## 19. Detritis - Particulate Organic Carbon (POC) and Dissolved Organic Carbon (DOC)

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### Background/Data Sources

Organic carbon bound in a dissolved form (DOC) represents the largest pool of organic matter in the ocean, exceeding standing stocks of particulate organic carbon (POC) and phytoplankton carbon by approximately one and two orders of magnitude, respectively. For example, Kepkay (2000) partitioned the carbon pools for the world ocean (in Gt C) as: DOC (200-700); POC (20); phytoplankton (1-11); and other biota (0.4). He further partitioned the DOC pool into a refractory low molecular weight component (120-630) and a bioavailable colloidal component (20-280). The combined DOC + POC is often referred to as "detritus" and represents a major source of carbon for the microbial food web.

In oceanic waters, the concentration of DOC generally decreases with depth from the surface to the level of the seasonal or permanent thermocline. In the MAB, Vlahos *et al.* (2002) and Del Vecchio and Blough (2004) found that DOC concentrations generally decreased from the coast to the shelf break.

### Quantitative Approach for Estimates

Our estimation of the standing stocks of DOC is based on two steps. The first involves the construction of a generalized vertical profile of DOC, using the data from Guo *et al.* (1985) supplemented by near surface measurements of DOC made by Aluwihare *et al.* (1997) and by Vlahos *et al.* (2002). The second step involves the vertical integration of our generalized DOC profile from surface to bottom, using high resolution bathymetry data (1 km).

Guo *et al.* (1985) measured the vertical profile of DOC at a station in the MAB southeast of Chesapeake Bay during May 1993 (Figure 19.1). We have redrawn the data from Guo and Santschi in Figure 19.2 and show our estimates of DOC concentrations for sampling depths between 25 m and 2,500 m below the surface.

Aluwihare *et al.* (1997) measured DOC in surface waters of the MAB, on Georges Bank, and near shore waters near Woods Hole, MA (Figure 19.3). The mean DOC measured in these seven surface samples is 97.0 µM C.

Kepkay (2000) reported that DOC concentrations for the MAB ranged between 45 and 102 µM C. Vlahos *et al.* (2002) measured DOC in the MAB during surveys in April 1994, March 1996 and August 1996 (Figure 19.4) and reported that DOC concentrations ranged from 60 to 165 µM C in surface waters and converged to 49 µM C at depths below 200 m. The mean DOC in 137 samples from the upper 10 meters of the water column is 97.0 µM C, based on Table 3 in Vlahos *et al.* (2002). From these two studies, we assume a value of 97 µM C represents a typical DOC concentration in surface water in our region. Our generalized vertical profile of DOC is illustrated in Figure 19.5.

The standing stocks of DOC were estimated for each region by combining the generalized DOC profile with a highly resolved map of bottom depth for the ecosystem (developed from the SRTM30 Plus bathymetry data set of Becker and Sandwell 2004). A frequency distribution of bottom depths was constructed for each region at a resolution of 1 meter and a spatial resolution of 1.25 x 1.25 km per pixel. (For the purpose of illustrating the bathymetric differences among the four regions, a less resolved frequency distribution is shown in Figure 19.6.). For each bottom depth interval in increments of 1 meter, the generalized DOC profile was integrated from surface to bottom depth and these results were summed to yield the total and mean DOC concentration for each region (Table 19.1).

**Results**

Our estimate of average standing stocks of DOC in the MAB (44.5 g C $m^{-2}$) is in good agreement with the mean value 43.9 g C $m^{-2}$ which we computed from the MAB shelf surveys reported by Vlahos *et al.* (2002; their Table 1).

Our estimates of particulate organic carbon (POC) standing stocks for the GOM (8.1 g C $m^{-2}$) assume an approximate 15:1 ratio between DOC and POC (Millero 1996; Kepkay 2000; Ogawa 2000). If we also apply a 5:1 ratio for POC:planktonic C ratio (Volkman and Tanoue 2002; Valiela 1995), then our estimated ratio of DOC:POC:Phytoplankton Carbon is 75:5:1, compared to the traditional oceanic water assumption of 100:10:1 (Parsons *et al.* 1984). The modern perspective on this ratio suggests that continental shelf waters are proportionally richer in POC and phytoplankton carbon than the oceanic water column, since coastal waters receive nutrient inputs from coastal land use which increases the rate of primary production and also receive inputs of POC from estuaries/bays. The planktonic carbon based on this simple proportionality scheme is 1.61 g C $m^{-2}$. This value is somewhat lower than our estimate of 2.01 g C $m^{-2}$ for phytoplankton biomass derived from water column integrated chlorophyll concentrations (see in this document Section 2: Phytoplankton and Primary Production).

Given the operational separation of POC and DOC by filtration on glass fiber filters (nominal pore size 0.7 µm), a portion of the POC is living, while there are small particles (viruses and some bacteria) in the "dissolved" DOC fraction. Some biological oceanographers analyze either ATP (adenosine triphosphate) or chlorophyll *a* and its degradation products (pheaophytin or phaeophorbide) to estimate the living portion of POC. For example, off the California coast, the living fraction of POC varies from 14% to 79% in the upper 100 meters of the water column, decreasing to 6% at intermediate depths and below 3% at 500 to 1,000 meters below surface. Direct chemical composition of POC suggests that it is primarily carbohydrate and protein with small amounts of fat (Parsons *et al.* 1984). The water-soluble carbohydrate fraction disappears between 50 and 300 m, so that below 300-1000 m only the water-insoluble fraction persists. A variable fraction of the particulate detritus is calcium carbonate which can be mistaken for the non-living organic carbon component of POC (Parsons *et al.* 1984). The chemical and biological degradation of POC tends to decrease with depth (becomes more refractory). Bacteria and protozoa colonize some of these particles and their enzymatic activities convert POC to DOC. This colonization by microbes increases the nutritional value of POC for vertebrate/invertebrate detritivores.

In EMAX we assumed that 10% of the net primary production (Pnet) was exported out of the mixed layer and transferred to the detritus compartment (noted as an assimilation efficiency of 90% in the EMAX spreadsheet). Cebrian (2002) utilized a value of 17% for the export of primary production out of the mixed layer. Net primary production is conventionally divided into recycled production (based on using ammonia) and new production (based on nitrate). In theory the new production in the euphotic zone is balanced by export production out of the mixed layer. The export ratio (ef) values range between 0.25 and 0.5 (Falkowski *et al.* 2003; Muller-Karger *et al.* 2005). A number of models have been developed to relate net production, temperature and/or depth to the ef value (Falkowski *et al.* 2003; Muller-Karger *et al.* 2005). We do not know how much of the Pnet value estimated from ocean color satellite measurements is new versus recycled production, so we assumed that export was 15% of Pnet.

The DOC node was not explicitly incorporated as a food source for the microbial loop in the EMAX network given the uncertainty on its bioavailability to bacteria and microzooplankton (see discussion in those chapters). The POC node inputs include: phytoplankton dissolved production; phytoplankton that sediments out of the euphotic zone; and the detritus produced by egestion from each living node (since the assimilation efficiency is less than 100% of the consumption). The output from the POC node is consumed by bacteria, microzooplankton, mesozooplankton and various other larger benthic/pelagic filter feeders (see diet matrix in spread sheets). The microbial loop increases the efficiency of the grazing food chain by recycling the DOC excreted by phytoplankton and the POC egested from other nodes and linking it back to the grazing food chain through the use of POC as a food source. This recycled carbon passes through the indirect flow pathways in network models with the consequence that at the higher trophic levels (fish and marine mammals) much of the carbon received is via indirect pathways. This tendency is reflected in the recycling index parameter. The recycled carbon from the lower trophic levels allows the marine food web to be longer (more trophic levels) than that in lakes/estuaries. This is reflected to a degree in the average trophic level parameter for each node.

## References


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Table 19.1. Average standing stocks of DOC for the MAB, SNE, GB and GOM ecoregions.

| REGION | AREA ($m^2$) | DOC (g $region^{-1}$) | Avg. DOC (g C $m^{-2}$) |
|---|---|---|---|
| MAB | 5.73E+10 | 2.55E+12 | 44.5 |
| SNE | 6.46E+10 | 3.83E+12 | 59.2 |
| GB | 4.43E+10 | 3.29E+12 | 74.4 |
| GOM | 7.92E+10 | 9.66E+12 | 121.9 |


Figure 19.1. Location of station where Guo and Santschi (1997) measured the vertical profile of DOC.

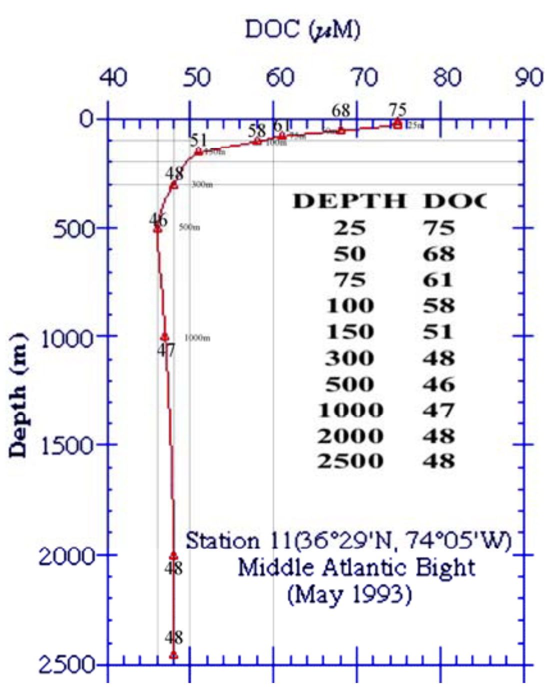


Figure 19.2. Vertical profile of DOC measured in the MAB, redrawn from Guo *et al.* (1995), showing our estimates of depth and DOC derived from the graph.

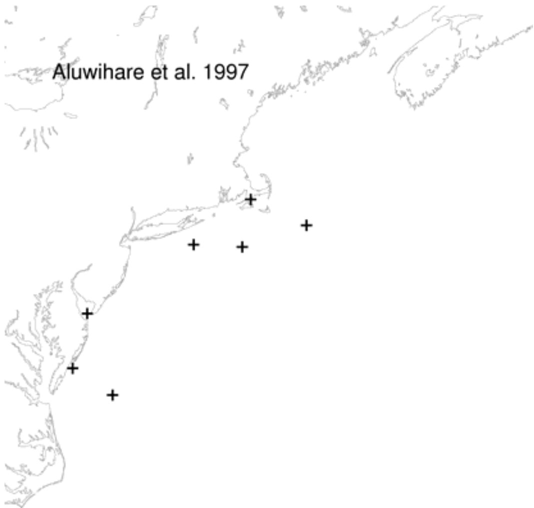


Figure 19.3. Sampling locations for DOC measurements made by Aluwihare *et al.* 1997.

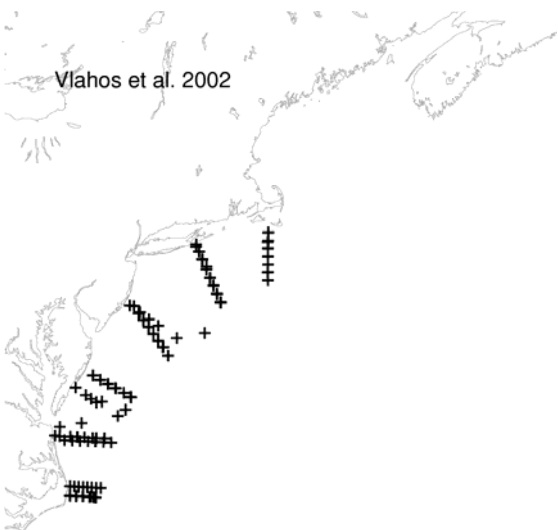


Figure 19.4. Sampling locations for DOC measurements made by Vlahos *et al.* 2002.

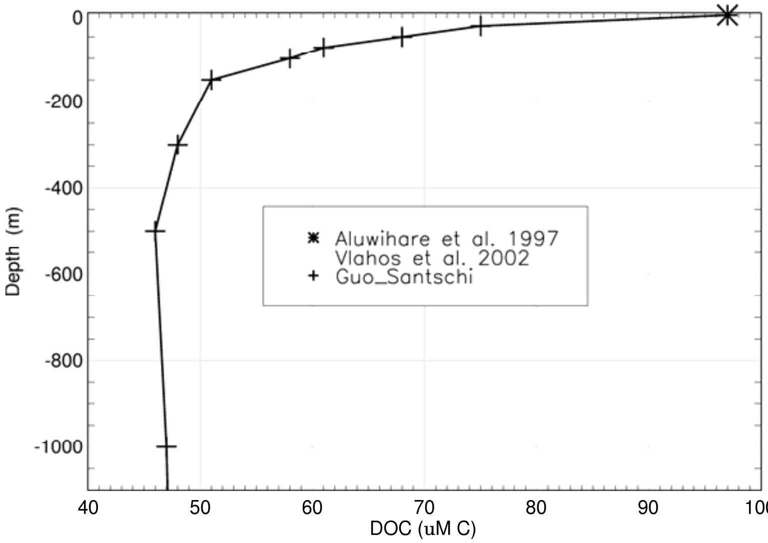


Figure 19.5. Generalized vertical profile of DOC concentration.

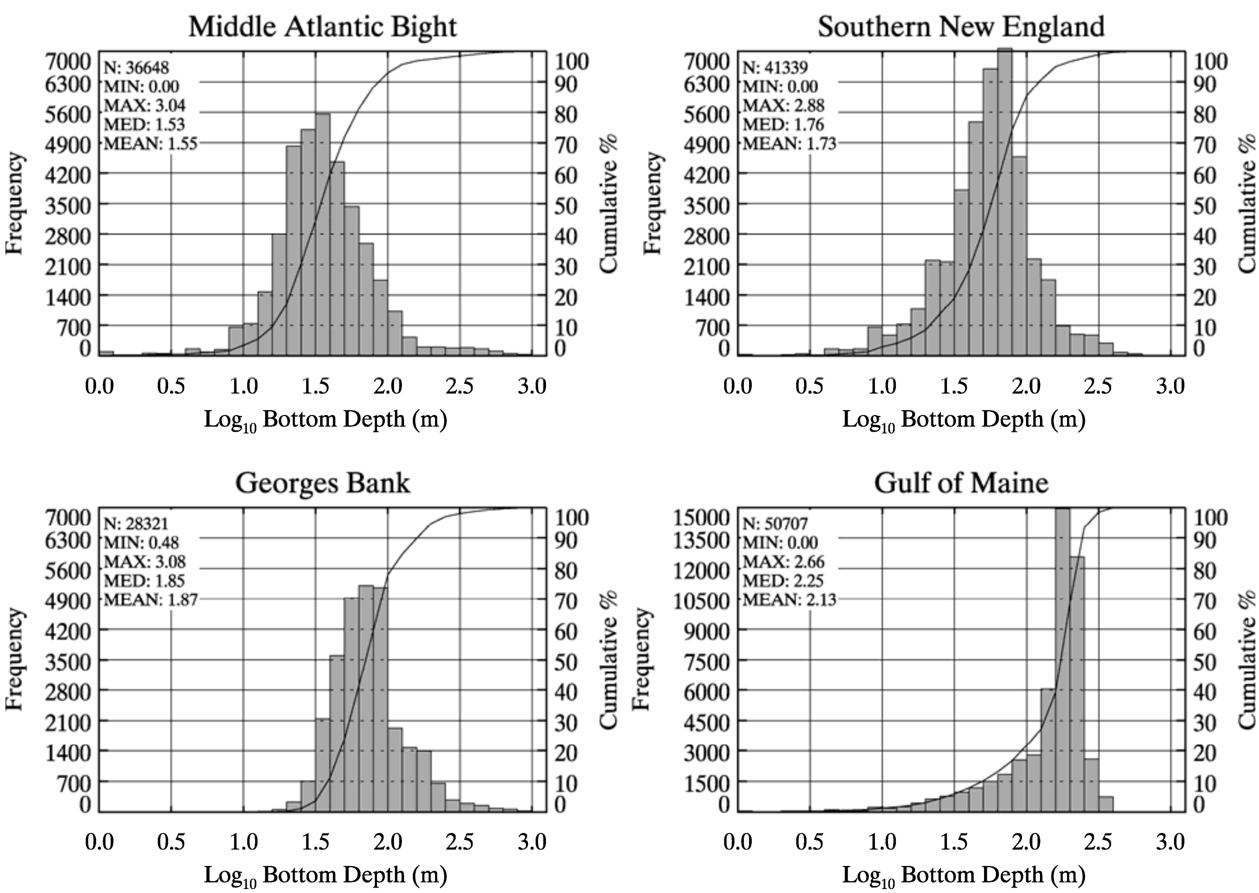


Figure 19.6. Frequency distribution of bottom depth for the GOM, GB, SNE, and MAB ecoregions based on data from a bathymetric map with 1.25 km resolution per pixel.