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Modelling the Transformations, Transport, and Fate of Organic
and Particulate Matter off Southern California.

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This project was part of the multi-investigator, multi-disciplinary West Coast program to study the carbon flux in marine basins (California Basin Study— CaBS).

There have been two major projects during the last year. The first has been to model the fate of a phytoplankton bloom by including only physical processes. The most important such process is coagulation, the formation of large aggregates by the multiple collision and sticking of smaller ones. Coagulation processes have been intensively studied in descriptions of smog formation, generation of raindrops, and water treatment and purification. The rate of coagulation depends on the rate of collision between particles and the probability that two particles will stick to form one when they collide. Because the collision rate is proportional to the square of particle concentration and algal growth is proportional to just the particle (algal) concentration, the equations describing rate of algal concentration when there are only growth, coagulation, and sinking rates are nonlinear. Numerical solutions of the relevant equations as well as mathematical simplifications show that coagulation can place a maximum concentration that algae can achieve, that this concentration is within the range of concentrations which have been observed, and that this concentration is extremely sensitive to algal size. Because increased coagulation leads to larger particles which sink faster, coagulation can enhance the movement of particles to the ocean floor. Coagulation can occur in non-bloom conditions as well, but will share the role of particle removal with such biological processes as zooplankton grazing. In either situation, it is a mechanism for particle removal which has not been adequately studied.

Our second major project has been the application of inverse techniques to study particle dynamics in the planktonic systems. A major problem with studies of planktonic food webs is the practical impossibility of measuring material flows among all the compartments. This has been especially true in the Southern California Bight where CaBS researchers have found that the large crustaceans, such as copepods and euphausiids, formerly believed to be the dominant grazers on phytoplankton actually consume a small fraction of the primary production. Most of the algal production appears to be consumed by the smaller grazers, such as protozoans and microzoa, for which we have little information. By using inverse models which incorporate information from laboratory measurements as well as the actual field measurements, we have been estimating values for the unmeasured flows which are consistent with those field measurements that do exist and with laboratory measurements.

Using the model, we have been able to estimate protozoan and microzoan grazing rates. These results suggest that animal excretion is the dominant source of organic matter that sustains bacteria rather than phytoplankton leakage. The total of flows going into

each organism is more than twice the primary production, indicating the importance of recycling in the system dynamics. The differences between carbon, which can essentially leave the planktonic system by being respired, and nitrogen, which is essentially conserved, give the two substances much different residence times in the euphotic zone.

We have further extended the inverse technique to include a description of the benthic community. This situation is complicated by the importance of chemical fluxes and transformations of elements in addition to carbon and oxygen as well as the difficulty of studying organisms at great depth. Our results help to delineate the activities of different bacterial communities and their interactions with larger organisms. Our results accentuate the differences between a benthic community in a region with low oxygen concentrations in overlying waters, such as Santa Monica Basin, and one where there is substantial oxygen.

Inverse techniques should form a useful adjunct to field measurements when describing ecosystems. In the planktonic case, our results suggest that the interactions with detritus and with dissolved organic matter are important and need to be measured.

In the last 3 years, there have been 4 papers published, 6 papers accepted for publication, and 1 submitted but not yet accepted. All resulted from work at least partially supported by this grant.

PUBLICATIONS RESULTING FROM THIS PROJECT:

PUBLISHED

Jackson, G. A. 1990. A model of the formation of marine algal flocs by physical coagulation processes. *Deep-Sea Res.* 37:1197-1211.

Eldridge, P. M., and G. A. Jackson. 1992. Benthic food web flows in the Santa Monica Basin estimated using inverse methodology. *In: G. T. Rowe and V. Pariente (eds.), Deep-sea food chains and the global carbon cycle*, pp 255-276. Kluwer Academic.

Jahnke, R. A., and G. A. Jackson. 1992. The spatial distribution of sea floor oxygen consumption in the Atlantic and Pacific Oceans. *In: G. T. Rowe and V. Pariente (eds.), Deep-sea food chains and the global carbon cycle*, 295-307. Kluwer Academic.

Jackson, G. A., and S. E. Lochmann. 1992. Effect of coagulation on nutrient and light limitation of an algal bloom. *Limnol. Oceanogr.* 37: 77-89

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Jackson, G. A., and P. M. Eldridge. Food web analysis of a planktonic system off Southern California. *Prog. Oceanogr.*

Jackson, G. A. Flux feeding as a mechanism for zooplankton grazing and its implications for vertical particulate flux. *Limnol. Oceanogr.*

Jackson, G.A., and S. E. Lochmann. Modeling coagulation in marine ecosystems. *In: H. P. van Leeuwen and J. Buffie [Eds.], Environmental Particles, v. 2, Lewis Publishers, Boca Raton, Florida.*

Jackson, G. A. Coagulation of marine algae. *In: Huang, C. P., C. R. O'Melia, and J. J. Morgan (eds.) Aquatic chemistry: principles and application of interfacial and inter-species interactions in aquatic systems.*

Jackson, G. A. The significance of the DOC pool for primary production estimates. To appear in "ICES Marine Science Symposia."

Murray, A. G., and G. A. Jackson. Viral Dynamics: A Model of the Effects of Size, Shape, Motion and Abundance of Single-Celled Planktonic Organisms and Other Particles. *Mar. Ecol. Prog. Ser.*

SUBMITTED

Eldridge, P. M., and G. A. Jackson. Benthic trophic dynamics in California coastal basin and continental slope communities inferred using inverse analysis. Submitted to *Marine Ecology Progress Series*, November 1992.