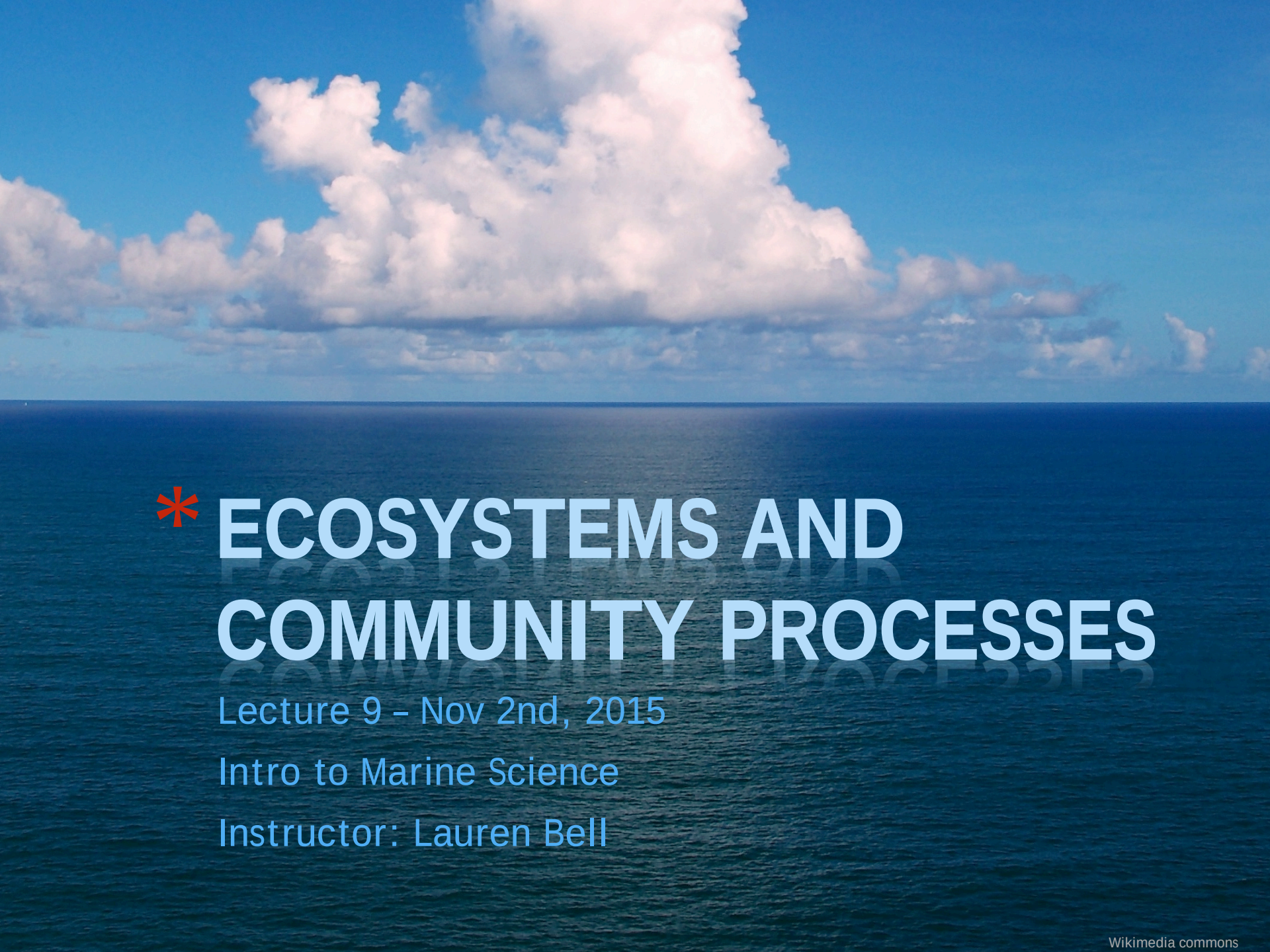


ECOSYSTEMS AND COMMUNITY PROCESSES

Lecture 9 – Nov 2nd, 2015

Intro to Marine Science

Instructor: Lauren Bell

Wikimedia commons

*Midterm Debrief

4 questions no one got correct
8 questions that only one of you got correct
= 30 pts total that were removed from exam score/120pts

AVERAGE SCORE: 103pts
STANDARD DEVIATION: 14.55pts

May ask repeat questions on final – know why you missed a question this time!!

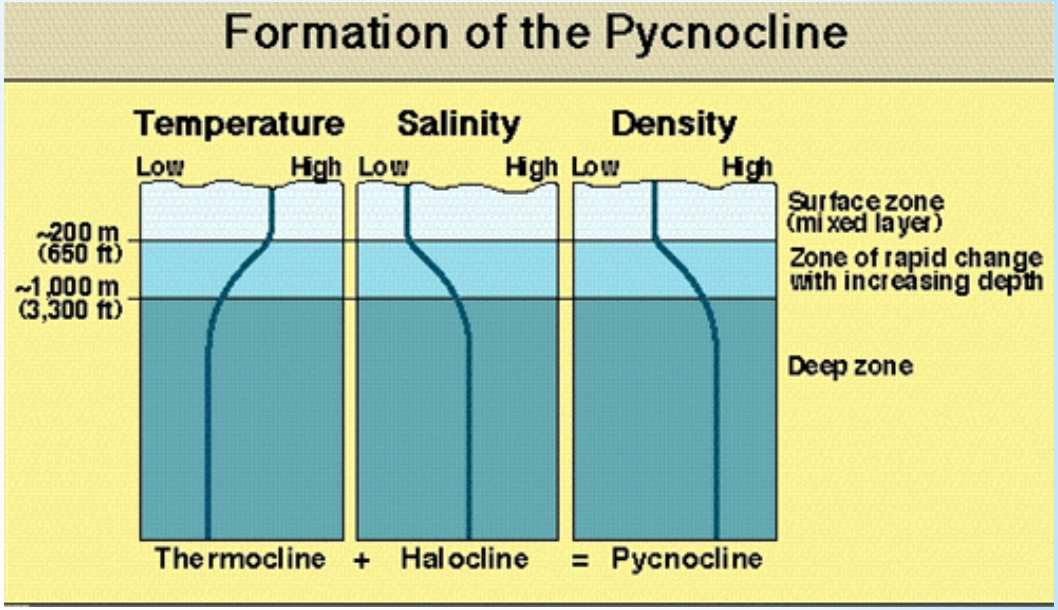
*Important terms

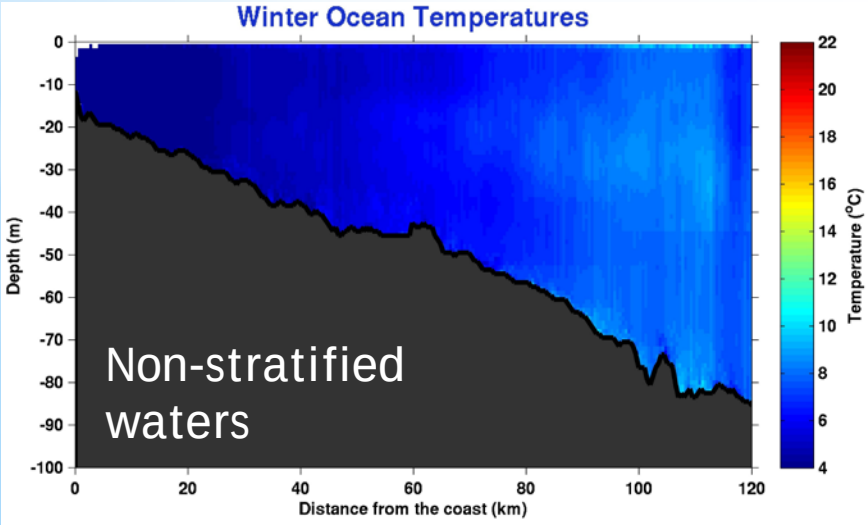
PYCNOCLINE

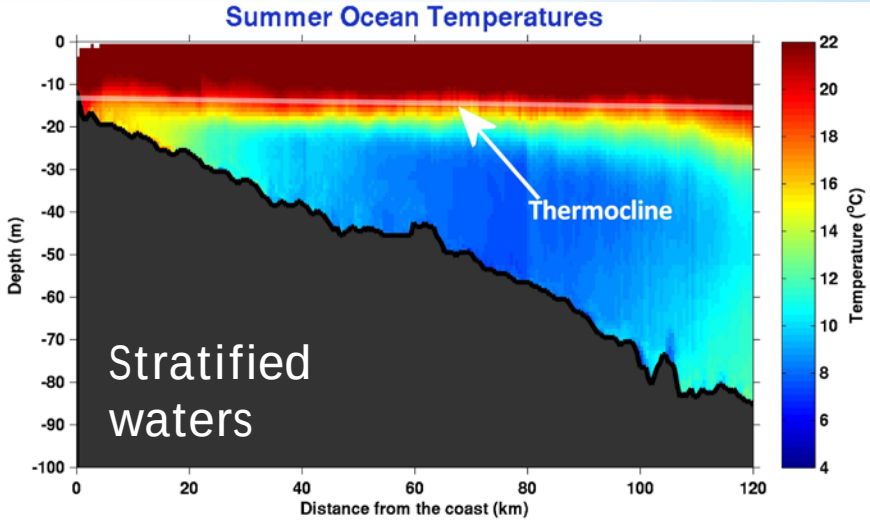
Vertical zone of rapid DENSITY change with increasing depth

STRATIFICATION

Increased intensity of the pycnocline – more stratified waters have greater barrier to mixing between layers



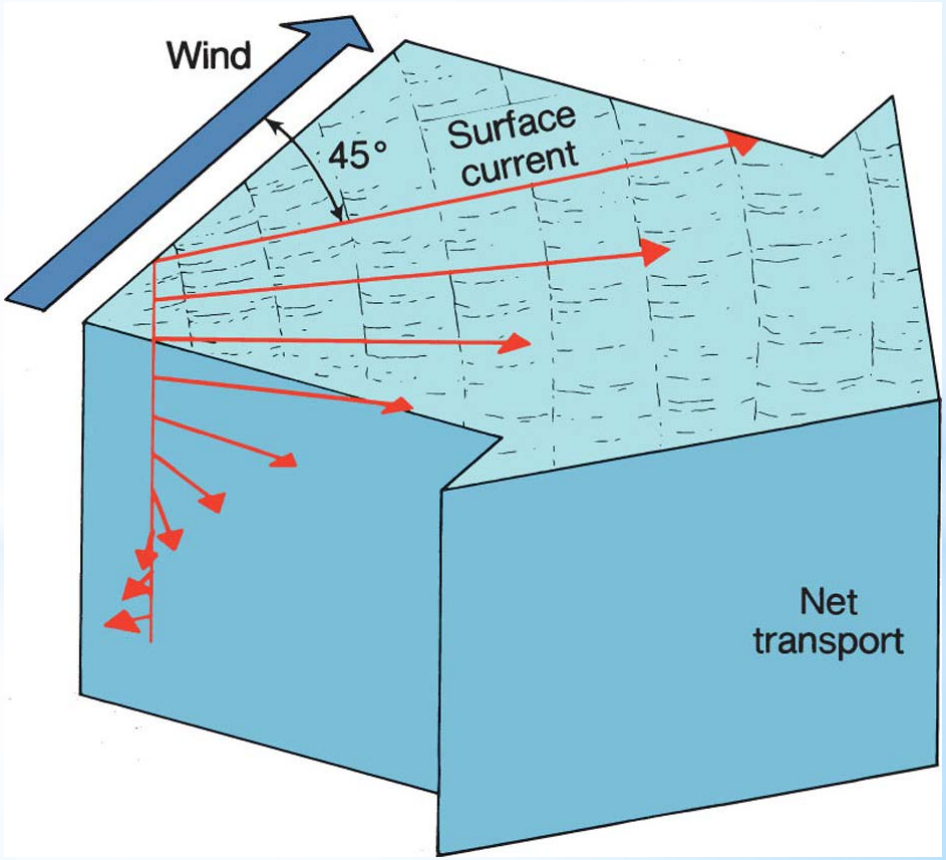




*Q's missed by all

13. In the northern hemisphere, at what angle does the **net transport** of all water *directly* set in motion by a sustained wind travel in relation to that wind? 0/5

a. 0°
b. 45°
c. 90°
d. 180°



*Q's missed by all

22. **Select all answers that apply.**
During coastal upwelling in the northern hemisphere:

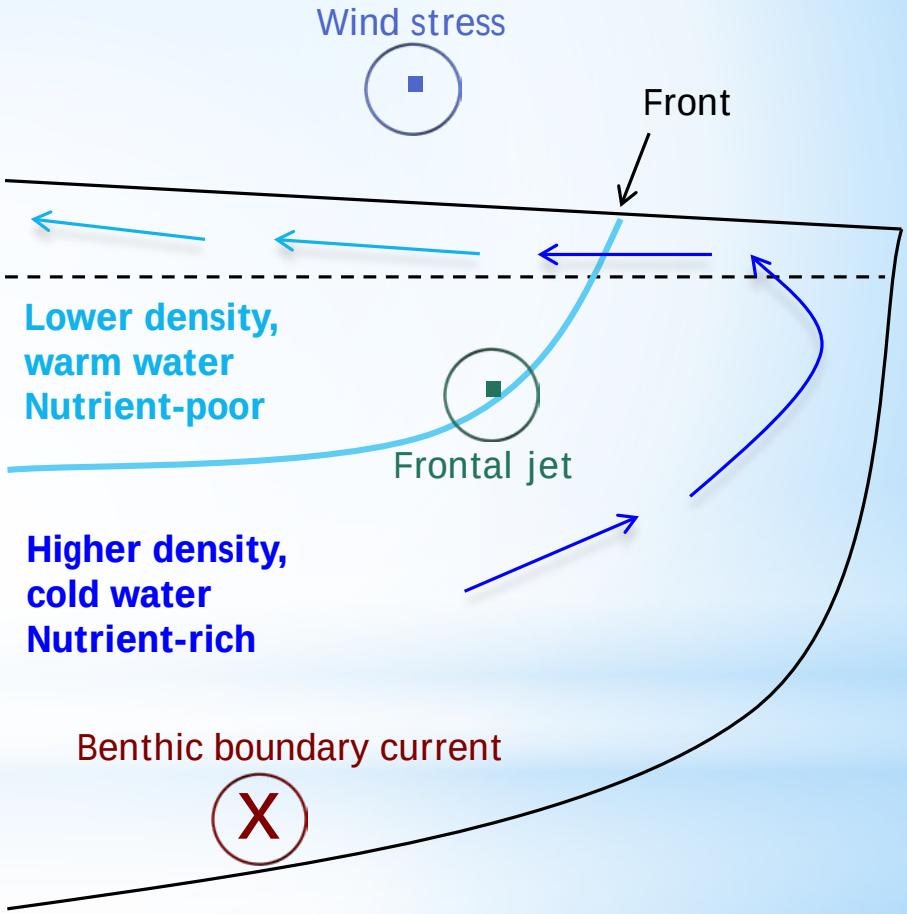
a. colder, nutrient rich waters are driven to the surface
b. warm, nutrient poor waters are pushed against the shore
c. wind blows roughly perpendicular to (directly towards) the coastline
d. a "a frontal jet" is established that carries water parallel to shore
e. the coastal area experiences enhanced productivity

*Coastal upwelling

(not just about water moving offshore)

3D water movement, as well….

1.) Ekman transport moves surface water away from the coast
2.) This lowers sea level adjacent to the coast relative to offshore
3.) The resulting cross-shelf sea surface slope tilts downwards towards the coast.
4.) This slope drives an alongshore geostrophic flow in the **downwind** direction!
5.) The geostrophic flow eventually causes a bottom Ekman Layer to develop in which the mass transport is **opposite** to the Ekman transport in the surface layer.



*Q's missed by all

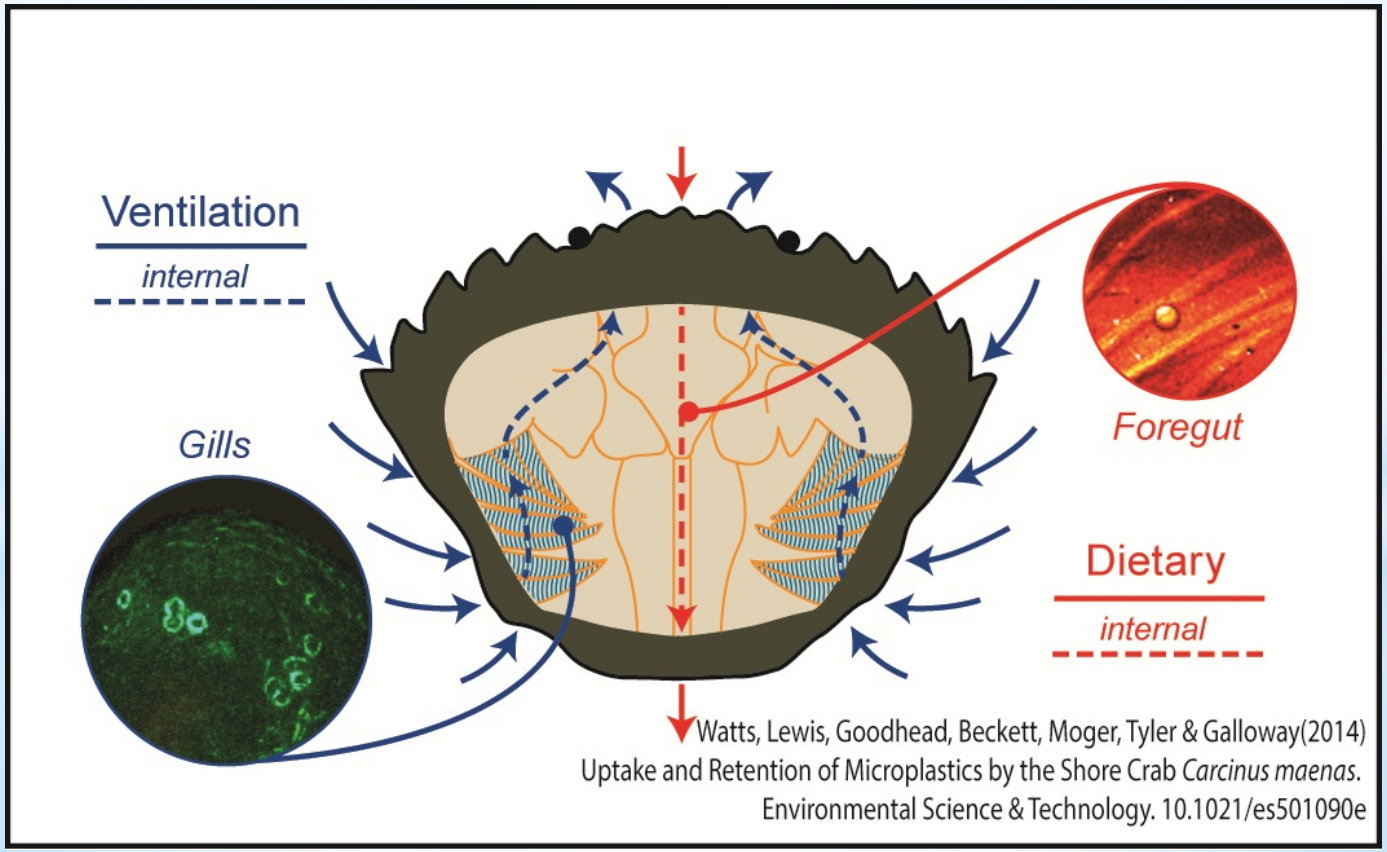
27. Which common gas has the **greatest** relative solubility in seawater?

a. oxygen
b. nitrogen
c. carbon dioxide
d. helium

Gas	% in dry air	% in surface seawater	Water/ Air	Solubility
Nitrogen	78	63	0.8	Lowest
Oxygen	21	34	1.6	Intermed.
Carbon Dioxide	0.03	1.6	>50	Greatest
Ar, H, Ne, He	1	1.4	1.4	Intermed.

*Q's missed by all

42. List two ways that microplastics can have negative physiological impacts on marine organisms.



*Q's missed by most

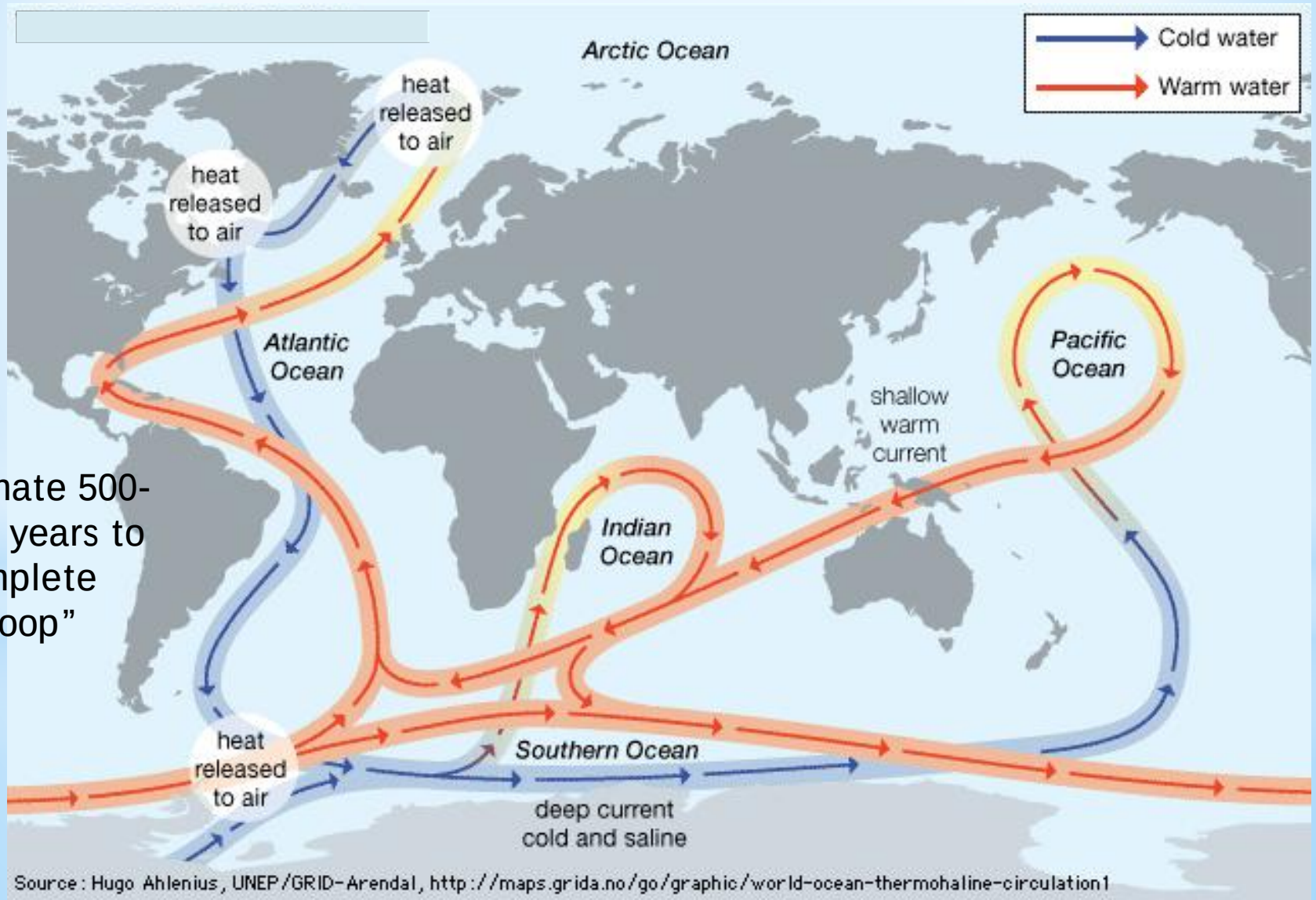
14. What drives the "global conveyor belt" of oceanic deepwater circulation?

a. salinity and temperature
b. salinity and wind
c. temperature and wind
d. wind, salinity, and temperature

*Thermohaline circulation (THC)

thermo = heat **haline** = salt

with wind-driven surface currents



Estimate 500-1000 years to "complete the loop"

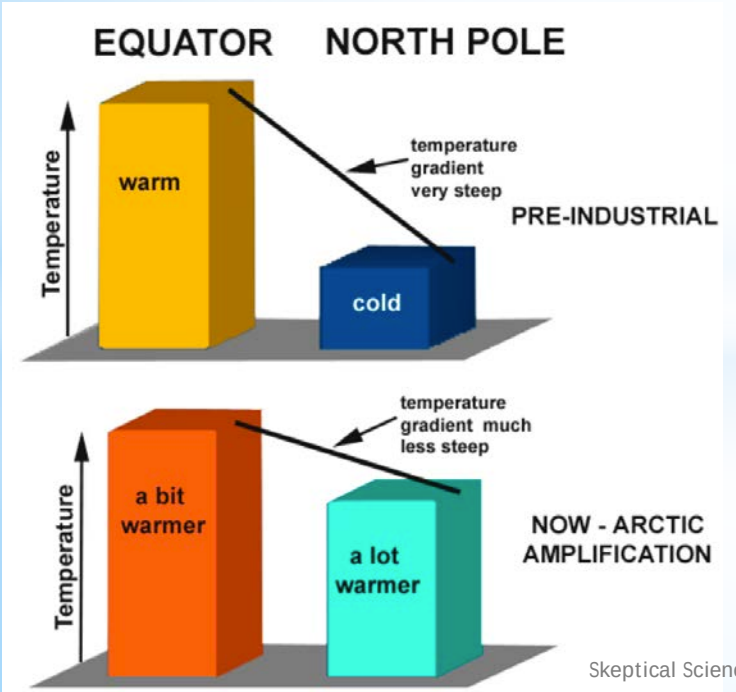
*Q's missed by most

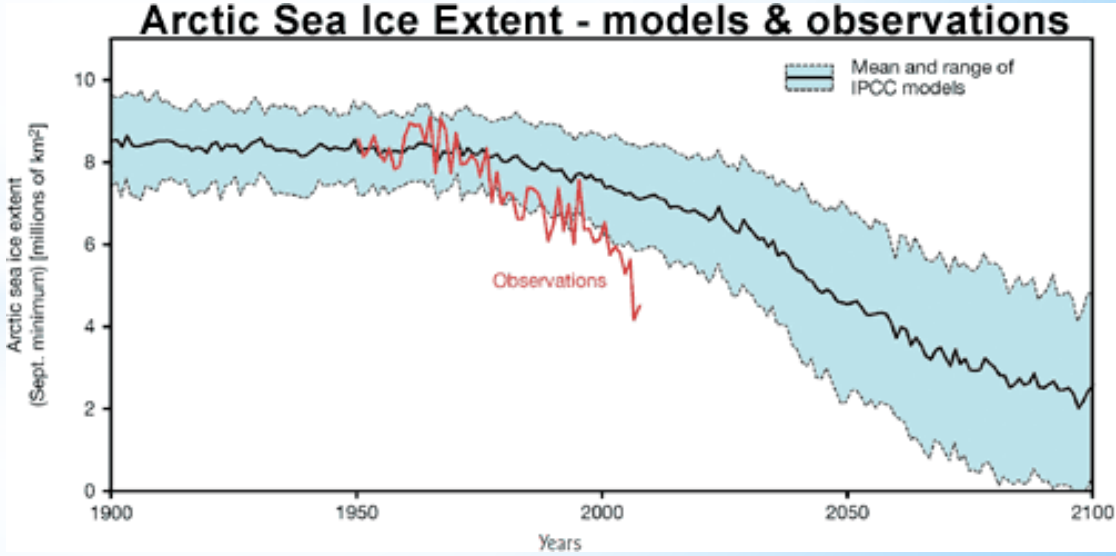
15. Arctic Amplification may _____ the Jet Stream by _____ pressure gradients between higher and lower latitudes

a. weaken; weakening
b. weaken, strengthening
c. strengthen; weakening
d. strengthen; strengthening

* Arctic Amplification

- Arctic is experiencing disproportionate effects of climate change
- Results in weakening of pressure gradient/temperature gradient between higher latitudes and lower latitudes
- Jet Stream strength relies on that gradient
- Weakened jet stream = similar to negative AO conditions
- Loss of Arctic sea ice compounds the problem
  - ✧ Loss of **albedo** = reflectivity of surface
  - ✧ Less albedo = more absorption = faster melting





Skeptical Science

Wunderground

*Q's missed by most

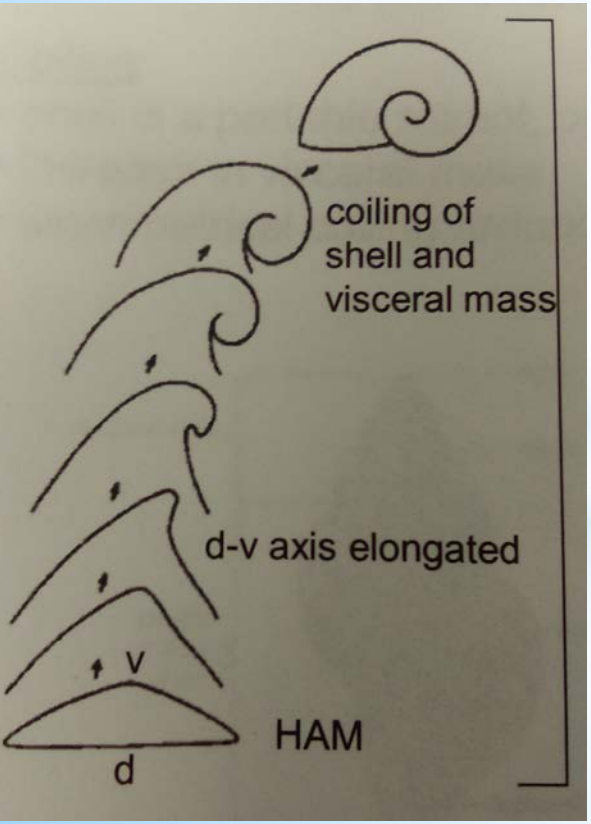
16. What is theorized as the evolutionary advantage of torsion in the Gastropoda class of the mollusks?

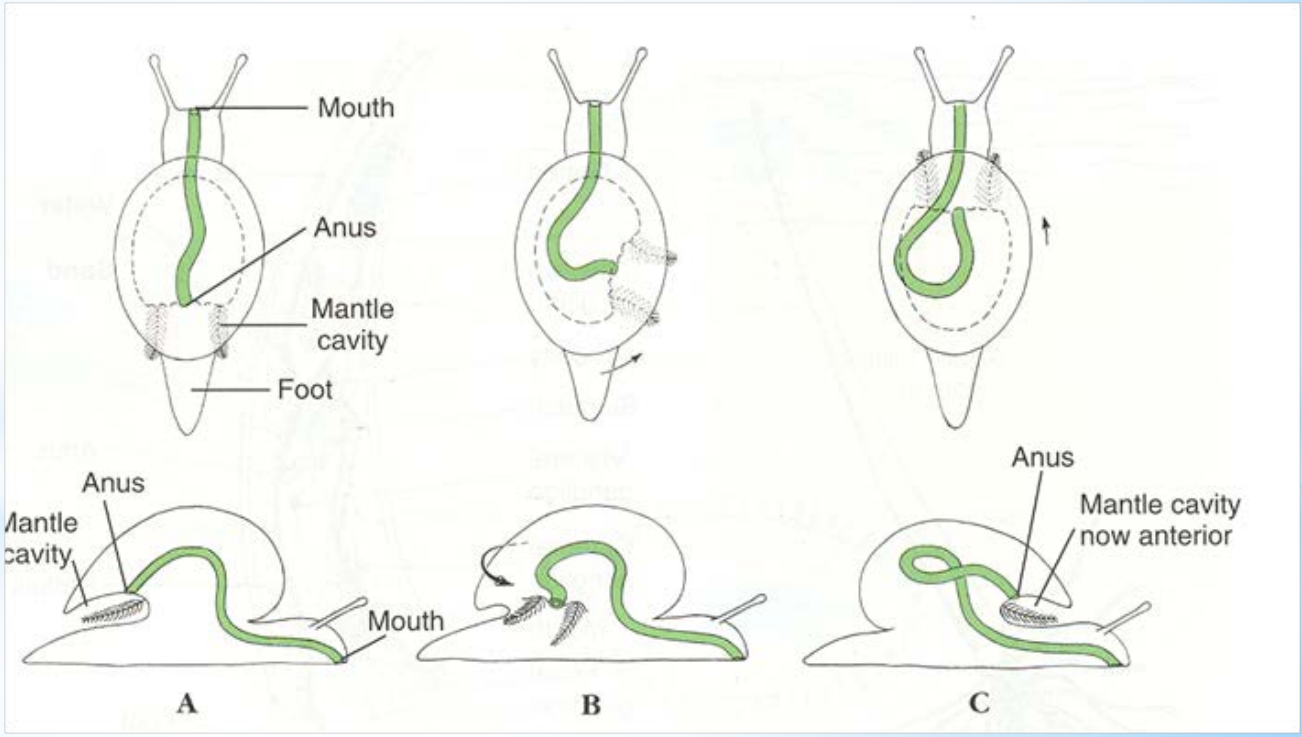
a. allows for easier retraction of the head
b. increases distance between the anus and the gills
c. allows for tighter adherence to the substrate
d. enables quick retraction of adductor muscle to close shells

*Class Gastropoda (snails, nudis, limpets)

Three big differences from HAM:

1) Dorsoventral elongation (can grow bigger)
2) Coiling
3) Torsion (mantle cavity rests above head, can retract!
   → also brings all organs nearer to brain



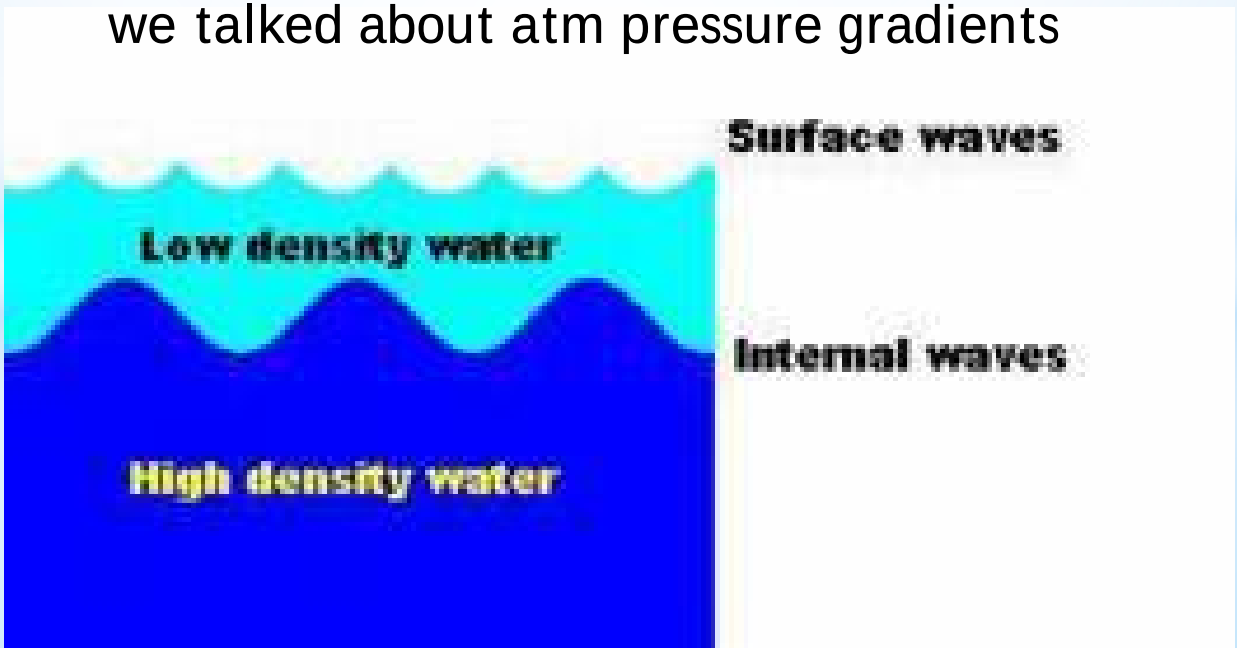


*Q's missed by most

20. Waves between mid-ocean layers are larger in amplitude and slower than waves at the interface between water and air because the difference in _____ is smaller.

DENSITY

This was in video assigned, also came up when we talked about atm pressure gradients



*Q's missed by most

21. What is a polynyna?

a. a large tidal influx that occurs all at once
b. a site of relatively high primary productivity
c. an area of open water surrounded by ice
d. both a and b
e. both b and c
f. none of the above

*Polynyas

An area of open water surrounded by sea ice

Polynyas that occur seasonally at same time and place each year allow animals to adapt life strategies to take advantage.

- Marine mammals need air holes
- Thin/absent ice allows penetration of light: early plankton blooms!
- Very productive systems

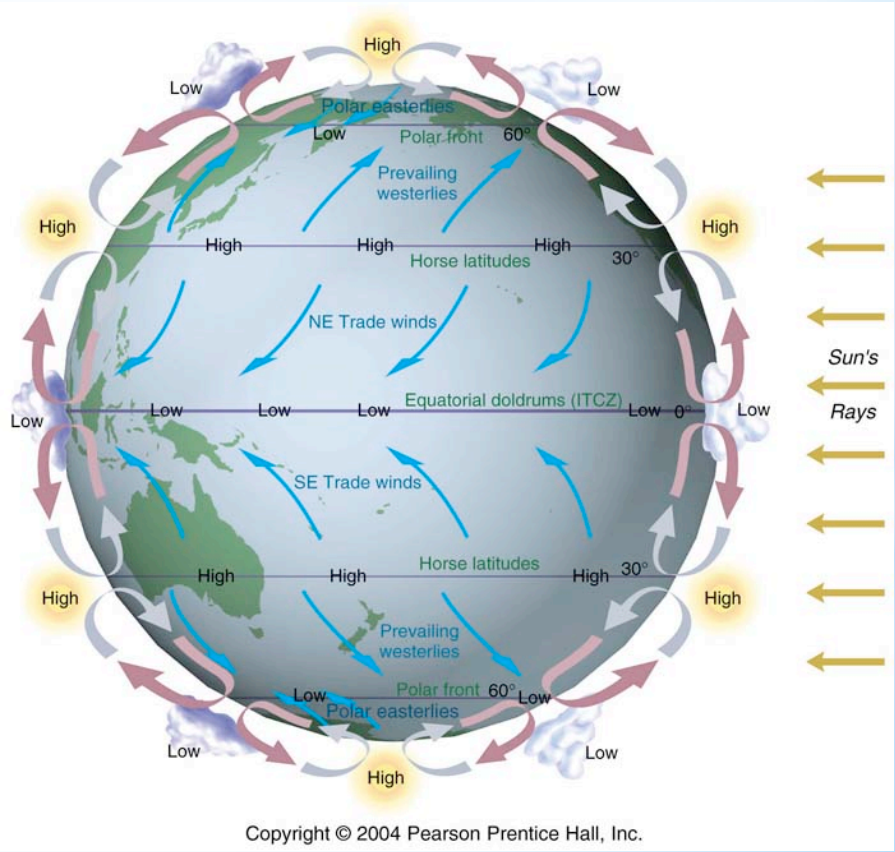
Polynya by St. Lawrence Island & Spectacled Eiders

Entire world population of these eiders congregates here in winter!

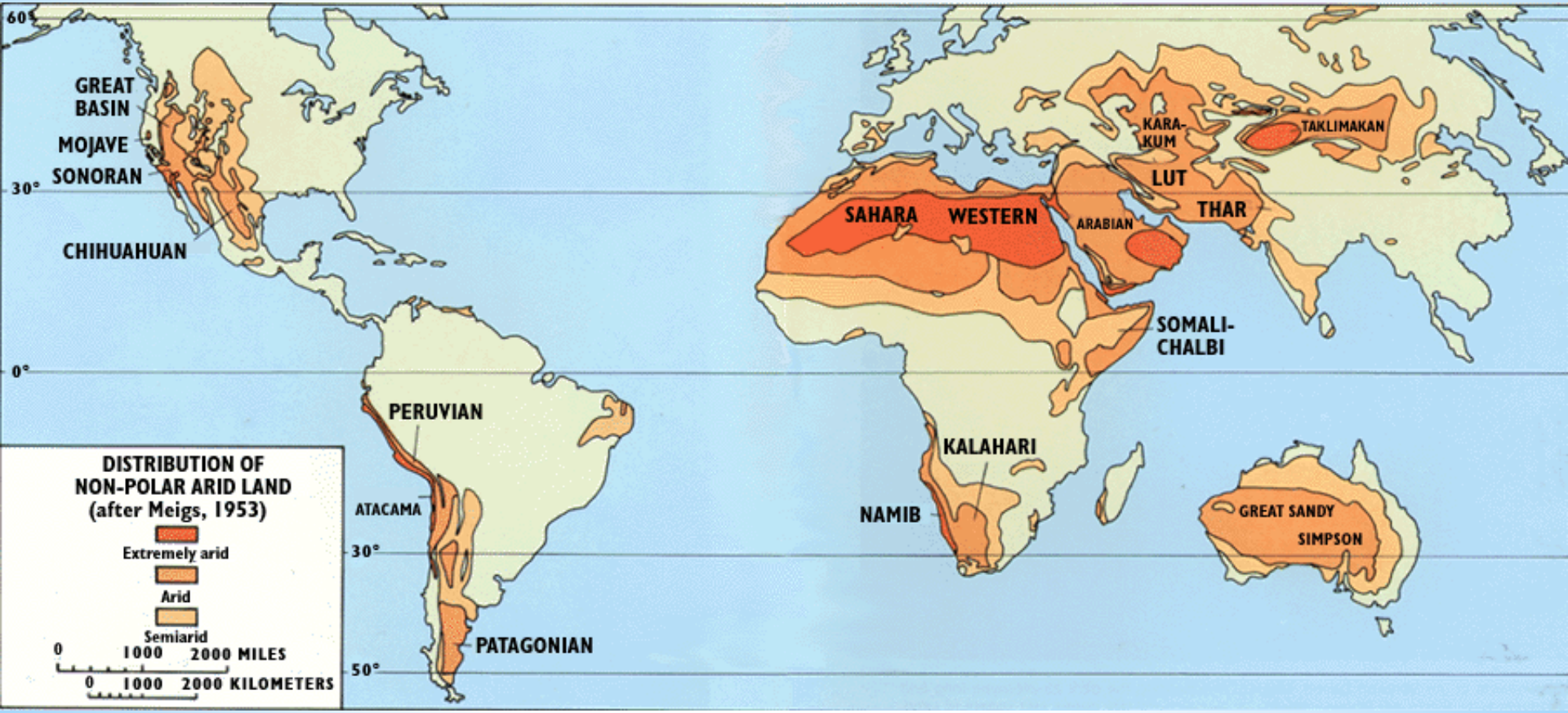
*Q's missed by most

24. Generally, at latitudes 30° North and 30° South, _____ atmospheric pressure dominates and _____are prevalent on land

a. high; rainforests
b. high; deserts
c. low; deserts
d. high; rainforests



*Convection cells drive prevailing climates!

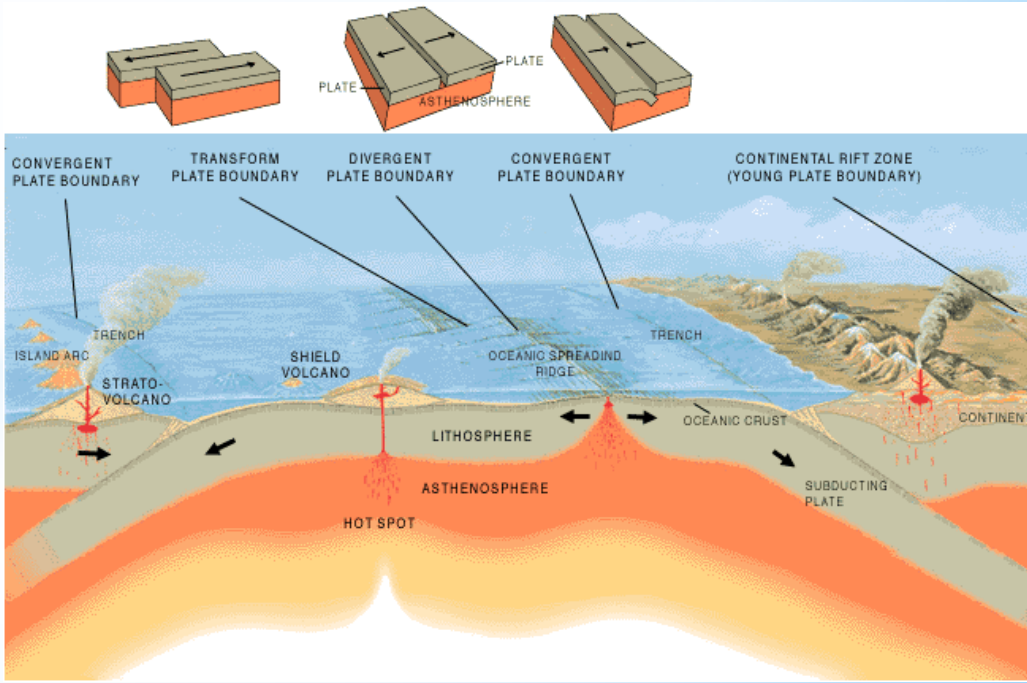


USGS

*Q's missed by most

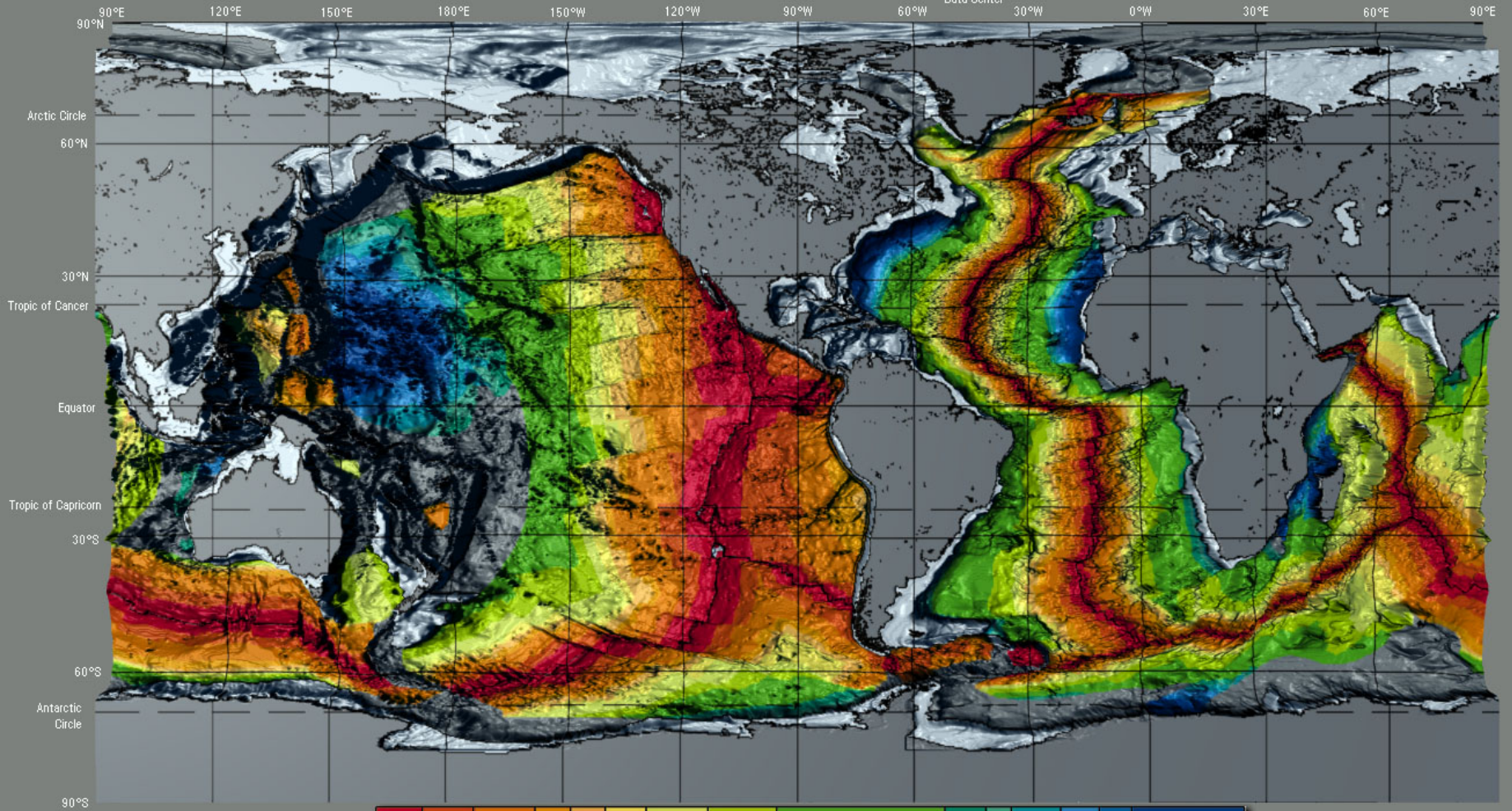
31. At what location in the world's oceans is the age of earth's crust generally the youngest?

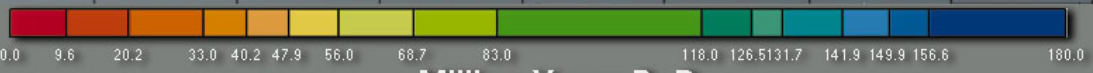
a. along continental shelves
b. in deep ocean trenches
c. around the ring of fire
d. at mid-oceanic ridges



Crustal Age

National Geophysical Data Center





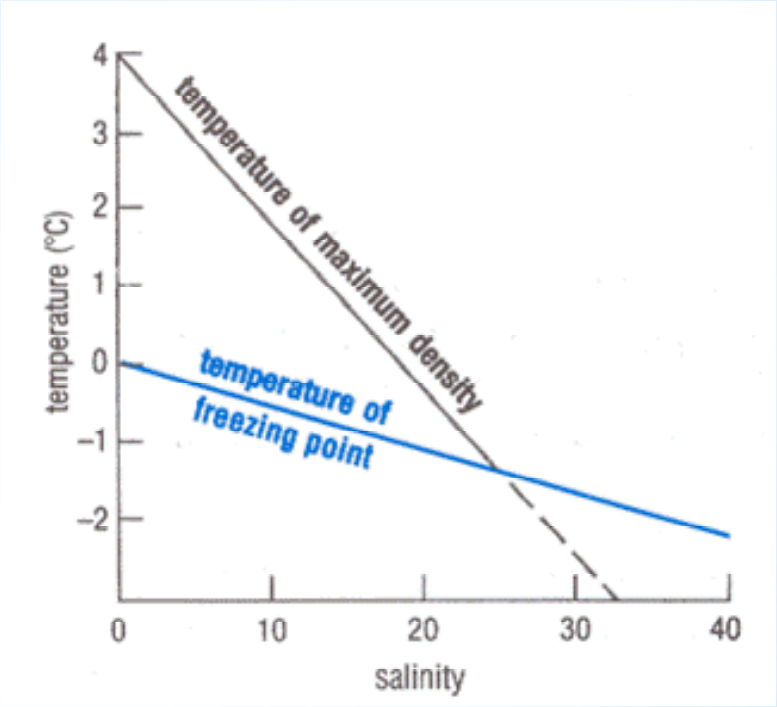
Million Years B. P.

Data for the image from "Digital Age Map of the Ocean Floor" by Müller, Roest, Royer, Gahagan, and Schlater, Scripps Institution of Oceanography Ref. Series No. 93-30

For information on this and other images produced by NGDC's Marine Geology and Geophysics Division, contact Peter Sloss at plsoss@ngdc.noaa.gov

*Q's missed by most

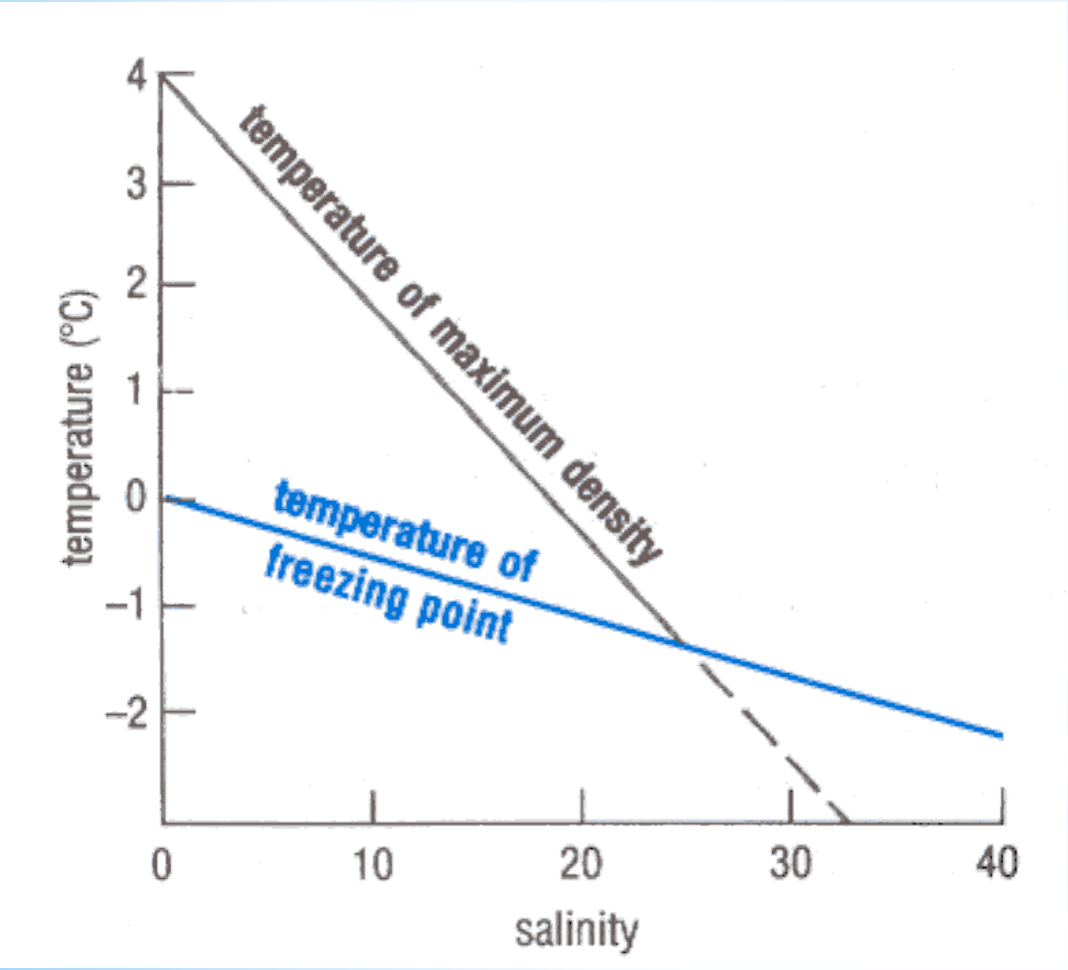
46. The following figure shows how the temperature at which water reaches its maximum density varies with changing salt content.



Explain why the characteristics shown in this figure are important to the vertical structure of a freshwater lake during cooling and ice formation.

How would the vertical structure of this lake differ if the lake waters had a uniform salinity of 32ppt?

*Saltwater vs. freshwater



Why don't freshwater lakes freeze completely solid in the winter?

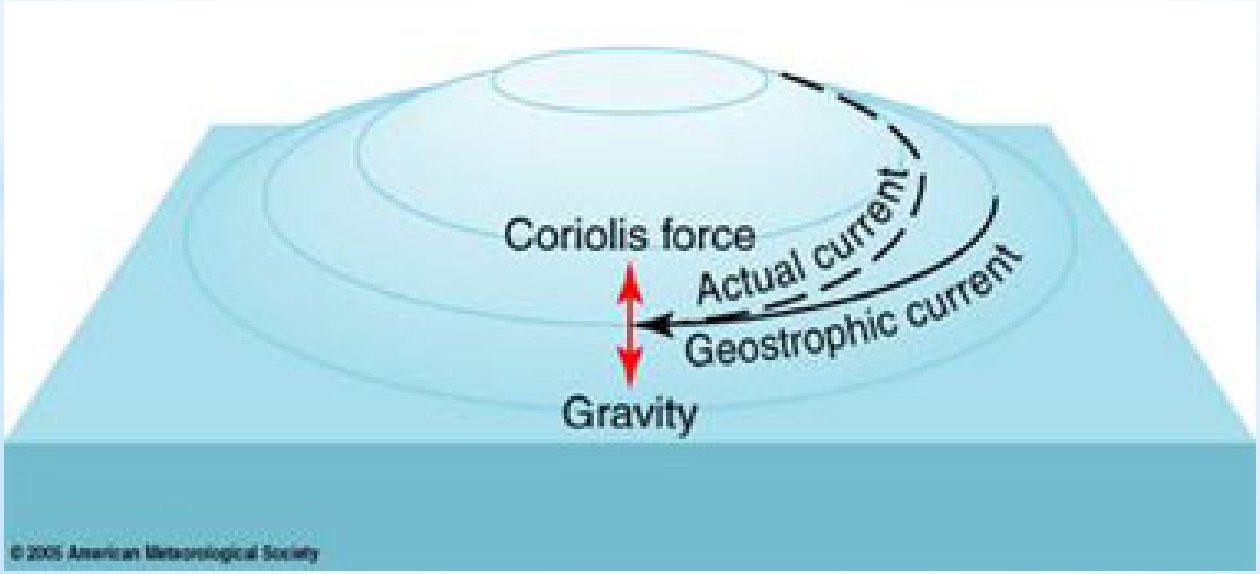
- Fundamental difference in relationship between temperature and density when salinity changes
- In FW, ice insulates 4°C water below it
- SW just keeps cooling below 0°C

Biological Oceanography/Wiley-Blackwell

*Q worth 20 pts

44. You are a whale looking for a big feast of phytoplankton in the open ocean. What kind of eddy should you look for food in, a **warm-core (clockwise spinning) ring**, or a **cold-core (counter-clockwise spinning) ring**?

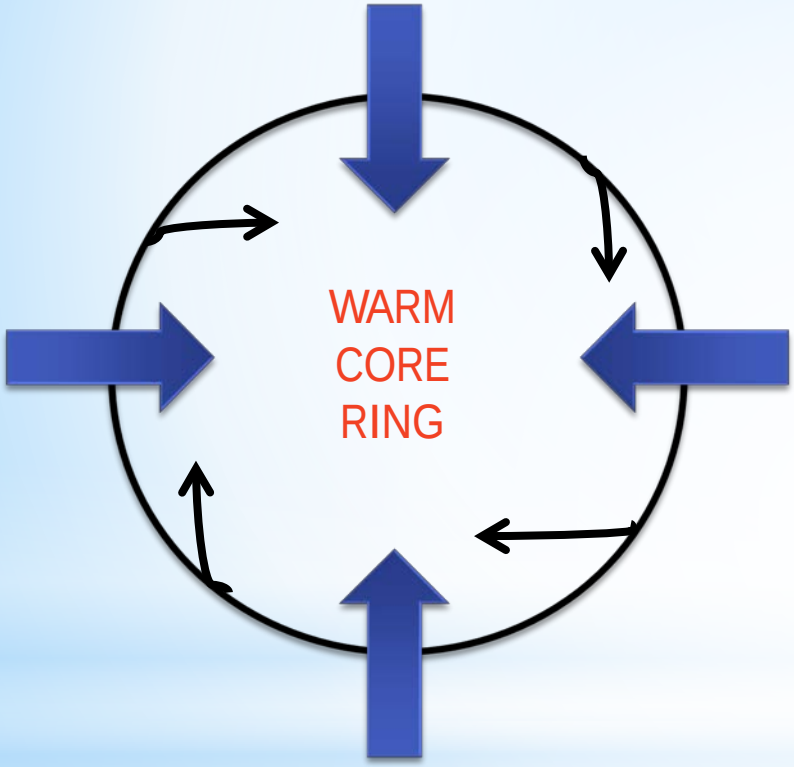
Why? (explain how the physical processes of the eddy could benefit you)

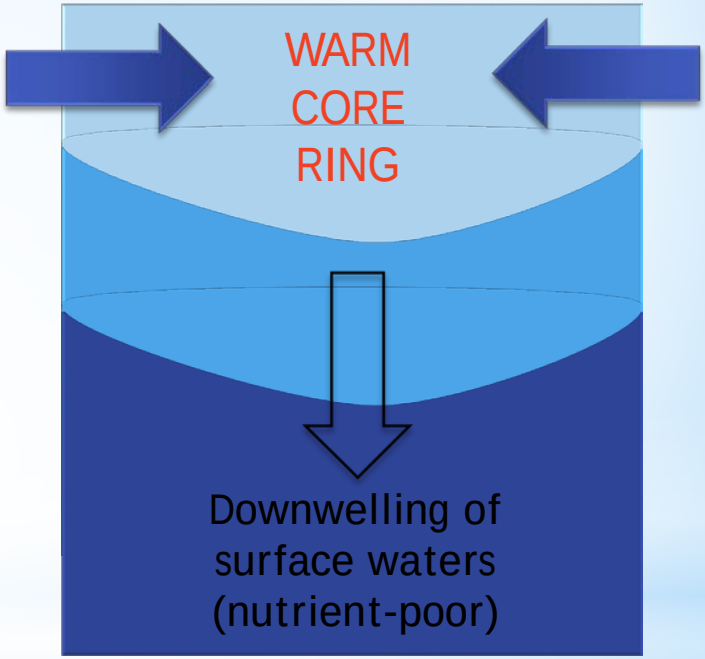


*Open-ocean vertical movement

Northern Hemisphere

(Coriolis deflection to the right)



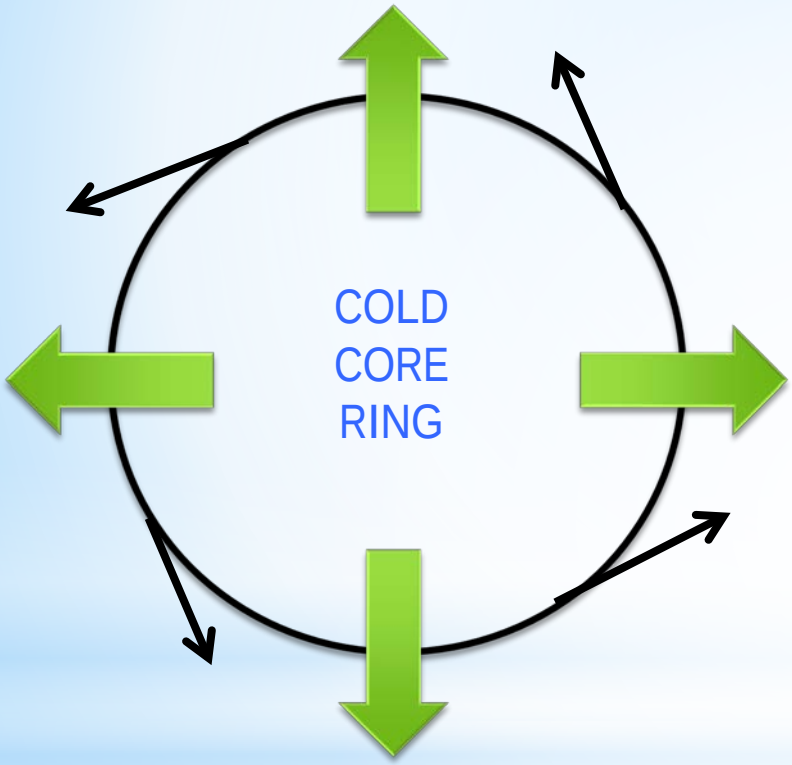


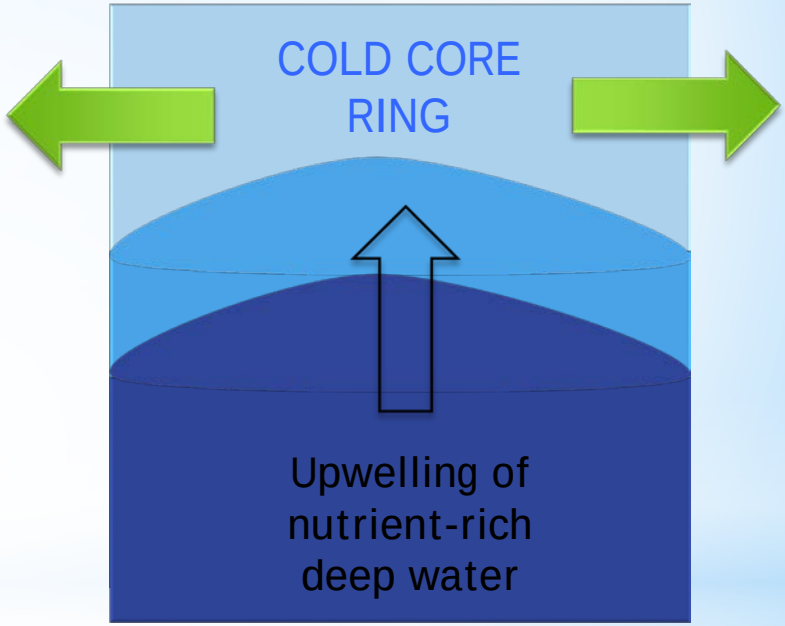
- Warm ring has high pressure downwelling in the center
- Depth of **pycnocline** (large density gradient) increases
- Moves nutrient-rich waters away from the light
- Low primary production (low Chl a)

*Open-ocean vertical movement

Northern Hemisphere

(Coriolis deflection to the right)

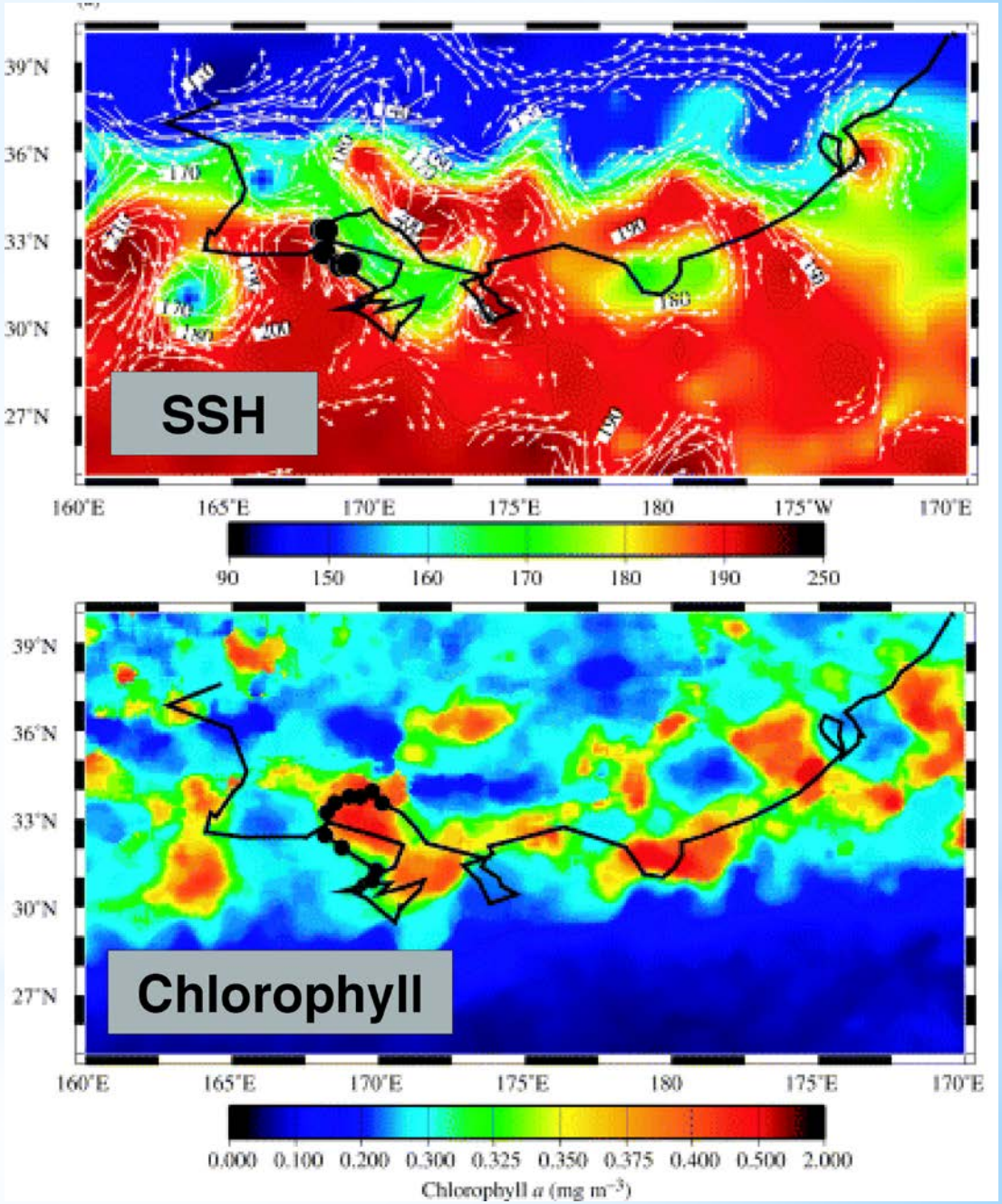




- Cold ring has low pressure upwelling in the center
- Depth of **pycnocline** decreases
- Nutrient-rich waters closer to (well-lit) surface
- Primary production increases!!

Loggerhead turtle track (solid line) overlain on satellite maps of sea surface height (SSH) and surface Chlorophyll a content

- ✧ Note relationship between SSH and primary production
- ✧ Why are the turtles going to these high Chl a areas?



Polovina *et al.* (2000), Fisheries Oceanography, 9, 71-82.

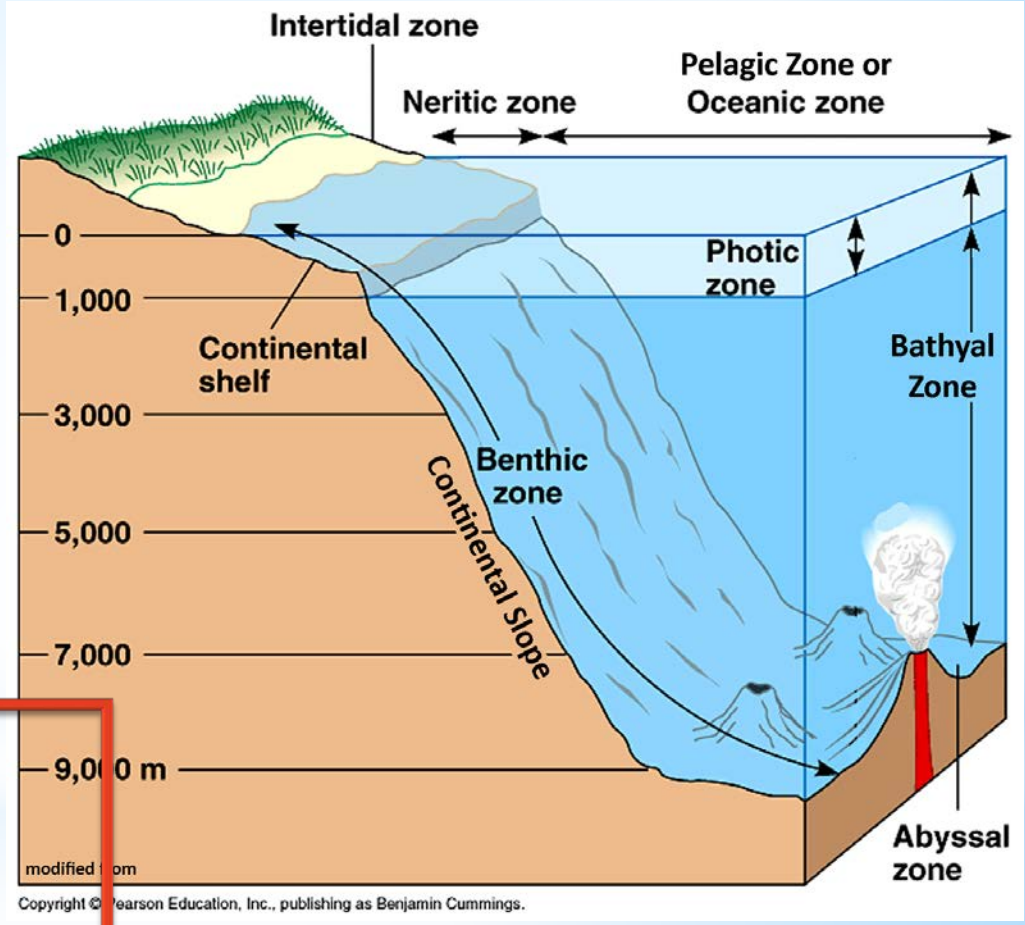
*Learning objectives

After this lesson, you will be able to:

- Compare and contrast the overlying structure and function of each marine ecosystem
- Describe some adaptations that have enabled particular species to thrive in these unique environments
- Outline some factors that may render certain ecosystems more vulnerable to external stress and change than others
- Recognize the interactions and regimes that shape specific marine communities/ecosystems
- List some major ecological metrics and theories used to describe community processes

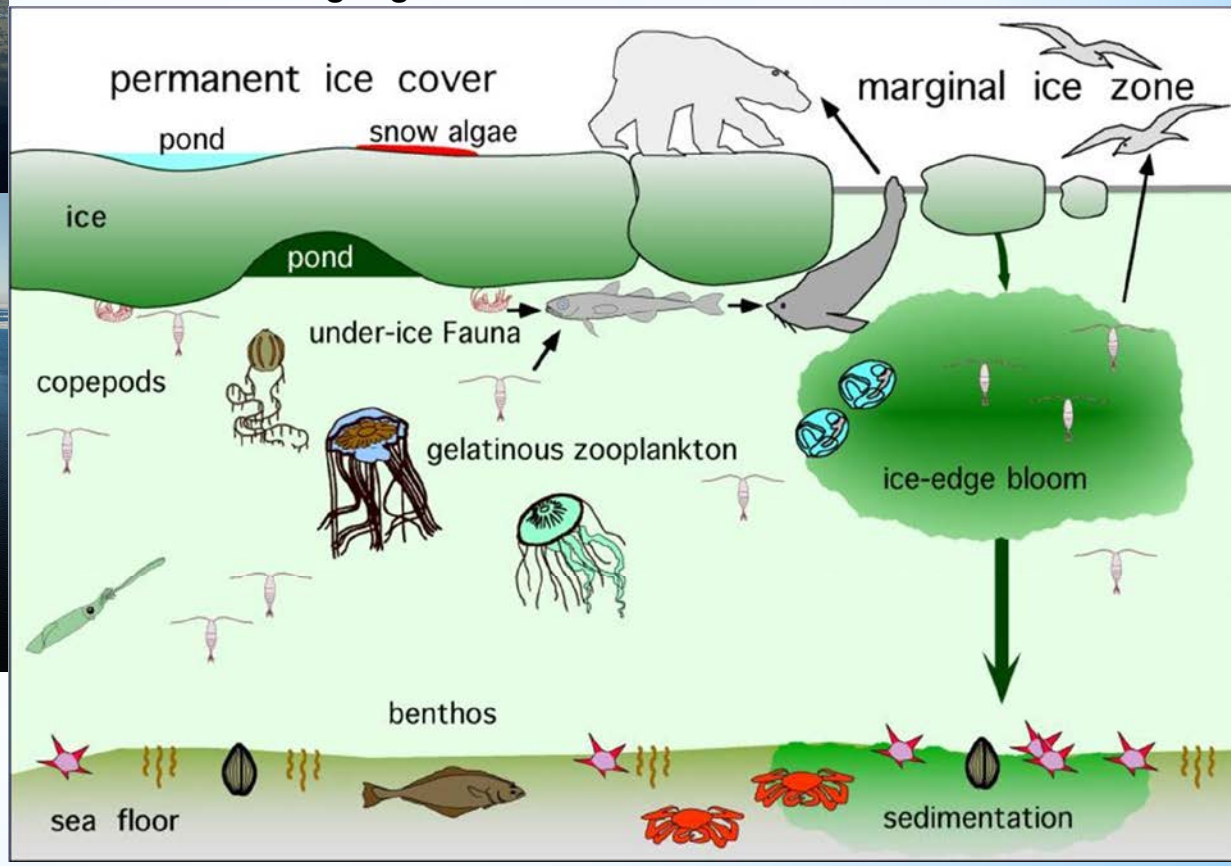
*Major Ecosystems

- Intertidal
  - ✧ Rocky
  - ✧ Mudflats
  - ✧ Estuaries
  - ✧ Salt Marsh
  - ✧ Mangroves
- Neritic
  - ✧ Seagrass Beds
  - ✧ Kelp Forests
  - ✧ Coral Reefs
- Polar Seas
- Deep Sea
  - ✧ Whale Falls
  - ✧ Seamounts
  - ✧ Hydrothermal Vents



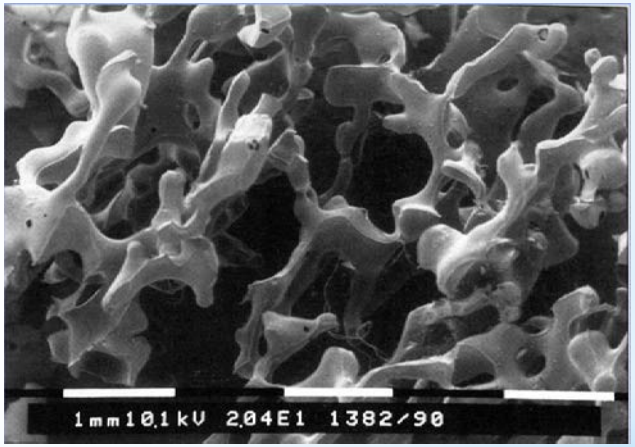
*Polar Seas

- High latitudes
- Coldwater year-round (average)
- Highly seasonal in light and ice cover
- Rich benthic communities!
- Polar ecosystems dynamics change with changing ice cover



*Sea ice

- Freezing water expels high-salinity brine (>200psu! Reg is ~32)
- Brine expelled within ice creates supercold, fluid channels within ice



- Brine expelled into water column sinks (cold + saline = dense!)

BRINICLES can form Channels of brine through relatively warmer waters

*Sympagic (sea-ice assoc'd) communities

- Shade-adapted photosysnthesis on underside of ice
- Accounts for 5-25% total production in Arctic
- Ice-assocated fauna feed on algae, live in brine channels
- Fish important link between ice production and top predators (i.e., seals)

*Slower, bigger, longer-living

	Polar	Temperate
Amphipods	4 - 10 years	0.5 - 2 years
Sea urchins	40 - 80 years	4 - 15 years
Sponges	> 1000 years	< 20 years

LIFE SPANS

"Polar gigantism" – species at higher latitudes tend to be much larger than their relatives at lower latitudes

THEORY: due to low temps, low metabolism, high O_2?

*Unique adaptations

CROCODILE ICE FISH

Channichthyidae

- Live in waters to -1.9°C
- Lack hemoglobin and most myoglobin
- Colorless blood!

Water is so oxygen-rich, don't need Hb!

But, have to be:

- Slow-moving
- Low metabolic rate
- Have greater blood volumes
- Have larger blood vessels

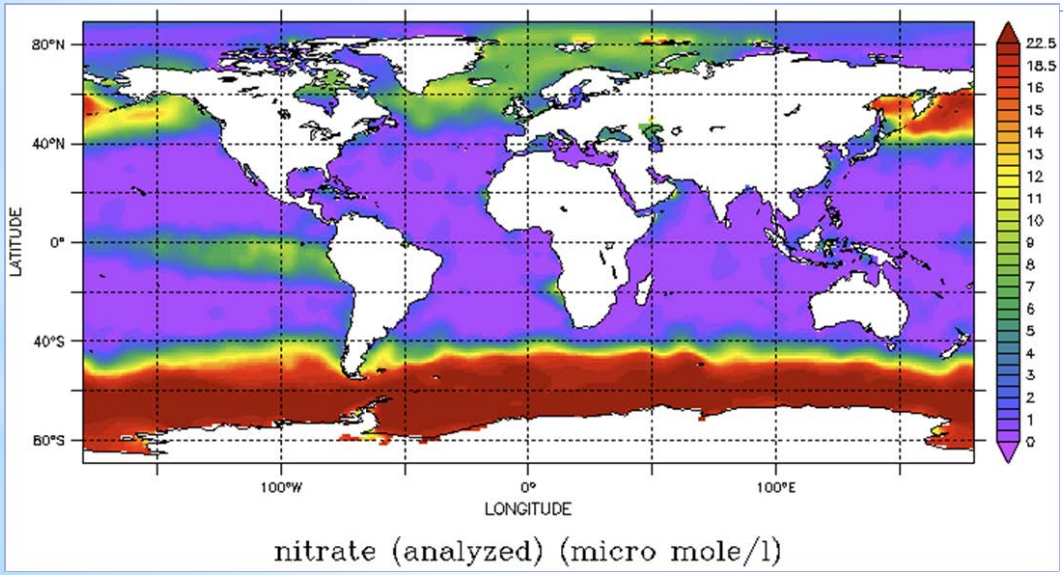
*Pelagic primary production

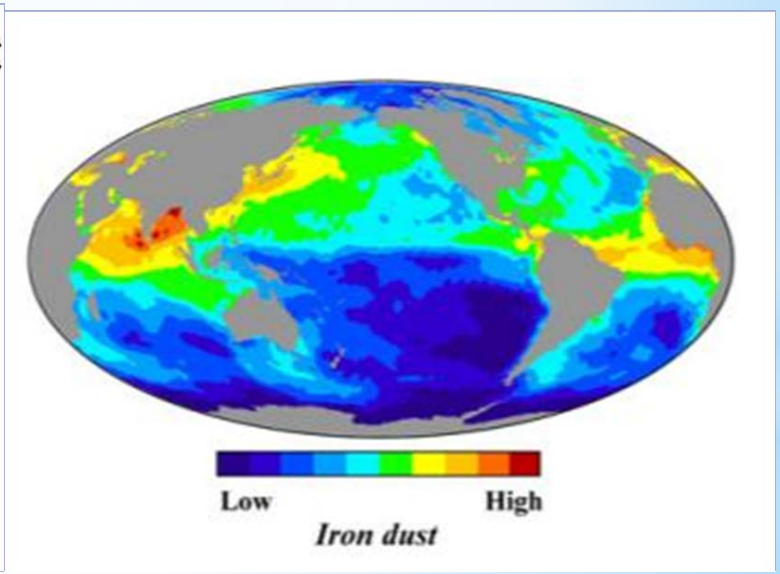
Water-column phytoplankton bloom occurs at onset of water column stratification in spring (due to warming & freshwater)

PELAGIC PRODUCTIVITY

ANTARCTIC
40-200 g C/m^2/yr

ARCTIC
~1 g C/m^2/yr

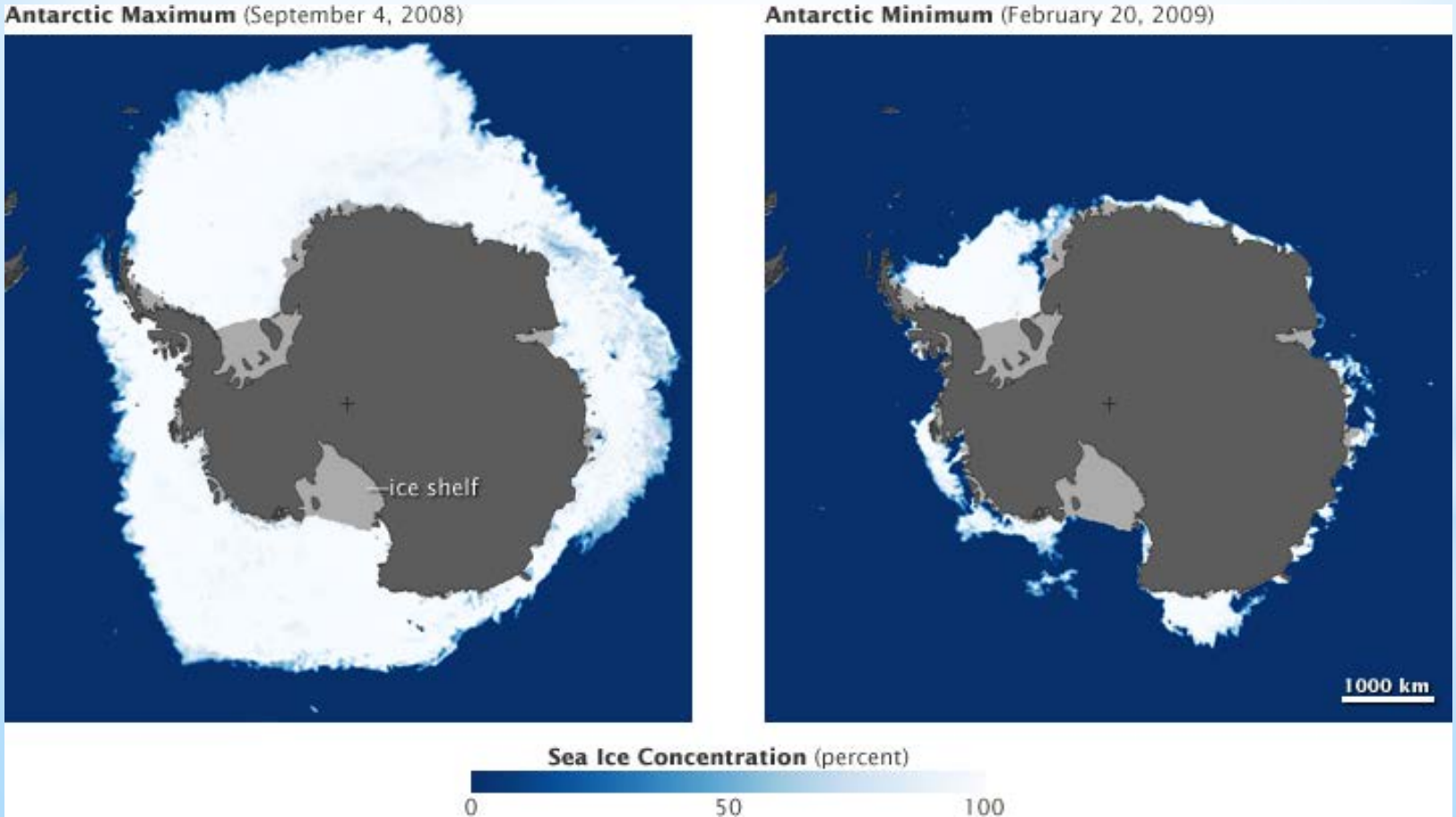




- **Need both macronutrients (Nitrate) and micronutrients (Iron) for photosynthesis**
- **Arctic Ocean more light-limited than Southern Ocean ….Why?**

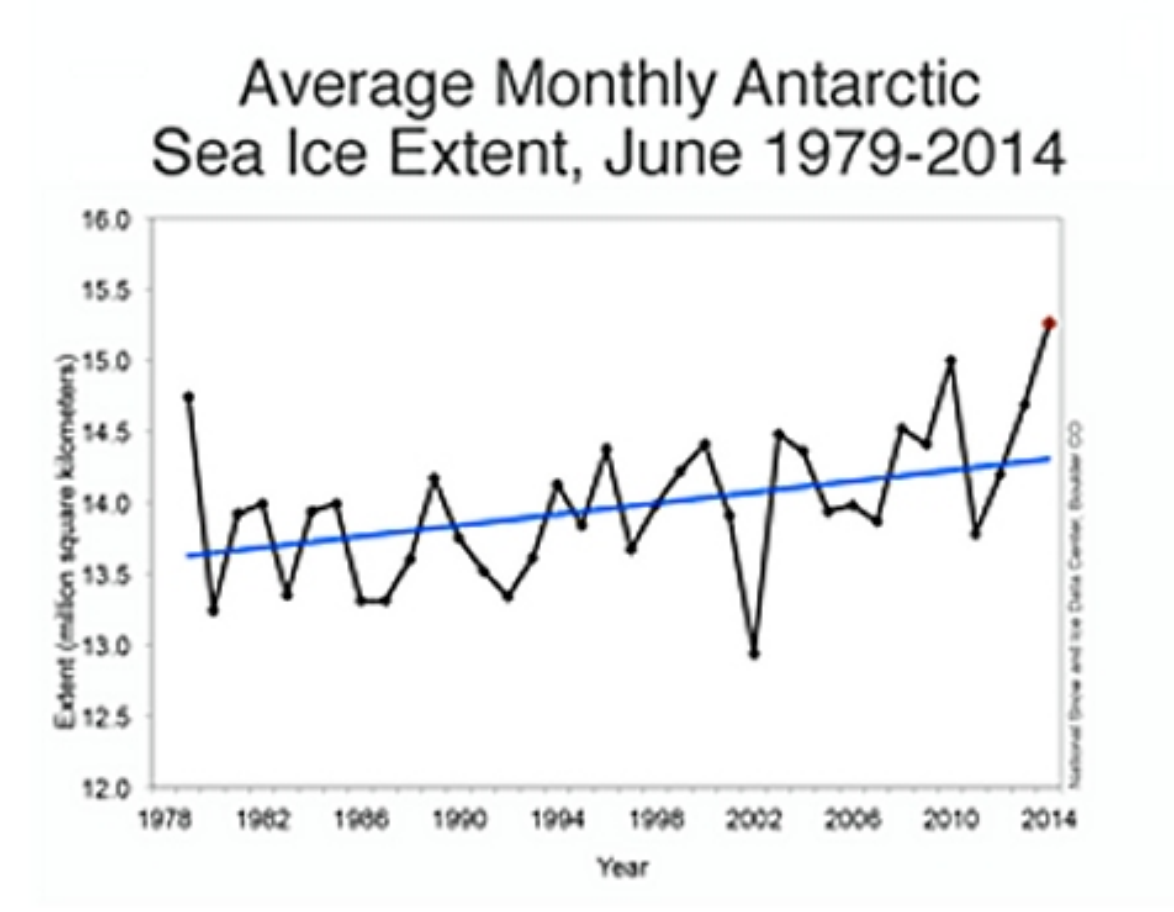
*Antarctic & Southern Ocean

- Deep basins around a central continent
- Ring-like surface circulation
- Narrow shelf
- Highly seasonal ice cover over Southern Ocean



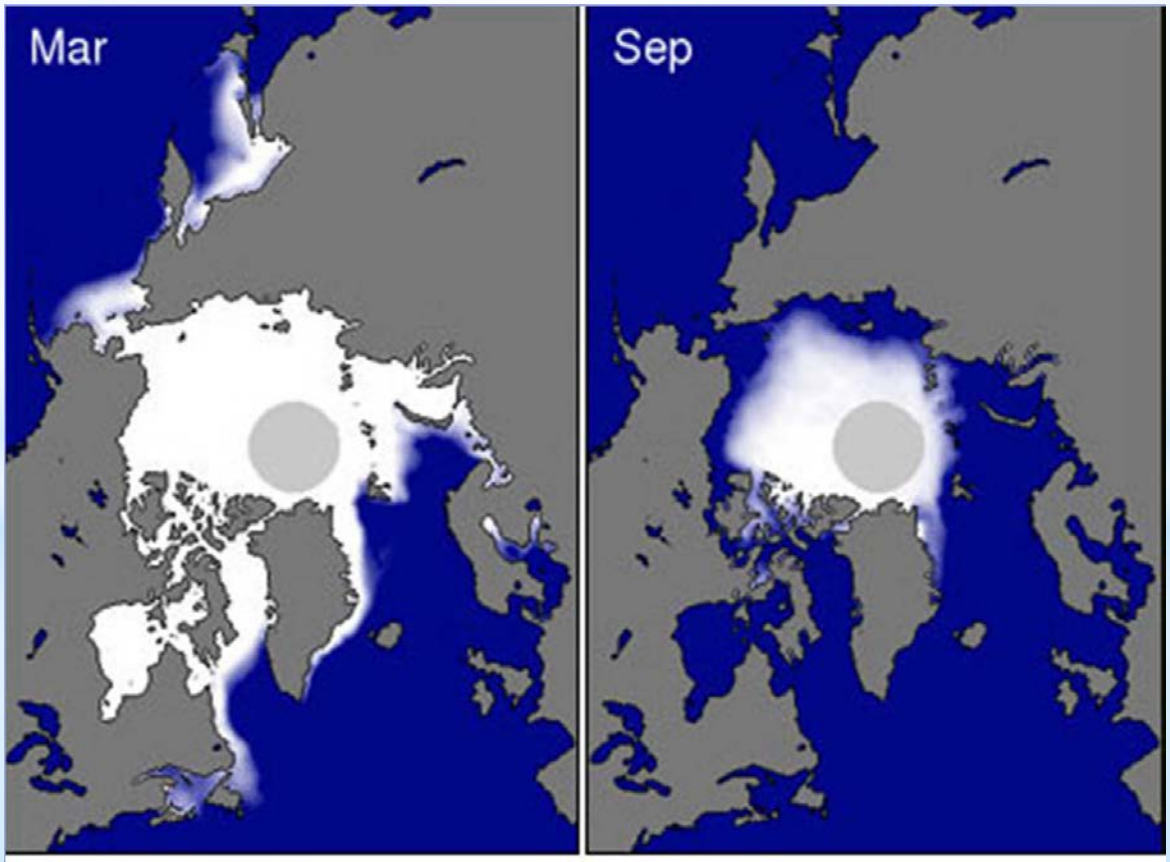
*Antarctic sea ice trends

- Southern Ocean sea ice slightly expanding*
  *not statistically significant
- Ozone hole over Antarctic cools the stratosphere, increases land to sea wind intensity
- Increased rain over time stratifies surface waters, prevents warmer water from reaching surface and melting ice
- Land-based glacial ice is melting rapidly



*Arctic Ocean

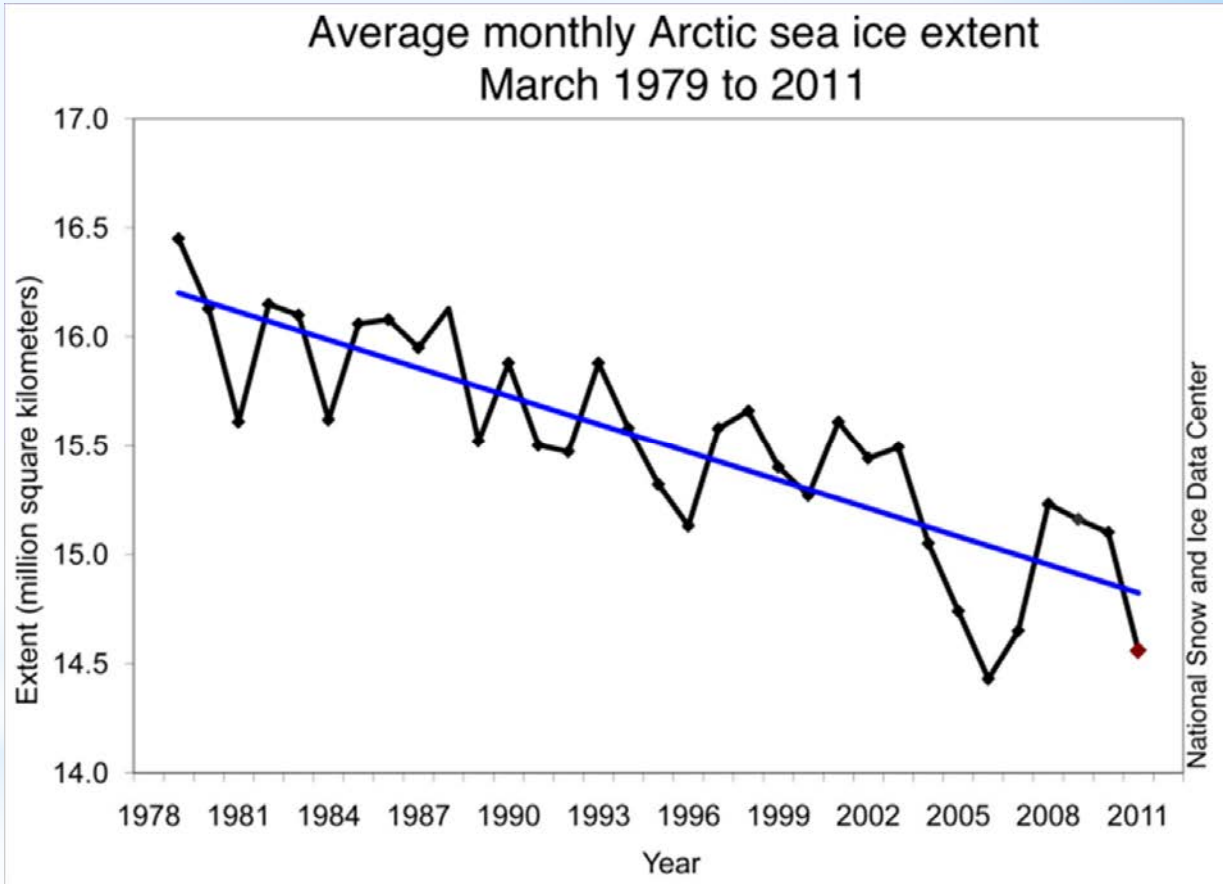
- Small ocean surrounded by continents
- Broad, shallow shelf ~50% of total area
- High freshwater inputs (many rivers drain to Arctic)
- Transpolar circulation (generally)
  - Pacific => Bering Strait => across Arctic => Greenland Sea => Atlantic
- Center of Arctic Ocean permanently ice covered = *multiyear ice* ~3m thick



*Arctic sea ice trends

- Arctic sea ice shrinking significantly (~500,000 km^2/decade)
  - Heat inflow from Pacific and Atlantic increasing
  - increased evaporation = increased cloud insulation
  - Loss of ice decreases **albedo**

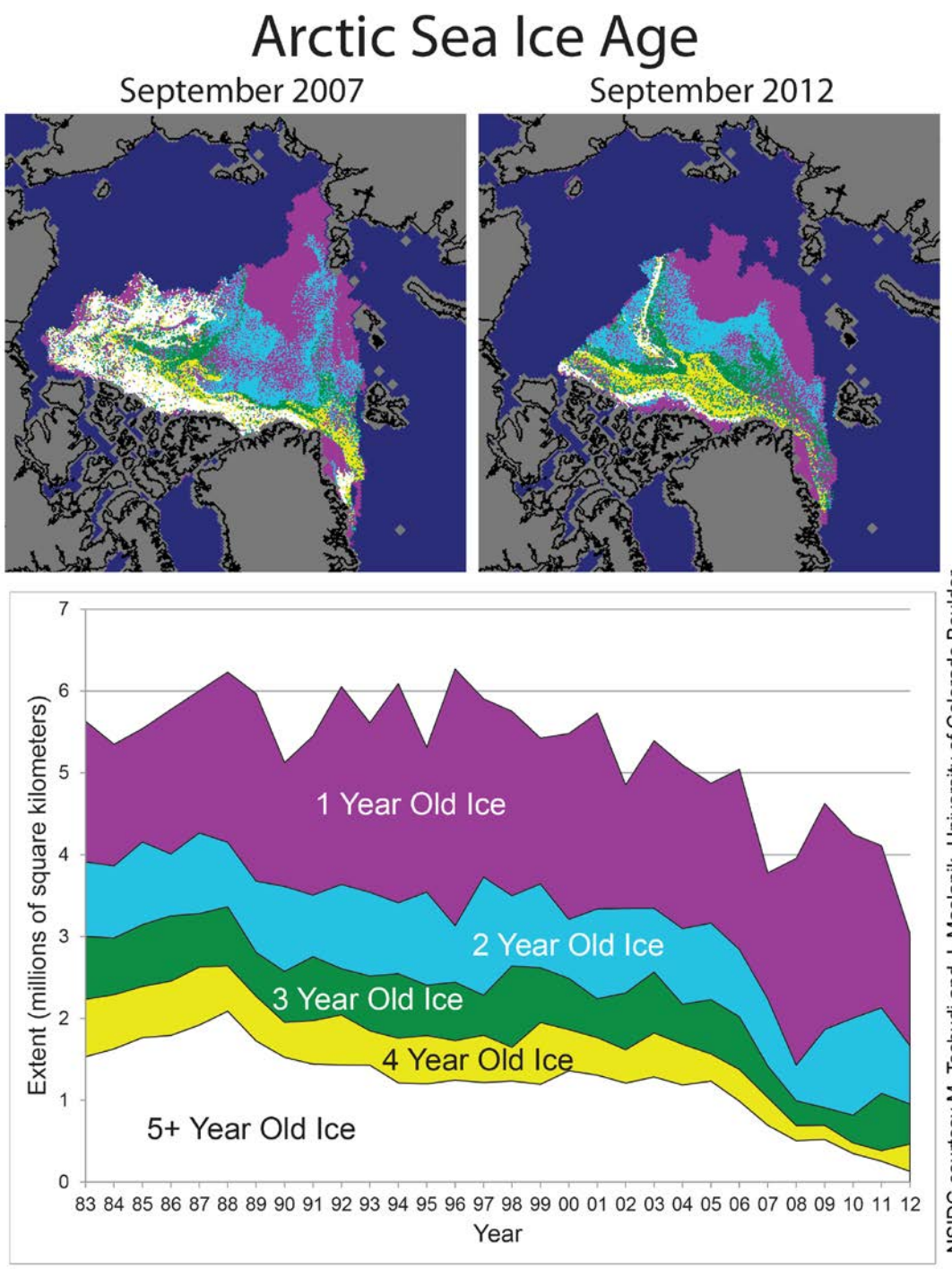
reflectivity of surface, meaning more heat absorbed



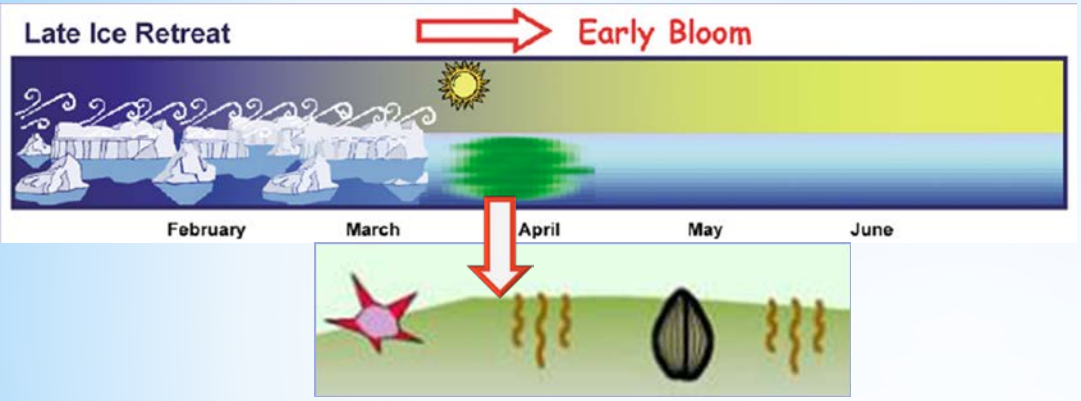
FEEDBACK LOOP!

*Multiyear ice loss

- Multiyear ice does not melt in the summer
- Dramatic declines in this type of ice since the 80's
- MY ice important freshwater source in the Arctic – salt is slowly leeched out, creates drinkable water pools
- MY ice also is more resistant to storm action, doesn't break apart as easily

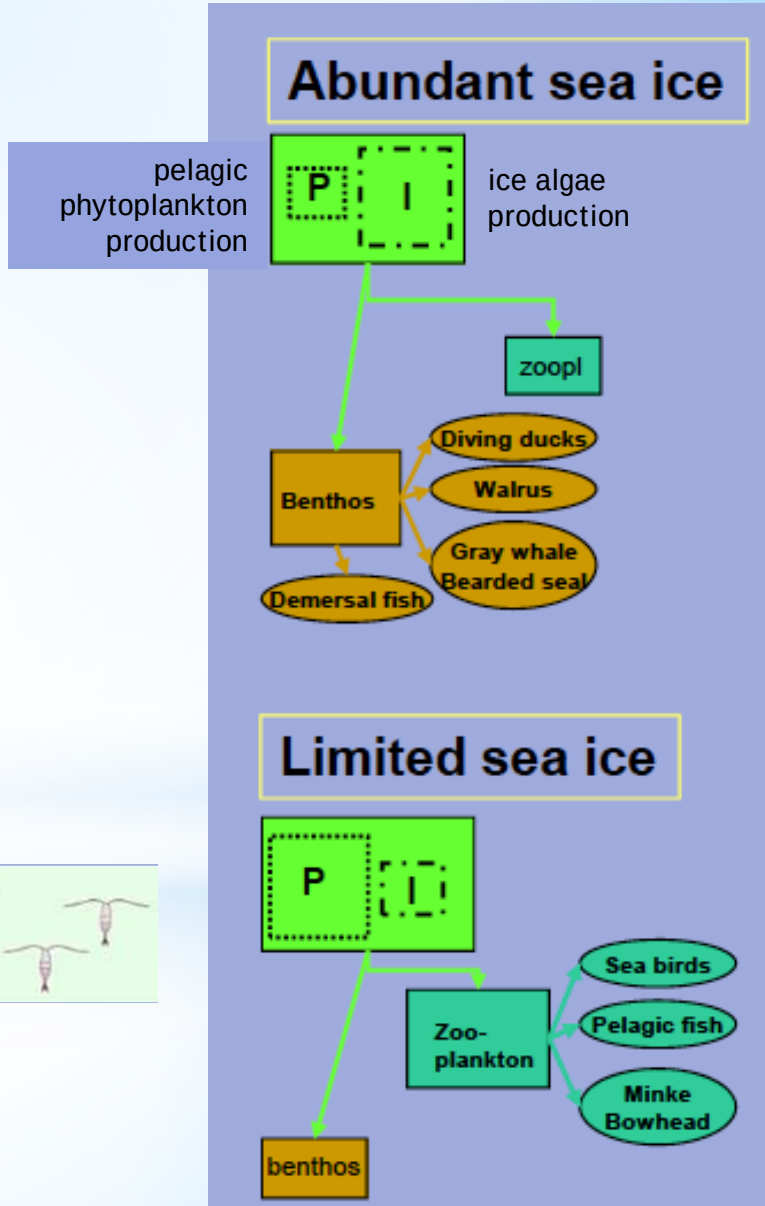


*Ice extent impact on ecosystem

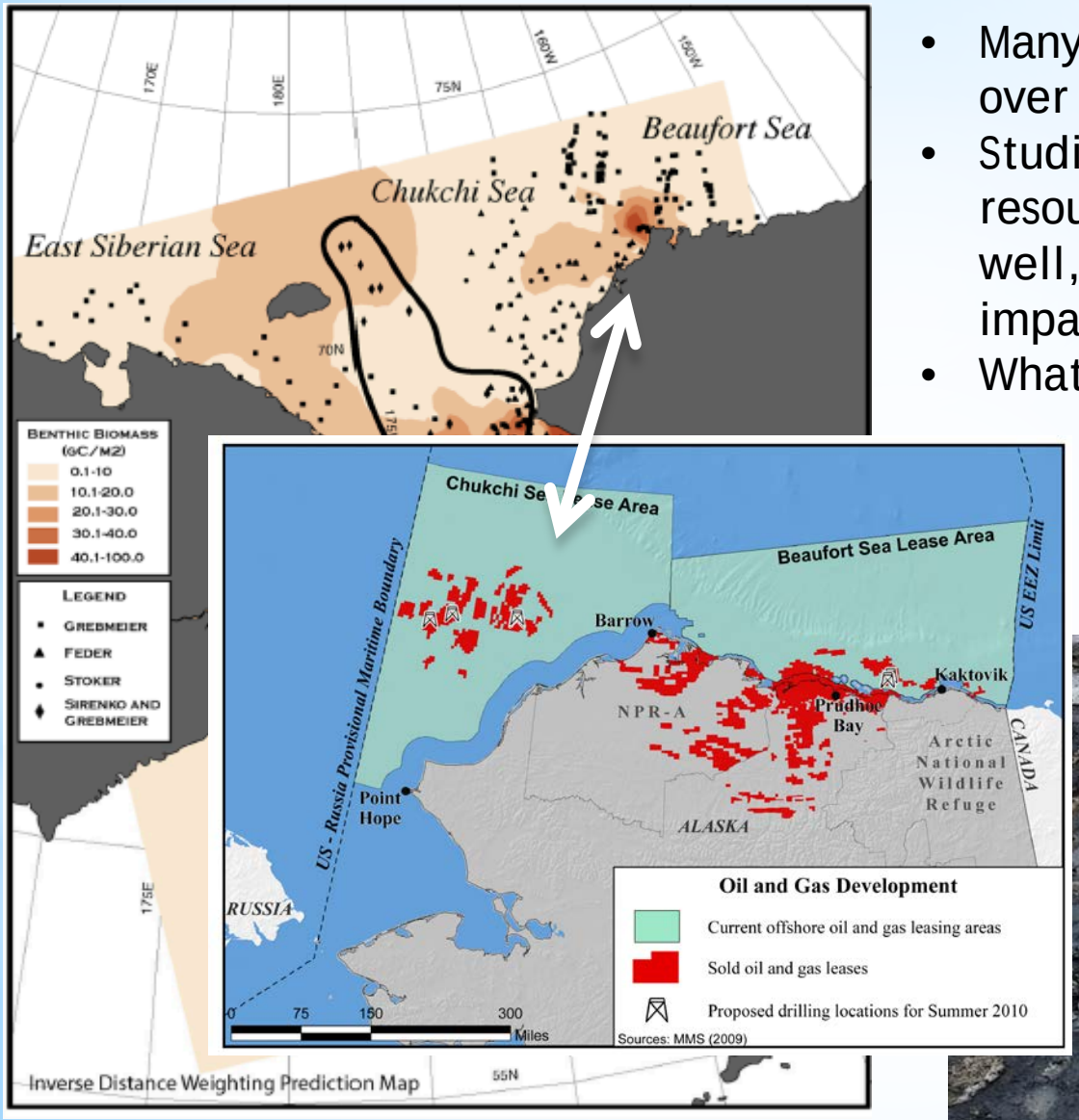


MORE ICE: remains into spring until sufficient light
= greater ice algae growth
when does melt, zoops haven't returned yet
most ice algae production goes to benthos

LESS ICE: melts before light returns
= no / minimal ice algae bloom
pelagic phytoplankton dominate
zoops have had time to return
most pelagic prod stays pelagic



* Oil fields & increased traffic

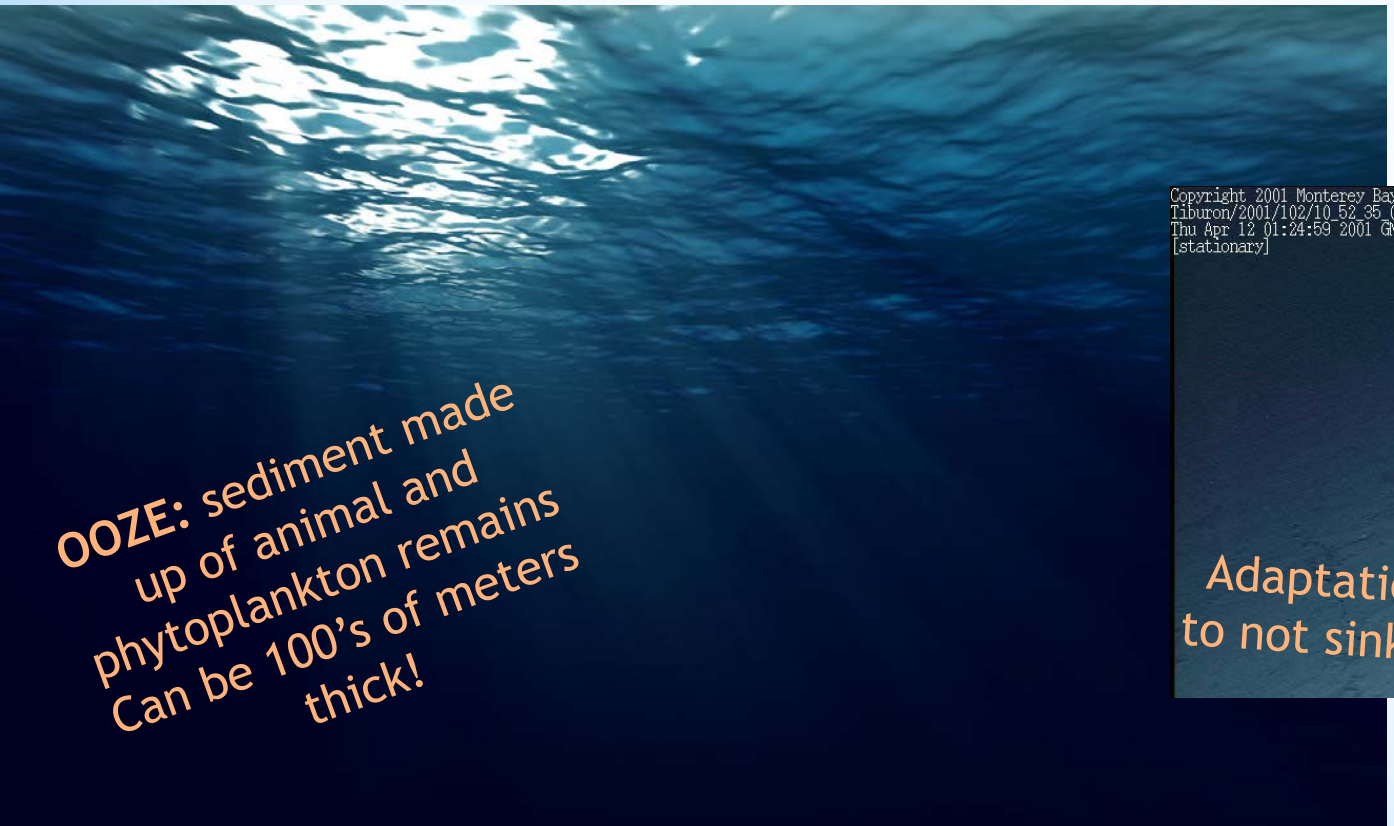


- Many oil lease blocks are directly over high-biomass areas
- Studies have shown that natural resource extraction, when done well, does **not** significantly impact surrounding biota
- What happens with an oil spill in icy, cold waters?

Still trying to figure it out…

*Deep Sea

- Everything below the photic zone (>200 m depth)
- Represents 85% of the ocean, and only 1% of this has been explored
- Mainly soft bottom – ooze or clay
- Large benthic boundary layer
- Mixing through tidal action, downward transmission of surface storms, underwater land slides

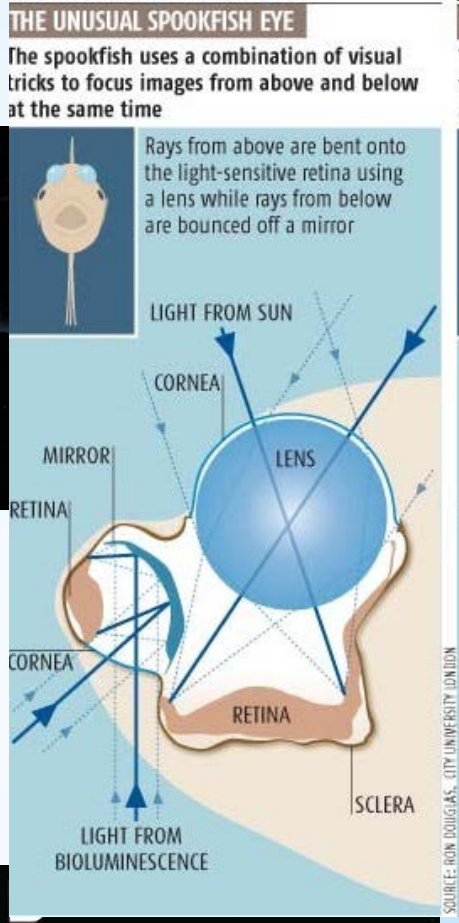


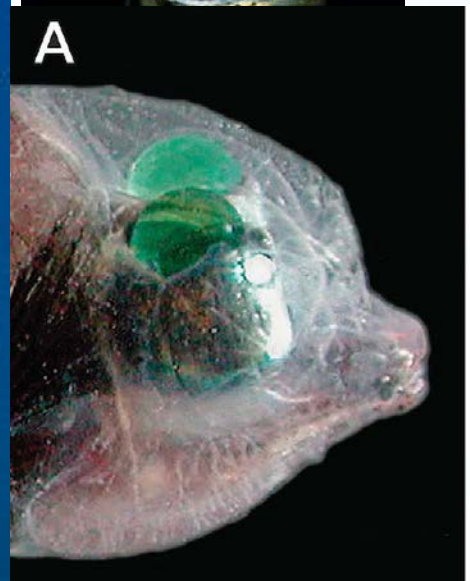
*World of darkness

Light doesn't penetrate

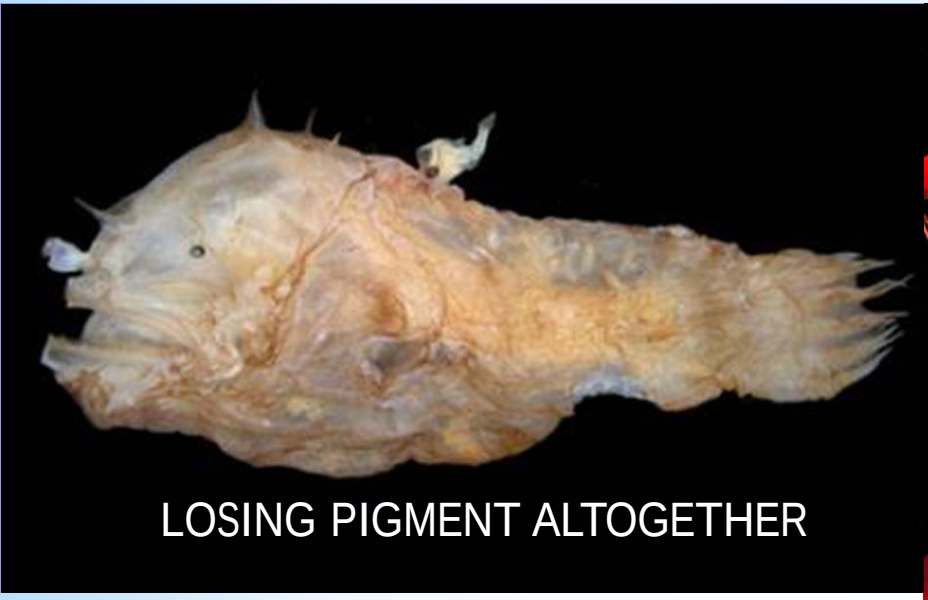
HOW TO SEE?

1) Reduce or lose eyes all together
2) Make your eyes huge
3) Have tubular eyes with 2 retinas
4) Have 2 different-sized eyes





*Pigments & bioluminescence



LOSING PIGMENT ALTOGETHER

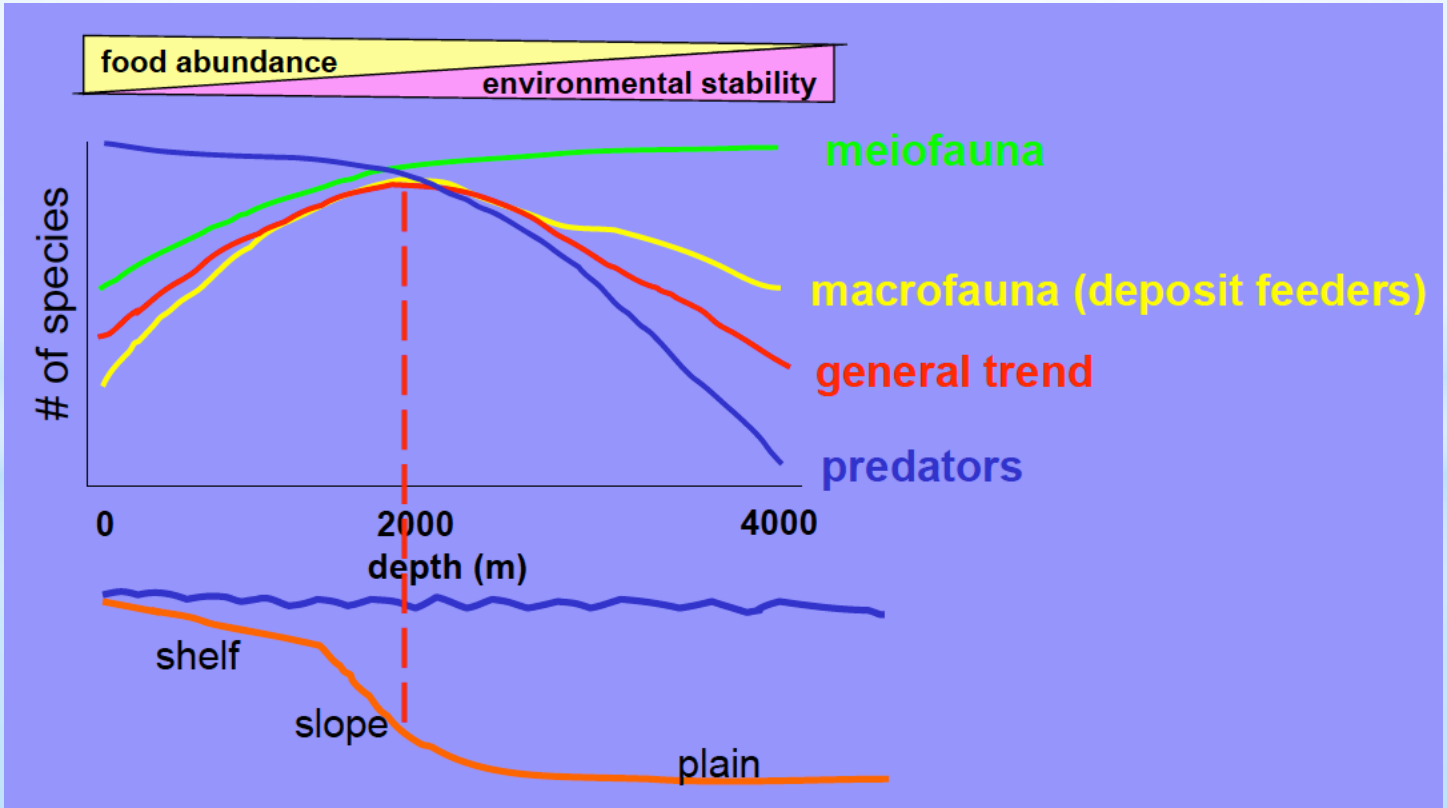
RED COLOR APPEARS BLACK

- Bioluminescence for prey capture, and predator defense

*Food availability

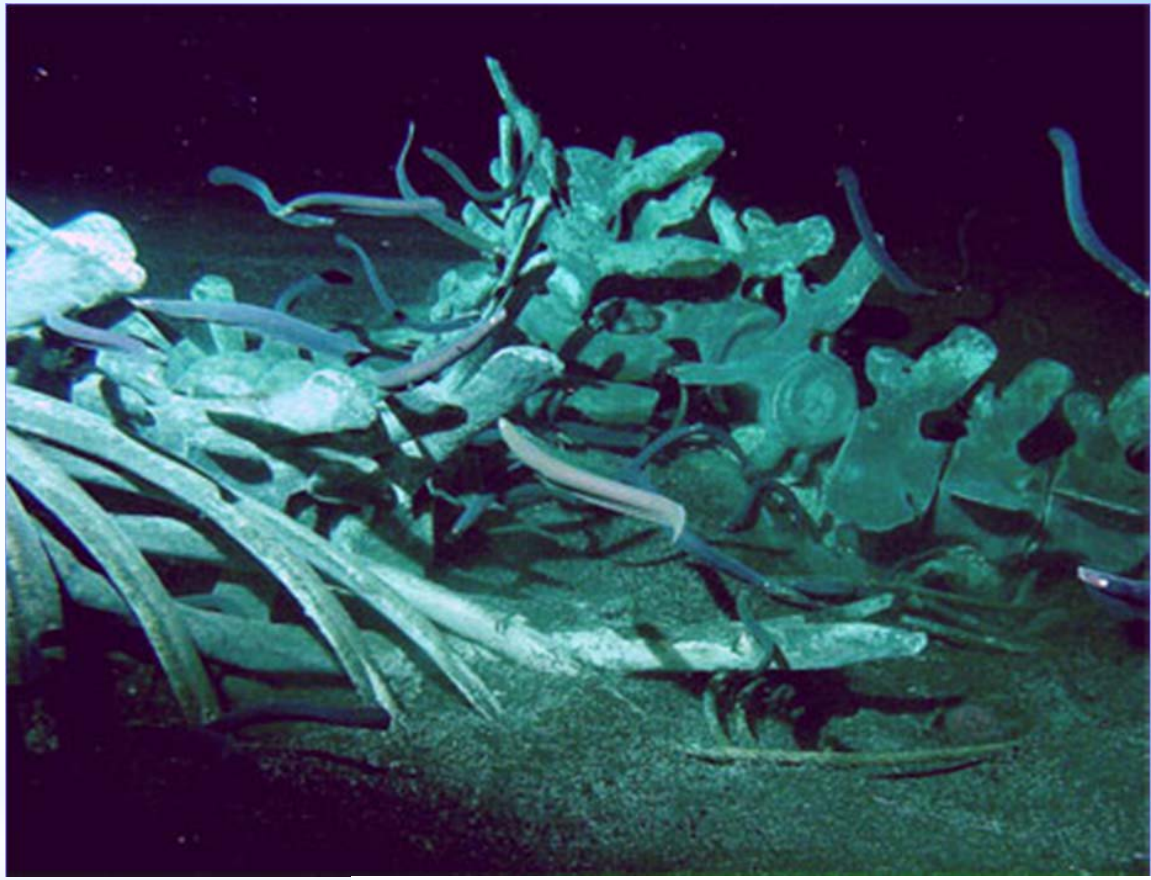
No light = no photosynthesis = food shortage

- Rely on import
  - Vertical transport of production in shallow waters
  - Lateral advection from slope regions
- Most food highly degraded by the time it reaches bottom
- Some taxa do better than others at exploiting

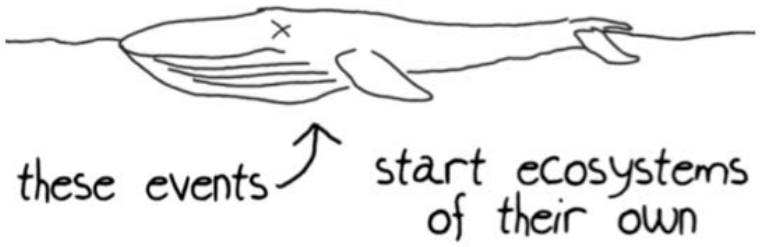


*Large food falls

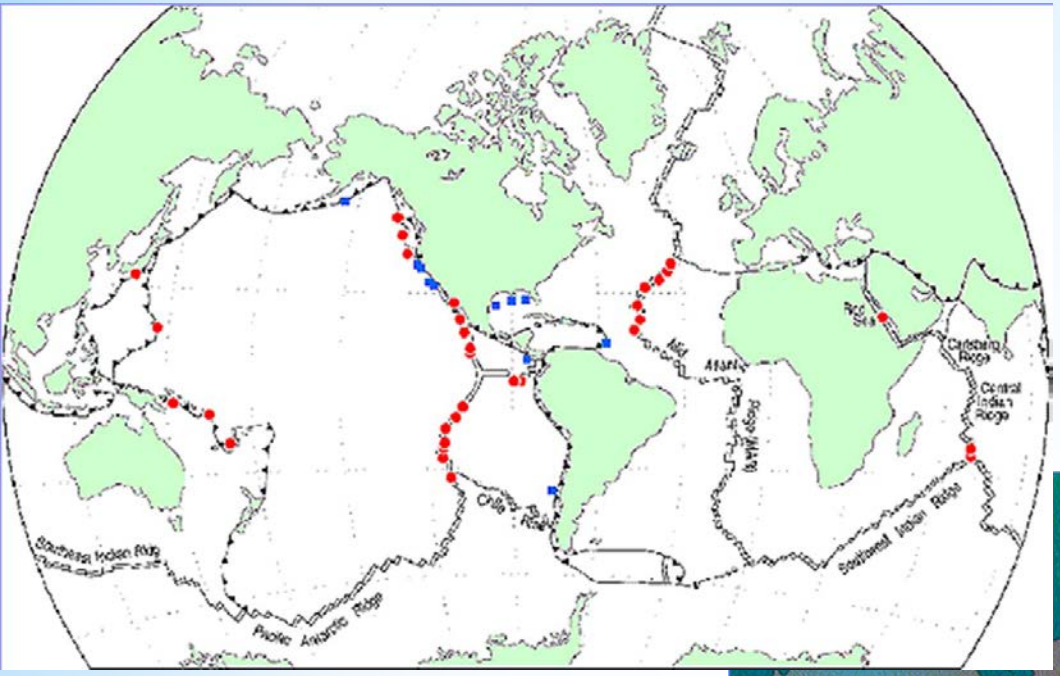
- Whales, fish, algal rafts
- Unpredictable, but can be common
- Succession of species
  - Scavengers (sleeper sharks/hagfish)
  - Enrichment opportunists (polychaetes, crustaceans)
  - Sulfide-based chemoautotrophs (worms) – can last decades!



~ 400 species found to be associated
28 species UNIQUE to whale falls



*Hydrothermal (hot) vents

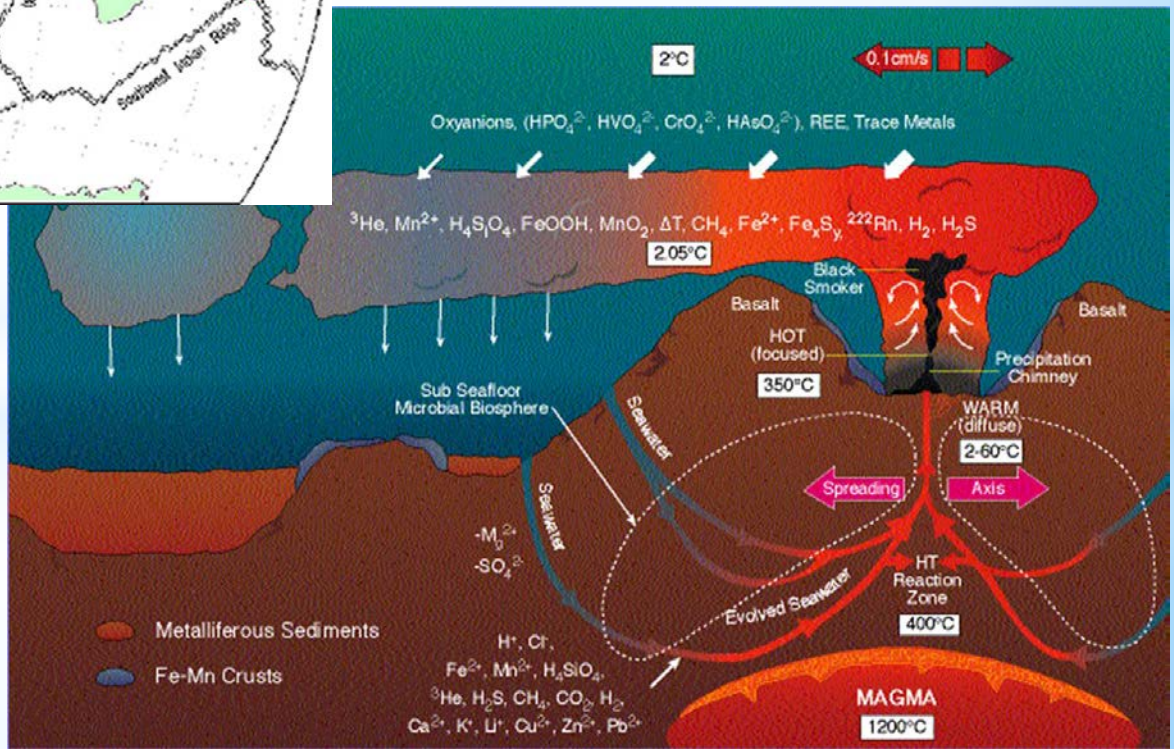


- Occur along areas of tectonic activity – mid ocean ridges
- H_2S rich
- Very hot at source, but rapid temperature decay
- Last years to decades

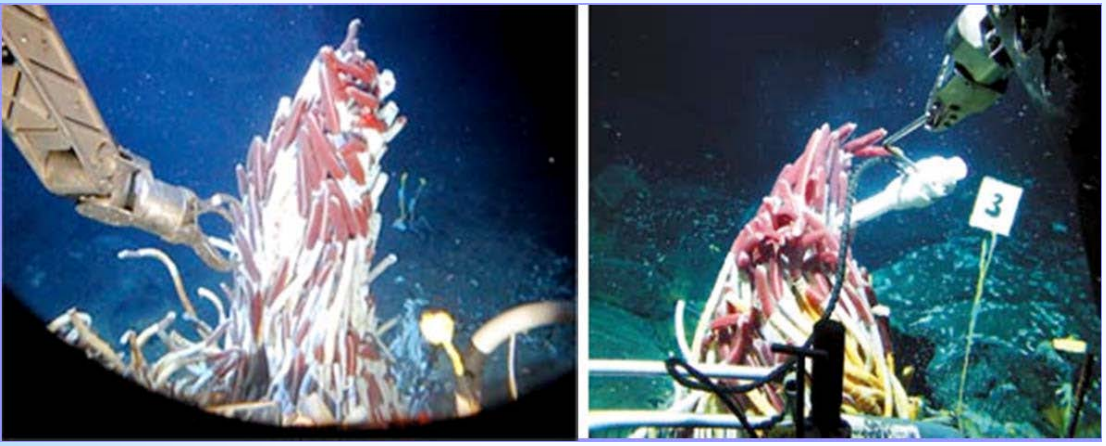
CHEMOAUTOTROPHIC BACTERIA!

Carbon dioxide + sulfide + water

Glucose (energy) + sulfate



*Hydrothermal (hot) vents



Tubeworms

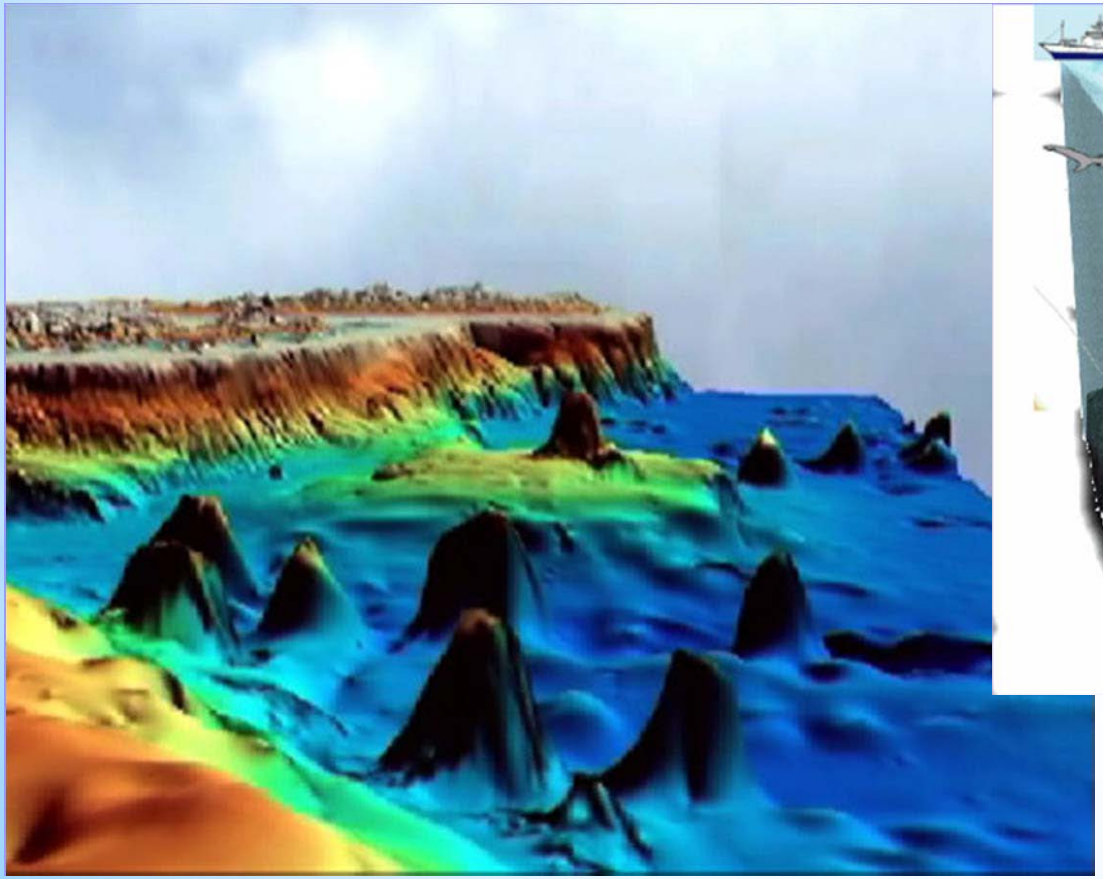
50% of body mass is chemoautotrophic bacteria!
May constitute most of food source!

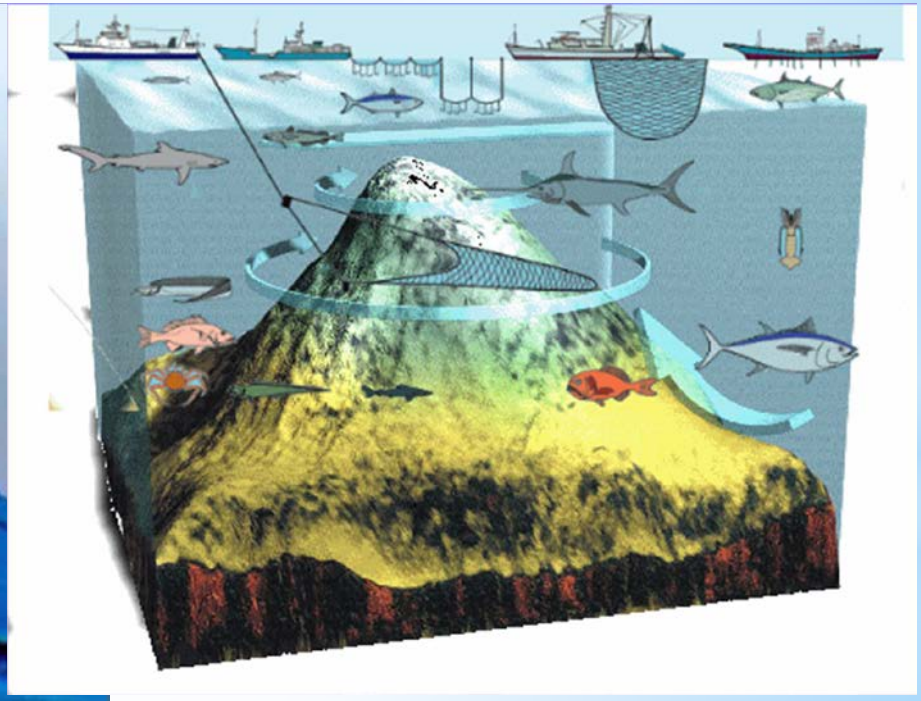
Giant clam

Have enormous amounts of chemoautotrophic bacteria in their gills!

*Seamounts

- Underwater mountains that don't reach the surface
- Formed from volcanic activity
- Estimated 30,000 in Pacific Ocean
- Change water flow, increase mixing & localize upwelling
  = **PRODUCTIVE HOTSPOTS**

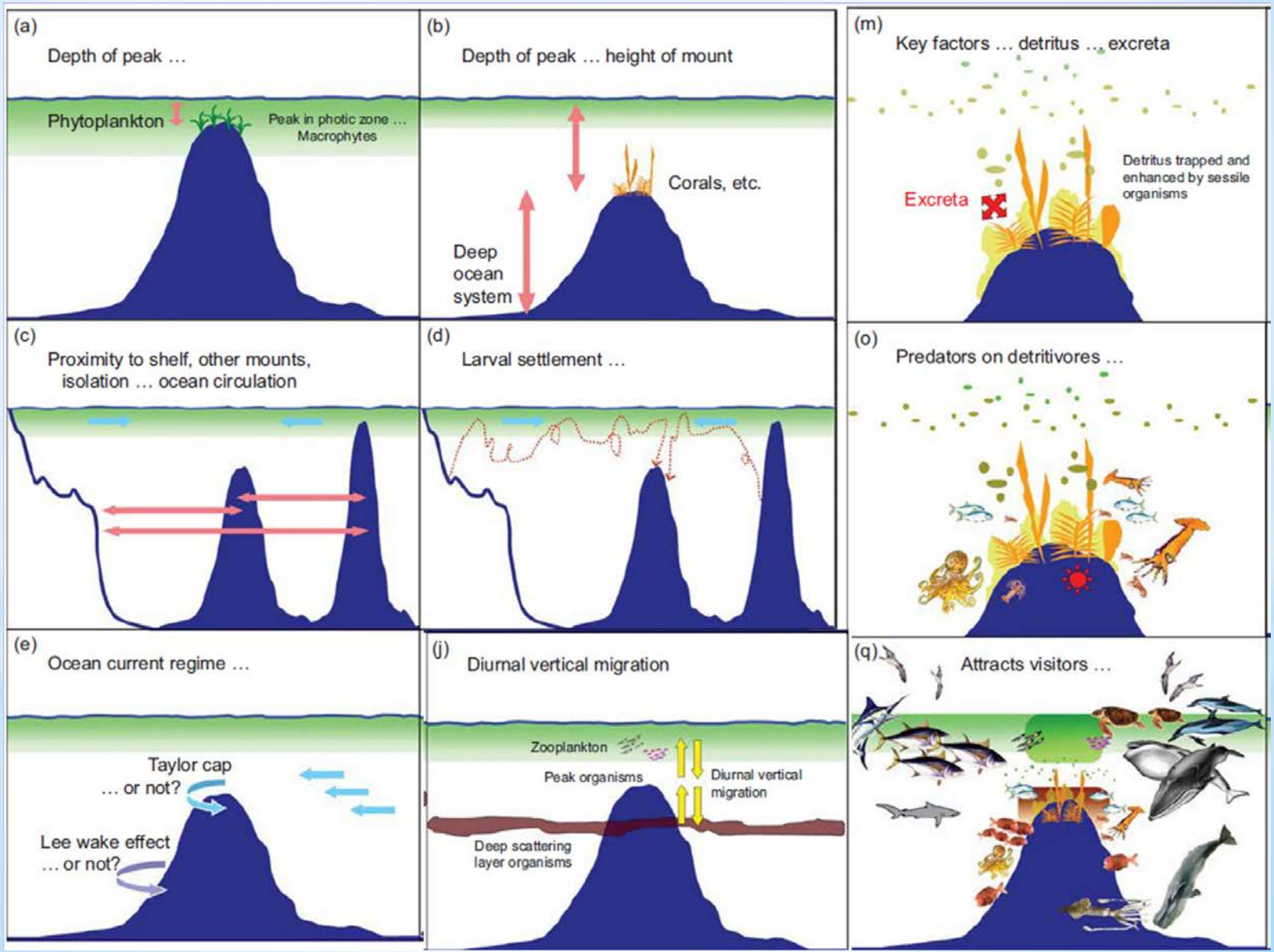




Also means they are susceptible to over-exploitation

*Seamounts

Factors shaping seamount communities



*COMMUNITY PROCESSES

*What shapes marine communities?

ABIOTIC

- Temperature
- Salinity
- Hydrodynamics
- Substrate
- Physical Disturbance

BIOTIC

Competition
Predation
Larval supply
Facilitation
Mutualism
Productivity/food supply

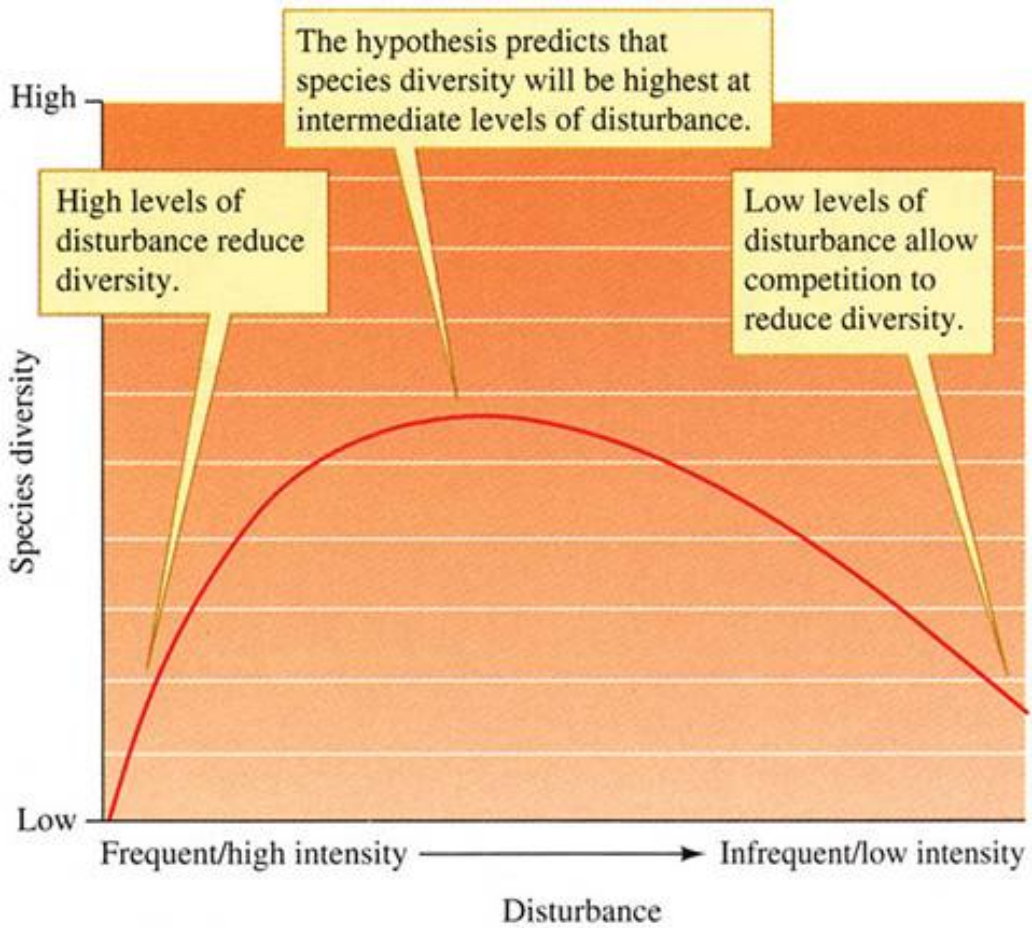
*Disturbance

Damage or mortality inflicted by an external source
e.g., wave impact, ice scour, etc.

- Can be acute (one-time) or chronic (ongoing)
- Provides space for or access to a limited resource

Intermediate Disturbance Hypothesis

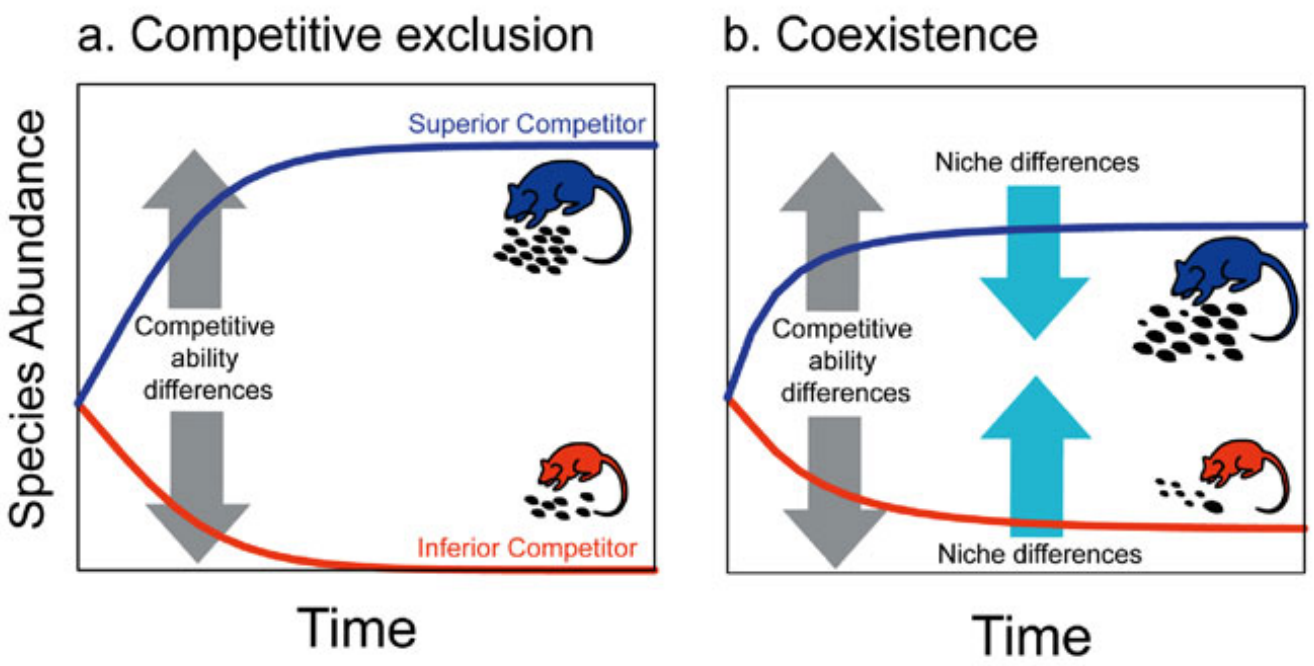
- Greatest biodiversity occurs when intermediate levels of disturbance occur
  - Allows niche overlap
  - Competitive exclusion can't set in



*Competition

Interaction for access to LIMITED resource – space, food, light

With no other forces present, competition drives community composition (remember barnacle example)



If competition doesn't knock one species out completely, then there is "coexistence", with each species in its own niche

*Predation / Grazing

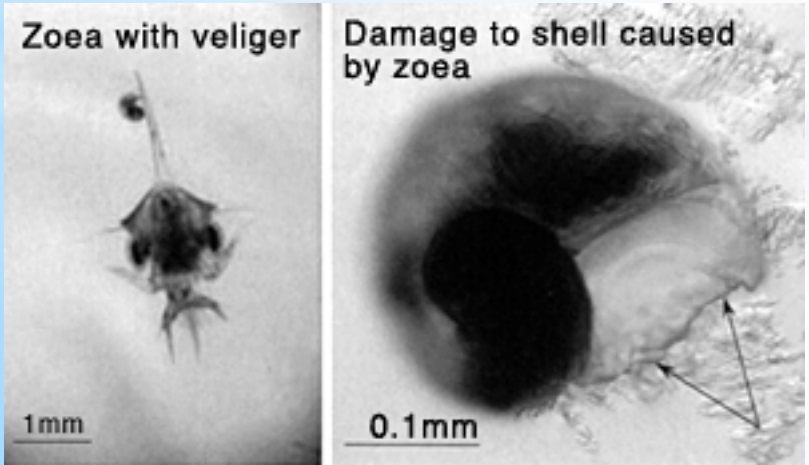
Predation: predator eating prey

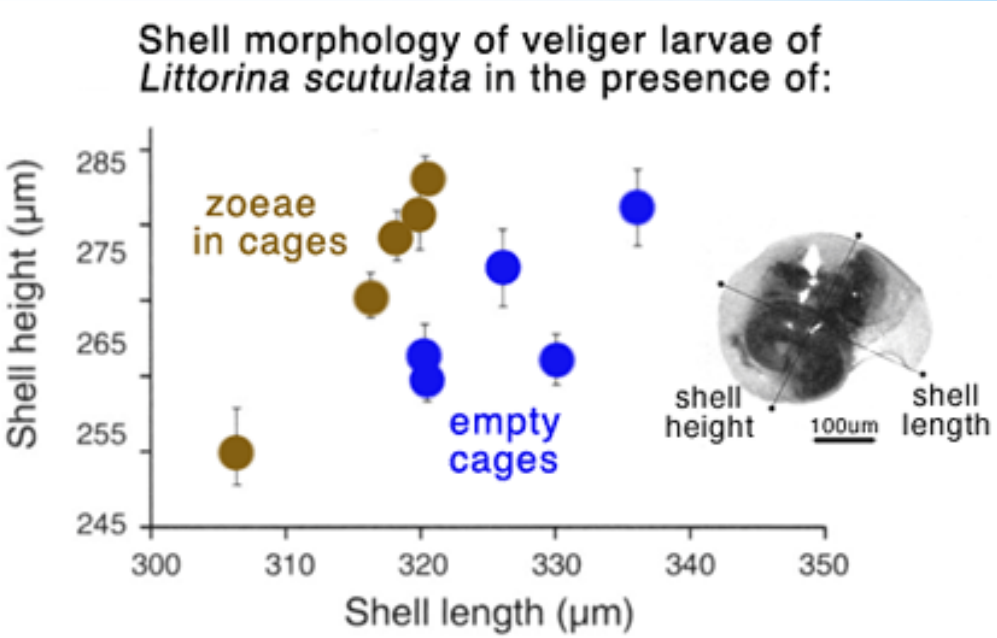
Grazing: herbivore eating primary producer

Predation effects can control abundance, size distribution, spatial distribution, and presence of prey
= biological disturbance!

Prey respond with defense mechanisms:

- **Camouflage**
- **Chemical**
- **Life history adjustments**
- **Morphology changes**





*Facilitation a.k.a. ecosystem engineering

PRESENCE

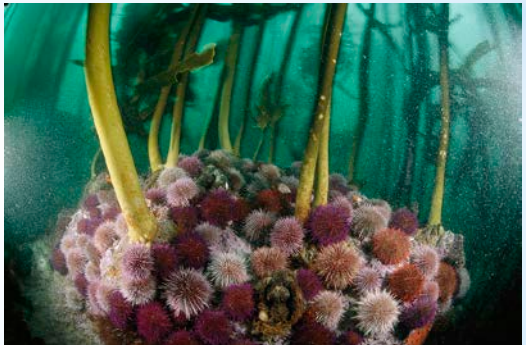
(foundation organisms = seagrass, mangroves, kelp, etc.)

- Stabilize substrate, change water flow, alter habitat complexity

ACTION

(often predators)

- Disproportionate impact on their surrounding environment



*Larval supply & recruitment

Larval stage important for:

- Dispersal
- Genetic mixing
- Reduced competition with conspecific adults
- Recolonization of area following disturbance

3 strategies:

Planktotrophic larvae

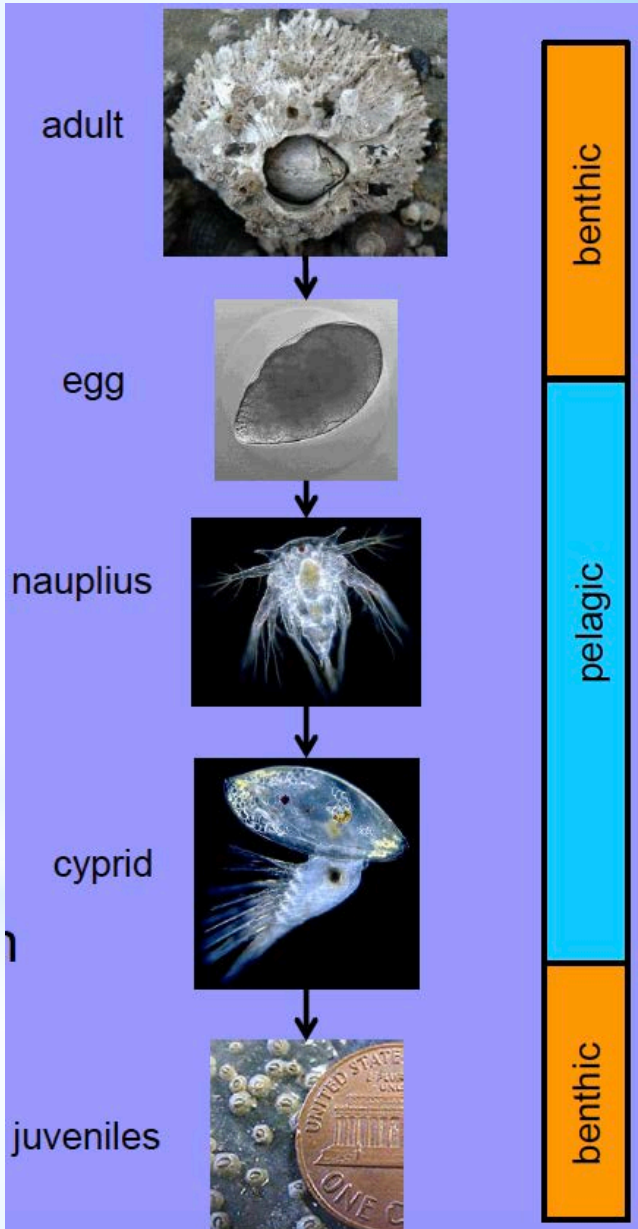
✧ Many eggs (1,000s)
✧ Little parental investment per egg
✧ No yolk – depend on food resources in plankton

Lecithrotrophic larvae

✧ Many eggs (100s)
✧ Moderate parental investment per egg
✧ Feed off of rich-yolk, short time in plankton

Direct Development (no larval state)

✧ Very few, very yolk-rich eggs
✧ Most parental investment per egg

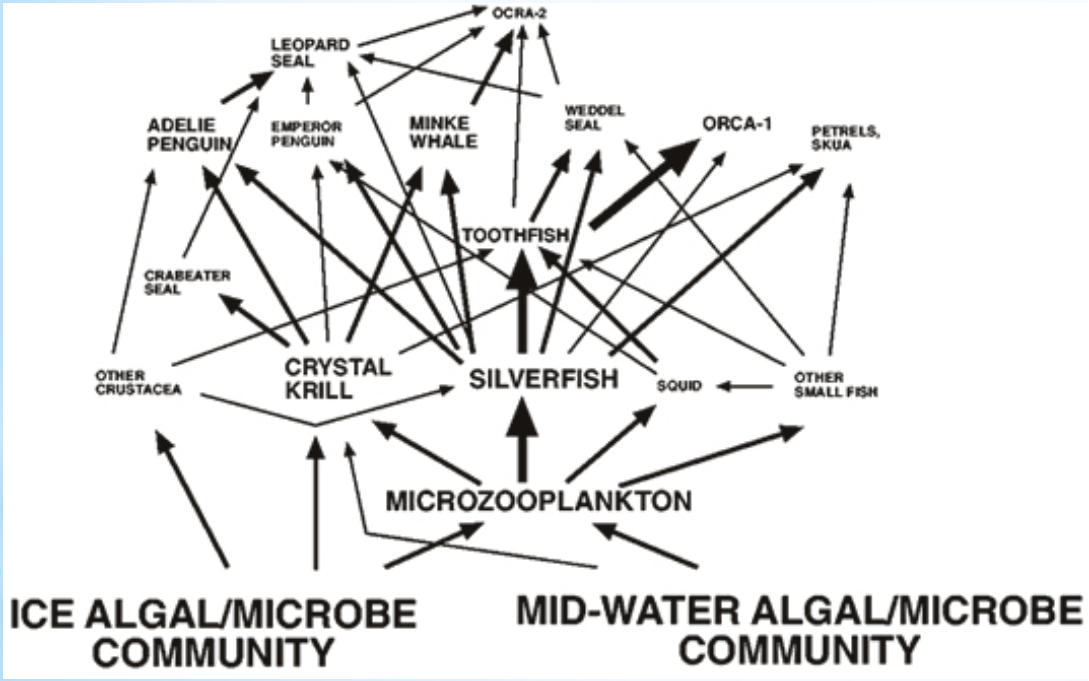


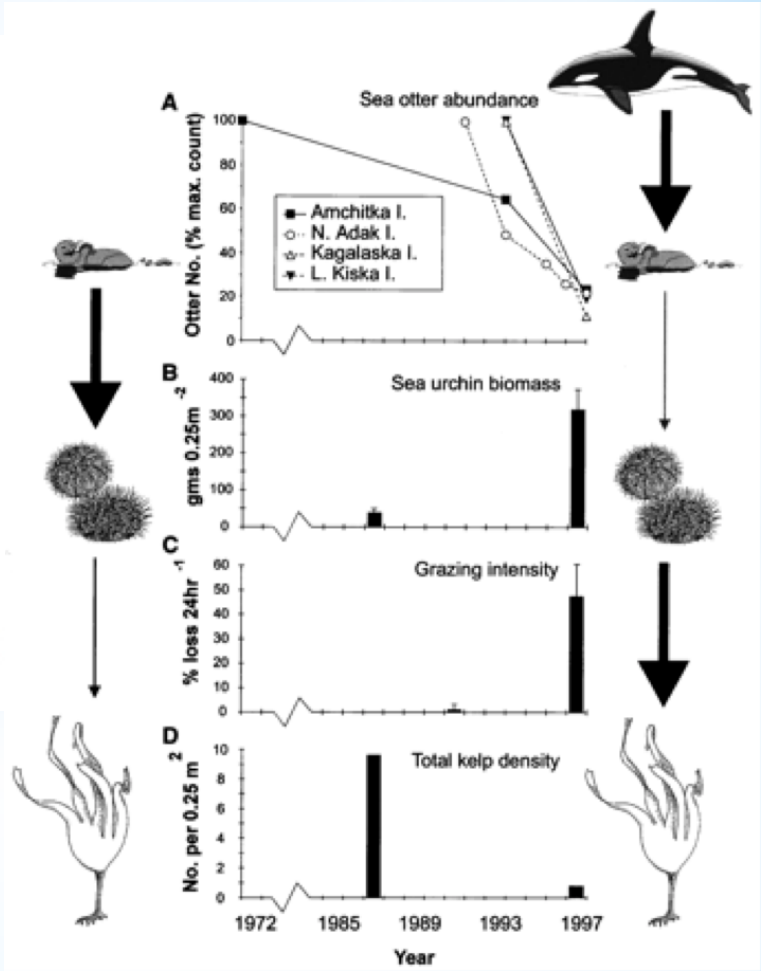
*Structuring forces

BOTTOM-UP versus TOP-DOWN

(resource limitation)

(predation)





*Biodiversity ecosystem functioning

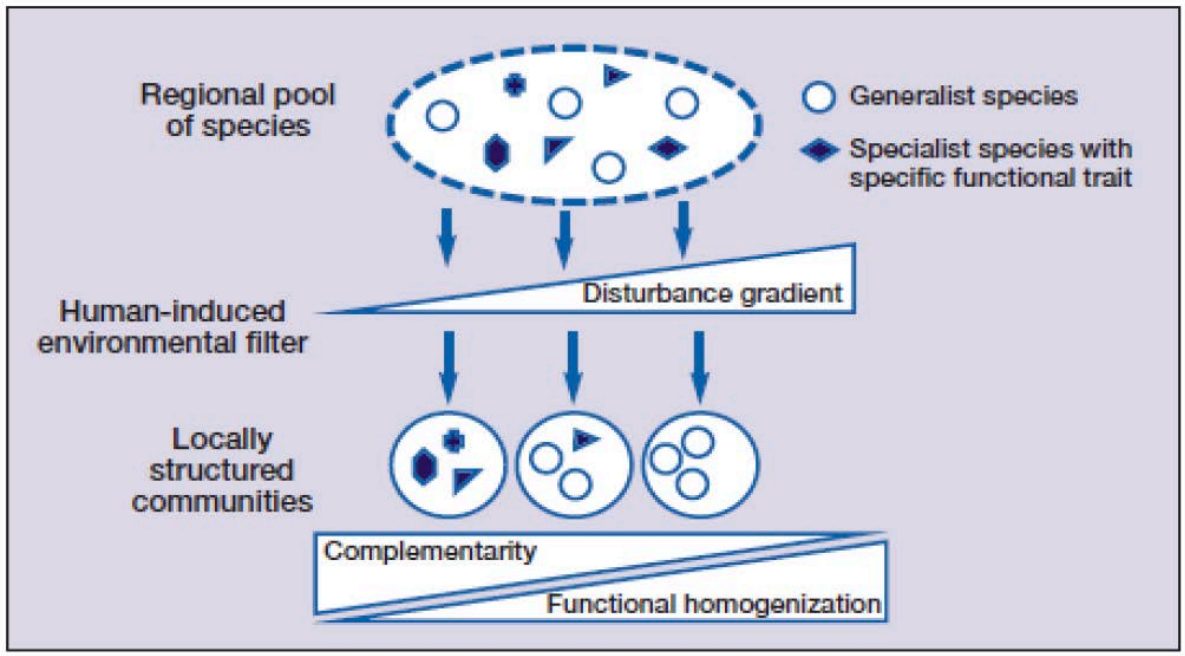
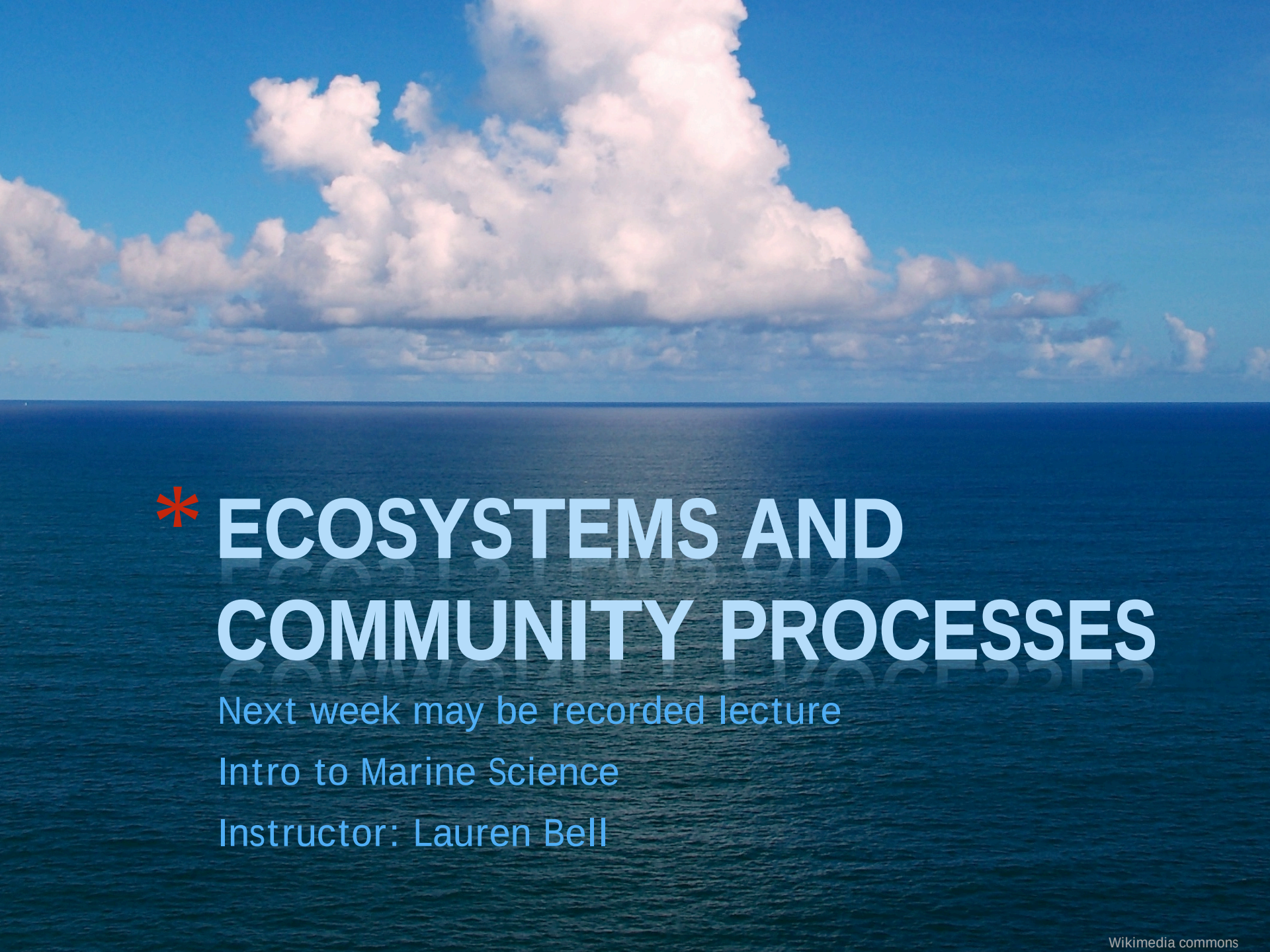


Figure 2. *Diagram describing how loss of specialists engenders loss of functional complementarity and thus functional homogenization.*

Loss of biodiversity

→ **Functional Homogenization**

- One generalist fills niche instead of multiple specialists
- Loss of small-scale functional variability
- Loss of resilience
- Loss of productivity



ECOSYSTEMS AND COMMUNITY PROCESSES

Next week may be recorded lecture

Intro to Marine Science

Instructor: Lauren Bell

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