INITIAL SETTLEMENT OF MARINE INVERTEBRATE LARVAE: THE ROLE OF PASSIVE SINKING IN A NEAR-BOTTOM TURBULENT FLOW ENVIRONMENT

by

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ABSTRACT

The hypothesis that planktonic larvae of benthic invertebrates sink through the water like passive particles in turbulent flows near the seabed was tested in the field using several groups of geometrically different sediment trap designs. A priori predictions regarding the rank order that the various traps would collect larvae in the field were dictated from laboratory flume experiments to determine the relative particle collection efficiencies of traps. The flume flow was seeded with particles having fall velocities similar to those measured, in the laboratory, for nonswimming polychaete larvae. The flume flow speed (of ~ 10 cm/sec) was within the range of near-bottom current velocities measured during trap collecting intervals at the study site.

In seven field experiments, each lasting from one to eleven days, trap collections of Mediomastus ambiseta (a polychaete worm) postlarvae, total bivalve larvae and postlarvae, sabellariid polychaete larvae, and enteropneust postlarvae generally fit the patterns predicted for passive particle collections between or among the trap designs. While the results were statistically more significant during some intervals than during others, the rank order of larval collections within each group of trap designs tested nearly always corresponded precisely to the rank order of passive particle collections by the traps in the flume experiments. Thus, the hypothesis that larvae sinking toward the seabed in the field and passive particles (with fall velocities similar to larvae) sinking in a flume are collected in the same rank order of abundance by near-bottom traps could not be falsified for collections of organisms from three invertebrate phyla.

Collections of the polychaete, Pectinaria gouldii, and of metamorphosing seastar larvae between or among trap designs significantly differed from the patterns predicted for passive particle collections. A testable hypothesis to explain the Pectinaria collections involves unique hydrodynamic properties of these postlarvae, relative to the other organisms collected, and is consistent with the passive sinking hypothesis. Trap collections of the seastars may have resulted, at least in part, from larvae adhering to solid trap surfaces during metamorphosis.

The passive sinking hypothesis could not be falsified in most of the field experiments conducted in this study. Thus, hydrodynamical processes must be included in any future studies of processes that determine patterns of larval settlement. However, passive sinking by larvae is not the explicit result of this experimental study. Other processes that could have produced the observed patterns of larval collections among the trap designs now must be tested against the passive sinking alternative hypothesis. However, much more information on the biology and ecology of the larvae collected in this study is required before future process-oriented experiments can be designed.

If larvae sink like passive particles to heights of ~ 50-cm above the seabed, as the results of this study suggest, then it is possible that larvae initially reach the seafloor at sites where particulates, with fall velocities similar to larvae, initially settle. This hypothesis requires experimental testing. Larvae may not remain at these initial settlement sites; however, after larvae initially reach the seafloor via passive physical processes, the larvae may redistribute by actively choosing a preferred microenvironment within that location, by actively swimming above the bottom or remaining on the sediment surface to be resuspended and transported away, by resuspension only during storm events, and/or by passively accumulating around microtopographic structures.

As a precursor to the flume tests of traps, a theoretical analysis of the physical nature of trap biases was conducted. A dimensional analysis of the independent variables involved in the process of trapping particulates suggested that trap collection efficiencies should be a function primarily of trap Reynolds number, trap aspect ratio, the ratio of the fluid velocity to the particle fall velocity, and trap geometry. A review of data from previous studies that flume-tested various trap designs further suggested that particle collection efficiencies of cylindrical traps should decrease over some range of increasing trap Reynolds number, decrease over some range of decreasing particle fall velocity and increase over some range of increasing trap aspect ratio. Theoretical models were then provided to account for these effects. Flume tests, in the present study, of cylinders varying by one order of magnitude in trap Reynolds number supported one of the predictions: particle collection efficiencies of the cylinders decreased by a factor of two over this range of increasing trap Reynolds number. Results of this theoretical and experimental study of trap collection characteristics suggest that more flume experiments to quantitatively determine the nature of trap biases are required before flux estimates, using traps in the field, can be adequately interpreted.

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BIOGRAPHICAL NOTE

The author was born on 26 November 1954 in Albany, California and was raised in Concord, California where she graduated from Clayton Valley High School in June 1972. She then attended San Jose State University (San Jose, CA), studying both botany and zoology, and eventually graduated with a B.A. in Zoology in June 1976. The scale was tipped toward invertebrate zoology during her last year at S.J.S.U. when she was the curator for the Invertebrate Zoology Museum at the University. From June 1976 through August 1978, the author attended Moss Landing Marine Laboratories (Moss Landing, CA) and S.J.S.U. in a Master's program while simultaneously coordinating a research grant, funded by the California State Water Resources Control Board, to design methods for using life history analyses of benthic invertebrates to monitor marine pollution. One aspect of this study, testing the feasibility of the life history approach at a local marine sewer outfall, constituted her Master's thesis research for which she obtained an M.A. in Biology (Marine) in May 1980. She was admitted to the W.H.O.I./M.I.T. Joint Program in Biological Oceanography in September 1978. After studying primarily physics and math during her first two years at M.I.T., it was possible for her to conduct interdisciplinary research on the role of small-scale hydrodynamical processes in determining sites for initial settlement of invertebrate larvae onto the seabed. During the spring of 1981, the author also taught a semester course in General Marine Ecology to undergraduates at Yale University. The author has accepted a position as a Postdoctoral Investigator at W.H.O.I. in the Ocean Engineering Department.

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