ISSN 0254-380 X

MARINE FISHERIES INFORMATION SERVICE

No. 171 January, February, March, 2002

TECHNICAL AND EXTENSION SERIES

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

COCHIN, INDIA

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

Title	:Aquaculture and water resource management
Editors	:D.J. Baird, M.C.M. Beveridge, L.A. Kelly and J.M. Muir
Publisher	:Blackwell Science Ltd., Osney Mead, Oxford OX2 OEL, UK
Price	:£ 39.5
ISBN	:0-632-03926-4
Year of publication	:1996
No. of pages	:352
Binding	:Hard cover

As fish production from the wild has been stagnating for more than a decade, increasing thrust is given to aquaculture development all over the world. However, the unbridled expansion of aquaculture in many countries has generated a number of problems because of its linkage with natural ecosystem. These problems and issues were discussed at a conference held at the University of Stirling from 21-25 June, 1994. The book Aquaculture and Water Resource Management is the compilation of eight scene-setting papers by invited speakers presented at the conference.

After explaining the limited scope for expanding capture fisheries, Robin L. Welcomme explores how aquaculture could compensate the shortfalls in wild catch. He however, observes that diversification in aquaculture is taking place within a fixed resource base and as yet no new form of culture has been introduced which would allow for a substantial increase in potential. He identifies a series of constrains such as the limits imposed by diseases, intensification of land use, water demand, availability of feed stuffs, social and economic constraints etc., causing the slowing down of culture of current species. Discussing the prevailing trend to search for and measures to increase the productivity of natural and seminatural systems, he details two main approaches for intensification, namely the stock enhancement approach and the system enhancement approach.

Increasing concern over the impact of aquaculture has catalyzed a shift in public opinion, generating political pressure to evolve a negative regulatory approach to aquaculture development in many parts of the world. This 'zero tolerance' approach, apart from magnifying the severity of the impacts of aquaculture and focussing on wrong issues, is feared to allow other more

environmentally damaging activities unchallenged. Identifying this as a particular consequence of 'single issue approach' to environmental matters, James F. Muir suggests a 'systems approach' to development and management of aquaculture. Elaborating the systems perspective, he explains how aquaculture can be identified as a distinct sub component within a wider system and can be treated in terms of its system structure and properties, input output relationships, relative values and dynamics of change. He states that if a workable approach is to be proposed for aquaculture and its development, the concept of sustainability must be the first point of consideration.

Reviewing the available information about waste production from aquaculture, Asbjorn Bergheim and Torbjorn Asgard observe that the quantity of total waste which leaves the system to load the environment is closely related to the culture system used. Wastes from intensive aquaculture are predominantly from feed, which include uneaten feed, undigested feed residues and excretion products. Factors related to quality and formulation of feed stuff, feed production technology and feeding practices greatly influence the total waste loading. Pond fertilization by various livestock manure is another source of waste loading. Discussing the pathways of animal manure nutrients and manure conversion ratios (MCR), the authors observe that the nutritional value of manure inputs appeared to be closely related to the existing contents of essential nutrients in the pond soil and water. Residues of chemicals like lime and chemotheraputants like antibiotics, parasiticides, fungicides, algicides etc., in aquatic system are also raising concern. While citing the evidence of reduction in the waste output of nutrients and organic matter from intensive culture systems due to better quality control and husbandry practices, the authors stress the need for reliable global information on the use of drugs and chemicals in aquaculture.

New sources of pollution in the form of nutrient from aquaculture to the already overburdened, damaged and degraded natural ecosystem is of great concern both to scientists and public. Addressing this issue, Barry A. Costa-Pierce states that aquaculture has to evolve ecosystem approaches and sustainable operating procedures. It is mentioned that nutrient inputs of floating cage and raft aquaculture systems are of greater environmental concern than intensive recycling systems and semi-intensive pond systems. The quality of aquaculture waste and its temporal variability are important determinants of environmental impacts. Wastes from intensive aquaculture are enriched in total Phosphorus (TP) and consequently have low TN/TP ratio. This results in increased phytoplankton production and favouring a change towards blue green algae. Sediment loading at substratum reduces the redox potential, increases the sedimentary oxygen demands (SODs) and stimulates facultative anaerobic microbial activity. Intensive, ecological aquaculture systems that incorporate technological advances in biological waste treatment, solar and wind power and integrated with agriculture is suggested for development of sustainable aquaculture.

Escapes of cultured species into the wild are virtually impossible to be prevented in all types of aquaculture practices. Species interaction, especially those resulting from the establishment of self sustaining introduced species or the alteration of indigenous gene pools are believed as potentially most damaging environmental consequences of aquaculture. Reviewing this topic, Angela H. Arthington and David R. Bluhdorn describe five categories of adverse impacts *viz.*, alterations to host environment, disruption of host community, genetic degradation of local stocks, introduction of parasites, diseases and socioeconomic effects. The adverse impacts of European carp in 50 countries, the exotic catfish in Philippines, invasive predatory fishes such as bass and trout in South Africa, tilapia in several countries and interbreeding of salmonids from Norwegian rivers are detailed as examples. Accepting escapes as inevitable and invasion irreversible, the authors suggest that the

risks can be reduced by selecting appropriate scale of operation, using sterile stocks wherever possible, improving quarantine measures and adhering to international protocols for introductions.

The environmental consequences of antibiotic use in all form of animal production are a matter of concern, which is particularly acute in aquaculture. Donald P. Weston identifies the reasons for this as relative newness of use of antibacterial drugs in aquaculture, little or no treatment of effluents causing immediate transport of residues into the environment and paucity of reliable scientific data on their aquatic fate. Of the many antibacterial drugs used in agriculture, only a small fraction has been tested for potential application in aquaculture and a smaller portion still (probably less than 24) is routinely used in aquaculture. While Japan has a list of 26 approved antibacterials for aquaculture, in countries such as Bangladesh, India, Indonesia, Nepal, Pakistan and Srilanka, there is no established procedure for approval of antibacterials, leave alone their regulated distribution. The various implications of global trade in aquaculture products, transport of residue through excreta/uneaten feed, retention of residue in sediments, accumulation in bivalved and other organisms, increased resistance of sediment bacteria etc. are discussed before listing several recommendations to reduce the effects of antibacterial drug use in aquaculture.

Compared to the study and treatment of domestic sewage water, aquaculture effluent treatment is relatively a new field. Identifying nutrient, BOD, suspended solids and pathogens as the four major components of wastes, Simon J. Cripps and Liam A. Kelly state that low concentration of wastes and high flow rates are the two crucial factors affecting treatment of effluent from aquaculture. They suggest that the spatial and temporal variations in waste characteristics of effluents are to be considered while designing treatment devices, flow rates etc. The choice of strategy of waste reduction must be customized to the operation of the particular culture system. A brief description of the waste collection technologies in use for cage systems and tank systems and the use of stationary screens, rotary screens, the axial flow and radial flow screens, media filters in recycling systems, settlement ponds for sedimentation etc. is provided. The author hopes that in the near future, due to the change in the environmental philosophy, effluent treatment would be considered as a positive economic activity.

In spite of the long history of aquaculture, the legal regime regarding aquaculture has received attention only recently. Reviewing the developments in this area, William R. Edeson discusses the basic considerations in formulating legal regimes for aquaculture. In countries where development of aquaculture has taken place, attention is paid to build up legal framework for controlling the access to or prevent problems of pollution from aquaculture activities. While the concern regarding environmental impacts caused and suffered by aquaculture is increasing, there is good reason for aquaculture to be environmentally regulated in its own interest and in the interests of others affected by the activity. After narrating the examples of Korea and Vietnam, the author explains the advantages in having the legislation in place. As policies and institutions develop, the already existing legal framework will provide the basis for implementation of the policies and their enforcement.

The editors have done a commendable work by judiciously compiling comprehensive and up-to-date review papers on eight important topics in order to provide an in-depth analysis of the issues related to water resource management in aquaculture. The book would be an invaluable reference to all those working the field of aquaculture, especially those dealing with the environmental impacts and sustainable development of aquaculture.

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