In summary, we believe this is a very useful book, better suited for the researcher than for the undergraduate and should be part of any well-rounded stream ecologist's library. Our comments are intended to describe the scope of this book and use it as a barometer of the state and direction of the discipline. Stream ecology is a healthy, broad discipline and this book can help an individual researcher increase the scope of his or her research interests by facilitating application of new techniques.

Stuart Findlay
Robert O. Hall, Jr.

Institute of Ecosystem Studies
Millbrook, New York 12545

William V. Sobczak

Section of Ecology and Systematics
Cornell University
Ithaca, New York 14853

References

BOON, P. J., P. CALOW, AND G. E. PETTS [EDS.]. 1992. River conservation and management. J. Wiley and Sons.

UNITED STATES GEOLOGICAL SURVEY. 1993. National Water Quality Summary. USGS Water Supply Paper 2400. United States Government Printing Office, Washington D.C.

Limnol. Oceanogr., 43(5), 1998, 1021

MILNER, A. M., AND M. W. OSWOOD [EDS.]. 1997. **Freshwaters** [sic] **of Alaska: Ecological syntheses.** Springer. ISBN 0-387-94379-X. 369 p.

Exploitation of the environment results in profound alterations of natural ecosystems. Evaluation of these changes, as well as their potential suppression or reversal, presumes some understanding of conditions at an earlier stage. In spite of the intensive modifications of the temperate and tropical regions of the world by rampant, exponentially increasing human exploitation, vast areas of the arctic and subarctic regions are relatively unmodified by direct human interventions. Alaska is a small but important portion of these regions. Our understanding of existing limnological characteristics of the inland waters of Alaska is largely in its infancy.

The small book on the fresh waters of Alaska makes no attempt to be encyclopaedic in summarizing limnological data available from this large, relatively remote state. Rather, examples of different freshwater ecosystems are synthesized, in as much as is possible at these early stages of evaluation and understanding. Some ecosystems are studied most intensively—coupled descriptive and experimental analyses of these few systems provide disproportionately greater insights into the resiliency and potential recovery capacities of these systems.

Because of the uneven and usually limited depth of understanding of the structure and functioning of waters of Alaska, coverage in this book is similarly uneven. The severe climate along an extensive latitudinal gradient results in a vast habitat and climatic diversity of the state. The small human population and restricted access to surface waters has resulted in limited degradation. Recognition of the need for understanding of these resources, however, and excellent support logistics associated with the military have attracted a bevy of good limnologists to the region. By far the most thoroughly studied lake ecosystem in Alaska is Toolik Lake, where the seemingly simple food-web structures are in reality large and complex. Importantly, the largely phosphorus-limited planktonic food-web is dominated by microbial components, and clearly most organic matter and energy emanates from benthic and allochthonous sources. Frequent seemingly dogmatic statements given as fact regarding controlling mechanisms for carbon and energy fluxes in the Toolik ecosystem are perhaps founded in the many studies cited, but often many alternative explanations exist. The limnological summary of the shallow, highly humic stained, and eutrophic cryogenic Smith Lake provides a marked contrast to the Toolik system and touches on the enormous lake diversity of this region.

The detailed studies of the Kuparuk River indicate the marked temporal variability that occurs in tundra riverine ecosystems. Although little is known of the microbial utilization of organic matter, the fluctuating regulatory capacities of phosphorus, nitrogen, and invertebrate grazing on attached communities demonstrate the temporal volatility that exists in these tundra systems. The concluding chapter by M. W. Oswood presents a particularly instructive analysis of both the diversity and commonalities among streams and rivers of Alaska, in which the comparative climatic and edaphic traits of the region are integrated with biological components.

Much of the book is devoted to the effects of organisms on surface waters. Discussion of waterfowl and wetlands is most general, and where the general characteristics of waterfowl distributions and migrations emerge, practically no ecology of the vast wetlands is presented. Much attention is directed to effects of land management, mining, and forestry on salmon habitat, behaviors, and migrations. Clearly the loading of nitrogen from marine sources by the migration, spawning, and death of salmon can be significant in some lakes, although quantification is very difficult. The management practice of fertilization of oligotrophic lakes to increase growth rates of salmon has been variably successful because of the individualistic balances among nutrients and fry stocking. Eutrophication of lakes for salmon, most of which are never harvested, is quite antithetical to contemporary management strategies and cannot be justified.

Climate is obviously a dominant driver of the bioenergetics, biodiversity, rates of biogeochemical cycling, and productivity in the aquatic ecosystems of this arctic region. Climatic variability results in frequent disturbances of habitats, community structure, and productivity. The idea that these freshwater ecosystems are simple is obviously misplaced. The primary messages of this eclectic collection of limnological essays are how little we understand of these tundra and arctic fresh waters and the difficulty of extrapolating our general concepts of ecosystem operation to these systems so severely constrained and modified by climate.

Robert G. Wetzel

Department of Biological Sciences
University of Alabama
Tuscaloosa, Alabama 35487-0206

Limnol. Oceanogr., 43(5), 1998, 1021–1022

RICHARD Y. MORITA. 1997. **Bacteria in oligotrophic environments: Starvation-survival lifestyle.** Chapman & Hall. 529 p.

Bacteria have extraordinary capability for survival in the absence of energy and nutrient sources. Viable (i.e. capable of growing and producing progeny following resuscitation) bacterial cells have been recovered from rocks, coal, frozen soils, ice cores, solar salt deposits, subsurface deposits, and waters with apparent ages of thousands of years. Owing to the ease with which such samples can become contaminated during handling, it is often difficult to verify claims

of such old but viable cells. But even in reliably prepared and sealed laboratory media lacking any energy sources, bacteria retain viability over many decades. Richard Morita, a marine microbiologist at Oregon State University, argues in *Bacteria in Oligotrophic Environments* that bacterial survival under starvation conditions is not just one among many adaptations, but the fundamental aspect of bacterial existence, that most bacteria in most environments are experiencing most of the time.

Most L&O readers see the term oligotrophic and immediately think of the open sea or certain types of lakes, in which the nutrient input is limited and primary production is low. However, for Morita:

> Nearly all the Earth's biosphere is oligotrophic, especially when one considers the vast volume of the oceans. Although soil is generally not placed in this category, soil microbiologists recognize its oligotrophic nature. It is rare that we see truly eutrophic environments, but even within eutrophic environments, there are some physiological types of bacteria that do not find available sources of nutrients (energy) or find nutrients only in limited supply. (p. 21)

Thus in the context of bacterial lifestyle, the term oligotrophic refers to organic matter content and availability, rather than to the inorganic nutrient or primary productivity status more familiar to L&O readers. Morita goes on to argue that bacteria (especially starving bacteria) are generally so well adapted to utilize organic matter (energy) when it becomes available that bacterial activity creates and maintains oligotrophy in the biosphere. His book, then, is an extended exploration of the chemical nature of oligotrophic environments, as well as bacterial performance and survival under those energy-limiting conditions.

After discussing bacterial survival in ancient samples and laboratory systems, Morita addresses the bioavailability of utilizeable organic matter in oligotrophic environments (i.e. nearly all environments), and analyzes current methods of determining bacterial activity and nutrient availability. He surveys much of the past and current literature (to 1994) on measurement of bacterial activity in the field, and finds it particularly wanting. It is here that many aquatic microbial ecologists will be most challenged by Morita's viewpoint. He argues forcefully that most approaches contaminate samples with organic matter and "prime" possibly starving cells, stimulating their activity:

> The . . . low organic matter content of ecosystems makes this author question the accuracy of microbial data in the literature because it is premature to assume that the techniques are accurate. In all probability the rates of activity reported are too fast when extrapolated back to the environment. (p. 191)

For example, Morita argues that when oceanographers make measurements of microbial activity, their samples are inadvertently contaminated with volatile organics, to which the (starving) bacteria respond with enhanced growth. Thus, growth rates measured in the field may often be not only artifacts of inadequate methods, but also reflect eutrophication of naturally oligotrophic samples.

The heart of the book is comprised of chapters on starved bacteria in various systems and the physiology of starvation–survival. This latter subject is the one to which Morita has devoted the latter part of his career, and it forms the book's strongest chapter. The book is also graced by two excellent, well-written chapters—one by Paul Blum on the genetics of starvation survival, and one by Holly Schrader et al. on bacteriophage dynamics in starved hosts. The book has a bibliography with more than 2,000 references (126 pages). Judging by the nature of most citations in the main text, Morita has accomplished a very thorough job of synthesizing a large and diverse literature ranging across all microbiology and related fields. Far from limiting his analysis to the water world, Morita has equally much to say about soils and sediments. Students in particular will benefit from this eclectic treatment.

Few microbiologists would question the ability of bacteria to survive under starvation conditions. The biology of bacterial starvation responses is beginning to be understood at the molecular level, as described by Blum. Furthermore, few chemists would disagree with Morita's main conclusion that most organic matter in the environment is of inferior quality or otherwise unavailable for bacterial utilization. There will be those though, and I am one, who remain skeptical of Morita's overall conclusion that microbial activity in nature (at least in aquatic habitats) is minimal and mostly static. There appears to be a fundamental divide between physiologists and ecologists on the question. One shortcoming of Morita's treatment is the lack of an incisive analysis of bacterial ecology in the context of current ecological and geochemical knowledge of population dynamics and fluxes. The key objection raised by ecologists to claims that most bacteria in fresh and marine waters are inactive is the difficulty of reconciling this notion with the large, active, and diverse populations of bacteriovores present in the same habitats. How are constant stocks of inactive cells maintained and protected from removal? Shrader et al.'s chapter suggests an answer for viral attack: temperate bacteriophages may delay induction of the lytic phase until host growth increases. But nowhere does Morita address the question of bacteriovores.

In part I think this difference of opinion derives from the traditional training of many environmental microbiologists in general microbiology. Bacteria are grown in laboratory media containing tens of grams of labile carbon per liter, but even in rich lakes dissolved organic carbon seldom exceeds a few 100 μM (i.e. milligrams per liter). When grown in such abundantly luxurious media, bacteria grow quite large (at least 1–10 μm^3 in cell volume) with multiple copies of nucleiods. Bacteria in natural habitats are on the order of 0.1 μm^3 with single copies of DNA. Not surprisingly, they appear to be starving. New generations of microbial ecologists trained in the field, and adept at replicating naturally occurring habitats in the laboratory, will more readily think of small bacteria in the context of existing substrate concentrations instead of in reference to irrelevant laboratory media.

Unfortunately the book suffers from poor editing. There are numerous typographical errors, including technical data. Overall the text is redundant and could have been perhaps 20% shorter. Finally, I was disappointed by a shortage of illustrations and especially by the absence of a concluding chapter. The book lacks a rigorous theoretical structure and remains, in the end, mainly descriptive. Although I was not completely convinced by Morita's thesis, I admire his effort. The book is provocative and contains a wealth of knowledge and insight. His very strong statements will surely induce counterattacks by which the field will progress. I have already passed it to my students.

Hugh Ducklow

Virginia Institute of Marine Science
The College of William and Mary
Box 1346
Gloucester Point, Virginia 23062