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Perspectives on the hyporheic zone: integrating hydrology and biology. Introduction

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Abstract. This introduction to six articles on the hyporheic zone notes the rise in the number of presentations on this topic at meetings of the North American Benthological Society, and traces the recent merging of "process-functional" perspectives with "population-community" approaches. Acquiring a broad understanding of the hyporheic zone and its role as a component of stream ecosystems requires the integration of ecological and hydrological techniques and perspectives.

Key words: hyporheic zone, processes, communities, hydrology, groundwater.

Hydrologists have long considered streams and rivers to be dynamic regions that link groundwater with water that drains from the earth's surface. Ecologists, on the other hand, have typically perceived streams as bounded systems, consisting of the stream bottom and overlying water. In a broad sense, the hyporheic zone (sensu Orghidan 1959) can be defined as the subsurface region of streams and rivers that exchanges water with the surface. The recognition of the hyporheic zone as an integral component of streams has expanded the spatial extent of lotic ecosystems to include the vertical dimension (Ward 1989).

Research presented at annual meetings of the North American Benthological Society (NABS) reflects increased interest in the hyporheic zone and recognition of the ecological importance of subsurface hydrology. Following the eloquent plea for integration of groundwater science and stream ecology (Hynes 1983) the number of abstracts dealing with the interstitial environment has steadily increased (Fig. 1). Three of four plenary presentations at the 36th annual meeting of NABS (1988) featured aspects of lotic subsurface regions. The presidential address at that meeting emphasized the hyporheic zone as a critical dimension of stream ecosystems (Ward 1989). Special sessions held at both the 1990 and 1991 meetings of NABS focused on hydrologic and ecological perspectives of interstitial regions in estuarine and freshwater environments.

Historically, research focusing on the hyporheic zone has employed one of two differing

perspectives. Most work has investigated the interstices as habitat for macroinvertebrates. In this "population-community" perspective (sensu O'Neil et al. 1986), the ecosystem is considered as a series of interacting populations superimposed on an abiotic template. Because of a long history of research, stream ecologists are now aware of the unique and varying biota of interstitial environments (i.e., hyporheos, sensu Williams and Hynes 1974). In the "process-functional" perspective (sensu O'Neill et al. 1986) the ecosystem consists of interacting physical, chemical, and biological processes. Research efforts continue to address the distribution and composition of interstitial fauna, but presentations at annual NABS meetings indicate a recent increase in studies of functional

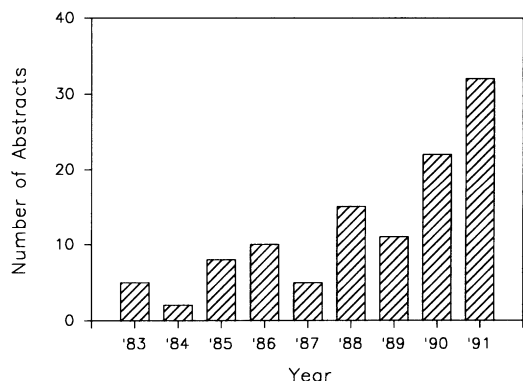


FIG. 1. Number of abstracts on interstitial habitats presented at the annual meetings of the North American Benthological Society, 1983-1991.

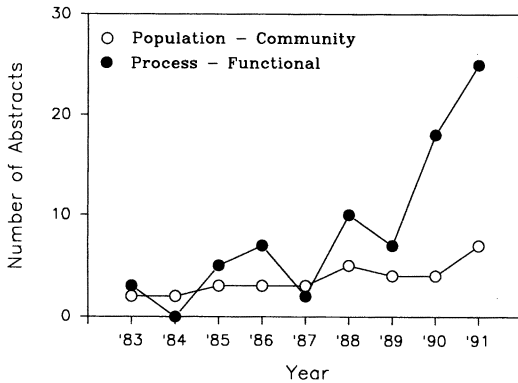


FIG. 2. Orientation of recent research on the hyporheic zone. Number of abstracts presented at annual NABS meetings relating to population-community perspectives vs. process-functional approaches.

aspects of the hyporheic zone (Fig. 2), including investigations of hyporheic influences on stream metabolism, nutrient cycling, and surface-sub-surface interactions.

It is clear that the population-community and process-functional perspectives are merging (Fig. 3), drawn together by efforts to incorporate the influence of hydrology on hyporheic communities and processes. Descriptive biology and static measures of "traditional" physicochemical factors are now being supplemented by process biology and dynamic measures that include temporal resolution and recognize the key role of hydrology.

The following series of papers addresses the integration of hydrology and ecology in studies of the hyporheic zone. The papers presented here expand on ideas originally presented at a 1991 NABS workshop; they examine current and anticipated problems and suggest future lines of research. The varying topics and perspectives reflect the differing interests and backgrounds of the authors. Bencala (1993) provides hydrologic perspectives on the linkage between streams and their catchments, while Stanford and Ward (1993) expand on linkage between groundwater and floodplain-riverine ecosys-

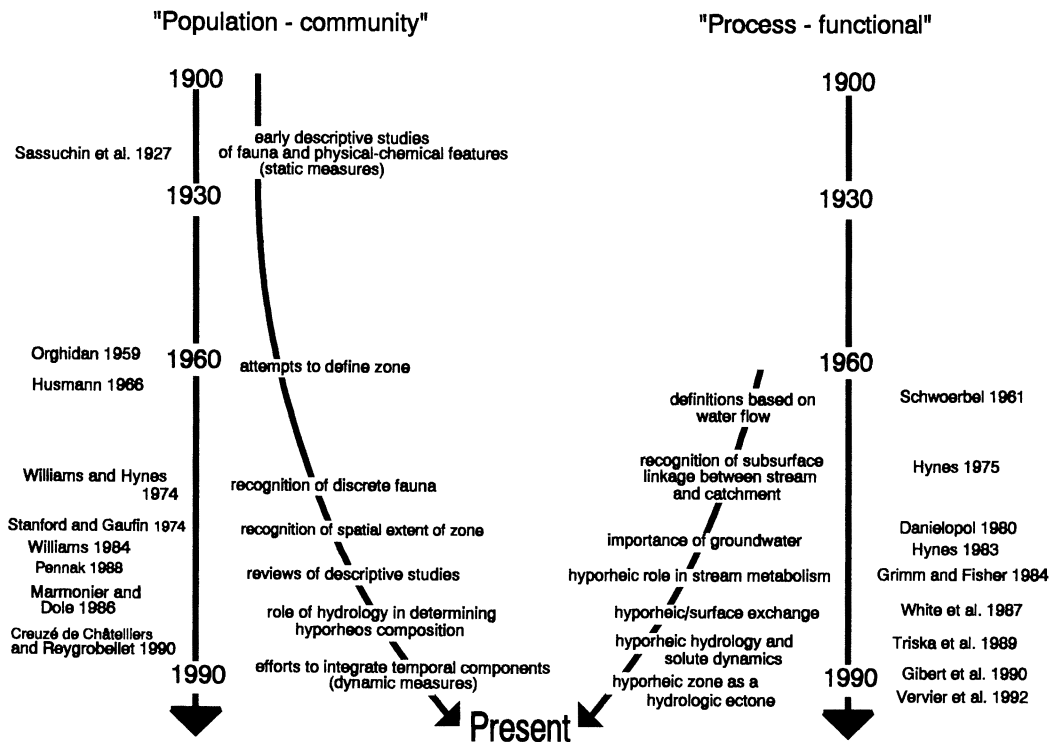


FIG. 3. Diagrammatic representation of the merging of research perspectives in the studies of the hyporheic zone. Listed studies illustrate increasing emphasis on hydrology, but do not represent an exhaustive survey of research contributions.

tems. White (1993) considers theoretical and operational definitions of the hyporheic zone, and Hendricks (1993) presents a case study to address microbial dynamics of this zone. Stanley and Boulton (1993) focus on hydrologic influences on interstitial community composition in two very different lotic ecosystems. Finally, Palmer (1993) examines issues of experimental design that are pertinent to the continuing study of hyporheic processes and communities.

Acknowledgements

The series of papers introduced here are the result of a number of related events. Many discussions at the 1989 and 1990 annual meetings of the North American Benthological Society led to a workshop at the 1991 meetings in Santa Fe, New Mexico, that dealt with hydrologic influences on hyporheic ecology. We thank the large number of individuals who contributed to those discussions and helped instigate the workshop, including Nancy Grimm, Stuart Fisher, and LeRoy Poff. We especially thank the following individuals for the effort required to generate the papers presented here as perspectives on the study of the hyporheic zone: Ken Bencala, Sue Hendricks, Margaret Palmer, Emily Stanley, Jack Stanford and David White. In addition, we would like to acknowledge the contributions made by *J-NABS* Editor Rosemary Mackay, Ad Hoc Associate Editor Jane Rutherford, and a number of anonymous reviewers who helped produce this series of papers. HMV was supported by NSF grants BSR #88-18612 and BSR #90-20561; AJB by NSF grants BSR #88-18612; and CCH by the Chesapeake Bay Fund, NSF grants #R11-8620422 and BSR #9006002, and the Maryland Agriculture Experiment Station.

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