Historical Perspective: Ocean Productivity in the 20th Century

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Introduction

ASLO, Boulder, CO, 1987

Obstacles both large and small

The Ocean is Big

Phytoplankton are Tiny

Oceanography, Ecology

Physiology
1940s
Oceanographic, Ecologic Approach to Productivity


A marriage of biological, physical, and chemical dynamics

Gordon A. Riley
1950s

Introduction of the C-14 Method

Decade also marked by dispute between Riley and Steemann Nielsen, between an oceanographic and physiologic approach to productivity
1960s

Global Surveys Using the C-14 Method

FIG. 10.6 Distribution of primary production in the oceans. (After Koblientz-Mishke et al., 1970.)
1970s

Questions

**Oceanography**
- Bacterial Respiration too large to be supported by 14C PP
- Rain rate of particles
- Oxygen utilization in the deep ocean implies higher surface PPs than measured
- Fish catches require higher PP

(these are difficult to evaluate)

**Phytoplankton**
- Effects of Incubation?
- Contamination from
  - sampling and samplers?
  - incubation containers?
  - the isotope itself?
There were other fundamental problems with the C-14 Method

- The method is easy
- Only a positive result (C assimilation) is possible
- Extremely sensitive: it can’t be compared to other flux measurements

As a result, you can make lots of measurements, can console yourself by the positive results, and not worry about validation.
"It is difficult to conceive of success at understanding marine ecosystems or chemical cycles in the ocean without accurate knowledge of the rate of primary photosynthetic production, closely tied as it is to the distributions and abundances of nearly all marine organisms and all particle-reactive elements.

"Yet there is currently large uncertainty and abundant debate about this rate brought about by inferred imbalances between measurements of photosynthetic carbon fixation and measurements of consumption or loss elsewhere in the oceanic carbon cycle."

Dick Eppley (with Ed Renger)
Did PRPOOS Double Oceanic Productivity?

Arrived at a “canonical” value for the daily rate of C-assimilation under a square meter of ocean.
1990s
The Joint Global Ocean Flux Study

• JGOFS
  • biological and chemical oceanography go international
  • establishes protocols for PP and other “core” measurements
• Process Studies: NABE Arabian Sea Exp., EqPac, AESOPS
• Time series: HOT, BATS
A Comparison of Methods: NABE

POC (beam-c) and TCO$_2$ are measured in the water column.

$^{14}$C assimilation and Net O$_2$ are measured in incubations.

Fig. 4. Comparison of rates determined using incubation methods (C assimilation and net O$_2$ production) with rates determined from in situ changes ($\delta$TCO$_2$, $\delta$POC) in the mixed layer for the North Atlantic Bloom Experiment (NABE) in 1989 (from Marra 2002). The low points in the $\delta$POC data are rates of loss overnight. The horizontal line on the right y-axis indicates the mean of all productivity measurements.

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Marra, 2009
In Conclusion…

Both water column (in situ, oceanographic) and physiological (incubations) approaches have their advantages and disadvantages.

Water column methods give a number, useful for budgets and serve as a valuable check.

Incubations can show which organisms are photosynthesizing, and interactions among the plankton.

If the water column is highly variable, physically, both approaches will have problems.