

FARMING THE EDGE OF THE SEA

E S IVERSEN



The Author

Now one of the group of senior professors at the famous Institute of Marine Science, University of Miami, Florida, E. S. Iversen, author of this book, was born in 1922 in Ferndale, Michigan, U.S.A. He first studied fish diseases at the Fish and Wildlife Service Disease Laboratory in Seattle, Washington. Next he gained experience in Hawaii with the same Service's Pacific Ocean Fisheries Investigations. As a research biologist he participated in cruises round Hawaii and the Central Pacific gaining intimate knowledge of the distribution, abundance and biology of tuna and related species. During research at Kodiak Island and various parts of South Eastern Alaska he investigated the spawning population and migration routes of salmon and the physical and chemical factors affecting the survival of salmon eggs and larvae.

At the University of Washington, Seattle, he took the degrees of B.S. and M.S. and in 1961 became a Ph.D. in Biological Oceanography from Texas A. and M. University. His special research interests and teaching cover the fields of protozoan parasites, population dynamics and general marine and coastal fishery biology. He is on the Board of the American Fisheries Society, is a member of the Institute of Fishery Research Biologists and the American Society of Ichthyologists and Herpetologists.

To revise and up-date this work for its second edition and cover all advances made over the last ten years he took nearly a year's special leave to travel widely and personally investigate special developments and research. Much new material and many pictures of modern developments are incorporated and all reference material has been supplemented from modern literature and achievements so that the work is completely updated at time of issue.

Farming the Edge of the Sea

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Foreword to First Edition

More than half of the surface of planet Earth is buried beneath a mile depth of seawater. The surface of this water receives the major part of the solar radiation reaching the earth and is thus potentially capable of providing a great deal more food than the land itself. It seems appropriate, therefore, that we give serious attention to the possibilities of increasing our exploitation of the living resources of the ocean. At the very least, we should give to this task the amount of finances, scientific manpower and thought that we are currently giving to outer space exploration, a dubious venture that promises relatively little scientific return and no useful resources, but merely the superficial satisfaction of competing for prestige.

In the exploration of inner space we must not be led into the same wild adventures that characterize the outer space effort. Rather, we should continually re-examine the imaginative dreams of large-scale sea farming, fish husbandry and the like, in the light of our advancing knowledge. This does not mean that we should curb our imagination. It means that we must try to reduce the products of imagination to practical workable schemes. Dr. Iversen has done well to produce a book which brings us back to earth.

F. G. WALTON SMITH

Preface to First Edition

In my work at the University of Miami Institute of Marine Sciences, I receive many inquiries about sea farming. Is sea farming practical? Can I make money at it? Where can I get information on sea farming? How can I prepare myself for such a venture? How much would it cost to get set up in business as a sea farmer? People in all walks of life, most of whom are engaged in businesses totally unrelated to the sea, and corporations interested in product diversification, are asking these questions. My experience with such queries is not unique. The same questions are being asked, with increasing frequency, at the governmental fishery laboratories in the United States and doubtless in most countries throughout the world.

This book is an attempt to answer these questions. It is not a handbook, nor a 'how-to' book. It reviews important principles of sea farming for anyone who is interested in general works on the sea. More important, it will help those readers who have more specific interests to determine, for instance, what their chances for success in fish farming are after taking into account their qualifications and financial resources. In addition, for more detail, the reader is directed to specialized books and reports. Marine and brackish water algae, molluscs, crustaceans, and fishes presently being cultivated are discussed, including important facts about their life histories, and their suitability for farming is evaluated.

This volume emphasizes farming activities in the developed nations in temperate and subtropical waters of the Northern Hemisphere. Significant differences exist between the temperate and tropical zones in factors affecting sea farming, such as economic conditions, species available for farming, and climate. Increasing food production is important in both the wealthy and the developing nations. In the wealthy nations, demand for more variety in diet develops as wealth increases and as education, incentive, and technical knowledge improve living standards. In poor countries, there is quite a different problem—the production of badly-needed, inexpensive protein food. In these developing countries extensive economical and social studies are required, first, to stimulate a demand for seafood, second, to determine how best to produce it, and finally, how to arrange for its distribution. In the wealthy nations the avenues for distribution already exist, but the application of recent technological

advances to supply this demand with an improved product is needed. Too, the demand (which is already high) may be greatly increased by promotion.

Another striking difference between sea farming in temperate and tropical areas is the availability of land and land values. In the wealthy countries there is an ever-increasing demand for salt marshes to be used for housing, industrial development, and recreation; consequently, land values are high. In some regions, land is so expensive that almost any farming scheme involving use of estuarine areas is doomed to failure unless profits are high. In the undeveloped countries, however, where the land value of estuaries is low, ventures in sea farming that produce even small profits can and do succeed.

Discussion is further restricted to estuaries and near-shore waters, as opposed to deep, offshore waters, because it is in these former areas where most sea farming is being practised and where immediate future potential exists.

I have emphasized the biological aspects of sea farming. I am not an economist, and the general observations on this aspect should be evaluated accordingly.

As an aid to the non-scientist, some of the specialized terms used are defined in the glossary. Conversions from the metric system to the English system are approximate.

Experts have been most helpful by reading portions of this manuscript and offering comments and criticism. Grateful acknowledgment of assistance is made to Mr. William W. Anderson, Dr. John S. Bunt, Dr. Donald P. de Sylva, Mr. James Ellis, Dr. John R. Hendrickson, Dr. Elmer R. Noble, Mr. William M. Stephens, and Mr. David H. Wallace. Dr. de Sylva read a version of the entire manuscript, and Mr. Ellis and Dr. Hendrickson read part; all have suggested helpful improvements in organization, style, and accuracy. Mrs. E. Elizabeth Owen and Mrs. Jean Bradfish made useful comments on organization and style in versions of the manuscript.

Many other persons, too numerous to mention individually, have gone to considerable inconvenience to provide photographs and information. I am grateful for their cooperation.

To my wife, Jane, who worked diligently throughout the preparation of this book and provided confidence and encouragement, goes my everlasting gratitude.

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Preface to Second Edition

Approximately six years have passed since the first edition of *Farming the Edge of the Sea* was published. Accelerated research in the field of sea farming, and the considerable interest in the whole subject in the developed countries has produced many new research results. This thoroughly revised second edition brings the text up-to-date, with changes and revisions throughout.

The purpose of the book remains the same: to be a general, integrated summary of sea farming and the state of the art, primarily in the developed countries.

Most of the necessary additions and changes are found in the sections on pollution, economics, food and fertilizing (using domestic sewage), laws affecting fish farming, and biological aspects of certain species suitable for farming where considerable research attention has been focused. Recent research progress of farming potential for shrimp, particularly, could justify lengthy sections. Instead, I have summarized this vast material, seeking to report only the information of greatest importance and interest. For a more complete study of particular species the reader is directed to my *Selected References* on pages 375–411.

Fish farming has been going on for centuries as a means of satisfying the food needs of people in the developing nations. But when the reason behind fish farming is profit instead of subsistence, we in the developed countries cannot comprehend the incentive to work, or the amount of labour expended, even to put a few fish on the table, as in the undeveloped countries. The primitive techniques and intensive labour in undeveloped countries would never be considered economic here.

Since descriptions of sea farms in many of the developing countries can be found in the FAO literature, and in the recent book edited by T. V. R. Pillay, my comments on those activities are brief and confined to a description of practises that could be of value to prospective fish farmers elsewhere. Production figures per unit of water used to raise indigenous species and market conditions and trends are so different in undeveloped countries throughout the world that it is not only difficult, but in many instances impossible, to translate results into a model that can be used in developed countries to determine even the basic aspects of economic feasibility.

At this time, and at the present level of the fish farming costs and skills in the developed countries, it is illogical to suggest that sufficient food can be raised by sea farming cheaply enough to help feed the needy countries; unfortunately, this notion has been used by sea farming promoters.

The descriptions of types of research activities related to sea farming in the second chapter are brief because the direction of research activities has changed rapidly, and many operations have been terminated in response to shifting priorities by governmental agencies and large corporations.

Many pilot or full-scale sea farming operations in the United States, United Kingdom, and elsewhere, after many years of study and experimental production, have been terminated despite continued strong interest in this industry. The causes, in many cases, have been poor management decisions, unco-ordinated research activities, and high operating costs.

The majority of successful small aquaculture operations around the world have grown up with little or no technical help. In relatively recent years scientists in the developed countries have contributed greatly to aquaculture in specific areas, but many problems remain. These information gaps are, to name a few, economics, nutrition, disease prevention and control, artificial spawning, and high density culture. Such knowledge is necessary to the operation of a successful enterprise. Biologists have worked out life histories and growth rates of many of the farmable species; however, their work has been done mainly in laboratory environments, not in a typical, crowded, farm-type operation, or with an eye to profit. Few studies have included even basic consideration of the economic aspects of the product.

Government and private research in the United States have been characterized by expenditure of available research funds in many directions, involving duplication of effort, that have resulted in limited knowledge about a variety of species and their possible value in sea farming. Administrators of research funds now agree that centralization of sea farming research activities at a few large facilities that are best equipped to handle specific problems would probably be a more efficient way to achieve usable information.

Economic information on truly commercial fish farms is very hard to get. Sea farming for profit is still in the pioneering stage; therefore, when large sums of money are invested in these operations, it is understandable that the investors are going to be somewhat unwilling to make public their cost and return figures. Investors have been mainly large corporations that can afford to continue new ventures for several years until they show whether they will be profitable. There are many, often complicated,

motives behind such corporate investments, for instance, favourable public relations and tax shelters. When motives for this type of investment are unknown, it is wrong to assume that because a sea farming project has been in operation for several years that it is breaking even, making money, or has profit potential.

At this writing, world economy is unsettled and subject to rapid and rather violent fluctuations. Conditions of this sort affect not only the research and development of large corporations, but also the individual who goes into business for himself. Despite economic problems, interest in sea farming remains high and the need for current factual information on the subject is real. The desperate need for protein foods is also an overriding incentive to investigate sea farming potential within the developing countries to determine the extent to which it can contribute to their protein production. Such an evaluation takes on increased relevance when the possible failures of large areas of land farming and fisheries are considered.

New also in this second edition is a chapter on economic feasibility of sea farming. It is, of necessity, general. The economic studies available on this subject become outdated soon after publication because of the present rapidly changing and complex world economic situation. I report this information with the hope that the opinions expressed and examples given will encourage and assist in making an economic feasibility study an integral part of any plans for sea farming.

All of the references from the first edition are included here together with two useful additions.

One, a part entitled 'General References,' appears at the beginning of the references section and contains annotated references to many good works on aquaculture and mariculture which have been published since the first edition. A word of caution to the general reader: while several of these recent books on fish farming have titles that promise well-rounded, integrated discussions on the subject, they are mostly compilations of work on a technical level of specific research which are more useful to other scientists than to the general reader seeking basic knowledge on the subject.

Two, the addition of the important new information is placed alphabetically at the end of each chapter's first edition references. I have purposely not integrated the new references with the old, so that the reader can see the new literature and tell at a glance those research areas and species on which most new information has been published.

Also new in this edition is an index to the subject matter to help the reader.

Several prominent scientists in the field of aquaculture have died since the publication of the first edition of this book, among whom are Drs. Robert Lunz, Homer Swingle, and Motosaku Fuginaga. These men pioneered the establishment and improvement of aquaculture in developed and developing countries long before the scientific community and the public realized the importance of their research. They lived to see their ideas and dreams recognized and implemented.

I am grateful to the following for information on their research given to me when I visited their laboratories: Dr. George Allen, Dr. John Couch, Mr. Timothy Joyner, Mr. Warren Landers, Dr. Richard Neal, Mr. Guthrie Perry, and to the many persons who have kindly provided photographs and information.

Special thanks go to Mrs. Lois Higman for editing the entire manuscript and recommending many improvements in style and content. Professor James Higman offered valuable suggestions on organization and subject matter.

Corrections for errors in the oyster and mussel chapters in the first edition were graciously provided by Dr. P. Korrinda.

To my wife, Jane, I offer my grateful thanks for her help on the manuscript from start to finish.

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I. GENERAL

CHAPTER 1

Why Farm the Sea?

Schemes to farm coastal waters are old. Most records are lost in antiquity, but some show that oysters were raised by the Japanese as early as 2000 B.C. and by the Romans about 100 B.C. In Java, laws to protect milkfish farmers from fish thieves were established as early as A.D. 1400. Although farming marine and brackish waters is an old, old occupation, it has progressed little over the centuries. Subsistence farming of these waters in the tropics is practised today almost as it was in the distant past. This is not surprising for in many of these tropical countries most industries change very slowly. The striking illustration in *Fig 1* shows the pond development in a Javan estuary.

Marine and brackish-water farming is neglected in the very countries that have the means to do it most successfully, for these countries possess the scientific knowledge and the latest equipment to cut production costs and increase efficiency. There is also great demand in these wealthy countries for the species which can be cultivated, such as oysters, mussels, and shrimp.

Why are there few fish and shellfish farms in the coastal waters of wealthy nations? The reasons for this limited farming are complex as will become evident in subsequent chapters. In the past development was retarded by a lack of biological knowledge and because other cheap and abundant sources of fish and land-grown food were available to feed the growing human populations. The problems associated with large human populations in the developed countries also work against the success of sea farming for profit. Pollution and high real estate values are prime examples. On the positive side, however, the position of sea farming has greatly

Fig 1 Vast areas in tropical countries are devoted to brackish water farming. The ponds (tambaks) form a crazy quilt pattern on an estuary in East Java (see next two facing pages). (*W. H. Schuster*)



