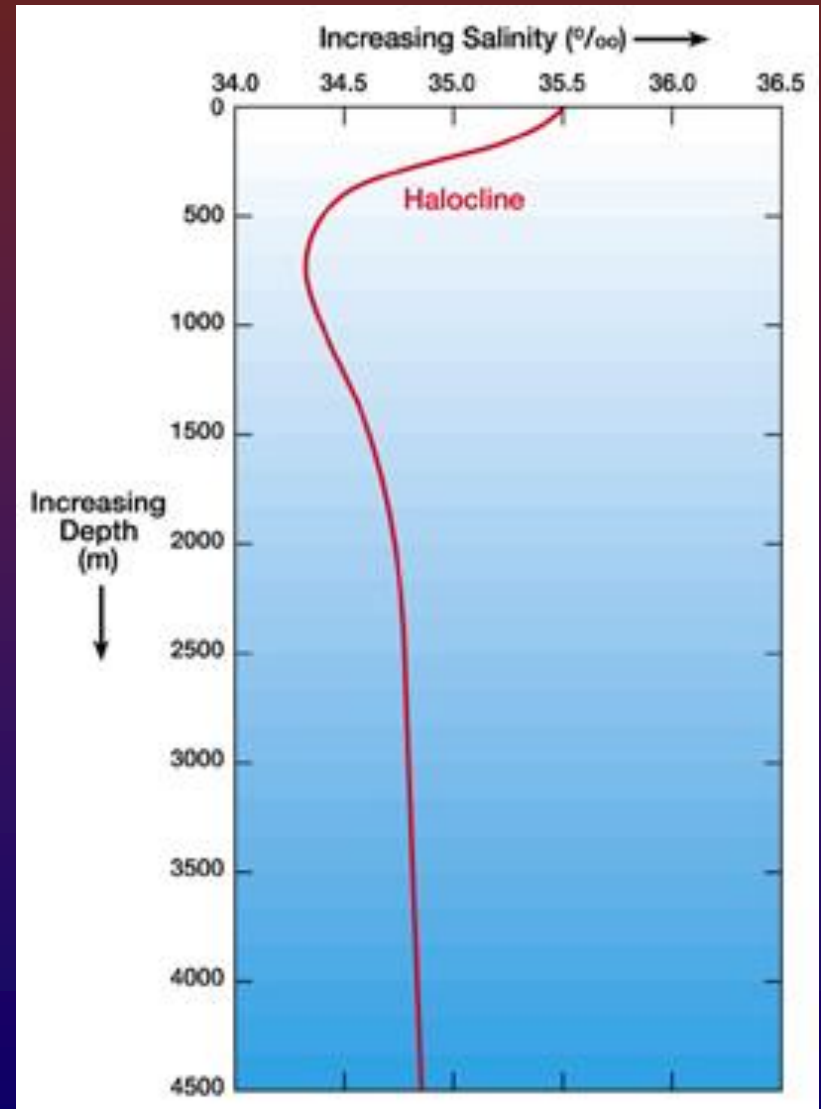


- ❖ 85.6% is made up of Sodium (Na) and Chlorine (Cl)
- ❖ Magnesium (Mg), Calcium (Ca), Potassium (K) and Sulphate (SO_4) combined with above make up some 99.4%
- ❖ Every element in Periodic Table is present in small amounts



Salinity Profile

- ❖ Where does it come from? Dissolved salts from continental rocks
- ❖ Ions constantly brought into solution
- ❖ Balance achieved with ionic removal – silica and calcium carbonate removed as skeletons or absorbed on clays
- ❖ South Atlantic Ocean profile – halocline where the water's salinity changes rapidly
- ❖ Salinity at surface is high – decreases until a depth of about 1000 – increases again slightly with depth



Increase salinity

Decrease salinity

**Evaporation
of
seawater**

**Precipitation
of rain
or snow**

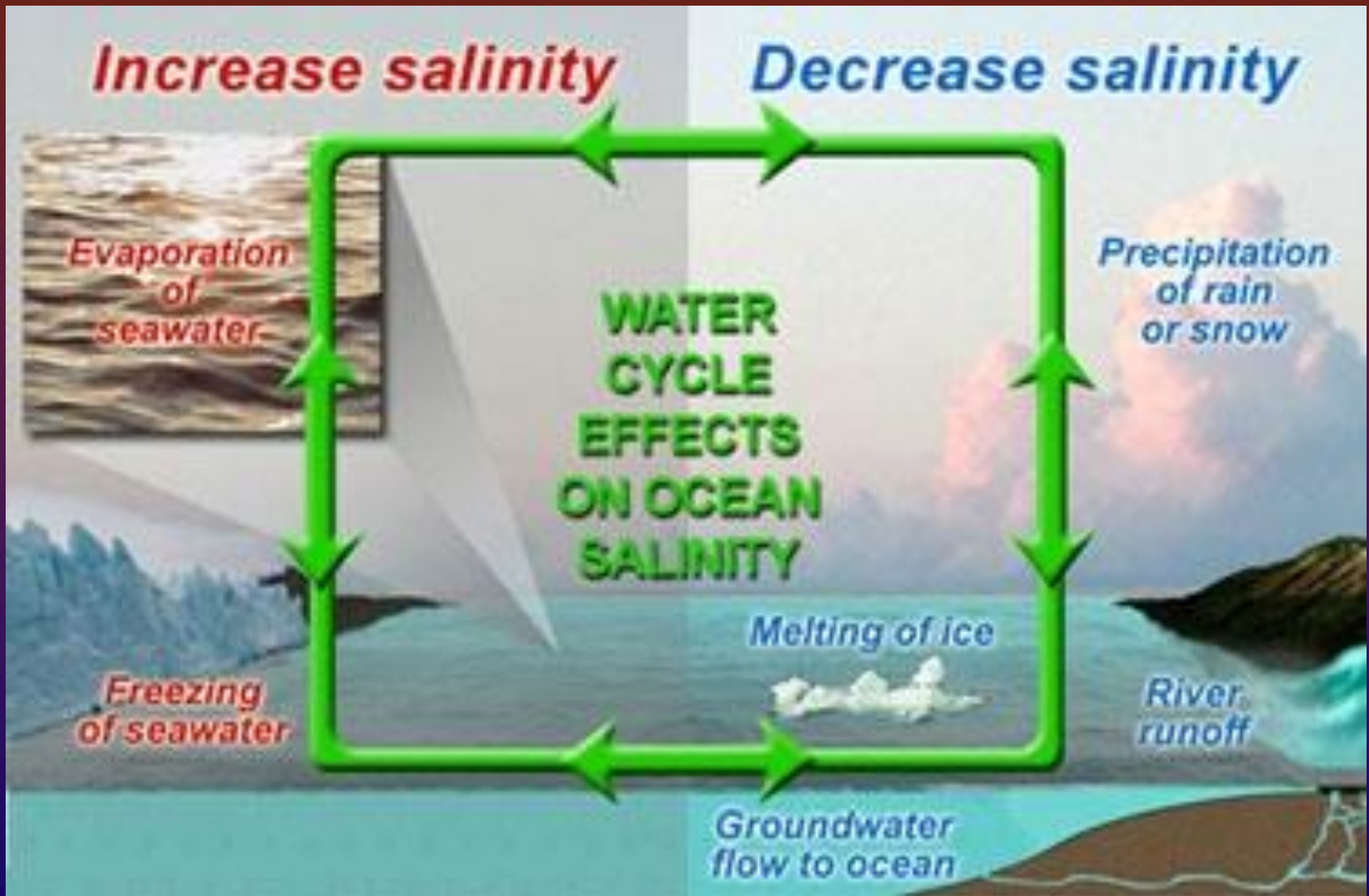
**WATER
CYCLE
EFFECTS
ON OCEAN
SALINITY**

**Freezing
of seawater**

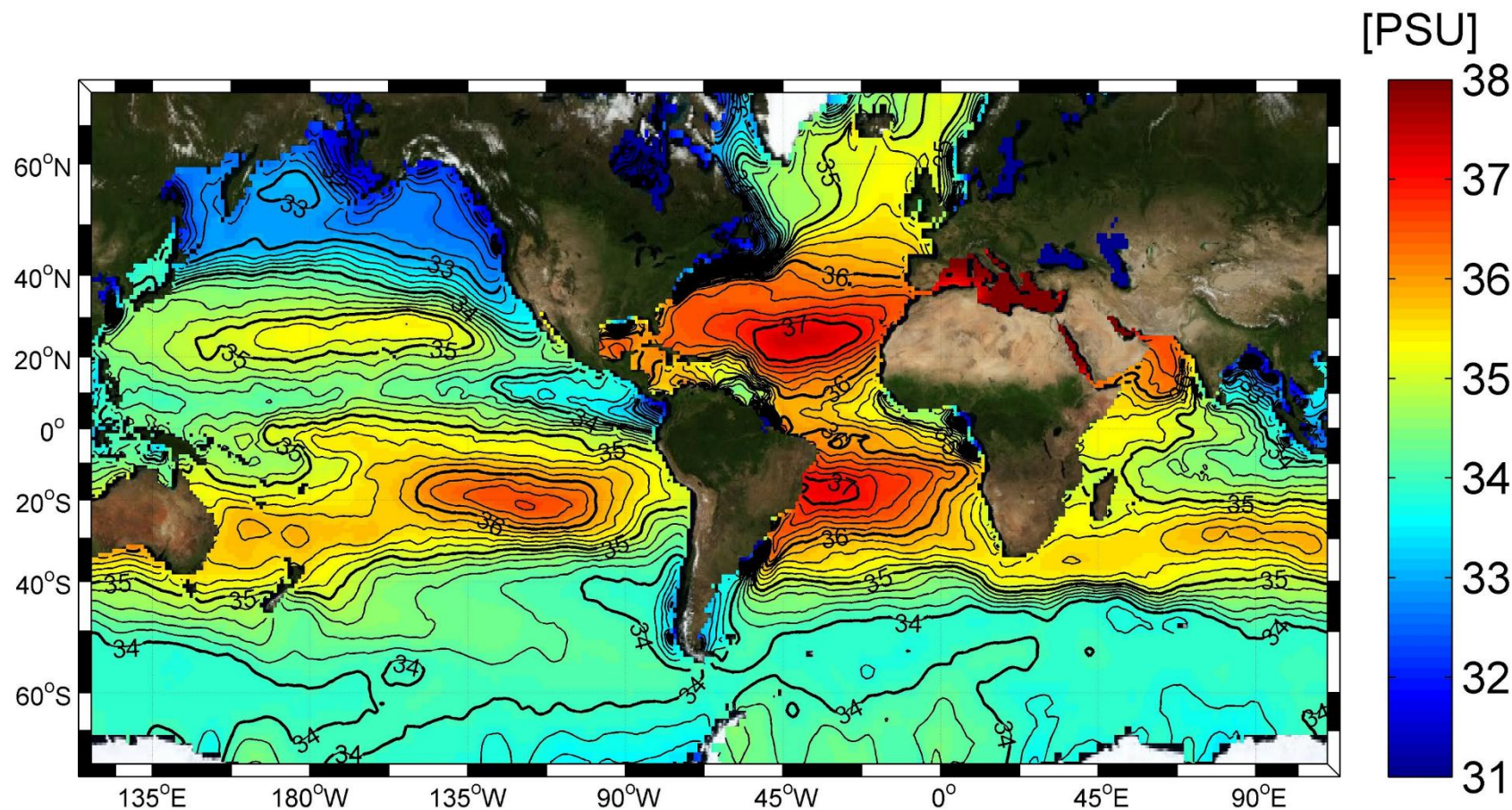
Melting of ice

**River
runoff**

**Groundwater
flow to ocean**



Salinity Chart – World Map



Physical & Chemical (abiotic) Factors



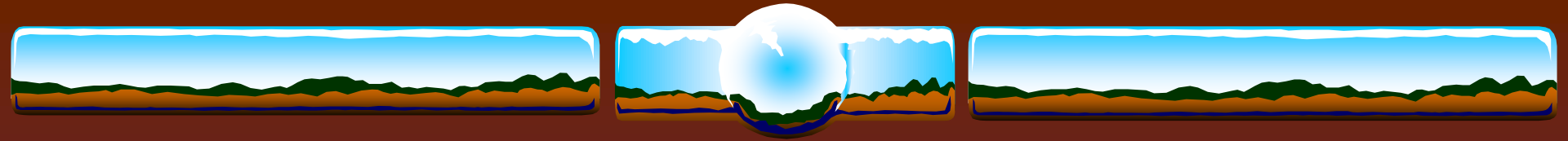
2. Light

Light changes seasonally, especially at high latitudes, with depth and diurnally

- ❖ Important for photosynthesis
- ❖ Predator vs prey relationship
- ❖ Migration through the water column
- ❖ Bioluminescence

Deep sea jellyfish *Atolla spp.*

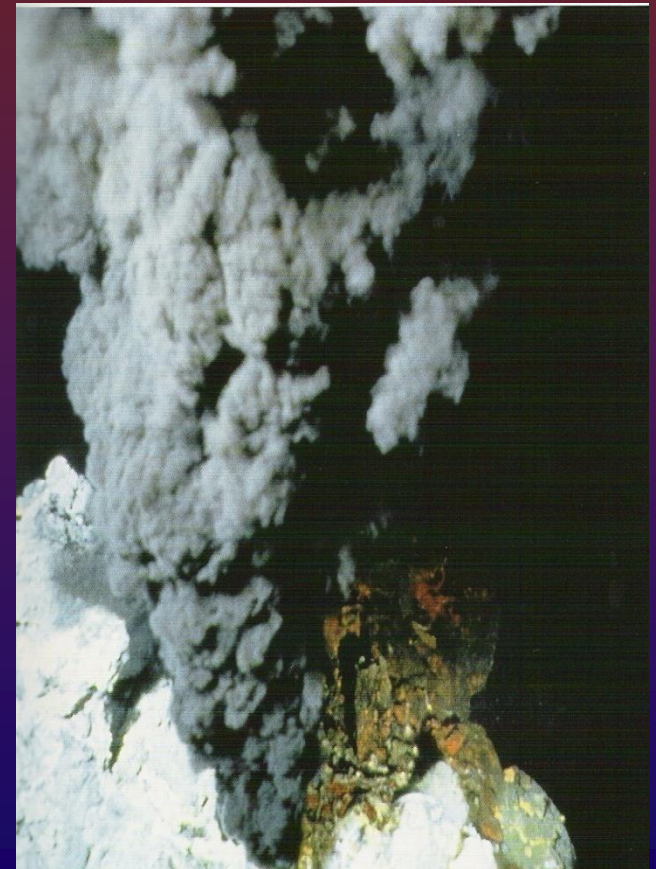




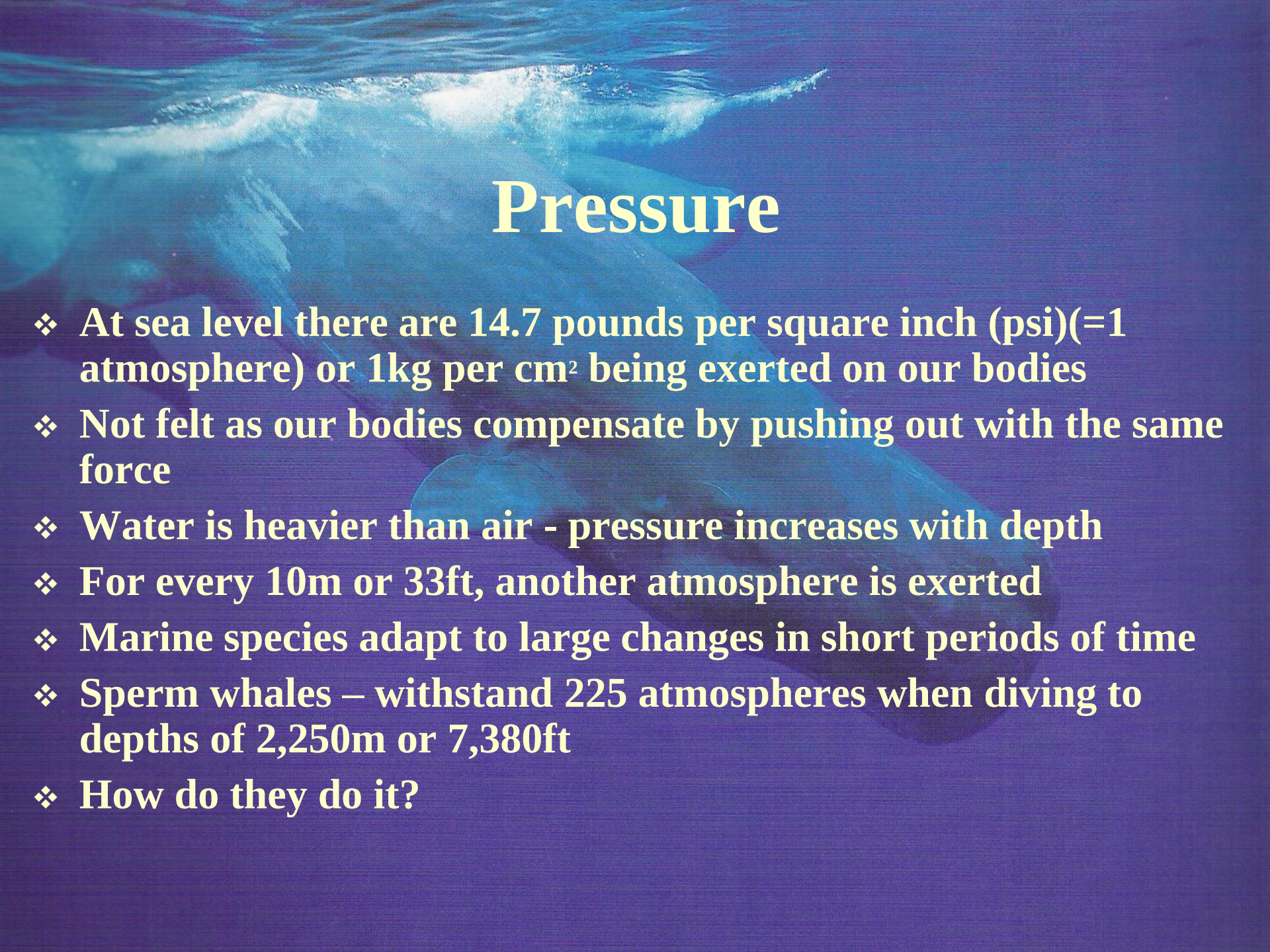
Where there is no Light

❖ Aphotic Zone

- ❖ 90% of the ocean
- ❖ Water pressure is extreme
- ❖ Temperature near freezing
- ❖ What of the food chain here?
- ❖ Body forms very different
- ❖ Some species have adapted – bacteria living in fissures of the earth's crust utilise hydrogen sulphide as food
- ❖ Bacteria forms basis of food chain in this zone
- ❖ Angler fish, sea cucumber and vampire squid are known to inhabit this area





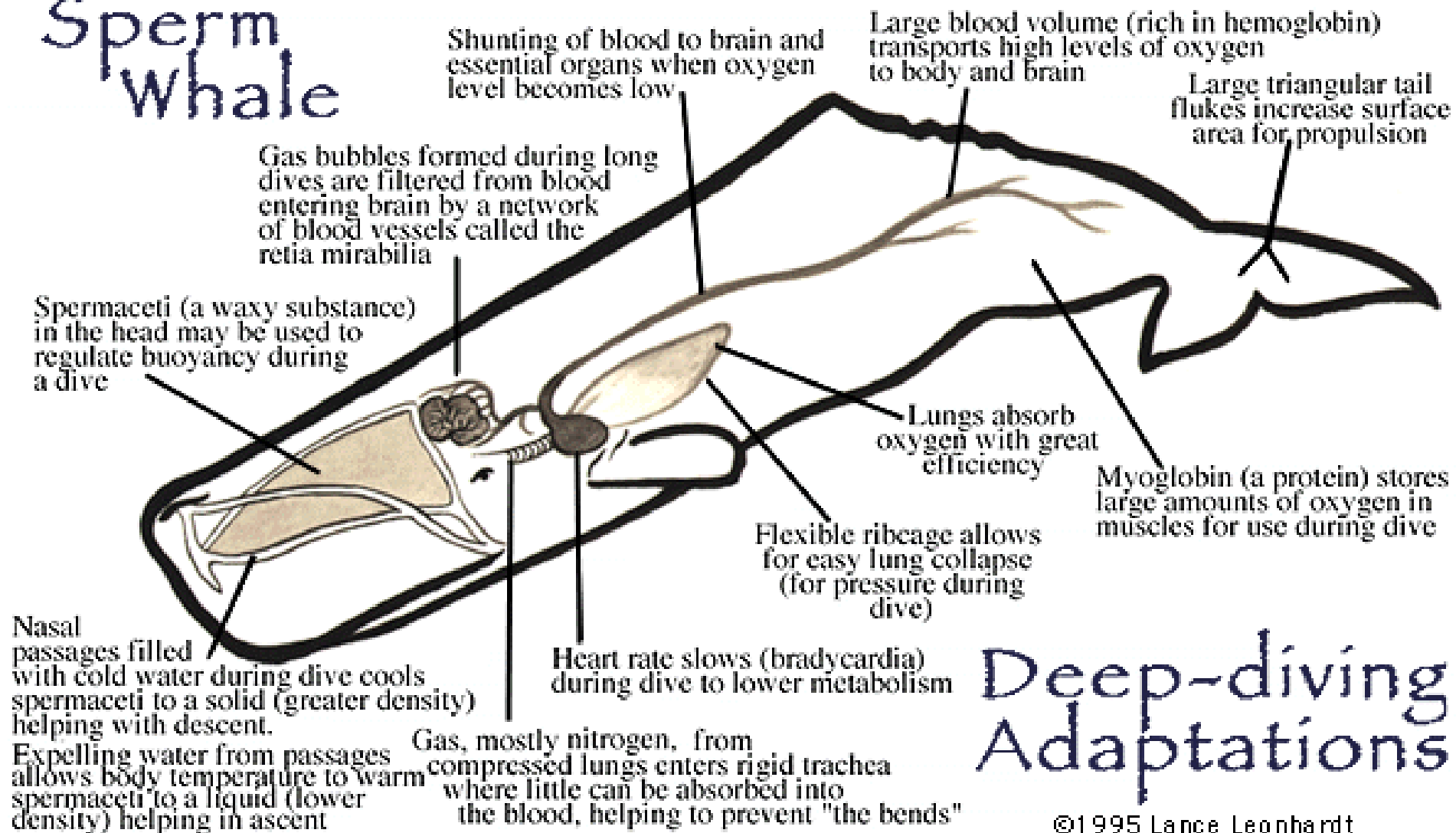


Pressure

- ❖ At sea level there are 14.7 pounds per square inch (psi)(=1 atmosphere) or 1kg per cm² being exerted on our bodies
- ❖ Not felt as our bodies compensate by pushing out with the same force
- ❖ Water is heavier than air - pressure increases with depth
- ❖ For every 10m or 33ft, another atmosphere is exerted
- ❖ Marine species adapt to large changes in short periods of time
- ❖ Sperm whales – withstand 225 atmospheres when diving to depths of 2,250m or 7,380ft
- ❖ How do they do it?

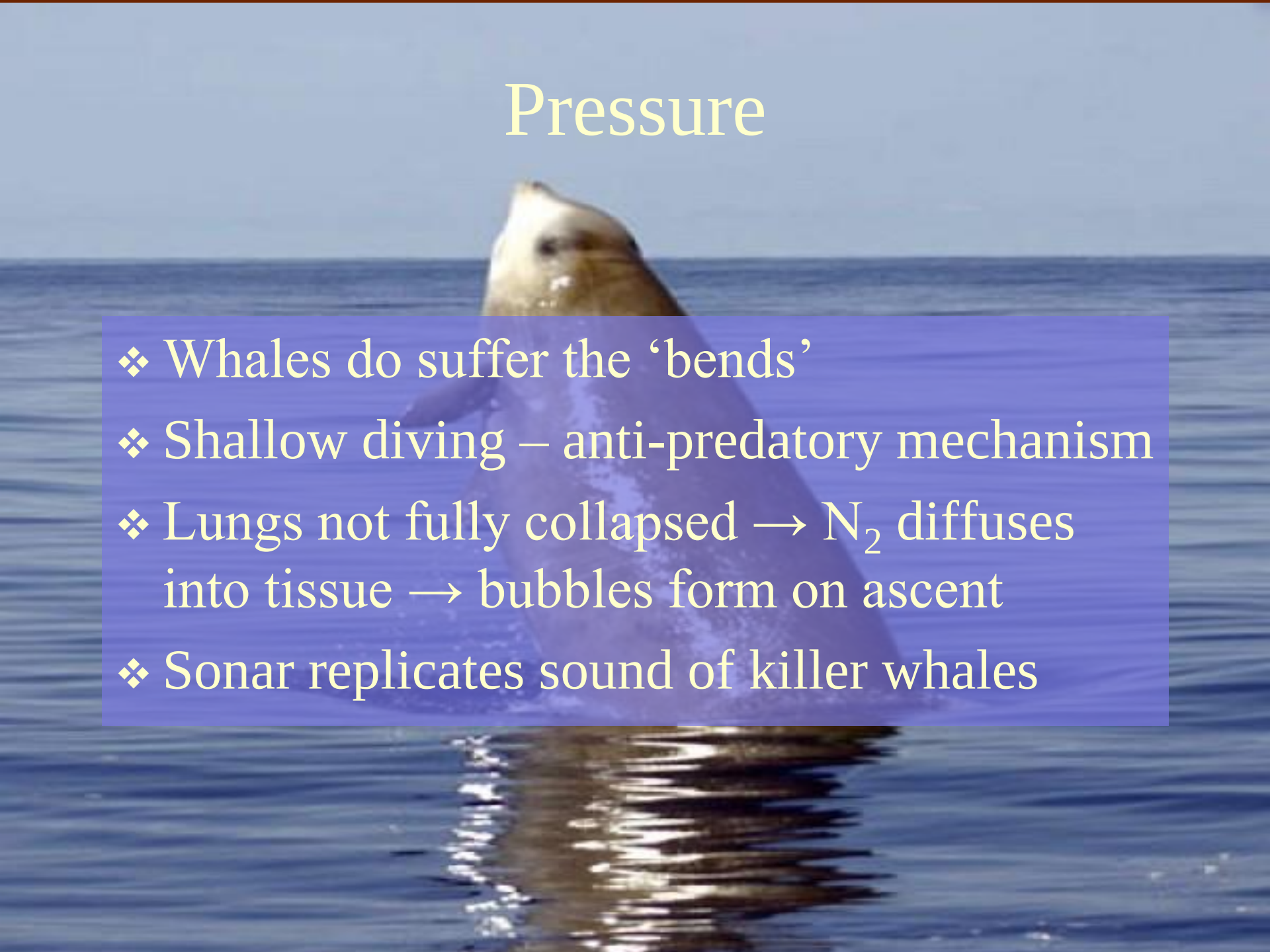
Sperm Whale Deep-Diving Adaptations

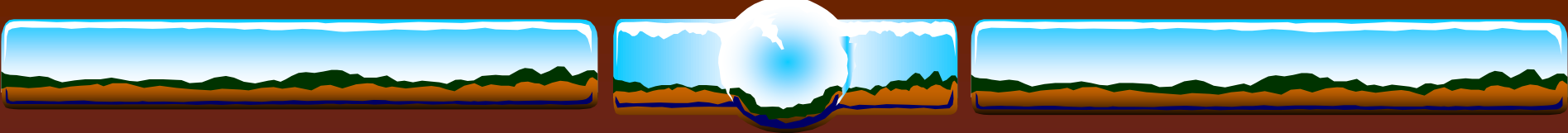
Sperm Whale



Deep-diving Adaptations

Pressure

- 
- ❖ Whales do suffer the ‘bends’
 - ❖ Shallow diving – anti-predatory mechanism
 - ❖ Lungs not fully collapsed → N_2 diffuses into tissue → bubbles form on ascent
 - ❖ Sonar replicates sound of killer whales



Physical (abiotic) Factors

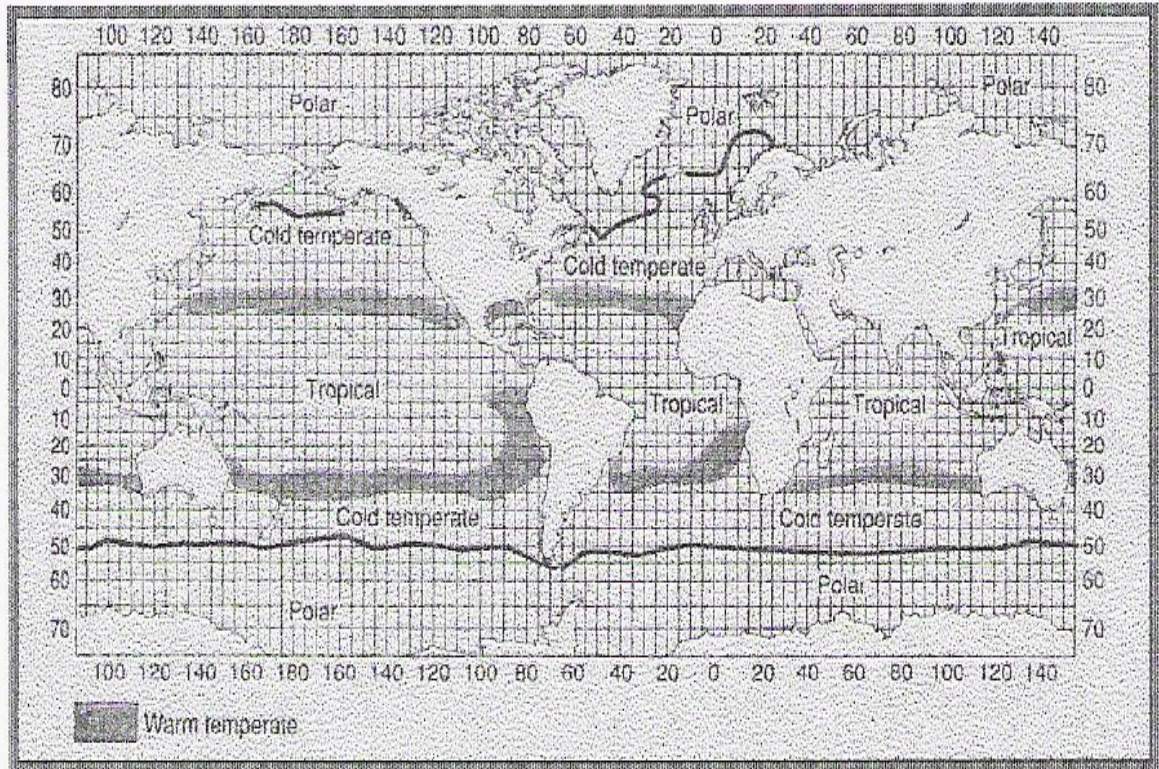
3. Temperature

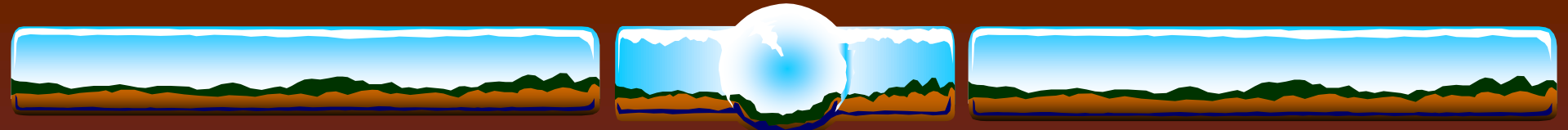
- ❖ A measure of the energy of molecular motion
- ❖ Varies both horizontally with changes in latitude and vertically with depth
- ❖ Important consideration – marine organisms function within a narrow band of temperature tolerance
- ❖ Affects density – warm waters are less dense than cooler seas of the same salinity

Temperature

❖ Four distinct biogeographical zones based on temperature:

- ❖ Polar
- ❖ Cold temperate
- ❖ Warm temperate (subtropical)
- ❖ Tropical (Equatorial)

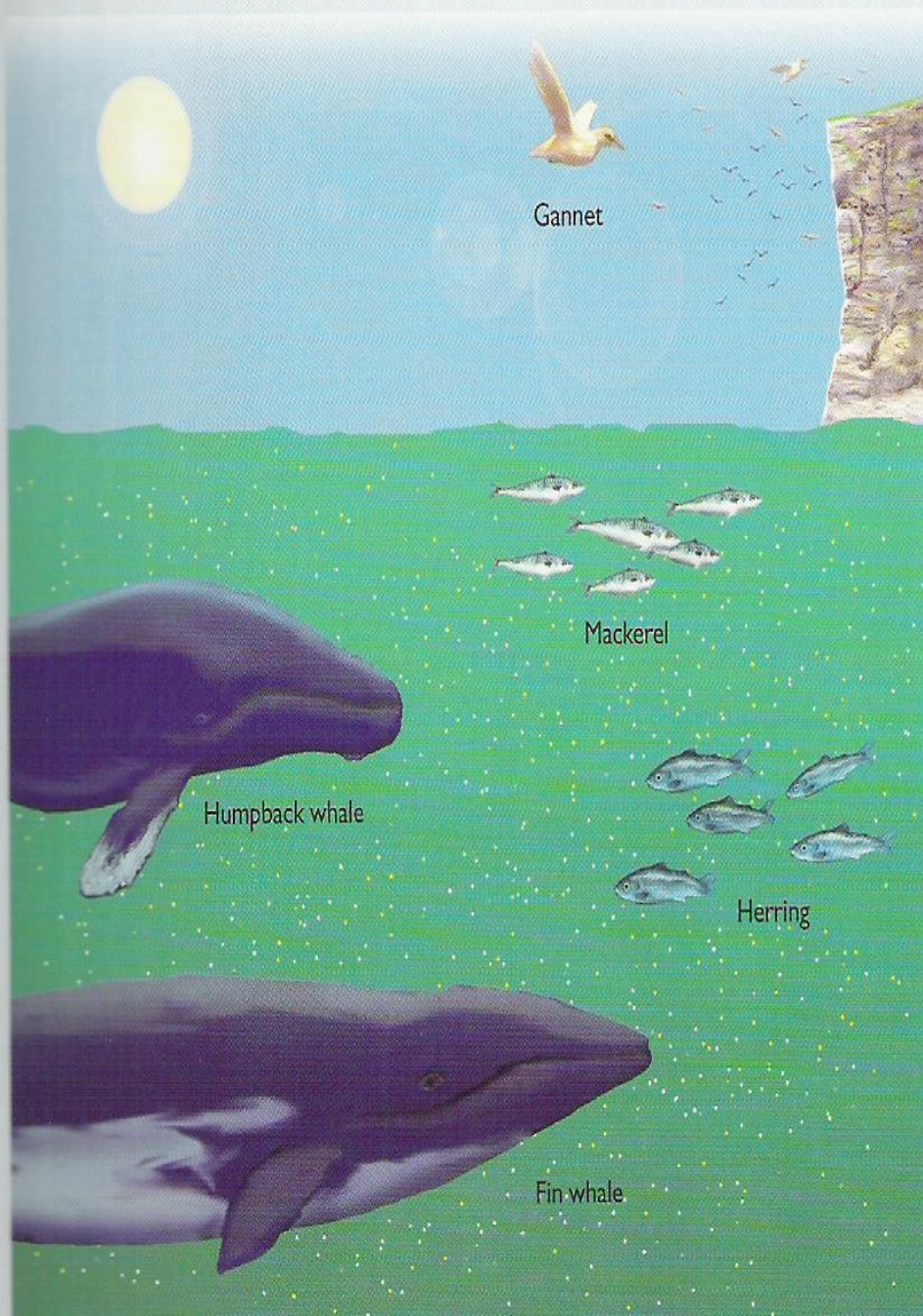




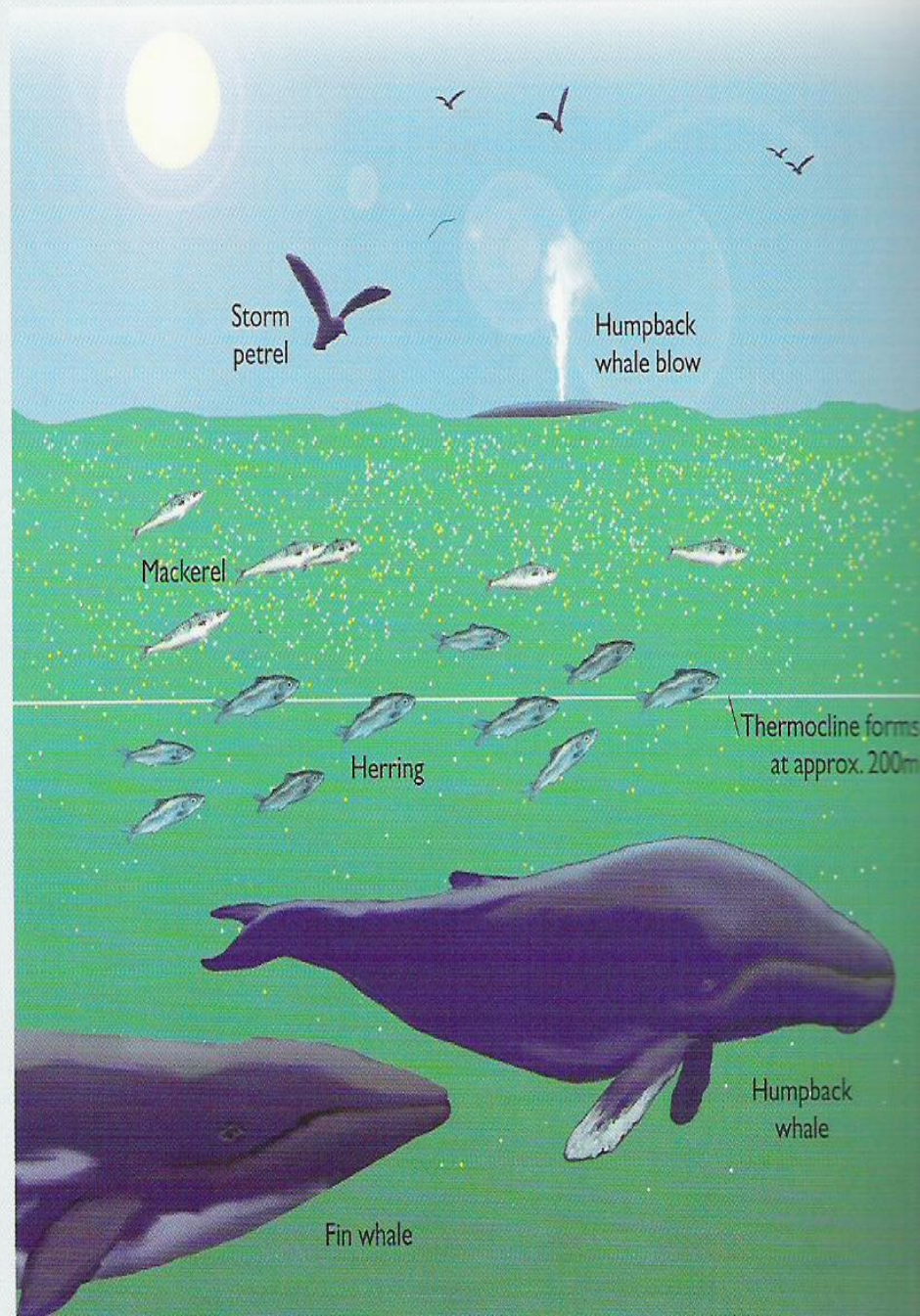
Temperature

- ❖ Thermocline – separates euphotic region from deep ocean
- ❖ At low latitudes - strong thermocline
- ❖ At high latitudes, none at all. Cold from top to bottom
- ❖ Greatest variation in Tropics
- ❖ Cloud cover and direction/speed of wind
- ❖ Vertical mixing – wind and waves action distribute surface heat downwards

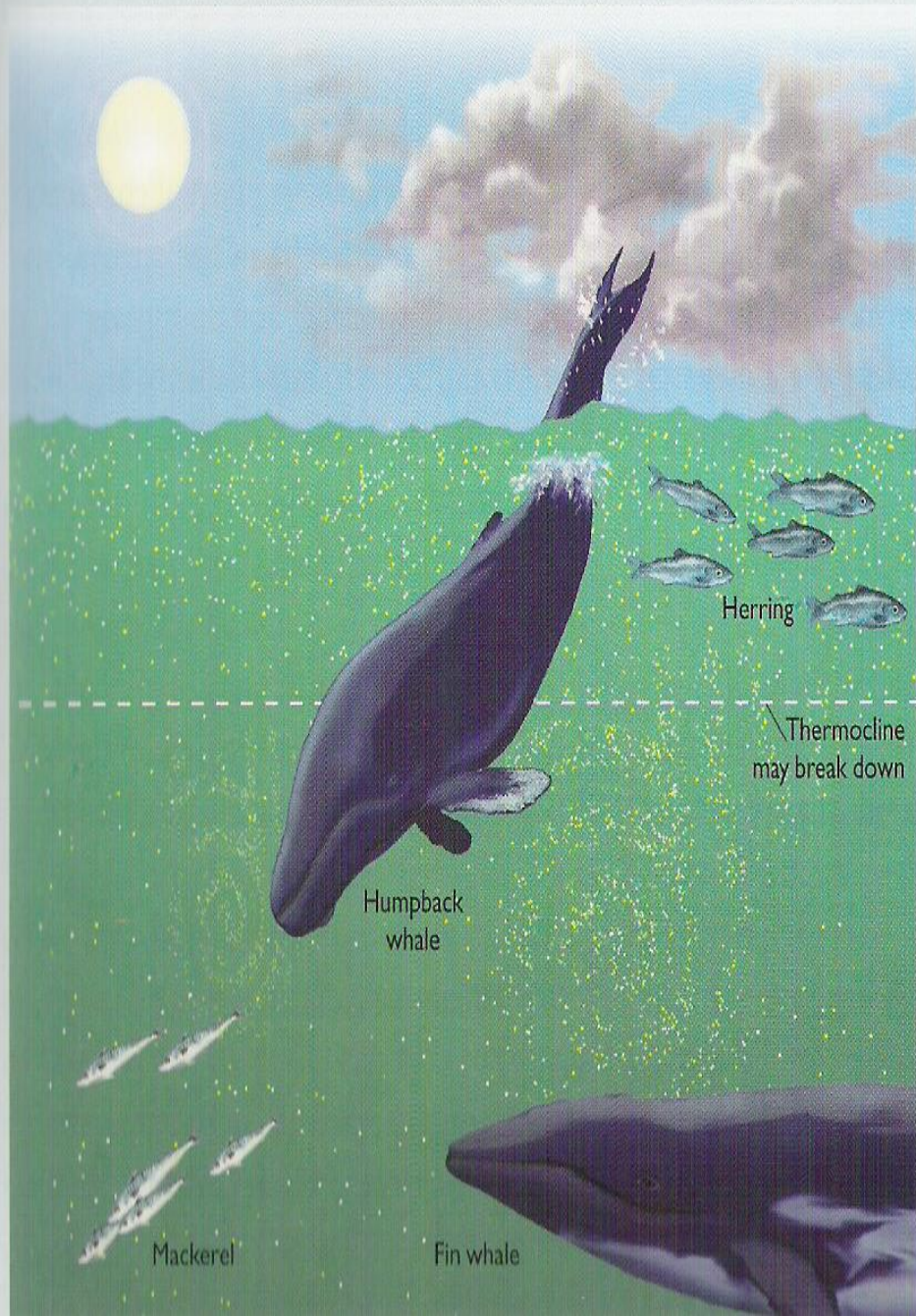
SPRING



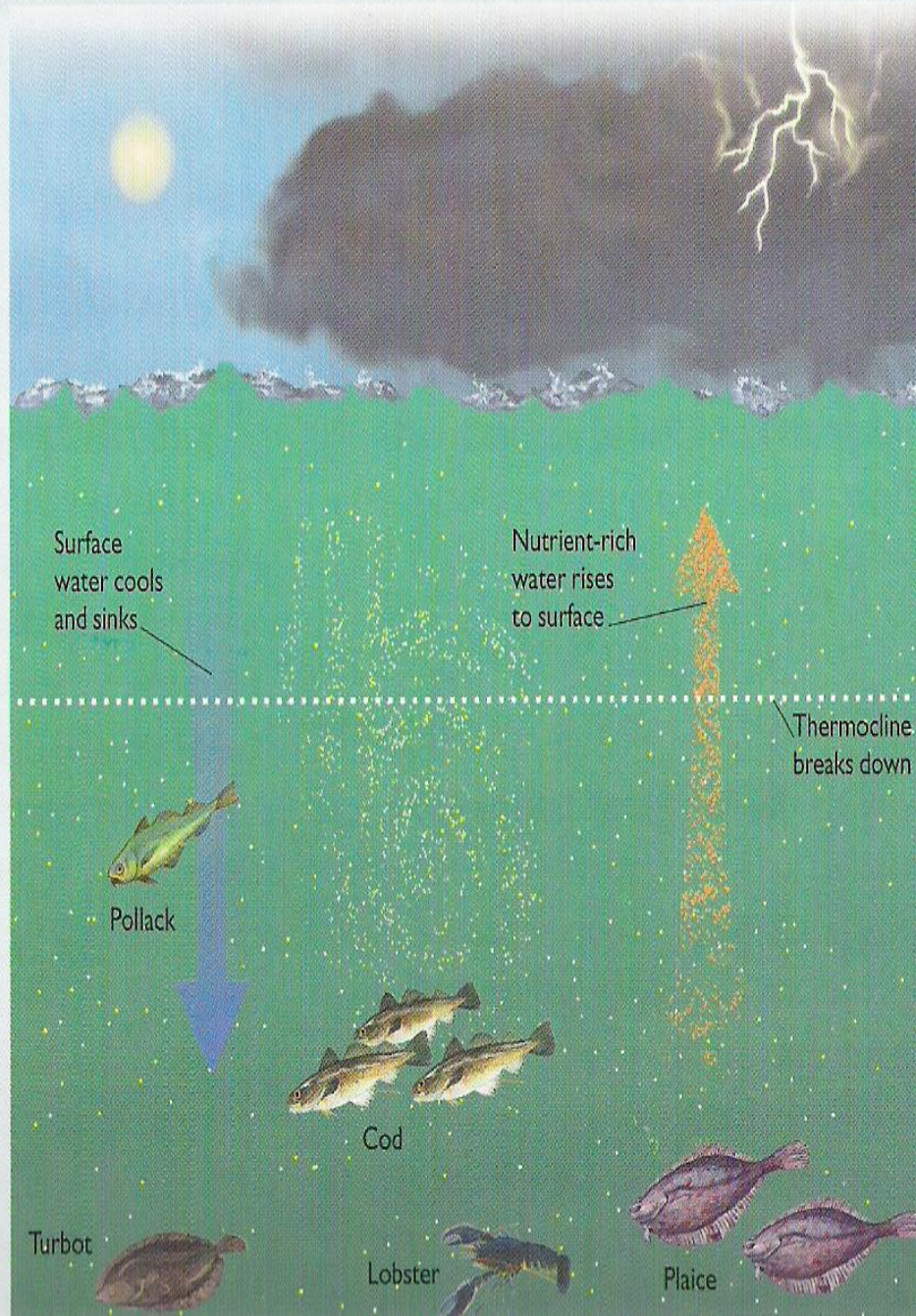
SUMMER

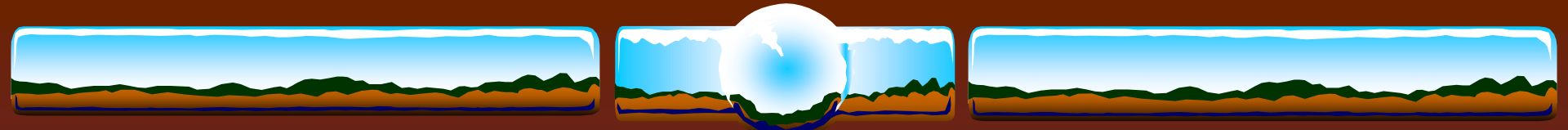


AUTUMN



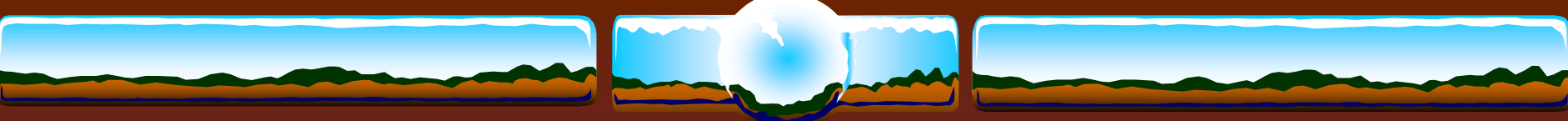
WINTER





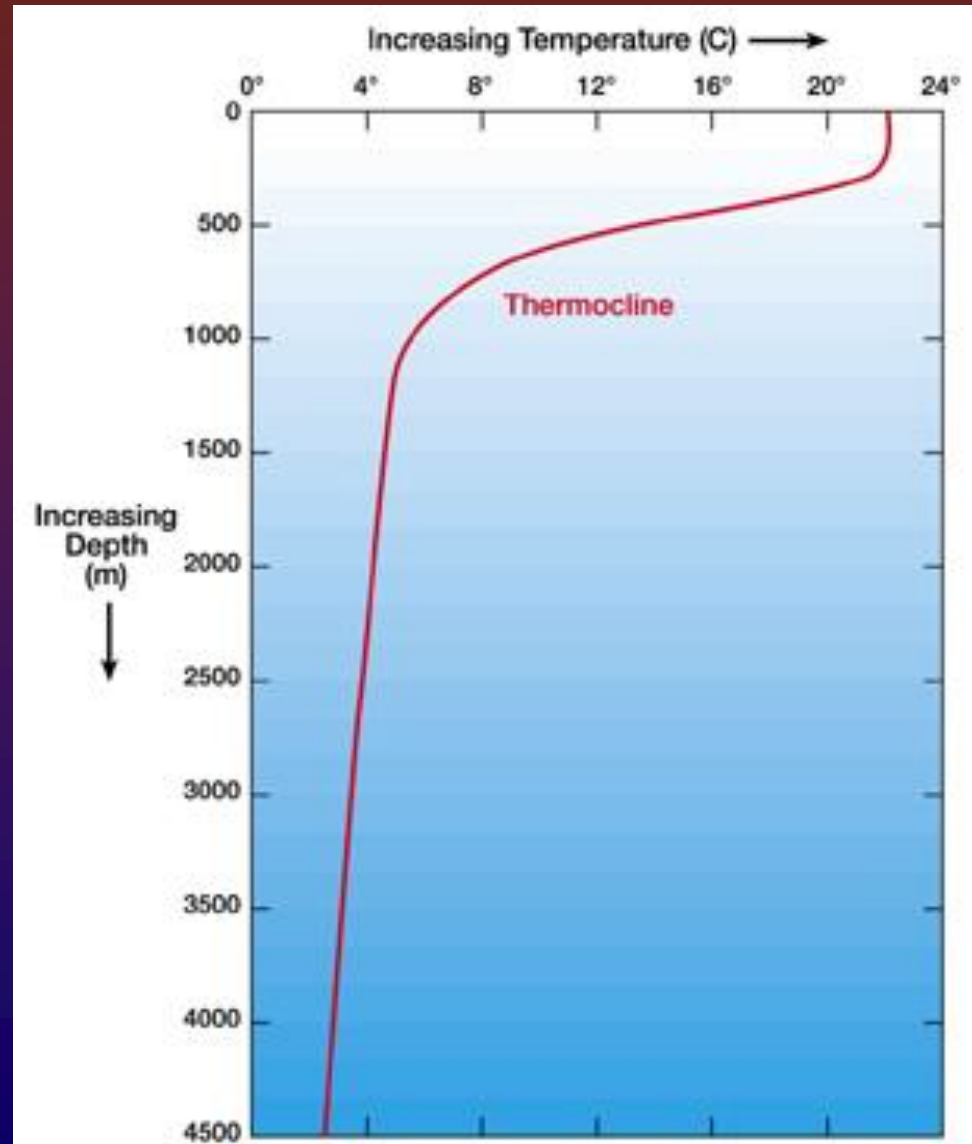
Temperature

- ❖ High specific heat capacity of water ($1\text{kg}/1^{\circ}\text{C}$)
- ❖ On average, ocean surface waters are 17°C
- ❖ Highest recorded was 36°C in the Persian Gulf (EPS 2000). Land can exceed 50°C
- ❖ Temperature below the thermocline - between 0 and 3°C
- ❖ Diurnal temperature changes in subsurface waters are unknown – thought to be extremely small



Temperature Profile

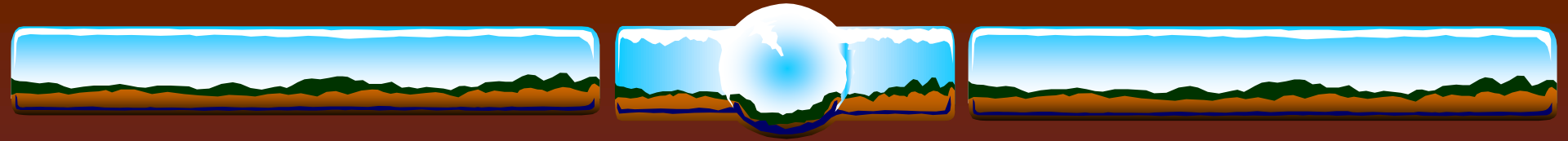
- ❖ Below the thermocline is colder, more saline and denser
- ❖ At mid latitude and Equatorial waters, the deep ocean is always stratified and separated from the surface layer





Greenland's ice shelves underwent extensive melting in 2019 (UN, 2019)

This is taken from the UN and IPCC's landmark research on climate and the oceans, (September 2019). Of the major ice sheets, Greenland's -- which has the potential to raise sea levels around 6m, is melting fastest, and lost more than 275 gigatons on average per year between 2006 and 2015. But the even larger Antarctic ice sheet is also shrinking, and its mass loss tripled between 2007 and 2016 compared to the previous ten years.

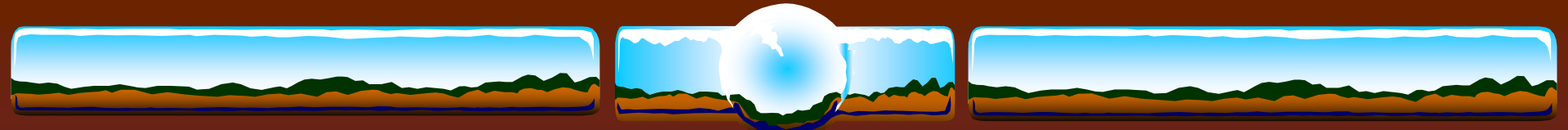


Group Work

- ❖ Separate out into two break out groups:

- ❖ Is there evidence that marine organisms are changing their distribution patterns in relation to climate change?

Persuade me that this is happening – stats are important!



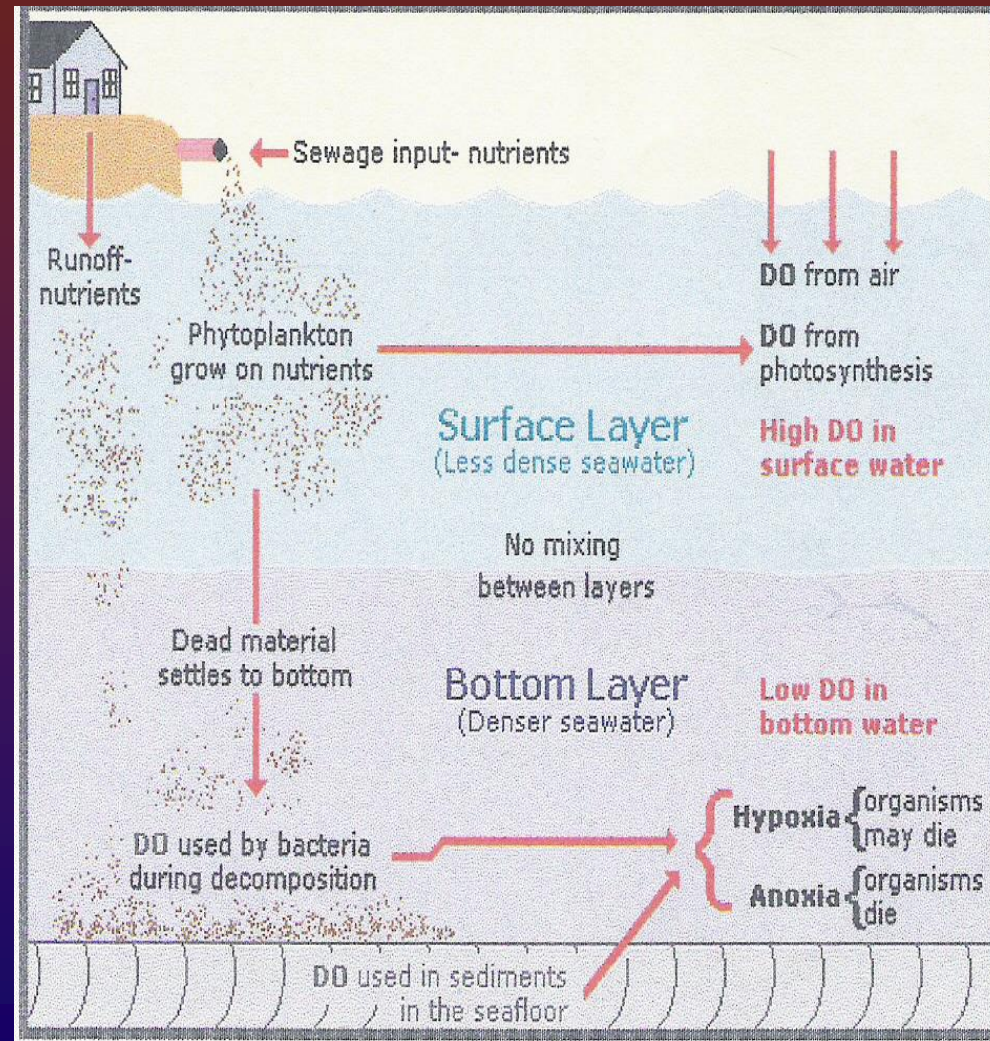
Chemical (abiotic) Factors

4. Dissolved Oxygen (DO)

- ❖ Good indicator of water quality
- ❖ DO levels dependent on temperature and salinity
- ❖ Cold water holds more DO than warm; fresh more than salt
- ❖ DO measurements are given as a percentage of saturation point or in mg l^{-1}

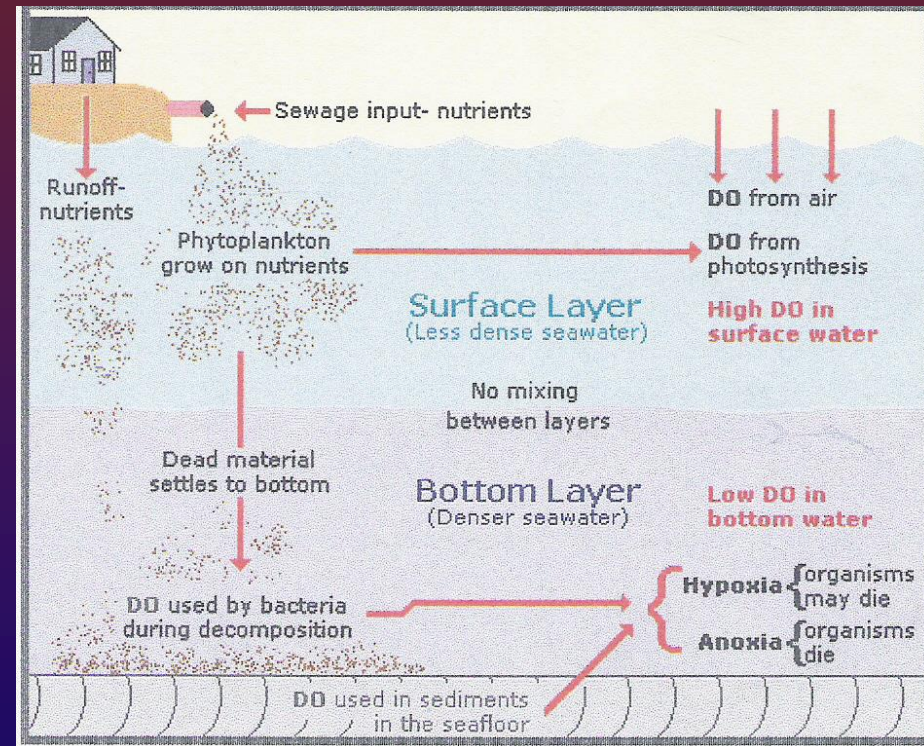
Dissolved Oxygen

- ❖ Mixing by action of waves and wind
- ❖ DO – a by-product of phytoplankton photosynthesis
- ❖ Needed for respiration
- ❖ Breakdown of organic material by bacteria – DO in deep water can be used up
- ❖ If little mixing- stratification – no addition O_2 – water quality deterioration at bottom



Dissolved Oxygen

- ❖ Most marine mammals have sufficient O_2 at 5mg/l or above
- ❖ As levels fall below 3mg/l – water quality described as hypoxic
- ❖ Below 0.5mg/l – anoxic
- ❖ Under hypoxic conditions, many marine plants and animals may not survive
- ❖ None requiring O_2 can survive anoxic conditions

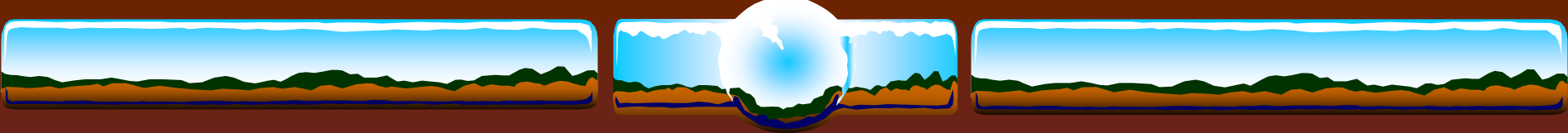




Blue Marlin *Makaira nigricans* now crowding the surface to hunt off California as they flee the low-oxygen zones in deep water.

Oceanic Dead Zones

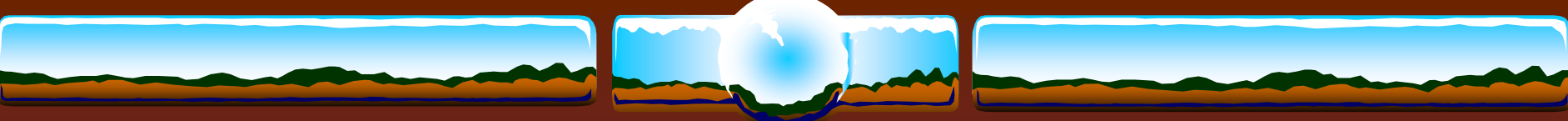
- Coastal dead zones can occur naturally
- They have increased by $> 4.5\text{mil km}^2$
- Low oxygen levels are growing by $> 1\text{m}$ per year
- World's oceans have lost 2% oxygen in last 50yrs
- Low oxygen regions often produce NO – a ghg – positive feedback loop (Welch, 2018)



Physical, Chemical and Biological Factors Affecting the Oceans

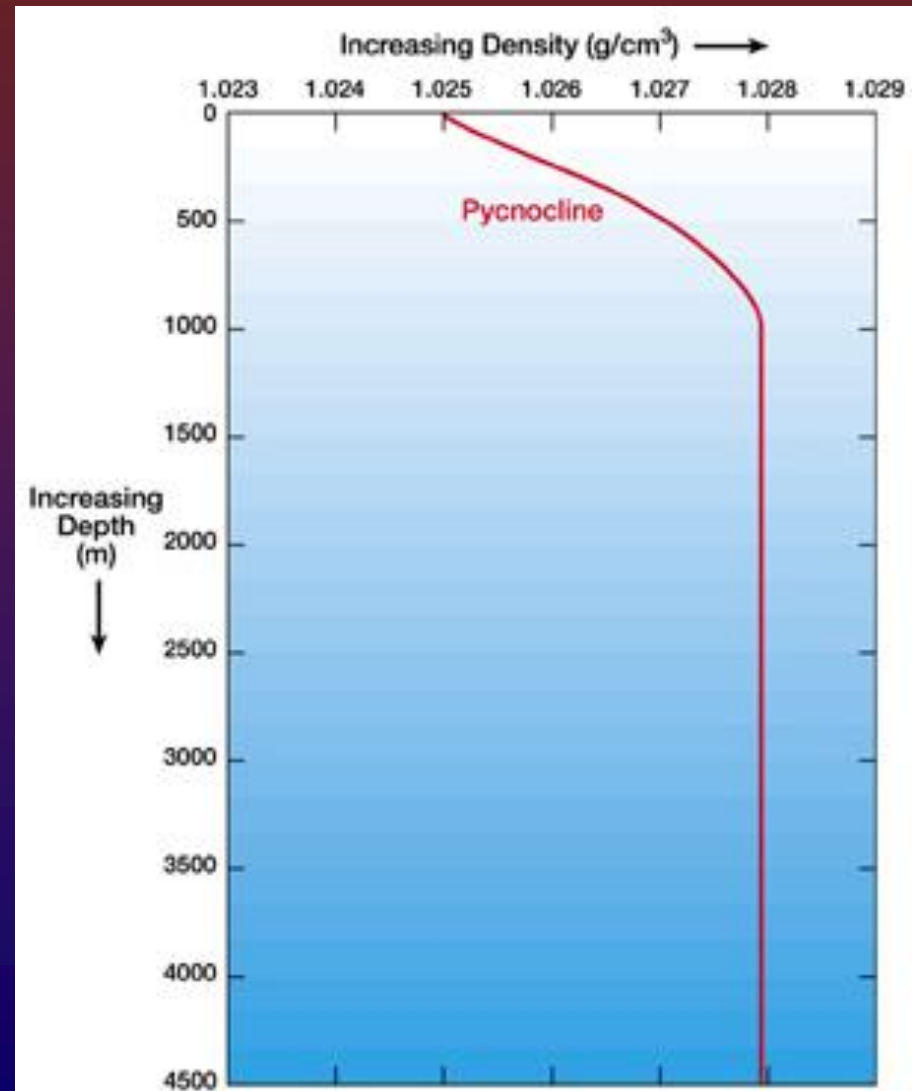
- ❖ Introduction – the Marine Environment
- ❖ Physical / Chemical Factors
 - ❖ Salinity
 - ❖ Light and Pressure
 - ❖ Temperature
 - ❖ Dissolved Oxygen
 - ❖ Density and pH
 - ❖ Chlorophyll a
 - ❖ Waves/currents/upwelling/tides





Density

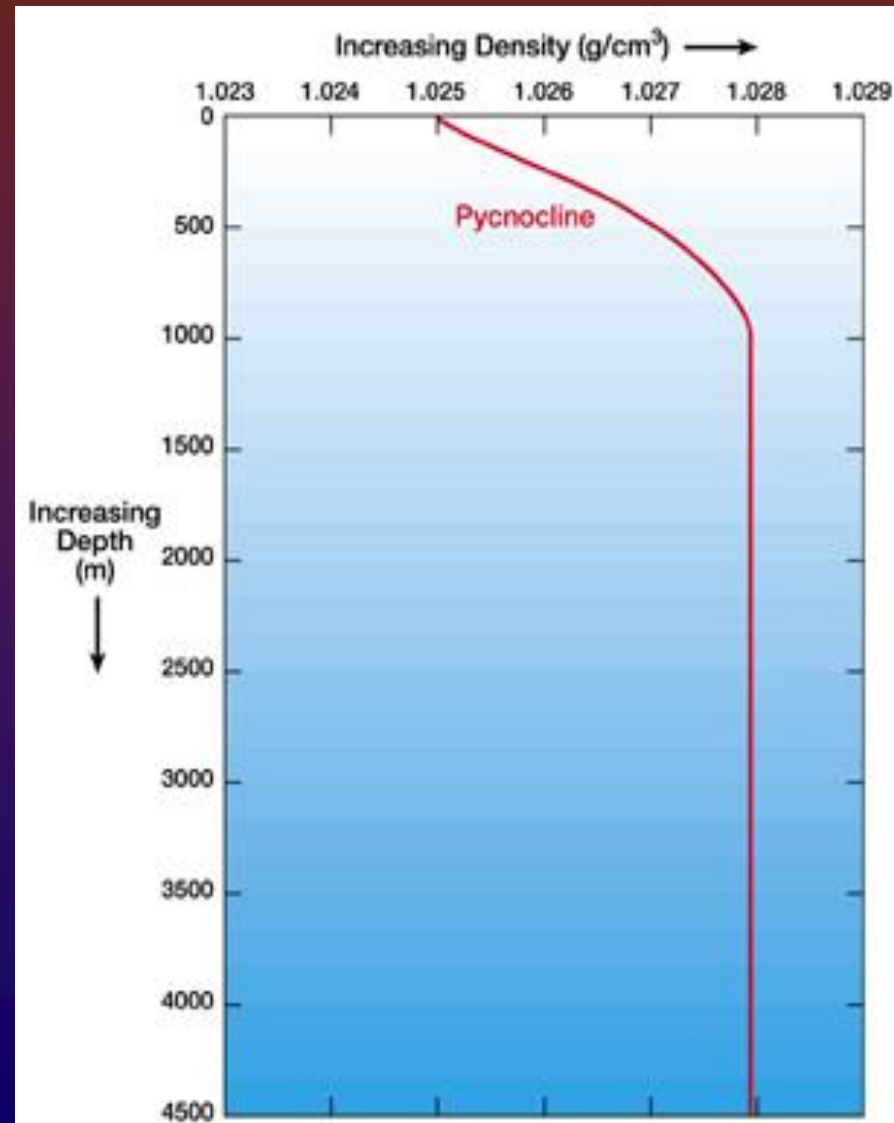
- ❖ Sediment
- ❖ Pressure
- ❖ Temperature — colder the water, the more dense it is
- ❖ Salinity — the higher the salinity, the more dense it is
- ❖ Temp has more of an influence on density than salinity
- ❖ Density of pure water 1000kg/m^3
- ❖ Density of oceanic surface water is about 1027kg/m^3

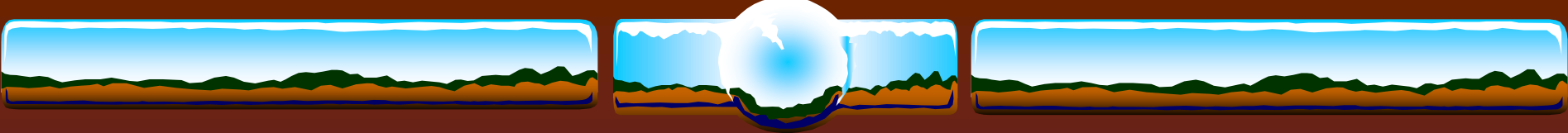




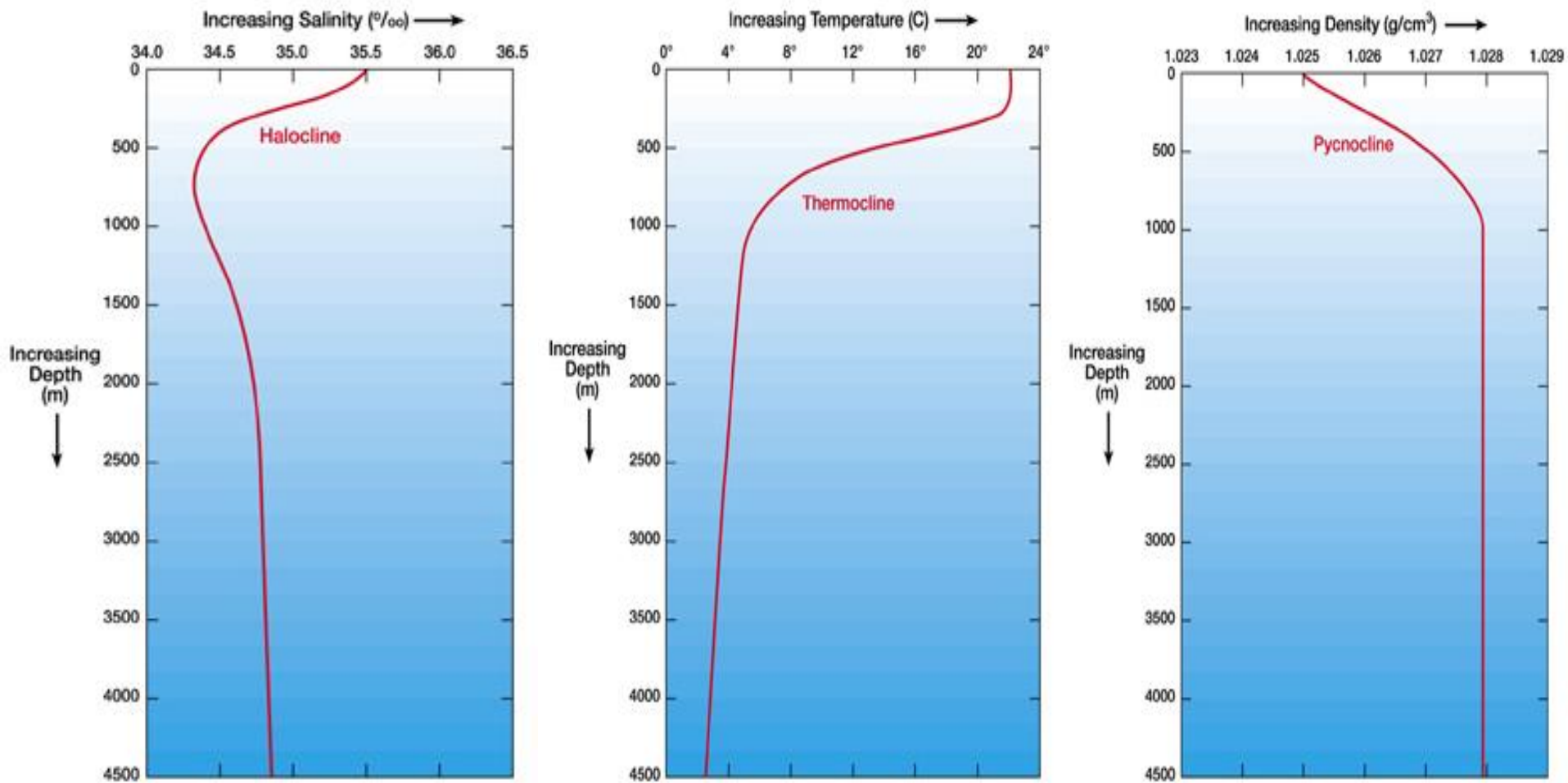
Density

- ❖ Densest water at bottom
- ❖ Pycnocline – rapidly changing density
- ❖ Separates the deep ocean from the surface layers
- ❖ Circulation at depth is horizontal -
- ❖ Water moves along layers of the same density





Salinity, Temperature and density Profiles



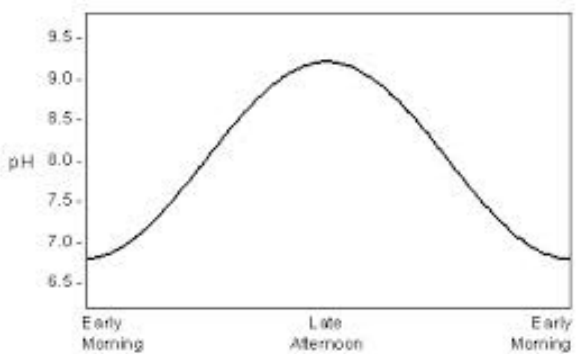


Fig. 1. Daily pH cycle in a hypothetical production pond.

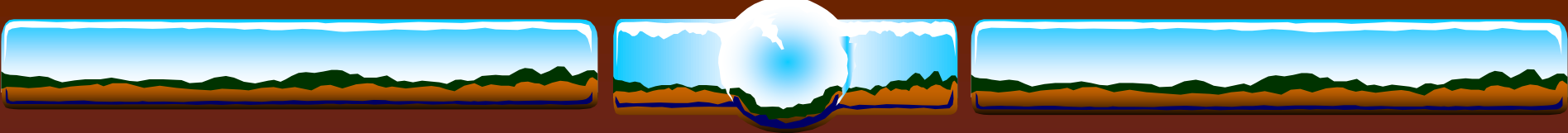
pH

- ❖ 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 → photosynthesis
- ❖ Decomposition – lowers pH
- ❖ Seawater does not alter pH appreciably – natural buffer
- ❖ pH above 9.0 or below 5.0 – survival rates fall

	Name	Example	pH Scale
14	Base	lye	14
13		bleach	13
12		ammonia	12
11		milk of magnesia	11
10		borax	10
9		baking soda	9
8		sea water	8
7	Neutral	distilled water	7
6	Acid	milk	6
5		corn	5
4		boric acid	4
3		orange juice	3
2		vinegar	2
1		lemon juice	1
0		battery acid	0

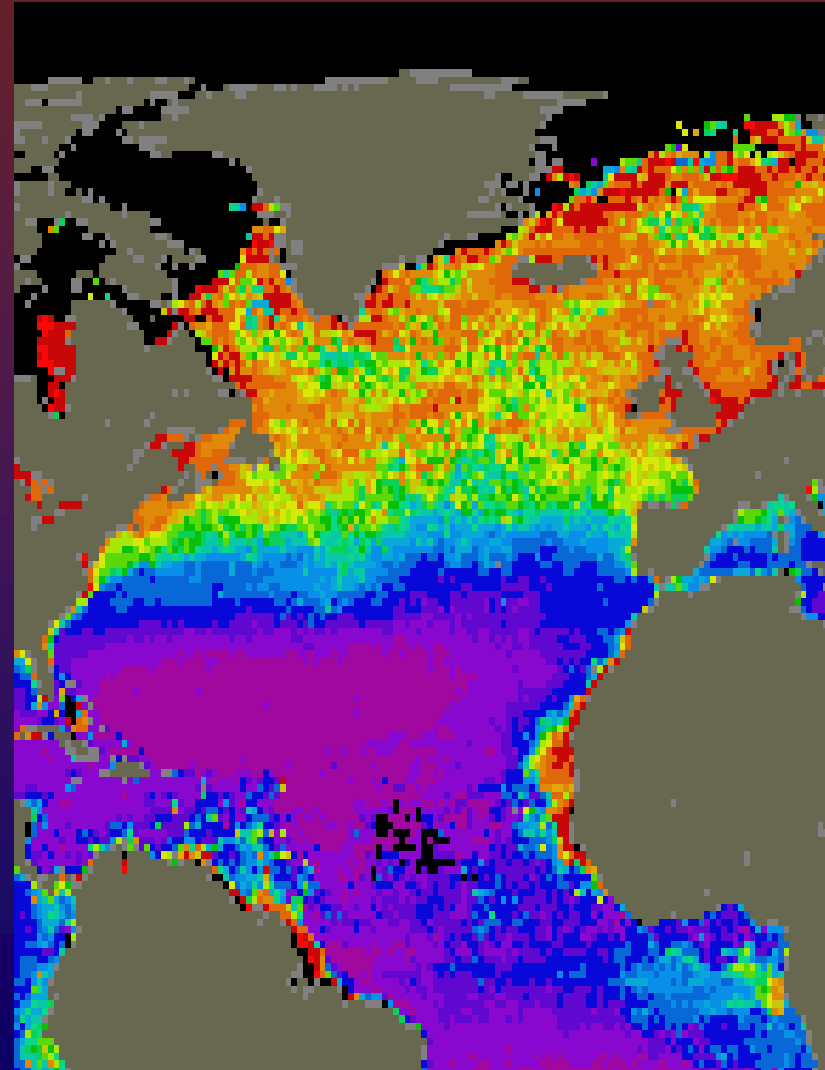
Coral Bleaching due to Acidification



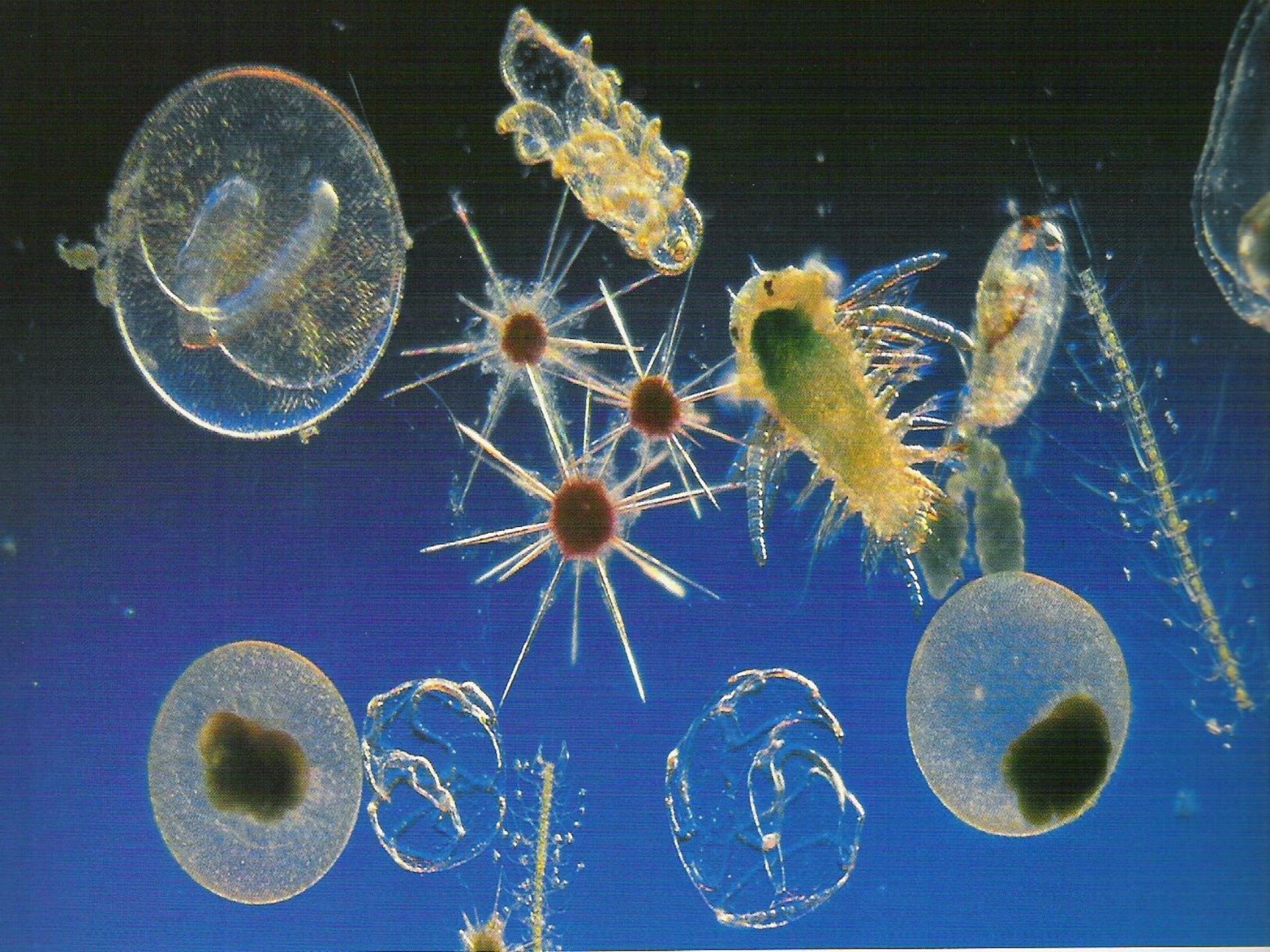


Chlorophyll a

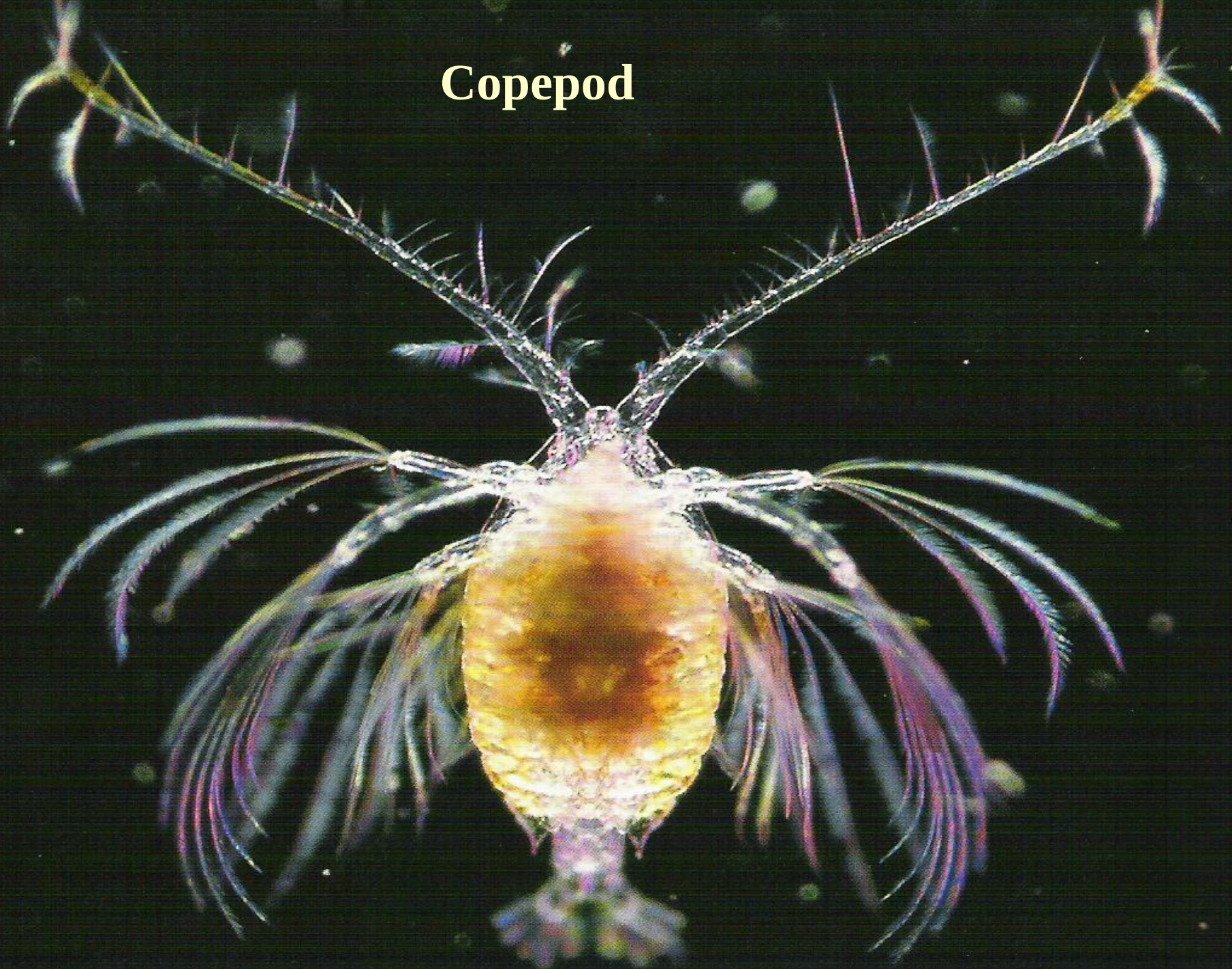
- ❖ Used to measure relative abundance phytoplankton
- ❖ Concentrations generally highest just beneath surface waters rather than at the surface
- ❖ Factors affecting growth:
 - ❖ Sunlight
 - ❖ Nutrient availability(nitrate & phosphate)
 - ❖ Stratification
 - ❖ Temperature
 - ❖ Water quality

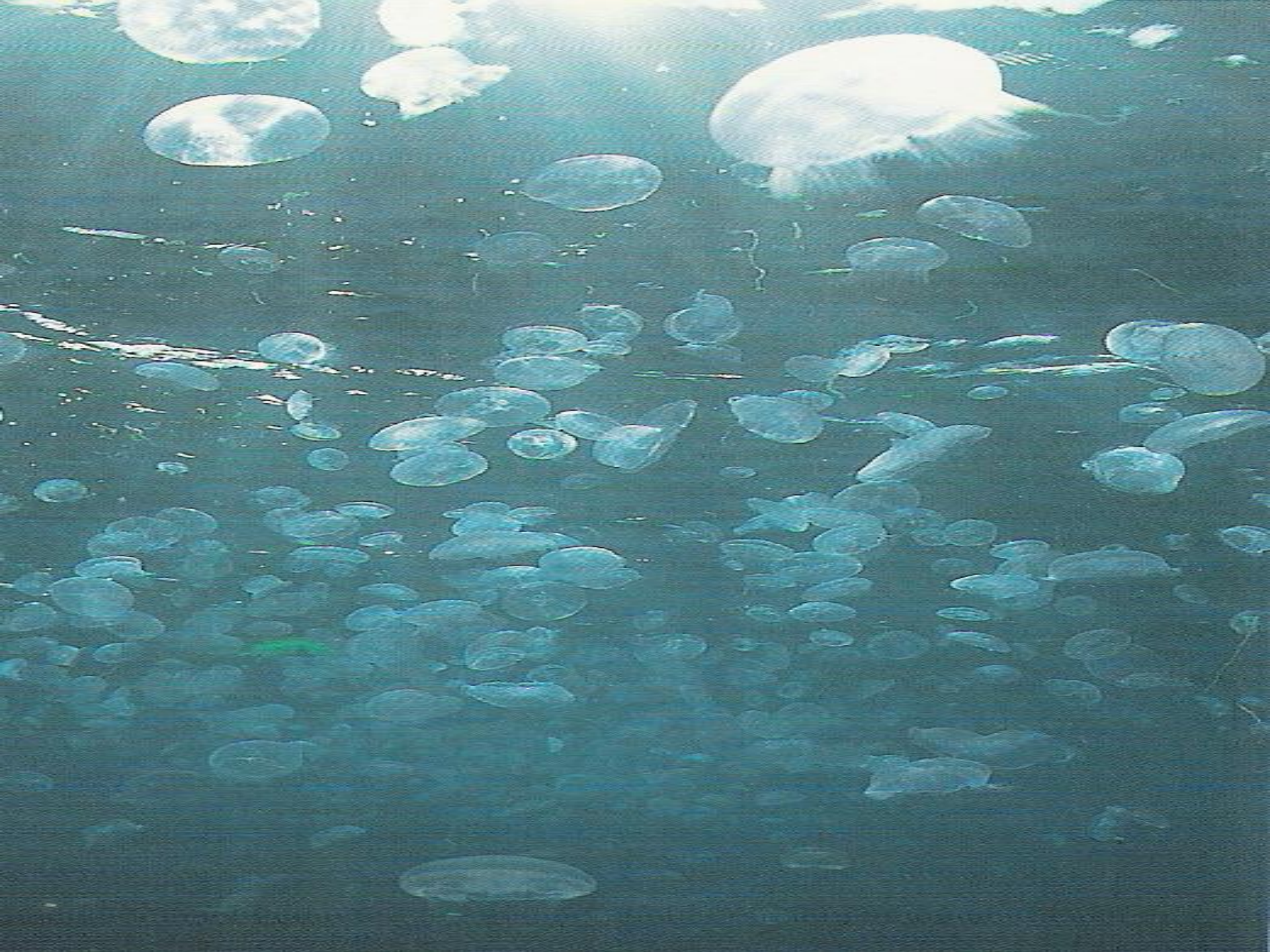


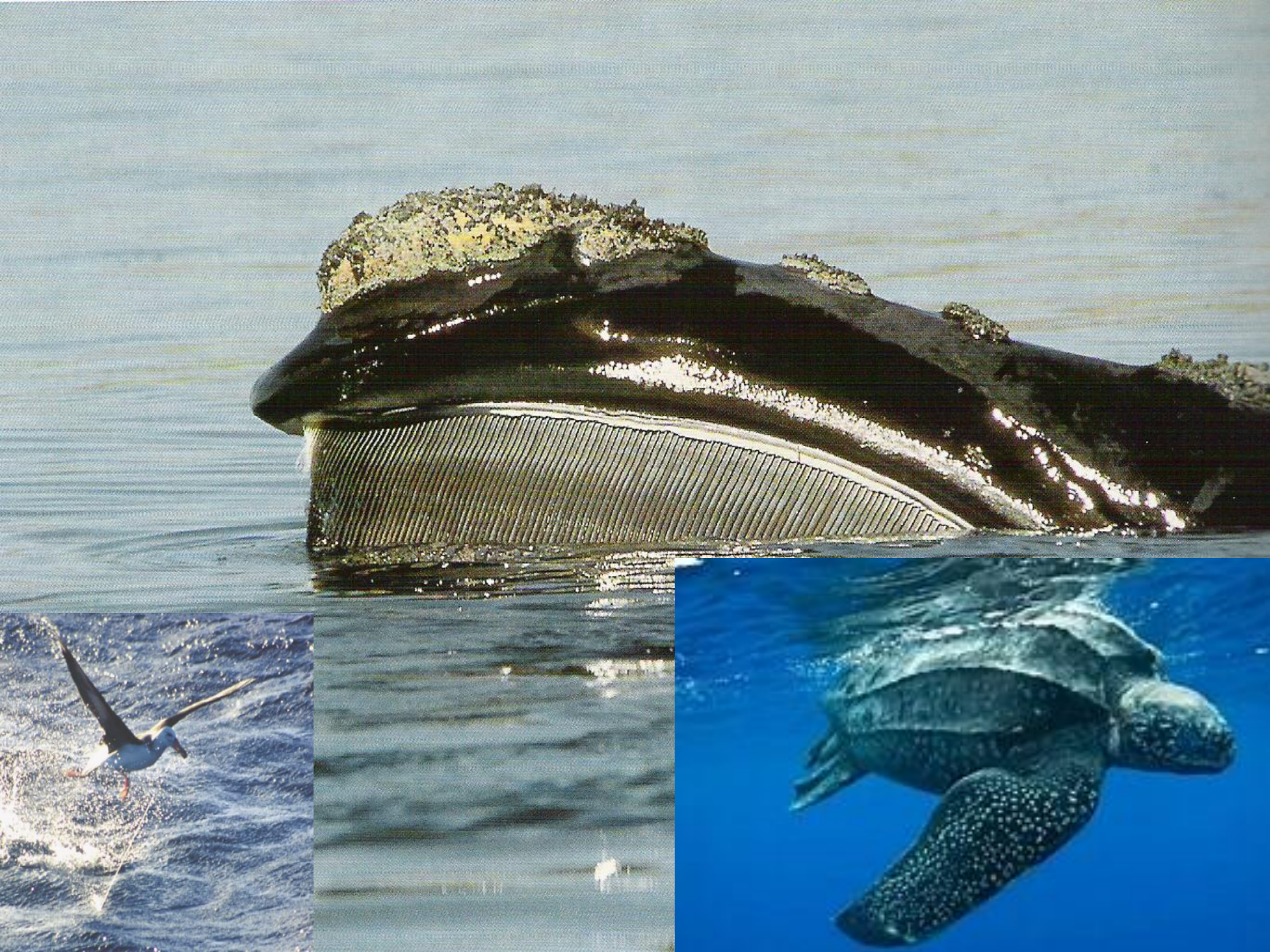


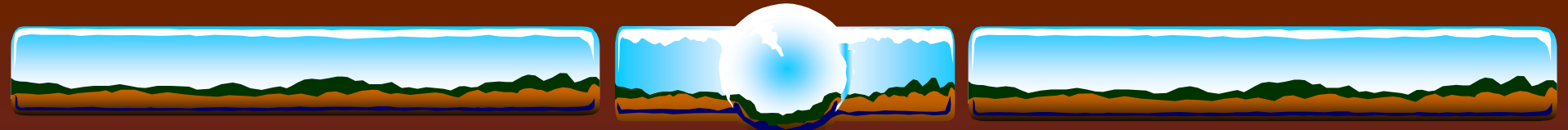


Copepod



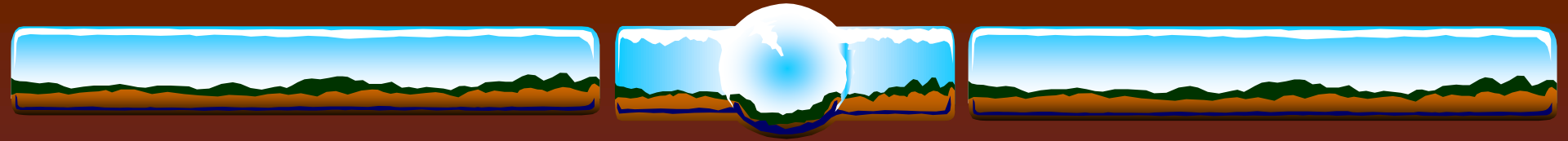






Leatherback Turtles... not quite Carmarthen Bay



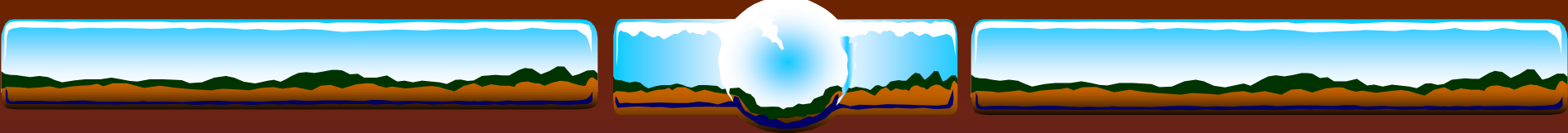


Group Work

- ❖ Separate out into break out groups:
 - ❖ 1. Evidence that nature's calendar is changing. Weather patterns that are altering and throwing the natural food chain predator : prey sequence out.
 - ❖ 2004 may be a year to consider

Neuston layer

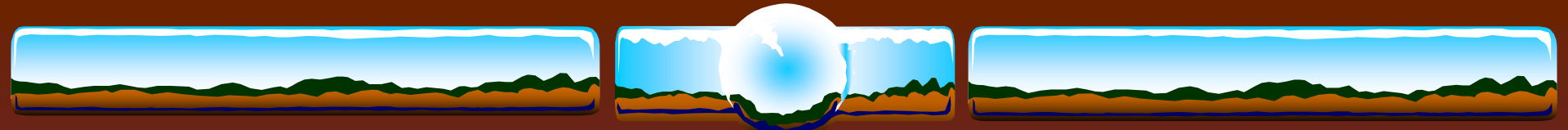
- Rich in nutrients
- Waste excreted from plankton in deeper water
- Decaying larger organisms
- Ideal habitat for bacteria, protozoan & microscopic algae
- Attracts swarms plankton amongst others



Physical, Chemical and Biological Factors Affecting the Oceans

- ❖ Introduction – the Marine Environment
- ❖ Physical / Chemical Factors
 - ❖ Salinity
 - ❖ Light and Pressure
 - ❖ Temperature
 - ❖ Dissolved Oxygen
 - ❖ Density and pH
 - ❖ Chlorophyll a
 - ❖ Waves/currents/upwelling/tides

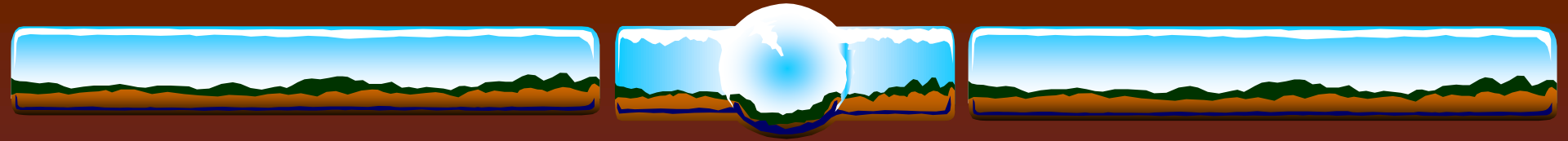




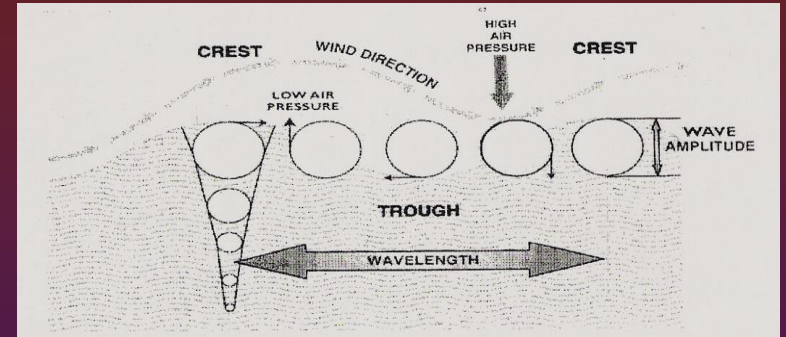
Waves and Currents

- ❖ Waves generated by:
 - ❖ Wind – atmospheric pressure
 - ❖ Sea craft
 - ❖ Earth movements
- ❖ Wavelength and height are determined by:
 - ❖ Wind speed
 - ❖ Water surface distance
 - ❖ Storm duration
 - ❖ Water depth



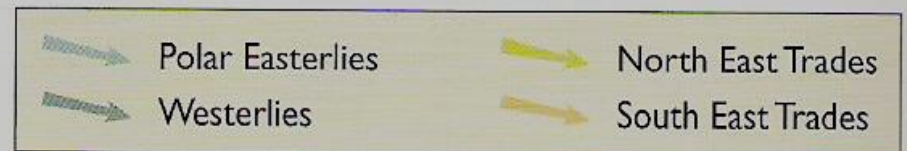
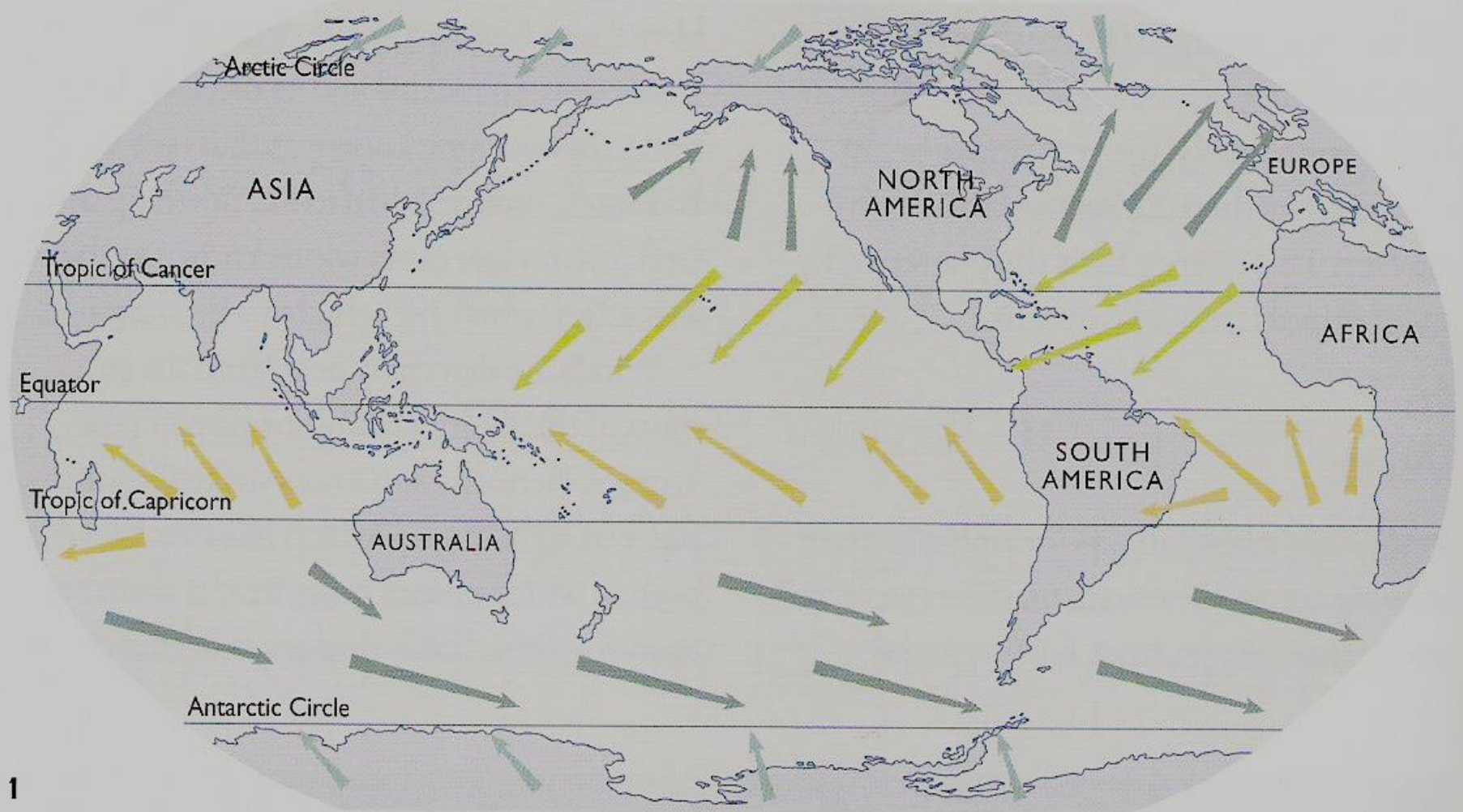


Waves

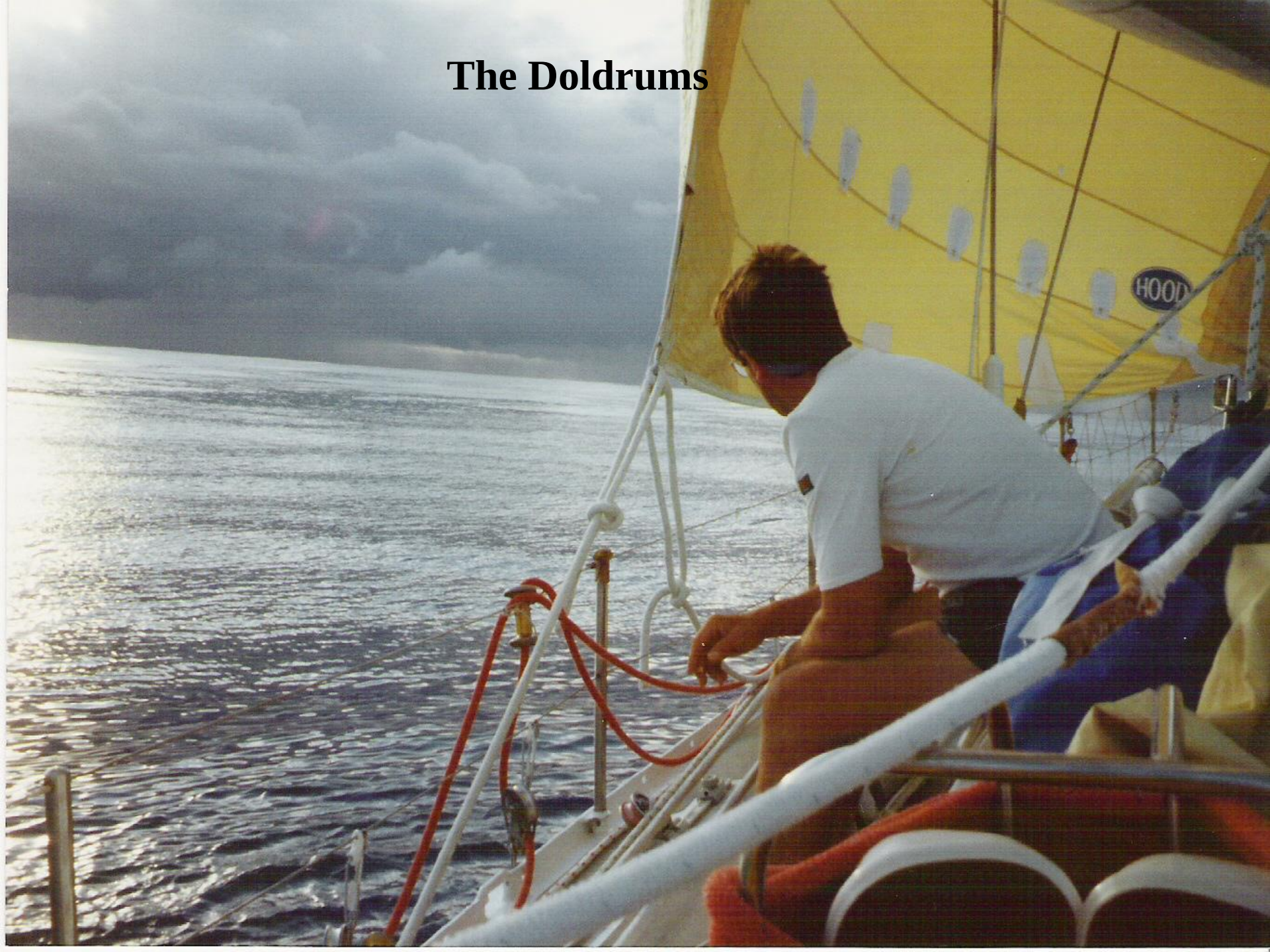


- ❖ Formation by wind blowing over an area in a constant direction
- ❖ Swells form
- ❖ Amplitude – height between crest and trough
- ❖ Wavelength – distance between each successive crest/trough

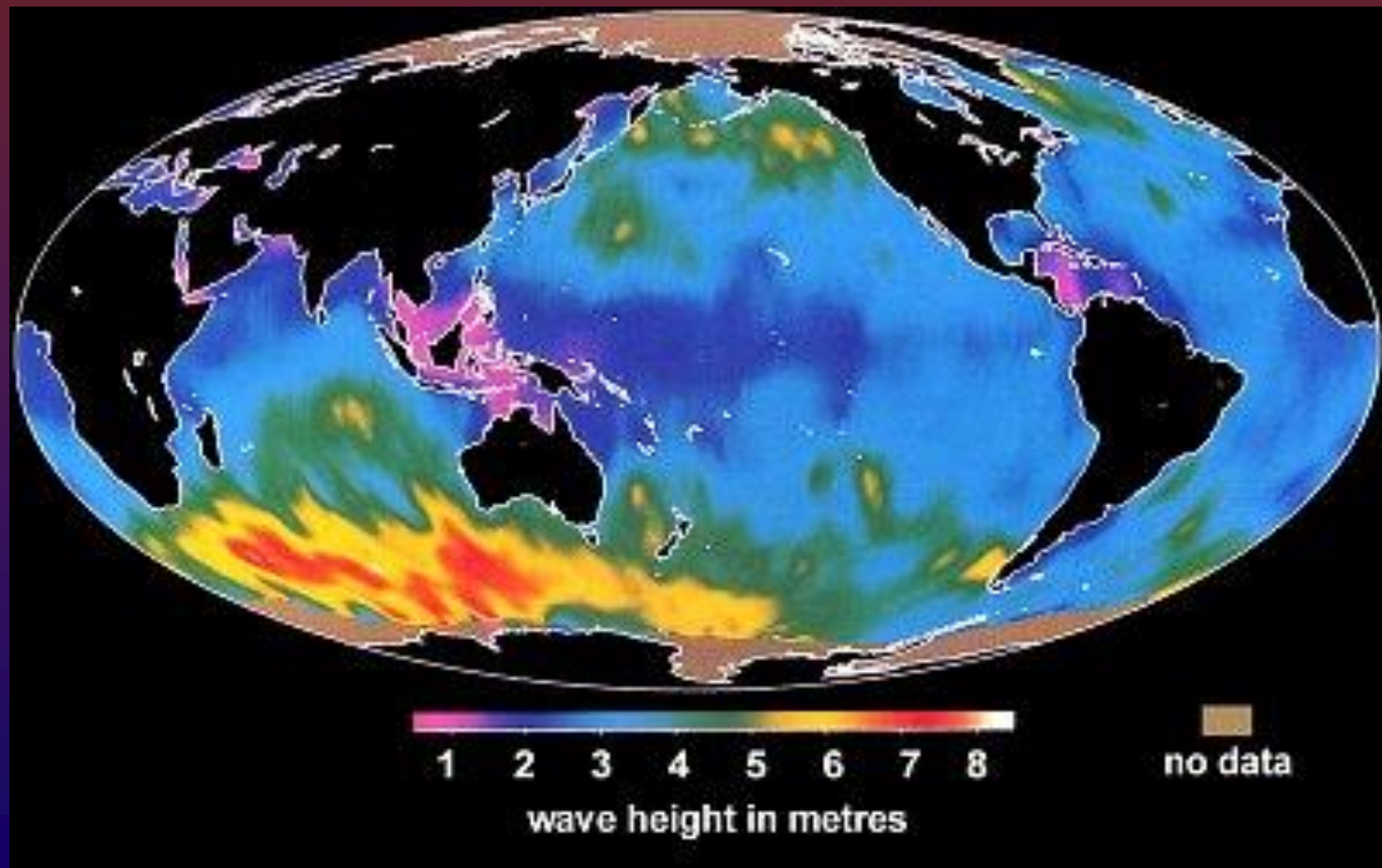
WIND PATTERNS OF THE WORLD



The Doldrums

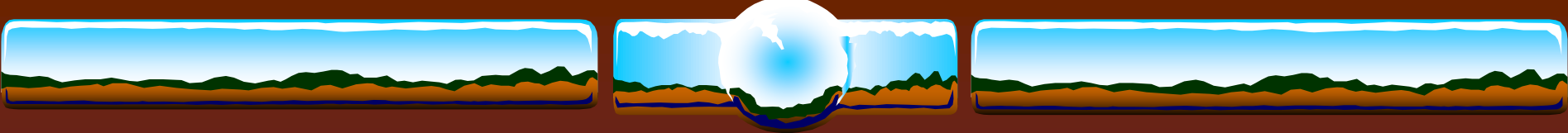


Global Wave Height



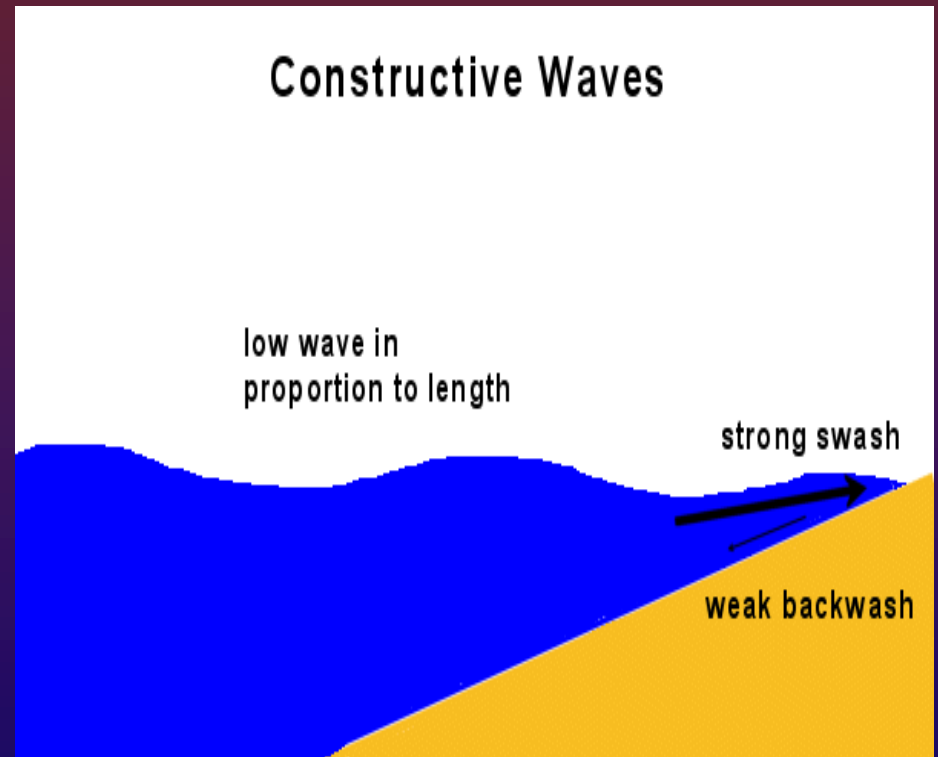
Rogue Wave

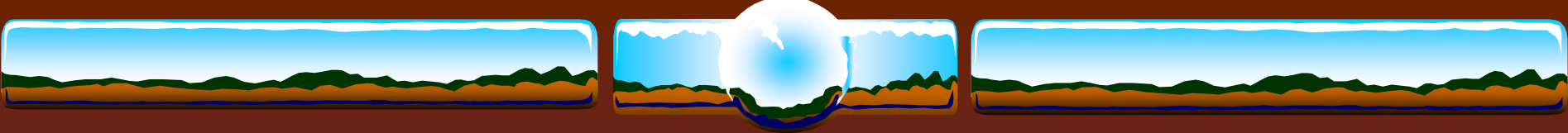




Waves

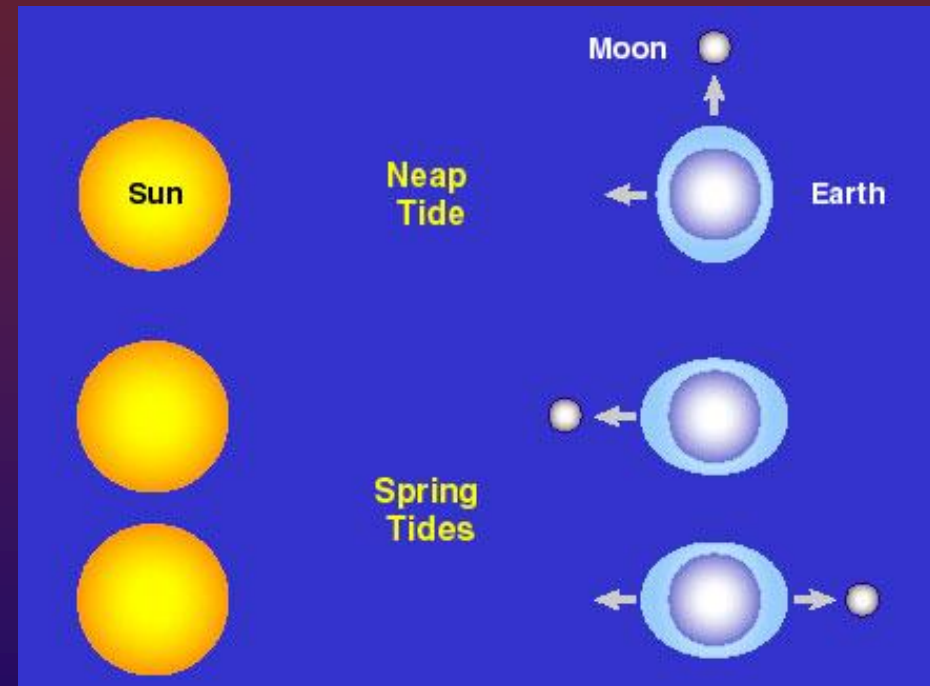
- ❖ Constructive as well as destructive
- ❖ Coastlines are dynamic
- ❖ Cleansing, oxygenating and circulating nutrients
- ❖ Organism adaptation





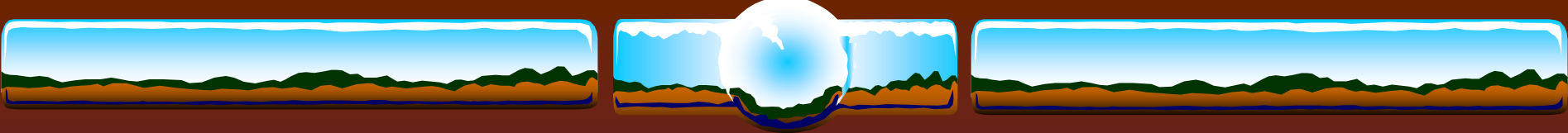
Tides

- ❖ Gravitational pull between sun and moon
- ❖ Local influences:
 - ❖ Shape of land
 - ❖ Shape ocean floor
 - ❖ Depth of water
 - ❖ Restrictions to flow
- ❖ Tidal current is slowed by friction at the shore and at the sea bed – highest speeds in middle of a Bay



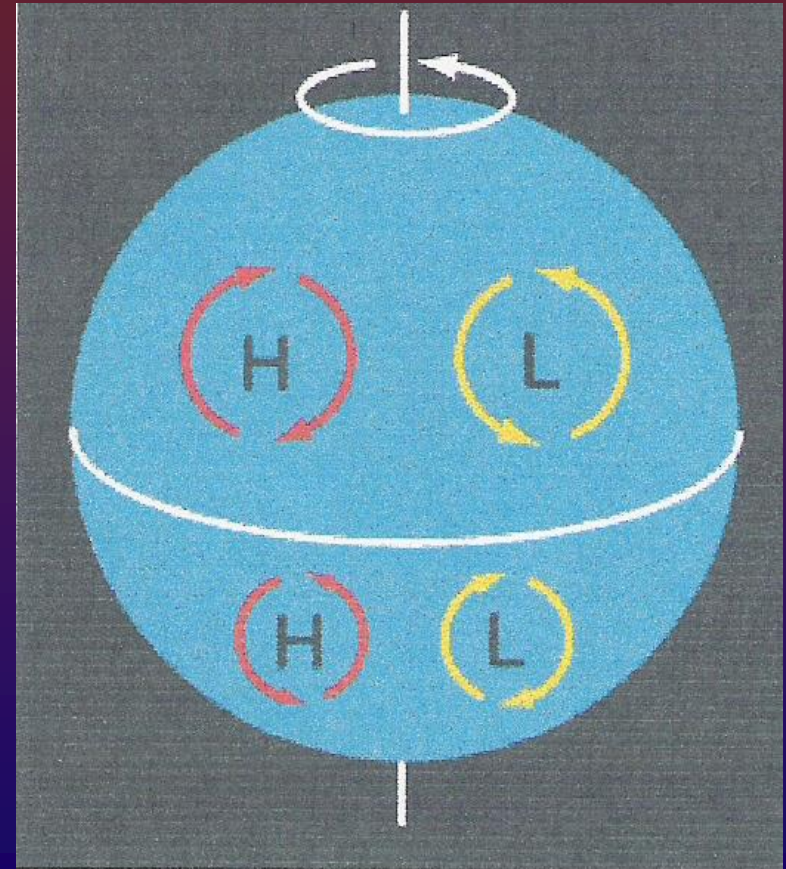
Bay of Fundy





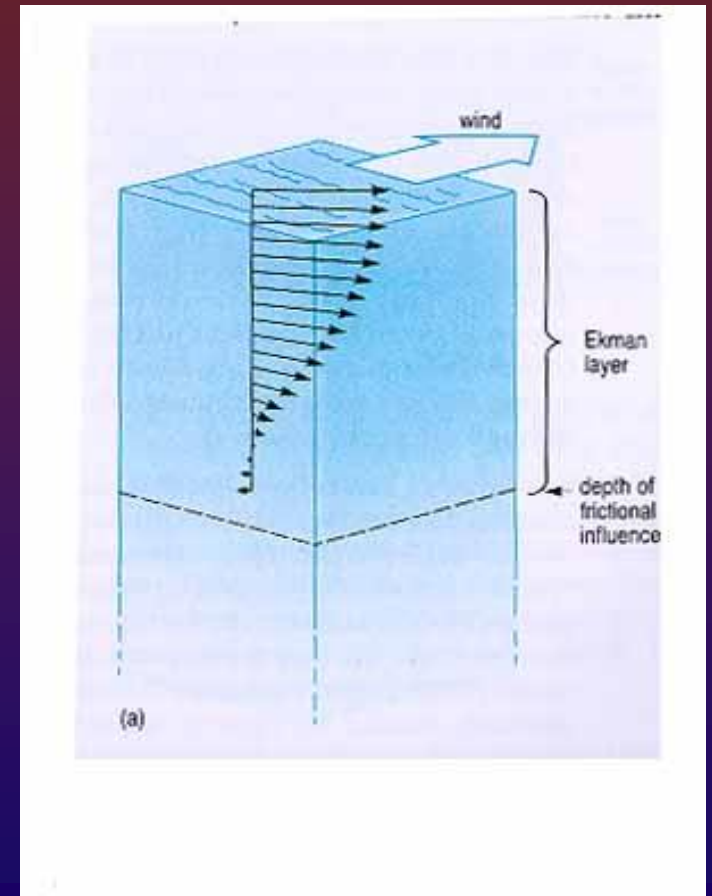
Ocean Circulation

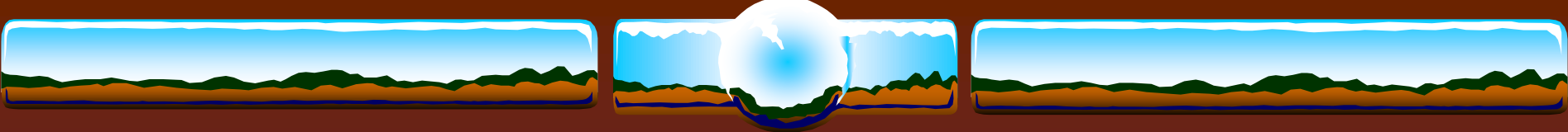
- ❖ Result of tides, wind and density differences
- ❖ Surface currents – produced by wind:
 - ❖ Cold – Labrador
 - ❖ Warm – Gulf Stream
- ❖ Also affected by location of land masses and the ‘Coriolis effect’
- ❖ All moving particles on the earth’s surface:
 - ❖ Northern Hemisphere – right
 - ❖ Southern Hemisphere – left



Eckman Spiral

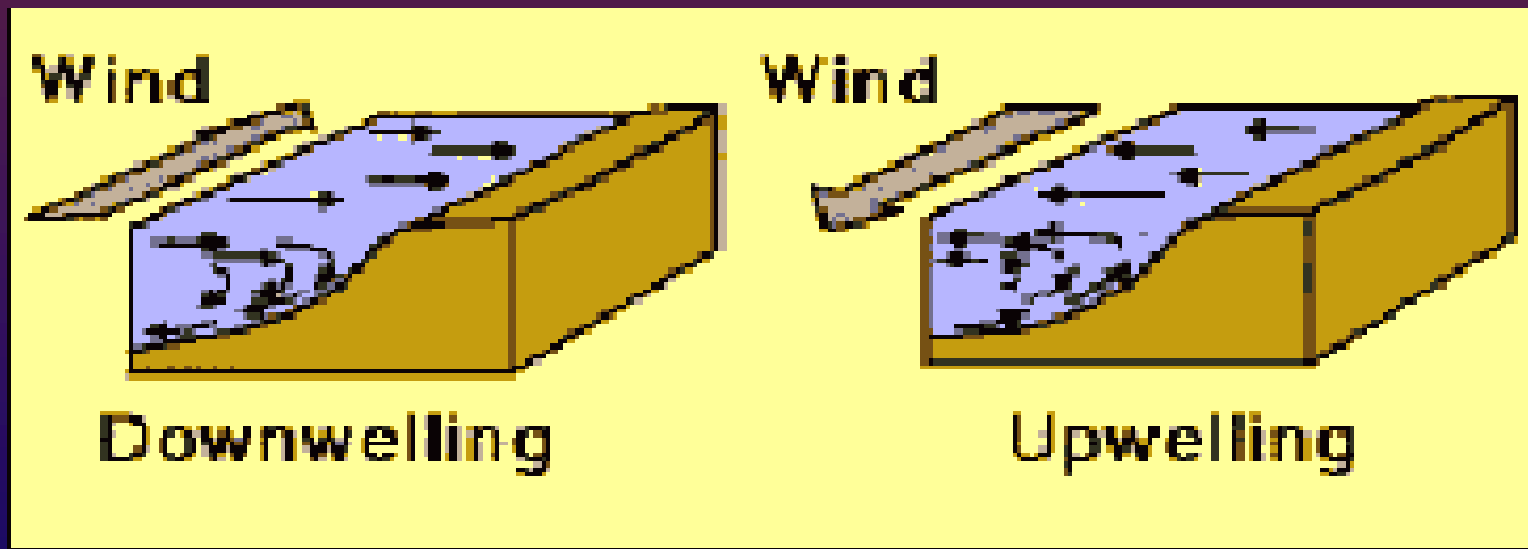
- ❖ Combination of friction and Coriolis effect
- ❖ Deflection of wind-driven currents
- ❖ Layered ocean – moving at differing speeds – the slower the rate the more affected by the Coriolis effect
- ❖ Net movement 90° deflection
- ❖ In coastal areas this effect can lead to upwelling or downwelling

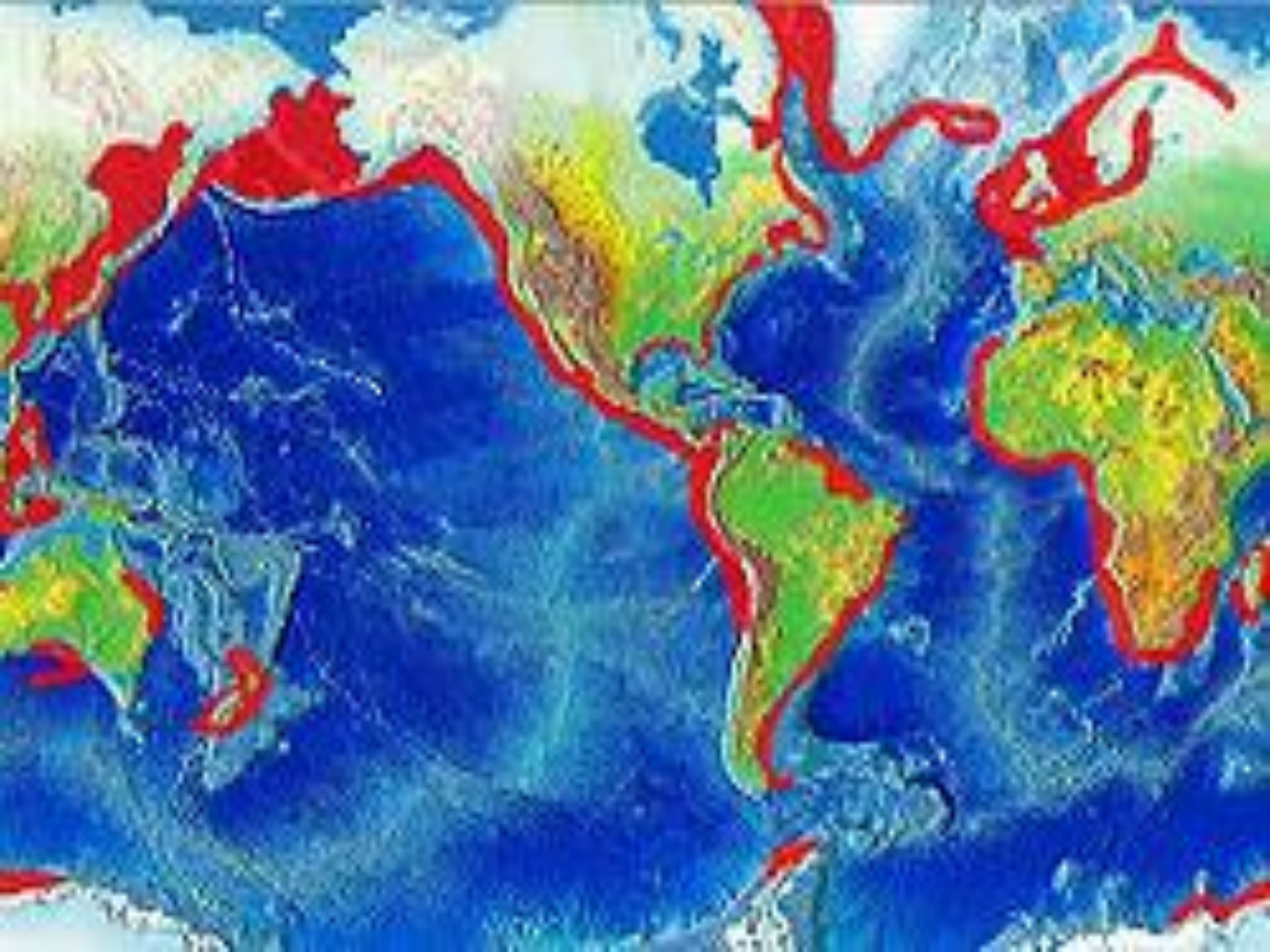


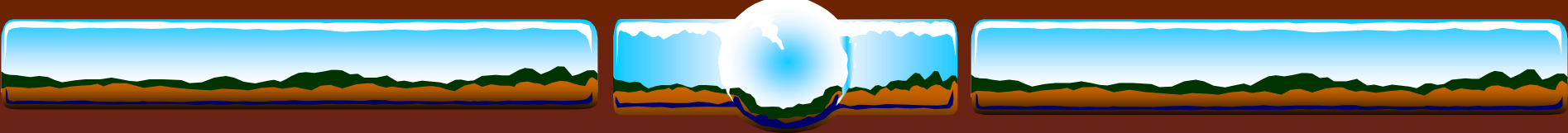


Upwelling

- ❖ Provision of nutrients from depth to surface waters
- ❖ 1% of the ocean surface – supports more than 50% fish populations
- ❖ Often densely inhabited areas (coastal) risk of pollution upsetting nutrient balance



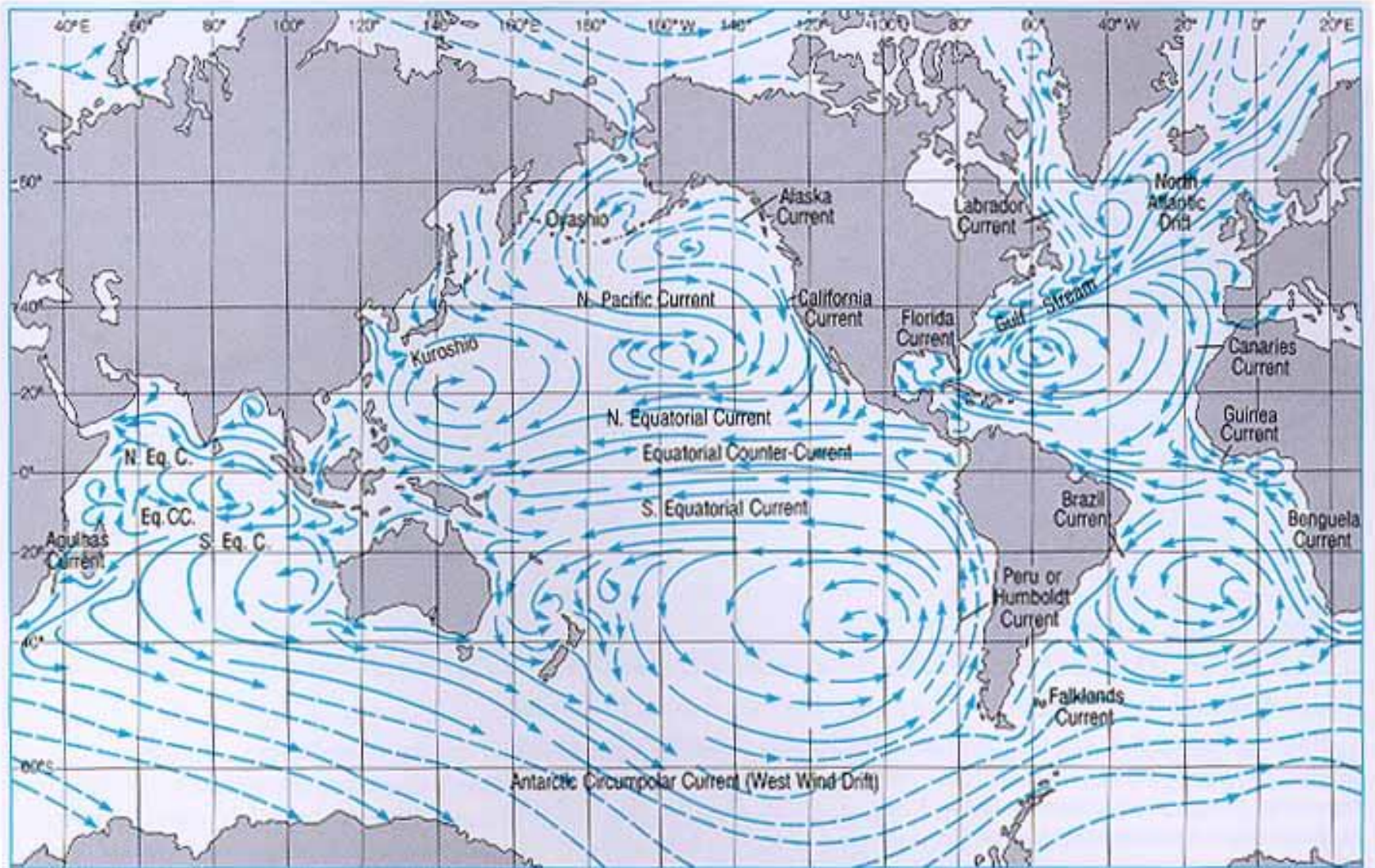




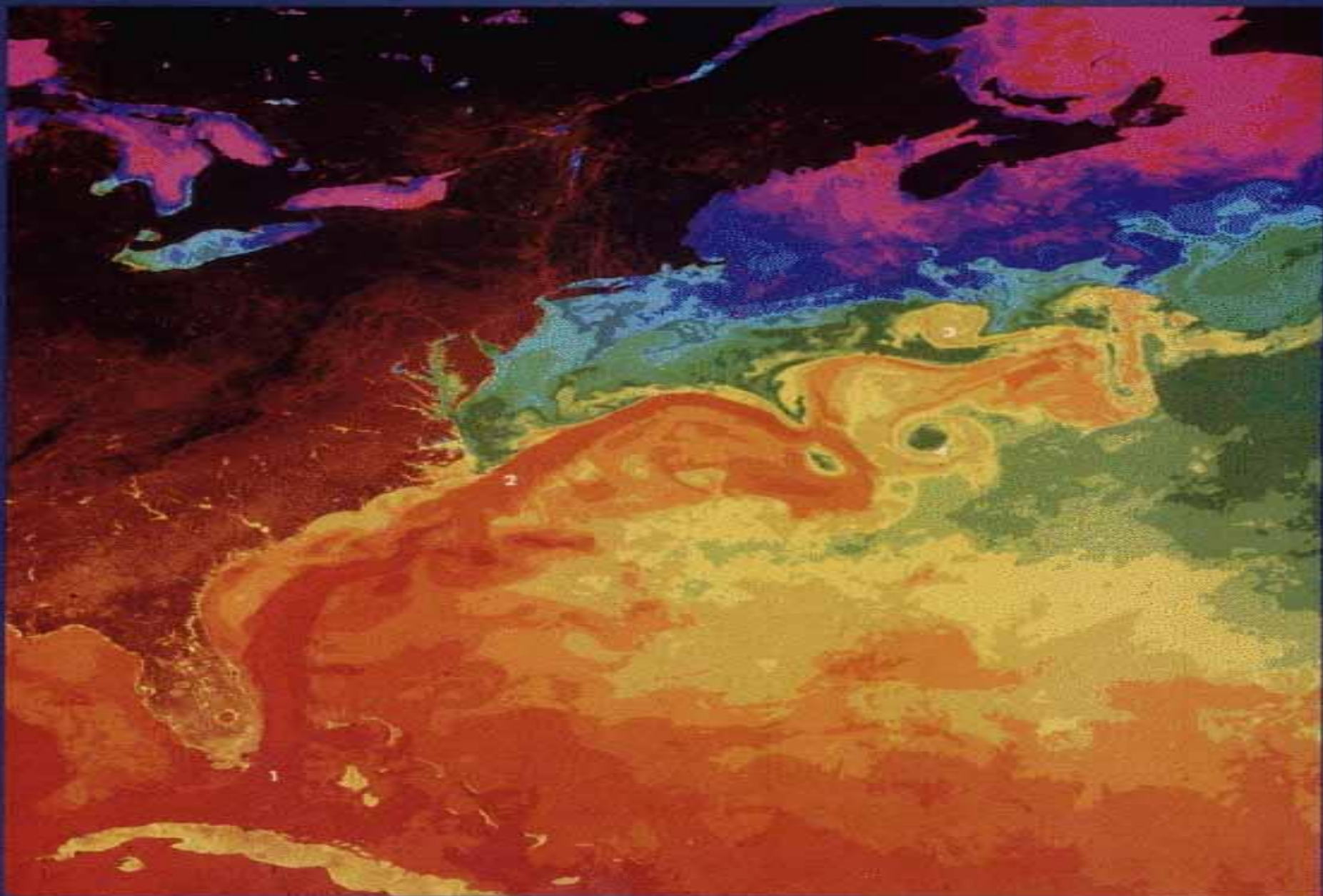
Ocean Currents

- ❖ 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
- ❖ Transport of heat – beneficial to UK's climate

Ocean Currents

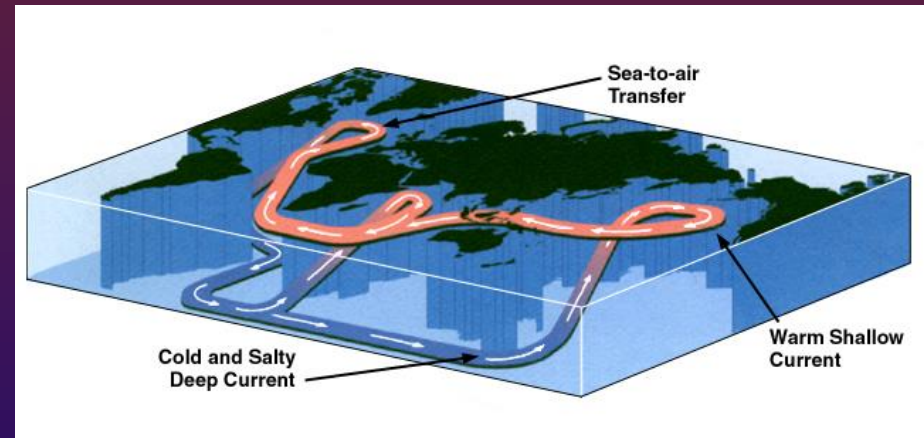


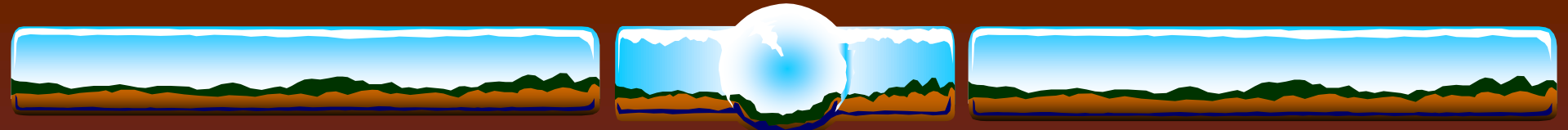
Gulf Stream Temperature



Vertical circulation

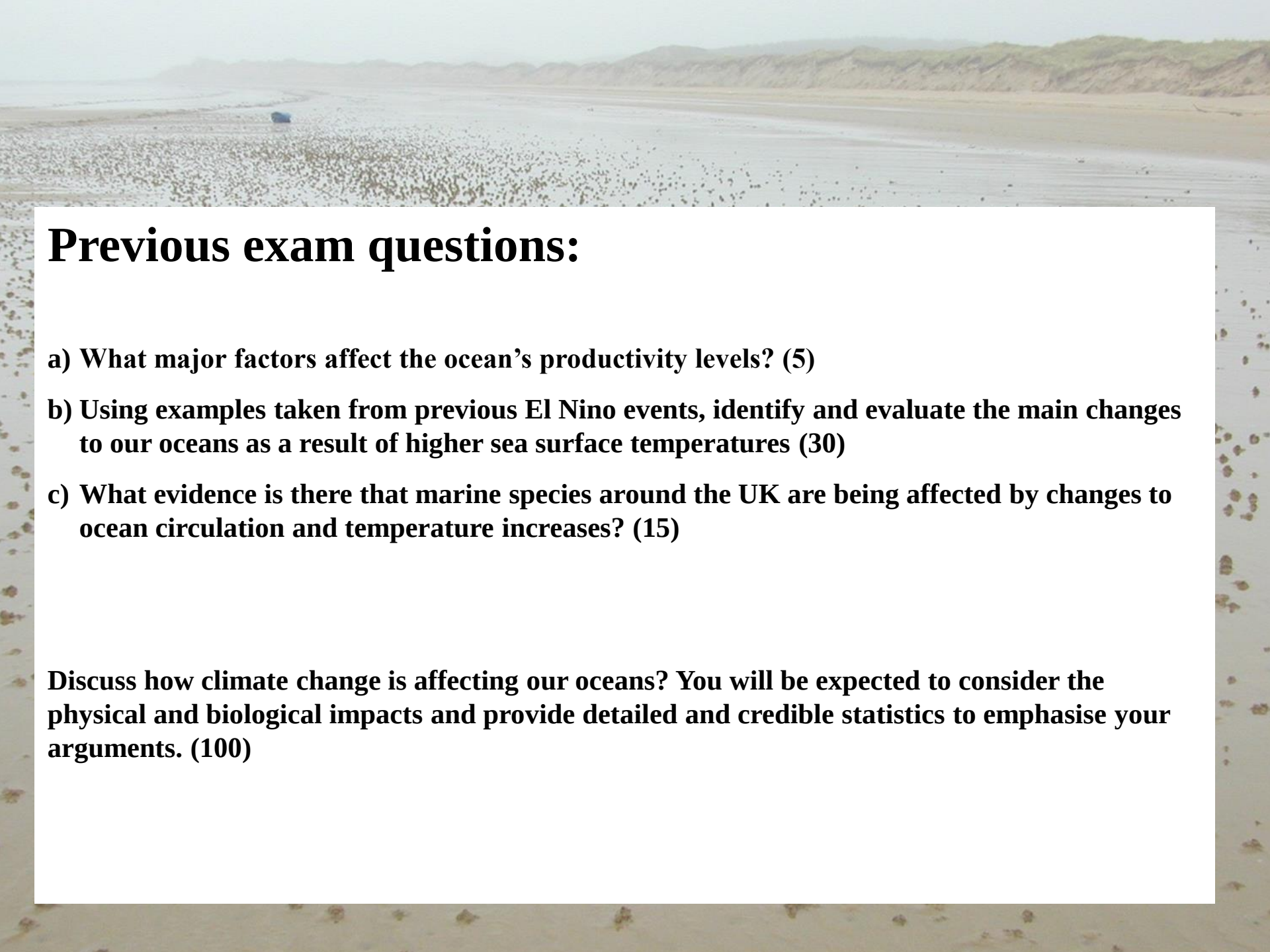
- ❖ Thermohaline circulation
- ❖ Thorough mixing deep ocean
- ❖ Driven by differences in density – function of temperature (thermo) and salinity (haline)





Research Tips

- ❖ In preparation for the climate change lectures in coming weeks, what evidence is there that ocean circulation may be affected by climate change?
- ❖ Look for papers detailing stats and studies of current strength – is the Gulf Stream slowing for example?



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)