



Aquaculture

Many people are now pointing to the farming of fish, shellfish and aquatic plants as the solution to the world's food problems. These people note that there are several advantages of water as a growth medium. For instance, aquatic animals can convert more of their food into growth since most of them do not need to support their weight. Most fish do not spend energy to regulate their body temperature. In addition, water is a three-dimensional growing space, so yields per unit area can be quite high when compared to land-based farming.

These advantages have given aquaculture the label of an "appropriate technology." But just as solar energy technology can include solar-paneled satellites beaming microwave energy to earth, so aquaculture can be approached from a number of technological starting points. Many appropriate technology aquaculture groups in the United States are working with extremely high densities of organisms in recirculating water systems. Some examples of these "intensive" designs are basement fish tanks, backyard fish farms, dome ponds and greenhouse ponds. Most of these require careful biological monitoring and management (because a small problem in the system can kill all of the fish), and the economics are not yet acceptable.

While the work is certainly important to our urban areas, where little space is available, the high capital and material requirements of such aquaculture strategies make them much less relevant to the developing countries. In fact, many people are convinced that the key to large-scale aquaculture development in the United States as well lies in the enormous potential of farm ponds and reservoirs used for irrigation, fire protection, recreation, livestock watering, etc. Throughout the world, these unused or poorly managed lakes, ponds, streams and rivers represent a vast resource of harvestable waters. At the same time, they are subject to a wide variety

of other uses. As we manage these water resources, our goal must be expanded from short-term production to long-term stewardship which integrates all potential needs. There are many examples of aquaculture which include sewage treatment, mosquito control and aquatic weed control. And aquaculture can play a major role in the maximization of traditional fisheries through spawning and ranching techniques—many coastal and inland fisheries are the best producers of cheap protein because the fish raiser does not have to supply the feed.

*The following selections partially reflect these views. Much work remains to be done. If you are trying to decide what growing fish might be like, choose between **Fish Culture in Central East Africa** (the most extensive), **Freshwater Fish Pond Culture and Management**, and **Elementary Guide to Fish Culture in Nepal**. The remainder of the selections cover specific topics in aquaculture and fishing with small booths.*

Freshwater Fish Pond Culture and Management, MF 09-313, book, 191 pages, by Marilyn Chakroff, Peace Corps/VITA, 1976, free to Peace Corps volunteers and development organizations from Peace Corps, others may obtain it for \$12.00 (overseas orders add \$3.00 for surface mail, \$5.00 for airmail) from VITA; also available from ERIC (order no. ED242565), NTIS (accession no. PB85 239994/AS), ITDG, and TOOL.

The Peace Corps has done a lot of aquaculture work in different parts of the world. Several good local manuals were written in the past by their Indian branch. This latest publication integrates all the freshwater aquaculture projects, with the emphasis on warmwater species of fish. It is introductory in nature, aimed at an audience which did not like math or science in high school. Good illustrations complement the clearly written text. The contents cover the basic subjects important to a fish farmer: why grow fish, pond site selection, planning, construction and sealing, water chemistry and fertilization, fish spawning, stocking, feeding, harvesting, preserving and diseases.

"**Freshwater Fish Pond Culture and Management** is a how-to manual. It is designed as a working and teaching tool for extension agents. It is for their use as they establish and/or maintain local fish pond operations. The information is presented here to 1) facilitate technology transfer and 2) provide a clear guide for warm water fish pond construction and management. A valuable listing of resources at the end of this manual will give further direction for those wishing more information on various aspects of fish pond operation." In fact, the resources section is practically impossible to use. It is not at all integrated into the subjects in the text, and most of the references are only available to those with access to excellent libraries. This is the only failing of an otherwise good book.

Fish Culture in Central East Africa, MF 09-312, book, 158 pages, by A. Marr et. al., 1966, available from TOOL; 1979 edition \$15.00 from UNIPUB.

Of these general "how-to" manuals, this is our favorite. More than any of the other manuals, it emphasizes the economic and ecological constraints which demand flexibility by fish farmers. Besides a good summary of the essentials of fish pond management, there is an excellent chapter on growing fish in lakes, reservoirs and seasonal farm ponds. The combination of fish farming and other branches of agriculture is also stressed.

The book has a definite regional focus. Tilapias native to Africa are the only

fish considered. Nevertheless, many of the ideas would be applicable in other areas. For instance, three aquacultural practices of wide interest are discussed: the polyculture of ducks and fish, the use of other animal manures as fish food and fertilizer, and the culture of fish in irrigated paddies. Fish such as carp or non-herbivorous tilapia can be stocked any time after the rice has rooted in paddies having a water depth of 30-40 cm or with 10-15 cm of water over the central rice growing area surrounded by a 11/2 m-wide trench, 70 cm deep.

A glossary and 73 illustrations make the text easier to follow, but the last two chapters on biological production and fish biology are a bit dense.

Elementary Guide to Fish Culture in Nepal, MF 09-310, book, 131 pages, by E. Woynarovich, 1976, FAO, out of print.

"**Elementary Guide to Fish Culture in Nepal** is designed for practical use in the training of extension workers and progressive fish farmers in the techniques of fish culture." This FAO publication emphasizes the culture and polyculture of the common carp, *Cyprinus carpio*, Chinese carps and Indian carps. In addition to the usual discussion of pond construction, management and harvest, there is a chapter on the biological background of fish production which includes information more sophisticated than is necessary for the successful management of a pond. There is also a good section on the food value of various feeds made from agricultural by-products.

Don't be fooled by the word "elementary." While the book includes many simple illustrations, the author's attempt to cover all ecological processes very briefly can be confusing to someone who does not already know about them.

Freshwater Fisheries and Aquaculture in China, Fisheries Technical Paper No. 168, MF 09-314, book, 84 pages, by D.D. Tapiador, H.F. Henderson, M.N. Delmendo, and H. Tsutsui, 1977, FAO, out of print.

China accounts for more than half the world's fish production, yet very little was known about its aquaculture efforts until the visit of the FAO mission in 1976. "The particular forms of fish culture practiced in China may not be directly applicable in many countries, particularly outside Asia. But the perspectives of Chinese fish farmers on self-reliance and on the interdependence of aquaculture, agriculture and animal husbandry, and their familiarity with fish and fish behavior under conditions of intensive culture, make their experience most valuable elsewhere."

"It seemed particularly significant that all of the major inputs, such as feed, fertilizer and fish seed, are produced within the farm The use of organic fertilizers and locally-produced feed materials is especially to be recommended for most of the developing countries. Unfortunately, the latter have often elected to adopt commercial fertilizers and feeds simply because it is the practice in the developed countries."

Many people talk about making full use of water resources, recycling wastes and decentralizing planning decisions. In China they do it on a scale that produces four million tons of fish annually.

Freshwater Fish Farming: How to Begin, Better Farming Series No. 27, MF 09-324, booklet, 43 pages, FAO, 1979, \$3.00 from FAO or \$5.00 from UNIPUB.

This is a good, simple introduction to fish farming. Rudimentary information is given on building, filling, fertilizing and stocking the fish pond, care of fish and pond, and harvesting. Those undertaking fish culture will need to consult an extension agent or other publications listed in the **Sourcebook** for further details on many of these topics. Written in easy English with good illustrations.

Better Freshwater Fish Farming: The Pond, Better Farming Series #29, MF 09-322, booklet, 43 pages, FAO, 1981, \$3.00 from FAO or \$5.00 from UNIPUB.

This book was written for fish farmers with simple operations who wish to expand their fish ponds. It is assumed that the farmer has built his or her first pond using **Freshwater Fish Farming: How to Begin** (from this series). However, we feel this would be a good book for the beginner to read before building the first pond. Includes information on site selection and construction details. Clearly written in simple English and well-illustrated.

Better Freshwater Fish Farming: The Fish, Better Farming Series Booklet #30, MF 09-323, booklet, 48 pages, FAO, 1981, \$7.50 from UNIPUB.

Another booklet in the Better Farming series, this one with basic advice on raising, feeding, and harvesting the fish in ponds. Well-illustrated with text in simple English. Due to the biological complexity of fish ponds and the hazards of disease among fish populations, this booklet is probably of most value as a supplementary reference for fish farming promotion programs. Portions of the booklet can easily be adapted and left with farmers.

Aquatic Weed Control, book, 154 pages, by Chris Seagrave, 1988, £13.20 postpaid from Fishing News Books, 1 Long Garden Walk, Farnham, Surrey GU9 7HX, United Kingdom.

When aquatic plants become too numerous in a stream or a pond, they can begin to cause problems, and the issue of how to control them arises. This manual was originally written for the U.K., Northern Europe and the U.S.A., and the last third of the book is devoted to identification of the types of plants that can be found in those places.

Readers in other parts of the world will find the material on mechanical, environmental, and biological control to be more universally applicable, while chemical weed control is for the most part to be avoided. Mechanical control includes both handtools and mechanical devices to cut the weeds; the chain scythe (see illustration) is perhaps the most widely applicable intermediate technology for this task. Environmental control involves controlling the light, depth of the water, and access to nutrients. Biological control involves the use of certain species of fish, such as grass carp, common carp, silver carp and crayfish.

Making Aquatic Weeds Useful: Some Perspectives for Developing Countries, MF 09-315, book, 175 pages, by National Academy of Sciences, 1976, \$8.50 from BOSTID, HA-476E, National Academy of Sciences, 2101 Constitution Avenue N.W., Washington, D.C. 20418, USA; also available from TOOL.

Aquatic weeds present serious problems to public health, fisheries production, water quality and navigation in the tropics, where they grow most

prolifically. "This report examines methods for controlling aquatic weeds and using them to best advantage, especially those methods that show promise for developing countries. It emphasizes techniques for converting weeds for feed, food, fertilizer and energy production. It examines, for example, biological control techniques in which herbivorous tropical animals (fish, waterfowl, rodents and other mammals) convert the troublesome plants directly to meat."

The major sections of this book focus on harvesting aquatic weeds either by herbivores, which themselves can be harvested (e.g. grass carp, manatees, crayfish, ducks and geese), or by machines with additional treatment and processing. Throughout the book, the emphasis is on aquatic weeds as a resource rather than a nuisance.

Fishery Development Experiences, book, 160 pages, by W.H.L. Allsopp, 1985, £14.95 from Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey GU9 7HX, United Kingdom.

The author reports on a number of interesting projects to improve fisheries in various ways. These include upgrading support services for artisanal fisheries in the Red Sea, motorizing fishing canoes in West Africa, training for small boat construction in Latin America, credit for marine fishing and aquaculture in Southeast Asia, and others.

Catalogue of Small-Scale Fishing Gear, book, 223 pages, FAO, second edition, 1987, £17.60 from Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey GU9 7HX, England.

This remarkable book "deals especially with small-scale fisheries using gears operated from the shore or from small boats in coastal or inland waters. Maximum size of fishing vessels included in this catalogue is approximately 15m length overall, with an engine power of not more than 150 h.p. or 110 kW."

"... This catalogue is by no means an exhaustive list of all existing types of fishing gear; it merely covers a limited, though quite representative, selection of the main types of gear that have proved profitable in commercial fisheries ... confined ... to gear made from conventional materials, i.e. nets, ropes and lines, whereas miscellaneous gear such as harpoons, grappling tools and harvesting machines, as well as gear made from unconventional materials such as boughs, bamboo, rattan, etc., have been excluded because their local variations are too numerous." (See **Fish Catching Methods of the World** for more coverage of traditional techniques.)

"It is ... hoped that this fairly wide range will enable users to select more efficient gears, adapting them where necessary to the fishing conditions usually encountered. Furthermore, because of the different sources of gear, used in both developed and developing countries, the reader will find new ideas or general principles here, on the basis of which he will improve or adapt his own traditional gear."

The collection consists of line drawings with technical terms in English, Spanish and French. The technical details of net construction are provided. The major topics are surrounding nets, seine nets, trawls, dredges, liftnets, falling gear, gillnets, traps, hooks-and-lines, and scoop-nets.

Fishing with Bottom Gillnets, FAO Training Series 3, MF 09-325, booklet, 39 pages, by I. Rosman, 1980, from FAO.

A heavily illustrated manual for use by fishers to make their own bottom-set gillnets and use them effectively. These nets are placed along the bottom and held down with weights. This booklet will be most useful to people who already use other kinds of nets.

Pair Trawling with Small Boats, FAO Training Series 1, MF 09-326, booklet, 77 pages, by H.S. Noel and M. Ben-Yami, 1980, from FAO.

Pair trawling with small boats uses less energy and smaller engines than single-boat trawling with the same sized nets. Thus it represents an interesting choice of technology for fishers who can't afford larger boats.

Well-illustrated instructions are provided on how to make the trawlnets, as is advice on how to use the nets effectively with very small boats and engines as small as 5hp.

Profitable Cage Culture, MF 09-317, booklet, 30 pages, by Gregor Neff and Paul Barrett, 1979, \$4.00 to U.S., Canada, or Mexico, \$5.00 elsewhere, from Inqua Corporation, P.O. Box 86, Dobbs Ferry, New York 10522, USA.

This is the most in-depth summary of the hows and whys of cage culture available — in part a publicity promotion for their brand of plastic mesh cages. If you keep in mind that indigenous materials can be used for the cage mesh and framing and you have access to alternative feeds, then cage culture can add to your fish raising options. **Profitable Cage Culture** can give you hints on stocking, harvesting and managing your cages.

Cage Aquaculture, book, 352 pages, by Malcolm Beveridge, 1987, £21.00 from Fishing News Books, 1 Long Garden Walk, Farnham, Surrey GU9 7HX, United Kingdom.

Here is a welcome book on cage aquaculture, a small-scale technology that is growing in popularity around the world. Cages allow the fish farmer to take advantage of the energy and nutrient flows in natural bodies of water while retaining control of the fish.

The initial chapters "deal with the origins and principles of cage aquaculture, its advantages and disadvantages, bringing out the differences between traditional cage aquaculture and modern cage fish farming, whose growth is a phenomenon of the 1970s and 80s. Then follow detailed chapters on practical aspects of cage construction and factors affecting design and materials; the criteria for site selection in marine, freshwater and heated water environments; a review of the processes for evaluating carrying capacity."

"Next comes a substantial chapter on such management aspects as stocking densities, feeds and feeding, monitoring water quality, fish husbandry and maintenance of cages and gear. Many potential problems arising from environmental factors or predators are aired, with hints on prevention or mitigation."

"Finally, the author examines a selection of cage farming industries—some included as being economically important and others for their innovative features. Those chosen are: yellowtail farming in Japan, Atlantic salmon farming in Scotland, tilapia farming in the Philippines, whitefish farming in Northern Europe, and tiger prawn farming in the Indo-West Pacific."

There are numerous photos and drawings of equipment throughout.

Aquaculture publications from New Alchemy Institute, P.O. Box 432, Woods Hole, Massachusetts 02543, USA. While this group's publications are reviewed elsewhere, certain articles merit special attention by prospective fish farmers. Journals 1-4 are out of print.

1) "Midge Culture," by W. McLarney, J. Levine and M. Sherman, Journal 3 (MF 0280), on pages 80-84.

Providing cheap sources of natural protein for fish feed is one way to speed their growth. Bug lights will collect protein-rich insects. An alternative is to raise the larvae yourself. This article tells you how.

2) "A New Low-Cost Method of Sealing Fish Pond Bottoms," by W. McLarney and R. Hunter, Journal 3 (MF 02-80), on page 85. Also found in **Book of the New Alchemists** (see review).

Various methods have been used to seal the bottoms of ponds to allow them to hold water, but most methods are expensive. Here the authors describe a virtually cost-free method using layers of manure and other farm wastes to create an anaerobic zone impenetrable to water.

3) "Cultivo Experimental de Peces en Estanques," Journal 3 (MF 02-80), on pages 8690. Also reprinted in **Book of the New Alchemists**.

This is a translated excerpt from a paper by Professor Anibal Patino R. which presents a plan for tropical aquaculture. For information on obtaining the original paper (in Spanish), write Cespedesia, Jardin Botanica del Valle, Apartado Aereo 5660, Cali, Colombia.

4) "Cage Culture," by William McLarney, Journal 4 (MF 02-81), on pages 77-82.

Growing fish in floating cages is a traditional technique in Southeast Asia and of recent interest in the U.S. This article describes the reasons and methods for building and stocking cages. It also describes some of the pitfalls.

Fish Catching Methods of the World, MF 09-311, book, 432 pages, by Andres von Brandt, 3rd edition 1984, £35.00 from Fishing News Books, Blackwell Scientific Publications Ltd., Osney Mead, Oxford OX2 OEL, England.

This book is a testimony to the ingenuity of fishers in their invention of an astounding variety of fishing gear and techniques to meet different environmental, economic and social requirements. While basically a scholarly treatment of the principles of fishing technology, its comprehensive discussions of both commercial and subsistence technologies present a fascinating tale to the lay reader. Of particular interest are the chapters on fish hooks, traps and nets. The potential utility of this book lies in the large number and variety of methods it presents.

Raising Fresh Fish in Your Home Waters, MF 09-318, pamphlet, 34 pages, by B. Bortz, J. Ruttle and M. Podems, 1977, Barebo, Inc., out of print.

For the reader new to the idea of raising fish, this booklet is useful as a brief introduction to many of the topics of concern to a fish farmer. The central section, "A Catalog of Fish," is a nice collection of the water quality tolerances and

preferences of the major fish cultured in the U.S. While the pamphlet is written for the North American fish farmer, the sections on pond management are of general interest.

Practical Shellfish Farming, MF 09-316, book, 91 pages, by Phil Schwind, 1977, International Marine Publishing Company, out of print.

This easy-to-read book tells how to grow shellfish along the northeast coast of the United States. Consequently, it looks at the question of local regulations more deeply than would be appreciated by those living in other areas. The lively writing makes these few dull pages barely noticeable. The book's strength is its discussion of the management of bottom areas or rafts for maximizing shellfish growth. It lacks a good review of the physical characteristics, which influence where shellfish larvae will settle, and imaginative ways to collect these settled larvae.

Tropical Oysters: Culture and Methods, MF 09-320, book, 80 pages, by D.B. Quayle, 1980, IDRC, out of print.

"Bivalve shellfish such as oysters, mussels, and clams are very widely distributed throughout the world and have long enjoyed a high consumer preference and market value in temperate climates. The change of techniques from bottom cultivation to off-bottom or suspended cultures has contributed to considerably increased production in many countries. However, in general, production from tropical countries has been traditionally very limited even though bivalves flourish and reproduce abundantly in warmer climates. In such tropical countries, native oysters are often harvested for subsistence and rural fisheries. They are not a luxury item.

"Only comparatively recently have there been serious attempts at oyster cultivation, but where favourable conditions exist, rapid growth has been observed and marketable oysters are obtained in nine months."

This book provides a good introduction to the methods and considerations for raising oysters in the tropics.

Aquaculture Practices in Taiwan, MF 09-308, book, 146 pages, by T.P. Chen, 1976, Fishing News Books, Blackwell Scientific Publications, United Kingdom, out of print.

T.P. Chen has provided a sampling of Taiwan's aquacultural practices for 29 species of animals including turtles, frogs, fresh and saltwater clams, shrimp and eighteen species of fish. The major emphases are on milkfish, eels and Chinese carps with a wealth of production statistics and economics. This book is the best source of information on the culture of snakehead (*Ophiocephalus*), walking catfish (*Clarias*), mud skipper (*Boleophthalmus*), *Corbicula* clams, and the seaweed *Gracilaria*.

Publications, Department of Fisheries and Allied Aquacultures, Swingle Hall, Auburn University, Auburn, Alabama 36849, USA.

This is the most comprehensive collection of publications concerning the culture of freshwater, warm water fishes. While many of these articles have appeared in scientific or trade journals, most of them would not be difficult for the

nonprofessional to understand. Topics include aquatic ecology and marine biology, aquatic plants, baits and minnows, commercial fish production and aquaculture, farm pond management, fishery biology and population dynamics, fish feeds, fish food habits and nutrition, and water quality and waste management.

Foremost among the 300 available papers is H.S. Swingle's classic "Biological Means of Increasing Productivity in Ponds," in which he discusses use of efficient pond fish, polyculture species combinations and stocking rates, control of reproduction, and increasing production of fish food organisms. Swingle's successful combination of pond ecology with aquaculture has been unmatched and will be the key to future development of appropriate technology in aquaculture.

Auburn also has an international branch for aquacultural development in conjunction with USAID. Some of the publications from these groups would be of local interest to those people living near the various projects in El Salvador, Brazil, Colombia and the Philippines.

The Israeli Journal of Aquaculture: Bamidgeh, quarterly magazine, since 1948, \$20 per volume (add \$4.00 for airmail), make checks payable to Fish Breeders Association in Israel, from Bamidgeh Editorial Office, Nir-David 19150, Israel.

Now published in a separate English edition, **Bamidgeh** presents the results of Israeli research in pondfish culture. In recent years, their semitropical systems have centered on carp, mullet and tilapia. Although some of the articles are extremely complex, using sophisticated engineering and ecological analysis, many show practical techniques and equipment that can be useful in other countries. The Israeli communes have never been wealthy, so the scientific approach is based on intermediate-level technology, using a maximum of ingenuity and energetic labor.

The topics covered in this magazine are usually strategies for efficient fish production, such as pest control, safe use of manure fertilizers/feeds, and various species combinations in ponds. This is a magazine for those actually engaged in fish culture, who may want to use agricultural wastes for fish food, culture insect larvae for the same purpose, or start a selective-breeding program to reduce the number of bones in a fish. Particularly interesting recent research has been in all-male hybrids of tilapia, cage culture of carp, and comparison of low-cost aeration systems. If for no other reason, practicing fish culturists might consult **Bamidgeh** to appreciate the value of good recordkeeping journals. Subject indexes are published each year for easy reference.

Salmon Rancher's Manual, MF 09-319, book, 95 pages, by William McNeil and Jack Bailey, 1975, University of Alaska, free from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Washington, D.C., USA.

"The North Pacific Ocean is a vast nursery ground for the Pacific salmon that spawn in streams and lakes in North America and Asia. These salmon reproduce in fresh water, but most of their growth occurs at sea. When mature, they return to their freshwater ancestral spawning grounds, where tens of thousands of genetically-separate stocks segregate for reproduction."

In the past, growing salmonid fishes has required a capital investment beyond the means and interests of most groups. But the chemical imprinting of young fish so that they will return to the hatchery area to spawn after several years in the wild reduces the obstacle of their carnivorous habits. Fish can be spawned, hatched, raised and released from a hatchery to increase their chances of survival. While feeding at

sea (or, in the case of steelhead rainbow trout, in a lake), the fish convert protein unavailable to humans into animal flesh; hence the comparison to range cattle and the term "ocean ranching."

"Production of healthy fry is the 'core' of any salmon aquaculture system because the success of ocean ranching will depend largely upon the quality of juvenile fish released into the ocean. The primary purpose of this manual is to assist salmon ranchers with planning, constructing, and operating systems for artificial propagation of salmon fry."

Artificial Salmon Spawning, MF 09-309, pamphlet, 21 pages, by William Smoker and Curtis Kerns, 1978, free from Marine Advisory Program, University of Alaska, 3211 Providence Avenue, Anchorage, Alaska 99504, USA.

"This manual is designed primarily for the aquaculturalist who is just getting started (It includes) procedures that are least likely to go wrong for the novice egg-taker. Not all have been scientifically tested. But where they have been used, incubators have been filled with live eggs."

ADDITIONAL REFERENCES ON AQUACULTURE

The Book of the New Alchemists describes the Ark, with its indoor fish tanks; see GENERAL REFERENCE.

Permaculture II includes fish ponds in its plan for ecologically-sound development; see AGRICULTURE .

How to Salt Fish and Small Scale Processing of Fish; see CROP STORAGE.

Aquaculture: A Component of Low-Cost Sanitation Technology can be found in the sanitation section of WATER SUPPLY AND SANITATION.

Books on small boat design and construction are found in TRANSPORTATION.