Evidence from the Ocean

Productivity of the Ocean. Present and Past. W. H. BERGER, V. S. SMETACEK, and G. WEFER, Eds. Wiley-Interscience, New York, 1989. xviii, 470 pp., illus. $146. Life Sciences Research Reports, vol. 44. From a workshop, Berlin, F.R.G., April 1988.

With the discovery by French and Swiss researchers, from the analysis of polar ice cores, that the carbon dioxide content of the ice-age atmosphere was some 30% lower than modern preindustrial values, intense scientific interest has focused on the sensitivity of global biogeochemical cycles to climatic change. The signal is astonishing. In spite of the fact that the atmosphere exchanges some 30% of its carbon dioxide each year with other reservoirs the level is fairly insensitive to small climatic changes and has been quite constant for millennia before the recent intrusion of humans. Yet the change triggered by an ice age is large—by some estimates, temperatures in the last glaciation were some 30% to 40% lower than those that would result from orbital forcing alone, owing to the loss of this greenhouse gas from the atmosphere. Can equivalent surprises of opposite sign be in our greenhouse–gas-rich future?

Most researchers agree that this ice-age signal arose principally from perturbation of the biogeochemical cycles of the ocean, that the record of it is written there, and that a sharp increase in knowledge of the contemporary operation of these cycles is essential for assessing the possibility of a future unpleasant trigger.

Brought together in Dahlem Conference format, some 43 experts here report and debate in engaging manner the relationships between the productivity of the modern ocean, the geochemical record preserved in marine sediments, and the validity of possible climate signals. Effects of an anticipated warming are of implicit concern but are not directly addressed.

A masterly summary by the editors leads the way, linking modern maps of phytoplankton productivity with the transfer function to the sediments provided, not always simply, by sediment-trap observations. Such collecting devices, moored or drifting in the ocean, catch the fluctuating, dissolving, decomposing downward rain of debris and return samples for study.

Paleoceanographers have long been used to coupling difficult measurements with soaring imagination, and that is revealed in the imagery here. Is the downward flux simply "diminished by road tolls . . . and by import duties at the sea floor"? Or is it "trash left over from (seasonal) Oktoberfest events and from (sporadic) rock festivals"? The validity of reconstructions can critically depend on the answers to these questions, and modern observationalists frequently find large events dominating their signal.

Legendre and Le Fèvre argue for a dominant role of hydrodynamical singularities in the control of the size fractionation, and thus sinking rate, but the physics here is not obvious. Toggweiler points out the newly determined critical role of dissolved organic carbon fields in controlling ocean chemistry, a factor that reduces the emphasis that must be placed on the purely vertical transports. The measurement of dissolved organic carbon and nitrogen in sea water with the required accuracy and precision is a major problem. The reservoir for carbon is large, about twice that of the atmosphere, and the response of this system to climate change is unknown. Wefer confronts the episodic-production problem head on with Antarctic data showing annual flux variations of a factor of 300, strongly correlated with surface events often due to the bloom of a single species.

The Group Report here refers to the challenge that has been posed by Martin and Fitzwater, who have observed stimulated plankton growth following the introduction of nanomolar (so depleted is the remote ocean) amounts of iron and have postulated that atmospheric dust input, strongly enhanced in glacial times, can be a critical control through release of trace amounts of iron to sea water. Should this be so then "rock festival" becomes a double entendre; and the "sporadic" events can be extra-oceanic, associated with continental debris carried for great distances before deposition.

Over most of the ocean more than 90% of the material leaving the surface is consumed before reaching the sediments. Continental shelves provide one exception, for shallow depth means the "road tolls" are diminished. Walsh tackles this issue, with its horrendous sampling problem, and boldly extrapolates. What reaches the sediments is the object of intense study. Stirred by animals, dissolved by carbonic acid, and rotted by bacteria, a vestigial fraction remains to tell its tale. New tools from organic geochemistry (Prahl and Muehlhausen) and new views of the transfer function (Mix) can be brought to bear to help with the geologic reconstruction of marine productivity.

What did I find lacking? Consideration of technique, particularly the power of radiochemistry in key areas. Regrettably only one woman scientist is included among the contributions, Claire Reimers, who does an outstanding job on the control of benthic fluxes by the particulate supply. Direct reporting of Japanese contributions, rather than the frequent reference made, would also have helped; a debate between Yoshimi Suzuki and Shizuo Tsunogai, both with legitimate views, would have been something! A hard-nosed prediction of the effects of a long-term warming has yet to come.

What did I get? An excellent synthesis of an important field. The photographs of participants in Group Report clusters are a nice touch. New maps of productivity appear, and the satellite ocean color images now driving so much new thinking are beautifully reproduced. The next generation of satellite linked-ocean observing programs, particularly JGOFS (the Joint Global Ocean Flux Study) will, it is clearly stated here, be necessary for progress.

Berger, Smetacek, and Wefer have produced a near-perfect example of the conference-volume format.

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Clostridial Renascence

Clostridia. NIGEL P. MINTON and DAVID J. CLARKE, Eds. Plenum, New York, 1989. xiv, 304 pp., illus. $49.50. Biotechnology Handbooks, vol. 3.

The ups and downs of clostridia in the industrial arena are illustrated by the acetone-butanol-ethanol (ABE) fermentation of *Clostridium acetobutylicum*. Discovered in the 19th century, this saccharolytic species was developed for the production of acetone and butanol early in this century. However, in the 1950s the fermentation process succumbed to competition from cheaper synthetic processes using petrochemical feedstocks. Recently, interest has resurged in ABE fermentation as a future source of chemical feedstocks from renewable resources, such as agricultural wastes.

This handbook describes and summarizes our current understanding of the physiology and genetics of the clostridia and their potential for industrial-scale production of organic acids, alcohols, neutral solvents, and enzymes, as well as the use of these orga-