

## Dynamics and management of Asian culture-based reservoir fisheries

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Reservoir construction for irrigation has a long history in Asia, dating back more than 6000 years in China and 2000 years in Sri Lanka for example. The present century has witnessed an explosive increase in the number and total surface area of reservoirs in Asia. Despite the long history of reservoir construction, the utilisation of the man-made water bodies for fisheries started only around 1950.

Natural fish production in tropical Asian reservoirs is low. Natural lakes are rare in tropical Asia (apart from Indonesia and the Philippines), and consequently there are few indigenous fish species that can reproduce successfully in standing waters. Two different approaches have been taken to remedy this situation. In some countries like Sri Lanka, lake-dwelling African tilapia have been introduced to form self-reproducing populations, and given rise to substantial fisheries. Other countries like China, India and Thailand have developed culture-based fisheries for various cyprinids in their reservoirs. Culture-based fisheries are extensive aquaculture systems, which due to their extent and their communal or open access harvesting retain many features of capture fisheries. Culture-based fisheries pose unique management problems and require specific methods to assess not only the harvesting, but also the stocking regime and their interrelation. The methodologies are not well established, and at present the management of culture-based fisheries remains largely ad hoc.

The ODA Fisheries Management Science Programme has funded a project aiming to develop assessment methods and management guidelines for culture-based fisheries. The research is being conducted by the Marine Resources Assessment Group in collaboration with four of the foremost fisheries institutions in Asia: The Asian Institute of Technology and the Royal Thai Department of Fisheries in Thailand, the Zhejiang Institute of Freshwater Fisheries in China, and Mangalore Fisheries College in India.

In the project, a population dynamics model for culture-based fisheries has been developed and tested. The model is based on mathematical descriptions of the two key processes in cyprinid populations: density-dependent growth and size-dependent mortality. Different stocking and harvesting regimes for culture-based fisheries have been evaluated using the model.

As might be expected, the model has shown that the optimal stocking and harvesting in a culture-based fishery are closely related, and must be considered together in management. Maximal biological production is achieved by stocking at a high density and harvesting at the smallest marketable size. If stocking density is limited by the availability of seed, fish must be allowed to grow to a bigger size to achieve the best possible production from the seed stocked.

If over-fishing occurs in a culture-based fishery, this can be averted by an increase in stocking density, which will give a higher level of production for the same level of effort. If fishing effort is low (as is the case in many reservoirs), the fishery is easily overstocked, leading to stunting of the population and increased mortality. The best option then is to increase fishing effort, alternatively stocking density can be reduced. In a developing reservoir fishery, increases of fishing effort and stocking density should go hand in hand.

An important consideration in the management of culture-based fisheries is the optimal size of seed fish for stocking. The model has shown that a wide range of seed fish sizes can yield a similar level of production if stocked at the

appropriate density. Small seed fish must be stocked at much higher densities than large seed fish. However, the biomass of large seed fish stocked at optimal density is much higher than the biomass of small seed fish stocked at the respective optimal density. This has two implications: first, if large seed fish are stocked, a higher biomass needs to be produced and handled. Second a higher biomass stocked initially limits the production potential of the population. These results indicate that the stocking of small seed fish can sometimes be a better option, particularly when seed production is limited by the capacity of farms to rear advanced fingerlings. The production achieved from the stocking of large seed fish is also particularly sensitive to stocking density. Stocking of small seed fish is therefore more likely to yield a good production if there is considerable uncertainty regarding the optimal stocking density.

The population model for culture-based fisheries is a tool not only for the evaluation of management regimes in general terms, but also for the quantitative assessment of particular fisheries. The quantitative assessment of a fishery requires information on the growth response to population density. Such information can be gained by judicious management experiments, which can often be designed to simultaneously provide information and increase yields. This approach is called adaptive management, and the design of adaptive management policies for culture-based fisheries is a key area of ongoing research in the project.

The culture-based fisheries project is keen to expand its collaboration with institutions involved in the management of tropical culture-based fisheries. Interested individuals or organizations should contact Mr Kai Lorenzen at MRAG. Details of the population model and the evaluation of management strategies are provided in a forthcoming paper in Fisheries Management and Ecology.



### Guidelines for harvesting species of different life spans

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unexploited biomass was more likely to be one third of the natural mortality rate, or less, rather than one half the natural mortality rate as Gulland suggested.

For longer-lived species, sustainable yields were both low and almost independent of lifespan. For very short-lived species, however, the life cycle dominates their response to exploitation. Such species can produce sustainable yields well in excess of the biomass at the start of the fishing season.

Tables of yield-biomass ratios have been calculated for a wide range of combinations of biological and fishery parameters. Yield-biomass ratios were also calculated for selected commercially exploited marine fish species, for which estimates of the key parameters were contained in the FISHBASE database. This impressive database is being jointly developed by the International Center for Living Aquatic Resource Management (ICLARM) and FAO and MRAG is a collaborator.

Use of guidelines and tables such as these, especially when parameters have to be guessed or estimated by analogy, will never remove the need to undertake field research. However, it should increase the likelihood that management meanwhile will at least be roughly right.