The Ocean's Biological Carbon Pump
مضخة الكربون البيولوجية في المحيط

By
Dr.Muayad Albehadili
Ass. Prof. of Marine Chemistry
College of Marine Sciences
Basrah University
IRAQ

What is it? The "carbon pump" refers to the biologically produced flux of carbon out of the euphotic zone of the ocean

Why do we (and many others) study this?

1- It regulates to some extent the pCO_2 content of the atmosphere.

2- It determines the O_2 and nutrient content of the deep sea.

3- If it changes in response to global warming, we should know this.

Some terminology:

Gross and Net primary production refer to the activity of plants:

A- *Gross primary production (**GPP**)* – is the rate of organic carbon fixed by plant photosynthesis.

B- *Net primary production (**NPP**)* – is the rate of organic carbon fixed by plant photosynthesis after accounting for respiration.

C- *Net community production (**NCP**)* – is the net organic carbon fixed by plant photosynthesis after accounting for both plant and animal respiration.

^{14}C primary production is measured by addition of ^{14}C labeled DIC to a flask of the water to be studied and incubating the flasks at the depth it was taken form the ocean. Most biological oceanographers believe that ^{14}C primary production is something between *Gross* and *Net primary production*

The term **New Production (NP)** was coined by scientists who study nitrogen cycling in the ocean (Dugdale and Goering, 1967) and refers to that nitrogen fixation into organic matter that originates from nitrogen outside the euphotic zone (mostly NO_3^- but also N_2). At steady state NP is equal to the flux out of the euphotic zone.

Methods for Measuring the Net Carbon Pump and New Production

New Production NP is measured by incubating seawater samples with $^{15}NO_3^-$ and then measuring the amount that ends up in organic matter. Eppley and Peterson (1979) were the first to recognize the relationship between new production and the biological pump. New production was shown to be a fraction of ^{14}C primary production.

This fraction would depend on the presence of NO_3 in the euphotic zone. Eppley and Peterson (1979) established an empirical relationship between primary production and new production (see figure below). If one knows the global production, one can calculate the global new production from this relationship.

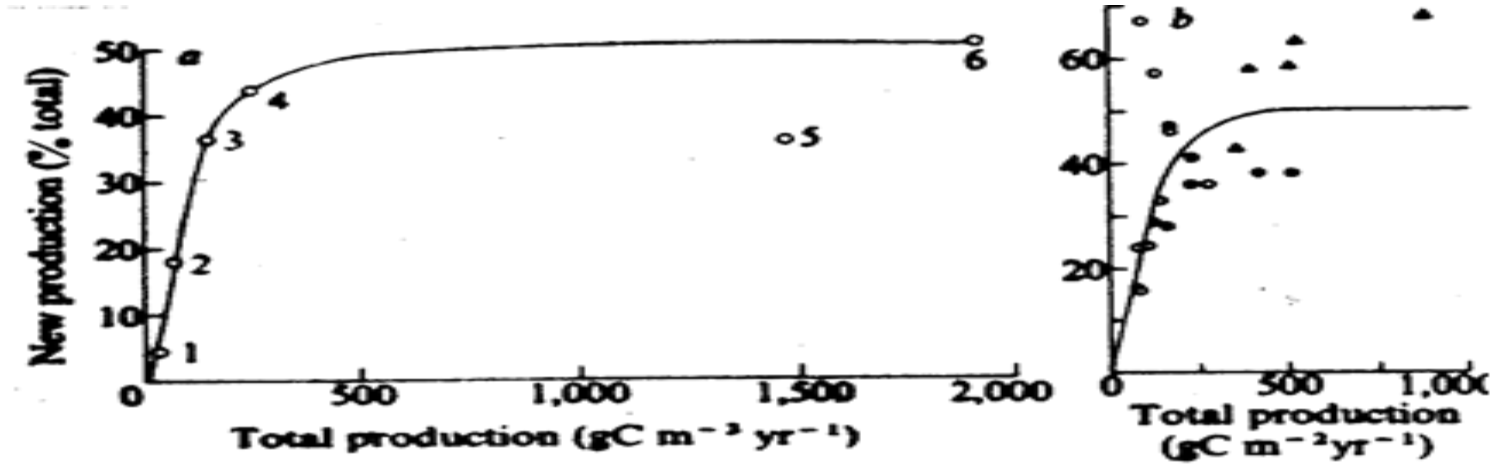

Fig. 2 a, New production as % of the total primary production versus total production for various ocean areas: (1) Central North pacific, (2) eastern Mediterranean Sea, (3) Southern California Bight, (4) eastern Tropical Pacific, (5) Costa Rica Dome, and (6) Peru upwelling. Total production was measured by the ^{14}C

Sediment Traps

Sediment traps are used to determine the particulate fraction of the biological carbon pump. There are two problems with this estimate of the carbon pump:

1- There is also a dissolved organic carbon component that "mixes" out of the upper ocean (recent estimates are that this is about 30 % of the flux.)

2- There are questions about the accuracy of the particle fluxes determined this way in the upper ocean. In particular traps may under or over collect particles depending on horizontal advection.

Regardless of these limitations a lot can be learned about relative changes in particle flux over time from sediment traps

The ^{234}Th method

The particulate thorium flux determined by the integrated deficiency of this isotope relative to its parent ^{238}U is a measure of the particulate carbon flux if one determines the organic C/ ^{234}Th ratio in the particles. Again, this method determines only the particulate portion of the carbon flux. Buessler (1999) compared the organic C flux determined by this method with ^{14}C primary production and showed that the ratio (analogous to the f ratio in Eppley and Peterson's study) is 2-10 % in most of the ocean. Exceptions are high latitudes (where NO_3^- concentrations are high in surface waters) and large "bloom" events in the ocean.

Oxygen Mass Balance

A simplistic view of the oxygen mass balance approach is that the flux of O_2 produced in the euphotic zone by photosynthesis must balance the carbon flux into the ocean interior.