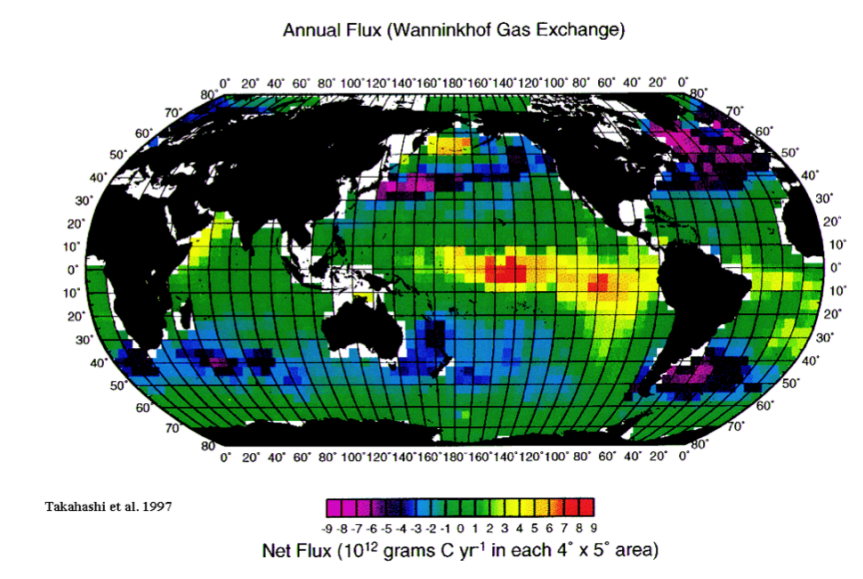
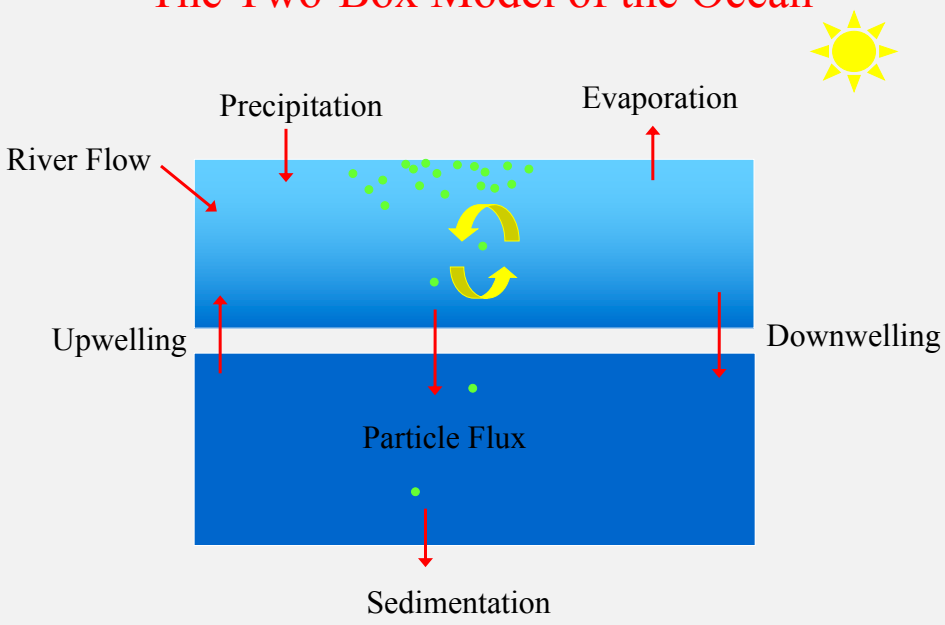


SeaWiFS website: NFS/NASA

The Two-Box Model of the Ocean



Decomposition/breakdown of organic C

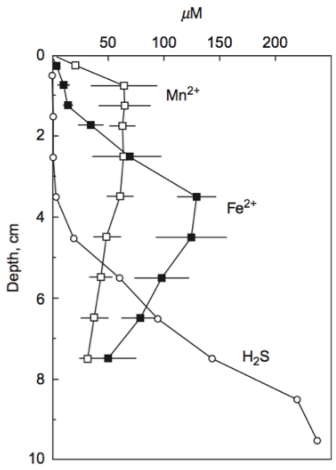


FIGURE 9.10 Pore water distribution of Mn^{2+}, Fe^{2+}, and H_2S in coastal sediments of Denmark, showing the approximate depth of Mn-reduction, Fe-reduction, and SO_4-reduction, respectively. *Source: From Thamdrup et al. (1994).*

Cycling of inorganic carbon (carbonate)

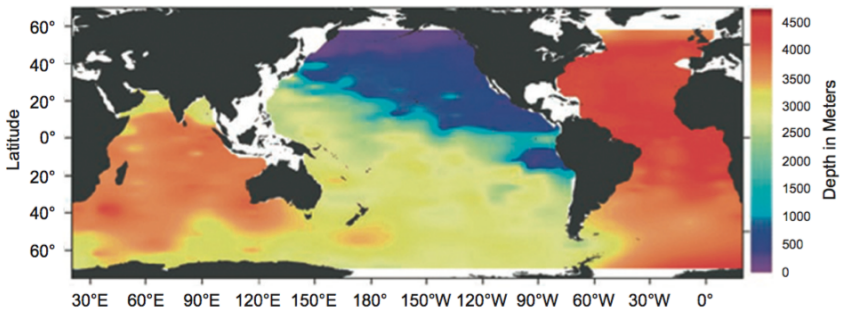
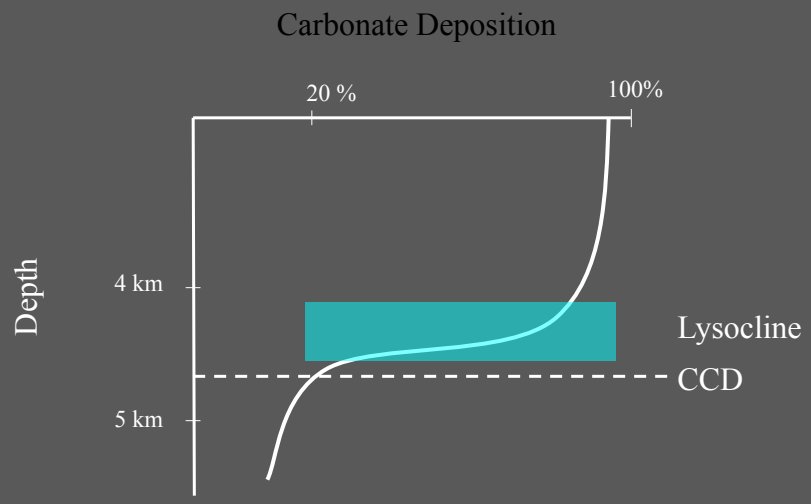


FIGURE 9.14 Calcite saturation depth in the world's oceans. *Source: Feely et al. (2004). Used with permission of the American Association for the Advancement of Science.*

Lysocline and CCD (a cartoon)



Actual data…

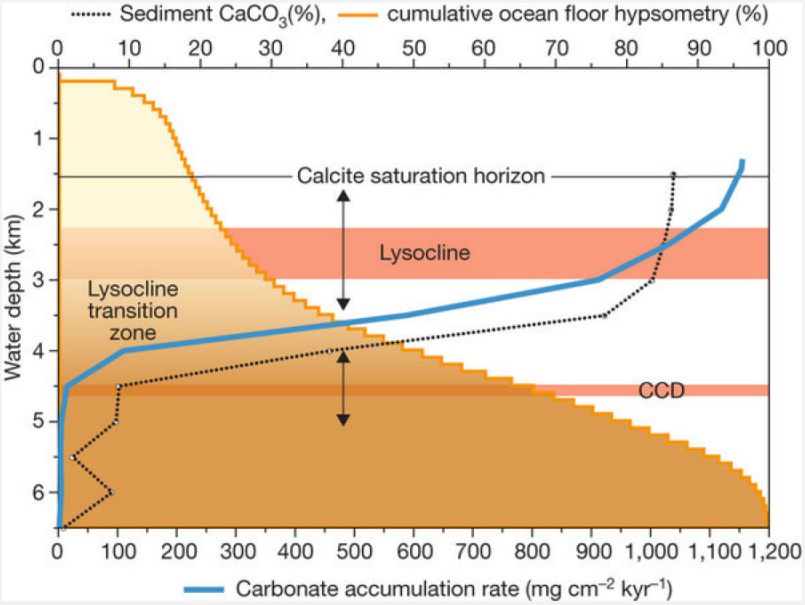
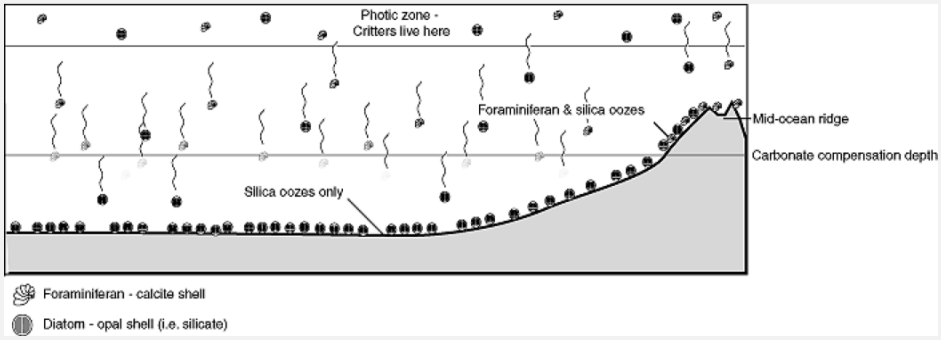


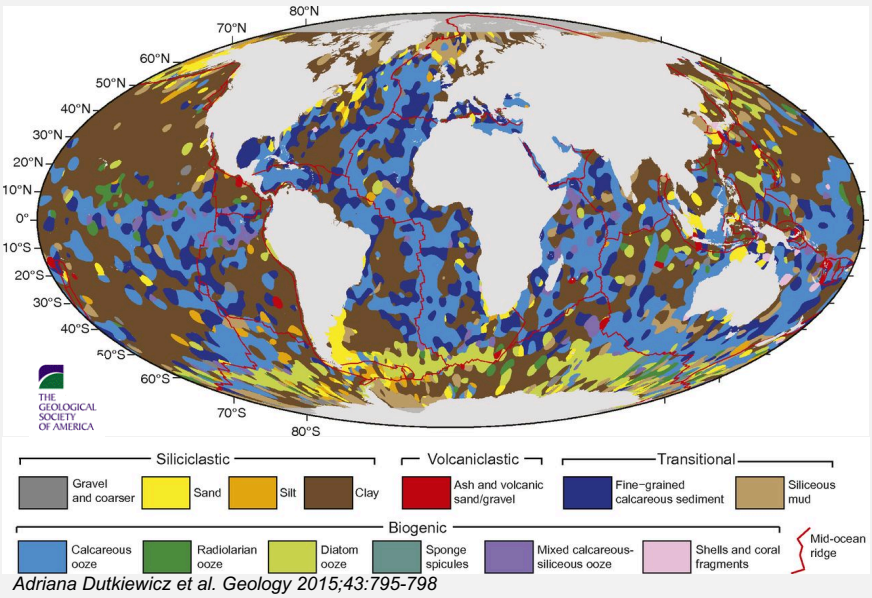
Image by Pälike et al. (2012)
http://www.nature.com/nature/journal/v488/n7413/full/nature113

What happens below the CCD?



http://www.geol.umd.edu/~jmerck/geol100/lectures/31.html

Digital map of major lithologies of seafloor sediments in world's ocean basins.



Adriana Dutkiewicz et al. Geology 2015;43:795-798

Depth Profiles of N and P

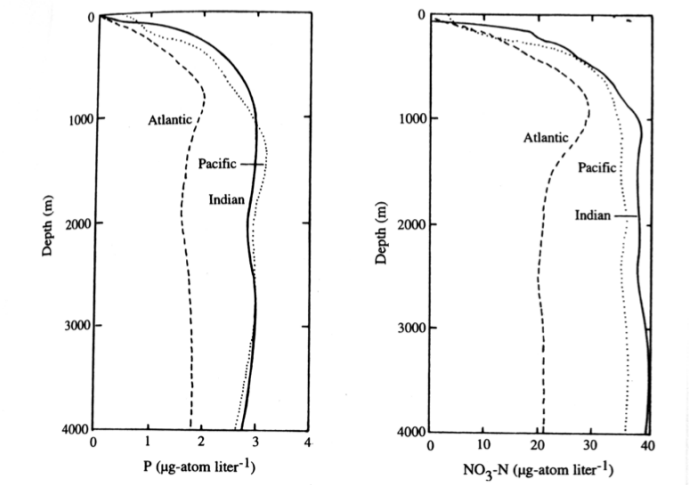


Figure 9.12 Vertical distribution of phosphate and nitrate in the world's oceans. From Svedrup et al. (1942).

The Redfield Ratio (Redfield, 1958)

ATOMIC RATIOS OF ELEMENTS IN THE BIOCHEMICAL CYCLE

	P	*N*	*C*	*O*
Analyses of plankton	1	16	106	−276
Changes in sea water	1	15	105	−235
Available in sea water	1	15	1000	200–300

A Garrels & Lerman style reaction…

$$106CO_2 + 16NO_3^- + HPO_4^{2-} + 122H_2O + 18H^+ \leftrightarrow (CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 138\ O_2\uparrow$$

But with inorganic C in excess...

Recycling of nutrients

Redfield, 1958

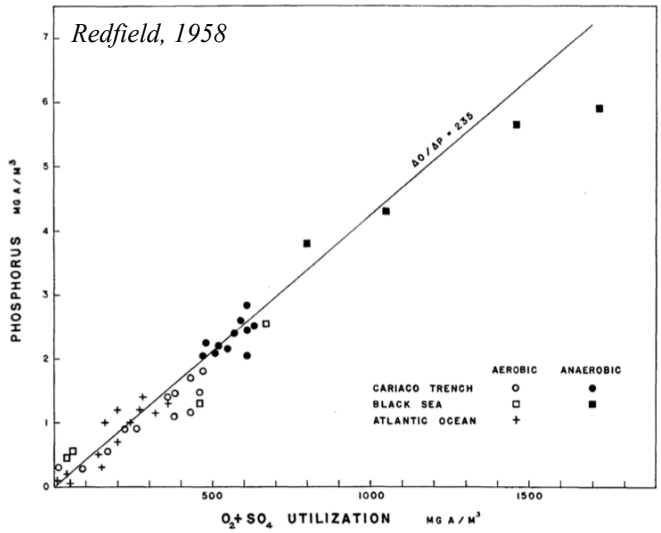


FIG. 2. Relation between the inorganic phosphorus and the combined utilization of oxygen and sulfate in waters of Cariaco Trench, Black Sea, and western Atlantic Ocean. After Richards and Vaccaro [3].

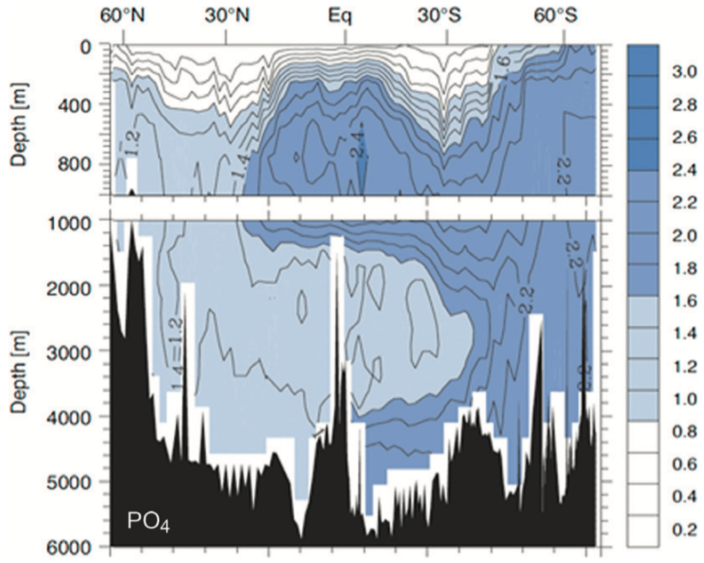
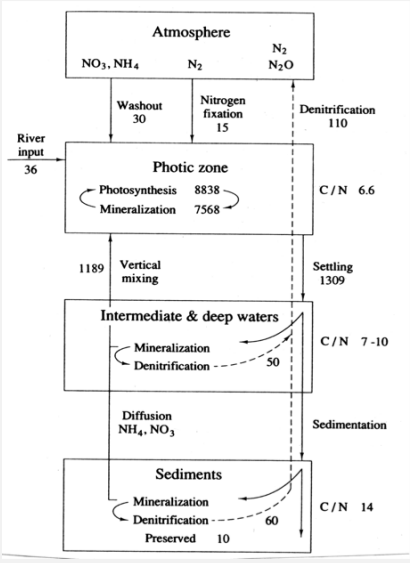


FIGURE 9.19 Phosphorus in the Atlantic Ocean, showing the increase in its concentration in deep waters as they travel from north to south. *Source: From Sarmiento and Gruber (2006). Used with permission of Princeton University Press.*

Nitrogen Cycling

- Complex because of oxidation states
- Bacterially mediated transfers require anoxic environment or microenvironment
- N-Fixation limited by SO_4
- Gaseous species lost to atmosphere
- Anthropogenic inputs
- New vs. Recycled Nitrogen



Recycling of nutrients

TABLE 9.3 Calculation of the Sources of Nutrients That Would Sustain a Global Net Primary Productivity of 50 × 10^{15} g C/yr in the Surface Waters of the Oceans

Flux	Carbon (10^{12} g)	Nitrogen (10^{12} g)	Phosphorus (10^{12} g)
New primary production[a]	50,000	8800	1200
Amounts supplied			
By rivers[b]		50	2
By atmospheric deposition[c]		67	1
By N fixation[d]		150	—
By upwelling		700	100
Recycling (by difference)		7800	1100

Note: Values taken from Figures 9.21 and 9.22, with rounding. Based on an approach developed by Peterson (1981).
[a] *Assuming a Redfield atom ratio of 106:16:1.*
[b] *N from Galloway et al. (2004); P from Meybeck (1982).*
[c] *Duce et al. (2008).*
[d] *Deutsch et al. (2007).*

Other nutrient-like elements

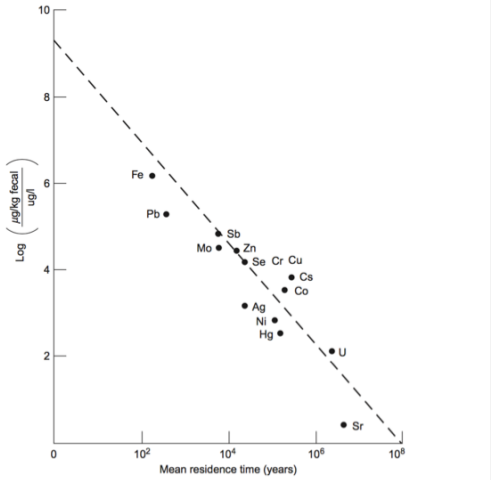


FIGURE 9.25 The ratio between the concentration of an element in sinking fecal pellets (μg/kg) and its concentration in seawater (μg/l), plotted as a function of its mean residence time in the ocean. *Source: From Cherry et al. (1978). Reprinted with permission from* Nature, *copyright 1978 Macmillan Magazines Limited.*