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CONFLICTING INTERESTS IN THE USE OF KERALA'S PENAEID SHRIMP RESOURCES : A CASE IN QUESTION*

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ABSTRACT

In the drive to increase foreign exchange on the shrimp resource base, the development strategy has been to bring additional backwater area under the open semi-intensive culture system. Apparently, the nature of the shrimp resource complex is such that any increased harvesting/trapping of postlarvae and juveniles in the backwaters (nursery grounds) will adversely affect the recruitment levels in the fishing grounds. The case in question is the Cochin Backwater System, along the adjacent sea in which, overfishing has contributed to reduced catches. Further, loss of nursery grounds due to large scale enclosures for mariculture, will greatly reduce the natural ingress and survival of postlarvae in the backwaters. Hence, the government policy on the promotion of open semi-intensive culture system appears to be flawed.

Against this background, we examine the emerging competing interests and conflicting uses of the resource with the basic research questions directed toward what constitutes optimal use ; what is the alternative in terms of maximising social benefits and what policies may be formulated. In the evolving resources-development scenario, the rational allocation and future use of the shrimp resource is seriously threatened by environmental externalities and competing forces that are peripheral to the fisheries sector. In the allocation of penaeid shrimp resources, a balance predicated by the life-cycle of the species and socio-economic exigencies must be established for sustainable use. Furthermore, in the case at hand, the options to continue shrimp farming or to translocate in a phased manner to other brackishwater systems along the coast requires urgent examination, in view of the grave environmental problems there. This study provides some useful insights into the complexity of managing a renewable, but shared aquatic resource along a developing coast.

INTRODUCTION

THE CONVENTIONAL wisdom in public policy making is that development precedes management and as such mangement will impede rapid economic development. The tragedy of the foregoing duality is amply illustrated by the present ecological crises in many developing countries. For all planning purposes, development and management must be conceptualised as two inseparable positive-change processes, having the same basic objective(s), be they socio-economic benefits, productivity, conservation or a combination of objectives. The problem in the use of Kerala's shrimp resources underscores this rational view and is discussed hereby the growing dilemma in allocating the shrimp resources of the Cochin region and translating the social benefits in the overall human predicament in which it is set. We will

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attempt to juxtapose the nature of the shrimp resource complex with the problem of increasing fishing pressure. In the light of these ecologic and economic correlates, we will examine State sponsored development and speculate on the resolution of present conflicts. We will also examine briefly the human impacts on the coastal system and recommend social adjustments imperative for the future use of the shrimp resource of the State. It should be clear that our attempt here is not to reiterate the ecology or the shrimp fishery resources of the Cochin Backwater or the 'why' questions of managing the resource or the human situation in the Cochin region. There exists abundant literature on all these aspects in this case (Gopinath, 1956; George, 1961; George *et al.*, 1968; CMFRI, 1969; Kurian and Sebastian, 1975; Kurian, 1978; George and Suseelan, 1980; Silas *et al*, 1984) and there have been no lack of warnings on the resource-environment situation (Menon, 1967) Jhingran and Gopalakrishnan, 1972: Gopalan, 1984; Gopalan *et al.*, 1983; Gopalan and Doyil, 1986; Stephen, 1984, 1985). Instead we intend to help bridge the gap beween rhetoric and reality by addressing the vital question of 'how' the resource may be innovatively planned, developed and managed for the present and future use.

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Background

Penaeid shrimp resources support one of the most valuable marine fisheries of the World. The exploitation systems in the penaeid shrimp fisheries is closely related to the spatial evolution of the life-cycle and the ecology of the different stages (Gracia and LeReste, 1981). In most tropical coastal areas *e.g.* Bangladesh, India, Ivory Coast and Suriname, shrimp resources are subjected to two exploitative phases in a sequential pattern. In general, artisanal fishermen (the term includes shrimp farmres) exploit the juveniles in estuaries and backwaters, while trawl operators using mechanised vessels exploit the subadults and adults after they migrate to the sea. However, in Bangladesh, India and the Persian Gulf for example, artisanal fishermen were exploiting the shrimp in the sea, even before the advent of mechanised fishing in their respective coasts. Conflicts between artisanal fishermen and industrial fishermen exist to varying degree in many coastal shrimp fisheries. These conflicts are mainly due to unequal sharing of the same stock(s) in the same fishing grounds (parallel exploitation) or fishing in isolated regions, but on the same resource complex (sequential exploitation). The case of the Ivory Coast shrimp fishery is of interest here, because artisanal fishermen being at an advantage, drastically reduced recruitment of shrimp to offshore trawling grounds. This led to the disappearance of the trawl fleet as the catch rates and profitability declined (Willmann and Gracia, 1985). Apparently, the nature of the shrimp resource complex is such that any increased harvesting/trapping in the backwaters (nursery grounds) will adversely affect the recruitment levels in the fishing grounds (George and Suseelan, 1980; Gracia and LeReste, 1981; Kalawar *et al.*, 1985).

The rapid development of the industrial shrimp fisheries, since the late Fifties have been, by and large, to the neglect of the historicartisanal fisheries. In general, the socio-economic impacts of these changes in the shrimp fisheries have not been satisfactorily assessed nor have conflicts been resolved (Sathiadas and Venkataraman, 1981; Silas *et al.*, 1984). Furthermore, encouraged by increasing demand and strong price rise in the export trade and because of the need for larger

amounts of foreign exchange (Smith, 1985), most developing countries have neglected management of the resource for short term benefits. As one might expect, problems stemming from the common property nature of the resource and the sequential pattern of exploitation have caught up with the industry in every case. Conservation oriented management of the shrimp resources have become unavoidable with increasing effort directed to augmenting production through aquaculture (FAO, 1984).

Coastal aquaculture production in Asia between 1975 and 1984 has had an estimated average annual growth of 6.4%, but the crustacean production, mainly penaeid shrimp increased by 55.5% (Palomares, 1985). Shrimp culture is now recognised as a lucrative production opportunity to meet the export demand. Investment in shrimp farming and research has dominated the aquaculture scene and we may well begin the midst of a Shrimp Era. Many developing countries with their large potential for shrimp farming are rapidly expanding their production areas. Export markets in Japan, USA and Europe are becoming saturated even as these countries attempt to jump the shrimp bandwagon. There is speculation that the unit price of shrimp may come down, but that consumption will increase as this gourmet item becomes available to lower income groups (Sakthivel, 1985). Be that as it may, coasta aquaculture as widely practised in many developing countries as introduced a new dimension in the sharing and managing of shrimp resources. We believe that a serious problem in resource use was created by erroneously treating the postlarvae in estuaries and backwaters as 'seed resources' for shrimp culture by many research and development agencies, national and international. Thus constituting an encroachment of the resource complex in the case of historic users and also in other cases where fully developed industrial shrimp fisheries were already in place.

The phenomenal growth of Ecuador's shrimp culture industry is a case in point. In 1965, the shrimp industry produced some 5,000 tonnes, but by 1984, the total production had climbed to a record 35,000 t annually through the development of aquaculture (Meltzoff and LiPuma, 1986). But the recent declining trend has sent a clear message of what went wrong. Shrimp culture there depended on 'natural seed resources'. The supply of seed dwindled due to overexploitation and loss of nursery grounds to pond area. It has been suggested that the relationship between shrimp recruitment and nursery area appears to be logarithmic. The loss in shrimp due to destruction of a given area of nursery can be expected to increase rapidly as the remaining area of nursery decreases (IOFC, 1973). At present, shrimp culture is being expanded in many developing countries even before hatchery technologies are commercially available to them. Although the situation in many developing countries has the potential for ar Ecuadorian experience, nothing as dramatic may be expected, if the correct lessons are learnt and actions taken. But the Ecuador example clearly shows that a better development opportunity exists in culturing shrimp rather than capturing it at sea, provided the exploitation of juveniles from natural sources for seeding ponds is managed.

From the foregoing discussions on the shrimp resources use, two important management issues emerge : 1. The allocation of fishing effort — the problem created by the increasing fishing pressure of different user groups on the resource complex as a whole and 2. Maximization of value — the question of weight and numbers harvested by these groups (FAO, 1984). It is often argued that management decisions cannot be made as adequate knowledge on the shrimp stock(s) is not available, but the record shows that policy decisions or regulating or allocating the resource are not taken even when existing knowledge demands it. The crux of the problem

lies in mustering the political will, rather than just the difficulties of readjusting existing patterns of use without causing major social unrests. While the ecological problems caused by the sequential fishing pressure are similar in most coastal shrimp fisheries, the socio-economic and political set up in which the resource exists differs and so do the means to resolving management problems.

In the case of India, government involvement (Deviah, 1985; GKDF, 1983, 1986) with the objective of improving the welfare of lower income fisherfolk and at the same time augmenting export through shrimp culture may be questionable, due to the entry of wealthy newcomers into the system from outside the targeted fisherfolk population (Smith, 1985). Already artisanal farmers are being pushed to marginal areas and many have lost the opportunity to farm or become employees there. The 'trickle down effect', from government projects, if expected, will not be significant. Obviously, little or nothing has been learnt of the adverse impacts of the 'Green Revolution' in the agricultural sector or of the mechanisation of fishing in the making of the so-called 'Blue Revolution' in the fisheries sector. In most cases, government development programmes cause management problems, because of their failure to consider all options. Furthermore, the government is often unable to implement its own management measures which invariably come when a crisis has set in. It may be argued that in the allocation of scarce financial resources, direct monetary transfer to target groups will produce more real benefits than through 'schemes' implemented by the government. Management measures cannot be coercive nor can development projects encroach on the rights of other users. But there is little doubt that impact assessments, conflict resolutions through available means, provision of incentives, motivation and trade off strategies can significantly improve resource use. Managers and decision-makers must weigh the options, knowing that there are no easy solutions, but only difficult choices. But choices must be made by setting the priorities for the resource, within the overall context of the multiple use of land and water in the coastal system. Putting off these critical decisions will not solve the problems. In fact, the present situation in shrimp fisheries strongly suggests that in many cases opportunity for balanced development and optimal profitability may have been lost.

Shrimp Resource Use and Human Impacts in the Cochin Region

The history of artisanal and industrial shrimp fisheries of India has its beginning in the Cochin region Artisanal methods of fishing in the sea and backwaters and trapping juvenile shrimp in modified lowlying paddy fields catered to the local market and also sustained an export trade in dried shrimp of some significance. The introduction of mechanised fishing rapidly changed this pattern of use to an industrial scale, with export of shrimp in frozen form (CMFRI, 1969 for the early history of shrimp fisheries of India). Artisanal farmers now had the incentive for growing shrimp to larger sizes to suit export market. But the other fishing groups, mainly the stakenet operators continued to capture juveniles in strategic canals to supply the local market for juveniles (in dried and fresh form), the export of dried shrimp soon stopped (Kurian and Sebastian, 1975). The stakenet operators being physically disposed between the farming area and the trawling grounds had the advantage of capturing postlarvae/juveniles entering the backwaters and also the subadults leavings for the sea (Menon and Raman, 1961). It has been estimated that about 600 t of juveniles/subadults of shrimp are caught in the Cochin Backwater every year by stakenet and sluice gate operators (Sakthivel, 1985). It may be mentioned that over 3000 stakenets are deployed in these backwaters (Kalawar *et al.*,

1985). In this three way partitioning of the shrimp resource complex, the exploitation of juveniles was considered an irrational use as it precluded the opportunity for growth and export at higher prices. A management measure in favour of farmers was introduced by allowing the stakenets to be operated only during the ebb tide. The stakenet operators were now in greater competition with trawl operators by capturing the recruiting shrimp. In addition to these problems, artisanal fishermen and industrial fishermen competing for shrimp and fish in the adjacent sea, led to serious conflicts and many social disturbances (Somasekharan and Jayaprakash, 1983; Silas *et al.*, 1984; Kalawar *et al.*, 1985). Zoning inshore areas and also giving exclusive fishing rights to artisanal fisherman in mudbanks, appears to have resolved the problem. Although this may not constitute an efficient utilization of the available shrimp resource, it may be argued to have satisfied the optimality concept to some extent. Having recognised the high profitability of shrimp farming in the region, due mainly to many free and cheap inputs, the collection of shrimp juveniles from the backwaters has intensified (CMFRI, 1985), placing the trawl operators at a greater disadvantage. Furthermore, the lease rate for farming area has soared into the tens of lakhs of rupees, with contractors and rice field landowners entering the business. Large financial assistances are now available to them from shrimp processing firms, banks and government (MPEDA, 1986).

In the overall competition for shrimp resources the relation between fishing pressure and production is often blurred by the migration of stocks to and away from the region and by multiple species composition, nevertheless, the general relation is reflected in the production picture. Shrimp migration studies show that the recruitment of shrimp to the offshore area may also support fishery further south of this region and also in Sri Lanka and Tamil Nadu (CMFRI, 1982). Kalawar *et al.* (1985) in their report on the Kerala's marine fisheries, emphasised the need to strike a balance between the backwater harvesting of shrimp and capture in the adjacent sea, both judiciously and scientifically, but keeping the backwater harvesting at a modest level, in view of the parent stock-recruitment relation. They recognise the difficulties in reducing the fishing pressure in the backwaters and what it entails in socio-economic and political terms. At present, about 150-200 trawlers operating in the adjacent sea capture only about 3000-4000 t (Silas *et al.*, 1984) annually, as compared to farmers who currently harvest over 2,500 t in about 5000 hectares in the backwaters (CMFRI, 1985). However, it is generally recognised that the shrimp production from these backwaters has drastically declined. Earlier reports indicate about 10,000 t of shrimp as a gross estimate of the take from the backwaters during its more productive years in the past (Kurian and Sebastian, 1975; Rao, 1982, Purushan and Rajendran, 1984). Even this is said to be an underestimate for the shrimp caught in the backwaters for 1984 is estimated to be have been in the range of 20-25 million rupees (Kalawar *et al.*, 1985). This includes the earlier mentioned estimate of 600 t may even be as high as 1000 t) of juveniles taken by stakenet and sluice gate operators (Sakthivel, 1985; Stephen, 1985). To date, there are no reliable production figures from these backwaters for a number of reasons, particularly due to scattered informal markets. Nevertheless, roughly summing up these production figures in numbers, suggest that the natural ingress of postlarvae or juveniles is of the order of a few tens of billions (Chandran, 1984; Kalawar *et al.*, 1985). What boggles the mind is not the reproductive capacity of the shrimp population, but rather the costs of producing these numbers in hatcheries should the backwater ecosystem collapse.

In the exploitation of the shrimp resources of the Cochin region, the following economic and ecologic correlates take importance: 1. A large population of fisherfolk depend on the resource for their livelihood. 2. The backwater system serves as a foodshed for the riparian population and as nursery grounds for shrimp. 3. The fishery supports the local economy significantly and contributes to national foreign exchange needs. The backwater system also facilitates other activities, such as port and inland water navigation. These are also legitimate uses of the water system. However, development of the Cochin Port (Bristow, 1967) and the establishment of the FACT fertilizer plant and the construction of the Thanneermukkam Dam are major events in the making of the present ecological crisis there. Developments over the last three decades have led to large scale alterations in the physiography, water quality, biological composition and fisheries production of the system. In a recent study by one of us (Stephen, 1985), impacts of agricultural, industrial and urban developments on the Cochin Watershed (includes catchment area of river systems and backwaters) show a general lack of horizontal-communication across the various economic sectors, independent planning, lack of foresight in the multiple use of land and water resources. As a result, the backwater system has fragmented and environmentally deteriorated, with a drastic reduction in the aquatic resource potential. The environmental issues there are too many to mention here, but land reclamation (KSSP, 1978, Gopalan *et al.*, 1983; Balakrishnan and Lalithambika Devi, 1984), impoundments and diversion of fresh water flows (Kannan, 1979; Stephen, 1986) and aquatic pollution (including radionuclides) are major concerns (Remani, 1979; Stephen, 1984; GKPCB, 1982). In fact, harvesting of edible forms from the backwaters are questionable from the human health stand point (Gore *et al.*, 1979; Kalawar *et al.*, 1985; Stephen, 1987).

However, given these environmental problems, recent fisheries development there has also compounded the economic losses. State sponsored shrimp culture development projects, in areas down stream of pollution sources and location of hatcheries near unsuitable water source are mentioned here (Choudhury, 1985), just to examplify the shoddiness in the decision-making process. Further, the failure of regulatory agencies in controlling pollution and in overseeing land and water uses, strongly suggests that, there is also a legal and institutional crisis. The resolution of this crisis is bound to improve the backwaters and the use of natural resources in the region. This involves in part, the establishment of an apex coordinating body with the necessary political clout to oversee all major land and water uses and to set the priorities within an ecosystem framework for the entire Cochin Watershed. Establishing such a working system, the likes of which this country has not experienced yet, will in itself be a major challenge to the political set up in the State. It is in anticipation of such arrangements only, that the planning of the future use of the shrimp resources and aquaculture can take place in the Cochin Backwater.

Development Options and Management

In most penaeid shrimp fisheries failure to incorporate mangement measures in development planning, lack of foresight and poor choice of development options have led to excessive fishing pressure on the resource, resulting in over investment, low economic returns, higher cost of production, reduced total value and over population of the industry. Based on production levels it is certain that the net economic rent would be significantly higher by reducing the fishing effort. However, measures to reduce effort in the short term will have serious social and economic consequences. This is the case with the Cochin shrimp fisheris (Kalawar *et al.*, 1985). Nevertheless, shrimp

are annual stocks with high natural mortality and therefore it is advisable to fully exploit the available stocks at sea, but protecting the nursery areas and recruiting stages in the backwaters. These aspects indicate that the socio-economic factors are more important than the biological factors (Silas *et al.*, 1984).

Penaeid fisheries with their sequential pattern of exploitation present a special problem in the allocation of fishing effort. Reducing effort in the estuaries and backwaters will directly benefit the fishermen at sea by increasing their catch, the converse can also be true. Whereas in most other fisheries, the larger benefits of a management measure can be shown to directly accrue to the targeted fisherfolk population. Furthermore, migration of stock(s), multiple stocks and species composition in the fishery make assessment of the benefits of a mangement measure difficult. Additionally, presence of parallel or multiple exploitation on the same resource complex with diverse fishing methods, also complicates the allocation of fishing effort and management. Nevertheless, it is believed that with a first level management based on available knowledge on the stock (inadequate as this may be) and a common sense approach, much larger social and economic benefits may be had than presently evident.

To begin with development and management of a natural resource must be conceptualised as a means to achieving maximum benefits to society, but taking into account the biological, social, economic and political values of the society using the resource (Optimal Sustainable Yield Concept) (Roedel, 1975). Furthermore, the desired objective(s) for management must be clearly established and the legal and institutional arrangements in place for efficient application of management policies. These policies must relate to the short term and long term objectives of management. The following objectives may be considered relevant to the Cochin shrimp fisheries : Maximisation of the physical yield (in weight); (Maximisation of the total value of the catch in terms of foreign exchange ; Maximisation of net economic rent ; improvements in the socio-economic condition of the lower income user groups ; Conservation of reseources (Silas *et al.*, 1984). The first three objectives have direct economic-ecologic linkages and are of short term consequence. The last two objectives have long term implications and requires social adjustments and technological advancement. The improvements in the welfare of fisherfolks requires the translation of some of the revenue generated from the resource base, this need not necessarily be reflected in their income. The conservation of the shrimp resources for future uses have interstate, national and international implications.

In the case at hand, given the ecological crisis in the backwater system and the vulnerability of aquatic resources, there are just two development options : 1. To restore the ecosystem and optimise the shrimp and other aquatic resource potential and 2. Abandon all future investments in aquaculture/fisheries in the Cochin Backwater System, but translocating in a phased manner to other coastal systems in the State that are not beset with enviromental problems, protecting these and other potential areas. Implementation of either option entails a series of changes in the whole system of the human matrix in the coastal environment and it cuts across hoizontally through the various ecoromic sectors and determining forces there. With reference to the first option, sustaining an aquatic resource base in an unplanned multiple use set up with many conflicting uses increases the costs for all users, if incompatible uses (*e.g.* ecologically conditioned fisheries/aquaculture primary use and polluting industries, are to co-exist in the same system (Stephen, 1985 ; Smith, 1985). This option seems unrealistic only because of the continuing poor

performance of planning and regulatory agencies in the State, the high costs of readjusting existing patterns of land and water uses, notwithstanding. However, the second option appears more practical and achievable. Development planners, decision-makers, resource managers and special interest groups must come to terms with the reality of the situation in the Cochin Backwater. The growing urban, industrial and agricultural demands of a burgeoning population sets the priorities for land and water uses against aquatic resource harvesting and aquaculture. Therefore, the attempt must be to makeup the losses in the Cochin Backwater elsewhere in the State, rather than to seek adjustments in the present pattern of use. Needless to say, the maintenance of sanitary conditions in the backwaters from the human health point is necessary.

In the foregoing discussions, we have taken a more realistic view of the wider canvas showing the problems and opportunities shrimp resources present and the needs of a coastal urban agglomeration and the costs of irreversible manipulation of the environment. The Cochin situation presents valuable lessons in coastal-regional planning and focuses attention on the vulnerability of ecologically conditioned aquatic resource use in the coastal environment. It is clear that effective management of the environment and resources lies not just in our greater undertanding of 'nature at play', but rather of 'man at work'. As to where, developments in the Cochin Backwater will lead depends on the decisions and actions to be taken. But realistic decisions taken now may hold the key to making the subsequent saga of Cochin more favourable to mankind there and to nature.

REFERENCES

BRISTOW, R. 1967. *Cochin Saga.* Paico Publishing House, India.

BALAKRISHNAN, K. P. AND C. B. LALITHAMBIKA DEVI 1984. Development and Ecodisaster : A lesson from the Cochin Backwater System. *Wat. Sci. Tech., Rotterdam,* **16** : 707-716.

CHANDRAN, K. K. 1984. Productivity and Conservation of prawns. *Seafood Export Journal,* **16** (3).

CHOUDHURY, R. C. 1985. Status paper on brackishwater prawn and fish culture in Kerala. *Proc. Seminar Present status of prawn farming in India. Bhubaneswar,* May 1985. MPEDA, India, pp. 98-112.

CMFRI 1969. The prawn fisheries of India. *Bull. Cent. Mar. Fish. Res. Inst.,* **14**.

——— 1982. New light on the migration of the Indian White Prawn *Penaeus indicus. Mar. Fish. Inform. Serv. T & E Ser.,* 45 : 1-9.

——— 1985. A guide to prawn farming in Kerala. *CMFRI Special Publication,* **21**.

DEVIAH, M. C. 1985. Prawn farming scheme of the 7th Five Year Plan of the Ministry of Agriculture. *Proc. Seminar on Present Status of Prawn Farming in India.* Bhubaneswar, May 1985. MPEDA,

FAO 1984. FAO/Australia Workshop on the Management of Penaeid shrimp/Prawns in the Asia-Pacific Region. *FAO Fisheries Report,* 323 : 19 pp.

GEORGE, M. J. 1961. Studies on the prawn fishery of Cochin and Alleppy Coast. *Indian J. Fish.,* **8** (1) : 75-95.

——— 1968. The influence of backwaters and estuaries on the marine prawn resources. *Proc. Symp on the Living Resources of the Seas Around India.* ICAR/CMFRI, India.

——— AND C. SUSEELAN 1980. Distribution of species of prawns in the backwaters and estuaries of India with special reference to coastal aquaculture. *Proc. Symp. Coastal Aquaculture,* MBAI, **1** : 273-284.

GKDF 1983. *Status paper on schemes implemented by the Department of Fisheries.* Part 2. Government of Kerala, Department of Fisheries, 30-41.

——— 1986. *Plans to be implemented during* 1986-87. Government of Kerala, Department of Fisheries, Planning and Monitoring Unit, 22 pp.

GKPCB 1982. *Environmental Status Report on Greater Cochin, Kerala (with special reference to water pollution).* Prepared by Govt. of Kerala State Pollution Control Board, Trivandrum, Kerala, India, No. 58/ CHN.

GOPALAN, U. K. 1984. Estuary : Need for legal protection. *Cochin University Review*, p. 268-273.

———, D. T. VENGAYIL, P. UDAYAVARMA AND M. KRISHNANKUTTY, 1983. The shrinking backwaters of Kerala. *J. mar. biol. Ass. India*, **25** (1 & 2) : 131-141.

——— AND T. V. DOYIL 1986. Environmental constraints on the progress of brackishwater prawn farming in Kerala. *Seminar on Brackishwater Prawn Farming (MPEDA, India) held at Cannanore, Kerala, Oct.* 1986, 68-78.

GOPINATH, K. 1956. Prawn culture in the rice fields of Travancore - Cochin, India. *Proc. IPFC/FAO, 6th Session*, 18 : 419-424.

GORE, P. S., O. RAVEENDRAN AND R. V. UNNITHAN 1979. Pollution in the Cochin Backwater with reference to indicator bacteria. *Indian J. Mar. Sci.*, **8** : 43-46.

GRACIA, S. AND L. LE RESTE 1981. Life-cycles Dynamics, Exploitation and Management of Coastal Penaeid Shrimp Stocks. *FAO Fisheries Technical Paper*, **203**, 215 pp.

IOFC 1973. Report on the First session of the Indian Ocean Fishery Commission Special Working Party on the stock assessment of shrimp in the Indian Ocean area. Manama, Baharain, 29 Nov. 2 Dec., FAO Fish. Report 138, 40 pp.

JHINGRAN, V. G. AND V. GOPALAKRISHNAN 1972. Multifarious use of coastal areas suitable for aquaculture development. *IPFC/FAO Proceedings : Coastal Aquaculture and Environment, Section* 3, p. 24-30.

KALAWAR, A. G., M. DEVARAJ AND A. H. PARULEKAR 1985. *Report of the Expert Committee on Marine Fisheries in Kerala.* Submitted to Government of Kerala. CIFE, Bombay, 467 pp.

KANNAN, K. P. 1979. Economic and socio-economic consequences of water control projects in the Kuttanad region of Kerala. *Proc. Indian Acad. Sci.*, C **2** (4) : 417-433.

KSSP 1978. Problems of Kuttanad — a study report. *Kerala Sasthra Sahitya Parishath.* 73 pp.

KURIAN, C. V. AND V. O. SEBASTIAN 1975. Prawns and prawn fisheries of India. Hindustan Publishing Corporation (India), 280 pp.

KURIAN, J. 1978. Socio-economic conditions of the coastal rural population with special reference to the fisheries sector. In : *Seminar on the role of small-scale fisheries and coastal aquaculture in integrated rural development. Bull. Cent. Mar. Fish. Res. Inst.*, 30A : 45-52.

MENON, M. K. AND K. RAMAN 1961. Observations on the prawn fishery of Cochin Backwaters with special reference to stakenet catches. *Indian J. Fish.*, **8** (1) : 1-23.

MENON, D. M. 1967. Carpe Diem. *Seafood Trade Journal*, **2** (1) : 99-106.

MELTZOFF, S. K. AND E. LIPUMA 1985. The social and political economy of coastal zone management : Shrimp mariculture in Ecuador. *Coastal Zone Management Journal*, **14** (4) : 349-380.

MPEDA 1986. *Seminar on brackishwater prawn farming.* MPEDA, Cochin, India, held at Cannanore Kerala, 23 Oct., 98 pp.

PALOMARES, L. D. 1985. Developing countries dominate the shrimp scene. *ICLARM newsletter*, **8** (3) : 3-5.

PURUSHAN, K. S. AND C. G. RAJENDRAN 1984. Prawn production in Kerala. Budding or withering. *Seafood Export Journal*, **16** (11) : 1-4.

RAO, S. N. 1982. Status of traditional fishermen in Kerala. *Bull. Cent. Mar. Fish. Res. Inst.*, **30B** : 29-34.

REMANI, K. N. 1979. Studies on the effects of pollution with special reference to benthos in Cochin Backwaters. *Ph.D. thesis, Universtty of Cochin (Kerala, India).*

ROEDEL, P. 1975. A summary and critique of the symposium on optimum yield. In : Optimum sustainable yield as a concept in fisheries management. *Spec. Publ. Amer. Fish. Soc.*, 9.

SAKTHIVEL, M. 1985. Shrimp farming — A boon or bane to India. *ICLARM Newsletter*, **8** (3) : 9-10.

SATHIADAS, R. AND G. VENKATARAMAN 1981. Impact of mechanised fishing on the socio-economic conditions of the fishermen of Sakthikulangara-Neendakara, Kerala. *Mar. Fish. Infor. Serv. T & E. Ser.*, **29** : 1-18.

SILAS, E. G., M. J. GEORGE AND T. JACOB 1984. A review of the shrimp fisheries of India : a scientific basis for the management of the resources. In : J.A. Gulland and B.J. Rothschild (Ed.) *Penaeid Shrimps — their Biology and Management.* Fishing News Books Ltd. pp. 83-103.

SMITH, I. R. 1985. Social feasibility of coastal aquaculture. *ICLARM Newsletter*, **8** (3) : 6-8.

SOMASEKHARAN, K. V. AND A. A. JAYAPRAKASH 1983. Clash between purse siene and artisanal fishermen at Cochin. *Mar. Fish. Infor. Serv. T & E. Ser.*, **49** : 14-16.

KURIAN, J. 1978. Socio-economic conditions of the coastal rural population with special reference to the fisheries sector. In : Seminar on the role of small-scale fisheries and coastal aquaculture in integrated rural development. *CMFRI (India) Bull.*, 30A : 45-52.

STEPHEN, D. 1984. Imperatives for the future development of shrimp culture in the Cochin Backwater System (Kerala, India). *Proceedings of the First International Symposium on the Culture of Penaeid Prawn/Shrimp.* Dec. 1985, Philippines.

——— 1985. Impacts of Agricultural, Industrial and Urban Developments on the Aquatic Resources of the Cochin Backwater System (Kerala, India) : Resource Development and Management Implications. *Doctoral Dissertation, Department of Geography, Univerisuty of Hawaii*, USA, 405 pp.

——— 1986. Impacts of water-based develop: ments on the Cochin Backwater System (Kerala, India) - Implications for Water Management. *Proceedings of the International Symposium on the Impacts of Large Water Projects on the Environment, UNESCO, Paris*, Oct. 1986.

——— 1987. Water resource developments in the Cochin Backwater System (Kerala, India) : Environmental Management and Policy Implications. *Ibid.*

WILLMANN, R. AND S. M. GRACIA 1985. A bio-economic model for the analysis of sequential artisanal and industrial fisheries for tropical shrimp (with a case study of Suriname Shrimp Fisheries). *FAO Fisheries Technical Paper*, 270, 49 pp.