*Hydrobiologia* **247**: 209–214, 1992.
*V. Jaccarini & E. Martens (eds), The Ecology of Mangrove and Related Ecosystems.*



# Mariculture development in Kenya: alternatives to siting ponds in the mangrove ecosystem

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*Key words: Artemia*, salinas, mangrove, pond, shrimp, prawn

## Abstract

Pond culture of brackishwater prawns and shrimps has recently generated much interest in Kenya. The mangrove areas are the target zones for the construction of these ponds. With the increasing awareness of the unique ecological role played by the mangroves, there is an urgent need to stop the conversion of mangrove swamps into aquaculture ponds. To develop pond aquaculture without destroying the mangroves, a shift from tide-fed to pump-fed pond systems is recommended in order to divert the farming from the mangroves to higher grounds. 'Mangrove-friendly' mariculture practices like pen, cage and raft culture are discussed. Methods of efficiently utilising the already destroyed mangrove areas are considered.

## Introduction

Mangroves and other coastal wetlands are highly complex and productive ecosystems which serve a wide variety of useful functions including prevention of coastal erosion, encouraging soil deposition, providing food, shelter and sanctuary for birds and mammals, providing spawning, nursery and forage ground for a wide variety of aquatic organisms, and an organic food factory through its litter production (Bailey, 1988; Singh, 1987; Saenger *et al.*, 1983; MacNae, 1974; Turner, 1977). Mangroves thus support important coastal and nearshore fisheries and indeed good correlations have been found between prawn and fish yields and the area of mangroves adjacent to the fishing ground (Brusher, 1974; MacNae, 1974). Despite these unique physical, biological and economical functions, mangroves and other coastal wetlands are being destroyed with little regard for the consequences. This has been due to an upsurge of interest in the pond culture of brackishwater prawns and shrimps as a result of the high demand of these products in the markets of Western Europe, Japan and USA. The export potential has increased so much that mariculture has become established as a significant source of foreign exchange earnings in a number of developing countries. The success story of countries like Ecuador has attracted world wide attention and encouraged many developing tropical countries with large stands of mangrove forests to invest in shrimp mariculture development.

Kenya has a total of about 59 980 ha of mangrove forests on its 450 km long semi arid coastline (Doute *et al.*, 1981). These mangroves have been cleared mainly for salt farming and for wood (fuel and building purposes). Although aquaculture was introduced in Kenya soon after the first world war, well over 250 ha of the total pond area in the country has been devoted for the culture of freshwater finfish especially *Tilapia* (Allela, 1986).

The mariculture subsector has been lagging behind and it was in 1978 that a pilot project was set up to test the technical and economic viability of brackishwater aquaculture of shrimps on the Kenya coast. The production levels of an average of 525 kg $ha^{-1}$ $yr^{-1}$ has created considerable interest among private sector entrepreneurs and national policymakers resulting in plans being drawn up for large scale commercial operations.

This paper proposes a cautious approach to the envisaged mariculture development which would involve the integration of aquaculture with the management of mangroves and the efficient utilisation of already reclaimed mangrove areas.

## Efficient utilisation of already reclaimed mangrove lands

Pond aquaculture is currently recognized worldwide as the major culprit in the large scale clearing of mangrove forests and other coastal wetlands (Bailey, 1988; Singh, 1987). So far in Kenya, it is salt farming which has been mainly responsible for the destruction of large tracts of mangroves with 50% of the total salt farm acreage in the coast being located within former mangrove areas (Jira, pers. comm.). The Ngomeni aquaculture pilot project executed under the FAO/UNDP funding is responsible for the destruction of about 60 ha of mangrove forests in the Ngomeni creek. Utilising the reclaimed mangrove land more efficiently rather than further clearing of more mangroves is an avenue which should be considered. One viable alternative is for the solar salt producing companies to diversify into aquaculture. Another alternative is the intensification of pond aquaculture instead of the extensive method which was used in the FAO/UNDP pilot project.

### *Integrated solar salt – aquaculture production*

Irrespective of locality, the solar salt making process is fairly uniform, with sea water being evaporated in controlled areas to produce brine for crystallising salt. A typical saltworks in Kenya consists of a series of ponds where the brine is transferred as it gets progressively more saline. As many as six transfers are involved from the first reservoir through a series of evaporation ponds to a serving pond and finally to the crystallisers (Fig. 1). The first reservoir ponds which generally occupy 7–15% of the saltworks total area are indeed ready-made extensive ponds suitable for fish and shrimp farming. The sea water in the reservoir is always freshly drawn and has a salinity which does not differ much from that of the ocean since the pumps are constantly in operation. Using the estimates of Sammy & Tyler (1986) that some 65 tonnes of sea water are needed to produce one tonne of salt, a solar salt producer could culture plankton feeding animals

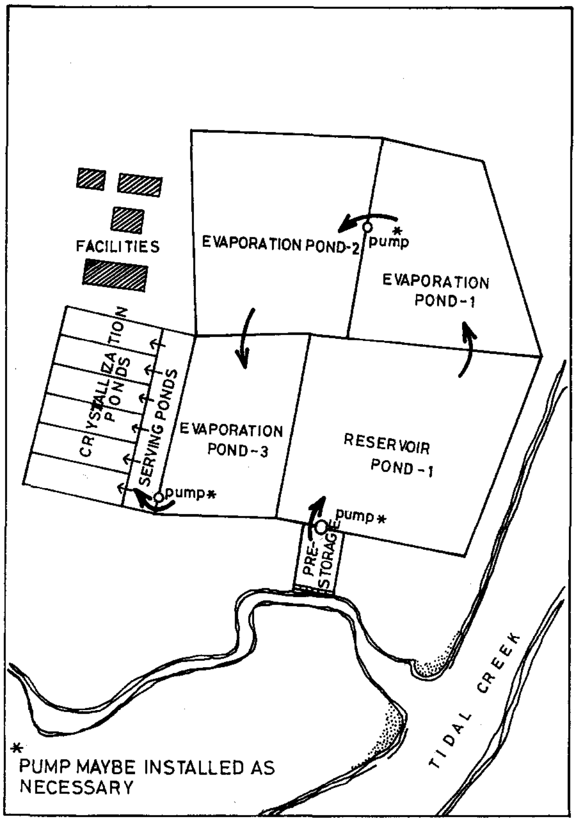


*Fig. 1.* Generalized layout of a saltwork in Kenya (Source: Yap & Landoy, 1986).

like oysters, mussels and milkfish on the plankton content of this volume of pumped sea water. These reservoir ponds could also be used as extensive shrimp ponds in which the shrimps could subsist and grow on the naturally occurring food in the ponds. Considering that the physical facilities, civil works, and equipment required is common with that for the salt industry and that there is an existing pool of manpower with actual experience in all aspects of pond construction and maintenance, the establishment of an aquaculture facility in the first reservoir makes good economic sense. The necessity and cost of pumping sea water are inherent in the operation of a salt field hence no extra costs would be incurred in obtaining the plankton biomass.

*Integrated solar salt –* Artemia *culture*

As the sea water gets progressively more saline with passage through a salt field there is a natural mortality of organisms because of the increasing salinity. Those organisms that survive tend to proliferate through lack of competition. One of these organisms is the brine shrimp *Artemia* which thrives in the evaporator ponds where the brine attains a concentration of 60–300% (Fig. 2). In the low salinity ponds (100–150 g salt $l^{-1}$) the *Artemia* reproduces by ovoviviparity (free-swimming larvae) while at higher salinities (> 150 g $l^{-1}$) the animal responds to the sub-optimal conditions by producing cysts (oviparity). Jones *et al.* (1981) have shown that *Artemia*

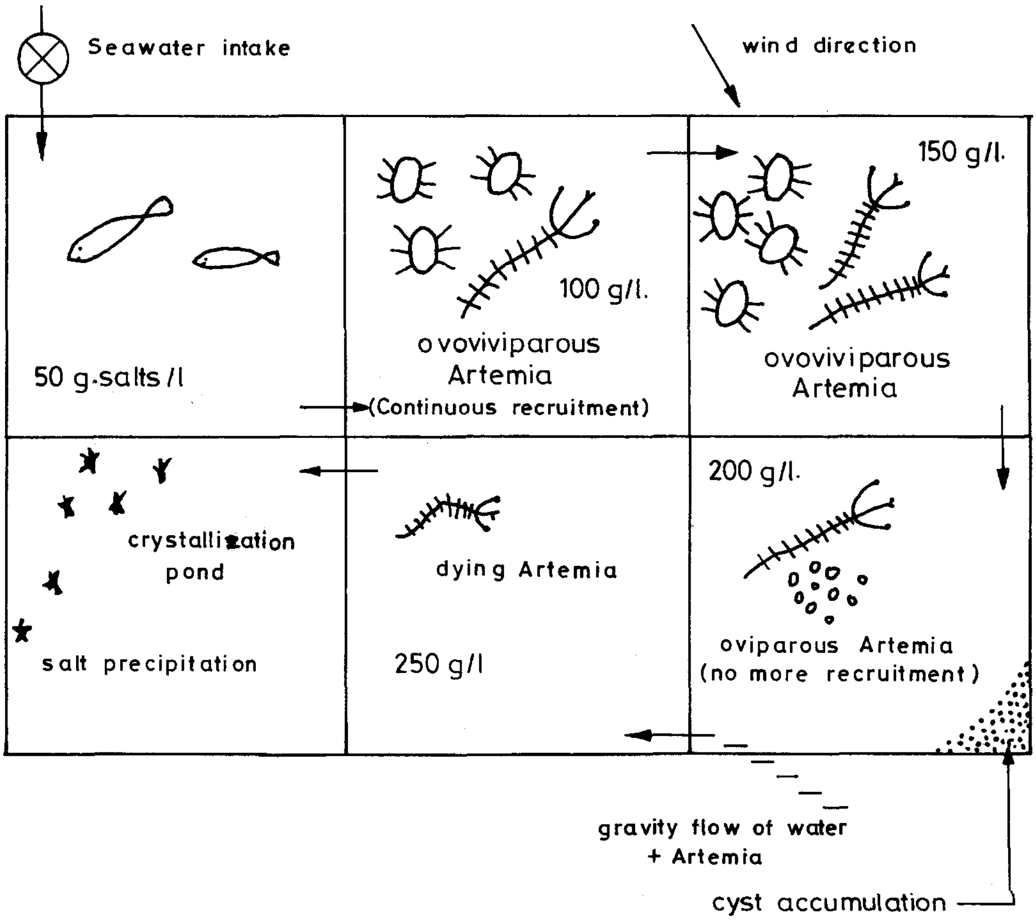


*Fig. 2.* Schematic diagram of solar salt operation with natural occurrence of *Artemia* (Source: Sorgeloos, 1983).

plays a fundamental role in the salt making process. The continuously non-selective filter feeding *Artemia* keeps under control the algal blooms which usually prevent early precipitation of gypsum and in extreme situations even hamper salt crystallisation. The *Artemia* metabolites or the decaying *Artemia* also provide a suitable substrate for the halophilic microbes of the genus *Halobacterium*, the presence of which assures a red coloration of the cyrstallisers. Dark red crystallisers assures much better heat absorption and thus faster salt crystallisation than in a situation where the white salt at the bottom of the pond reflects most of the light (Sorgeloos, 1983; Jones *et al.*, 1981). In crustacean hatcheries *Artemia* is used as a practical and suitable larval food source either in the form of nauplii that can easily be hatched from the dry cysts or as adults (biomass) that can be harvested from evaporator ponds. *Artemia* biomass would alleviate the feed supply problem in the ponds while the *Artemia* cysts which can command as high as $50 per kilogram in the world market could be a source of foreign exchange earnings. *Artemia* culture in the coastal saltfarms has already been investigated and found viable (Rasowo & Radul, 1986) and only needs management to enhance cyst and biomass production.

### *Intensification of existing pond aquaculture*

Maximising the output in the existing ponds would negate the need for expanding the pond area. Thus intensification in place of extensification of the pond culture seems to be a means of saving the mangroves from further destruction. Since intensive farming involves great production costs because of the use of sophisticated technology, Kaptesky (1987) points out that it can only be a viable management solution if appropriate local technology and manpower trained to utilise it is available. Kenya lacks this technology and hence semi-intensive methods which also include feeding, pond fertilization, predator control and aeration should be adopted.

## **Aquaculture in the mangroves**

Some types of aquaculture activities can be practiced in mangrove areas without adverse effects on the mangrove ecosystem. Pen, cage, raft, long line, and tray culture are good alternatives to pond culture in the mangroves although the methods require biological, technological and infrastructural inputs. Oyster culture is currently being practiced in one creek in Kenya where a simple and inexpensive culture system using a combination of rack and raft method for growth and roofing tiles for spat collection has given very impressive results with the local species *Crassostrea cucullata*. Kenya possesses 22 extensive mangrove creeks covering 52 000 ha in surface area, thus the potential for growing oysters is vast provided that a market can be established. Some species of *Tilapia*, e.g., *T. spilurus* and *T. mossambica*, show remarkable tolerance to salinity. The feasibility of tilapia cage culture within the many sheltered tidal creeks should be studied. The culture of brackishwater fish like rabbit fish (*Siganus* spp.), mullets, and milkfish in floating cages or fish pens should be encouraged. Bwathondi (1986) reports successful attempts at cage culture of *Siganus canaliculatus* in neighbouring Tanzania, though the identity of the species in question is probably *S. sutor* (Fischer & Whitehead, 1974).

## **Pump-fed ponds**

Almost all tropical countries with mangrove forests have enacted legislation regulating the utilisation of the mangrove swamps. But as pointed out by Csavas (1988), conservation measures however strictly enforced cannot completely stop further destruction of mangroves. Hence, alternative solutions have to be found. Diverting coastal aquaculture development out of the mangrove and onto adjacent higher grounds could be an answer. Locating ponds on higher grounds requires pumping to provide water circulation. It has been shown that the pumping costs are more than counterbalanced by the savings on construction costs as there is a marked reduction in the volume of earthwork and structures. Higher production is also achieved with the improved circulation independent of tidal rise and fall (Gedney *et al.*, 1984). Since the ponds are easier to drain a more efficient and complete harvesting facilitating the drying and treatment of the pond bottom is possible. Construction out of the mangrove areas means a substantially decreased danger of hitting acid sulphate soils, especially as the ponds are also only shallowly excavated.

## Conclusion

Many tropical countries with extensive areas of inter-tidal land suitable for shrimp production have began to develop the resource for shrimp production with a view to foreign exchange earnings, agricultural diversification and employment generation. As a result, large tracts of mangrove forests are being converted into aquaculture ponds. This large-scale conversion may eventually be detrimental to the aquaculture industry itself because the viability of shrimp mariculture is closely linked to the status of mangroves in the local ecosystem. Indeed, in the majority of these countries the hatchery systems are not well developed hence much of the shrimp culture industry is dependent on the mangrove areas to supply wild fry for stocking the ponds. A number of conservation measures may be employed to minimize the loss of the mangrove habitats: ponds should be sited on the landward side of the mangrove area so as to have the more productive seaward area undisturbed. Where cleared inter-tidal land is available this should be used in preference to intact mangroves. Mangroves should be retained and planted on the banks of ponds. There is a clear indication that aquaculture activity can exist in harmony with the mangrove ecosystem when 'mangrove-friendly' aquaculture methods like pen, cage, raft and long-line are employed. Ultimately emphasis should be laid on a more efficient use of existing pond areas by encouraging intensification as well as integrated aquaculture practices.

## Acknowledgement

This paper was prepared with the support of a grant from Moi University.

## References

Allela, S. O., 1986. Development and research of aquaculture in Kenya. In E. A. Huisman (ed.), Aquaculture Research in the Africa Region. Pudoc, Wageningen, 274 pp.

Bailey, C., 1988. The social consequences of tropical shrimp mariculture development. Ocean & Shoreline Management 11: 31–44.

Brusher, H. A., 1974. The magnitude, distribution and availability of prawn (Penaeidae) resources in coastal and estuaries of Kenya. J. mar. Biol. Ass. India 16: 335–348.

Bwathondi, P. O., 1986. A review of aquaculture practices in Tanzania. In E. A. Huisman (ed.), Aquaculture Research in the Africa Region. Pudoc, Wageningen, 274 pp.

Csavas, I., 1988. Shrimp farming developments in Asia. Infofish International 2: 11–16.

Doute, R., N. Ochanda & H. Epp, 1981. A forest inventory of Kenya using remote sensing techniques. KREMU Technical Report Series No. 30. Kenya Ministry of Environment and Natural Resources.

Fischer, W. & P. J. P. Whitehead (eds), 1974. FAO Species Identification Sheets for Fishery Purposes Vol. 4. Rome, FAO, Pag. Var.

Gedney, R. H., Y. C. Shang & H. L. Cook, 1984. Comparative study of tidal and pumped water supply for brackish-water aquaculture ponds in Malaysia. Coastal Aquaculture Demonstration and Training Project, FI:DP/MAL/77/008. Field Document No. 2: 119–60.

Jones, A. G., C. M. Ewing & M. V. Melvin, 1981. Biotechnology of solar salt fields. Hydrobiologia 81: 391–406.

Kapetsky, J. M., 1987. Conversion of mangroves for pond aquaculture: some short-term and long-term remedies. Workshop on the Conversion of Mangrove Areas to Aquaculture. UNDP/UNESCO Regional Project RAS/79/002.

MacNae, W., 1974. Mangrove forests and fisheries. Indian Ocean Programme, Indian Ocean Fishery Commission, Roma, IOFC/DEV/74/34.

Rasowo, J. & J. Radul, 1986. Inoculation of brine shrimp, *Artemia salina*, in Kenya; expected impact on aquaculture development. In E. A. Huisman (ed.), Aquaculture Research in the Africa Region. Pudoc, Wageningen 274 pp.

Saenger, P., E. J. Hegerl & J. D. S. Davie, 1983. Global status of mangrove ecosystems. Commission on Ecology Papers No. 3, International Union for Conservation of Nature and Natural Resources, 88 pp.

Sammy, N. & J. Tyler, 1986. Opportunity knocks for solar salt field aquaculture. Australian Fisheries, November 1986, 2–4.

Singh, T., 1987. The use of mangrove-managed areas for aquaculture. Workshop on the conversion of Mangrove areas to Aquaculture. UNDP/UNESCO Regional Project RAS/79/002.

Sorgeloos, P., 1983. Potential of the mass production of brine shrimp *Artemia*. Journal of the Society for Underwater Technology. Spring 1983, 27–29.

Turner, R. E., 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. am. Fish. Soc., 106: 411–6.

Yap, G. W. & R. J. Landoy, 1986. Development of Coastal Aquaculture. Report on a survey of the coastal areas of Kenya for shrimp farm development. KEN/80/018, Fisheries Department, FAO, Rome.