

SHRIMP AQUACULTURE IN AFRICA
AND THE MIDDLE EAST:
THE CURRENT REALITY
AND TRENDS FOR THE FUTURE

Sherif Sadek

Arab Aquaculture Consultants Office,
Zamalek, Cairo, Egypt.

Rafael Rafael

SEACAM - Secretariat for Eastern African Coastal Area Management
Maputo, Mozambique.

Mebdi Shakouri

Shrimp Aquaculture Division,
Department of Fisheries (SHILAT), Tehran, Iran.

Georges Rafomanana

De l'Environnement et de la Qualite de la Vie
Madagascar

Fernando Loforte Ribeiro

Department of Aquaculture
Fisheries Research Institute (IIP)
Maputo, Mozambique.

and

Jason Clay

WWF US, Washington DC, USA

A Report Prepared for the

World Bank, Network of Aquaculture Centres in Asia-Pacific,
World Wildlife Fund and Food and Agriculture Organization of the United Nations
Consortium Program on Shrimp Farming and the Environment

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Preparation of this document

The research reported in this paper was prepared under the World Bank/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment. Due to the strong interest globally in shrimp farming and issues that have arisen from its development, the consortium program was initiated to analyze and share experiences on the better management of shrimp aquaculture in coastal areas. It is based on the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture¹, a World Bank review on Shrimp Farming and the Environment², and an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. The objectives of the consortium program are: (a) Generate a better understanding of key issues involved in sustainable shrimp aquaculture; (b) Encourage a debate and discussion around these issues that leads to consensus among stakeholders regarding key issues; (c) Identify better management strategies for sustainable shrimp aquaculture; (d) Evaluate the cost for adoption of such strategies as well as other potential barriers to their adoption; (e) Create a framework to review and evaluate successes and failures in sustainable shrimp aquaculture which can inform policy debate on management strategies for sustainable shrimp aquaculture; and (f) Identify future development activities and assistance required for the implementation of better management strategies that would support the development of a more sustainable shrimp culture industry. This paper represents one of the case studies from the Consortium Program.

The program was initiated in August 1999 and comprises complementary case studies on different aspects of shrimp aquaculture. The case studies provide wide geographical coverage of major shrimp producing countries in Asia and Latin America, as well as Africa, and studies and reviews of a global nature. The subject matter is broad, from farm level management practice, poverty issues, integration of shrimp aquaculture into coastal area management, shrimp health management and policy and legal issues. The case studies together provide an unique and important insight into the global status of shrimp aquaculture and management practices. The reports from the Consortium Program are available as web versions (<http://www.enaca.org/shrimp>) or in a limited number of hard copies.

The funding for the Consortium Program is provided by the World Bank-Netherlands Partnership Program, World Wildlife Fund (WWF), the Network of Aquaculture Centres in Asia-Pacific (NACA) and Food and Agriculture Organization of the United Nations (FAO). The financial assistance of the Netherlands Government, MacArthur and AVINA Foundations in supporting the work is also gratefully acknowledged.

Correspondence: Jason Clay: E-mail: shrimpaquaculture@wwfus.org

Reference:

Sadek, S., R. Rafael, M. Shakouri, G. Rafomanana, F.L. Ribeiro and J. Clay .2002. Shrimp Aquaculture in Africa and the Middle East: The Current Reality and Trends for the Future. Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment. Work in Progress for Public Discussion. Published by the Consortium. 42 pages.

¹ FAO. 1998. Report of the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture. Bangkok, Thailand, 8-11 December 1997. FAO Fisheries Report No. 572. Rome. 31p.

² World Bank. 1998. Report on Shrimp Farming and the Environment – Can Shrimp Farming be Undertaken Sustainability? A Discussion Paper designed to assist in the development of Sustainable Shrimp Aquaculture. World Bank. Draft.

Abstract

This case study reviews shrimp aquaculture development in East Africa and the Middle East, as well as the problems and prospects for future development. There has been increasing investment in shrimp farming in these two regions, and it is clear that further investments will occur in the future. Given that these are two of the last tropical regions of the world where shrimp aquaculture development has not occurred on any significant scale, it should be possible to learn the lessons from other parts of the world and apply them in these contexts. The countries in this report are: Egypt, Iran, Mozambique, Madagascar and some information on other countries in both regions.

Content

ABSTRACT	IV
CONTENT	V
ABBREVIATIONS AND ACRONYMS	VII
INTRODUCTION TO SHRIMP AQUACULTURE IN AFRICA AND THE MIDDLE EAST	1
SHRIMP AQUACULTURE IN EGYPT	4
INTRODUCTION	4
LAND USE AND INDUSTRIAL DEVELOPMENT	4
HATCHERIES	5
NURSERY	6
FARMING SYSTEMS	6
SHRIMP FEED	8
CONSTRAINTS	8
SUSTAINABLE MARINE SHRIMP CULTURE DEVELOPMENT	9
SHRIMP AQUACULTURE IN IRAN	12
INTRODUCTION	12
SHRIMP AQUACULTURE DEVELOPMENT PLANS	14
LAWS AND REGULATIONS	14
THE SHRIMP AQUACULTURE SYSTEM IN IRAN	15
SHRIMP AQUACULTURE MANAGEMENT	15
PROBLEMS AND CONSTRAINTS FACING SHRIMP AQUACULTURE IN IRAN	16
SHRIMP AQUACULTURE IN MOZAMBIQUE	18
SUMMARY	18
INTRODUCTION AND BACKGROUND	18
RESOURCES AND POTENTIALS FOR SHRIMP CULTURE DEVELOPMENT	19
INDUSTRIAL SHRIMP FARMING	19
AQUACULTURE PLANNING AND DEVELOPMENT POLICY	20
INSTITUTIONAL FRAMEWORK	21
LEGAL FRAMEWORK	21
PRELIMINARY ASSESSMENT	21
SHRIMP AQUACULTURE IN MADAGASCAR	24
SUMMARY	24
INTRODUCTION AND BACKGROUND	24
POTENTIAL FOR SHRIMP AQUACULTURE DEVELOPMENT	26
SEMI-INTENSIVE PRODUCTION	26
INTENSIVE PRODUCTION	27
ARTISANAL SHRIMP CULTURE	27
INSTITUTIONAL FRAMEWORK	27
LEGAL FRAMEWORK	28
ENVIRONMENTAL ISSUES	28
WATER	28
MANGROVE	29
HEALTH	29
SOCIO-ECONOMIC	29
CHEMICALS	29
FEED	29
CONSTRAINTS	30

INFORMATION ON SHRIMP AQUACULTURE FROM OTHER AFRICAN COUNTRIES	31
INTRODUCTION	31
ERITREA	31
GAMBIA	32
GUINEA	32
SEYCHELLES	32
SOUTH AFRICA	32
TANZANIA.....	35
INFORMATION ON SHRIMP AQUACULTURE FROM OTHER COUNTRIES IN THE MIDDLE EAST.....	36
INTRODUCTION	36
KUWAIT	36
SAUDI ARABIA.....	36
INFORMATION ON SOME OF THE PLAYERS	36
HATCHERY.....	39
PROCESSING PLANT.....	39
DISEASE	40
REFERENCES.....	41

Abbreviations and Acronyms

FAO	Food and Agriculture Organization of the United Nations
NACA	Network of Aquaculture Centres in Asia Pacific
Ha	Hectare
PL	Postlarvae
WB	The World Bank
WWF	World Wildlife Fund
ppt	Parts per Thousand
EEAA	The Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
SEACAM	The Secretariat for Eastern African Coastal Area Management

Introduction to Shrimp Aquaculture in Africa and the Middle East

Large sections of Africa and the Middle East, with their rich natural heritage, high biodiversity and relatively unspoiled coastal environment, hold tremendous potential for the development of commercially viable shrimp aquaculture. More than a dozen countries in the two regions already have some 50-100 commercial shrimp aquaculture operations up and running. These operations range from tiny, extensive artisanal operations to quite large, intensive production systems.

In fact, given the problems of disease (and crashing production systems) and the over development of the industry in a number of other countries, investors have begun to look seriously at Africa and the Middle East as potential areas for investment. Environmental activists are interested in preventing the negative impacts of the industry in these regions. To date, however, the perceived advantages of these two regions have been insufficient to lure significant investments in shrimp aquaculture in either region.

However, investments are increasing. Madagascar, Egypt and Iran already have small, but important shrimp aquaculture industries. This report is intended to review the actual situation of shrimp aquaculture development in the two regions as well as the problems and prospects for future development. It is clear that a certain amount of investment will occur in the future. Given that these are two of the last tropical regions of the world where shrimp aquaculture development has not occurred on any significant scale it should be possible to learn the lessons from other parts of the world and apply them in these contexts.

Some governments have already seen shrimp aquaculture contribute to economic development and the generation of foreign exchange. All governments in the two regions have heard about the actual contributions of shrimp aquaculture to the economy in Asia and Latin America. Such governments are interested in luring investors to come to their countries to make similar investments with similar return. Few understand the potential impacts and economic, social and environmental implications of the uncontrolled expansion of the industry.

For the most part, governments in the region see large expanses of unspoiled coastal habitats throughout their countries that offer potentially suitable sites for shrimp aquaculture development. Many governments are beginning to evaluate the potential of their coastlines for development and to lure investors to commit themselves to the countries.

The ability to develop sustainable shrimp aquaculture operations in these two regions will depend on the establishment of a number of necessary institutional and technical preconditions. Public sector institutions play an important role in each stage of mariculture project development. This begins with project planning and approval and goes through the monitoring of construction and operations impacts. Governments promote the growth of the industry, to be sure, but they also regulate it. Since shrimp aquaculture is a new industry throughout these two regions, there is little institutional structure or capacity to oversee the development of the industry in any comprehensive way.

Great care must be taken not to reduce either the ecological or the economic value of critical habitats. Shrimp aquaculture development must be undertaken in such a way that safeguards vital natural resources, maximizes social benefits and remains economically viable and competitive within a global economy.

Several issues will have to be addressed in order to gain the full potential of any shrimp aquaculture development that takes place while minimizing the risks and impacts.

The soundest basis for sustainable shrimp aquaculture development is careful planning, zoning and prioritization of sites among the different potential users. Conflicts with other users and other economic activities (e.g. fisheries, agriculture, forestry, tourism, and subsistence users) can be costly and result in the failure of the investment as well as the irreversible damage to ecologically

and economically critical resources.

Detailed shrimp aquaculture development guidelines bring clarity and transparency to the approval process while reducing conflict. Such guidelines focus attention and debate on real and significant issues while minimizing the chances of conflicts developing around tangential issues. Such guidelines include environmental impact assessments (EIAs), zoning, siting and monitoring criteria, and the identification of key indicators and environmental performance standards.

Another key factor is the clear identification of policies and procedures. This is essential for successful mariculture planning. This means that the procedure for obtaining permits, licenses, concessions, land titles and approvals for projects should be clear and transparent. This is one way to insure that proponents are in compliance with the appropriate procedures and that government officials have clear guidance about how to proceed with approvals in the face of controversy. Development inevitably is about conflict as it is about change. The conflict can be between different ministries, different industries, different local users of resources, or some combination of all three.

In most countries, but especially in African and Middle Eastern countries, the ability of individuals, companies, governments and development agencies to plan for shrimp aquaculture projects that are financially and environmentally sustainable is hampered by a lack of technical capacity as well as scarce resources. There is very little aquaculture experience in general in these regions and even less experience with shrimp aquaculture in particular.

Governments that are interested in promoting sustainable shrimp aquaculture to insure the long-term performance of the industry should establish clear policies and procedures before the development of the industry explodes uncontrollably. Such policies and procedures do not have to be exhaustive, but they should address the most common issues and impacts that shrimp aquaculture raises. In the initial stages, zoning, siting, and other pre-construction issues need to be addressed through appropriate policies, procedures and approval processes.

Once farms are operating, the goal of government should be to encourage the adoption of better management practices that reduce the ongoing operational impacts of the industry. Government should also link on-going approval to monitoring the main impacts of shrimp aquaculture. This can either be accomplished by regulations and policies or by linking permits, licenses and concessions to independently verified performance compliance with specific standards. Or, these two approaches can be linked. The important thing is that the shrimp aquaculture companies must be able to prove that they are in compliance with the better practices as required by law in order to continue to operate in the country.

In many forms of aquaculture, it is essential for government and development agencies to demonstrate the financial viability of the aquaculture enterprise to potential investors. With the overall profitability of shrimp aquaculture, that has not tended to be the case. Governments in Africa and the Middle East, by contrast, have a more difficult time convincing potential investors that they are sufficiently stable to warrant investments and that the lack of infrastructure and expertise can be overcome. Limited infrastructure (e.g. poor roads, port facilities, power supplies, communication, utilities, etc.) and limited technical capacity (e.g. directly related to aquaculture or in related fields such as food processing, marketing, etc.) are two of the biggest problems limiting the development of shrimp aquaculture in Africa and the Middle East.

However, whether addressing financial viability or political instability or the lack of technical expertise, government-sponsored model or pilot operations can help to erode concerns. In several of the countries reported on in this paper, the FAO has worked with government to establish model farms, which are then normally sold off to private investors. In any case, these initial pilot programs generally create sufficient confidence to leverage other investments. In addition, such pilot programs provide government with a chance to learn first hand about shrimp farming. Such

insights could even allow governments to fine tune their regulations, policies and procedures.

Finally, and perhaps most importantly, a climate that is more conducive to sustainable shrimp aquaculture development is one where various stakeholders are not only permitted but also encouraged to provide inputs and raise concerns about projects that are under consideration. Transparency with regard to consultations will tend to reduce or even prevent conflicts that cost local communities, shrimp companies and governments alike millions of dollars each year. This type of open, transparent consultation and participation in the approval process is more common in countries that have a strong history of democratic institutions.

Shrimp Aquaculture in Egypt

by
Sherif Sadek and Rafael Rafael

Introduction

In the mid-1990s, when Egypt's catch of wild-caught shrimp began to decrease in size, the government began to encourage the private sector to develop shrimp farming. The goal was to create an industry capable of producing large commercially valuable shrimp.

From 1988-1997, the annual total shrimp fisheries production from Egypt's Mediterranean and Red Sea coasts—including the Suez Canal-Bitter Lakes, the coastal lagoons of Manzala, Burullus and Bardawil and inland lakes of Qarun—averaged 6,339 MT (Figure 1) and represented less than 2% of the total fish and shellfish landings in Egypt. The majority of shrimp fisheries production consists of small species (*Metapenaeus stebbingi*, *Trachypenaeus curvirostris*, *Parapenaeus longirostris* and *Solenocera crassicornis*), while larger sized species (*P. japonicus*, *P. semisulcatus*, *P. kerathurus*, *P. latisulcatus* and *Metapenaeus monoceros*) are caught only in small quantities.

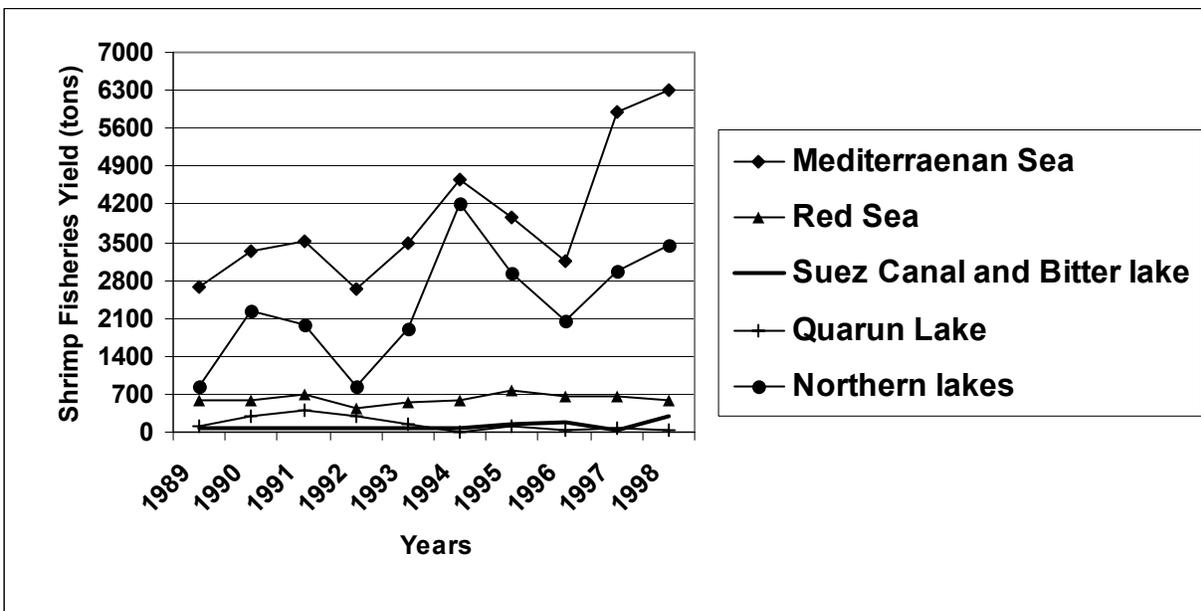


Figure 1. Egyptian shrimp fisheries yield during the period from 1988 to 1998 (CAPMS, 1989-1999).

Aquacultural production in Egypt has increased progressively. In 1977 aquaculture production was 12,400 MT, representing 8.3% of total fish production that year. By 1998, production had increased six fold to 139,389 MT, representing 26% of total fish production. It is expected that shrimp aquaculture will continue to expand in the coming decade.

In 1985 a shrimp farm near Alexandria was the first commercial shrimp hatchery and farm to be established in Egypt. The farm went bankrupt early in 1992 due to financial and managerial problems that arose from inadequate site assessments. One year later, a private firm began to develop a farm on the coast of the Red Sea. Today Egypt has 6 hatcheries with a yearly production of 382 million PL/year, 5 farms in production with a total surface of 444 ha and divided into 96 ponds. In the year 2000, the estimated annual heads-on production was expected to reach 320 MT, which still represents less than 5 % of the shrimp fisheries. Egypt is just beginning to develop its potential, and the government is encouraging shrimp farming.

Land use and Industrial Development

The aquaculture map in Egypt is divided into four regions: (a) the Nile Valley and Delta (which are made up of four sub-regions—the Northern Littoral Region, the Delta, Middle Egypt and Upper Egypt); (b) the

Eastern Nile Delta; (c) the Mediterranean Sea Coast; (d) the Red Sea Coasts (Balarin 1986).

Egypt has selected sites for mariculture projects (7 sites for extensive farming in coastal lagoons, 3 sites in artificial lakes, 32 sites for floating cages, 23 sites for semi-intensive culture in earthen ponds and 13 sites for enclosures). During a recent survey, about 68 sites covering an area of 83 thousand hectares (77% on the western Egyptian Red Sea coast and 23% on the eastern Egyptian Red Sea coast) were found to be suitable for mariculture (GAFRD 1996a and b).

Sadek (1997) and Sadek and El-Gamal (1997) studied the possibility of culturing marine finfish and shrimp in a new marine complex located in the northwestern area of the Sinai Peninsula. The Egyptian Company For Fisheries and Equipments (ECFE) identified 11,350 ha for mariculture, and the land has already been leased for mariculture projects. Thousands of hectares contain soil unsuitable for aquaculture due to its high porosity and poor compacting qualities. Seawater supplied from the Mediterranean Sea is used in these operations.

Most shrimp aquaculture is undertaken northeast and northwest of Nile delta near the Mediterranean Sea as well as along the Red Sea coast. Marine shrimp farming areas are distributed in the following areas— Alexandria, Damietta, Port Said, North Sinai, South Sinai and Red Sea (Table 1).

Table 1. Some characteristics and status of marine shrimp projects in Egypt (names in *Italic characters* indicate government institutions/enterprises).

Company name	Hatchery production target (million PL/year)	Grow-out		
		Number of ponds	Average pond size (ha)	Total area (ha)
ARC (Aquaculture Research Centre, El-Arish, North Sinai)	3	-	-	-
GAPP (Gona Aquaculture Pilot Project, Hurghada, Red Sea)	-	4	0.2	0.8
<i>EL-WAAFA (El Waafa Company for Ducks and Aquaculture, El-Balah, Ismailia)</i>	12	18	0.4	8
MFFC (Maryut Fish Farming Company, El America, Alexandria)	3	24	0.2	5
<i>NIOF (National Institute for Oceanographic and Fisheries, El Anfoushi, Alexandria)</i>	1.5	-	-	-
SAFICO (Shrimp and Fish International Company, Nabq, South Sinai)	2.5	25	0.7	20
SAINI 21 (SINAI 21 for Shrimp, Port-Fouad, Port-Said)	360	25	16	400
Total	382	96	-	433.8

Egypt has 444 hectares of shrimp ponds in five operations. All of these are being stocked with hatchery-supplied seed. In 2000, six hatcheries reportedly had a combined annual production capacity of 382 million PL.

Hatcheries

Table 1 indicates that more than 98% of the total volume of Penaeid production comes from private companies.

Seed stock is not a problem in Egypt because it is easy to capture, mature and spawn *P. semisulcatus* and *P. japonicus*. Professional fishermen collect spawners from coastal waters. There are two pronounced spawning seasons for *P. japonicus* in the Mediterranean and Red Sea, December to March and June to September.

The feasibility of producing *Artemia* locally has been shown by Baert and Goneim (1990). With the

increasing demand and high cost of *Artemia* in Egypt, a commercial *Artemia* production venture was started in 1990 at the Nasr Salt Co. (NSC) in Port-Said. Production of the brine shrimp *Artemia* is largely based on integration with existing salt pond systems. *Artemia franciscana* is introduced into the normally unstocked highly saline evaporation ponds. *Artemia* cysts and biomass are harvested. A production of 1 and 1.2 MT of cysts and 10-15 and 20 MT of biomass has been estimated to be produced for the years 1992 and 1993, respectively (Baert, personal communication). In 1991, the price for *Artemia* cyst was US\$ 38/kg while *Artemia* biomass was US\$ 2.1/kg. Egypt has different saline depressions and lakes, which could be developed for the production of *Artemia*. No governmental or private projects actually were under commercial production, but NSC is planning to restart a commercial project near Alexandra.

Nursery

Two of the five shrimp operations, SAFICO and GAPP, grew out the PL in small ponds before stocking them in the grow-out ponds. Both companies prefer to grow out the PL from PL8 to PL20 before stocking. This takes a couple of weeks. The expected weight at the end of the nursing phase was around 1.5 g. Their aim was to stock the grow-out ponds with juveniles to ensure good survival rates. Also these companies are able to produce shrimp seed during the winter season using warm, underground brackish water from more than 100 m depth with water temperature a relatively constant 29 C. In this way the farm can begin production in April with juvenile instead of PL. Both of these operations are located in the Red Sea area where average air temperature during the year is 4 degrees higher than in the Mediterranean Sea. This helps keep animals alive and growing slowly during the winter (Figure 2).

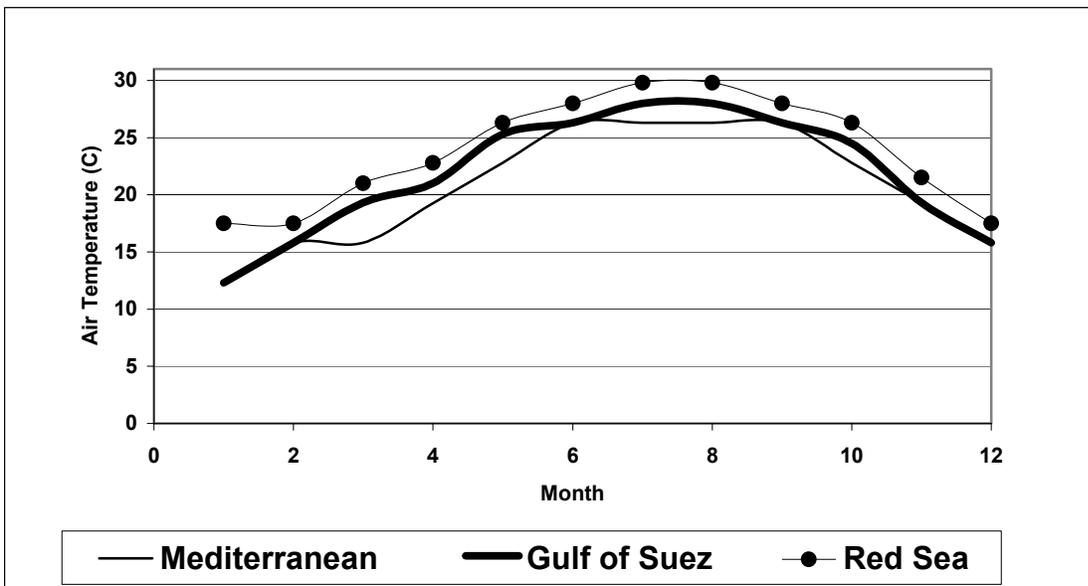


Figure 2. Air temperature variation between three zones in Egypt (Aly 1982).

Farming Systems

Both extensive and semi-intensive shrimp culture systems are used in Egypt. Extensive shrimp aquaculture is only used in Qarun lagoon where salinity was 38 ppt. The most common system was the semi-intensive. Figure 2 showed the different locations where different types of shrimp aquaculture is taking place.

Extensive

Qarun Lake was the first and last place in Egypt where wild penaeid PL were used to stock ponds directly. This was in 1977. Since this time, no other trials of stocking wild caught PL have been undertaken. In 1999 a trial of *P. semisulcatus* from artificial hatcheries was used.

The extensive shrimp culture is located close to Qarun Lake. This lake is the best site for growing and reproducing shrimp using extensive management culture system. The General Authority For Fish

Resources Development (GAFRD) of the Ministry of Agriculture own and manage the fisheries of the inland Qaran Lake. The GAFRD allow Egyptian fishermen to fish in the lake and take shrimp and other animals during specific months of the year.

Shrimp were first stocked in the lake during the winter of 1977. The lake was stocked with 3 million shrimp collected from the Mediterranean coast near the Damietta branch of the Nile Delta. The study showed that *P. kerathurus*, *M. monoceros* and *M. stebbingi* were the most adapted species. *M. stebbingi* can be increased through a continuous control of the fisheries, while the other species *P. kerathurus* and *M. monoceros* can be increased through a program of realizing a monthly growth-rate of 10.0 mm for females and 5.0 for males (condition factor 0.62 and 0.58, respectively). Growth rates and local conditions in Lake Qarun do not vary much from those observed in stocks in the Mediterranean Sea. In Lake Manazala, *M. monoceros* and *M. stebbingi* have the same growth rates as the species in Qarun, 5 and 3 mm/month respectively. The average annual production of Lake Qarun as an extensive culture system is 12 g/ha/yr of marine species. Recently Lake Qarun has been restocked in 1999 with two million post-larvae of *P. semisulcatus*, which the SINAI 21 Company has devoted to the development of the lake fisheries. In the year 2000, the SINAI 21 Company restocked earthen ponds near the lake using the same water of the lake. This grow-out phase in earthen ponds will allow observation of the adaptation of the animal to the local environment and depending on the results could be spread into the lake. Depending on the result, a restocking program could be continued in the future (Bishara 1976; Isak et al. 1980; Abdel-Razek 1991).

Semi-intensive

Sadek (1989a; 1989b) has recorded that the average weekly weight gain is 1.91g for ponds enriched with fertilizer and commercial feed, while 1.44 g for ponds enriched only with fertilizer. Annual yield varied from 360 to 864 kg/ha for *P. japonicus* using fertilizer and commercial feed. It takes approximately 4 months to produce 33 shrimp per kg and 7 months to produce 12 to 15 shrimp per kg (Sadek, 1993).

The production characteristics and operational techniques of different shrimp farms in Egypt are presented in Table 2. Pond stocking densities vary between 3 and 15 shrimp/m² and harvest size is between 20 and 41 g. Farmers average one crop per year, either in the Mediterranean or Red Sea Coasts, and production per hectare ranges from 600 to 2,250 kg of shrimp per year.

Table 2. Production characteristics and operational techniques of different shrimp farms in Egypt.

Company name	Location	Water source salinity (ppt)	Stocking density Animal/m (average weight)	Survival (%)	Final weight per animal (gm)	Production kg/ha	Feed	FCR
GAPP	Red Sea (North Hurghada)	41	7 (0.3 gm)	64	41 gm (S)	1,837 (S) 1,344 (J)	FF TF	1:2.8 1:4.5
EL-WAAFA	Suez Canal	44	10 (PL18)	25	30 gm (J) 20-28 (J)	600	FF	?
MFFC*	Mediterranean	25	3 (PL22)	0	-	-	FF	-
SAFICO	Red Sea (Aqaba Gulf)	42	6-15 (1.5 gm)	75	20	900-2,250 (S)	FF	?
SINAI 21	Mediterranean	45	10 (PL10)	50	27	1,350 (S)	FF	?

FF = Formulated Feed TF = Trash Feed J = *Penaeus japonicus* S = *Penaeus semisulcatus*

* Survival has reached zero % when PL is stocked at the end of summer and water has reached less than 8.5 C during winter.

Once a grow-out operation is stocked with PL, it takes approximately six to eight months to produce a crop of market-size shrimp. Most of the Egyptian production is based on one crop per year, as the Egyptian climate near the Mediterranean allows for the outdoor cultivation of marine shrimp only during the warmer 9 months of the year. In the Red Sea area shrimp farming operations can 1.5 cycles per year.

Shrimp Feed

The production of marine fish and shrimp feed for commercial farming is being attempted domestically for the first time. At present four governmental feed manufacturing plants as well as seven private factories are producing pelleted feeds. All of these plants were devoted to the production of fish feed. None of them produced shrimp feed. The quality of the feed is still below international standards. Two new extrusion feed manufacturing plants are scheduled to be installed soon. Two farms, SAFICO and EL-WAFAA, manufacture their own feed on the farm. The main composition of the shrimp feed is fish meal (either local or imported), local shrimp meal, concentrates, soya meal, corn meal, local fish and vegetable oil, and perimex (soya lecithin, cholesterol, vitamin, mineral and binder). The percentage of crude protein can fluctuate from 38-45% for *P.semisulcatus* and from 42-50% for *P.japonicus* based on the age of the animal.

Table 2 indicates that the current feed conversion ratio was 1:2.8 for local formulated feed and 1:4.5 when trash fish was used as the feed source. Recently, the SINAI 21 company has imported shrimp feed from Ziegler (USA) with different protein levels (35-45%) for different shrimp operations and to experiment and evaluate the results.

Constraints

Seed

Attempts are being made to secure the availability of PL through domestic hatcheries. At this time, however, there is a gap between demand and supply of PLs from hatcheries in Egypt. Producers are faced with trying to obtain wild caught PL, importing PL from other countries or leaving their ponds un-stocked. It is likely that most will import from other countries.

Production in hatcheries is seasonal (from April to August) so prices also fluctuate according to the demand of shrimp farms along the Mediterranean coast where temperature decline in winter and rearing stops in December at the latest. Current prices for *P. semisulcatus* or *P. japonicus* are US\$ 22 for one thousand PL10 and US\$ 29 for one thousand PL22. Prices often decline by as much as 20–25 % in July and August when hatcheries are in full production compared with April to June when they have few broodstock. The future development of shrimp culture in Egypt depends on developing a better hatchery system that can produce PL earlier in the year as well as reducing the overall cost PL.

Table 2 indicates that the survival rate of the stocked animals can fluctuate from 25 to 75 % depending on the size of seeds at stocking period, the time of the stocking, and the stocking density.

Competition and Restrictions on Coastal Land

The jurisdiction of the land along the Egyptian coasts is increasingly divided among the Ministries of Tourism, Urbanism, Petroleum and Defense. The Tourism Development Authority (TDA) has seized Sea Coasts for tourism projects and is planning to seize other land for future projects. However, such lands are still important candidates for petroleum production, industry and urbanism as well as for conservation of protected areas. The Egyptian Environmental Affairs Agency (EEAA) has proclaimed seven areas for protection in the Mediterranean and Red Sea (Zaranik lagoon and El-Amid in the Mediterranean Sea; Ras Mohamed, Nabq, Ras Abu Galum, Tiran Iland and Safanir Island in the Gulf of Aqaba; Abrak, El Daib and Gabal Elba in the Red Sea; Lake Quarun in Fayum). The EEAA has protected 24 islands in the Red Sea.

Availability of Specialized Feeds

The existing feed manufacturing infrastructure has the overall capacity to support the growing aquaculture industry to a certain extent. However, marine shrimp culture normally requires high quality feed, which in turn requires some ingredients that are lacking in the local market—especially high quality fishmeal. It is extremely difficult to obtain supplies of good quality raw material in local markets, especially attractants, binders and cholesterol. It is also clear that all the available feed manufacturing plants in Egypt are not

adapted to produce shrimp feed. Their main focus is not even fish feed, but rather feed for chicken and beef.

Specialized larval feed such as enriched live food and microencapsulated larval feeds may also be required. However an economic analysis is required in order to assess the feasibility of mariculture projects using such expensive feeds.

Manpower and Research

Shortage of technical manpower exists in the shrimp aquaculture industry. This includes in shrimp breeding, culture, disease detection and treatment, processing, marketing, extension, socio-economics, environment, water quality and soil profiles.

All the shrimp projects were managed through Egyptian aquaculture specialized. Only SINAI 21 has designed and constructed the project with the help of Ecuadorian expertise. Sadek (2000) has reported that in general aquaculture research priorities are mostly academic.

Environmental Assessment

There is a lack of information regarding the impact of nutrients and sediment from pond discharge on the local environment. The Egyptian Environmental Affairs Agency (EEAA), which is the sole environment protection authority, requires, as a precondition, an Environment Impact Assessment (EIA) for any aquaculture project. The EEAA required the Egyptian law "The Law and the Executive Statutes of the Law on Environment; No. 4 for year 1994" to be addressed in all EIAs (EEAA 1994). The law describes the different stages of data collection, and outline, and the specific information required from companies in order to develop a full EIA of tourist and urban establishments:

- Executive summary
- Description of the proposed establishment
- Legislative and regulatory considerations
- Description of the Environment (Physical/chemical environment, Biological environment and Sociocultural environment)
- Determination of the potential impacts of the proposed project
- Alternatives to the proposed project
- Development of a monitoring plan
- Public participation
- Environmental Assessment Report

For aquaculture projects, the law has defined a good set of baseline data that is required in the EIA from which it will be possible to compare the potential impacts over time. The aquaculture guidelines also require specific information with regard to the use and /or disposal of certain materials that might end up in either freshwater or marine environments.

Sustainable Marine Shrimp Culture Development

During the last decade farmed shrimp production activities developed very quickly in Egypt. Both *P. semisulcatus* and *P. japonicus* are farmed. These species are indigenous and available in the Egyptian environment either from the Mediterranean or the Red Sea. There appear to be several possible reasons that these indigenous species have been cultivated to the exclusion of imported species—they perform well in the single crop/year production systems common in Egypt, they do best in low stocking density systems also common in Egypt, they are both acclimatized to high water salinity in the Red Sea, and both appear to perform well with low quality shrimp feed.

It is not clear which of the two species, in the two locations, actually perform better. Monitoring performance over time should make the answer clearer. It is quite likely that one of the species will outperform the other, but that is not yet clear. Even if one of the species performs better in one of the sites,

which does not mean that cultivation of the other would not also be profitable. At any rate, to date there have not been disease problems in either of the grow out areas with either of the species.

It is recommended that Egyptian aquaculture could benefit from experiments conducted in other countries. However, it is essential that these “lessons” be adapted to physical, technical and social conditions in Egypt before being adopted and put into practice. Also Egypt must learn from its own mistakes. The failures and problems that have appeared in different Egyptian companies should also help to shape future activities (Tables 3 and 4).

Several constraints to the shrimp culture could be avoided by the following:

- Decrease the cost of seed by decreasing the operating costs and increasing the intensity of production.
- Evaluate production parameters for both *P. semisulcatus* and *P. japonicus* in the two different ecosystems, e.g. the Red Sea and the Mediterranean Sea coasts.
- Enhance the availability of skilled staff and increase the capacity of unskilled staff.
- Support investments in the production of shrimp feed and ensure that necessary quality standards are met.
- Enhance a sustainable marine shrimp aquaculture research based on both a short and long term vision.
- Encourage the private sector to establish local dealer companies to import feed and equipment needed for the industry (aeration systems, feeders, etc).
- Establish a pilot shrimp farm in the area of the Red Sea to study the impact of pollution on the ecosystem as well as to identify and analyze the costs of mitigation methods.

Table 3. Major selected problems and their mitigation in the Egyptian marine shrimp hatcheries.

Company name	Problem	Mitigation
EL-WAAFA	- Contamination risks between marine finfish and shrimp in the hatchery	- Separate finfish and shrimp seed production.
SAFICO	- Contamination risks - Shortage of broodstock - Low survival rate in the larval tanks, as larvae are only fed zooplankton (Artemia) and microparticles.	- Separate maturation, spawning, larval rearing and Artemia departments. - Implement a broodstock production unit to domesticate the species and improve zootechnical performance of the farmed strains. - Use live phytoplankton as it contains a number of essential trace elements and vitamins; it could act as a buffer when the ammoniac concentrations increase.

Table 4. Major selected problems and their mitigation in the Egyptian marine shrimp farms.

Company name	Problem	Mitigation
GAPP	<ul style="list-style-type: none">- Environmental legislation- Limited culture sites	<ul style="list-style-type: none">- Undertake a study to identify basic legislation and policies required.- Develop an integrated project between tourism and aquaculture.
SAFICO	<ul style="list-style-type: none">- Raised water salinity levels (> 42 ppt), which could have a negative effect on growth. Increased levels of nutrients or eutrophication, stimulation of algal blooms (e.g. phytoplankton, macroalgae) causing problems such as oxygen depletion and the accumulation of hydrogen sulfide in the water column.- Lack of productivity in soil- Ponds are not water tight- Bad feed quality.	<ul style="list-style-type: none">- Water exchange in the rearing ponds is too low (5 %/day). Exchange rates could be increased to 10 % per day.- Add clay- Add clay or use a polyethylene pond liner- Improve shrimp feed manufacturing plant by adopting standard production procedures and equipment.
SINAI 21	<ul style="list-style-type: none">- Production of macro-algae hampers production.- High salinity in hot weather- Limited growing season	<ul style="list-style-type: none">- Use a bio-IPM treatment by stocking rabbit fish (<i>Siganus</i> spp) or tilapia.- Increase water exchange- Stock larger PL or juveniles.

Shrimp Aquaculture in Iran

by
Mehdi Shakouri

Introduction

Iran is famous for its long history (2,600 years of civilization), pistachios, fantastic carpets and delicious caviar. Now the country is beginning to develop shrimp aquaculture. Ten years ago, none believed in Iran's capability to develop a shrimp aquaculture industry. Today the industry is one of the most important parts of fisheries sub-sector.

Commercial shrimp culture began in 1993 just at the time that other shrimp producing countries (China, Philippines, Thailand and Ecuador) were beginning to experience serious disease problems. With the assistance of the government, the industry expanded very fast—from 16 MT in 1993 to 3,700 MT in 2000.

By 1999, there were 150 farms and 23 hatcheries in the country. They are located along the 2,000 km coastline from Abadaw and Chouebdeh in the NW through Bushehr, to west of Bandar-e Abbas and finally to Chahbahar in the SE. In Helleh, there are 50, 20-ha farms and 3 large hatcheries. Delvar has 32, 20-ha farms (with 20 more under construction) as well as 3 hatcheries. In Bushehr, 3,000 additional hectares of shrimp ponds were under construction and scheduled to be brought on line in 2000.

In 1999, Iranian shrimp hatcheries produced 370 million PL. The following year, 24 hatcheries produced 600 million PL. All but two of the hatcheries use Filipino or Thai technicians. All hatcheries depend on wild spawners. There is only one location in the country to catch spawners and the catch is declining. Broodstock facilities are being developed, but with temperatures as low as 10 C in the winter, covered ponds are essential.

Characteristics of Semi-Intensive Shrimp Aquaculture Systems in Iran

Main species	<i>P. indicus</i>
Production (MT/ha/yr)	1.5 to 3 MT
Stocking density (PL/m ² /crop)	22 to 25
Seed source	Hatchery
Maximum standing crop (gr/m ²)	300
Feed source	Supplement and natural
Feed conversion ratio	1.8 to 2
Days of culture cycle	120
Average body weight at harvest	13 to 16
Unwanted species	Common, but only a few
Polyculture	None
Water exchange rate (%/day)	10 to 20
Water supply system	Pump
Water drainage mode	Gravity
Aeration	Natural and paddlewheel
Pond size and shape	75-1.3 ha, rectangular
Water depth	1.4 to 1.6 m
Survival rate	70 %
Dike and bottom	Earthen
Number of crops per year	1 on most, 2 on a few farms
Labor needs (person/ha)	0.6 people/ha
Disease problems	None
Production cost (US\$/kg)	3 to 4

Source: Shakouri 1999

Iran's Shrimp Aquaculture Industry at a Glance

	1990	1992	1994	1996	1998	2000
Pond Area (Ha)	0	2	51	183	620	2,400
Production (MT)	0	3	57	162	868	3,700
PL Production (MM)	0	30	6	31	126	655
Feed Production	0	2	115	324	1,590	6,500
Shrimp Farms	0	2	123	40	80	205
Shrimp Hatcheries	0	2	3	6	10	23
Feed Mills	0	0	0	1	2	4
Processing Plants	0	2	2	4	12	17

Using feed from two local mills, farmers average FCRs of 2:1 and produce shrimp weighing 14-16 grams. While disease was not a problem, shortages of broodstock and PL limited production. Some feed ingredients were also in short supply.

In 2000, the sector was expanding rapidly. At that time, one consulting company was managing or developing 10 shrimp farm projects ranging from 500 to 4,000 ha. More than 12,000 ha of farms were being designed and built in Bushehr alone. By 2000, 205 shrimp farms had 2,500 ha of ponds stocked with 590 million PL. The one crop per year growing season lasts for five months. Harvests average 1.8 MT/ha with a food conversion ratio of 1.6 and survival rates of around 65%. Virtually the entire crop is exported to Europe and must be certified by the Veterinary Organization and labeled with a European Economic Community Code.

While there have been no major diseases up to 2001, there are some environmental issues such as high pH and toxic plankton. The most serious problem facing hatcheries is water quality.

The Department of Fisheries regularly brings in Indian and Filipino extension workers to help shrimp farmers get started. Filipinos were also brought in by Ghannadian Trading to help with the operation of their five shrimp hatcheries.

Two feed mills are already in production; two more are under construction. One is expected to produce 20,000 MT of feed per year.

Nearly all the coastline is uninhabited because it is unsuitable for traditional farming. With strong government involvement and financing and with a pilot project financed by the FAO, shrimp farming has taken off in the past few years. All of the farms practiced semi-intensive production and stocked only with *P. indicus*. The hatcheries are all medium sized. However, there is still a very long way to go to meet the goals of the Third 5-Year National Development Plan.

A Shrimp Farming Complex in Bushehr

In Bushehr, 3,000 new hectares are under construction. All farms are 20 ha, with 14-15 ha of ponds. All new farms have 14, 1-ha ponds. Some of the older farms have 21, 0.7-ha ponds. The trend is toward larger farms with less government financing and more private sector (domestic and foreign) investment. Sites of 200 ha have also been approved by the government.

With the exception of some sites along year-round rivers, farms use seawater ranging in salinity from 37-42 ppt. In most cases, salinities reach 50 ppt by the time the water gets to the ponds. *P. indicus* is the species that is cultured. In areas with access to freshwater rivers, there is some interest in culturing *P. monodon*.

In 1999, Bushehr State had 3 operating hatcheries; nine more were expected to be operational in 2000. The most successful operations use Filipino and Thai technicians.

All farms and hatcheries are financed by low-interest government loans. The intent is to improve living conditions and nurture private industry and employment in underdeveloped areas. The government encourages private investment through joint ventures with investors from other countries. The government fisheries agency (SHILAT) controls and supervises all developed through a designated private consulting firm in each state.

Iran is also producing a medium quality Artemia, first in Fars Province and when heavy rains wiped out those operations in Lake Urumieh in western Iran. Producers intend not only to supply Iran but international markets as well. The Artemia was sold for US\$6/kg in 1999.

Careful planning and government control of the locations and design of shrimp farms has kept them sufficiently distant from each other that diseases do not spread easily. To date, there have been no disease problems and no trace of white spot. Careful government supervision is imposed on all aspects of shrimp farming. New construction has to be approved by the fisheries department.

Source: Rosenberry 1999.

Shrimp Aquaculture Development Plans

Preliminary surveys show that there is high potential for the development of shrimp farms along the southern coastline and also in the northern part of Iran. The total area suitable for development is nearly 110,000 ha. By 2000, some 16,000 ha had been allocated to investors. Out of this land, some 2,400 ha is in operation and 2,000 ha will be developed and in operation in 2001. Some 4,000 ha are under development and to begin operation sometime in the future.

The Second 5-Year National Development Plan was based on some very optimistic projections for shrimp aquaculture development in Iran. A projected growth of 10,000 MT was not very realistic for a country with no background or experience with the industry. In the end, only 37% of the targeted growth could be achieved. For the next 5-year development plan, 50,000 MT would be a very optimistic target while 20,000 MT would be achievable if the situation in the country and the industry remains stable.

Laws and Regulations

Fisheries and aquaculture activities are under the supervision of a number of different government entities—Ministry of Energy (and the Department of Water Resources), Veterinary Organization, Department of Forestry, Environmental Protection Organization, and Department of Fisheries (Shilat). The major body of law that affects aquaculture is a code entitled, “Protection and Exploitation of Natural Aquatic Resources.” Each of the above named entities had input on the development of the code.

The Fisheries Department of Iran has responsibility to provide related regulations and codes of conduct. The “General Guideline for Aquaculture and Fisheries” was published in 1999 and consists of 81 acts. Some 28 acts make the legal framework for aquaculture activities. According to the guidelines, Fisheries

of Iran regulates all aquaculture activities and inland fisheries. Acceptance of development plans, licenses and supervising aquaculture activities, farm operations, and so forth are the responsibility of the Aquaculture Department. The Veterinary Organization is responsible for health and disease issues. It works in close association with the Department of Fisheries of Iran.

The Shrimp Aquaculture System in Iran

Iran is a late entry into the world of shrimp farming. As a consequence, the country has had an opportunity to learn valuable lessons from the pioneer shrimp producing countries. Iran's shrimp aquaculture techniques are based on Thai and Filipino production systems. Many Iranians have taken part in training courses held in those countries. Experts from both countries have come to Iran and shared their expertise with their Iranian counterparts. The information, experiences and practices were then adapted to Iranian conditions. This local reality is, in fact, quite different from those of Southeast Asian countries.

Shrimp aquaculture development has taken place along the Persian Gulf Coast and the Sea of Oman in the supra-tidal zone. In this area, soils are alkaline and infertile. Ocean water is alkaline (37-42 ppt), and salinity increases to 47-50 ppt in the ponds. Air temperature reaches 50 C. These are generally considered harsh conditions yet the shrimp not only seem to survive but to thrive in them.

Iran practices semi-intensive shrimp aquaculture. Ponds are rectangular with a surface area of 0.75 to 1.3 ha. *Penaeus indicus* is the main species cultured. It is harvested at an average size of 13 to 16 grams. Target production levels are about 3 MT/ha/crop. Stocking density is about 22-25 PL/ha. Since the mid-1990s, average production per ha is stable, around 1,400-1,500 kg/ha.

Shrimp Aquaculture Management

Because of climatic conditions most of the farms are in operation only for one crop per year, so there is a gap of 5-6 months between crops. This down time allows the ponds to recover and possibly eliminate future problems. Removal of organic matter, ploughing and liming are usual pond preparation procedures. No chemicals are used for disinfection or soil treatment.

Each farm has pumping systems that pump water from the main supply canal to a reservoir or directly to the secondary supply canals. Water passes through screens to prevent entrance of unwanted organisms. Tea seed cake is not locally available so only a few farmers (less than 5%) apply tea seed cake to eradicate unwanted species. Presence of unwanted species like mud skippers, crabs, and so forth are common but are not seen as a problem for production.

The salinity level is from 37-42 ppt in the supply canals. In the ponds, salinity increases to 50 ppt at the end of the 4-month culture cycle. The average water depth is 1.4 to 1.6 m and the daily water exchange is 10-20%. Discharge of effluent is into a central drainage canal. The main drainage canal is very long (usually 5-7 km), and ponds are designed so that effluent tends to meet the sea 4-8 km from the mouth of the supply canal.

Inorganic fertilizers (urea, ammonium phosphate, ammonium nitrite) are the most common fertilizers. If it is available, some farmers apply chicken manure. Total fertilizer in one grow-out season is 150-300 kg per ha.

PL is stocked in the ponds at an average of 12-16/m³. Stress tests and microscopic examinations are increasingly common. However, there is not a national standard for PL quality assessment. Low quality and also improper handling are the main reasons for high mortality in the ponds. In addition, some farmers (mostly new ones) are not aware of importance of acclimation, or they do not pay attention to this. A survival rate in such farms is very low.

About 60 % of the farms use mechanical aerators. Paddlewheel aerators are the most usual. They are manufactured in local work shops. Two aerators with 16 propellers (8 propellers in each arm and 5.5 hp petrol engines) provide aeration for two adjacent ponds. Electric short-arm paddlewheel units are not

common. Efficiency of the aerators and their real effect on production has not been studied.

More than 95 % of required feed in the country is supplied by two feed mill plants. Hardware and also software problems brought about higher price and lower efficiency of produced feed. Average FCR is from 1.8-2:1. Some farmers use additives (e.g. vitamins, fish oil, and so forth) and fresh feed in order to increase shrimp appetite and compensate possible shortage of some elements in the feed.

Feeding is on the basis of demand (checking feeding trays). Fisheries of Iran undertook some experiments on the use of feeding trays. Inexperienced farmers follow feeding tables. Fisheries of Iran was planning to issue local feed management strategies by the end of 2001.

According to the Fisheries Act, permission is necessary for applying chemicals in aquaculture. On the other hand, probiotics and chemicals are not available everywhere. Few factories produce aquaculture chemicals. The import of agricultural drugs and chemicals is under supervision of the Veterinary Organization. In general, chemical use in shrimp grow out farming is limited to lime and fertilizers. Some chemicals are used in the hatcheries.

Normally, shrimp buyers send their own harvesting teams to the farms to supervise and organize harvesting procedures. Buyers are connected to the processing plants. Farmers cut off the feeding 12-24 hours before harvest time to reduce risk of black head. After washing and icing, the shrimp are sent to processing plants. Some 17 processing plants have CE code. Almost 90 % of shrimp are packed head on for the European market.

Production costs vary by province and farm. On average, cost of production is about 25,000 Iran Rials (RIs) (US\$ 3.1). Farm gate price ranges from 28,000 to 45,000RIs (US\$ 3.50-5.50).

Since most of the farms are new, many are not aware of the importance of health management or the methods for decreasing risks of disease outbreak. Veterinary Organization (and the Department of Fisheries) has responsibility to supervise health and disease status of aquaculture operations. Their staff visit all the shrimp farms, take samples, and analyze the situation. Fortunately, there are no serious problems in the country at this time. According to a survey, the most common problems in Iranian shrimp farms are as follow:

- High pH (15-20%)
- Black gills (20%)
- Luminous algae 50-60%)
- Occasional red tide (Dinoflagellata <2%)
- Very occasional vibriosis (not serious)

Problems and Constraints Facing Shrimp Aquaculture in Iran

There are three main problems facing the shrimp aquaculture industry in Iran:

- Shrimp aquaculture is a new industry in Iran. Consequently, there is a lack of knowledge among farmers. This is perhaps the single most important problem and a high potential risk for the future development of the industry.
- *P. indicus* is the only commercial species cultured in Iran. It is perhaps not reliable for the industry to rely on a single species.
- The source of wild spawners is limited and is not sufficient to supply future needs. Fisheries of Iran has an extension plan to introduce techniques for rearing spawners in captivity. At present, some demonstration facilities are in operation.

While there are no serious disease problems at this time, there is always the possibility of disease outbreaks. Establishment of a central diagnostic laboratory (and regional centers) for close supervision of shrimp in the ponds and quality control of PL is a priority for both Fisheries of Iran and Veterinary

Organization.

Iran has big plans for shrimp aquaculture development and is committed to make the industry sustainable. Discharge water and possible changes in fauna and flora of the natural water bodies are being monitored. The construction of sedimentation/bio-filtration ponds within each of the farms are planned future requirements by Fisheries of Iran. On the basis of an agreement between Fisheries of Iran and the Environmental Protection Organization, Shilat will provide a monitoring center in protected areas (e.g. mangroves) near shrimp farming operations.

Shrimp Aquaculture in Mozambique

by

Rafael Rafael and Fernando Loforte Ribeiro

Summary

Shrimp aquaculture development in Mozambique is still in its infancy despite an excellent environment and vast resources for shrimp farming along the 2,700 km coast. In the past, several issues have hampered the development of shrimp aquaculture in Mozambique—the centralized economic system, lack of aquaculture traditions in the country, and a long and devastating civil war. In recent years, political stability and free-market government policies have resulted in economic growth, which in turn has created a momentum for the industrial development of shrimp farming. However, clear development policies and incentives will be required to maintain the momentum and sustain long-term growth.

Current shrimp aquaculture production is limited to a single operation with 20 ha of ponds producing some 60 MT per year. Over the short and medium term, shrimp farms and new projects in the process of obtaining government approval could represent an estimated US\$39 million in private sector investment and result in the construction of more than 900 ha of shrimp ponds. The production potential of such an area is approximately 2,500 MT/year. These proposed developments represent significant important foreign investments and hard currency injections into the national economy.

Introduction and Background

Mozambique is located in Southeastern Africa between the parallels of 10°27' and 26°52' South, with a coastline of 2,700 km. The coast is very diverse from coral in the north, swamp and wetlands in the center-north to parabolic dunes alternated with wetlands along the south coast.

Mozambique benefits from diversity of tropical and sub-tropical environments and availability of suitable native species for aquafarming. The natural stocks of shrimp sustain an annual production from capture fisheries of about 11,000 MT including artisanal and industrial fisheries.

In the early 1980s the Government of Mozambique and French Aquaculture evaluated and selected three main areas for shrimp culture development—Maputo, Beira and Quelimane. The FAO set up a 10-ha demonstration shrimp project in Maputo. The main problem was the lack of wild shrimp PL to stock the pond. There were no hatcheries. There are four different shrimp species in the area and it proved to be difficult to sort them out. Each had different growth characteristics, and they could not be cultured together.

In the 1990s, Mozambique had its first commercial shrimp farm, but it was still in an experimental phase. Over the years it has shown promising results, but there are no public production figures from the initial experiences. In 1997, the French agency SEPIA had provided technical assistance to a pilot operation called AQUAPESCA local on the central coast. At that time the facility had 20 ha of ponds and a hatchery (with maturation and algae culture). The total operation is expected to produce 2,000 MT/year when completed. In 1997, there were reports of Taiwanese investors operating a shrimp farm about 300 km south of the AQUAPESCA farm.

In 2000, however, there was a number of shrimp aquaculture proposals submitted to the government for approval. The government is also in the process of developing an aquaculture act. It is currently under discussion. As it is being proposed, any shrimp farm that is larger than 5 ha will have to undertake an Environmental Impact Assessment prior to receiving the appropriate permits required for implementation.

In the past, several factors hampered the development of a viable shrimp aquaculture industry in Mozambique. These included a highly centralized, socialist economic system and political instability including a long and devastating civil war.

During the last 5 years there as been an increasing interest of private investment in industrial development

of shrimp culture. To cope with this demand, the national institutions are now involved in a series of actions for planning and development, which are expected to establish a platform for management and sustainable development of shrimp culture in Mozambique. There are no particular environmental problems associated with the shrimp aquaculture industry operating in the country at this time. At this time, the main problems that must be overcome if Mozambique is to develop a commercially viable shrimp aquaculture industry include:

- The lack of aquaculture traditions in the country, which makes it difficult for people even to consider it as an appropriate or viable income generation strategy.
- The lack of the most basic knowledge and information about shrimp aquaculture in the country and, as a consequence, the lack of trained staff.
- The inadequate infrastructure to support an economically dynamic and vibrant industry such as shrimp aquaculture.

Resources and Potentials for Shrimp Culture Development

The northern coast of Mozambique (10°32' to 17°20' S) is predominantly coral and rocky, scattered with small but deep bays and sandy beaches and a very narrow continental shelf. This coast contrasts with the central-north region (16°14' to 21°10' S), which consists of wetlands composed of alluvium soils and mangroves covering river estuaries. Most of this coastline, along which the wide continental shelf and particularly the Sofala Bank, is the main shrimp fishing ground. This region includes the large delta of Zambezi River. The south coast is mainly sub-tropical with parabolic dunes and a rocky shore alternating with swamps and mangroves located at the river estuaries. Five rivers converge to Maputo bay forming the Maputo estuary.

Over 30,000 ha were identified by the government as having potential for short and medium term development of coastal aquaculture. These areas were deemed to be free from conflicting use claims and free of protected resources. The long-term, overall potential for coastal aquacultural development is estimated to be 170,000 ha including coastal lands and protected seashore.

The central-north coast is the most favorable for shrimp aquaculture. Two large regions of 2,500 km² each, Beira (20° S) and Quelimane (18° S) were surveyed for shrimp aquaculture development. The potential area for farming behind the mangroves was estimated as 19,200 ha for Beira and 6,100 ha in Quelimane. Some potential was observed in the south, and early studies for shrimp aquaculture have identified 7,500 ha around Maputo suitable for development in the short and medium term.

It is thought that the northern coast may also contain some potential for shrimp aquaculture although the area has not been surveyed extensively.

In addition to the identification of appropriate sites, fisheries policy in Mozambique has established government incentives and technical backing to encourage coastal aquaculture. Investment laws provide tax and capital incentives, which are applicable to aquaculture investments, as new and costly ventures.

Industrial Shrimp Farming

In the past the Fisheries Department has conducted detailed studies in three main regions, Maputo (South, 26°S), Beira (Centre, 20°S) and Quelimane (Centre-north, 18°S) over an area of 2,500 km² in each region for development of shrimp aquaculture. These studies identified potential zones to plan and allocate industrial-scale development of shrimp farming. Detailed information on potential area, physical and chemical quality of soil and water, availability of penaeid species, and existing infrastructure have been gathered in the reports to assist investors in site selection for development of shrimp aquaculture operations.

The single shrimp farm in operation and all new projects under review for licenses by the fisheries and environment departments focused on the culture of giant tiger shrimp, *P. monodon*. Industrial developments are not permitted to exploit wild stocks of penaeid post-larvae or to capture spawners

directly to supply hatchery operations. The government has begun to inform hatchery operators that shrimp breeders have to be purchased from licensed fisheries in order to reduce the pressure on natural stocks and increase the value obtained from capture fisheries otherwise destined for human consumption. However, for developments in the sub-tropical southern region the Indian white shrimp, *P. indicus*, possesses better potential for farming. Species indigenous to Mozambique that might also be cultured includes two other common penaeid species, *P. japonicus* and *P. semisulcatus*.

The most common farming system used is semi-intensive with relatively low stocking densities of 10-20/m². These systems commonly use formulated feed with little or no aeration. Economic studies carried out in Mozambique indicate that this system is the most profitable, initially taking advantage of extensive sites located behind vast areas of mangroves, low cost land leases (leasing is for 50 years), and inexpensive labor. Intensive shrimp culture is subject to strict technical review by the government and is required to have environmental impact assessments.

Aquaculture Planning and Development Policy

As Mozambique had no tradition of shrimp aquaculture and, to date, there is still very little on the ground experience, one of the first tasks carried out by the government was to assess the potential for its development in the country. Priority was given to shrimp aquaculture due to its potential contribution to the economy, the availability of extensive wild shrimp stocks, and the extensive suitable natural environment for shrimp farming.

The current government program involves directing potential investors to the selected areas, reviewing their proposals, and providing technical advice. In short term, physical zoning of coastal aquaculture development will be based on a regional system where suitable sites for farm and hatchery development have been identified. This planning will be integrated in a general regional integrated physical plan for overall integrated development of the coastal zone.

Exploitation of coastal areas for aquaculture will depend on technical, environmental and socio-economic approval of project design by the Government's fisheries department for each proposed development. One immediate task the central Government is addressing at different sectors is the need for multi-sectoral co-ordination at provincial level on coastal land concession in order to avoid large areas suitable for aquaculture development being leased for other purposes without proper evaluation or planning. This sensitive issue for management of land and water resources for aquaculture, in the context of coastal environment and the mangrove ecosystem, is being addressed by all stakeholders involved in coastal aquaculture from farmers and environment NGO's to the public sector.

It is envisaged that commercial shrimp aquaculture operations will have an important role in promoting satellite farm development by bringing know-how and providing the inputs required for extension within a certain geographic boundaries of influence. The implementation of large integrated farms also is seen by the government as a way to create a potential for development of small and medium-sized operations, which will depend primarily on availability of expertise, PL, and feeds.

A set of priorities under discussion within the Ministry of Fisheries (MP) and related institutions for near future include:

- Update and extend the inventory of potential coastal areas for development of aquaculture;
- Define policy and establish a master plan for development of aquaculture; and
- Prepare legal instruments including specific regulations for different aquaculture activities, norms for development of freshwater and marine aquaculture, and codes of conduct for both operations.

These major planning and development tasks will be parallel with capacity building and strengthening of the appropriate government departments responsible for planning, management and administration, research, and development of aquaculture.

A recently established fisheries trust fund provides financial support for development programs in shrimp

aquaculture. Government funds for aquaculture have increased in the last years with an aim of investing US\$19 million over a ten-year period to support actions in planning and promotion of shrimp aquaculture development. These funds are also targeted to benefit local communities where conditions for inland aquaculture exist and to create the required credit, fiscal and financial framework support for private investment. Although the current financial inputs come from allowances generated within the fisheries sector, the government expects to attract donors and investors' attention to this fund to increase capital support for development of these activities.

Institutional Framework

The Ministry of Fisheries, which only became a Ministry in early 2000 after Fisheries was split off from the Ministry of Agriculture, has the overall responsibility for the aquaculture sector. Within the Ministry, two executive departments, the National Directorate for Fisheries and the Fisheries Research Institute have jurisdiction over administration, and research and development of aquaculture, respectively.

On planning and development of aquaculture, the fisheries sector works in co-ordination with different national departments including the National Directorate for Geography and Inventory, the Directorate for Environment Impact Assessment, the Center for Sustainable Development, and the Investment Promotion Centre. Within MICOA, the Center for Sustainable Development co-ordinates multi-sectoral planning, development and management of the coastal zone and the Directorate for Environmental Impact Assessment is responsible for establishing and conducting environmental impact assessments for all developments including aquaculture.

Legal Framework

The country's first regulations on aquaculture were under final preparation and submitted for approval by the Council of Ministers by the end of 2000. As aquaculture is a new activity in Mozambique, it has been dealt with indirectly, to date, within the broader context of the laws regulating fisheries, water, land, environment and other relevant issues.

The proposed aquaculture regulations aim to establish a legal framework where the activity is recognized as far as concerns with regard to sharing common resources like water, land and renewable resources. Key conditions and criteria for development are outlined for both coastal and inland aquaculture. The main elements of the proposed aquaculture regulations include:

- The National Directorate of Fisheries will have the jurisdiction over approval and licensing of aquaculture projects.
- Licensing of projects depends on type of exploitation (subsistence, experimental or industrial), and farming system (extensive, semi-intensive or intensive).
- Import of exotic species is permitted under observation of quarantine norms established by the Fisheries Research Institute.
- Import of indigenous species is restricted to research activities only.
- Exploitation of wild larvae, PL, and juveniles for aquaculture is restricted to application of extensive aquaculture systems and depends on management measures established for coastal resources in each region.
- Construction of aquaculture ponds in mangroves is prohibited. The use of mangrove areas is restricted to access to water (rivers, canals) and the construction of related infrastructures.
- Inland aquaculture installations must have sedimentation facilities for treatment of wastewater before draining to natural water bodies.

Preliminary Assessment

The development of the shrimp aquaculture industry in Mozambique will contribute to increased foreign investments and export earnings. On a community level, the socio-economic benefits may result in direct and indirect job creation, stability of employment, and improvement of infrastructure and logistics. Shrimp aquaculture is also expected to contribute directly to poverty alleviation and improve living

standards both in the areas of operations as well as the country as a whole.

There are several factors, however, that could hamper shrimp aquaculture development. Perhaps the most important is the shortage of logistical services and infrastructure in most of the potential areas for development. This will certainly slow the pace of shrimp aquaculture development. In addition, land ownership is a possible limiting factor, which may affect the development of shrimp aquaculture. Current land law provides for long concession periods of approximately 50 years. In the future, it is expected that land will be privatized.

While there is legislation for the environmental impact assessments of industrial shrimp farming, local expertise for carrying out the studies and monitoring the foreseen impacts during production is limited. Recently, the Secretariat for Eastern African Coastal Area Management (SEACAM) published the first guidelines for environmental impact assessment of shrimp aquaculture farms. To date, this publication represents a substantial contribution to capacity building within the region.

Between the 1970s and 1990s mangroves covered a total area of 400,000 ha in Mozambique, more than all the rest of East African countries combined. The deforestation of mangroves, mainly for housing material and firewood, represented only 4% of the total. This resource has suffered little pressure overall, to date. Signs of heavy depletion exist in or near coastal cities. However, mangroves should not be affected by the development of shrimp aquaculture; environmental laws exist to protect them. In Mozambique aquaculture development is not allowed on former or current mangrove forests. The process of screening begins when project proposals are submitted for approval by the National Directorate of Fisheries. Any project seeking to develop aquaculture operations on mangrove areas is rejected with the appropriate government departments (National Directorate of Fisheries and the Fisheries Research Institute) suggesting new site locations. A schematic overview of the development of shrimp farming in Mozambique can be seen in Table 5.

Government departments are carrying out the following major tasks:

- Identification of potential sites and physical zoning for coastal aquaculture. These activities will allocate industrial shrimp aquaculture development to sites whose potential has been evaluated and where there has not been any competition between stakeholders. Likewise, protected resources such as mangroves have been zoned out of development.
- Physical planning of aquaculture development together with a set of key, better practices (including EIAs) will permit operations to achieve a balance between the resources that are needed by the industry and other stakeholders as well as demand for the services that the mangroves may provide for both inland and water-based coastal aquaculture.

Table 1. Summarized information of shrimp farm development in Mozambique

Name of farm	Specie cultured	Location	Farm size	Hatchery capacity	Potential area	Imported Feed	Yields	Farm system	Current production	Investment in US\$
AQUAPESCA Ltd	<i>P. monodon</i>	Inhasunge, Quelimane	450 ha	72 million/year	1,600 ha	2,500 MT/year	3.6 MT/ha/year	Semi-intensive (10-15 Pls/m ²)	60 MT/year	72 million
AQUAMAR Ltd	<i>P. indicus</i>	Costa do Sol, Maputo	10 ha	*20 million/year	70 ha	undisclosed	2.5 MT/ha/year	Semi-intensive (15-30 Pls/m ²)	15 MT/year	undisclosed
SOL & MAR AQUACULTURE & FISHING Co. Ltd.	<i>P. monodon</i>	Rio Maria, Beira	133 ha	40 million/year	450 ha	** 2,400 MT/year	7.5 MT/ha/year	Intensive and semi-intensive (20-50 Pls/m ²)	1,000 MT/year	13 million
BIOAQUATICA Ltd ¹	<i>P. monodon</i>	Pebane, Zambezi	-	-	1,000 ha	-	-	-	2,000 MT/year	undisclosed
VELEIRO DE MOÇAMBIQUE Ltd	<i>P. monodon</i>	Rio Maria, Beira	80 ha	16 million	100 ha	undisclosed	2.0 MT/ha/year	Semi-intensive (10-15 Pls/m ²)	160 MT/year	2.1 million
QUELIMAR Ltd	<i>P. monodon</i>	Angoche, Nampula	200 ha	?	2,000 ha	undisclosed	2.5 MT/ha/year	?	500 MT/year	15.8 million
CATEMBE DEVELOPMENTS Ltd	<i>P. indicus</i>	Catembe, Maputo	70 ha	?	130 ha	undisclosed	4.0 MT/ha/year	Semi-intensive (15-20 Pls)	280 MT/year	undisclosed

* It is not in place this moment

**Produced locally

¹Feasibility studies and project layout planned for short term

? No source of PLs identified

Shrimp Aquaculture in Madagascar

by
Rafael Rafael and Georges Rafomanana

Summary

The shrimp culture industry is the most important and developed commercial aquaculture activity in Madagascar. Madagascar is the biggest shrimp aquaculture producing country in Africa. In 2001, Madagascar had just over 1,200 ha of ponds in production and total production for the year was just less than 6,000 MT. The four main farms in production in 2001 were Aqualma, Aquamen, Aquamas, and Somaqua. Two operations were built out in 2001 but not yet producing—Aqualma 2 and LGA. Another company, Biomed did not yet have any of its ponds built. In 2002, total area of production in ponds will be 1,660 ha.

The largest farm is Aqualma, which was founded in 1993. The company expanded into a second site in 2001. Its annual production reached 3,200 MT in 2001. Other emerging shrimp aquaculture companies (e.g. Aquamen, Aquamas and Somaqua) are increasing their annual production as well. The shrimp culture industry is based on culturing *P. monodon* in a semi-intensive system. This activity must adhere to Fisheries and Aquaculture regulations, be compatible with environmentally friendly technology, and Madagascar's shrimp aquaculture code of conduct.

The government of Madagascar requires an annual audit from a National Directorate of Aquaculture expert who evaluates the impact of management and techniques used in shrimp aquaculture projects for the sake of environmental standards. In case of mismanagement, audit experts propose mitigation methods to reduce impacts and to optimize shrimp aquaculture practices of the particular farm. All audits are confidential.

Introduction and Background

Madagascar is the biggest island in the African continent. Its coastline is 5,000 km in length with 1,400 km of coral reefs and more than 30,000 ha of mangroves. In Madagascar, the exploitation of marine and coastal areas has become an economic necessity. Madagascar's shrimp industry is more developed than all the eastern African countries because it has vast areas appropriate for shrimp aquaculture, climatic conditions adequate for the development of the industry, and received significant and important technical assistance from the FAO during the early stages of development.

The development of aquaculture in Madagascar started in the 1990s with a FAO-funded project in Nosy-Bé. This shrimp aquaculture project produced 2,800 MT of shrimp in 1997. Other commercial investments followed due to the promise of the experience at Nosy-Bé. At this time, the total shrimp pond area in Madagascar is about 3,000 ha. The industry is growing under the orientation of the Ministry of Fisheries and Aquaculture.

In the late 1980s, the FAO set up a demonstration shrimp aquaculture project. As a result of the success of this project, other investments in the industry began to occur. In October 1998, Autrand Michel, a French aquaculture consultant, reported that there were three semi-intensive operations in the country and another under construction. A year later there were four operating farms with 1060 ha and producing some 3000 MT/year of whole shrimp. By 2000, production was expected to reach 5,000 M. All of the initial farms were built on salt marsh areas behind the mangroves. They all stock a local strain of *P. monodon*. Four large hatcheries produce the PL.

AQUALMA is located on the northwest coast. The operation was started in 1993 and had produced a total of 5,000 MT of shrimp by the end of 1996. Mangrove protection was reportedly a big priority for this company. It agreed with the government and the World Bank not to use more than 3 percent of the mangroves on its property for shrimp operations. Satellite pictures show that it adhered to the agreement.

By 1998, AQUALMA was the biggest farm with 670 ha, a hatchery (with a capacity of 300 million PL/year), and a modern processing plant. The company utilizes 9-ha semi-intensive ponds. The company reported production of 2,700 MT in 1996. In 1998, the company planned to produce 2,500 MT of whole animals with an average weight of 30 grams. In 1999, it planned to start its own broodstock and maturation facility. The hatchery does not utilize algae, just micro particles (Frippak) and Artemia. It is owned by French and Malagasy (from the shrimp trawling business) investors. Most production is sold in France.

AQUAMEN, another shrimp aquaculture company, is located on the central west coast. French and Malagasy investors, too, finance it. The primary investor is a French cooker/processor who originally fished shrimp along the African coast as long as 50 years ago. In May 1977 it stocked the first phase of its operation, some 120 ha of ponds. Aeration was used in some of the ponds. It has a hatchery capable of producing some 75 million PL. It uses 5-ha semi-intensive grow out ponds. Some of the operations were sabotaged in early 1998, but it had restarted operations later in the year. Production in 1998 was expected to be around 300 MT. Production was expected to be 2,000 MT per year when fully operational.

SOMAQUA is a small pilot operation of about 40 ha producing some 60 MT in 1998. It has Japanese and Malagasy investors. The Malagasy investors are from the trawling industry. The plans are to have 400 ha of ponds and eventually produce some 2,000 MT per year.

AQUAMAS has French and Malagasy investors. The Malagasy investors are from the shrimp trawling industry. It was under construction in 1998. It was expected to have about 200 ha of ponds.

Quelimar, a South African and Malagasy owned company, purchased 3,000 ha of salt flat and low savanna to establish a shrimp farm. The goal was to build 500 ha of ponds. The company intends to raise *P. monodon* and *P. indicus*. The company planned to use at least some wild-caught PL, which are available from November to March during the rainy season.

In 1997, the European Union embargo on seafood products from Madagascar caused major disruptions in the shrimp trawling and aquaculture industries. Even so, in 1998 shrimp aquaculture farms produced 2,500 MT of shrimp and the following year produced an estimated 3,850 MT.

In order to get the development under control, in 1998, the government of Madagascar conducted a survey of aquaculture sites and developed a master plan to guide aquaculture development. The plan was intended to take into account interactions between aquaculture and the environment and to define the government's overall development strategy for the sector. Subsequently, the government decided to insure that their policies and regulations were compatible with those outlined in the GAA code of practice.

Finally, in addition the French, FAO and the Japanese government financed a shrimp development center and hatchery. A local feed manufacturing plant began to test its feed with producers, but in 1998, nearly all shrimp feed in Madagascar was still imported from Taiwan, Indonesia and France.

Today, there are more than 1,600 ha of production ponds in the country with thousands of MT of shrimp production. In addition, there are dozens of applications to the government for permits and licenses to establish shrimp aquaculture operations. One of the main concerns in the country is that many of the

proposals are from individuals and groups who do not have any experience with shrimp aquaculture and who do not have the necessary capital to invest in operations that will have a reduced impact.

Potential for Shrimp Aquaculture Development

More than 1,000 ha were identified for short and medium term development of coastal shrimp aquaculture. These areas are free from conflicts over resource use and exclude protected areas and resources. The primary species cultured in Madagascar is *P. monodon*. It occurs naturally in Madagascar's waters. The economical potential of shrimp aquaculture development in Madagascar is quite large and can be sustainable so long as it is done in environmentally friendly way.

In the 1980s, the FAO evaluated the potential areas suitable for shrimp aquaculture in Madagascar. Some of the areas that were identified with potential are situated along the northwest and central-west coastal areas of the country. High temperatures and extensive plains behind mangrove belts were some of the parameters used for site selection. In 1989, a pilot project was set up in Nosy-Bé under the recommendation of FAO. The results of the project were encouraging, stimulating the first commercial shrimp aquaculture investment, AQUALMA, in Mahajanga.

From the FAO's evaluation as well as the performance of the initial project, three big zones were selected for the development of shrimp aquaculture industry. All three zones are located on the western coast of the country. The areas are characterized by temporary inundation (deltas and estuaries) and are covered by salt water during high tides. Those zones identified initially were then subdivided into the 5 following different areas:

- The region from Ambanja to Antsiranana in the north.
- The Mahajamba delta.
- The area from Mahajamba-Antalihy subdivided in three regions (the Betsiboka delta, the region of Namakia, south region and from A Soalala to Antalihy Bay.
- The area from Manambolo to Besalampy.
- The area from Morondava to Belo sur-Tsiribihina.

The total potential for shrimp aquaculture in Madagascar is large. The main system that is recommended is semi-intensive. Extensive shrimp aquaculture production in Madagascar will be difficult to develop due to problems with the water supply. Most of the priority sites do not have topography that allows the evacuation of water supply via tides. In addition, there is so little infrastructure in the country that only more industrial operations make sense financially. And, once the investments have been made it is necessary to run them as semi-extensive operations similar to those in Latin America.

Semi-intensive Production

The main species cultured in Madagascar is *P. monodon*. The results obtained to date suggest that animals of 20-25g can be produced resulting in a total of 3.5-5 MT/ha/year using semi-intensive production systems. The grow-out period varies from 120 to 160 days depending on temperature and other factors. In general the shrimp are stocked at densities of 8-9 animals per m² with final survival rates of 80%. Juveniles are stocked at 1g (after 18-20 weeks in the nursery). Animals are commonly grown to 28 g (after 23-25 weeks). The ponds used in this type of production are typically 5-10 ha.

During the "cold" season (temperature between 23-25°C) the growth rate fluctuates between 0.5 and 1 g/week. While in the "warm" season (temperature between 27-31°C) the growth rate of shrimp in Madagascar can reach 1.5-2 g/week. The water temperature in the Morondava and Antsiranana zones allows companies to produce a minimum of two crops per year using *P. monodon*.

In some farms, aeration is used to maintain optimal oxygen levels and good water quality. They are used full time depending on biomass, evolution of oxygen, pH, light and the state of degradation of the pond bottoms. In general, however, more aeration is used at night than during the day.

Intensive Production

Intensive operations are used on two farms in Madagascar with a total of some 430 ha with individual ponds ranging from 1-3 ha. Yields are approximately 3.6-7 MT/year. Daily water exchange is 10-25%. Some 4-10 hp/ha are used for mechanical aeration. Stocking densities are up to 20 PL/m².

Environmental impacts, the lack of infrastructure and investment and operating costs are the primary factors that discourage the adoption of intensive production systems in Madagascar. The expenses reduce the profit of intensive production systems with pumping water the main cost.

Table 6 summarizes the characteristics of the different type of shrimp aquaculture production in Madagascar.

Table 6. Characteristics of the different type of shrimp culture

Development	Production System	Pond Characteristics
Artisanal-familial	Extensive (Production from 50-300kg/ha/yr)	From 1,000 m ² and above. Water supply only using tide
Semi-industrial and industrial	Semi-intensive (Production from 2-5 MT/ha/yr.)	1 to 10 ha; water supply by pump
Semi-industrial and industrial	Semi-intensive “intensive ” (Production from 6-8 MT/ha/yr.)	0.5 ha to 4ha; water supply using pump. Generally using aeration.
Industrial	Intensive (Production from 7-20 MT/ha/yr.)	0.25 to 2 ha; water supply-using pump. Always using aeration

Artisanal Shrimp Culture

In the countryside, the development of artisanal shrimp aquaculture or semi-industrial shrimp aquaculture using semi-intensive techniques using pumps for water exchange is being promoted. Communities are encouraged to organize themselves to share the resources (e.g. the pumping station or the cost of other inputs). One way of developing artisanal shrimp culture has been the involvement of satellite farms by one big farm. The hub farm provides all the inputs for shrimp aquaculture, and then it buys the production from the satellite producers.

Institutional Framework

Several consultations were done to guide the development strategy of shrimp aquaculture in Madagascar. Some of those institutions undertaking the work included the Ministry of Fisheries and Aquaculture, Coastal and Marine Environmental Unit; National Office of Environment; National Coordination of Regional Program of Environment (PRE-COI); General Directorate of Ministry of Environment; Institute of Water and Marine Science in Toliara and National Center of Oceanographic Research of Nosy-Bé. Also some public institutions, involved directly or indirectly in fisheries and shrimp aquaculture, were heard.

Legal Framework

Since 1995 all the shrimp aquaculture projects in Madagascar are required to undertake an environmental impact assessment of their project before they set up the farm (according to Act n° 95-377). Shrimp aquaculture projects must also comply with the Madagascar shrimp aquaculture code of conduct.

To comply with the two requirements cited above, investors must prepare a technical and socio-economic feasibility study of the selected area and an EIA. In the process of preparing those studies, the company is required to undertake public consultations because article 24 of act n°60-024 allows the villages to ask the government to stop or prevent the installation of shrimp aquaculture projects. The public hearing is intended to reduce conflict by avoiding those proposed shrimp projects that would use lands that have value for other stakeholders (e.g. ancestral patrimony, agriculture, etc.).

Such studies allow decision-makers to evaluate the revenues that the project can bring to the country balanced against the other impacts and forward the project or take decisions according to the following regulations:

- For the area equal or larger than 2,000 ha the government counsel must take a decision after hearing the recommendation of the Ministry of Fisheries and Aquaculture;
- For the area from 50 and 2,000 ha Ministry of Fisheries and Aquaculture takes the decision;
- For the area from 10 to 50 ha provincial authority takes the decision; and
- For the area less than 10 ha the decision is taken by prefecture.

The decision-makers prioritize feasibility studies and EIAs or other environmental reports before any decision on shrimp aquaculture projects is taken. The details of the study depend on the value of the investment and the level of intensification.

Environmental Issues

The development of shrimp aquaculture must go hand in hand with environmental impact concerns. In the 1980s Madagascar committed itself to sustainable environmental management as part of its overall development program. One of the main objectives of environmental policy is to allow the development of shrimp aquaculture industry while integrating environmentally friendly technology and management practices to avoid diverse socio-economic conflicts. This is why Madagascar developed the code of conduct to assure that shrimp aquaculture development be environmentally friendly, ecologically acceptable, and economically viable.

In Madagascar, mangrove areas, beaches, reef areas and areas with marine plants are considered sensitive areas. Their use for shrimp aquaculture has to be according to environmental management strategies and has to consider that 10 km from the farm is considered the zone of shrimp farm influence. In Madagascar, this is considered the distance that a shrimp farm can alter the environment.

Water

The quantity and the quality of water discharged depends on the intensity of shrimp production practices by the shrimp farm. According to the code of conduct in Madagascar, it is expected that the discharge of water from a farm will be around 15% of the volume of water used at any time in the shrimp operation in a semi-intensive system. In the intensive system, from 20-40% of the water volume is exchanged per day. The effluent contains nitrogen, phosphorous, organic carbon and organic matter. The effect of these substances cannot be neglected. To avoid self-pollution of the farm, the pumping station has to be isolated from the discharge.

Mangrove

In Africa, 58% of mangroves were destroyed before the development of shrimp aquaculture. The lessons learned from countries like Vietnam, Indonesia, Equator and Bangladesh allowed the Madagascar authorities to implement shrimp aquaculture development without the destruction of mangroves. Shrimp farms are constructed behind the mangroves. A minor area of mangroves can be destroyed during the construction of the pumping station and the intake and effluent canals. Discharged water is often passed through mangrove areas for filtration. In Madagascar it is assumed that water from one ha of ponds under semi-intensive culture requires 2-3 ha of mangrove area to remove the nitrogen and phosphorus. Therefore, one of the conditions to start the shrimp farm is to have a mangrove belt in the region to reduce nutrients before they are diluted in the sea.

Health

No disease problems have been noted in Madagascar during the grow out period of shrimp aquaculture. In hatcheries, mass mortality of PL due to diseases has rarely occurred. As a prevention measure, the law forbids the importation of live shrimp for aquaculture in order to avoid the possible importation of diseases. As an additional prevention strategy, farmers are recommended to follow strict pond management procedure (e.g. use of good feed quality, good water exchange, etc.) and to source shrimp only from well-run hatcheries.

Socio-economic

There is very little conflict over land use because the land used for shrimp aquaculture in Madagascar is not fertile and there are no other uses in competition for it. However, shrimp farms do affect the fishermen. The access to some traditional areas for common use is restricted to the farmers after the implementation of shrimp aquaculture operations.

In case the farm has to be built in the area that has local infrastructure or housing, the investor has to negotiate with local authorities and the public. The main consensus has to end with how to re-allocate the population. One of the best practices in Madagascar has been to incorporate the local population in the establishment and operation of the new company. In that way, the local people help the investor to set up the farm. However, the attitude of the local population in Madagascar is not always uniform as there are some locals who are always against shrimp aquaculture while others support it. Investors normally take advantage of those supporting them.

Chemicals

In Madagascar rotenone and tea pasta are used in the ponds when necessary to reduce predator and competitors, especially *Tilapia*. Lime is also used to change the pH and to disinfect the ponds. Its use varies from a kilogram or two or three MT/ha/year. Chlorine products are used in case of bacterial or viral disease outbreak. Chlorine products are also used to reduce the proliferation of other crustaceans (which was common in the pilot project in Nosy-Bé). There is no report about the use of antibiotics in the shrimp aquaculture industry in Madagascar.

Feed

All of the feed used in Madagascar at this time is imported. Most of it comes from Seychelles, Mauritius, and Taiwan. Aqualma is planning to build a feed plant in 2002. Since the joint venture partner is in the feed business, it is likely that this operation will sell feed to the other producers in Madagascar.

Constraints

One of the major constraints confronting shrimp aquaculture in Madagascar is feed. The use of imported feed is a very large impact on the economy of the country. In 1990, with help of an FAO expert, Madagascar decided to study the possibility of manufacturing shrimp feed locally using raw material from the country. Some 70% of the ingredients like tuna meal, peanut, rice and maize can be source locally as raw material for shrimp feed. The feed can be 20% lower in quality than standard imported feed but it has advantage of being low priced feed, always available, with a stable price because there is no influence of the international exchange rate on the local market. The other advantage is the control that the company can have in terms of quality and hygiene because the feed is fresher.

The most significant cost for the local manufacture of feed was the transfer of know-how and the technology. But in the long run, the projects can benefit and other institutions can collaborate in training and research in order to make the shrimp development industry not dependent on imported feed.

Information on Shrimp Aquaculture From Other African Countries

Introduction

There is not a lot of information on shrimp aquaculture in other African countries. The information that follows is taken largely from Fish Farming International (various years 1994-2001) with the permission of Bob Rosenberry, the editor. Madagascar, Mozambique and Tanzania are considered to have the greatest potential for shrimp farming in East Africa. However, as the following descriptions make clear, the industry has made tentative toeholds throughout the continent. It is likely that quite a few more experiments are being undertaken or contemplated in the region. The consortium would welcome any information on specific operations in Africa or country-wide assessments. We would also appreciate any up-dates or corrections regarding the information included in this report. The goal is to attempt to make the best information available to the widest range of individuals and institutions interested in the topic.

Eritrea

Seawater Farms is a joint venture of the Eritrean Government and American investors. Its operations along the coast of Eritrea offer a promising new approach to integrated shrimp aquaculture. The project is based on two organisms and the direct use of seawater from the Red Sea that is channeled, diverted and pumped into cement runways/ponds.

The nutrient rich effluents from the shrimp ponds are then used to fertilize fields of salicornia, a rubbery looking succulent that thrives, rather than withers at the touch of salt water. This 1,000 ha farm produced its first shrimp for export in 2001. The green spears of salicornia will be pounded to produce animal feed and vegetable oil for the domestic market.

In addition, three artificial lakes will also produce fish for the local market. Mangrove is being sown by the tens of thousands seedlings will ultimately play their part in turning the dry sands into fertile soil.

By recycling waste as fertilizer, Seawater Farms hopes to avert the fate that has dogged so many initially profitable shrimp farms which involve into environmental blackspots. If successful, this project will take full strength seawater, utilize it to cultivate shrimp in the desert and then use salicornia, mangroves, and fish to treat the effluent and eventually return it to the Red Sea.

The project represents the culmination of 25 years and \$27 million dollars invested in research by scientists who believe that salt resistant plants hold the answer to combating world hunger and reducing environmental impacts.

The project is symbolic in many ways. It is the first major commercial investment in Eritrea and it is built on the site of one of the most famous tank battles in Eritrea's war for independence from Ethiopia. But the farm is symbolic in other ways as well. It is one of the first attempts to produce shrimp with undiluted sea water that actually becomes far more saline as the grow out cycles continues. It is one of the first commercial shrimp investments to cultivate at least three marketable products.

The dreams and expectations are quite large. In 2002, the operation wanted to turn \$6 million in shrimp sales. Salicornia and fish will take a little longer, but by 2005, management hope to be generating \$100 million. Given the natural resources involved, this project is an attempt to turn the proverbial straw into gold.

However, if sales are even a fraction of those projected by management, there are 13 other sites already identified in Eritrea that are suitable for production. Moreover, if successful there innumerable sites throughout dry coastal areas where the technology could be implemented.

Gambia

Little is known about shrimp farming in Gambia. However, in March 1999 an issue of Fish Farming International carried an ad for the sale of a shrimp farm in Gambia. The operation was billed as “complete,” including the production farm with 52, 4-ha ponds, a hatchery producing 10 million PLs per month. The pumping capacity of the operation was 250 m³ per minute. The operation also contained offices, stores, workshops, freezer, cold storage and an ice plant. The property was located 40 km from an international seaport and 25 km from Banjul International Airport.

Guinea

By 1997 a master plan for the development of shrimp farming in the West African country of Guinea had been completed and the prospects for the expansion of the industry were reportedly quite good. In 1998, there was one reported shrimp aquaculture development project underway. The government was the main shareholder in the project. It hoped that the project could serve as a model for shrimp farming in the rest of Africa. Initial indications appeared to be good. The country has year round water temperatures of 25 C. The major problem is the dependence on foreign manufactured feed.

The experimental, prototype farm is located 2 hours north of Conakry. It had 400 ha of ponds and by early 1997 had produced 60 MT of shrimp. Production initially included *P. notialis* a local species. However, by 1998 production was expected to reach 300 MT, some 200 MT of *P. vannamei* and 100 MT of *P. monodon*. By 1999, the operation was producing an estimated 2000 MT of shrimp a year after the government privatized it, selling it to a South African company.

The operation has a 200 million PL/year hatchery that is located on an island off of Conakry. The *P. vannamei* broodstock, now in its fourth generation, is originally from Venezuela. Fishermen from Senegal to the Ivory Coast captured the *P. monodon* broodstock in the Atlantic. Since *P. monodon* is not supposed to be native to the area, it has been suggested that they may have escaped from other farms, possibly one in Gambia or that the PL were brought into the country from the Pacific or Indian ocean where the species is indigenous. The hatchery has a capacity of 150 million PL per year.

Seychelles

By 1999, there was one shrimp farm with 37 ha of ponds in production. The farm produced 650 MT in 1998 and expected to produce 700 MT in 1999. In 1999, there was a single hatchery, but another one was under construction. By 1999, there was a shrimp feed mill in the Seychelles that sold to local farmers as well as into Madagascar.

South Africa

Shrimp culture is a new, promising activity which begun 10 years ago in Kwazulu Natal Province on the Northeast coast of South Africa. However, the prospects for development are restrained due to sub-tropical to temperate climate and lack of resources (especially suitable coastal land, sources of wild shrimp for broodstock, and trained personnel. Yet, two commercial shrimp farms are in operation in the area, Amatikulu and Mtunzini, and production from intensive culture of *Fennopenaeus indicus* has reached over 100 MT this year. The major setbacks that shrimp culture has faced in recent years in South Africa are related to feed, nutrition, availability of breeders, and overall management of the nursery phase. Despite local interest in shrimp aquaculture, there are no prospects at this time for new farms or further development of current farms managed by Amatikulu Prawns (Pty) Ltd. The sub-optimal conditions have driven the attention and interest of most South Africans seeking to invest in shrimp culture across the border to Mozambique.

Introduction

The East coast of South Africa is sub-tropical but the Mozambican warm water, oceanic current flowing southwards, influences the northern section of the coast. This water provides the environment for wild shrimp at the Tugela River estuary as well as for limited conditions for inshore shrimp aquaculture. Penaeid shrimp stocks are restricted to a single fishery located offshore of Tugela river, at approximately 28° S which constitute the only local supply of breeders for farming.

Shrimp culture is a quite recent aquaculture activity and it is restricted to the Northern coast of Kwazulu Natal at Amatikulu and Mtunzini. Despite a sharp increase in production in the last five years (Table 7), the prospects for further development of shrimp culture is restricted due to limitations of resource availability and the fact that the environment is only marginally acceptable for shrimp farming.

Table 7. Shrimp production from aquaculture in South Africa (MT)

1992	1993	1994	1995	1996	1997	1998	1999	2000
39	84	53	70	81	75	90	111	129

Overall, aquaculture activity in South Africa is driven by the private sector. There is no development master plan, and lack of government support, in general, hampers the development of shrimp culture.

Industrial Shrimp Culture

There are only 2 commercial prawn farms in Kwazulu Natal. Both farms are managed by Amatikulu Prawns (Pty) Ltd. The farms bare the local names of Amatikulu and Mtunzini. In both farms *Fennopenaeus indicus* (Indian White shrimp) is cultured at semi-intensive to intensive conditions.

Other native penaeid species available locally such as *Penaeus monodon* and *P. japonicus* were tested for farming but did not perform as well and gave lower yields than *P. indicus*, the Indian white shrimp.

The Amatikulu farm was developed from an old government research facility. It includes a small hatchery and 10 ha of plastic-lined ponds. This farm is part of a large, private aquaculture company whose main products are freshwater tropical fish and ornamental aquatic plants. Other production capacity at the farm includes a flake and pellet feed plant.

The Mtunzini farm also integrates a hatchery and a 12-ha of earthen ponds for growout. This farm was built in the late 1980s. Production was very erratic, however, until late 1990s.

Hatchery Production

The hatcheries of both farms operate both with wild caught breeders and pond harvested animals. The capacity at Amatikulu hatchery is 10 million PLs per annum while Mtunzini was built to produce approximately 40 million PLs. Production in both hatcheries is seasonal due to the seasonality of pond production. The hatchery season is from August to November. Heavy rains during this period as well as the reliance on outdoor algae culture facilities make it difficult to manage the hatcheries. Larvae tend to die at the mysis stage. Peas, due to their high vitamin B1 content, have been used more recently to replace algae as a major feed source in the hatcheries. This has improved the survival rate of both zoea and mysis.

The wild breeders are captured from the offshore fisheries near the Tugela River mouth, but in the past years there was also a sporadic supply of animals collected at Maputo bay in Mozambique. More recently, both farms have started selecting the best adult animals from their production ponds to supply their own breeders and reduce the costs of hatchery operations.

Farm Production

Amatikulu Company manages both farms, and due to their small size semi-intensive and intensive operations were established. Ponds are stocked once a year (one farming cycle per annum) with PL6 or PL12. One of the farms operates 10 ha of ponds, the other 26 ha.

Stocking of PL12 directly resulted in relatively low yields possibly from mortality caused by poor nutrition and cannibalistic behaviour. On the other hand, both farms have tried to stock PL6 directly into the grow-out ponds but they too have experienced low survival rates.

Current production practices include aquamats. In addition, improvements in early PL nutrition have been introduced thanks largely to discussions with people on the online Shrimp Discussion Group.

Stocking rates are 25 – 40 PLs/m² with a grow-out time of 6 to 8 months. Average yields have been about 3 MT/ha and 7 MT/ha, respectively, at the Mtunzini and Amatikulu farms.

Shrimps are fed 4 to 6 times a day with constant monitoring. In the past, over feeding by new, untrained staff resulted in feed conversion ratios that were in excess of 5:1 in most ponds. While this problem has been addressed, it leads to the need to increase water exchange. Feeds are currently produced at Amatikulu farm and FCR yields are poor, ranging from 2-3 kg of food for every 1 kg of shrimp harvested. Diets produced locally have been constantly adjusted in terms of raw material composition, its source of supply and micro-nutrients, in an attempt to improve the FCR at the farms.

In general, pond water quality is managed with both aeration and water exchange. Due to organic loading, organic waste and sediments accumulated on the bottom of ponds are periodically sucked from the small, lined ponds and disposed on land. The unlined ponds are cleaned at the time of harvest. Eliminating the organic matter is much easier in the lined ponds. Since there is only one production cycle per year, down time after the harvest is not an issue.

Production in the last 5 years has increased substantially to just below 130 MT (Table 1) in 2000. Some fluctuation in total production during mid 1990s resulted from changes in management and shifts from imported Taiwanese feed to locally produced feed. Initially, at least, this feed was of low quality. Both farms may well increase their yields, but annual production is not likely to exceed 200 MT over the next years.

The breakeven selling price this season was US\$ 7.00/kg, while the selling price on the local South African market averaged around US\$ 7.86. Consequently sales on the local market resulted in higher profits. However, having identified the problems encountered the 2000 season and correcting them, the farms have the potential to achieve a FCR of 2.5. Moreover, they can reduce the breakeven cost of production to about US\$ 6.00 per kilo. Other factors accounting the low price of 25-40 g shrimp come from macroeconomic issues specific to South Africa, loss of the value of the rand, and reduction in purchasing power for imports.

With an established export market to Europe and HACCP certification, the farms expect to improve the profitability of both operations for the new season.

Feed Production

At beginning of farming in early 1990s, feeds were imported from Taiwan. Despite the quality of the feed, high transportation costs, taxes and the prospects of a market in neighboring Mozambique pushed Amatikulu Company to invest in local manufacture of feed. Today, all feed used in the country is

manufactured locally from locally sourced ingredients. Fishmeal is the only marine protein in the diet. No cholesterol is used in the formulation, and soy comprises 28 percent of the feed volume.

The potential capacity installed is more than 4,000 MT per annum. A range of pellet sizes for aquafarming can be produced. Despite the current need to improve the nutritional value of diets, feeds produced on farm cost on average US\$0.62 per kg in 2000.

Diseases

No major disease problems have been reported at either farm. However, a minor incidence of a microsporidian infection in some ponds was observed recently accounting for up to 10 percent mortality in some ponds. Preventive measures have been introduced to eliminate the infection, which is thought to come from wild organisms. These organisms enter the ponds when the water is exchanged.

In addition to this problem, the recent import of cultured shrimp from India for re-processing and consumption in South Africa is being considered a high potential risk of infecting local stocks both in ponds and in the wild. This source of contamination and infection represents a far more serious way of introducing diseases that could affect the entire shrimp industry in the Southwest Indian Ocean region from Madagascar to Mozambique. This issue has been discussed between shrimp entrepreneurs of the region during the World Aquaculture Society 2000 annual meeting in Nice, France.

Institutional and Legal Framework

Shrimp aquaculture development in recent years has proceeded primarily with the financial backing solely of the private sector in South Africa. Farmers are organised in producer associations (Mariculture Association of South Africa) which in turn is affiliated with the Southern African Aquaculture Association fulfil this.

Within the government, mariculture including shrimp aquaculture is under the jurisdiction of the Department of Environmental Affairs and Tourism through the Directorate of Marine and Coastal Management. To date, however, no targeted, comprehensive plan has been developed for the industry. Producers are simply required to identify on their own and follow the relevant existing laws

Tanzania

While there has been considerable interest in and some controversy surrounding shrimp aquaculture in Tanzania, to date there has only been one small farm that has operated sporadically since the mid-1990s. This farm was built on a salt farm that had previously been established by cutting mangroves. The owner converted it to extensive shrimp aquaculture production. Wild PL (95 % *P. indicus* and 5 % *P. monodon*) is used to stock the ponds. Fresh feed is only utilized when shrimp stop growing. Water exchange is carried out by spring tides and by supplemental pumping as needed. In 1994 a Thai investor bought the 140-ha property and slowly created 3 1.6-ha ponds. He harvested 700 kg per ha every 6 months. In 1996, however, total production was only about 4 MT.

Four other commercial shrimp operations have been proposed—two in Bagamoyo (one 200-300 ha pond operation and one of 740 ha 30 miles north on the Wami River), one in the Rufiji Delta (6,000 ha) and another one about half way between Dar es Salaam and the Rufiji Delta (2,000 ha). While these proposed operations generated considerable public debate, they were approved in principle and with conditions by the government. To date, however, none have been able to obtain the necessary capital to move forward.

In 2000, Tanzania was in the process of developing aquaculture guidelines that would help to insure that better practices were the norm as the industry in the country developed.

Information on Shrimp Aquaculture from Other Countries in the Middle East

Introduction

There is not a lot of information on shrimp aquaculture in other North African and Middle Eastern countries. The information that follows is taken largely from Fish Farming International (various years 1994-2001) with the permission of Bob Rosenberry, the editor. While somewhat dated, this report contains relatively complete information for Egypt and Iran. A fair amount of detail is included below on shrimp farming operations in Saudi Arabia. It is likely, however, that quite a few more experiments are being undertaken or contemplated in the region. The consortium would welcome any information on specific operations in Africa or any countrywide assessments readers would care to send us. With your permission we would reproduce all or parts of them within the web site. We would also appreciate any up-dates or corrections regarding the information included in this report. The goal is to attempt to make the best information available to the widest range of individuals and institutions interested in the topic.

Kuwait

In 1999, General Bader Alghanim (Al-Muharak Company) advertised in the NFInsider seeking a US firm to establish an indoor shrimp farm in Kuwait. The ad suggested that either joint ventures or turnkey operations would be welcome.

Saudi Arabia

Despite temperature swings from 12-26 C and salinity fluctuations from 40-60 ppt, shrimp farming is making inroads in Saudi Arabia. While some experiments have been undertaken with *P. indicus*, to date farms only produce *P. monodon*. In 1999, Saudi Arabia's total shrimp aquaculture production was reportedly 2,000 MT on 16 licensed farms.

Information on Some of the Players

Saudi Fisheries Company

This company is partially owned by the government. Operations began in the late 1980s. The company has 108 circular, 1-ha ponds, a 60-ha reservoir for both settling and fertilizing, and 60 ha of shallow effluent treatment ponds that are stocked with fish and shellfish. The company has a 50-million PL capacity hatchery that is located on the Red Sea near Abha, about 500 km south of Jeddah. The farm produces from 3-4 MT/ha/160-day cycles and gets 1.8 crops per year. By 1999, production exceeded 15 MT/ha/year. Shrimp are sold head on, and the operation has a turnover of some \$15 million per year.

Red Sea Prawn Company

This operation is located 200 km south of Jeddah at a place called Al-Lith, also on the Red Sea. This operation began in 1998 with 32 ha of growout ponds. It now has a 50 million PL hatchery, 108 ha of ponds and a processing plant that can handle 8 MT/day. Stocking densities were lowered from 20, 30 or 40 PL/m² in 1997 to 16-20 in 1998. The cycle is 180 days. Feed is imported from CP in Thailand and President in Thailand. With an average stocking density of 15 PL/m², ponds produce 3,000 MT/ha/cycle. Total production in 1997 was 294 MT and in 1998 310 MT. Estimates for 1999 were 650 MT. Some 80% of production is sold to Japan and 20 % is consumed locally. This farm is unique because of 220 ha of water surface area, only 108 ha are actually rearing ponds. More than 50 % of the surface area is devoted to water quality control. White Spot affected production in this farm and the owners shut it down for six months to make modifications.

National Prawn Company

This company aimed to be the biggest shrimp farming operation in the Middle East. Located next to the Red Sea Prawn Company this US\$100 million dollar operation is being promoted by one of the partners of Red Sea Prawn along with the Al Rajhi Group, the biggest industrial group in Saudi Arabia. The farm is projected to have 9 modules, each with 36, 5-ha ponds. The hatchery is also to be divided into modules—one for maturation, one for nauplii, and four for PL production. The hatchery is designed to produce 300 million PL-20s/year. Plans call for both a processing plant and a feed mill. Construction was to begin in 2001.

Jizan Project

Located near Jizan, this 200-ha project, designed by Filipino consultants, is still on the drawing boards until it receives official government approval.

Al Mastura Project

Also still on the drawing boards in 1999, this project was waiting for government approval. The goal is to build a 100-ha farm on the Red Sea about 75 km north of Jeddah at a place called Al Mastura

Arasco Feed Plant

This company formulates feed to customer specifications. Originally producing feed for livestock, the company has begun to produce extruded shrimp feed as well, both floating and sinking.

The Al-Ballaa Shrimp Operation

A report in 1997 described the construction and operation of a 100-ha shrimp farm by the Al-Ballaa family on the Red Sea, approximately 20 km north of Al-Lith. The operation sits on a coastal site with access to the sea from what could best be described as a relatively narrow and shallow waterway formed by a series of barrier islands to the west of the mainland.

Each pond is 1 ha. They are square and laid out 100 m on a side. The bunds are approximately 3 m wide. The main canal is about 15 m wide while the lateral supply canals are about 6.5 m wide. Water depth in the supply canals is about 2 m. Each pond has a separate entrance and exit gate, and each exit gate has a 2.5 x 3 m harvest box.

The farm is located along a section of the coastline that is basically one long, dry riverbed. The coastal mountain range is about 5-15 km inland. Every fall during the rainy season tons of clay are washed out of the mountains onto the coastal plains. Over the centuries, the clay has mixed with the beach sand making sandy loam. The soil contains no more than 30-40% clay. If compacted sufficiently, it is relatively watertight, but it is very susceptible to erosion by wave action. If not compacted correctly, the soil will collapse under its own weight. This means that each bund has to be built up in 50-75 centimeter layers and then compacted.

Some 200 gates were constructed after the pond bunds were completed. They were built from 20 cm below the bottom grade and then build up with compacted gravel. Steel reinforced forms were used and PVC-coated rebar was used in these structures. The discharge outlets were built with deflectors that directed water down the discharge canal rather than straight through exists which would have caused wash-out problems on the opposite side of the canal.

The pump station is the key to success at most shrimp farms, particularly in Saudi Arabia where soil conditions are extremely unstable. Pumps, water pipes and the flow of water all cause vibrations which

effect soil stability. If not built correctly, the vibrations can destroy the station. In addition, the water turbulence must be prevented from undermining the pump's foundation.

The construction and operation of the farm illustrate a number of problems that are likely to occur in countries where there is little experience with shrimp aquaculture. The initial design called for the farm to be divided into 100, 1-ha ponds grouped into six sections. Unfortunately, the overall layout of the farm was ill advised. The farm's intake canal is located on the south end of the site while the discharge canal is located at the north end.

There are two major problems with this set up. The west coast of Saudi Arabia has a prevailing NW to SE wind for 10-11 months of the year. During daytime, the wind averages 10-15 mph. There is also a strong current flowing north to south along the west coast. These two forces combine to move large volumes of water in a southern direction and force it to hug the coast. One consultant reported to the owners that the configuration, as it was designed, would become a self-pollution problem in the future when all of the ponds were in operation. When the self-polluting implications of such a configuration were pointed out to the owners, rather than change the design of the farm the company opted to build a diverting barrier out from the intake canal to solve the problem. In short, they chose to fight nature rather than to work with it.

There were similar issues that arose from the aeration design. The original design called for 8, 1-hp paddlewheels in each pond. The design called for each section of the farm to have two 785 amp/175-hp generators. This design called for 6 generator rooms with 2 generators for the camp. In all a total of 14 generators. Rather than make an informed decision about the need for aeration in Saudi Arabia (and the purchase and installation and maintenance costs of generators, wiring, aerators, and diesel), the owners chose to over build the site.

Subsequent experiments showed that if stocking densities were kept at 20 PL/m² or less, and realistic exchange rates were used there would be no need for expensive aeration. In fact, the first ponds that were stocked did not have aeration. Water exchange was 6-7% per day and for the final 4 weeks about 15%. Harvest rates for the initial stocking ranged from 2,500 kg/ha of 36 gram shrimp to 4,900 kg/ha of 34 gram shrimp. Through 1997, a total of 43 ponds were harvested and they averaged 3,861 kg/ha/cycle.

As a result of these initial production results, an experiment was undertaken to determine whether aeration was necessary or not. The findings of the experiment were that lower stocking densities had higher survival and faster growth rates regardless of the lack of paddlewheels. At 20 PL/m², aerated and non-aerated ponds performed the same. However, at stocking densities of 30-40 PL/m² the ponds with aeration performed worse and one of the aerated ponds was the location of the start of an outbreak of *P. monodon* baculovirus (MBV) that spread to other ponds on the farm. Still, the owners were not convinced that they should abandon the aeration scheme.

The Production System²

The ponds at Al-Ballaa are run the same as ponds at other shrimp farms in the country—pond preparation, stocking, growout and harvest. The first 20 harvests were restocked without any particular treatment. The next 20 ponds had the bottom soil exchanged after only one crop. There is probably no need to remove the soil if no harsh chemicals or medicines are used. If anything, this practice not only affects the bottom line, it also poses a disposal problem.

Prior to stocking, preparation included the use of lime (CaCO₃) at about 1 MT/ha to bring the pH up to about 8. Immediately after the lime was added, the ponds were filled with 20-25 cm of water for about 24-48 hours. The ponds were then emptied and flushed for 24 hours. The ponds were then filled to about 75 cm. As the ponds were filled, burlap bags containing DAP (di-ammonium phosphate) and urea and TSP

(triple super phosphate) were suspended in the inlet gates. As the water entered the pond it slowly dissolved and spread the fertilizer throughout the pond.

The fertilizer requirements are determined separately for each pond. The usual rate was about 10 kg/ha and then adjusted up or down depending on the resulting algal bloom. Once the bloom was established there was normally no need to add more fertilizer. While the Red Sea is generally devoid of algal life, there was never any problem establishing algal blooms with fertilizer. After 7 days, the algal bloom in the ponds is sufficient for stocking. Initially, algal counts were undertaken daily but this was time consuming and costly. Later, visual evaluations with secchi disk readings were considered sufficient.

The ponds were stocked with PL 15 to PL 40 depending on what the hatchery had available. This was often affected because construction took longer than anticipated. One hundred PL were placed in survival boxes in order to have an understanding of the survival rate. Stocking was done in the morning or evening to avoid high mid-day temperatures.

Feeding in the ponds was started the day after stocking. Feeds were purchased from CP in Bangkok. Several problems arose with the feed. The quality and variability were problems, but the timing was perhaps the biggest issue. In some instances, feeding had to be suspended because the feed was not received in a timely way. In other instances, the feed that arrived was not the size that was ordered. All this points to the problems of not having sufficient demand in a country to encourage local manufacturing.

The actual feeding rate on any given day depends on what is happening in the pond, what the weather is like and how the animals appear to be doing. There is no cut-and-dried formula. And, there is no substitute for experience. This is another big problem in countries where there is no history of aquaculture. Most of the feedback comes at harvest—if the pond bottom is clean with no black sludge in the corners and if the shrimp have grown at the expected rates then the right amount of food was fed to the pond.

Ponds were harvested using a tubular net attached to a net frame. On harvest day, the level in the pond is lowered at about 2 pm. By dark, the level in the pond is at about 40-50 cm. As the water flows out of the pond, it flows through the net into the harvest box. Initially, the shrimp were emptied from the end of the net into plastic garbage cans and then lifted out of the harvest box. The garbage cans were then emptied into fiberglass tanks filled with water and ice, killing the shrimp and bringing down their body temperature for transportation to the processing plant. The shrimp are then loaded into plastic tote boxes with alternating layers of shrimp and ice. They are weighed at the pond and the processing plant. A system of chits has been developed so that the pond, transporter and processing plant are all required to sign for the shrimp and verify the quantity involved.

Hatchery

In 1998, the hatchery had the capacity to produce about 5 million PLs a month. Approximately 20 outside tanks were used to store adults for the hatchery. By improving the movement and handling of the broodstock, the company has been able to reduce the mortality from 50% to nearly zero.

Processing Plant

The main incentive to build a processing plant is because the price for unprocessed animals is about half the market price for processed animals. There were several problems with running a processing plant in Saudi Arabia. First, very few people have any experience so labor has to be imported from India, Sri Lanka and the Philippines. In addition, all workers had to be male. Unfortunately, males are only one-third to one-half as quick and efficient at processing shrimp as women. The men processed shrimp at a rate of 1 MT/4 hours. Since most ponds produced about 4 MT, it meant that about 24 hours (including meals and breaks) were required to process a pond. Consequently, only about 3 ponds could be harvested per week.

Disease

Once a disease such as MBV hits, there is very little that can be done about it. Viruses do not respond to antibiotics, so medicated feeds are not the answer. In any case, feed delivery time makes ordering medicated diets impractical when the feed companies are so distant from the ponds. Consequently, one fortunate aspect of the situation in Saudi Arabia is that needless medications are not introduced into the environment.

Many diseases are present in shrimp ponds. They become a problem when the shrimp become stressed. In Saudi Arabia, they have found that the best form of disease management is to ensure that shrimp don't become stressed in the first place. It is important that the ponds be filled with good water and that stocking levels and feed management be cautious.

Once disease was in ponds, they were harvested as quickly as the processing plant could handle it. All dead animals were burned, and the pond bottoms were treated with sodium hypochloride (HTH Chlorine) at the rate of about 100 kg/ha. The chlorine was spread dry and then the ponds were filled with about 10-15 cm of water. They were allowed to sit for 48 hours, then drained and dried for about 1 week.

Birds were a major problem with the spread of disease. They would eat or carry animals from one pond to another. Unfortunately, weapons are not allowed in Saudi Arabia to kill or drive off the birds.

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