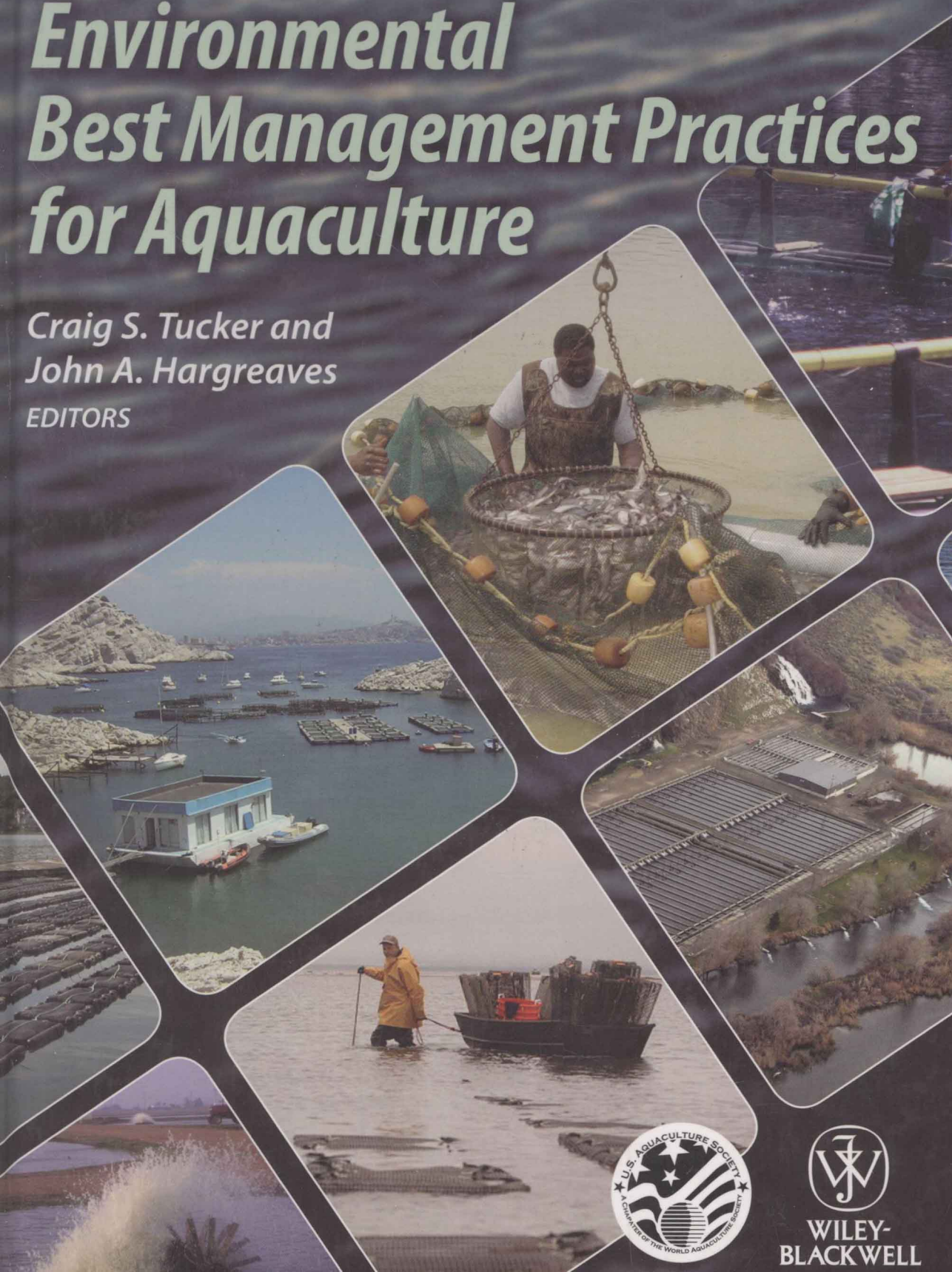
Environmental Best Management Practices for Aquaculture

Craig S. Tucker and
John A. Hargreaves
EDITORS



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Environmental Best Management Practices for Aquaculture

Edited by

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With 18 contributing authors

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Preface

Silver minnows were devising
Water ballet so surprising. . . .

Ray Thomas (1971), *Nice to Be Here*,
Every Good Boy Deserves Favour

In 1992, a court-ordered consent decree committed the United States Environmental Protection Agency (USEPA) to a schedule for proposing and developing national effluent guidelines for new industries. As part of the consent decree, USEPA agreed to publish a list of candidate industries for rule making every two years. Five years later the Environmental Defense Fund (EDF) published *Murky Waters: Environmental Effects of Aquaculture in the United States*. In that widely read report, EDF recommended that the federal government implement the Clean Water Act for aquaculture by developing national effluent limitations. As a consequence of those two events, USEPA announced in January 2000 that it would undertake formal rule making for commercial and public aquaculture facilities. This decision resulted in a multiyear national dialogue to evaluate effluent management options for United States aquaculture facilities. Most of the authors contributing to this book were active participants in that process, serving to provide technical information and leadership.

Early in the rule-making process it became clear that best management practices (BMPs) would be a prominent feature of the new regulation. In support of this approach, a cooperative agreement was established in 2001 among USEPA, the United States Department of Agriculture Cooperative State Research, Education, and Extension Service (CSREES), and Mississippi State University to develop a guidance document that would provide USEPA with a summary of management practices for mitigating certain environmental impacts of finfish aquaculture. Eight experts were asked to contribute to the report, which was extensively reviewed in draft form by various state agencies, professional organizations, and technical authorities. The final report was submitted to USEPA in December 2003 as a white paper entitled *Best Management Practices for Flow-Through, Net-Pen, Recirculating, and Pond Aquaculture Systems*. The final aquaculture effluents rule was subsequently published in the *Federal Register* in June 2004. One year later USEPA granted us permission to use the white paper as the basis for a more comprehensive publication accessible to industry, aquaculture researchers, environmental scientists, regulators, and policy makers. Shortly thereafter, we secured an agreement to publish this book with Wiley-Blackwell, in conjunction with the United States Aquaculture Society, a chapter of the World Aquaculture Society.

This book could have been organized in many ways, but we chose to build it around six core chapters that describe better environmental management practices for aquaculture systems, rather than for individual species. There are shortcomings to any approach, but we believe that environmental performance—at least at the farm level—is tied more closely to management of the culture system than it is to the production of a particular animal. The initial focus of the white paper was on BMPs for minimizing the environmental impacts associated with effluents from aquaculture facilities. The core chapters (6 through 11) retain this focus. However, in preparing this book, we recognized an opportunity to broaden the scope by including BMPs for other important environmental impacts. Although the primary emphasis of the core chapters is on waste management, we include consideration of BMPs for disease management (in Chapter 12) and for site selection, escaped fish, predator control, and facility management, among others. The book also includes chapters on BMP development and implementation, economics of aquaculture BMPs, and BMPs for shrimp and shellfish aquaculture—all of which were absent from the USEPA white paper. We round out coverage of the topic by including appendixes that provide guidelines for monitoring programs, chemical use, and species introductions and transfers for aquaculture, among others.

Ultimately, this is a book about farm-level technical solutions. We decided very early to avoid participation in the debate about environmental issues associated with aquaculture development. Review of these issues in Chapter 1 and discussions scattered throughout the other chapters are limited to what is needed to provide context for the management practices that are the core of the book. Our decision to approach the subject in this manner was based on what we perceived to be an imbalance in the literature dealing with aquaculture and the environment. The voluminous and expanding literature on environmental impacts is not matched by a corresponding body of literature providing solutions to those problems. Those solutions are rooted in practice and in policy. This book emphasizes what we consider to be the current better farm-level practices. Although publication of this book "fixes" those practices, Jason Clay, in Chapter 2, warns that improvement must be a continuous process. As such, BMPs are best conceived as an approach—as exemplified by descriptions of current better practices—but should not represent an end unto itself, only a transitional phase to further improvement. Although many of the book's authors have experience in the policy arena, the path of policy-based solutions does not easily lend itself to generalization, and we have deliberately chosen to emphasize practices that can be implemented by large-scale or small-scale producers to improve environmental performance, with corresponding improvements in the overall sustainability of aquaculture. Despite their importance to sustainable aquaculture, we chose not to include better practices that address social impacts of aquaculture, which are often grouped with environmental impacts by critics of aquaculture. Similarly, food safety concerns are not explicitly addressed in this book, although these too have been emphasized by critics and the media as an important environmental issue. Finally, this book does not provide specific technical guidance for development of aquaculture at the sectoral or regional level—again, because these are matters of policy.

This book has been difficult to edit and we feel sure that our contributors would agree that the chapters were difficult to write. Although this book was the outgrowth of a narrowly defined project, it was developed and written against a backdrop of rapid and ongoing changes in global and national aquaculture. As our expectations for the book

evolved over time, we asked our contributors to aim at a constantly elevating set of targets with respect to scope and depth of coverage. We appreciate the patience of our colleagues, all of whom probably feel that this was considerably more work than they originally agreed to.

We are grateful to all those involved in producing this book. Our contributors showed tenacity and patience, and we are proud of the collective body of work they ultimately produced. Gary Jensen deserves particular acknowledgment as the coordinator and facilitator of the original USEPA white paper, upon which this book is based. Further, Claude Boyd was instrumental in developing the concept of this book during a series of discussions in early 2005. We could easily justify including him as an editor, but we'll let his contribution to five chapters speak for his global influence on the topic of this book. We owe special debts of gratitude to Susan Kingsbury and Danny Oberle of Mississippi State University. Susan read and helped us improve each chapter manuscript and Danny was responsible for collecting, editing, and improving the quality of the photographs submitted by the contributors.

Craig Tucker and John Hargreaves

United States Aquaculture Society Preface

The United States Aquaculture Society (USAS) is a chapter of the World Aquaculture Society (WAS), a worldwide professional organization dedicated to the exchange of information and the networking among the diverse aquaculture constituencies interested in the advancement of the aquaculture industry, through the provision of services and professional development opportunities (source: U.S. Aquaculture Society website: www.was.org/Usas/Default.htm). The mission of the USAS is to provide a national forum for the exchange of timely information among aquaculture researchers, students, and industry members in the United States. To accomplish this mission, the USAS will sponsor and convene workshops and meetings, foster educational opportunities, and publish aquaculture-related materials important to U.S. aquaculture development.

The USAS membership is diverse, representing researchers, students, commercial producers, academics, consultants, commercial support personnel, extension specialists, and other undesignated members. Member benefits are substantial and include issue awareness, a unified voice for addressing issues of importance to the United States aquaculture community, networking opportunities, business contacts, employment services, discounts on publications, and a semi-annual newsletter reported by regional editors and USAS members. Membership also provides opportunities for leadership and professional development through service as an elected officer or board member, chair of a working committee, or organizer of a special session or workshop, special project, program, or publication, as well as recognition through three categories of career achievement (early career, distinguished service, and lifetime achievement). Student members are eligible for student awards and special accommodations at national meetings of the USAS and have opportunities for leadership through committees, participation in Board activities, sponsorship of social mixers, networking at annual meetings, and organization of special projects.

At its annual business meeting in New Orleans in January 2005, the USAS, under the leadership of President LaDon Swann, voted to increase both the diversity and quality of publications for its members through a formal solicitation process for sponsored publications, including books, conference proceedings, fact sheets, pictorials, hatchery or production manuals, data compilations, and other materials that are important to United States aquaculture development and that will be of benefit to USAS members. As aquaculture becomes increasingly global in scope, it is important for USAS members to gain an international perspective on the reasons for successful aquaculture developments at home and abroad. *Environmental Best Management Practices for Aquaculture* will provide technical guidance to improve the environmental performance of aquaculture. The book addresses

development, implementation, and economics of BMPs for specific aquaculture production systems in the United States but utilizes principles that can be applied globally. Written by internationally recognized experts in environmental management and aquaculture, this book will be a valuable reference for those involved in all aspects of the aquaculture industry.

Through collaboration with Wiley-Blackwell on book projects such as these, the USAS Board aims to serve its membership by providing timely information through publications of the highest quality at a reasonable cost. The USAS thanks the editors Craig Tucker and John Hargreaves for donating royalties, which will help provide benefits and services to members and to the aquaculture community, and Justin Jeffryes (Wiley-Blackwell) for his cooperation. The USAS Publications Committee members include Drs. Wade O. Watanabe (Chair), Jeff Hinshaw, and Jimmy Avery, with Ted Batterson and Jimmy Avery as immediate past and current Presidents, respectively.

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Environmental Best Management Practices for Aquaculture

Chapter 1

Aquaculture and the Environment in the United States

Craig S. Tucker, John A. Hargreaves, and Claude E. Boyd

The Global Demand for Fishery Products

> . . . the animals which live in the watery depths, above all in ocean waters . . . are protected against the destruction of their species at the hand of man. Their reproductive rate is so large and the means which they have to save themselves from his pursuits or traps are such that there is no evidence that he can destroy the entire species of any of these animals.
>
> Jean-Baptist de Lamarck (1908)

The oceans have historically been seen—and exploited—as an inexhaustible supply of food for human use. This perception, coupled with the concept of open access to that common resource pool, set the stage for ecological disaster. That disaster—in the form of a general collapse of commercial marine fisheries—either looms or has already become reality (see, for example, Pauly et al. 2002, 2003; Myers and Worm 2003; Caddy and Surette 2005; Worm et al. 2006). Persistent fisheries stock declines since the 1980s have been caused by a combination of factors, including increased industrial-scale fishing effort, advances in fishing technology, destructive fishing practices, and fishery management policies dictated by short-term economic interests. The result is that the number of fully exploited or overexploited stocks of marine fish is high and increasing, and the global potential for marine capture fisheries has been reached (FAO 2004c, 2006b).

Marine fisheries catch increased rapidly from 1950, reaching a peak of 80 to 85 million tonnes/year in the late 1980s. Since then, catch has been steady or even declining when corrected for presumed overreporting by China (Watson and Pauly 2001). Inland capture fisheries add about 8 to 9 million tonnes annually, bringing the total world catch from capture fisheries to about 90 million tonnes in 2003. About 30 million tonnes of the 2003 world fisheries catch was destined for nonfood uses—primarily reduction to fishmeal and fish oil for use in animal feeds. Therefore, approximately 60 million tonnes of fishery products destined for human consumption were extracted from world capture fisheries in 2003 (FAO 2004c).

Over the period 1990 to 2003, when foodfish output from capture fisheries was, at best, stagnant, global consumption of edible fishery products tripled to nearly 105 million tonnes annually. The difference between the nonexpanding supply from capture fisheries and the rapidly expanding demand was derived from aquaculture—farming aquatic plants and

animals in oceans and inland waters. In 1980, world aquaculture production (excluding plants) was approximately 5 million tonnes, which was approximately 7% of total world foodfish supply. In 2004, nearly 46 million tonnes of fish and shellfish were produced in aquaculture (FAO 2006b), representing almost half of global foodfish production. The annual rate of increase in aquaculture production since 1980 has been approximately 10%, which is faster than that for any other animal food producing sector (FAO 2006b).

Population growth, rising per capita incomes, urbanization, and increased appreciation of the role of seafood in human health will continue to increase the global demand for seafood. Capture fisheries must provide a large part of the world's supply of fish and shellfish, but dramatic changes are needed to assure that marine resources are managed sustainably. Oceans must be protected from environmental degradation caused by pollution and global climate change, and marine fisheries must be managed intelligently to restore and maintain the oceans' biodiversity and ecological integrity. Current "best-case" scenarios for fisheries management indicate, however, that it will not be possible to increase marine fisheries landings past levels obtained in the 1980s (Pauly et al. 2003). Aquaculture must therefore continue to expand to meet any increase in demand for fishery products (FAO 2004a).

The Changing Face of Aquaculture

Aquaculture evolved thousand of years ago as an activity with origins and goals similar to other animal husbandry activities. That is, methods were developed to provide animal protein when local human population growth or overexploitation of accessible wild populations made it difficult to obtain food by hunting—or fishing, in the context of aquaculture. Simple but elegant fish culture systems were developed in Asia that in many ways resembled natural aquatic systems in their fundamental ecosystem dynamics. For thousands of years aquaculture was practiced as a relatively low-input activity and was seen as a beneficial or, at worst, benign endeavor that provided high-quality animal protein for families or local communities. Much of current aquaculture remains rooted in these ancient practices. Countries in Asia and the western Pacific region presently account for approximately 90% of the world aquaculture production, and much of that activity is based on pond aquaculture of grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molotrix*), bighead carp (*Aristichthys nobilis*), and common carp (*Cyprinus carpio*)—the same species raised in traditional pond aquaculture in China thousands of years ago. In fact, freshwater pond culture of cyprinids for local consumption accounts for almost a third of global aquaculture production, including plants (FAO 2006b).

As aquaculture production rapidly increased in the last half of the 20th century, culture methods and technologies evolved in response to profit incentives and encouragement from aquaculture development agencies. In many instances, the goal of supplying food for local consumption changed to that of producing higher-value products for export. Associated with this trend was the use of culture practices with higher rates of resource use and greater environmental impacts than traditional aquaculture methods. The rapid expansion of aquaculture development occurred during a time of heightened environmental awareness and advocacy, and well-publicized problems in certain sectors led to closer scrutiny of aquaculture in general.