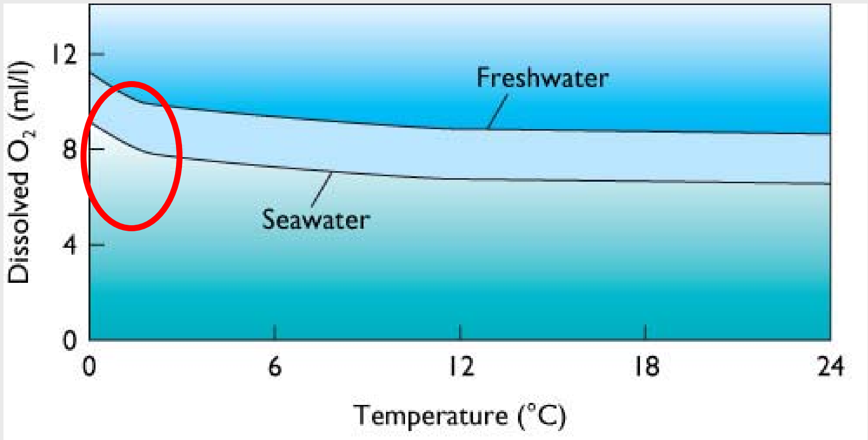
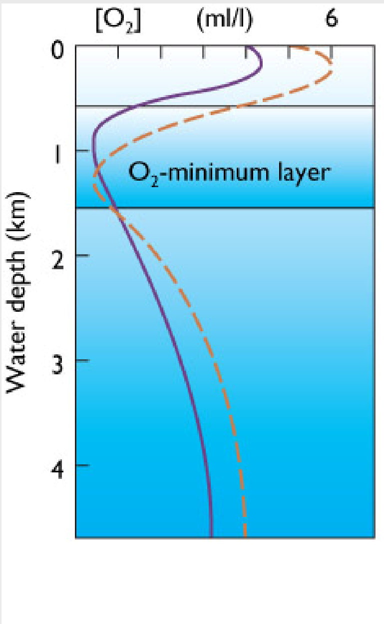
TABLE **5-9**

Summary of factors that regulate the concentration of gases in water

Factors	Effects
Wave and current turbulence	Increases the exchange of seawater gases with the atmosphere.
Difference in gas concentration	Gases diffuse across the air-sea interface from high to low areas of concentration until chemical equilibrium is attained.
Temperature	A drop in water temperature increases the solubility of gases.
Salinity	A rise in salinity decreases the solubility of gases.
Pressure	A rise in pressure increases the solubility of gases.
Photosynthesis	Increases concentration of O_2; decreases concentration of CO_2.
Respiration	Increases concentration of CO_2; decreases concentration of O_2.
Decomposition	Increases concentration of CO_2; decreases concentration of O_2.
pH	Controls the relative concentrations of the various species of CO_2 in water (H_2CO_3, HCO_3^-, CO_3^{2-}).

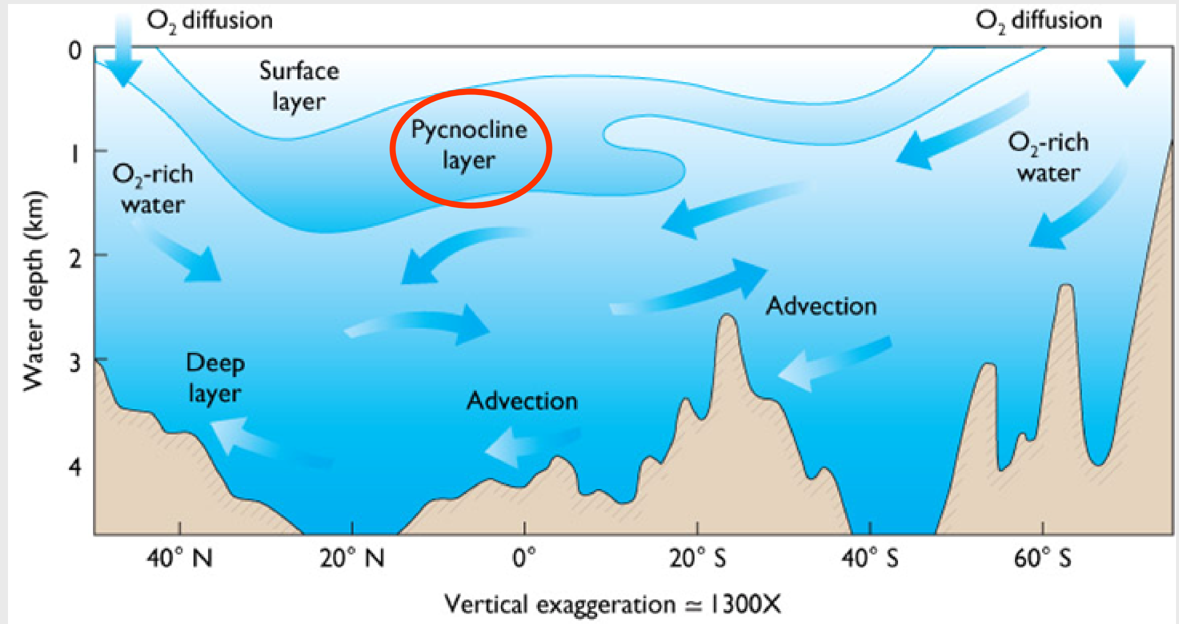
Source: Adapted from H. S. Parker, *Exploring the Oceans* (Englewood Cliffs, N.J.: Prentice-Hall, 1985).





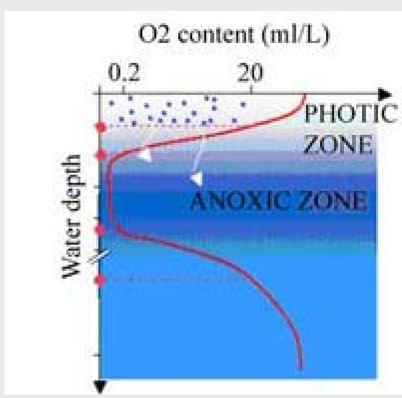
(a) VERTICAL O_2 PROFILES IN THE ATLANTIC OCEAN

?



(b) O_2-ADVECTION PATTERN IN THE ATLANTIC OCEAN

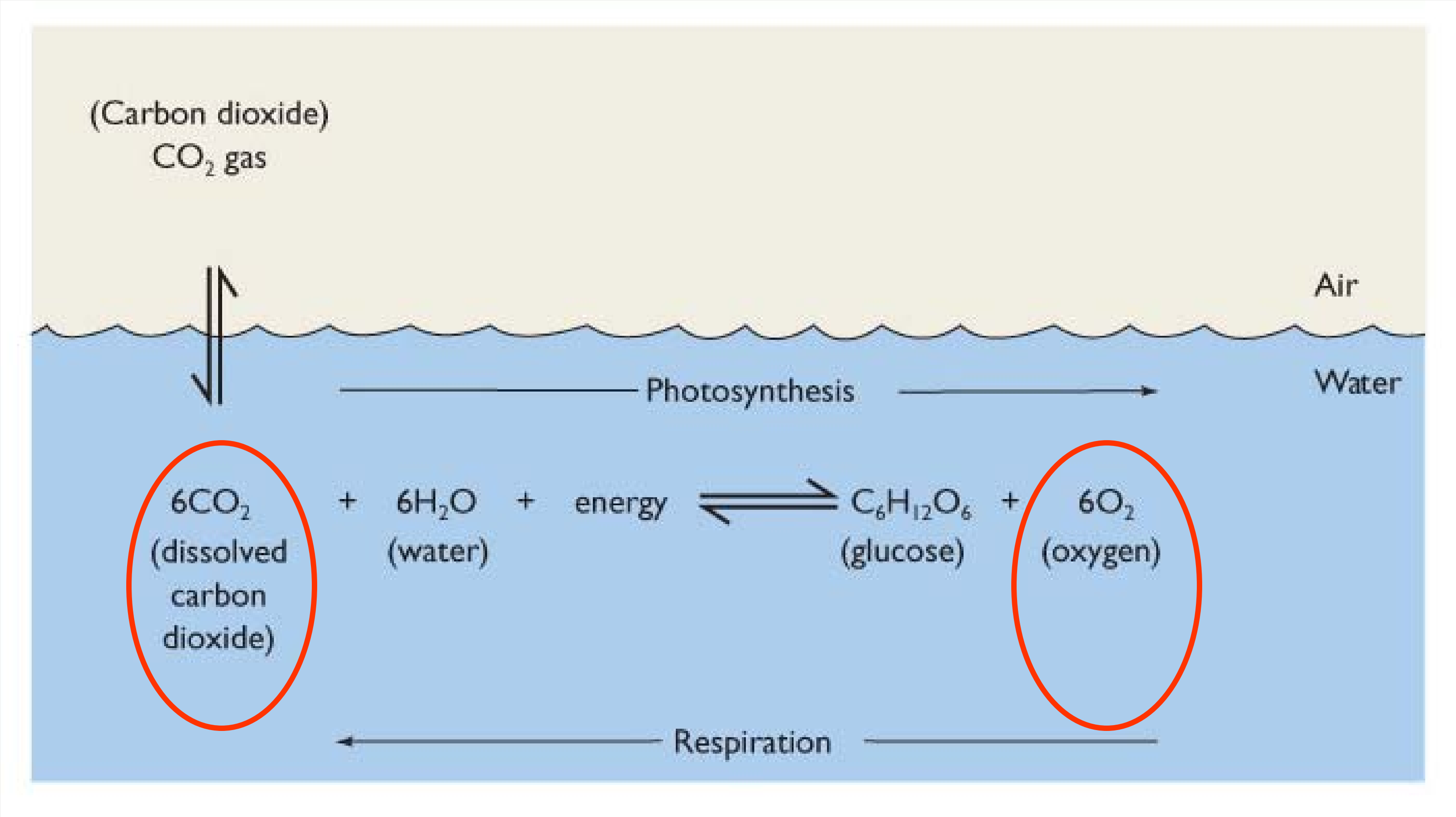
05.17



Phytodetritus sinks

Accumulates at pycnocline

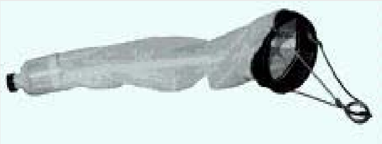
Bacteria respire O_2



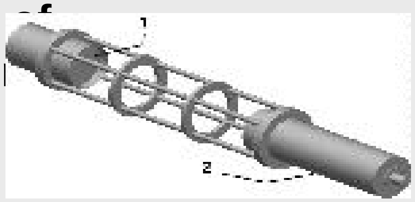
05.19b: Photosynthesis and Respiration.

Phytoplankton: Sampling

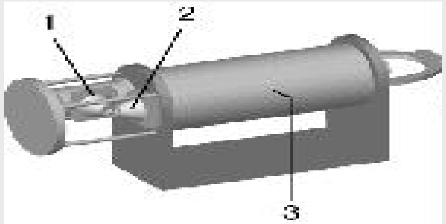
- net sampling
  - -small size of phytoplankton necessitates very fine mesh
  - -very poorly quantitative (clogging)
  - -stress on cells (some burst)
  - -miss smallest cells



- transmissometer - shine a beam of light across a path of water and measure how much light reaches the other
  - -not just phytoplankton blocking light, particularly in coastal waters



- fluorometer - generates light at a given wavelength, which will cause pigments to fluoresce.



Measure chlorophyll fluorescence to estimate phyoplankton conc.

- can be made *in-situ*
- fluorescence varies with different species and conditions
- can be related to carbon, but….
  - Fluor:Chl pigment and
  - Carbon:Chl not constant

Grazing

Production vs. Productivity

Production → Static Estimate

Productivity → Rate

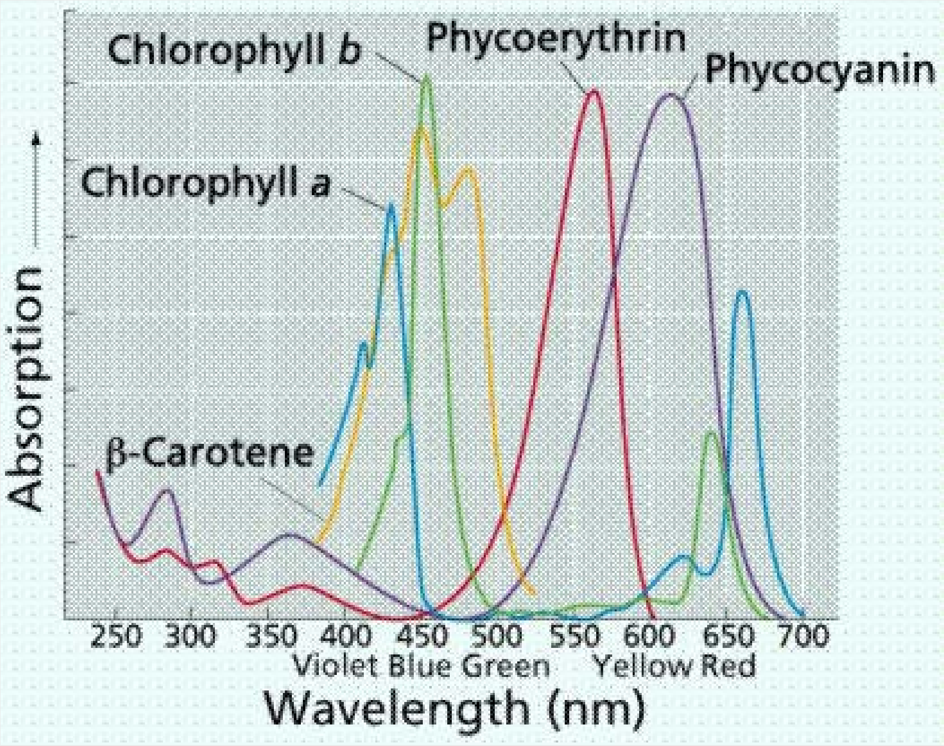
Standing stock
-the number of organisms per unit area or per unit volume of water at the moment of sampling

Biomass
the total weight (total numbers * average weight) of all organisms in a given area or volume

Different pigments absorb different wavelengths of light

Because different species may have different photosynthetic pigments they will thrive under different conditions

pigment - any substance that absorbs light
•color comes from the wavelengths of light reflected (those not absorbed)
•chlorophyll absorbs all visible wavelengths except green (reflected)
•all photosynthetic organisms have chlorophyll a



chlorophylls a, b, c & carotenoids (all groups of algae)

fucoxanthin and peridinin - (diatoms and dinoflagellates)

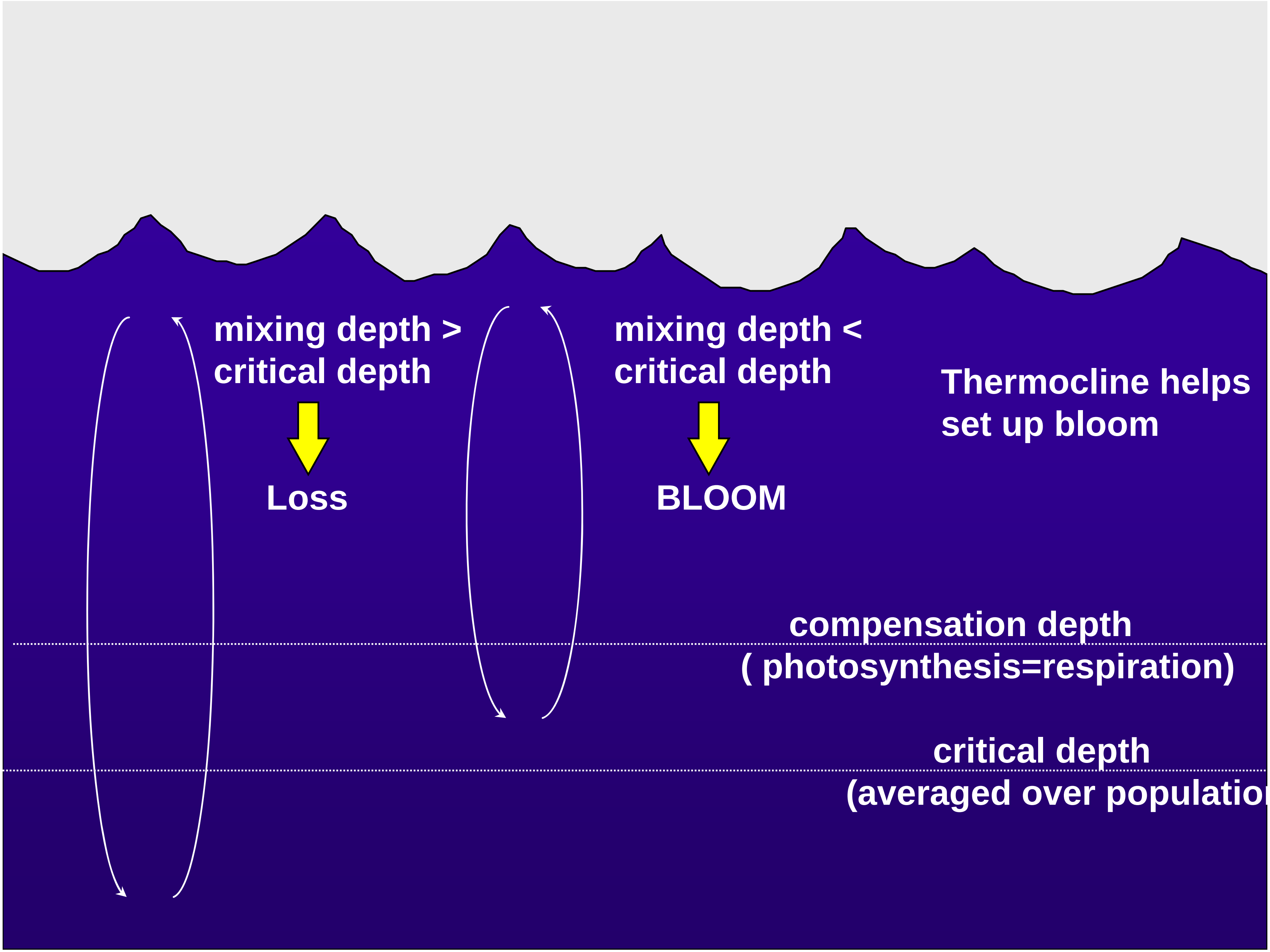
phycoerythrins (red & blue-green algae)

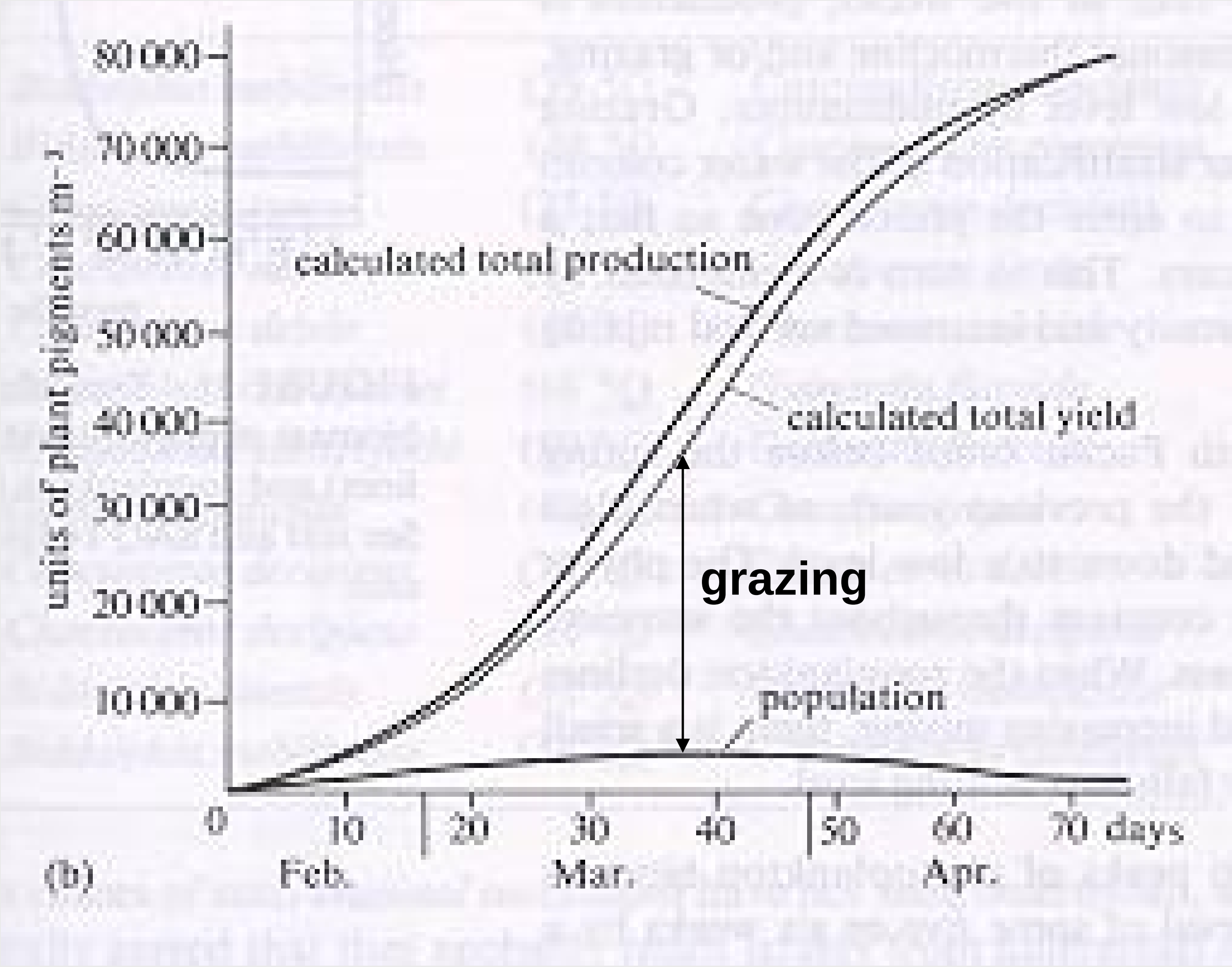
phycocyanin (cyanobacteria)

Relationship between compensation light depth, critical depth, and the depth of mixing...

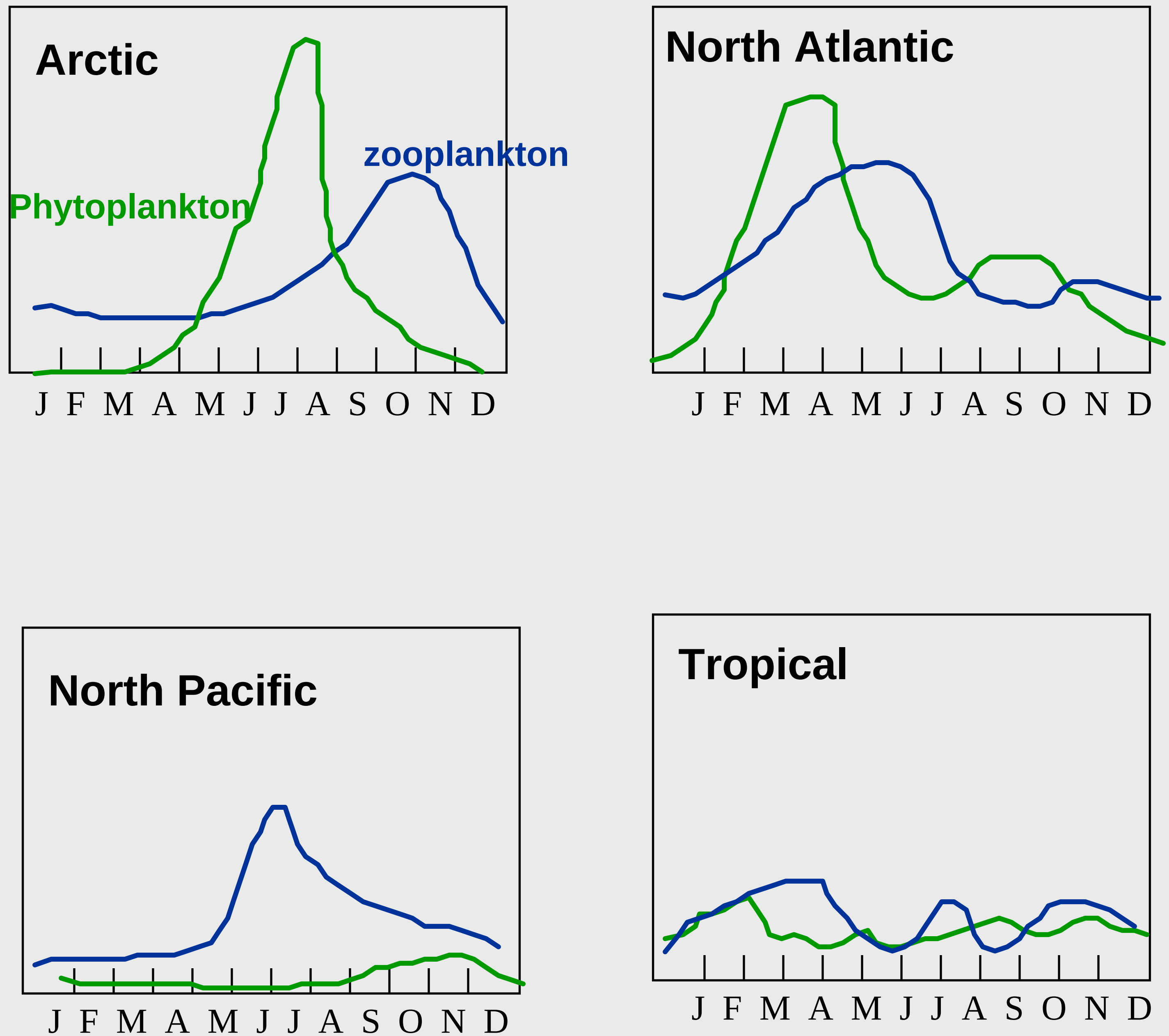
- **compensation depth (D_c) - where the light intensity (I_c) is such that the photosynthesis of a single cell is equal to its respiration**

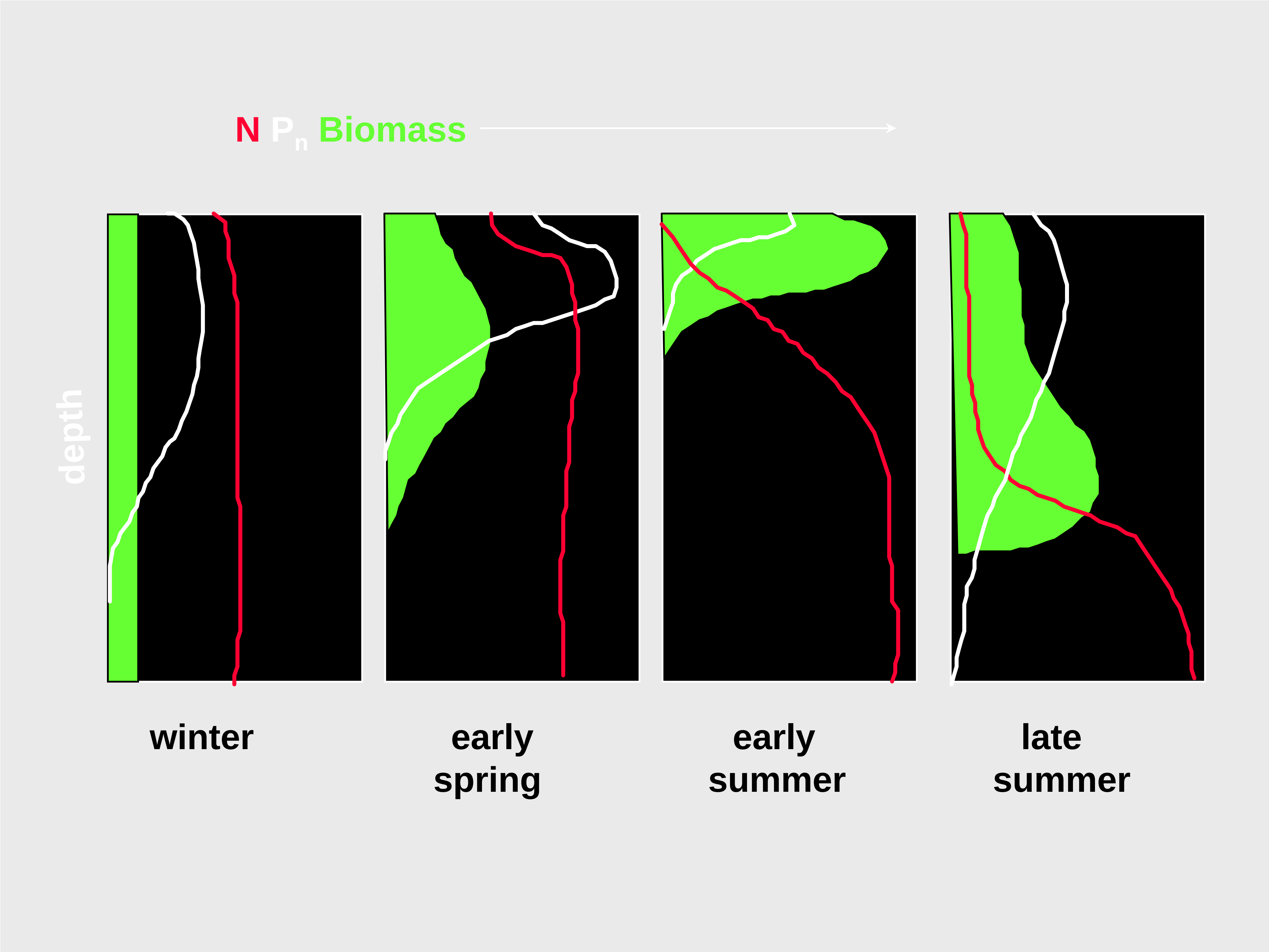
- **critical depth (D_{cr}) - where P throughout the water column is equal to respiration throughout the water column**


mixing depth >
critical depth
Loss
mixing depth <
critical depth
BLOOM
Thermocline helps
set up bloom
compensation depth
(photosynthesis=respiration)
critical depth
(averaged over populatio

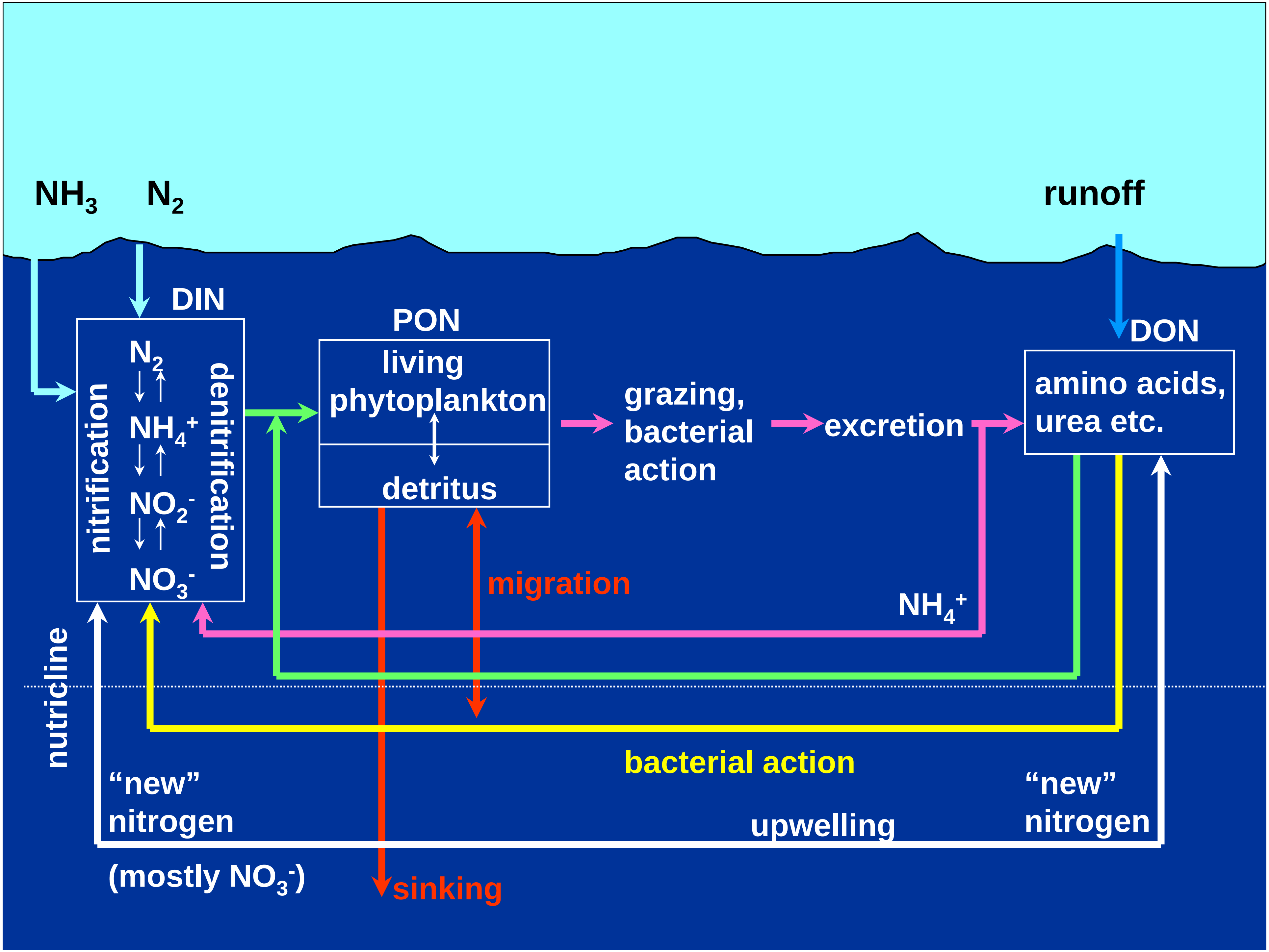


units of plant pigments m⁻²
80 000
70 000
60 000
50 000
40 000
30 000
20 000
10 000
0
10
20
30
40
50
60
70 days
Feb.
Mar.
Apr.
(b)
calculated total production
calculated total yield
grazing
population


Arctic
zooplankton
Phytoplankton
J F M A M J J A S O N D
North Atlantic
J F M A M J J A S O N D
North Pacific
J F M A M J J A S O N D
Tropical
J F M A M J J A S O N D



N P_n Biomass
depth
winter
early spring
early summer
late summer


NH3
N2
runoff
DIN
N2
NH4+
NO2-
NO3-
nitrification
denitrification
PON
living
phytoplankton
detritus
grazing,
bacterial
action
excretion
DON
amino acids,
urea etc.
migration
NH4+
nutricline
bacterial action
"new"
nitrogen
(mostly NO3-)
upwelling
"new"
nitrogen
sinking

Analysis of Biological Data

Hypotheses?

- Phytoplankton linked to thermocline depth
- Phytoplankton linked to wind (mixing)
- Zooplankton linked to wind (mixing)
- Zooplankton linked to bottom depth

•Bivariate correlation (e.g. zooplankton numbers and mixed depth

•Exploratory graphs

•Regression…is any environmental parameter a good predictor of numbers?...totals, major taxa, species richness

- •But perhaps relationship is non linear?

- •Maybe multiple variables are important


Many species
Few species

Two components of diversity….

Species Richness

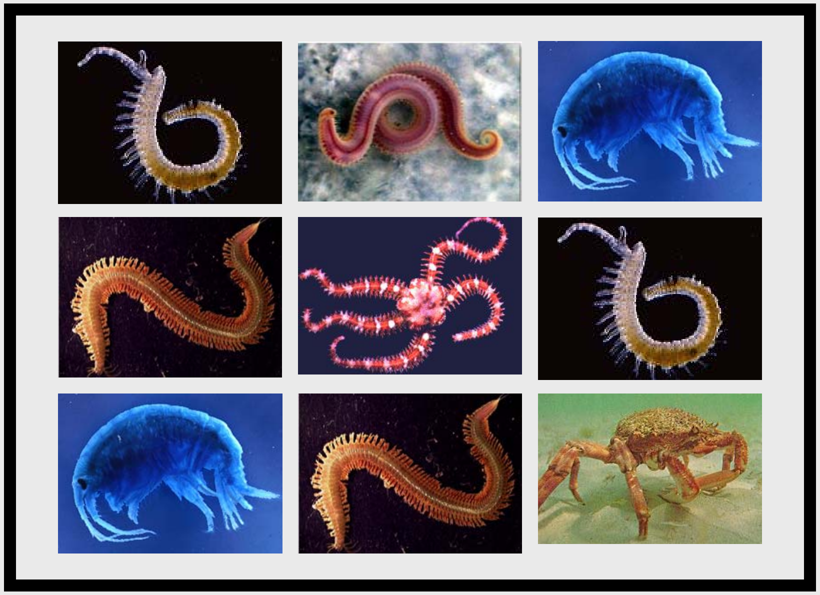
-some measure of how many species are present

Evenness (equitability)

-a measure of how equitably individuals are apportioned among the species that are present

Species Richness Indices

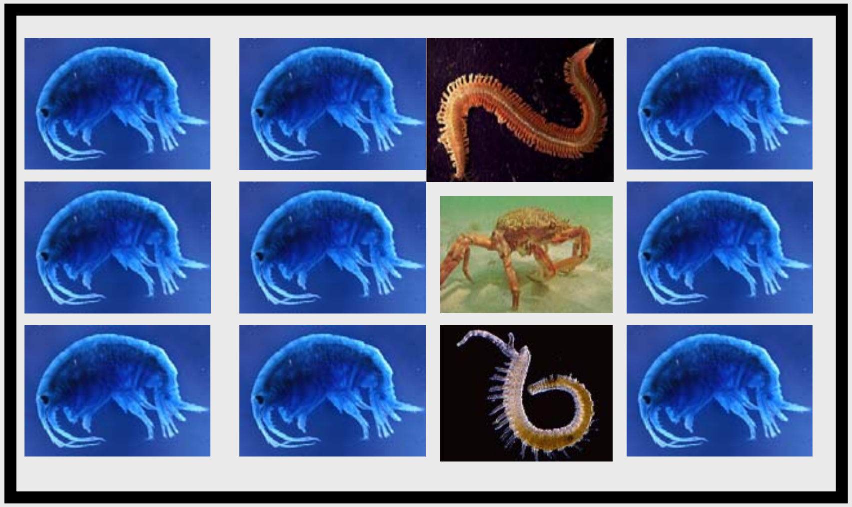
- number of species per unit area
-total species count
-number of species / x individuals



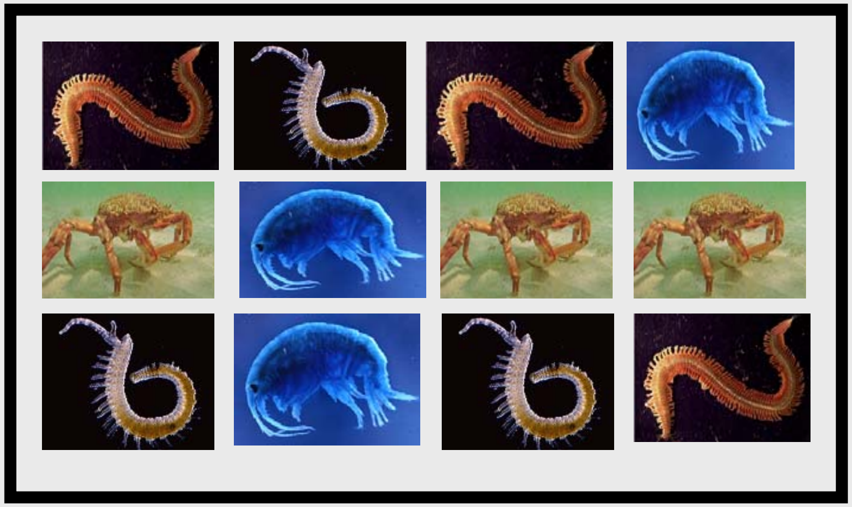
7 species

1 species

Evenness - equitability with which individuals are apportioned among species

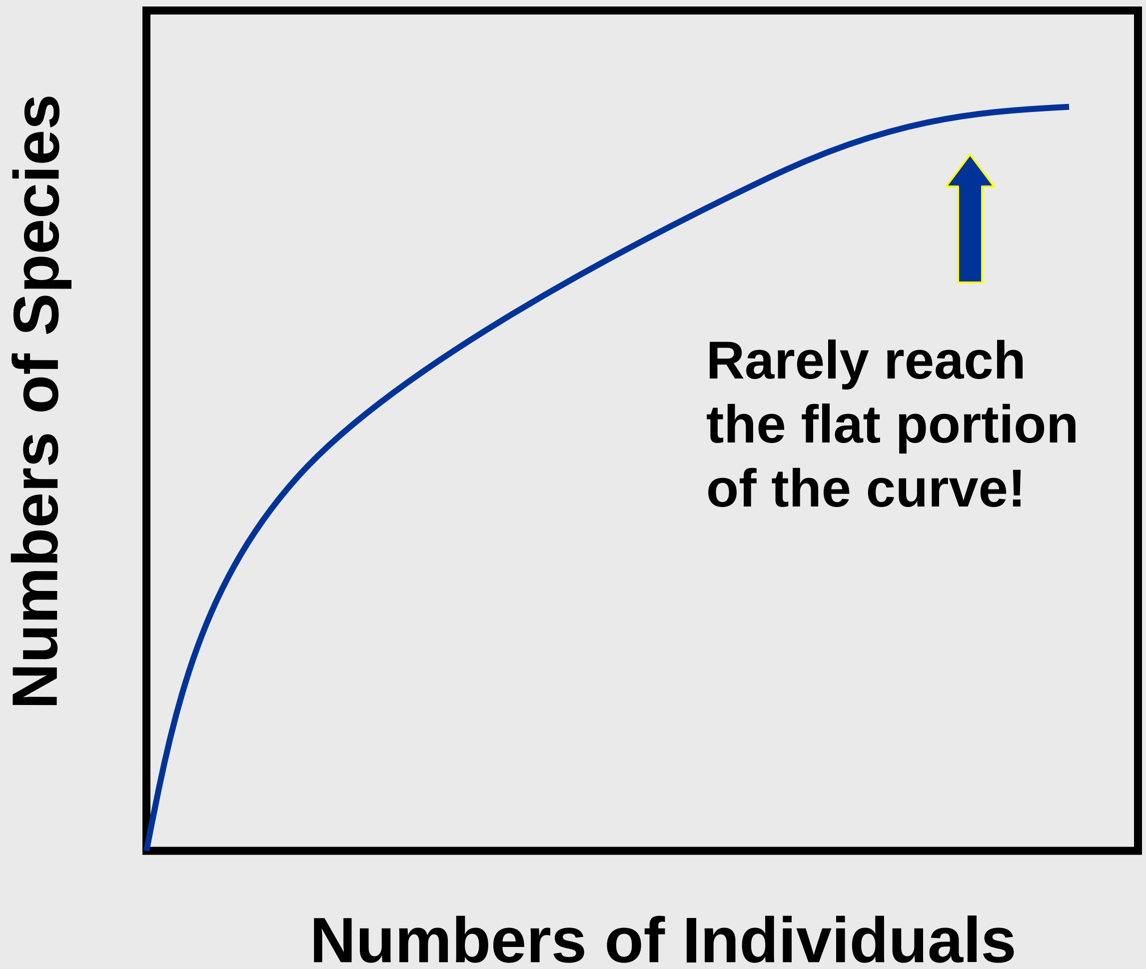


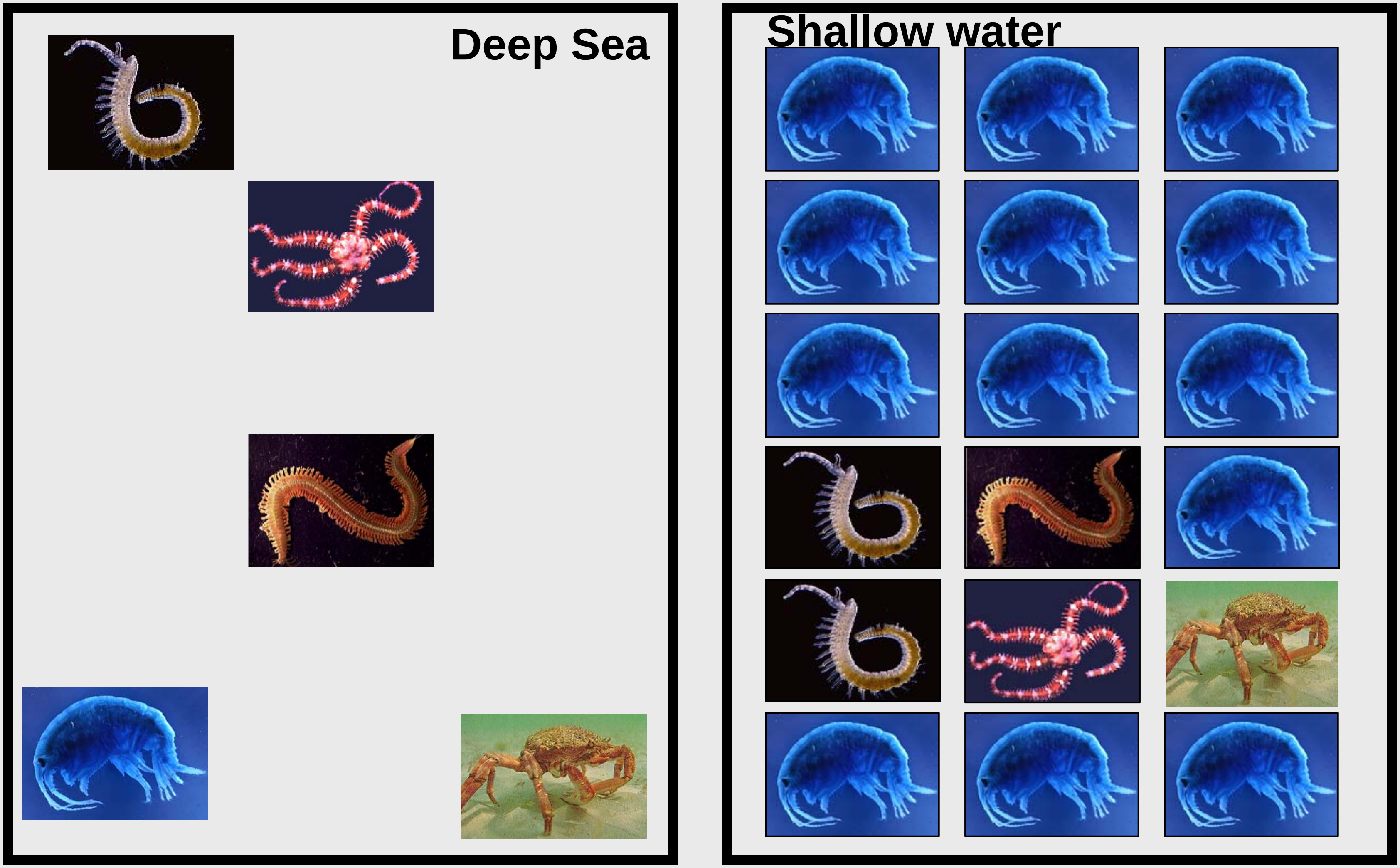
4 species



4 species

The problem with species richness...



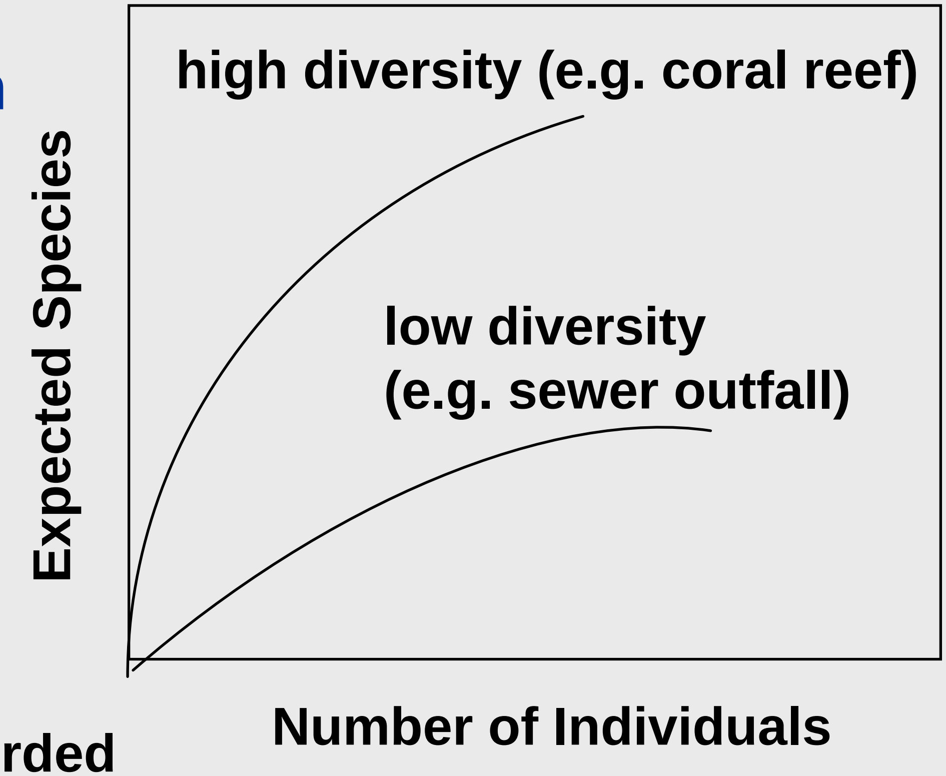


5 species **5 species**

Have you sampled the same numbers of individuals?
(May reflect sampling effort or differences in densities)

Hurlbert Rarefaction

$$E(S) = \sum \left\{ 1 - \left[\binom{N - N_i}{n} \Big/ \binom{N}{n} \right] \right\}$$



n = standardized sample size
N = total # of individuals recorded
N_i = # of individuals of the ith species

Intuitive explanation -
- Draw subsamples of different numbers of individuals
- On average, how many species does each subsample have? (based on how individuals are apportioned among species)
- Do this for many *n*'s and you get a curve - better than one number

Indices Based on Proportional Abundances of Species

Shannon-Weiner Index

$$H' = \sum p_i \ln p_i$$

RICHNESS VERY IMPORTANT

P_i = proportion of individuals found in the ith species

Evenness

Based on Shannon-Weiner...

$$E = H' / H_{max} = H' / \ln S$$

(sometimes expressed as *J'*)

Dominance Measures

Simpson's Index

$$D = \Sigma p_i^2$$

$$D = \Sigma \left(\frac{n_i (n_i - 1)}{N (N-1)} \right)$$

Diversity decrease corresponds to D increase…index often expressed as 1-D or 1/D

Dominance (equitability) is important

Why bias towards evenness or richness?

Dominance

Comparing different communities

Richness

Conservation of biodiversity

Emphasis on rare species

How to compare biological samples

in terms of similarity?

Similarity…how similar are two samples?

There are many different measures but a couple are good and commonly used.

1. **Bray-Curtis**

$$\delta_{jk} = \frac{\sum_{I=1}^{s} |Y_{jk} - Y_{jk}|}{\sum_{I=1}^{s} |Y_{jk} + Y_{jk}|}$$

Y_{ik}= score of the ith species in the jth sample

Y_{jk}= score of the ith species in the kth sample

δ_{jk}= dissimilarity of jth and kth samples

Good because it is unaffected by joint absences but gives greater weight to abundant species than rare ones.

Classification

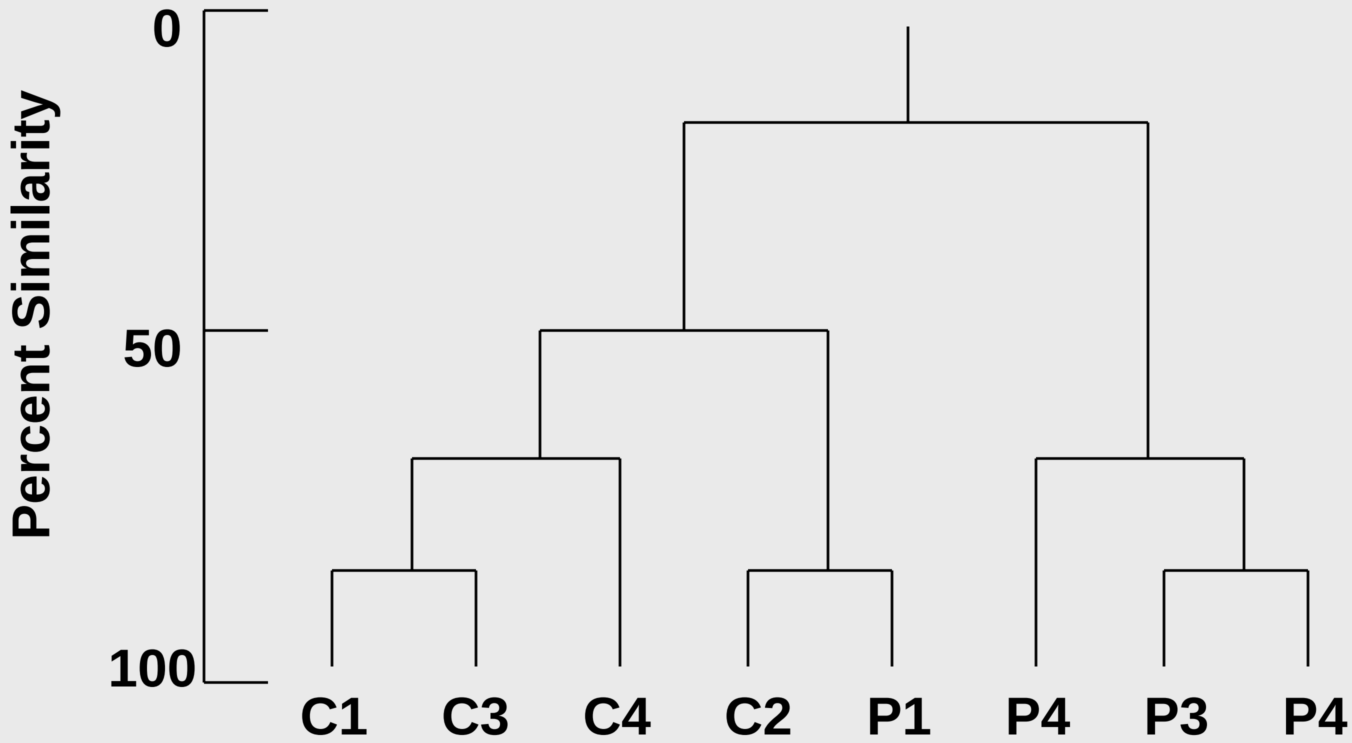
The assignment of entities (samples for example) into classes or groups

-hierarchical or non-hierarchical

-hierarchical, group-average sorting popular, effective

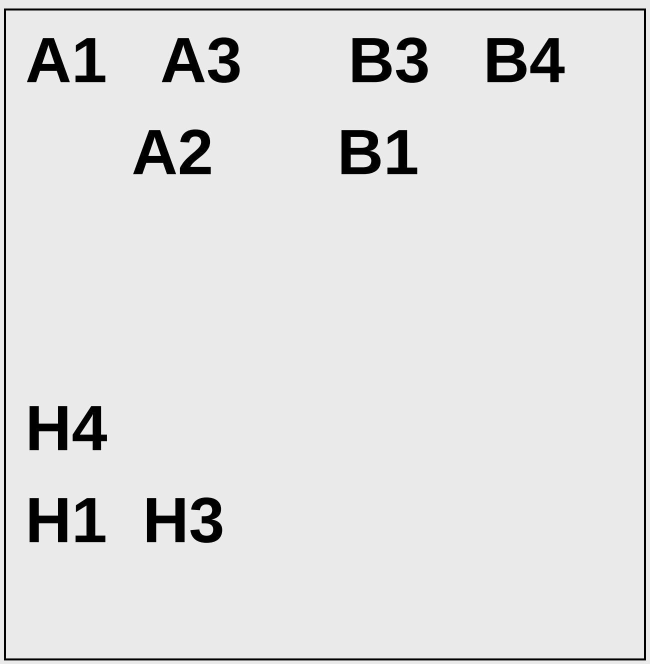
-dendrograms commonly used

-simple clustering of samples into groups



Data Analysis: a hypothetical example

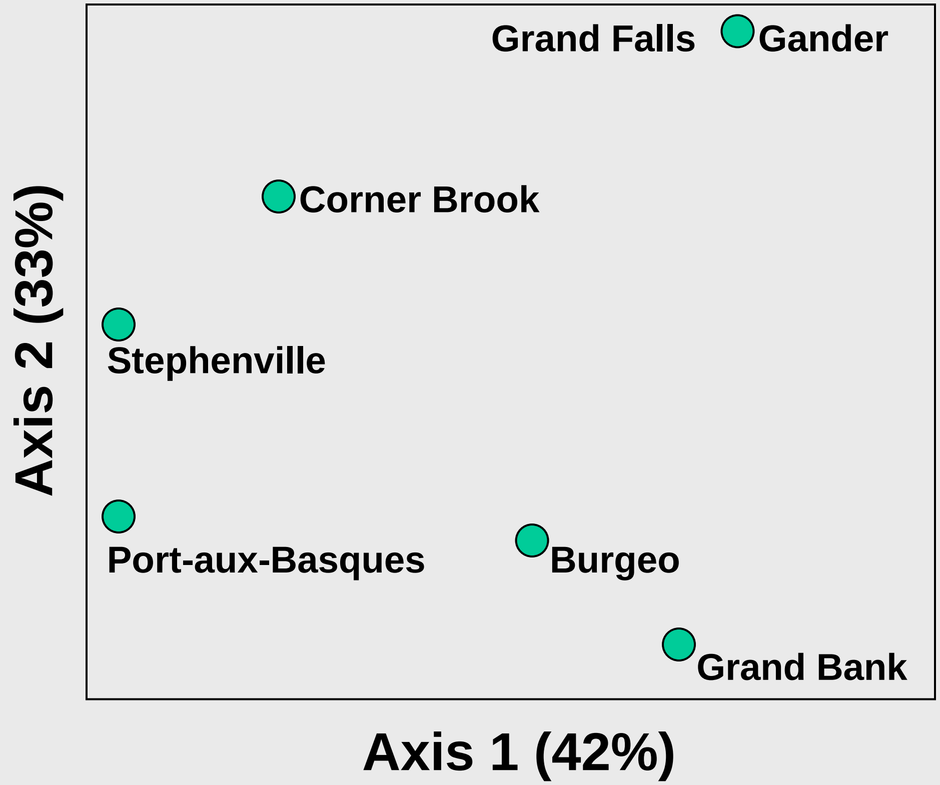
- MDS (multi-dimensional scaling): maps samples based on similarity (or dissimilarity)
- short distances between samples indicate similarity
- large distances indicate that samples are very different



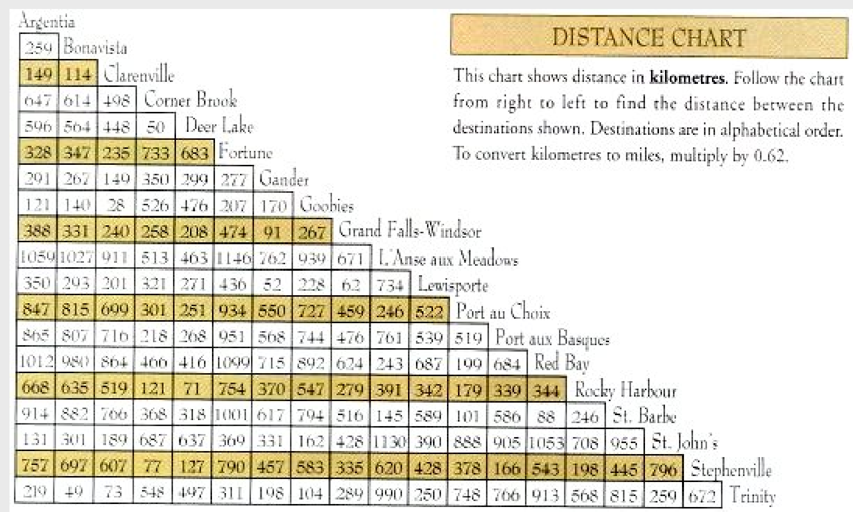
– uses the same similarity matrix

– similar approach but provides two (or more) dimensional detail

–can show gradients



Dissimilarity matrix



DISTANCE CHART

This chart shows distance in **kilometres.** Follow the chart from right to left to find the distance between the destinations shown. Destinations are in alphabetical order. To convert kilometres to miles, multiply by 0.62.

Argentia																		
259	Bonavista																	
149	114	Clarenville																
647	614	498	Corner Brook															
596	564	448	50	Deer Lake														
328	347	235	733	683	Fortune													
291	267	149	350	299	277	Gander												
121	140	28	526	476	207	170	Goobies											
388	331	240	258	208	474	91	267	Grand Falls-Windsor										
1059	1027	911	513	463	1146	762	939	671	L'Anse aux Meadows									
350	293	201	321	271	436	52	228	62	734	Lewisporte								
847	815	699	301	251	934	550	727	459	246	522	Port au Choix							
865	807	716	218	268	951	568	744	476	761	539	519	Port aux Basques						
1012	980	864	466	416	1099	715	892	624	243	687	199	684	Red Bay					
668	635	519	121	71	754	370	547	279	391	342	179	339	344	Rocky Harbour				
914	882	766	368	318	1001	617	794	516	145	589	101	586	88	246	St. Barbe			
131	301	189	687	637	369	331	162	428	1130	390	888	905	1053	708	955	St. John's		
757	697	607	77	127	790	457	583	335	620	428	378	166	543	198	445	796	Stephenville	
219	49	73	548	497	311	198	104	289	990	250	748	766	913	568	815	259	672	Trinity

Data Analysis: a hypothetical example

- **summarized (biological) distribution patterns using classification (cluster analysis) and ordination (MDS)**

↓

- **what species are important in causing these observed patterns?**

- **Principal Components Analysis or Factor Analysis of environmental data**
  - **Need to standardize data**