THE UNIVERSITY OF HULL

Aquaculture Development in the Philippines

being a Thesis submitted for the Degree of
Doctor of Philosophy

in the University of Hull

by

Romeo Esquivel Dieta
BSc (Fisheries), University of the Philippines, 1977
MSc (Fisheries), University of Hull, 1992

March 1997

ACKNOWLEDGEMENTS

I wish to express my sincere thanks and deepest gratitude to the ASEAN Aquaculture Development and Co-ordination Programme (AADCP)-European Economic Community (EEC) for providing the financial support which enabled me to obtain this fellowship. To the Bureau of Fisheries and Aquatic Resources (BFAR), particularly to Director Dennis B. Araullo, for his support and assistance for allowing me to complete this fellowship.

Special thanks and appreciation is accorded to my thesis supervisor, Dr. Ian Cowx for spending his valuable time editing the whole text and providing valuable guidance and improvements in the preparation of my thesis. Thanks are also due to Dr. Keith Haywood for giving directions and valuable comments in the preparation of the economic and development aspects of this report; and also to all the staff of the University of Hull International Fisheries Institute for their kind assistance given me during the course of my fellowship.

I would also like to express my thanks to all the staff of the BFAR National Brackishwater Aquaculture Technology Research Centre, Pagbilao, Quezon, for their assistance during the conduct of my research.

Lastly, my heartfelt gratitude goes to my mother, Patrocinia E. Dieta, whose inspiration and prayer have made my fellowship a successful one.

ABSTRACT

Philippine aquaculture is a dynamic industry and a fast growing sector of the economy. Tremendous progress in production and technology has been achieved during the past decade. However, the country is experiencing a fish production shortfall which the aquaculture sector is expected to address. Given the proper support and direction, the aquaculture industry in the Philippines has great potential for growth and development. The Philippines has the principal attributes necessary for expansion of aquaculture production (e.g. important aquaculture species, ideal climatic conditions, existing fish farms and large water resources, expertise and manpower, markets, technologies). As part of the present research, several production-oriented studies were conducted for the development of the brackishwater aquaculture sector. The studies have shown that aquaculture technologies are available (e.g. milkfish - semi-intensive culture in ponds and marine cage culture, salt-tolerant tilapia hybrid - pond-based and marine-based cage culture, grouper - pond culture, shrimp - semi-intensive culture) which are technically feasible and financially viable under present economic and environmental conditions. However, there are several important aquaculture constraints (e.g. seed supply and quality, feed supply and quality, government policies, marketing and post-harvest, environmental degradation and diseases, aquaculture credits) that must be overcome in order for the country to attain the maximum benefit from the potential of aquaculture. The study also identifies the important socio-economic benefits that can be derived (e.g. contribution to Gross Domestic Product, fish food supply, foreign exchange earnings, employment opportunities, tax revenues) from the development of the aquaculture sector. Finally, the study provides some strategies for the development of the brackishwater aquaculture sector with emphasis on the culture of milkfish, salt-tolerant tilapia hybrid, grouper and shrimp.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AADCP	- ASEAN Aquaculture Development and Co-ordination Programme
ABW	- Average Body Weight
ADB	- Asian Development Bank
ARMM	- Autonomous Region of Muslim Mindanao
ASEAN	- Association of Southeast Asian Nations
BAR	- Bureau of Agricultural Research
BAS	- Bureau of Agricultural Statistics
BFAR	- Bureau of Fisheries and Aquatic Resources
B/C	- Benefit-Cost ratio
CB	- Central Bank of the Philippines
CLSU-FAC	- Central Luzon State University-Freshwater Aquaculture Centre
DA	- Department of Agriculture
DBP	- Development Bank of the Philippines
DO	- Dissolved Oxygen
DOST	- Department of Science and Technology
EEC	- European Economic Community
EEZ	- Exclusive Economic Zone
EUS	- Epizootic Ulcerative Syndrome
FAO	- Food and Agriculture Organisation
FCR	- Feed Conversion Ratio
FLA	- Fishpond Lease Agreement
FNRI	- Food and Nutrition Research Institute
GMT	- Genetically Male Tilapia
GNP	- Gross National Product

FOB	-	Free On Board
FSP	-	Fisheries Sector Programme
GATT	-	General Agreement on Tariff and Trade
GB	-	Great Britain
GDP	-	Gross Domestic Product
GIFT	-	Genetic Improvement of Farmed Tilapia
GVA	-	Gross Value Added
ICLARM	-	International Centre for Living Aquatic Resources Management
IFC	-	International Finance Corporation
IRR	-	Internal Rate of Return
JICA	-	Japan International Co-operation Agency
LB	-	Land Bank of the Philippines
LGUs	-	Local Government Units
LLDA	-	Laguna Lake Development Authority
LSD	-	Least Significant Difference
MBV	-	Monodon Baculuvirus
MOA	-	Memorandum of Agreement
MP	-	Million Philippine Pesos
Mt	-	Million metric tonnes
MTADP	-	Medium Term Agricultural Development Plan
MTFMDP	-	Medium Term Fisheries Management and Development Programme
NACA	-	Network of Aquaculture Centre in Asia-Pacific
NAREA	-	National Agricultural Research and Extension Agenda
NBATRC	-	National Brackishwater Aquaculture Technology Research Centre
NCR	-	National Capital Region

NFFTRC - National Freshwater Fisheries Technology Research Centre

NGOs - Non-Government Organisations

NSCB - National Statistical Co-ordination Board

NSO - National Statistics Office

PBC - Pay Back Period

PCAMRD - Philippine Council for Aquatic and Marine Research Development

PCARRD - Philippine Council for Aquatic Resources Research and Development

PCFAR - Philippine Chamber of Fisheries and Aquatic Resources

PHRDC - Philippine Human Resources Development Centre

PNB - Philippine National Bank

QUEDANCOR- Quedan and Rural Credit Guarantee Corporation

R&D - Research and Development

RCB - Randomised Complete Block design

RFOs - Regional Field Offices

RFUs - Regional Fisheries Units

RR - Rate of Return

SAEP - Society of Aquaculture Engineers of the Philippines

SEAFDEC-AQD- Southeast Asian Fisheries Development Centre-Aquaculture Department

SRDD - Sea farming Research and Development Department

SRT - Sex-Reversed Tilapia

STAND - Science and Technology Agenda for National Development

UNDP - United Nations Development Programme

UP-BAC - University of the Philippines-Brackishwater Aquaculture Centre

USAID - United States Agency for International Development

1. INTRODUCTION

1.1. Background

The Philippines is located in the Southeast of Asia-Pacific region. It enjoys a tropical climate with temperature ranging between 25°C to 33°C most of the year. The country is heavily populated and fast growing, with a population of over than 68.6 million in 1995 and dependent mostly on rice and fish as the main source of protein. Before the 1970s, the Philippines had a relatively stable and progressive economy which was derived primarily from agricultural production and export crops such as sugar, coconut and hemp. During the 1980s, the Philippine economy suffered negative growth due to fast population growth, unstable economic and political environment and these factors were in turn aggravated by the world-wide economic recession. In the 1990s, the country's economy began to pick-up again with a growth rate of 1.3% in 1980-1984 and 2.1% in 1985-1994 (ADB, 1992). The Philippine literacy rate is over 80% and the educational standards are comparable to most countries of the world. The Philippine society is predominantly Christian with Catholicism as the main religion.

The Philippines is one of the major producers of fish and fishery products in the world. The country was the second biggest producer of tuna and tuna like fishes in the Indian Ocean and Southeast Asian region in 1991, with Indonesia and Thailand as the first and third biggest producers respectively (BFAR, 1996). In aquaculture, the Philippines is the highest producer of milkfish and a major producer of farmed seaweed, shrimp, grouper and tilapia. The fishing industry provides employment to about one million people. Total fish production in 1995 was 2.74 Mt valued at 83.64 billion Pesos, registering positive increases of 2% and 3% respectively over the 1994 values. Production was mainly contributed by municipal fisheries (36%), followed by commercial fisheries (34%) and aquaculture (30%). In terms of value, the highest share comes from aquaculture (40%), followed by municipal (32%) and commercial (28%). The country is a net exporter of fishery products and the balance of trade improved by 2.2% from US$483 million in 1994 to US$494 million in 1995. The Philippines exported a total of 15.6 billion Pesos (US$606 million) of fishery products in 1995, up by 4.2% in 1994. The leading markets are Japan, USA, Hong Kong, UK, Germany, Korea, Canada, France, South Africa and Taiwan in descending order, while the leading fishery exports are shrimps/prawns and tuna. In 1995, the fishing industry accounted for 3.7% and 4.2% of the country's Gross Domestic Product (GDP) at current and constant prices, respectively. Capture fisheries are the main source of fish production in the Philippines, however, several fishing grounds have shown definite signs of over-exploitation and declining catch (Dickson, 1993). On the other hand, the aquaculture sector significantly increased production during the last decade and is anticipated to become the major source of fish production in the future.

The major concerns of the present Government are food sufficiency and security, poverty alleviation, increase foreign trade, and environmental management and conservation. The fisheries sector plans, programmes and priorities are designed to ensure a long term sustainability of the resource bases, i.e. production from traditional marine and inland fishing grounds will be sustained and managed within ecological limits. In aquaculture, production from fishponds, fishpens and fish cages will be increased within ecological limits through the promotion of semi-intensive culture and high yielding species, and the expansion of culture in sheltered and suitable coastal marine waters throughout the Philippine islands.

1.2. The Philippines: a major consumer of fish

The Filipinos are primarily a fish and rice eating nation. The importance of fish in their lives cannot therefore be overstated, and most consider a meal incomplete without some fish and rice in their daily diet.

The Food and Nutrition Research Institute (FNRI) in its Third National Nutrition Survey made in 1987, reported that the per capita consumption of fish and other fishery products (ex market) was about 55 kg yr^{-1}, of which 40 kg was fresh fish and the other 15 kg was made up of dried and processed fish, and crustaceans and molluscs. Other animal protein sources such as dairy products, poultry meat, eggs, pork, beef and processed meat contribute only 36.3 kg yr^{-1} (Table 1.1). This means that the average Filipino consumes about 20% more fish than any other form of animal protein.

Table 1.1 Per capita consumption of fish and other food products (ex market) as of 1987

Food group	Total (kg yr^{-1})	Percent (%)
Fish and fishery products		
Fresh fish	40.0	43.8
Dried & processed fish	8.0	8.7
Crustaceans & molluscs	7.0	7.7
Total	55.0	60.2
Other protein sources		
Dairy	15.7	17.2
Poultry meat and eggs	7.0	7.7
Fresh meat/organs	11.4	12.5
Processed meat	2.2	2.4
Total	36.3	39.8

Source: FNRI, 1987 (as cited by BFAR, 1996)

A study of the historical consumption of fish and fishery products around the world was made for the Food and Agriculture Organisation (FAO) by Westlund (1995). The study estimated that the percentage of fish to animal protein intake in the Philippines was 55.9%. However, in terms of fish as a percentage of the total protein intake, the Philippines ranked seventh at 23.2% after the Maldives, Solomon Islands, Kiribati, Seychelles, Japan and Sao Tome in that order. The Filipinos get most of their protein from cereals such as rice and corn.

The last census conducted by the National Statistics Office (NSO) in 1995 placed the population of the Philippines at 68.61 million with an average annual increase of 2.32%. This means that the estimated population in 1996 was around 70.20 million Filipinos, and by the year 2000 about 76.95 million (Table 1.2). In 1996, this is equivalent to 3.861 Mt of fish and fishery products per year assuming that every Filipino consumes 55 kg of fish and other edible fishery products every year.

Table 1.2. Population and fish requirement projections for the Philippines, 1995-2000 based on an average annual increase of 2.32% and 55 kg per capita consumption

Year	Population (million)	Fish requirement (Mt)
1995	68.61	3.774
1996	70.20	3.861
1997	71.83	3.951
1998	73.50	4.043
1999	75.20	4.136
2000	76.95	4.232

The Bureau of Agricultural Statistics (BAS) of the Department of Agriculture (DA) in 1996 reported a total fish production of 2.74 Mt in 1995 and imported about

141,546 t of edible fishery products such as canned, fresh, frozen, chilled, salted and dried fish. However, the Philippines exported 169,746 t leaving a balance of 2.712 Mt for domestic consumption. There was therefore a large deficiency of fish and fishery products amounting to 1.041 Mt in 1995. As the population of the Philippines grows, the demand for fish will reach over 4 Mt (Table 1.2) by the year 2000. Consequently, the fish deficit is estimated to increase to more than 1.3 Mt by the year 2000 (Table 1.3).

Table 1.3. Projected fish production, import, export and fish deficit, 1996-2000

Year	Production[a] (Mt)	Import[b] (t)	Export[c] (t)	Balance[d] (Mt)	Fish deficit[e] (Mt)
1995	2.740	141,546	169,746	2.712	1.041
1996	2.777	140,300	177,758	2.740	1.121
1997	2.814	139,066	186,148	2.767	1.184
1998	2.852	137,842	194,934	2.795	1.248
1999	2.891	136,629	204,135	2.823	1.313
2000	2.930	135,427	213,770	2.852	1.380

Notes:

[a] Calculated from an average increase of 1.35% between 1991-1995
[b] Calculated from an average decrease of 0.88% between 1991-1995 (includes only edible fishery products)
[c] Calculated from an average increase of 4.72% between 1991-1995
[d] Calculated by adding column 2 and 3 and deducting column 4
[e] Calculated by deducting column 5 from fish requirement (Table 2)

1.3. Strategic alternatives and selection of species

Since marine catches are unlikely to improve in the future, the Government has put its thrust in the development of the aquaculture sector to play a major role in easing the gap between fish supply and demand during the next decade. At present, the aquaculture sector plays a significant contribution to the economy (e.g. domestic food supply, employment, export). Aquaculture production substantially increased during the last decade (from 471,000 t in 1986 to 825,000 t in 1995) due to the rapid development of culture technologies. However, due to fast population growth, the country experienced a fish production shortfall, and to compensate for this shortage, the country imports fish and fishery products from other countries. There is therefore, an urgent need to increase fish production to meet the demand of the growing population, and the most logical approach is to develop the aquaculture sector. There are several ways to improve production of the aquaculture sector, either by converting available mangrove swamps into fishponds, developing unutilised brackishwater fishponds, increase production of existing farms, or expand production in sheltered marine waters. With the increasing ecological concern on the destruction of remaining mangrove resources, the first option is not likely to be a popular decision. The most appropriate strategic options, therefore, are to develop unutilised brackishwater fishponds, increase production of existing farms and expand production in sheltered marine waters within ecological limits and through proper fish farm management.

This project identified four important species in the Philippines which have great potential for aquaculture development. These are milkfish, salt-tolerant tilapia hybrids, grouper and shrimp. The above species were selected based on their availability (e.g. seed supply, culture technology, farm sites, farming experience and expertise), consumer acceptability and demand (e.g. domestic and export markets), suitability for cultivation under local climatic conditions, and on the economic benefits being derived from the culture of the species (Section 1.1). The enhancement of milkfish and tilapia production will contribute significantly to the dwindling supply of fish in the domestic market, thereby, reducing the fish deficit; while the development of grouper and shrimp will provide foreign exchange earnings to the country and spur economic development. Other economic importance of these species is presented in more details in succeeding chapters.

1.4. The objectives and scope of project

The objectives of this project were to review the current status of fisheries and aquaculture industry in the Philippines and provide a strategy for the enhancement of the brackishwater aquaculture sector by:

- conducting studies aimed at improving the production technologies of some selected brackishwater aquaculture species such as milkfish (*Chanos chanos* Forskal), salt-tolerant tilapia hybrid (*Oreochromis niloticus* L. x *Orechromis mossambicus* Peters), grouper (*Epinephelus tauvina* F.) and shrimp (*Penaeus monodon* Fab.); and then
- develop strategies that would strengthen the transfer of these technologies into the private sector.

Specifically, a general review of the fisheries and aquaculture industry was undertaken to assess the current capabilities (e.g. technology, production, manpower, facilities, marketing, existing legislations, programmes and policies), impediments and opportunities associated with aquaculture development in the Philippines. To improve existing productions and enhance the development of the brackishwater aquaculture sector, several production-oriented studies on some important species were conducted. On milkfish, there were two studies conducted, i.e. semi-intensive milkfish culture in ponds and milkfish culture in marine net cages. The aim of the first study was to evaluate the technical and economic aspects of the semi-intensive culture technology under present conditions, while the second study was to develop a cage culture technology for milkfish adaptable for protected marine waters of the Philippines. On tilapia, studies were conducted to determine the technical and economic benefits of culturing the salt-tolerant tilapia hybrid (*O. niloticus* x *O. mossambicus*) in brackish water as well as in sea water conditions. On grouper, attempts were made to solve the problems of low grouper fry survival in the nursery phase and the lack of production technology. To address these constraints, a study on sorting frequency of grouper fry was conducted; and grow-out studies in ponds and pond-based net cages were also conducted to determine the technical and economic aspects of these culture methods. Since the 1980s, the shrimp industry has been plagued with disease as a result of culture intensification. There is an urgent need to develop an alternative and a sustainable shrimp culture technology for adoption by shrimp growers. A technology verification (e.g. production trials or field-testing of existing technology) on the semi-intensive shrimp culture technology was undertaken to determine its technical feasibility and economic viability under present environmental conditions. At the end of the Chapter, a brief development plan and strategies for the development of each of the species is presented.

This project is in line with the Medium Term Fisheries Management and Development Program (MTFMDP) of the Bureau of Fisheries and Aquatic Resources (BFAR). This is a component of the Medium Term Agricultural Development Plan (MTADP) of the Department of Agriculture being implemented by the National Government for the period 1993-1998. Specifically, the MTFMDP seeks to double the production of the aquaculture sector from 1.2 t $ha^{-1}yr^{-1}$ to 2.4 t $ha^{-1}yr^{-1}$ through the development and promotion of new or high yielding technologies within ecological limits or maximum sustainable yield. Part of the study was conducted as a commitment of the Philippine Government under the EEC-ASEAN Aquaculture Development and Co-ordination Programme (AADCP): Component 3-Technology Verification and Training, which was implemented between 1990 and 1995. Other activities were implemented under the priority programme of the Department of Agriculture-Bureau of Fisheries and Aquatic Resources.

2. THE STATUS OF FISHERIES AND AQUACULTURE IN THE PHILIPPINES

2.1. Fishery resources of the Philippines

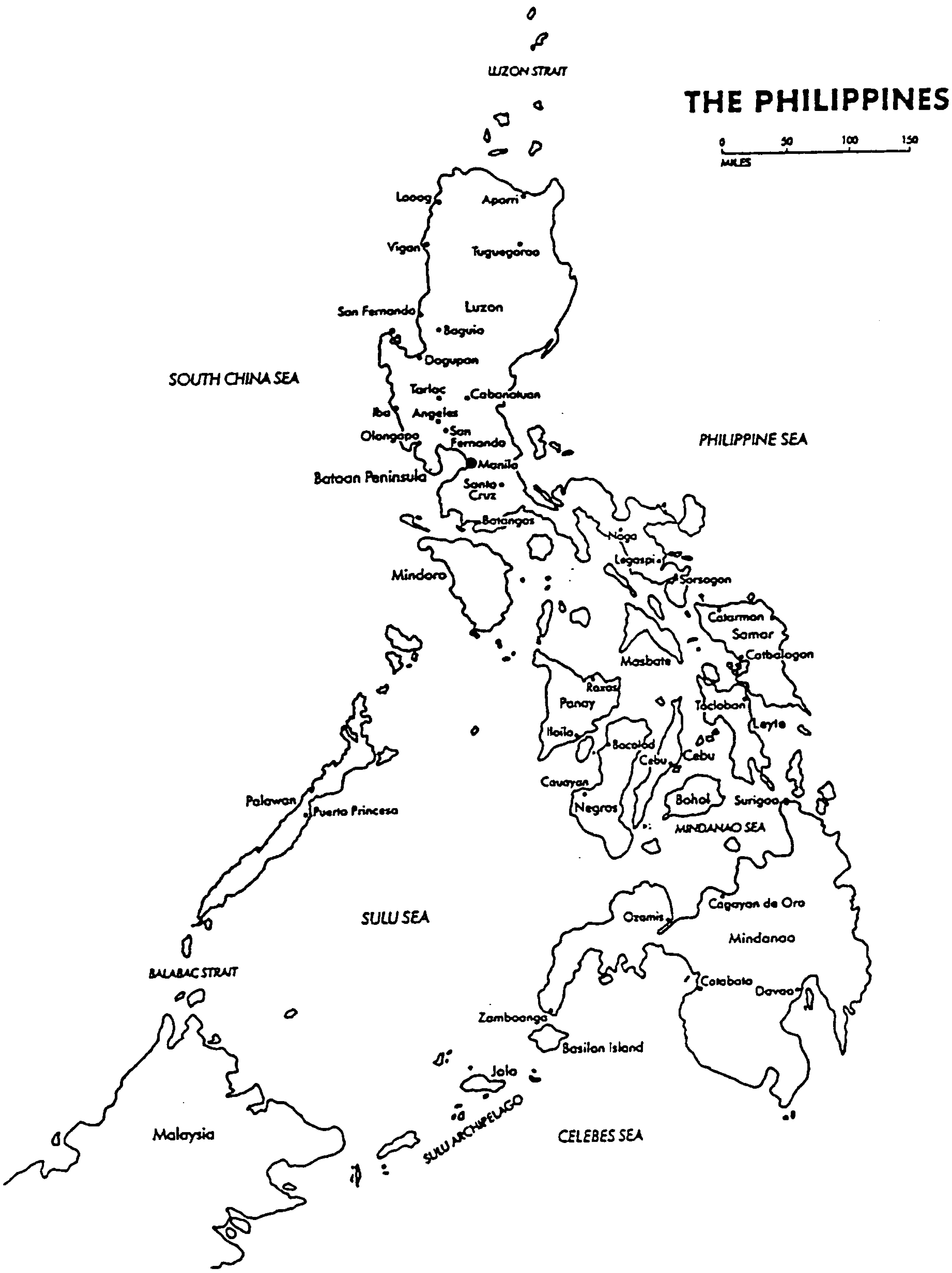
The Philippines is an archipelago comprising of more than 7100 islands (Figure 2.1). The marine and freshwater areas of the country are seven times larger than land area. The marine waters of the Philippines cover a shelf area of 18.46 million ha and coral reef of 2.7 million ha. It has a total coastline length of 34,600 km (NSO, 1992) and a total territorial water area, including the Exclusive Economic Zone (EEZ) of 220 million ha (BFAR, 1995). Some 30,000 villages are situated along this vast coastline.

On the other hand, the inland water resources have a total of 842,247 ha of swamps, existing fishponds, lakes, rivers and reservoirs (Table 2.1). In 1993, BAS reported that the productive brackishwater areas were 32,746 ha for shrimp and 68,448 ha for milkfish or a total of only 101,194 ha. The remainder of the existing brackishwater ponds (138,129 ha) were either undeveloped or unutilised. At present there are no available data on the total area engaged in freshwater fish production, although there are about 14,500 ha of freshwater fishponds and 500 ha of fish cages for the culture of Nile tilapia (*Oreochromis niloticus* L.) in lakes and reservoirs throughout the country (Guerrero, 1994) and about 13,700 ha of fish pens exist in Laguna lake (Juliano, 1996).

2.2. Fisheries contribution to the Philippine economy

In 1995, the fisheries contribution to the total Gross Domestic Product (GDP) of the Philippines was at 3.7% at current prices and 4.2% at constant prices

Figure 2.1. Map of the Philippine Islands showing territorial boundaries



(NSCB, 1995). It also accounted for 17% (70.2 billion Pesos) of the Gross Value Added (GVA) products of 412.9 billion Pesos in the Agriculture, Fishery and Forestry Sector at current prices, second only to Agriculture crops which was the largest contribution of 59.1% (244.2 billion Pesos).

Table 2.1. Inland water resources of the Philippines as of December 1995 (ha)

	ha
1. Swamps	
Freshwater	106,328
Brackishwater	232,065
Sub-total	338,393
2. Existing fishponds	
Freshwater	14,531
Brackishwater	239,323
Sub-total	253,854
3. Other inland water resources	
Lakes	200,000
Rivers	31,000
Reservoirs	19,000
Sub-total	250,000
Total	842,247

Source: 1995 Philippine Fisheries Profile. BFAR, 1996

In 1991, the Philippines was one of the major fish producers of the world, contributing 2.312 Mt of fish out of the total world production of 96.926 Mt (FAO, 1993). In terms of fish and shellfish aquaculture in 1993, the Philippines ranked seventh, exceeded only by China, India, Japan, Indonesia, USA and Thailand, with a production of about 392,000 t (Table 2.2).

Philippine fisheries is classified into three sectors namely: municipal, commercial and aquaculture. The municipal fisheries include fishing in coastal and inland waters with or without boats of three gross tonnes or less while commercial includes inshore and offshore fishing using more than three gross tonnes and interchangeably known as deep-sea fishing. Aquaculture includes three sub-sectors namely: fresh water, brackish water and mariculture.

Table 2.2. World aquaculture production of fish and shellfish by principal producers, 1989-1993 (Mt)

Country	1989	1990	1991	1992	1993
China	5.429	5.804	6.134	7.210	8.880
India	1.006	1.013	1.223	1.392	1.439
Japan	0.785	0.804	0.803	0.818	0.833
Indonesia	0.442	0.500	0.518	0.550	0.592
USA	0.371	0.315	0.364	0.414	0.434
Thailand	0.260	0.292	0.353	0.371	0.414
Philippines	0.361	0.381	0.409	0.391	0.392
Korea Rep.	0.404	0.377	0.342	0.376	0.391
Other Asia	0.235	0.334	0.283	0.250	0.277
France	0.225	0.257	0.245	0.250	0.271

Source: Aquaculture Production Statistics: 1984-1993. FAO Fisheries Circular No. 815, Revision 7. FAO, 1995.

The whole Filipino population depends primarily on fish as the main source of protein in their diet. In 1995, the fisheries sector employed approximately one million fishermen and fish farmers, of whom 68% were engaged in municipal fishing, 26% in aquaculture, and 6% in commercial fishing (Table 2.3).

The trend in fish production increased between 1991 and 1995, from 2.599 Mt to 2.740 Mt; or an average annual increase of 1.35% (Table 2.4). Specifically, aquaculture production and commercial fisheries increased during this period, while the municipal fisheries showed a decline. In 1995, aquaculture contributed 30.1%

(825,000 t); municipal fisheries, 36.1% (988,000 t); and commercial fisheries, 33.8% (927,000 t) to the total fish production of the country.

Table 2.3. Fisheries employment in the Philippines as of December 1995

Sector	No. of people	% of total
Aquaculture	258,480	26.1
Municipal	675,677	68.2
Commercial	56,715	5.7
Total	990,872	100.0

Source: 1995 Philippine Fisheries Profile. BFAR, 1996.

Table 2.4. Philippine fish production by sector, 1991-1995 (in '000 t)

Sector	1991	1992	1993	1994	1995
Aquaculture	692	736	772	791	825
Municipal	1,147	1,085	1,030	1,010	988
Commercial	760	805	845	885	927
Total	2,599	2,626	2,647	2,686	2,740

Source: Fisheries Statistics 1986-1995. Bureau of Agricultural Statistics (BAS), 1996.

The trend in fishery exports also increased between 1991 and 1995, from 141.939 Mt valued at 14.049 billion Pesos (Philippine) to 169.746 Mt valued at 15.657 billion Pesos. However, exports declined from 1994 to 1995, although the balance of trade value increased (Table 2.5). The increase in export value mainly came from shrimp.

Table 2.5. Balance of trade, 1994-1995

Type	1995			1994		
	Quantity	FOB Value		Quantity	FOB Value	
	(t)	(MP)	(M£)	(t)	(MP)	(M£)
Fishery Exports	169,746	15,657	412.0	172,080	15,027	395.4
Fishery Imports[a]	270,213	2,924	76.9	241,194	2,505	65.9
Balance of Trade	(100,467)	12,733	335.1	(69,114)	12,522	329.5

Source: 1995 Philippine Fisheries Profile. BFAR, 1996 [a] Includes edible & non-edible products
MP = Million Philippine Pesos M£ = Million GB Pound Sterling One GB£ = 38 Phil. Pesos

The leading fisheries export was shrimp/prawn followed by tuna. These fishery products contributed about 5.6 billion Pesos and 4.1 billion Pesos respectively, or equivalent to 62% of the total export value of 15.6 billion Pesos in 1995. Major fishery exports in 1995 are presented in Table 2.6, while the major countries of destination are presented in Table 2.7.

Table 2.6. Major fishery exports of the Philippines, 1995

Commodity	Quantity (t)	FOB Value ('000 Pesos)
1. Shrimp/Prawns	18,257	5,653,056
2. Tuna	68,886	4,137,467
3. Seaweed	38,246	2,136,658
4. Cuttlefish/Squid	3,573	627,368
5. Octopus	6,736	567,910
6. Ornamental Fish	6,399	226,996
7. Crabs/Crab Fats	1,850	192,057
8. Fish Fillet	1,068	187,879
9. Cultured Pearls	n	164,159
10. Capiz Shell, Articles	537	129,828
Total major commodity	145,554	14,023,378
other commodities	24,192	1,633,425
Grand total	169,746	15,656,803

Source: 1995 Philippine Fisheries Profile. BFAR, 1996.

On the other hand, fishery imports also increased over the period from 1991-1995, from a total of 193,635 t valued at 2.323 billion Pesos to 270,213 t valued at 2.923 billion Pesos. However, much of the increase came from the importation of fish meal indicating an increase in demand of artificial feeds in recent years. Conversely, if edible fishery products are considered, the trend was a decline from 150,993 t to 141,546 t (Table 2.8). The bulk of fishery imports in 1995 were fresh/frozen/chilled fish (47%), fish meal (45%), other commodities (8%).

Table 2.7. Quantity and value of fishery export by major countries of destination, 1995

Country	Quantity (t)	Value (Million Pesos)	% of total value
1. Japan	46,006	7.123	45.6
2. USA	31,344	2.557	16.3
3. Hong Kong	11,953	0.799	5.1
4. United Kingdom	9,982	0.678	4.3
5.Germany	9,271	0.612	3.9
6. Korea	5,256	0.607	3.9
7. Canada	7,357	0.558	3.6
8. France	8,592	0.338	2.2
9. South Africa	4,157	0.266	1.7
10. Taiwan	3,681	0.239	1.5
Total	137,599	13.786	88.1
Other Countries	32,147	1.871	11.9
Grand total	169,746	15.657	100.0

Source: 1995 Philippine Fisheries Profile. BFAR, 1996.

Table 2.8. Imports of edible fishery products by quantity and value, 1991-1995 to the Philippines

Type	1991	1992	1993	1994	1995
Quantity(t)	150,993	148,782	120,068	126,199	141,546
Value(M Pesos)	1,706	1,790	1,324	1,399	1,551

Note: Edible fishery products include only canned, fresh, frozen, chilled, dried, salted and smoked forms.

2.3. Aquaculture in the Philippines

2.3.1. *Aquaculture species*

The major species cultured in the Philippines are milkfish, tilapia, carp, shrimp, mussel, oyster and seaweeds. Aquaculture species commonly cultured in fresh waters are Nile tilapia (*Oreochromis niloticus* L.), carp species (*Cyprinus carpio* L., *Ctenopharyngodon idella* Val., *Labeo rohita* Hamilton. and Buchanan., *Hypophthalmichthys molitrix* Val. and *Aristichthys nobilis* Richardson, and milkfish (*Chanos chanos* F.). Milkfish production in fresh water comes from the operation of fish pens in shallow lakes and fish cages in deeper lakes. In brackish waters, milkfish is the most dominant species followed by shrimp (*Penaeus monodon* Fab., *P. indicus* H. Milne-Edwards, *P. merguiensis* de Man, *Metapenaeus ensis* De Haan). Other brackishwater species include the carnivorous species such as grouper (*Epinephelus tauvina* F.), seabass (*Lates calcarifer*) and mudcrabs (*Scylla serrata* F. and *S. oceanica*), and herbivorous species such as siganids (*Siganus* sp.) and spotted scat (*Scatophagus argus*). In marine areas, finfishes such as grouper and siganids are cultured in fish cages. More recently, milkfish culture in marine fish cages has also started. Various species of seagrass and bivalves are also being cultured. These include seaweed (*Kappaphycus* sp., *Caulerpa* sp., *Eucheuma* sp. *and Gracillaria* sp.), green mussel (*Perna* sp.), brown mussel (*Modiolus* sp) and oysters (*Crassostrea* sp.)

2.3.2. *Present aquaculture practices*

Aquaculture practices in the Philippines vary from the traditional extensive, semi-intensive, and intensive systems to polyculture. Aquaculture is practised in fishponds, fish cages, fish pens and open marine waters for seaweed and molluscs farming. Types of freshwater culture include earth ponds, concrete tanks, rice-fish farming, fish cages and fishpens. Culture in brackishwater areas is mostly in fishponds. Culture in marine waters uses net cages and pens for the finfishes while stake, rope and hanging methods are commonly used in oyster and mussel culture. The culture of seaweed is effected with the use of polyethylene ropes, or in seabed areas that have unpolluted water, sandy bottoms, and are protected from very strong water currents and wave action.

2.3.3. *Aquaculture credit and financing*

Among the major institutions that are involved in providing credit to aquaculture projects are the Development Bank of the Philippines (DBP) through its regular lending programme and the World Bank through financed credit lines, Central Bank (CB), Land Bank (LB), and the Philippine National Bank (PNB). Credit is available for fish production, mussel and seaweed culture, fishpond development, improvement and operation, fish pen, fish cages and oyster farming.

A recent development is the active participation of the Asian Development Bank (ADB) and the International Finance Corporation (IFC) in the provision of credit for the rehabilitation, renovation, improvement and operation of fishpond projects including the establishment of fingerling banks and hatcheries. In 1990-1995, the ADB provided credit support for the implementation of the Fisheries Sector Program (FSP) of the Department of Agriculture. The main thrust of FSP is to conduct studies and management of depleted coastal fishery resources as well as research and development (R&D) studies on potential aquaculture resources of the Philippines (Rabanal, 1995). Under the FSP scheme, about 1.555 billion Pesos is budgeted for credit during its five years of implementation. In the implementation of the FSP credit component, the DA entered into a memorandum of agreement (MOA) with the DBP and the Quedan and Rural Credit Guarantee Corporation (QUEDANCOR). In 1993 about 350 million Pesos were allocated as seed fund for the aquaculture sub-sector (Aypa, 1993). The present policy of fisheries credit is that lending facilities are only provided by financial institutions, and there is no direct lending by any government agency.

2.3.4. *Fisheries and aquaculture development legislation*

With the advent of the Martial Law regime in 1972, several promulgations were issued for the purpose of accelerating the development of the Philippine fishery industry.

Presidential Decree No. 43, known as Fishery Industry Development Decree of 1972 provided for the accelerated development of the fishery industry of the Philippines. It has declared fishery industry development as one of the priority measures for the national economic programme of the government and at the same time promulgated the state policy to accelerate the integrated development of the vast fishery resources of the Philippines that remained largely untapped.

Presidential Decree No. 704, otherwise known as the Fisheries Decree of 1975 became the main legislation on fisheries. Some of the salient features are:

(a) to accelerate and promote the integrated development of the fishery industry and keep the fishery resources in optimum productive condition through proper conservation and protection;

(b) to promote, encourage and hasten the organisation of, provide assistance to, and help integrate the activities of all persons, associations, co-operatives, or corporations engaged in the fishery industry;

(c) to encourage the exploitation of fish and fishery products;

(d) to ban the exportation of milkfish fry but not those of other species;

(e) to allow person and entitles to enter into charter contracts, lease or lease-purchase agreements with any foreign person or entity, or contracts for financial, technical or other forms of assistance regarding the various phases of the fishing industry;

(f) to name certain banking and lending institutions to grant loans to eligible borrowers of the fishery industry.

Other related promulgation on fisheries and aquatic resources which may affect the future development of the aquaculture industry are as follows:

(a) Presidential Decree No. 979, known as the marine Pollution Decree of 1976;

(b) Presidential Decree No. 1067, known as the Water Code of the Philippines;

(c) Presidential Decree No. 1151, holds each individual responsible for the preservation and enhancement of the Philippine environment and requiring all agencies of the government to consider these decree in every action, project or undertaking significantly affecting the quality of the environment.

Another development that may affect the future of fisheries and aquaculture is the recent promulgation of the Local Government Code. This 1991 law provides for the devolution of functions to the Local Government Units (LGUs), particularly those that are related to public services including fisheries extension. With the devolution of fisheries development, management and conservation functions to the local government, there is an anticipated slow-down in the dissemination of new and improved technologies to the fish farmers/end-users since the local government units do not have the capability and are not yet prepared to receive such responsibilities.

2.3.5. *Government policies and priority thrusts on aquaculture development*

The government gives high priority to the development of fisheries and aquaculture in the Philippines. All plans, programmes and policies related to aquaculture development are embodied in the MTFMDP which is being implemented by the National Government from 1993-1998. In general, the Department of Agriculture (DA) is the main agency involved in the development of the aquaculture industry. Considering that the majority of the Filipino people are farmers and fishermen, the mission of the DA is to improve the farmers' productivity, increase their real income and uplift the quality of their lives. Consistent with these objectives, the policies for fisheries are directed at increasing the income of the fish farmers and providing them with more equitable access to resources and an opportunity to be more productive (Camacho and Lagua, 1987).

In 1990, the Bureau of Agricultural Research (BAR) under the DA has set several objectives for aquaculture development. These are: (a) increased aquaculture contribution to total food fish requirements; (b) increased income for rural families; (c) improved and efficient utilisation of culture areas and accelerated development of unutilised fishponds; (d) increased utilisation of lakes, rivers, other inland bodies of water and coastal areas appropriate for mariculture; and (e) increased export of aquaculture products.

To achieve these objectives, several production, post-harvest and conservation-oriented strategies directed by the private sector are to be adopted. These are: (a) expansion of culture operations to high value species; (b) intensification of production in existing brackishwater ponds through improved culture technologies; (c) implementation of efficient post-harvest technologies and marketing arrangements; (d) increasing the productivity of lakes, rivers and other bodies of water; and (e) expansion of the participation of the private sector in all aspects of aquaculture.

The DA through the BAR, and in co-ordination with the Philippines Council for Aquatic and Marine Research Development (PCAMRD), has formulated the National Agricultural Research and Extension Agenda (NAREA) as a guide for researchers, extension workers, planners and policy makers to effectively and efficiently utilise limited resources for agricultural and fisheries research and development. The NAREA embodies all agricultural and fisheries research and development priorities of the country encompassing the upland, lowland and aquatic zones.

In 1995, an integrated approach to R&D management was launched by PCAMRD and BAR to consolidate the R&D directions of the Science and Technology Agenda for National Development (STAND), the National Fisheries Research Programme of the Fisheries Sector Programme and the Medium Term Fisheries Management and Development Programme of the Department of Agriculture (Guerrero, 1996). The national R&D priority species are milkfish, tilapia and shrimp. With respect to milkfish, the priority research areas are broodstock development and seed production, refinement of breeding and hatchery techniques, improvement of production, particularly polyculture systems with other species, and development of low-cost diets. In tilapia, the priority research areas are development of tilapia breeding and genetic improvement, culture of tilapia hybrids in brackish and marine waters, formulation of low-cost feed, and policy studies on the utilisation of lakes, rivers and reservoirs for aquaculture. In shrimp culture, the priority research areas are disease prevention and control, broodstock development, development of efficient and low-cost feeds, and environmental degradation.

Impact studies, and cost and production analysis constitute the socio-economic studies needed in the brackishwater aquaculture sector. In view of the increasing ecological concerns on the destructive conversion of the remaining mangrove resources, the Philippine government is pursuing the alternative of promoting intensification programmes to increase production within ecological limits (BFAR, 1993).

2.3.6. *Aquaculture issues and constraints in the Philippines*

In the recently concluded National Fisheries Workshop on Policy Planning and Industry Development held at Puerto Azul, Cavite, Philippines on February 6-9, 1996, the following issues were raised.

Seed supply and quality

The rapid development of aquaculture in the Philippines during the last decade has created shortages of seed supply for stocking aquaculture areas. The problem of seed supply is more pronounced in some important species like milkfish, tilapia, shrimp and grouper most particularly during the stocking periods from January to March and from November to December. The most affected is the milkfish industry such that the government has allowed short-term importation of milkfish fry from other Asian countries such as Taiwan and Indonesia. In the case of tilapia, the intensification of culture in fish cages has brought about the sudden demand of fingerlings. The shortage of milkfish fry has brought demand for tilapia hybrid fingerlings for stocking brackishwater ponds. The grouper industry, although only a new up-coming industry in the Philippines, is experiencing limited supply of fry and fingerlings because of the export demand for marketable live grouper. The supply of fry and fingerlings from the wild is not sufficient to meet the requirement for stocking. For shrimp and tilapia, the most important factor to consider is seed quality. In view of poor management, genetic deterioration of tilapia species has resulted in low yields (Guerrero, 1994). On the other hand, shrimp postlarvae are often contaminated with viral or bacterial disease (Cruz, 1994).

Widespread environmental damage

As reported by the Bureau of Agricultural Research (BAR) in 1995, one of the major issues and constraints identified for fisheries and aquaculture in the Philippines is the widespread ecological damage as a result of human pressure on the environment. Effluents from fish farms, pesticide and fertilisers from agricultural run-off, increased siltation of estuaries, oil spills, and destruction of mangroves are just some of the major causes of environmental damage. This constraint has undoubtedly resulted in pollution, disease and resource depletion as they are more or less interrelated. As the mangrove habitat and estuaries are important spawning and nursery grounds for fish and crustaceans, the degradation of these areas will affect the recruitment of stocks and result in depletion of coastal fisheries. The coastal and inland aquatic habitats are continuously under pressure throughout the world (Pollock, 1995). Therefore, the management of these areas should include efforts to conserve the aquatic habitats and if possible restore the degraded areas.

Credit and financing

A major problem of the aquaculture sector is credit and financing. The fish farmers claim that intensification or adoption of new technologies requires bigger capital investment. The improvement of farm facilities, equipment and feeds require major capitalisation. At present labour and material costs, a farmer needs between

100,000 to 200,000 Pesos to develop one hectare of fishpond (Rabanal, 1995). Therefore, it is almost impossible for the fish farmers to fully develop their ponds without financial assistance. At present there is credit available for aquaculture development, but there are only few takers due to stringent requirements and high interest rates. Most fish farmers lack the necessary equity or collateral normally required by the banking institutions. In 1994, total loans to fisheries reached 7.4 billion pesos with an average annual growth of 15% (ACPC. 1996). The trend from 1990 to 1993 is positive, at 2% average annual growth. However, actual lending always remained below the target.

Fisheries research and extension

Fisheries research in the Philippines is presently co-ordinated by two government agencies: the Philippine Council for Aquatic and Marine Research and Development (PCAMRD) of the Department of Science and Technology; and the Bureau of Agricultural Research (BAR) of the Department of Agriculture (Lacanilao, 1993). These two agencies share the responsibility for co-ordinating all research and development (R&D) on fisheries to prevent duplication of activities. In view of the budgetary limitations of the Philippine government, funding support for R&D programmes has always been inadequate (Juliano, 1990). A comparative analysis of the R&D expenditures of fisheries, agriculture and natural resources sub-sectors for the period 1992 to 1994 showed that the average expenditure for fisheries R&D was only 68.97 million Pesos, compared to 871.2 million Pesos for agriculture and natural resources over the same period (PCAMRD, 1995). There is therefore, an inequitable distribution of research funds in favour of agriculture and natural resources sub-sectors.

Studies conducted on the manpower resources for fisheries research revealed that there is enough available and qualified manpower to support the present R&D programmes of the government. In 1993, there was a total of 382 personnel involved in inland and aquaculture R&D. This included 25 PhD, 130 MSc and 215 BSc graduates (Guerrero, 1996). To enhance efficiency and productivity of research efforts, there is a need to strengthen the existing research facilities (e.g. experimental units, laboratories and equipment), the existing research co-ordination and monitoring system, and the transfer/dissemination of research results to the end-users.

Fisheries education system

There are about 66 schools, colleges and universities offering fisheries education in the Philippines (Santos *et al.*, 1991) and yet the fisheries industry suffers from lack of qualified manpower. The proliferation of fisheries schools has not contributed much to the manpower requirements of the industry. In fact, it resulted in the degradation of educational quality due to inadequate budgetary support, lack of qualified faculty personnel, and inadequate physical facilities, instructional equipment and libraries (Dieta, 1992). The proliferation of fisheries schools also created an over-supply of fisheries graduates that are inadequately trained (Juliano, 1987), therefore the fisheries industry has not been able to utilise their services. The industry has always complained that new graduates lack field exposure and the practical experience to deal with the problems of fisheries management.

It seems that the present practical element in the fisheries curriculum is inadequate to meet the practical skills needed by the fish farmers. There is therefore, an urgent need to review the present fisheries educational system and make it more relevant to the present issues and problems of the industry. In view of human concerns on the safety of the environment, the present fisheries curriculum should emphasise not only improvement of fish production but also conservation and management of fisheries resources.

Water quality and disease

Urbanisation of inland and coastal water resources has brought about the pollution of some aquatic areas and resulted in the outbreak of diseases in some parts of the country. The shrimp industry is heavily affected. In 1989, Philippine shrimp production collapsed mainly due to slow growth and high mortalities as a result of disease contamination of hatcheries and grow-outs by luminous vibriosis (*Vibrio* sp.) specifically known as the Luminescent Bacteria (Lavilla-Pitogo, *et al.*, 1996). In freshwater aquaculture, epizootic ulcerative syndrome (EUS) is considered the most economically devastating disease (ADB-NACA, 1991). In marine areas, the "red tide" which is caused by the proliferation of toxic dinoflagellates has caused widespread economic losses to the mussel and oyster farming industry since 1990. Therefore, the eminent threat of "red tide" has virtually stopped the growth and expansion of the shellfish industry.

Marketing and post-harvest practices

The local marketing system and practices for fishery products in the Philippines are still below the standard of more developed countries. There is no existing standard quality for fresh fish in the local market. Therefore, the situation does not create better pricing mechanism and product competitiveness. Dieta (1992) noted that one major constraint attributed to this was the lack of post-harvest and marketing facilities such as ice plants and cold storage. Although these facilities are available in cities and urban areas, normally they are not easily accessible in coastal and production sites. Generally, the fish harvests are not iced from the production sites, they are only iced upon reaching the auction market where ice is available.

Another factor which hinders the development of post-harvest and marketing is the limited infrastructure facilities such as roads, power supplies and communication lines. Limited access to these facilities makes aquaculture management and development very difficult.

2.3.7. *Potential areas for aquaculture development*

BFAR in 1987 reported that the improvement in aquaculture production could be attained by full utilisation of existing ponds. It was believed that proper management and utilisation of existing production areas would easily increase production by more than 100%.

In freshwater areas, new studies are necessary to expand fish cage operation to other lakes, rivers and reservoirs which have not been tapped for aquaculture production. In the brackishwater sector, potential areas for development are the 138,129 ha of undeveloped and unutilised fishponds, assuming that only 101,194 ha of shrimp/prawn and milkfish brackishwater fishponds were productive in 1993. Another potential location is the 41,493 ha swamp proposed for release by the Government to the private sector as of 1985. Lowland areas where there is salt intrusion, making these areas unsuitable for any agricultural crop production, can be also utilised for fishpond development. In the marine areas, protected coves, bays and estuaries are potential sites for the expansion of fish cage culture operation. Diversification of species has good prospects for catfish and prawn farming in freshwater areas and high value species such as grouper, snapper and siganids in brackishwater and protected marine waters (Rabanal, 1995). With the increasing export demand for crabs (Table 2.6), the culture of mudcrab in brackishwater ponds has high potential, most especially when the seed production technology becomes technically feasible and economically viable.

Brackishwater fish farming is primarily centred on milkfish. In recent years, this has diversified to prawn/shrimp cultures, and to a smaller extent, to grouper, seabass and mudcrab culture. However, the collapse of the prawn/shrimp industry in the late 1980s prompted some prawn/shrimp growers to revert to milkfish farming. Brackishwater ponds formerly utilised for prawn/shrimp production are much more physically developed and therefore, suitable for the adoption of improved and high yielding culture techniques.

Through regulated intensification and minimal expansion of the above areas, production can be easily increased by as much as 2 to 5 times of its current production levels (BFAR, 1987).

3. MILKFISH: OVERVIEW OF THE INDUSTRY, TECHNOLOGY DEVELOPMENT AND DEVELOPMENT STRATEGIES

3.1. Overview of the milkfish industry in the Philippines

3.1.1. *Background*

Milkfish (*Chanos chanos* Forskal) is locally called "Bangus". In the Philippines it is considered a national fish and is the most important finfish species cultured in brackishwater fishponds. The milkfish is a diadromous species which inhabit continental shelves and oceanic islands but migrates upstream to grow and returns to its natural habitat to spawn. It is the only species in the family Chanidae (Nelson, 1984), and can be found only in the tropical Indo-Pacific region from the east coast of Africa and Madagascar to California and from Southern Japan, Indonesia, Malaysia, New Guinea, New South Wales to New Zealand (Schuster, 1960) within the bearings 40^{o} E to 140^{o} W and 30 - 40^{o} N to 30 - 40^{o} S.

The major producers of milkfish are the Philippines and Indonesia (Table 3.1), while the minor producers are Thailand, Guam and Kiribati. In 1993, Cook Islands and Micronesia appeared on the list (FAO, 1995). In 1993, the Philippines contributed about 42% of the total world production of milkfish. In the Philippines, milkfish is the major aquaculture finfish species raised in ponds, pens and cages contributing about 18.3% (150,858 t) of the total national aquaculture production of 825,000 t and 58.13% (137,796 t) of the total national brackishwater pond production of 237,056 t in 1995 (BAS, 1996).

Milkfish is a highly preferred food fish in the Philippines due to its high quality flesh. The country's average per capita consumption of milkfish is 2.0 kg yr^{-1} representing about 5% of the total fish consumption of 40 kg yr^{-1} (BFAR 1996). The demand for milkfish annually is increasing as the population increases. Domestic supply can be easily met with the adoption of new and improved culture techniques, but the quality may have to be improved to expand the export market. The development of value-added products such as canned and boneless-smoked milkfish has diversified market outlets locally and abroad, but market promotion may have to be undertaken to improve the consumers' acceptance of these new products.

Table 3.1. World production (t) of milkfish in 1989-1993

Country	1989	1990	1991	1992	1993
Cook Islands	0	0	0	0	0
Guam	68	58	35	25	25
Indonesia	119,339	132,432	141,024	147,032	160,000
Kiribati	2	2F	2F	2F	1F
Micronesia	0	0	0	0	0
Other Asia	21,159	90,716	41,298	25,146	45,524
Philippines	192,896	210,882	234,123	171,116	148,965
Total	333,464	434,090	416,482	343,321	354,515

Source: Aquaculture Production Statistics: 1984-1993. FAO Fisheries Cir. No. 815, Rev. 7. FAO, 1995.
F = FAO Estimate from available sources of information
O= more than zero but less than half a metric ton

The milkfish fry which is a primary input requirement for aquaculture can now be produced under controlled condition (SEAFDEC-AQD, 1990). The present technology is to breed milkfish broodstock in marine net cages and hatch the eggs in land-based hatchery facilities. However, the present hatchery techniques need further refinement and improvement to reduce capital investment costs on broodstock development as well as to enhance the viability of the production technology. This process may be accelerated if the Government supports a collaborative undertaking with the private sector or the non-government organisations (NGOs).

The main players in the milkfish industry are the fishpond operators or producers, fish traders (wholesalers, retailers, exporters, importers), fry gatherers and suppliers, and the fish processors. The producers vary greatly from small-scale operators (less than 1 ha to 50 ha), through medium-scale operators (50 ha to 100 ha), to large-scale operators (100 ha to more than 1,000 ha). These groups are generally organised into associations, federations or co-operatives. To improve their production levels, the Government may have to encourage incentives such as tax reduction on land facilities and imported material inputs, and financial assistance in the form of capital or production loans.

3.1.2. *Production performance and trend*

Milkfish production mainly comes from farming of brackishwater fishponds. Other production areas are fish pens and fish cages in freshwater lakes and protected marine waters. In 1995, there were more than 239,000 ha of brackishwater ponds in the Philippines which were traditionally engaged in milkfish production. However, only about 68,448 ha were reported productive for milkfish culture (BAS, 1993). Most of these ponds are extensive and built manually by inexpensive labour. These ponds vary in size from 1 ha to 50 ha per compartment and production varies from 500 kg to 2,000 kg $ha^{-1}yr^{-1}$ depending on the level of technology being practised by the fish farmer.

The culture of milkfish in fish pens in freshwater lakes became popular during the early 1970s. However, it was only during the early 1990s where milkfish production in fish cages expanded to protected marine coves, bays and estuaries. Potential milkfish production from freshwater fish pen is between 5-10 t $ha^{-1}yr^{-1}$ while in marine fish cages it is between 30 and 60 t $ha^{-1}crop^{-1}$ cycle of four to five months depending on stocking rate. This production level is much higher than in ponds which can produce only between 0.5 and 3.0 t $ha^{-1}crop^{-1}$ cycle of five to six months (Sumagaysay *et al.*, 1990).

The total production of milkfish has fluctuated during the last five years, from a peak of 237,122 t in 1991, dropping to a low of 152,212 t in 1993 and then increasing to 158,357 t in 1995 (Table 3.2). The general trend, however, is a drop by an average annual rate of 8.8%. Decrease in production mainly comes from the aquaculture sector which is declining at an average rate of 9.6% annually.

The drop from the high in 1991 may be due to a shift from milkfish production to shrimp or other export species like grouper or mudcrab. It may also be due to the dwindling supply of milkfish fry experienced during the last decade as a result of illegal catching of spawner milkfish "Sabalos" or the destruction of spawning grounds due to increased dynamite and cyanide fishing activities.

Table 3.2. Philippine milkfish production (t) by sector, 1991-1995.

Year	Aquaculture	Municipal	Commercial	Total
1991	234,123	2,948	51	237,122
1992	171,116	3,394	19	174,529
1993	148,965	3,233	14	152,212
1994	157,025	5,135	12	162,173
1995	150,858	7,466	33	158,357

Source: Fishery Statistics, 1986-1995. Bureau of Agricultural Statistics, 1996.

3.1.3. *Milkfish price trend*

Milkfish commands a high price in the domestic market compared to other marine fishes. Prices of milkfish increased (Table 3.3), from 45.09 Pesos kg^{-1} wholesale price in 1991 to 58.19 Pesos kg^{-1} in 1995, or an average annual increase of 6.78%. A significant increase was observed in 1994 when the wholesale price increased by almost 18%. Consequently, the retail price also increased from 56.83 Pesos kg^{-1} in 1991 to 71.78 Pesos kg^{-1}in 1995, or an average annual increase of 6.10%. It can be assumed that the increasing price behaviour of milkfish during the last five years was due to inflation or simply a shift in demand in favour of milkfish.

On the other hand, the price margin is fluctuating, although the general trend is up, indicating that there is an increasing trend in the cost of the product. This may also be due to the increase in marketing cost as a result of inflation (e.g. increase in fuel and transportation costs). The average increase of wholesale price to retail price was about 23% between 1991 to 1995.

Table 3.3. Market price of milkfish in the Philippines, 1991-1995
(Price in Pesos kg^{-1})

Year	Wholesale price	Retail price	Price margin	% Increase in whole-sale to retail price
1991	45.09	56.83	11.74	26
1992	47.43	57.29	9.86	21
1993	47.53	59.57	12.04	25
1994	56.05	67.57	11.52	21
1995	58.19	71.78	13.59	23
Ave. Annual Increase				23.2%

Source: Fishery Statistics 1986-1995. Bureau of Agricultural Statistics, 1996.

There is also a seasonal variation in the prices of milkfish. Previous studies by BAS indicated that the price of milkfish was relatively high during the months of December to May and low in June to November (Dieta, 1992). This seasonal variation in prices of milkfish can be attributed to the seasonality of milkfish production which consequently dictate the interplay of supply and demand.

3.1.4. *Market outlets for milkfish: local and abroad*

At present, the markets for milkfish are established locally and abroad. Locally, milkfish are marketed in urban areas where there is greater demand and a higher market price. The biggest market is in Metro Manila where the population exceeds 6 million. Assuming that the per capita consumption of milkfish has increased from 2 to 3 kg yr^{-1} since 1987, and the population of the Philippines was 68.61 million in 1995, then the estimated domestic demand for fresh milkfish in 1995 was 205,830 t. Total milkfish production in 1995 was 158,357 t leaving a balance in demand of 47,473 t. It is safe to assume that the demand is even higher since other produce was marketed as processed products in the form of frozen fish, canned, dried, smoked and/or marinated forms.

The domestic demand is mostly in fresh form, although milkfish in canned, smoked and dried forms is becoming popular among housewives. Smaller size milkfish weighing less than 500 g are preferred on account of lower cost. Generally, the bigger the fish the higher the price per kilogram. This may be an added advantage to milkfish growers if they produce larger milkfish.

The Philippines also exports milkfish to other countries, although only in small amounts compared to total production. Exported milkfish are in the form of frozen, canned, smoked, dried and marinated products. Milkfish in the frozen form is exported to 30 countries; in the canned form to 23 countries; and in the dried or smoked forms to 17 countries. The USA is the leading export market for frozen, canned, dried or smoked milkfish while Saudi Arabia is the main destination for marinated milkfish. Recently, Guam has been added as a major export market. In 1990, milkfish export was about 868 t valued at 71.3 million Pesos. After 1990, the volume of exported milkfish declined and in 1994 the total export was only about 221 t valued at 15 million Pesos (Table 3.4). The decline in milkfish export after 1990 was possibly due to the reduced demand as a result of the inclusion of some low quality milkfish having poor organoleptic characteristics harvested from polluted lakes (DOST, 1994). This low quality milkfish either cannot be sold in the local market or is sold at a very low price. This has, however, damaged the credibility of the milkfish export market. To revive and expand this export potential, new product development on milkfish should be undertaken by the government and the private sector. The government should develop policies on quality standards and adopt strict rules and monitoring systems to avoid exportation of low quality fishery products in the future.

Table 3.4. Quantity and value of exported milkfish, 1990-1994.
(Quantity in kg and values in millions)

Type	1990	1991	1992	1993	1994
Quantity	67,718	451,320	637,462	653,615	220,886
FOB Value (US$)	2.547	1.079	1.825	1.799	0.600
FOB Value (Pesos)	71.33	29.49	49.28	48.58	15.00

Source: DOST, 1996.

3.1.5. *Production methods and practices*

Background

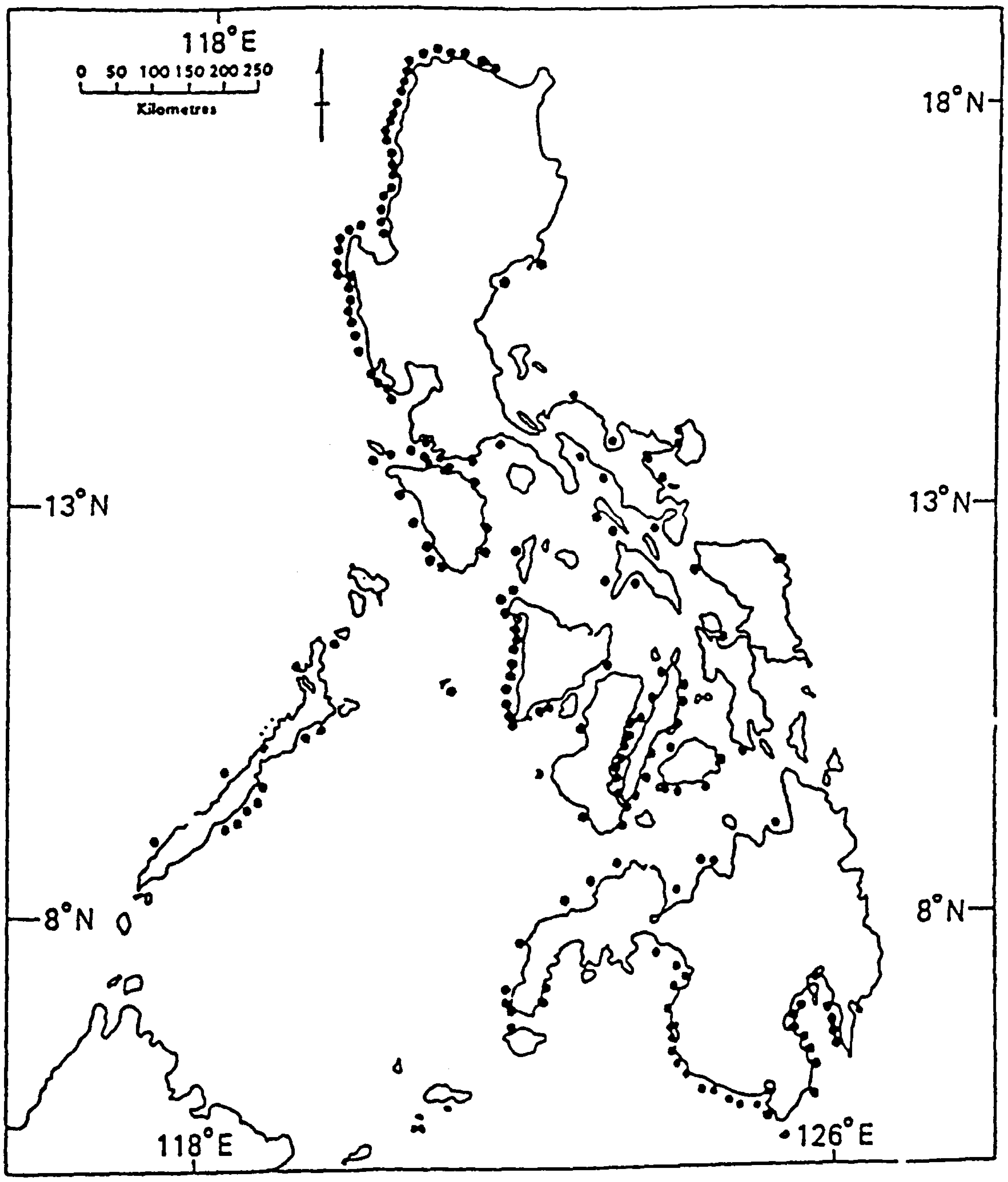
Milkfish are produced in three major phases, namely: fry collection or hatchery; the nursery; and the grow-out. Milkfish fry caught from the wild is still the main source of fish seed for stocking ponds, pens and cages. However, during the late 1980s restricted supply of milkfish fry was experienced by the industry which triggered a significant increase in fry cost (e.g. from 0.50-1.5 Pesos fry^{-1}). The breeding and hatchery techniques for milkfish have been developed by SEAFDEC-AQD since 1977, however, adoption of these techniques by private hatchery operators remains very slow due to the high capital cost required for broodstock development. Recently, the government has allowed short-term importation of milkfish fry from other Asian countries such as Taiwan and Indonesia.

Fry collection and hatchery phase

This phase includes the gathering of milkfish fry from natural waters. In the Philippines, milkfish fry are collected during the spawning period in coastal waters and bays which have sandy shorelines. The spawning periods appear almost the whole year round with the peak in the months of April, May and October. Most of the coastal areas of the country are potential sources of milkfish fry (Figure 3.1). There are no recent data available on the total number of fishermen engaged in the milkfish fry industry, although in 1982, milkfish fry gathering provided income to about 170,000 coastal fishermen (PCARRD, 1982).

At present, there are no available data on the total number of milkfish fry collected from the wild, although in 1981 over than one billion milkfish fry were

Figure 3.1. Milkfish fry grounds in Philippine waters
(Source: Smith, 1981)



reportedly caught in Philippine waters (Smith, 1981). This quantity may be adequate to meet the annual stocking requirements for extensive pond cultures. However, considering intensification of brackishwater ponds and expansion of production areas in marine waters, it is probably not enough to support milkfish aquaculture development. It is calculated that over than 3 billion milkfish fry are required to support an increase in milkfish production from the national average of 1.2 tons $ha^{-1}yr^{-1}$ to 2.4 tons $ha^{-1}yr^{-1}$. (PCAMRD, 1996). During the periods of fry scarcity, the inadequate supply causes the price of fry to increase making it more difficult for the small milkfish farmers to acquire their own fry requirement.

On the other hand, the present hatchery techniques developed by SEAFDEC-AQD involves two stages. The first stage is the breeding and collection of milkfish eggs from floating broodstock net cages in protected coves. The second stage is the hatching of the eggs and larval rearing in land-based hatcheries. The highest survival achieved so far in the hatchery is 24%, but the high cost of broodstock development (e.g. facilities, equipment, minimum of 5 years maturation period) makes the production technology financially non-viable in private hatchery operations. Research on broodstock development is underway to increase fry production and improve survival rate. The government has put priority on broodstock development to solve the problem of milkfish fry supply in the future.

In the 1990s, with the apparent decline in wild fry catch, other countries particularly Taiwan made considerable progress in the hatchery production of milkfish fry in commercial scale by breeding milkfish in deeper ponds. The system requires higher capital investments. Efforts are now being focused on adapting the breeding technique for the environmental conditions of the Philippines.

Fry nursery phase

The second phase is the stocking of milkfish fry in the nursery ponds or tanks and rearing them for 1.5-2 months to become fingerlings. The fingerlings, weighing about 0.10 - 0.50 g average body weight (ABW), are sold to milkfish growers, or the remaining fingerlings are stunted or kept in the transition pond for about six months to one year to provide a continuing supply of milkfish fingerlings for the grow-out phase for the year round operation.

This particular phase is a well-developed industry in northern Philippines where most of the small-time (e.g. 1.0 ha-5.0 ha farm) milkfish growers as well as fish pen and fish cage operators are dependant for their source of fingerlings. On the other hand, big time (e.g. with more than 50 ha milkfish farms) fish farmers, particularly in Luzon and Panay islands, normally maintain their own nursery and transition ponds to ensure ready supply of seed stock for a year-round grow-out operation.

Grow-out phase

The grow-out phase is the rearing of fingerlings to marketable size milkfish. The grow-out period is 4-5 months depending on the target size at harvest and the management technique employed by the fish farmer. Normally, if conditions are good, milkfish will grow between 200-350 g in the four-month culture period. The culture practice is generally a traditional extensive system based on growing natural foods such as lab-lab, plankton and algae in the pond before stocking with fingerlings at a rate of from 2000-3000 ha^{-1} (Chiu *et al.*, 1988). Organic and inorganic fertilisers are applied during pond preparation to hasten the production of natural foods. However, production from this farming technique is low, from 500 - 1,500 kg $ha^{-1}yr^{-1}$. A new and improved technique is the high density culture using artificial feed supplement to sustain the growth of milkfish up to harvest. Production from this technique is greater than 3 t $ha^{-1}yr^{-1}$ (Sumagaysay *et al.*, 1990).

The technology for the milkfish production in the Philippines is well-established and has been in practice for a long time. However, the shift from traditional farming to improved techniques is very slow mainly due to the lack of information and investment capital by the fish farmers. There is therefore a need to strengthen dissemination of new technologies and improve fisheries credit schemes.

3.1.6. *Issues and constraints in the milkfish industry in the Philippines*

Seed supply

At present, milkfish fry caught from the wild is not sufficient to provide for the needs of the milkfish farming industry. Developments in the growing or culture techniques being practised by the fish farmers have brought demand for more milkfish fry. The expansion of milkfish production areas to open waters using fish cages has increased tremendously the demand for fry and fingerlings for stocking. To alleviate the current problem, the government has allowed the short term importation of fry from neighbouring Asian countries, particularly Taiwan & Indonesia. The government, however, has put priority on broodstock development and refinement of hatchery techniques. Continuing studies are being conducted at SEAFDEC-AQD to solve the problem of fry scarcity.

Research and technology transfer

New research results on improved production technologies must be verified in commercial systems to determine a more realistic economic return on investment. Generally, the technology currently used by the fish farmers is traditionally extensive based on many years of experience. Many fish farmers are not receptive to the new and improved production technologies mainly due to the lack of appropriate information and production capital. With the promulgation of the new Local Government Code, the transfer of extension function to the local government units would further delay the dissemination of R&D results to the end-users since they are not yet well equipped and ready to undertake such responsibility. Therefore, there is a need to strengthen the capability of the local government technicians through intensified technology demonstration and training on new and improved milkfish production technologies.

Credit and financing

There are credit and financing available for milkfish production, however, there are few qualifiers. Most milkfish growers are not qualified to avail of the loan because they lack the necessary equity or collateral set by the bank. Although, these fish farmers have government land titles (Fishpond Lease Agreement or FLA holders good for 25 years but renewable for another 25 years) for their farms, the FLAs are not accepted by the banking institution as collateral.

Marketing

In recent years, the market price of milkfish significantly increased making artificial feeding methods financially feasible. However, the absence of market quality standards on fishery products has not led to the development of a competitive pricing mechanism for good product quality. These conditions are not conducive to the development of the milkfish industry. Although at present the trend in market price of milkfish is positive, the seasonal variation which dictates the supply and demand is a potential risk for milkfish growers. There is therefore a need to develop the markets for milkfish locally and abroad. The development of value-added products for milkfish will diversify market outlets. There is also a need to improve product quality and packaging to improve and expand the export markets. Studies must be undertaken to determine the economics of producing larger milkfish (more than 500 g body weight) so that the fish farmers can demand a higher price for their products.

3.2. Milkfish technology development

3.2.1. *Background*

While continuing efforts are being undertaken by various fisheries agencies and research institutions (e.g. SEAFDEC-AQD, DA-BFAR, DOST-PCAMRD) to solve the problem of milkfish fry supply in the country, the government will have to pursue short-term importation of milkfish fry from other Asian countries to sustain milkfish growth and development within the year 2000.

In support of the Medium Term Fisheries Management and Development Programme which is being implemented by the National Government between 1993-1998, the Bureau of Fisheries and Aquatic Resources through its National Brackishwater Aquaculture Technology Research Centre (NBATRC) in Pagbilao, Quezon has implemented studies on the improvement of milkfish culture technologies. The primary objectives are to double the production of existing milkfish brackishwater fishponds within ecological limits and to expand milkfish production to protected marine coves and bays. Two studies were conducted, one on semi-intensive farming in brackishwater fishponds and the other on net cage culture in sheltered marine waters.

3.2.2. *Semi-intensive milkfish farming in brackishwater fishpond*

Introduction

There is a need to increase milkfish production to sustain the declining growth of the industry and meet the demand of the growing population. Since the fish stocks in marine waters are threatened with over-exploitation, the most logical approach is to increase production of the existing brackishwater fishponds. The development and adoption of a semi-intensive and environmental friendly culture technology for milkfish will greatly enhance the production of brackishwater fishponds, thereby reducing the volume of fish imports.

The conventional milkfish farming techniques employed by fish farmers in the Philippines allow the use of organic and inorganic fertilisers to grow the natural food such as algae, lab-lab and plankton in the pond. This condition, however, limits the stocking rate to between 2000 and 3000 fish ha^{-1} (Sumagaysay *et al.*, 1990) although it may be up to 4000 ha^{-1} (Otubusin and Lim, 1985) during the dry season between February and June, thus, the production is low (1200 kg $ha^{-1}yr^{-1}$ national average).

Since the early 1980s, various farming techniques have been developed in an effort to increase yields. In the past decade, many studies were made to develop a semi-intensive pond culture technology for milkfish. During these studies it was shown that milkfish yields in brackishwater ponds could be increased through increased stocking rates and supplementary feeding (Sumagaysay, 1989 and Pascual *et al.*, 1991). Yet until recently, many farmers were hesitant to adopt the technology due to the high cost of feeding and the lack of an appropriate technology that would guarantee them a better return on their investment.

The aim of this study was to evaluate the technical and the economic considerations underlying the semi-intensive culture technology developed for milkfish in brackishwater fishponds. In line with the existing government policy to encourage only adoption of environmental friendly technologies, the study was limited to stocking rates lower than 10000 fish ha^{-1} which does not require environmental support mechanisms in the culture system (e.g. aerators). This stocking density limit was established in previous studies conducted during the 1980s (Chiu *et al.*, 1988;

Sumagaysay *et al.*, 1990). The general principle was to combine natural food with supplementary feeding to minimise utilisation of artificial fish pellets during the culture period thereby, reducing food wastage and the effects of pollution. Specifically, the studies were intended to verify the effects of stocking rates, feeding rates and seasonal variations on the growth, survival, production, and feed conversion factor (FCR) of milkfish and the economics of production under present conditions. Ultimately, the informations would be disseminated to interested clientele.

Materials and method

Study 1: Effects of stocking rates

In the first study, three 1,000 m^2 earthen ponds were used. To enable replicates to be made, the ponds were divided into three parts of 250 m^2 each using a polyethylene nylon net. The experiment was conducted in a randomized complete block design (RCBD). The ponds were cleaned of debris, sun-dried, fertilized and grown with algae and then stocked with half-grown milkfish averaging 200 g in weight at three different stocking rates: 2000 fish ha^{-1}, 4000 fish ha^{-1} and 8000 fish ha^{-1} respectively. The fish were given fish finisher pellets (24% crude protein content) equivalent to 3% of the fish total body weight about 3 weeks after stocking when the natural food in the ponds was depleted. The proximate composition of the feed is given in Table 3.5. The feed was given three times daily at 08.00 h, 12.00 h and 17.00 h respectively. The physico-chemical parameters of the rearing water such as salinity (S‰), temperature (^{0}C), water depth (cm) and turbidity (cm) were recorded daily between 07.00 h and 08.00 h in the morning and 17.00 h and 18.00 h in the afternoon. Water exchange was accomplished every two weeks when spring tides occur. An electric water pump was used to maintain water depth between 80-100 cm daily when tidal fluctuation was not possible. Approximately 10% of the experimental fish (e.g. 5, 10, 20 fish for Treatments I, II, and III respectively) was sampled every 15-day interval by weighing the fish individually using a portable balance to adjust feeding rate. The fish samples were collected at random using a cast net. The fish were harvested after 60 days. All production data were analysed using Stat Graphics multiple range analysis of variance.

Table 3.5. Proximate composition of supplementary fish pellet

Composition	Grower	Finisher
Crude protein	>28%	>24%
Crude fat	> 4%	> 4%
Ash	<10%	<10%
Moisture content	<12%	<12%

Note: > - Not Less Than   < - Not More Than

<u>Study 2</u>: Effects of feeding rates

In the second study, experimental ponds used were the same as with the first study. Ponds were prepared using the standard procedure and grown with algae. The ponds were then stocked with fish averaging 300 g in weight at a rate of 8000 fish ha^{-1} which gave the best production result from study one. The fish were fed with finisher pellets at different feeding rates equivalent to 2%, 3% and 4% of their average body weight (ABW) daily at 08.00 h, 12.00 h and 17.00 h from 2 weeks after stocking when the natural food in the ponds was depleted. The fish were sampled every 15 days to estimate total biomass and the feeding rate was adjusted accordingly. Other conditions were the same as with the first study. The experimental fish were harvested after 60 days. All production data were analysed using Stat Graphics statistical program.

Study 3: Effects of seasonal variation and economics

In view of the encouraging results from the previous studies, a third study was conducted to further verify the technology in a larger pond of commercial size. The aim of the study was to determine the effects of seasonal variation on the growth, production and FCR of milkfish and the economics of culture under present conditions. Due to limited fingerling supply of the same size and age, and the unavailability of another pond of the same dimensions, the third study was not replicated. The experiment was conducted for 90 days to compensate for smaller sized fingerlings used (15-20 g body weight). The first trial run was conducted during the wet season from mid June to September and the second trial run during the dry season from early March to June.

In this study, milkfish fingerlings weighing about 0.30 g and 2.71 cm long were purchased from a commercial fish nursery operator and stocked in a nursery pond at a rate of 3-5 fish m^2 and grown to about 15 to 20 g body weight. While the fingerlings were reared, the experimental earthen pond was prepared and grown with algae for at least 30 days. To induce the growth of algae, the pond was first dried and then applied with 500 kg ha^{-1} lime, 2 tons ha^{-1} chicken manure, 50 kg ha^{-1} urea fertiliser and 100 kg ha^{-1} ammonium phosphate. After filling, the pond was seeded with cultured algae cells at every metre of bankside. To maintain the growth of algae, fertiliser dressing (urea mixed with superphosphate at a ratio of 1:1) was applied weekly at a rate of 12.5 kg ha^{-1} after fish stocking. Fertiliser dressing was discontinued 30 days before harvest.

Post fingerling-sized milkfish (15-20 g) from the nursery pond were collected and stocked in the 0.70 ha experimental grow-out pond at a rate of 9000 ha^{-1}. The fish were fed with supplementary grower fish pellets having 28% crude protein content (Table 3.5) during the second month of culture when the natural food was almost depleted and then fish finisher pellet in the third and last month of culture. Feed was given three times a day (08.00 h, 12.00 h and 17.00 h) using scaled down rates of 4% and 3% of the fish average body weight in the second and third months of culture respectively. About 50 fish were sampled every 15 days to adjust feeding rate. Physico-chemical parameters such as salinity, temperature, water depth and turbidity were monitored daily. Water exchange was accomplished during spring tides that occurred every 2 weeks. An electric water pump was used to maintain water depth between 80-100 cm throughout the culture period. The fish were harvested after 90 days of culture.

Results

Study 1: Effects of stocking rates

The effects of different stocking rates on the growth, survival, yield and FCR of half-grown milkfish is shown in Table 3.6. The average initial weight of milkfish during stocking was 200 g. After 60 days of culture, the final mean weights of milkfish were 341.5 g, 384.7 g and 336.4 g in treatments I, II and III respectively. The average survival rates were 100%, 99% and 97.5% for treatments 1, 2 and 3 respectively. There were no significant differences noted among treatments with respect to growth (P=0.2071) and survival (P=0.2677) rates. However, there was a significant effect on the yield (P=0.0005) between treatments. Treatment III which had the highest stocking rate (8000 ha^{-1}) recorded a mean yield of 1,064 kg ha^{-1} while treatment II (4000 ha^{-1}) and treatment I (2000 ha^{-1}) had mean yield of 731.41 kg ha^{-1} and 283 kg ha^{-1} respectively. The FCR values varied from 1.55 to 2.17 indicating an upward trend with increasing stocking rate. However, the values were not significant (P>0.05).

Table 3.6. Effects of different stocking rates on growth, survival, mean yield and FCR of half-grown milkfish

Treatment (Stocking rate)	Growth rate ($g\ day^{-1}$)	Survival rate (%)	Mean yield ($kg\ ha^{-1}$)	FCR
I (2000 ha^{-1})	2.36	100	283.0	1.83
II (4000 ha^{-1})	3.08	99	731.4	1.55
III (8000 ha^{-1})	2.28	97.5	1,064.0	2.17

The effects of increasing stocking rates and supplementary feeding on the financial return of milkfish production in brackishwater ponds is shown in Table 3.7. The method of partial budgeting (Jolly and Clonts, 1993) was adapted in the preliminary analysis to look at the change in profitability as a result of intensification (e.g. increase in stocking rate, artificial feeding). The result showed that the profitability increased with increasing stocking rates provided the fish are fed enough food to sustain their growth. The change in profit in increasing stocking rate was highest in treatment II (22,893 Pesos) which had the lowest FCR value (1.55). The profit was mainly influenced by the feed cost. The result also indicated that supplementary feeding (3% BW) of half-grown milkfish (200 g body weight) to increase production per unit area is a feasible option.

Study 2: Effects of feeding rates

In study 2, the highest production output observed in study 1 (8000 ha^{-1}) was selected to further verify the results. The average initial weight of milkfish used was 300 g. After 60 days of culture, mean weight gains of milkfish were recorded at 106.53 g, 105.70 g and 100.30 g in treatments I (2% feeding), II (3%) and III (4%)

respectively (Table 3.8). However, the growth of milkfish between treatments were not statistically significant (P=0.9517). In terms of mean yield, treatment 1 (737.19 kg ha^{-1}) was no better than treatment 2 (744.13 kg ha^{-1}), which was no better than treatment 3 (744.66 kg ha^{-1}). Treatments 1 and 3 were also not statistically different. The result indicated the feeding bigger milkfish (>300 g) increased FCR values.

Table 3.7. Partial budget analysis of milkfish production stocked at different rates in brackishwater ponds

Treatment	I	II	III
Revenue			
Stocking rate (Fish ha^{-1})	2,000	4,000	8,000
Mean yield (kg ha)	283	731	1,064
Selling price (Pesos kg^{-1})	60	60	60
Gross sale (Pesos)	16,980	43,860	63,840
Production costs (Pesos)			
FCR	1.83	1.55	2.17
Feed quantity (kg)	518	1,133	2,309
Feed price (Pesos kg^{-1})	12	12	12
Total feed cost (Pesos)	6,216	13,597	27,708
Fingerlings (P2.00 $fish^{-1}$)	4,000	8,000	16,000
Interest on operating loan (6% $crop^{-1}$)	613	1,296	2,622
Total	10,829	22,413	46,330
Profit (Pesos)	6,151	22,893	17,510

The effect of increasing feeding rates on the financial return of milkfish production in brackishwater fishponds is shown in Table 3.9. The result indicated that profitability decreased with increasing feeding rates. Partial budget analysis showed that feeding adult milkfish (300 g above) higher than 3% of their total body weight is not financially profitable under present economic conditions.

Table 3.8. Effects of different feeding rates on mean weight gain, survival, mean yield and FCR of adult milkfish stocked at 8000 ha^{-1}

Treatment	Mean weight gain (g)	Survival rate (%)	Mean yield (kg ha^{-1})	FCR
I (2%)	106.53	86.5	737.19	2.39
II (3%)	105.70	88.0	744.13	3.54
III (4%)	100.30	92.8	744.63	4.67

Figures in parenthesis are feeding rates in % of total fish body weight

Table 3.9. Partial budget analysis of milkfish production fed at different rates in brackishwater ponds

Feeding rate (% BW))	2	3	4
Revenue			
Mean yield (kg ha^{-1})	737.19	744.13	744.63
Selling price (Pesos kg^{-1})	60	60	60
Gross sale (Pesos)	44,231	44,648	44,678
Production costs (Pesos)*			
FCR	2.39	3.54	4.67
Feed quantity (kg)	1,762	2,634	3,477
Feed price (Pesos kg^{-1})	12	12	12
Total feed cost (Pesos)	21,144	31,608	41,729
Interest on operating loan (6% $crop^{-1}$)	1,269	1,897	2,504
Total	22,413	33,505	44,233
Profit (Pesos)	21,818	11,143	445

Study 3.

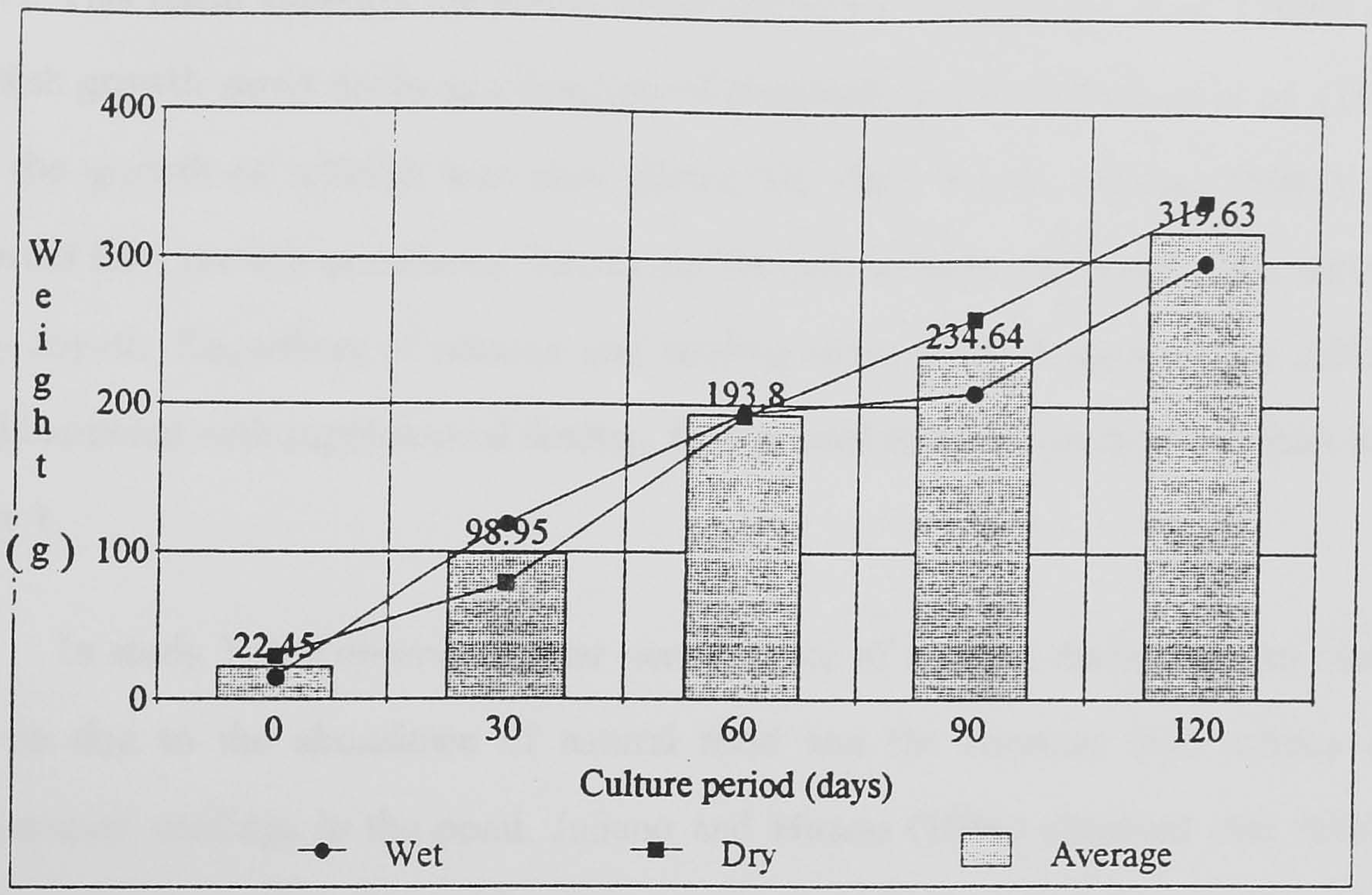
The third study demonstrated a marked increase in milkfish production when stocked at a higher rate of 9000 ha^{-1} provided the fish were given supplementary feed. The study revealed the existence of differences in growth, production and feed conversion ratio (FCR) when milkfish were reared semi-intensively under different seasonal variations (e.g. wet and dry). Milkfish showed better performance during the dry season in terms of growth, production and FCR (Table 3.10). Survival rates between treatments I (wet) and II (dry) were 93.2% and 82.6% respectively. The higher mortality rates observed were mainly due to stock sampling and handling stress. However, the survival rates were not statistically significant.

Table 3.10. Growth, survival, production and FCR of milkfish stocked at 9000 ha^{-1}

Treatment (Season)	Growth rate (g day^{-1})	Survival Rate (%)	Production (kg ha^{-1})	FCR Value
I - Wet	2.14	93.20	1,652	2.07
II - Dry	2.38	82.59	1,773	1.74
Average	**2.26**	**87.90**	**1,712.5**	**1.90**

Milkfish growth rates were 2.14 g day^{-1} during the wet season (June-September) and 2.38 g day^{-1} during the dry season (March-June). On the other hand, production greatly increased when stocked at a higher rate. The pond stocked at 9000 ha^{-1} yielded an average of 1652 kg ha^{-1} during the wet season and 1773 kg ha^{-1} during the dry season. The final weights of the fish averaged 209.3 g and 259.97 g during the wet and dry seasons respectively. The weight increase of milkfish stocked at 9000 ha^{-1} is shown in Figure 3.2. The FCR value during the dry season appeared lower (1.74) than the wet season (2.07).

Figure 3.2. Weight increase of milkfish stocked at 9000 ha^{-1} in brackishwater fishponds



Discussion

In study 1, it was shown that supplementary feeding was able to sustain fish growth up to 8000 ha^{-1} stocking rate without affecting survival rate. This rate (8000 ha^{-1}) significantly increased fish yield. Salinity and temperature were recorded at normal ranges, 28-33 ppt and 30-33°C respectively. Dissolve oxygen (DO) appeared not to be limiting during the culture period, thus resulting in very high survival rates (97.5-100%). Maintaining water depth between 80-100 cm was found sufficient to support favourable growth of the fish

On the other hand, study 2 failed to recognise any effects of increasing feeding rates on the growth, survival and yield of adult milkfish. This may be due to study 2 being conducted during the rainy season (August-September). Erratic fluctuation of water salinity (20-29 ppt) and temperature (25-33°C) caused by rainfall during this period may have influenced any effect of increased feeding rates. Abrupt changes in salinity may have caused stress and slowed down the growth of the fish (Pascual, 1991). This result supports the earlier observations by Sumagaysay *et al.* (1990) that milkfish growth slows down as a function of temperature and by Pascual *et al.* (1991) that the growth of milkfish was slow during the rainy season. Benitez (1984) also reported slow growth of cultured fish during the cold months which coincides with the rainy season. Regardless of seasons and feeding rates, study 2 showed that milkfish yield increased with supplemental feeding. It also confirmed the production result from study 1.

In study 3, the observed better performance of milkfish during the dry season can be due to the abundance of natural food and the constant high salinity and temperature readings in the pond. Juliano and Hirano (1986) observed that milkfish grows optimally during the month of May when temperature is relatively high, and the growth of natural food is luxuriant. This may explain why the average growth rate of milkfish during study 1 (May-July) was slightly higher (2.27 g day^{-1}) than in study 2 (1.74 g day^{-1}) (August-September), although the difference was not significant ($P>0.05$).

Moreover, the growth data from study 3 (2.14-2.38 g day^{-1}) support observations in studies 1 (2.27 g day^{-1}) and 2 (1.74 g day^{-1}). Pascual *et al.* (1991) reported a higher growth rate of 2.98 g day^{-1} using milkfish fingerlings with average body weight between 6.2 g and 10.2 g. However, the stocking rate used was much lower (4500 fish ha^{-1}). Sumagaysay *et al.* (1990) also observed a growth rate of 1.39-1.54 g day^{-1} at stocking rates of 6000 to 9000 ha^{-1}. However, the initial mean weight of fish used was much smaller (2 g). In this study, milkfish post-fingerlings averaging 15.5 g and 19.7 g in body weight were used and the average growth rate was 2.26 g day^{-1}. It appears that the initial mean weight and size of the fish at stocking also influence growth rate.

The results in study 3 suggest that supplementary feeding was able to sustain the growth of milkfish at a high stocking rate of 9000 ha^{-1}. These production data are however, higher than those reported by Sumagaysay *et al.* (1990) where ponds stocked at 9000 ha^{-1} (2 g ABW) yielded only 1042 kg ha^{-1} and the final mean fish weight was between 125 g and 143 g.

The higher production result from study 3 may indicate that feed efficiency is better during the dry season due to favourable climatic conditions (e.g. salinity, temperature). It may be that natural food in the pond aside from artificial feeds made a valuable contribution to the fish growth. Estilo and Chiu (1988) observed that the availability of natural food also affects the efficiency of feed utilisation. However, Pascual *et al.* (1991) reported an FCR of 2.1 at a stocking rate of 4500 ha^{-1}. It appears that the initial weight and size of fish at stocking as well as the quantity of natural food in the pond during the culture period influence FCR values.

Partial budget analysis of the production inputs versus outputs revealed that semi-intensive milkfish farming technology is more profitable when conducted during the dry season when the climatic conditions are more favourable for the growth of the cultured fish (Table 3.11). The study showed that milkfish production was higher during the dry season as a result of higher growth rate and final mean fish weight gain. The dry season also favoured the growth of natural food and the cultured fish in the pond. This condition increased the apparent efficiency of feed pellets which brought down the FCR value and feed consumption. Also bigger sized milkfish produced during the dry season can command higher price in the market. The data also show that the technology is profitable under present conditions regardless of season. The profitability of the technology however, was dependent on the market price of milkfish at harvest.

Table 3.11. Partial budget analysis of milkfish production at different seasonal variation

Variable	Wet season	Dry season
Production output (ha crop^{-1})		
Yield (kg)	1,652	1,773
Selling price (Pesos kg)*	57	60
Gross sale (Pesos)	94,164	106,380
Direct operating cost (Pesos crop^{-1})		
Fingerlings (2.00 Pesos fish^{-1})	18,000	18,000
Feeds (12.00 Pesos kg^{-1})	41,040	37,020
Fertilisers	2,525	2,805
Lime (2.00 Pesos kg^{-1})	1,000	1,000
Labour cost	5,175	5,175
Miscellaneous cost	5,701	5,514
Interest on operating loan (6% crop^{-1})	4,406	4,171
Total	77,847	73,685
Profit	16,317	32,695

For the purpose of looking at the financial feasibility of operating a one hectare semi-intensive milkfish farming project under present economic conditions, a cost and return analysis is shown in Table 3.12. The analysis showed that the semi-intensive milkfish farming technology is financially viable. The internal rate of return (IRR) is 49.98%, while the benefit-cost ratios (B/C) are higher than one, indicating that the technology is profitable under present economic conditions. The prevailing price at harvest is the most important factor which influences the profitability of production. The break-even cost to produce 1 kg of milkfish is 54.90 Pesos which means that the fish farmer will earn 11.10 Pesos for every kg of milkfish produced. Break-even production to pay total cost is 1,424 kg which means that production lower than 1,424 kg ha^{-1} $crop^{-1}$ is not financially feasible.

Table 3.12. Cost and return analysis for operating a one hectare semi-intensive milkfish farming project at a stocking rate of 9000 ha^{-1}

Capital cost of rehabilitation (Pesos ha^{-1})	
Pond improvement and repair	50,000
Equipment cost (pump)	50,000
Miscellaneous expenses	20,000
Total	120,000
Depreciation cost (3 crops yr^{-1} x 10 yr)	2,500 $crop^{-1}$
Production output (ha $crop^{-1}$)	
Yield (kg)	1,712
Selling price (Pesos kg)[a]	66
Gross sale (Pesos)	112,992
Operating cost (Pesos $crop^{-1}$)	
Fingerlings (2.00 Pesos $fish^{-1}$)	18,000
Feeds (12.00 Pesos kg^{-1})	39,034
Fertilisers	2,665
Lime (2.00 Pesos kg^{-1})	1,000
Labour cost	6,750
Miscellaneous cost (10% of cost)	6,745
Total operating cost	74,194
Marketing cost (5% of sale)	5,650
Direct cost	79,844
Interest on total capital[b] (6% $crop^{-1}$)	11,652
Depreciation cost ($crop^{-1}$)	2,500
Total costs	93,996
Profit (Pesos ha^{-1} $crop^{-1}$)	18,996
Break-even cost kg^{-1} of milkfish produced (Pesos)[c]	54.90
Break-even price to cover operating cost (Pesos)[c]	43.34
Break-even production to pay total costs (kg)[c]	1,424
Internal rate of return (IRR)[d]	49.98%
Benefit-cost ratio (B/C)[d]	1.42
B/C + Capital[d]	1.22

* Selling price was calculated from an average annual increase of 6.78% between 1991 and 1995
[b] Total working capital = capital cost of rehabilitation + first crop operating cost = P194,194
[c] Adapted from Jolly and Clonts, 1993.
[d] Calculated at 3 crops yr^{-1} for 10 yr discounted at 15%

3.2.3. *Cage culture of milkfish in marine waters*

Introduction

The Philippines has vast coastal area of 26,600,000 ha. This area is some 32 times bigger than the inland water resources of only 842,247 ha. Since aquaculture production from inland water resources is limited to the environment's capacity, it will soon be closed for further development. Expansion of production sites will focus on open marine waters which are abundant. Therefore, there is a need to develop a new fish farming system for adoption in sheltered marine coves and bays to meet the growing demand of the industry.

A brief review of previous work on milkfish cage culture showed that there is little information available (BFAR, 1996). Except for some technological information on production in freshwater fish pens (Juliano, 1996), there is no reported study conducted in marine waters. However, in the 1990s, the culture of milkfish in marine waters gained popularity in northern Philippines, particularly in Lingayen Gulf, due to the success of some fish farmers who tried the new system. The stocking rate varied from 20000 fish ha^{-1} to 50000 fish ha^{-1} with a potential production between 4-7 t ha^{-1} $crop^{-1}$. Recently, a fish farmer entrepreneur stocked his 1,000 m^2 fish cage with 30,000 milkfish fingerlings (5-8 g body weight) and reported a good harvest (Ramos, 1995. pers. comm.).

Milkfish culture in freshwater fish pens started in the late 1960s. It was located in Laguna de Bay by the Philippine Fisheries Commission in 1965 (Mane, 1980). In the 1970s, milkfish culture in fish pens became popular after the Laguna Lake Development Authority (LLDA) successfully demonstrated the commercial feasibility of the method. During the 1970s, milkfish production from fish pens was high due to the high stocking rates used of up to 60000 fish ha^{-1}. The fish grew fast although they subsisted only on abundant natural food in the lake and no supplementary feeding was given. Production was not less than 10 t ha^{-1} yr^{-1} (Felix, 1973). Compared to brackishwater fishpond, natural food produced through fertilisation can normally support a stocking rate of only 2500 - 3000 kg ha^{-1} (Sumagaysay, 1989).

However, during the 1980s milkfish production in fish pens decreased as a result of over exploitation and proliferation of fish pens in the lake. Stocking rates of milkfish dwindled to as low as 10000 fish ha^{-1} due to water pollution.

The primary aim of this study was to develop a fish cage culture technology for milkfish adaptable to sheltered marine waters. Specifically, the study dealt with the effects of stocking rate on the growth and survival of milkfish when stocked in marine fish cage. The data were also analysed to determine the financial economics of the production technology.

Materials and methods

The experimental site used in this study was evaluated and selected based on the suitability of the area for milkfish production. It was located in Tayabas Bay, Polo, Pagbilao, Quezon, Philippines about 160 km south of Manila. Specifically, the site was located inside a cove just beside two small islets, such that it was sheltered from strong winds and wave action. The water depth was at least one metre during the lowest tide levels. The site was free from run-off and pollution.

Fifteen (15) plastic net cages measuring 1 m x 1 m x 1 m each were suspended in floating bamboo rafts and installed 1.5 m apart. The net cages had 8 mm mesh size and were installed in rows of five. The whole experimental unit was anchored into bamboo posts which were fixed to the seabed but were free to move up and down with the tidal fluctuations. The net cages were closed at the top with the same netting material to prevent the escape of experimental animals.

The experiment consisted of five treatments replicated three times in a randomised complete block (RCB) design. The treatments were as follows:

Treatment		Stocking rate		Replicate
I	-	$15/m^3$	-	3
II	-	$30/m^3$	-	3
III	-	$50/m^3$	-	3
IV	-	$75/m^3$	-	3
V	-	$100/m^3$	-	3

Thirty to forty five-(30-45) day old milkfish fry weighing 0.10-0.30 g body weight were purchased from fish nursery operators and transported to the project site in oxygenated plastic bags. Upon arrival, the fingerlings were acclimatised to site water salinity and temperature and then stocked in a pre-prepared nursery cage measuring 10 m x 10 m x 4 m. The fingerlings were allowed to grow in the nursery cage for 30 days until they reached 3-5 g body weight. The fish were trained to feed on artificial starter mash by feeding them to satiation six times daily 08.00, 09.00, 11.00, 13.00, 15.00, and 17.00 h, respectively.

After 30 days in the nursery cage, the surviving fingerlings were sorted and transferred into the experimental net cages based on their assigned stocking rates. Only fingerlings of the same size and weight were selected for experimentation. The experimental animals were observed daily for a week after stocking. Any fish which had died as a result of stocking and handling stress were replaced. Fish that died after one week from stocking were considered as normal mortalities.

The experimental fish were fed to satiation daily with artificial feed after a day from stocking up to harvest. Feeding frequency was five times daily at 06.00, 09.00, 12.00, 15.00, and 18.00 h, respectively. During the first month, the fish were fed with starter crumble, in the second month grower pellet and in the third month finisher pellet. The proximate chemical analysis of the feeds is given in Table 3.13. To avoid unnecessary feeding and wastage, food was given manually in small amounts until such time the fish became sluggish and stop feeding. Feeding was deferred during heavy rainfalls or stormy weather conditions.

Table 3.13. Proximate composition of artificial fish feed.

Composition	Starter crumble	Grower pellet	Finisher pellet
Crude protein	>30%	>28%	>24%
Crude fat	>10%	> 4%	> 4%
Crude fibre	> 7%	> 8%	> 8%
Ash	<14%	<10%	<10%
Moisture content	<12%	<12%	<12%

Note: > - Not Less Than   < - Not More Than

At least 10% of the stock was sampled every 15 days up to 90 days after stocking to assess the growth of experimental animals. The fish were weighed individually using a portable balance. Physico-chemical parameters such as salinity, temperature and water transparency were monitored twice daily between 08.00-09.00 h and 17.00-18.00 h, respectively. Production data were calculated based on actual harvest results. Variables such as growth, survival and production were analysed using Stat Graphics multiple range analysis of variance and SPSS Windows LSD test for significance.

Results

The effects of stocking rate on the culture of milkfish in marine net cages are shown in Table 3.14. The mean weight gain and growth rate between treatments were not significantly different (*P*=0.7908). The mean weight gains were 162.08 g (T_1), 158.57 g (T_2), 158.45 g (T_3), 166.33 g (T_4) and 153.05 g (T_5), respectively. The average growth rates were 1.80 g (T_1), 1.76 g (T_2), 1.76 g (T_3), 1.85 g (T_4) and 1.70 g (T_5), respectively. The survival rate in all treatments was one hundred percent. However, production showed a marked increase with increasing stocking rates. Treatment I which was the lowest stocking rate (15 m^3) gave the lowest production (2.49 kg m^3) while Treatment V (100 m^3) gave the highest production (15.67 kg m^3). Treatment IV (75 m^3) performed better than the others in terms of average growth rate (1.85 g day^{-1}), however, the values were not statistically significant.

Table 3.14. Effects of different stocking rates on growth, survival, production and FCR of milkfish reared in marine net cages

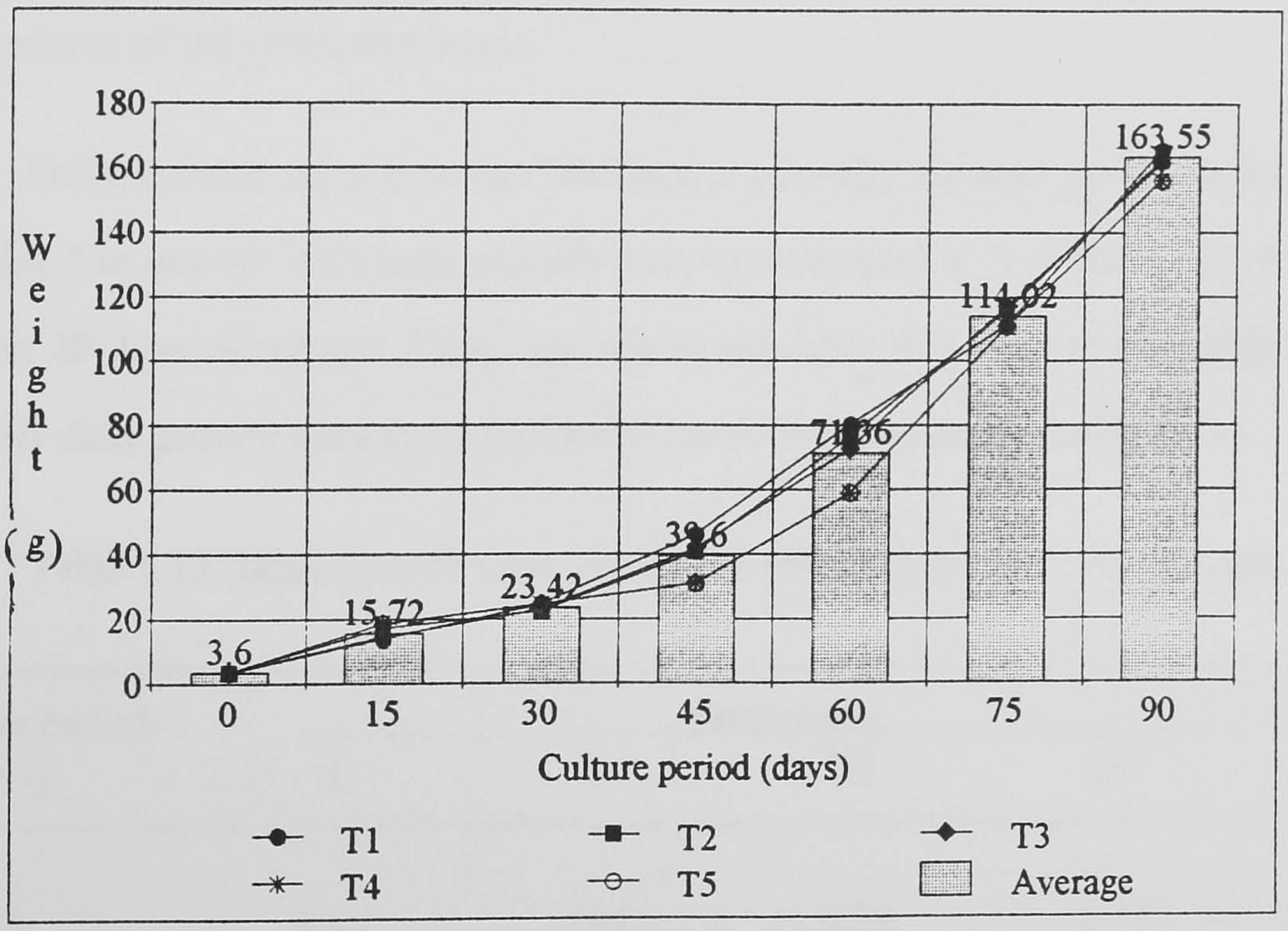
Treatment	Mean weight Gain (g)	Growth Rate (g day^{-1})	Survival Rate (%)	Production (kg m^3)	FCR
I - 15 m^3	162.08	1.80	100	2.49*	13.07
II - 30 m^3	158.57	1.76	100	4.87*	6.47
III - 50 m^3	158.45	1.76	100	8.10*	4.30
IV - 75 m^3	166.33	1.85	100	12.75*	3.08
V -100 m^3	153.05	1.70	100	15.67*	2.39

* Denotes a significant difference ($P<0.05$)

The weight increments of milkfish reared in marine net cages (Figure 3.3) at different stocking rates were almost identical indicating that the water environment was able to support total fish biomass up to 15.67 kg m^3. The feed conversion ratio

(FCR) decreased significantly with increasing stocking rates. Treatment V (100 m^3) had the lowest FCR value of 2.39 while treatment I (15 m^3) had the highest FCR value of 13.07.

Figure 3.3. Weight increase of milkfish reared in marine net cages



Discussion

The study showed that growth and survival rates were not affected when stocking rates were increased up to 100 m^3 provided there was sufficient water current to maintain good water quality within the culture site. This was confirmed by the 100% survival rates. The high survival rate may also be due to the experimental animals used being fingerling sizes (3-5 g body weight). The net cages were also closed at the top to prevent escape of the fish and entry of fish predators. The high survival rates markedly increased production per unit cage. The economy of production was apparent in this study. The water salinity and temperature during the culture period were within the normal ranges between 27.3-31.6‰ and 29.6-30.9°C respectively. A minimum water depth of 100 cm during lowest tide level was sufficient to flush out toxic substances excreted by the fish. It was observed that the water current created by the semi-diurnal tide (2 high tides and 2 low tides in 24 hours) was enough to sustain the dissolved oxygen level (DO>5ppm) within the optimal growth requirements of the cultured animals.

Daily growth rates between treatments generally showed an increasing trend from day 1 to day 90. Although, growth rates in treatments 2, 3, 4 and 5 varied during the first 30 days of culture. These variations may have been due to sampling errors, however daily growth rates in all treatments recovered thereafter (Table 3.15).

Table 3.15. Daily growth rates of milkfish reared in marine net cages (g)

Culture period	Treatments				
(Days)	I	II	III	IV	V
1-15	0.69	0.91	0.73	0.71	1.01
16-30	0.72	0.34	0.56	0.56	0.39
31-45	1.43	1.24	1.26	1.03	0.43
46-60	2.28	2.37	2.06	2.01	1.86
61-75	2.06	2.63	2.96	3.01	3.46
76-90	3.63	3.12	2.97	3.77	3.02

The proximate FCR values decreased significantly with increasing stocking rates. The results indicated that higher stocking rates had a higher feed conversion efficiency which was probably due to better utilisation of food as a result of increased intra-specific interaction. The higher density could have stimulated the fish to feed more actively, thus minimising feed wastage.

Looking at the financial economics of the technology, a cost and return analysis of milkfish culture in marine net cages is shown in Table 3.16. Assuming that one farm caretaker can maintain and supervise at least one unit of 500 m^2 net cage (25 m x 20 m x 2.5 m), the net cage culture technology on milkfish is financially feasible at a stocking rate of 100 m^3. The rate of return (RR) and internal rate of return (IRR) are 49.21% and 42.36% respectively, while the discounted benefit cost ratios (B/Cs) are 1.34 and 1.09 respectively. The analysis indicates that the technology is not profitable when the stocking rate is lower than 100 m^3. Feed cost is the primary factor which influence the profitability of the technology. Furthermore, the analysis indicates that FCR values higher than 3 is not financially feasible.

Table 3.16. Cost and return analysis of milkfish production in marine net cages

Capital cost of construction (25 m x 20 m x 2.5 m)					
Netting materials				20,000	
Bamboo and floating materials				15,000	
miscellaneous and contingency costs				10,000	
Total				45,000	
Depreciation cost (2 crops yr^{-1} x 3 yr)				7,500	
Production out ($crop^{-1}$)					
Stocking rate (fish m^3)	15	30	50	75	100
Yield (kg $crop^{-1}$)	1,245	2,435	4,050	6,375	7,835
Price (Pesos kg^{-1})[a]	66	66	66	66	66
Gross sale (Pesos)	82,170	160,710	267,300	420,750	517,110
Operating cost (Pesos $crop^{-1}$)					
Fingerlings (P2.00)	15,000	30,000	50,000	75,000	100,000
Feeds (P12 kg^{-1})[b]	195,266	189,053	208,980	235,620	224,708
Labour cost[c]	18,000	18,000	18,000	18,000	18,000
Miscellaneous	11,413	11,853	13,849	16,431	17,135
Total	239,679	248,906	290,829	345,051	359,843
Marketing cost[d]	4,109	8,036	13,365	21,038	25,856
Direct cost	243,789	256,942	304,194	366,089	385,699
Interest on capital[e]	17,080	17,634	20,150	23,403	24,291
depreciation cost	7,500	7,500	7,500	7,500	7,500
Total cost	268,369	282,076	331,844	396,992	417,490
Profit	(186,199)	(121,366)	(64,544)	23,758	99,620
Break-even cost to produce kg^{-1} (Pesos)	215.56	115.84	81.94	62.27	53.28
Break-even prod'n to pay total cost (kg)	4,066	4,274	5,028	6,015	6,326
Rate of return (RR)	-	-	-	12.18%	49.21%
Internal Rate of Return (IRR)[f]	-	-	-	0	42.36%
Benefit-cost ratio (B/C)[f]	-	-	-	1.15	1.34
B/C + Capital cost[f]	-	-	-	0.93	1.09

[a] Calculated at 6.78% average annual increase between 1991 and 1995
[b] Calculated from FCR of Table 3.14
[c] Calculated at P4,500 month x 4 months culture period
[d] Calculated at 5% gross sale
[e] Calculated at 6% interest $crop^{-1}$ of 4 months, or 18% per year
[f] Calculated at 2 crops yr^{-1} x 3 yr discounted at 15%

3.3. Milkfish development plan and strategies

3.3.1. *Background*

The importance of milkfish as a food fish in the Philippines has been fully described earlier in this Chapter. The existing milkfish resources (e.g. inland and coastal areas, fry grounds, etc.) are large and the production technology and expertise are available. Present production for milkfish is declining but the domestic demand is large and the potential for export is great with the development of new value added products. Milkfish enjoy a high price in the domestic market compared to other fish species, and the market price has increased during the last five years. Milkfish fry caught from the wild are the main source for stocking, however the supply is a limiting factor (Table 7.4), particularly when the spawning season is over. Propagation techniques have been developed and are now being refined to address fry shortage. At present, the existing milkfish ponds are under-utilised considering that most of the fish farmers are practising the traditional extensive system with production levels below 1200 kg ha^{-1} yr^{-1}. Since the ponds exist, only small amounts of capital investment are necessary to upgrade them for semi-intensive culture operation. Furthermore, about 138,129 ha of brackishwater fishponds are presently unutilised (Chapter II). Also, there exist vast areas of sheltered coves and bays still untapped for aquaculture production. Since the capture fisheries are not likely to improve in the future, there is a need to develop the milkfish aquaculture industry to meet the increasing demand for fish. Given the proper support and encouragement by the government, these potential areas can be made more productive with the adoption of new and improved milkfish culture techniques. Therefore, while the problem of seed production is being addressed by research institutions, it is essential for the government to pursue the short-term importation of milkfish fry from other Asian countries to sustain the present production and growth (Table 7.3). The strategic direction points to the proper utilisation and management of these production sites to fully exploit this potential advantage.

3.3.2. *Objective*

The primary objective of this development plan was to increase milkfish production over the next five years to overcome declining growth and meet the domestic and export demands by the year 2000. The increase of milkfish supply in the domestic market will help sustain the domestic fish requirement. It is anticipated that any increase in production can be easily absorbed by the current market demand for milkfish and the fish supply shortfall in the country. Thus, the targeted increase in milkfish production is not likely to affect the price of milkfish in the market. The specific objectives are:

(1) to improve the supply and distribution of milkfish fry and fingerlings through out the country;

(2) to intensify technology transfer on semi-intensive milkfish culture in ponds and on cage culture of milkfish in sheltered marine waters;

(3) to increase milkfish production by 10% annually from 1997 to 2001.

3.3.3. *Implementing strategies and targets*

To attain the above objectives, activities will be focused on the following strategies:

(1) Improvement of supply and distribution of milkfish fry and fingerlings - To attain this objective, milkfish fry bank and nurseries will be established in all strategic milkfish production areas in the country (Table 3.17). Initially, a nation-wide survey will be conducted to identify strategic farming areas throughout the 14 coastal

Administrative Regions of the country (Figure 3.4). Although major aquaculture production areas have been identified by the Government, it is necessary to evaluate the existing farms to determine status of farm facilities, production performance, fry requirements and constraints to production. Existing government fisheries outreach stations and fish farm demonstration stations at the regional and provincial levels will be evaluated to determine their suitability for the milkfish fry bank and nursery project. Suitable sites will be funded and re-activated for the said project. Additional milkfish fry bank and nurseries may have to be established in some strategic areas if so required, particularly in areas which are not accessible to the proposed site. This will be accomplished by utilising suitable private fish farms and nurseries. Fish farmers groups, particularly existing associations and co-operatives will be encouraged to participate in milkfish fingerling production activities during spawning seasons by providing input assistance in the form of fertilisers, feeds and nets, provided such capital inputs shall be returned to the government free of interest charge after the sale of fingerling products. During milkfish fry abundance, the fry bank and nurseries will be stocked with milkfish seeds. Government farms will produce at least 1 million fingerlings per year while the private farms will produce at least 2 million fingerlings during the first year and their production targets will be increased during the succeeding years to meet the total annual fry requirement. Milkfish fingerlings produced from government farms will be sold to the fish farmers at prevailing cost during stocking periods. Generally, there are two major spawning seasons for milkfish in the Philippines, namely: March to May and September to November. Since milkfish fingerlings can be stunted in the nursery and transition ponds for six months, schedule of fry stockings can be programmed before the end of each spawning periods, so that milkfish fingerlings are available to the fish farmers during their succeeding grow-out operations.

Figure 3.4. Map of the Philippines showing regional boundaries

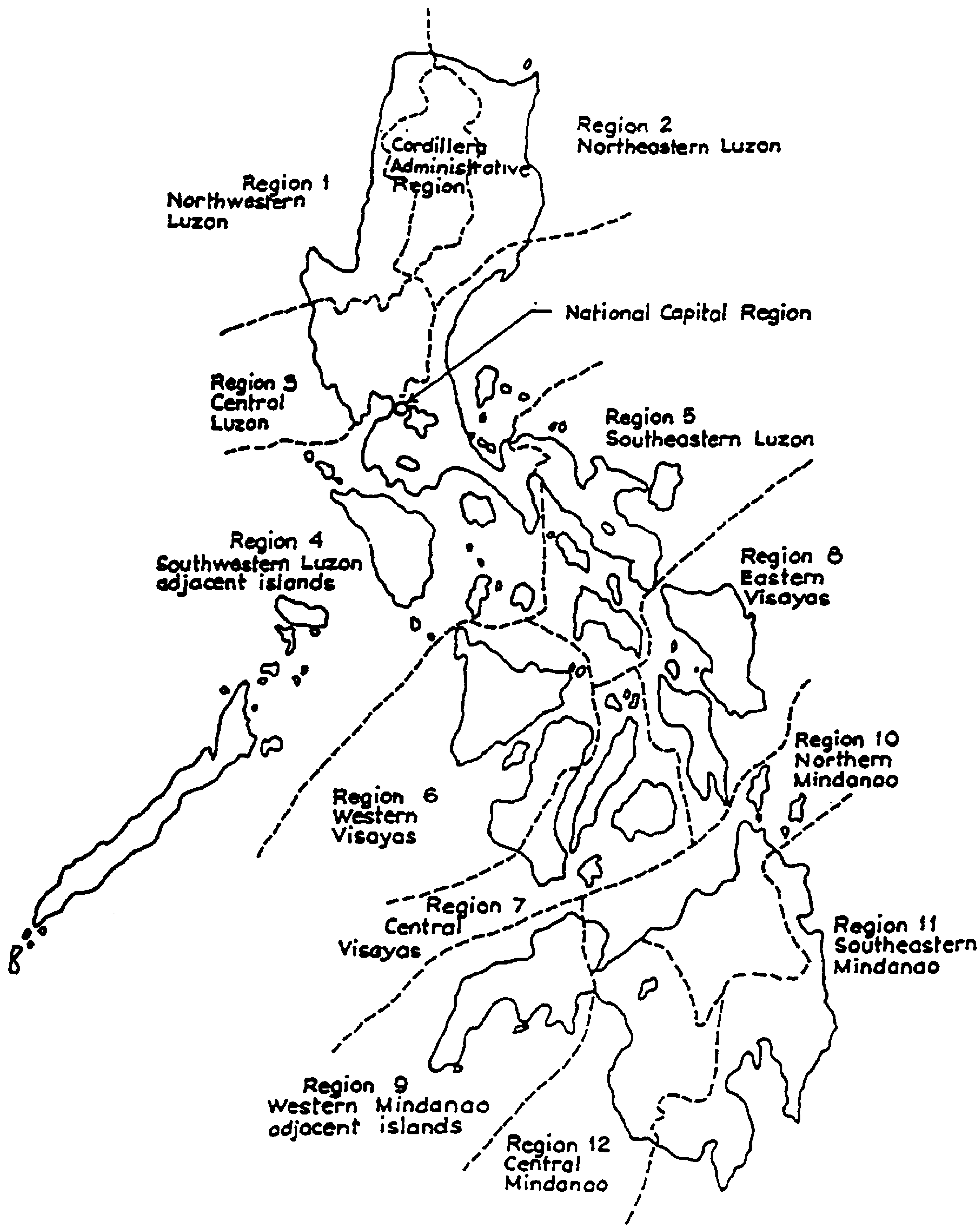


Table 3.17. Strategic areas, fry bank/nurseries and training targets for milkfish

Region	Strategic aquaculture provinces for milkfish	Fry bank and nurseries		Training programme		
		Gov't.[a]	Private[b]	EOs[c]	FF/FC/FN[d]	
					Pond SIC[e]	Marine[f]
I	Ilocos, La Union, Pangasinan	1	3	6	54	104
II	Cagayan	1	1	2	18	35
III	Bataan, Bulacan, Pampanga, Zambales	1	4	8	72	138
IV	Batangas, Cavite, Aurora Palawan, Marinduque, Quezon Mindoro Occ/Or., Romblon	5	9	18	160	312
V	Albay, Camarines Norte/Sur, Catanduanes, Masbate, Sorsogon	4	6	12	108	208
VI	Aklan, Antique, Guimaras, Capiz, Iloilo, Negros Occ.	5	6	12	108	208
VII	Bohol, Cebu, Negros Or. Siquijor	3	4	8	72	138
VIII	Samar (East/West/North) Leyte, Southern Leyte	2	5	10	90	173
IX	Zamboanga, Basilan	2	2	4	34	70
X	Surigao N., Misamis Occ/Or. Cagayan de Oro, Agusan	1	4	8	72	138
XI	Davao, Sarangani, Surigao S. South Cotabato	1	4	8	72	138
XII	Lanao N., Sultan Kudarat	1	2	4	34	70
ARMM	Lanao S., Sulu, Tawi-tawi Maguindanao	0	4	8	72	138
NCR	Malabon, Cavite, Bulacan	0	2	4	34	70
	Total	27	56	112	1,000	1,940

[a] No. of targeted existing government demonstration farms and fry bank

[b] No. of targeted private fish farms to be established, one for each province

[c] No. of Extension Officers to be trained at 2 EOs per province

[d] No. of fish Farmers (FF), farm caretakers (FC) and fry nursery operators (FN) to be trained

[e] No. of Fish farmers for semi-intensive culture (SIC) of milkfish in ponds calculated at 5 farmers ha^{-1} of pond area targeted for development in Table 3.18

[f] No. of fish farmers for net cage culture of milkfish in sheltered marine waters calculated at 1 farmer 1000 m^{-2} cage area targeted for development in Table 3.18

(2) Technology transfer - To attain this specific objective, training programmes on the semi-intensive milkfish culture in ponds and net cages culture in marine coastal waters will be developed for the fry nursery operators and technician, fish farmers, farm caretakers and extension officers. The training target will be set at 3,300 trainees (Table 3.17) for five years broken down as follows: 80 government farm managers and technicians (27 farms x 3 personnel farm^{-1}), 168 private farm nursery operators and technicians (56 farms x 3 personnel farm^{-1}), 112 extension officers (2 EOs province^{-1}), 1,000 fish farmers for semi-intensive pond culture and 1,940 fish farmers for net cage culture. To achieve this target, at least six training sessions will be conducted each year at 110 trainees per session, or at least 660 trainees year^{-1}. Selection of participants will give priority to members of fish farmers associations and co-operatives so that after their training they can be utilised for the technology demonstration trials. Furthermore, regional and provincial outreach stations and fish farm demonstration units will also be used to the conduct technology adaptation, verification and demonstration trials. These stations will serve as pilot farms or "show windows" and training grounds of regional technical personnel and trainees for the improved milkfish farming technologies.

(3) Increase in milkfish production - To attain this specific objective, a national policy should be instituted to promote the adoption of semi-intensive culture of milkfish in suitable brackishwater fishponds and the cage culture of milkfish in sheltered marine waters. At least 5000 ha of brackishwater fishponds will have to be improved and converted into a semi-intensive milkfish farming method with a production target of about 5 t ha^{-1} yr^{-1}at 3 cropping yr^{-1} (1.7 t ha^{-1} crop^{-1}). Since these ponds exist, investment in the improvement and conversion will be minimal. The developmental phase will be spread over five years at a rate of 1000 ha yr^{-1}(Table 3.18). On the other hand, about 194 ha of sheltered marine coastal waters will be

identified for the culture of milkfish in net cages. To contain any possible effects of pollution, developmental zones need to be strategically dispersed throughout the 14 coastal administrative regions of the country.

Aquaculture milkfish production is projected to decline by about 9.6% in 1996 based on production trends between 1991 and 1995. Starting in 1997, milkfish production will be increased by 10% annually up to year 2001. Milkfish production will have increased to 219,634 t or a total increase of 83,258 t over 5 years. Assuming that 10,000 fry is required to produce one ton (1,000 kg x 4 fish kg^{-1} at 40% survival rate starting from fry gathering to marketable size product) of marketable milkfish, total fry requirement will be about 2.2 billion to meet the production target of 219,634 t by the year 2001.

Table 3.18. Cumulative area development and production of milkfish for 1997-2001 (Area in ha, production in t)

Year		Brackishwater		Marine Water		Total Increase	
		Area	Prod'n[a]	Area	Prod'n[b]	Area	Prod'n
1996	(136,376)[c]						
1997	(150,013)[d]	1,000	5,000	29	8,637	1,029	13,637
1998	(165,015)[d]	2,000	10,000	62	18,639	2,062	28,639
1999	(181,516)[d]	3,000	15,000	101	30,140	3,101	45,140
2000	(191,668)[d]	4,000	20,000	118	35,292	4,118	55,292
2001	(219,634)[d]	5,000	25,000	194	58,258	5,194	83,258

[a] Calculated at 5 t $ha^{-1}yr^{-1}$. at 3 crops per year
[b] Calculated at 300 t ha^{-1} yr^{-1} at 2 crops per year
[c] Projected 9.6% annual decline of milkfish aquaculture production between 1991 and 1995
[d] Projected 10% annual increase in milkfish aquaculture production

3.3.4. *Implementing agencies*

There are various fisheries agencies and research institutions (local and international) that are involved in fisheries development in the country. These agencies have budgets to support extension activities and training programme. Existing facilities and manpower resources of the government, particularly the Bureau of Fisheries and Aquatic Resources (BFAR), the Department of Agriculture's Regional Field Office (DA-RFOs) and the Local Government Units (LGUs) can be utilized for the implementation of this development. Specifically, existing fish farm demonstration stations and outreach stations being operated by the DA and LGUs in the regional and provincial areas will be tapped for the milkfish fry bank and nursery project. The training section of the Fisheries Support Services Division of BFAR will be used for the implementation of the training activities. The National Brackishwater Aquaculture Technology Research Centre of BFAR can implement the technology adaptation, verification and demonstration trials. The extension agents being supervised by the DA-RFOs and LGUs will be trained for extension activities. Lastly, non-government organisations (NGOs) whose activities are related to fisheries development will be tapped for the implementation of symposia and national conferences to exploit their services and expertise for the nation-wide promotion of the improved milkfish farming technologies.

3.3.5. *Time frame*

The implementation of this development plan will be for a period of five years commencing in 1997 to 2001. The budgetary requirement for 1997 will be requested through the usual standard operating procedure. Regular budget can be re-aligned to support initial implementation of activities such as evaluation of areas which is normally conducted during the first year of project implementation. Assuming that project funds can be released in the first quarter of 1997, milkfish fry bank and nurseries can be stocked in the second and fourth quarter of the year. Consequently, training of fish farmers, caretakers and extension agents can be started in 1997. The technology adaptation, verification and demonstration trials will probably begin on the second year, to give way for the first training session. However, improvement and repair of farm facilities (e.g. ponds, control gates, equipment) and purchase of farm inputs (e.g. fertilisers, lime) can be conducted during the first year (1997). Project implementation should be in full swing in the second quarter of 1998 up to year 2001.

3.3.6. *Inputs and expected benefits*

The estimated budgetary requirements and expected benefits of the milkfish development plan is shown in Table 3.19. The development cost is estimated to reach 10.5 billion Pesos for the five year development activities, while the expected direct benefits is more than 17.0 billion Pesos. Direct employment that will be created is 10,388 people, benefiting about 93,500 additional Filipinos. Other significant socio-economic benefits are employment opportunities and increased trading activities in related industries such as the feed and milkfish fry industries, recycling of organic waste (e.g. chicken manure as fertilizer in ponds), and the conversion of unutilized marginal land and coastal waters into productive areas.

Table 3.19. Estimated budgetary requirements (Million Pesos) and direct benefits for the development of milkfish farming industry in the Philippines, 1997-2001

Item	Budgetary requirement
Inputs requirement.	
Research/extension facilities and manpower	Existing
Survey and data gathering (0.5 million x 14 Regions)	7.0
Research and Development (0.5 M x 56 Provinces x 5 yr)	140.0
Extension programme (TEV, 1 million x 14 Regions)	70.0
Training programme (3,300 trainees x P5,000/trainee)	16.5
Production inputs:	
Milkfish fry (2.26 billion x 1.00 Peso fry^{-1})[a]	2,260.0
Milkfish feed (225.97 t x 2.0 FCR x 12 Pesos kg^{-1})[b]	5,423.0
Ponds and equipment (5,194 ha x P150,000 ha)[c]	779.0
Miscellaneous expenses (10%)	8700
Contingency cost (10%)	957.0
Total budgetary requirements	10,522.5
Expected benefits.	
Gross value: Sale(225,966 t x 66 Pesos kg^{-1})	14,914.0
Land valuation (5,194 ha x 200,000 Pesos ha)	1,039.0
Tax revenues: Sale (14.91 billion Pesos x 10% tax)	1,491.0
Land (1.039 billion Pesos x 1% tax)	10.4
Employment (1 persons ha x 5,194 ha x P54,000 income yr^{-1} x 1%)	3.0
Total direct benefits (Pesos)	17,457.4
Direct additional employment and beneficiaries:	
Regular (calculated at 1 person ha^{-1} x 5,194 ha)	5,194 People
Part-time (calculated at 2 persons per regular worker)	10,388 People
Family dependents (calculated at 5 persons per laborer)	77,910 People
Total	93,492 People

[a] Calculated from Table 3.17
[b] Calculated at an FCR of 2:1
[c] Calculated from Table 3.12

4. TILAPIA: OVERVIEW OF THE INDUSTRY, TECHNOLOGY DEVELOPMENT AND DEVELOPMENT STRATEGIES

4.1. Overview of the tilapia industry in the Philippines

4.1.1. *Background*

Tilapia (*Oreochromis* sp.) is a group of warmwater fish species which originated from Africa (Guerrero, 1994). *Oreochromis* species were introduced into the Philippines some 40 years ago to help solve protein deficiency in the country (Angeles, 1992). Today, tilapia are widely distributed in the Philippines as a food fish and are highly acceptable to the Filipino consumers. The two most important species in the Philippines are the Nile tilapia (*Oreochromis niloticus* L.) which is cultured extensively in freshwater areas and the Mozambique tilapia (*Oreochromis mossambicus* Peters) which is cultured in brackishwater fishponds in polyculture with milkfish, shrimp and mudcrab.

Tilapia are widely cultured in many countries of Africa and the Asia-Pacific Region. In the Philippines, tilapia farming developed rapidly in freshwater lakes and reservoirs. The popularity of tilapia for cultivation can be attributed to: its ease of production; marketability; acceptability; fast growth rate; high resistance to parasite and disease; tolerance to poor water quality; and its ability to survive in a wide range of environmental conditions.

The Philippines is the second largest producer of tilapia in the world, and in 1993 contributed about 22% (120,297 t) to the world's total tilapia and cichlid production of 550,600 t (Table 4.1). China was the largest producer, contributing about 35% (191,257 t). Other major producers of tilapia are Indonesia, Thailand, Egypt, Cuba and Colombia in descending order (FAO, 1995). Based on a survey conducted by the NFRI in 1987, the average per capita consumption of tilapia in the Philippines was 1.0 kg yr^{-1}.

Table 4.1. Major producers (tonnes) of tilapia and cichlid, 1989-1993

Country/year	1989	1990	1991	1992	1993
China	89,473	106,071	119,852	157,233	191,257
Philippines*	101,647	97,424	96,330	110,631	120,297
Indonesia	38,000	53,768	54,287	59,945	64,400
Thailand	21,509	22,895	27,800	43,547	44,939
Egypt	25,000	24,916	22,156	21,505	19,857
Cuba	15,744	18,663	16,567	16,960	11,582
Colombia	1,000	2,040	3,040	11,050	11,046

Source: Aquaculture Production Statistics: 1984-1993. FAO Fish. Cir. No. 815, Rev. 7.
* Adjusted figure to include municipal production taken from Fishery Statistics 1986-1995. BAS, 1996.

In the Philippines, tilapia is a major aquaculture species raised in freshwater fishponds, pens and net cages comprising about 10% (81,182 t) of the total national aquaculture production of 825,387 t and about 78% (75,865 t) of the total freshwater ponds, pens and cages production of 97,122 t in 1995 (BFAR, 1996). At present, there are 14,500 ha of freshwater fishponds and 500 ha of net cages in lakes and reservoirs throughout the Philippines which are being utilised for Nile tilapia production. The expansion of freshwater fishponds is increasing rapidly due to the marketability of tilapia and developments in breeding and grow-out technologies.

Associated with this technological development, there has been an increasing demand for good quality fingerlings. This triggered the development of commercial hatcheries and nurseries throughout the country. Today, there are more than 1000 small-scale tilapia hatchery/nursery operators throughout the Philippines producing over than 500 million fry and fingerlings annually (Guerrero, 1994).

During the last decade, the lack of knowledge of the fish farmers with respect to the hatchery and breeding of Nile tilapia has resulted to genetic deterioration of the cultured species in the Philippines. This condition significantly decreased the growth of the species, and hence total production performance of the industry. The decreasing trend in tilapia aquaculture production since 1993 has been attributed largely to the lack of good quality tilapia fingerlings for stocking grow-out ponds and inadequate extension services.

To remedy the loss of genetic quality of Nile tilapia in the country, various strains were introduced to improve the local broodstock. In the late 1980s, a project on the genetic improvement of farmed tilapia (GIFT) was initiated by the BFAR in collaboration with the International Centre for Living Aquatic Resources Management (ICLARM) and Philippine Universities. The primary aim of the project was to produce a tilapia hybrid with better growth performance and other production qualities. The project led to the development of a new tilapia hybrid which grew at a rate 60% faster than its parental stock (Eknath, 1994). The new strain called GIFT tilapia is now being introduced to the freshwater fish farmers. However, in view of the limited hatchery facilities being operated by the government, mass production of the new tilapia strain cannot cope with the demand for stocking material. Efforts are now being made to disseminate the technology to accredited hatchery operators throughout the country.

Another new development in tilapia production is the culture of tilapia hybrids in brackishwater and protected coastal areas. Since the inland water resources of the Philippines are more or less over-exploited, there is an increasing demand from government planners and decision makers to expand production in sheltered marine areas. The hybrid resulting from a cross between a male Mozambique tilapia and a female Nile tilapia has been found to be more salt tolerant compared to other hybrids and has a fast growth rate. The problem at present is the lack of seed supply and an appropriate production technology for immediate adoption by the coastal fish farmers.

4.1.2. *Production performance and trend*

Tilapia production in the Philippines comes mainly from freshwater fishponds with a share of about 47% (38,410 t) of the total tilapia production of 81,182 t in 1995 (BFAR, 1996). Other production comes from fish cages (40%; 32,579 t); fish pens (6%; 4,876 t) and brackishwater fishponds (7%; 5,317 t) (Table 4.2). In 1995, there were 14,531 ha of freshwater fishponds and 500 ha of net cages which were primarily utilised for Nile tilapia production (Chapter II, Sec.1). Therefore, the average tilapia production can be calculated at 2.6 t ha^{-1} yr^{-1} for freshwater fishponds and 65.2 t ha^{-1} yr^{-1} for fish cages. At present, there are no available data on the total area engaged in tilapia fish pen culture, thus the average production from this type of culture cannot be determined.

Table 4.2. Aquaculture production of tilapia by type of culture, 1991-1995 (t).

Year	Fishponds	Freshwater fish pens	Fish cages	Brackishwater fishponds	Total
1991	37,358	4,092	21,048	14,072	76,570
1992	48,006	5,843	29,554	7,770	91,173
1993	47,893	4,939	35,563	7,944	96,339
1994	38,867	13,760	31,866	9,829	94,322
1995	38,410	4,876	32,579	5,317	81,182

Source: Fishery Statistics, 1986-1995. BAS, 1996.

Production performance of tilapia has fluctuated widely over the past five years, from a low of 96,330 t in 1991 to a high of 120,297 t in 1993 and then declining to 106,584 t in the 1995 (Table 4.3). The general trend, however, was still upwards at an average annual rate of 2.97%. The decline in production was most notable in 1993 and 1994 at 2.09% and 13.93% respectively. Central Luzon being accessible to research institutions and support services (e.g. BFAR-NFFTRC, ICLARM, CLSU-FAC) was the biggest producer contributing about 46% of the total tilapia aquaculture production in 1995.

Table 4.3. Philippine tilapia production by sector, 1991-1995 (t)

Year	Municipal		Aquaculture		Total	
1991	19,760		76,570		96,330	
1992	19,458	(-1.53)	91,173	(19.07)	110,631	(14.85)
1993	23,958	(23.13)	96,339	(5.67)	120,297	(8.74)
1994	21,541	(-10.1)	94,322	(-2.09)	115,863	(-3.69)
1995	25,402	(17.92)	81,182	(-13.93)	106,584	(-8.01)
Average		(7.36)		(2.18)		(2.97)

Source: Fishery Statistics, 1986-1995. BAS, 1996.
Figures in parenthesis represent annual growth rate (%).

4.1.3. *Tilapia price trend*

Prior to 1970s, the Mozambique tilapia was considered a pest in fishponds and therefore, did not have any market value. But in the 1980s, with the public acceptance of Nile tilapia, the price of the fish improved greatly. At present, large Nile tilapia (>400 g) cultured in net cages are sold for the same price as milkfish in the markets of Metro Manila.

The wholesale market price of tilapia in recent years has increased (Table 4.4) from 29.21 pesos kg^{-1} in 1991 to 42.39 pesos kg^{-1} in 1995, or an average annual increase of 10.08%. Significant price jumps were observed in 1991 and 1993 when prices increased by 22.9% and 12.5% respectively. Retail prices also increased by an average annual rate of 9.56%. It can be assumed that the price increase was due mainly to increase in demand due to improved product quality and aquaculture practices (e.g. bigger size fish, cage culture with artificial feeding).

Table 4.4. Market price of tilapia, 1991-1995 (Pesos kg^{-1})

Year	Wholesale price		Retail price		Price margin		% Increase in wholesale to retail price
1991	29.21		39.78		10.57		36.2
1992	35.90	(22.9)	43.52	(9.4)	7.62	(-27.9)	21.2
1993	37.18	(3.6)	50.79	(16.7)	13.61	(78.6)	36.6
1994	41.84	(12.5)	56.16	(10.6)	14.32	(5.2)	34.2
1995	42.39	(1.3)	57.02	(1.5)	14.63	(2.2)	34.5
Ave. annual increase		(10.1)		(9.6)		(14.5)	32.5

Source: Fishery statistics, 1986-1995. BAS. 1996.
Figures in parenthesis represent annual growth rate.

4.1.4. *Market outlets for tilapia: domestic and export*

Domestic market

Medium size tilapia weighing 150-300 g body weight are commonly sold fresh in the domestic markets. Most of the tilapia fish farmers in the Philippines are small-scale, with the bulk of their harvest saved for family use. For those operating on a commercial scale, the produce is marketed in urban centres; usually in the cities of Metro Manila, where the producers can demand a higher market price for their products. Marketing channels for tilapia vary with respect to the number of intermediaries before reaching the consumers. For small-scale growers, the small surplus is sold directly to local markets by the producers themselves. For the commercial growers, the produce is sold via the fish broker/trader, wholesaler, retailer, and finally the consumer. Small volumes go to the fish processors and exporters.

Total production of tilapia was 106,584 t in 1995. It is safe to assume that the per capita consumption of tilapia has increased from 1.0 kg yr^{-1} in 1987 to 1.55 kg yr^{-1} based on a population of 68.61 million Filipinos in 1995. Therefore, total domestic demand for fresh tilapia in 1995 was 106,584 t. The domestic market for tilapia can be easily increased with the devlopment of value-added products such as salt drying, smoking, canning or fish filleting.

Export market

The export market for Philippine tilapia is still very new and is currently not reported in Fisheries Statistics (Angeles, 1992). Some export markets exist in Japan, USA and Canada. The export market in Japan is for *sashimi* grade quality tilapia. which commands a price of about US$3.00 kg^{-1} or about 79.50 Pesos kg^{-1} (US$1.00 = 26.5 Philippine Pesos).

The USA and Canadian markets on the other hand, prefer frozen whole fish for the Asian ethnic groups (Filipinos, Chinese, Thais, Vietnamese, Japanese including some Latin Americans who patronise Asian Food) and tilapia fillets for the whites or Caucasian group. Tilapia fillets are distributed through the regular supermarkets and grocery stores across the US mainland, while the frozen whole fish are distributed through ethnic food stores. The price of frozen whole tilapia ranges from US$0.90 to US$1.00 kg^{-1} (Angeles, 1992), while for tilapia fillets the price would be within the range of other fish fillets sold in the market (e.g. US$1.69-4.18 kg^{-1}). At this export market price, the Philippines cannot supply the international market since the domestic market price of tilapia is almost the same. Unless the present export market price for tilapia improves, the Philippine tilapia export industry will not develop. To improve the tilapia export market, there is a need to reduce production cost and/or improve export price through development of value added products.

However, with the acceptance of tilapia in the export market, the demand is expected to increase tremendously within the next decade. The increasing number of Asians and Latin Americans in the USA, Canada and Europe will spur growth of the export market. The increasing awareness around the world of fish as a healthy and nutritious food will contribute to the consumption of tilapia in the future. The number of Filipinos in the USA and Canada was already more than 1.5 million in 1995. Thus, the potential annual demand is high.

4.1.5. *Production methods and practices*

Background

Over the years, the tilapia industry has developed many production technologies which are adaptable to any aquatic environment in the country. The technology for extensive, semi-intensive and intensive cultures in ponds and cages was developed and is now being disseminated to interested fish farmers. At present, the emphasis is on the culture of Nile tilapia species in freshwater ponds and net cages. There are various production techniques developed for freshwater culture such as sex-reversed tilapia (SRT), the genetically YY super male tilapia (GMT) and the genetically improved farm tilapia (GIFT). These technologies can be adopted in freshwater ponds, pens or cages, but the adoption of high yielding techniques is hampered by the increasing cost of artificial feeds and other production costs. While the problem on genetic deterioration of Nile tilapia stocks is being addressed by government R&D institutions, the demand for good quality fingerlings for stocking grow-out ponds is increasing. The most important advantage of tilapia over other aquaculture fish species is that it can be propagated easily and can be cultured even in poor quality water conditions. The tilapia production system can be divided into three major phases, namely: breeding; nursery; and grow-out.

Breeding phase

This phase includes broodstock development and hatchery management. The end product is the fry or newly hatch larvae. Breeding starts with the selection of good quality breeders weighing at least 100 g. There are several methods being practised in tilapia breeding, namely: earth pond; net cages (hapa); and tanks (concrete, fibreglass or plastic). The earthen pond method is the simplest and most common method practised by the fish farmers (Tayamen, *et al.*, 1993). The pond serves for conditioning of breeders as well as spawning. Generally, the selected breeders are stocked in the pond at a sex ratio of 1 male to 3 females and then allowed to spawn naturally. They are fed with supplemental fish pellets at 2-3% of their total body weight daily when the natural food is not sufficient. After about 2-3 weeks, newly-hatched larvae are collected every morning as they swim at the water surface using a fine mesh scoop net and these are transferred to the nursery tanks or hapa nets. To avoid in-breeding and contamination of fish predators, the pond is completely drained after 45-60 days, then prepared again for the second crop cycle. The collected breeders are reconditioned in other ponds or net cages and then restocked again after rematuration. However, breeders more than one year old, weighing over than 250 g body weight are replaced with new ones. This breeding method is also being adopted for mass production of salt-tolerant tilapia hybrids, except that the breeders used are male *O. mossambicus* crossed with female *O. niloticus*.

Nursery phase

The nursery phase is the mass production of quality tilapia fingerlings so that they are always available to the grow-out operators. This includes the rearing of newly collected fry stocked in the nursery units. The nursery can be a "hapa" net cage, an earthen pond or a tank. Depending on the requirement of the grower, there are several technologies practised for tilapia fingerling production such as: sex-reversed tilapia, GIFT tilapia, genetically male tilapia (GMT), or mixed sex tilapia produced by normal methods. The technology for sex reversal has long been developed but adoption by fish farmers is minimal. The most common practise is the nursery pond or net cage. Tilapia fry from spawning ponds or cages are collected and transferred to the nursery ponds or net cages for rearing up to fingerling size. Stocking rate in the nursery net cages is 1,000 m^{-3}. The fry are fed with starter mash at a rate of 10-15% of their total body weight 4-5 times daily when natural food in the pond is not available. The culture period in the nursery normally takes about 15-30 days, depending on the size requirement of the grow-out operators. Based on practise, the earthen nursery pond is more advantageous compared to tanks or net cages in terms of management costs since: management in ponds is very simple and easy; the same area serves for spawning and nursery rearing; fingerlings produced are bigger and no supplementary feeding is required since the fry depend on natural food grown in the pond. However, the number of fingerlings produced per unit area of pond is low when compared to the nursery net cage or tank which have higher survival rates of the fish. Also the fingerlings produced in ponds are not uniform in size.

In the case of tilapia hybrids for stocking saltwater areas, the fry collected are first acclimatised to brackishwater condition in separate aerated tank. Acclimatisation is conducted by raising the salinity level of the tank by 5 ppt day^{-1} until the desired salinity is attained. Newly acclimatised fry are stocked into brackishwater nursery ponds or net cages for 30 days until they reach 5-10 g body weight.

Grow-out phase

The grow-out phase is the rearing of tilapia fingerlings to a marketable size of about 150-400 g body weight. There are several methods being practised by the fish farmers namely: earthen ponds, net cages and fish pens. The culture practises vary from extensive, semi-intensive and intensive to polyculture. In ponds, the traditional stocking rate is 10,000 ha^{-1} utilising organic and inorganic fertilisers to grow natural food in the pond. In semi-intensive culture, the stocking rate varies from 30,000-50,000 ha^{-1} using a combination of natural food and supplementary fish pellets to sustain the growth of the fish up to harvest. Intensive culture is usually practised by those engaged in monosex culture or sex-reversed tilapia. In intensive culture, the stocking rate is over than 50,000 ha^{-1} relying mainly on intensive feeding to sustain the growth of the fish. Life support mechanisms such as aerators and pumps are necessary to maintain the desired oxygen level in the pond water.

Net cage culture of tilapia is practised in rivers, lakes, reservoirs and flowing ponds or canals. The development capital required is comparatively lower than that for fishponds. The size of production units varies greatly depending on the capability of the fish farmer, but the most common size is 10 m x10 m 2.5 m in lakes or reservoirs. There are three types of grow-out cages used by the fish farmers, namely: floating; fixed; or submerged. But the most common is the floating net cage used in deep water lakes. Generally, the fingerlings stocked in net cages are uniform in size weighing about 5-10 g. Stocking rate varies from 50-100 m^{-3} depending on water conditions. The fish are fed with commercial fish pellets which became readily available during the early 1990s. One disadvantage of the net cage grow-out units is that management is more difficult when compared to fishponds. The net cages need regular inspection and cleaning to prevent the growth of fouling organisms. However, harvesting of the fish is easier.

Fish pen culture of tilapia practised in shallow lakes is confined to the Philippines (Pillay, 1990). The structure is built of synthetic polyethylene net material embedded 30 cm depth into the muddy lake bottom. The net is held upright at least 1.5 m above the water line by a bamboo framework and bamboo poles stuck vertically at 2 m intervals forming a square or a rectangle of about 0.5-1.0 ha. Stocking rates vary from 10,000-50,000 ha^{-1} depending on water condition and management employed. One major problem with tilapia pen culture is the difficulty of harvesting the fish even with the use of a seine or gill net.

4.1.6. *Issues and constraints of the tilapia industry in the Philippines*

Seed supply and quality

Despite various developments in the breeding and hatchery production of tilapia fry for stocking grow-out units (e.g. SRT, GMT, GIFT, salt tolerant hybrid) the tilapia industry is still beset with problems such as lack of good quality fingerlings, poor distribution of hatchery seed, inavailability of quality broodstock to produce quality seed, lack of salt-tolerant hybrid fingerlings for brackish and salt water cultures, poor broodstock management and the poor knowledge of hatchery technology by fish farmers. Unless these problems are resolved, the tilapia industry will continue to deteriorate and the concern of the present administration for food sufficiency and security will not be realised by the year 2000. At present, the existing hatchery facilities operated by the government are not enough to supply total seed requirement. There is a need to intensify the transfer of new hatchery and broodstock management technologies to private hatchery/nursery operators strategically located to improve distribution of seed and technology.

Research and technology transfer

During the last decade, much work has been carried out on the improvement of tilapia production technologies. However, their uptake by the fish farmers has been limited due to inadequate extension services and the lack of knowledge on the economic benefits of these technologies, most particularly on broodstock management and hatchery methods. The inadequacy of extension services was identified as one of the major problems facing the tilapia industry in the recent summit on Aquaculture and Marine Fisheries held on May 1-4, 1995 at Bacolod City, Philippines. Therefore, there is underutilization of research results to the detriment of the fish farmers/end-users.

Despite these developments in the tilapia industry, there is still a need to develop further new strains with better growth performance through genetic improvement and continue studies related to the development of low-cost feeds. Mass production of salt-tolerant tilapia hybrid fingerlings must be promoted for stocking brackishwater ponds, especially during the periods of milkfish fry scarcity. The availability of salt-tolerant tilapia hybrids will provide fish farmers with another alternative choice for stocking their grow-out units.

Environmental management and conservation issues

In an effort by the government to increase production since the 1970s, problems of overcrowding, over-exploitation and conflicts on the use of inland water resources have cropped up, particularly during the last decade (Table 7.4). In freshwater lakes, small fishermen have complained of lower fish catch due to reduced fishing grounds as a result of proliferation of net cages; intensification of tilapia production has caused fish disease and massive fish kills in some regions causing significant losses to investors. Improper application of technology and feeding management particularly in intensive culture system, has caused rapid deterioration of lake waters due to pollution. There is a need to conduct studies on the proper utilisation of water effluents from intensive pond cultures. In cage culture, there is an urgent need to establish developmental zones to restrict cage culture within ecological boundaries. There is also a need to train end-users in environmental management and conservation through proper application of technologies.

Marketing and post harvest

One factor that hinders the development of the tilapia industry in the Philippines is the high cost of production (Table 7.4). In intensive culture system, artificial feed alone contributes 60-70% of the total production costs. The development of a low-cost feeds for tilapia based on local materials would greatly improve the profit margin of tilapia growers. There is a need to improve the market price of tilapia by developing value-added products (e.g. fillet, canned, smoked, dried, fish burgers, fish flakes/crackers) to diversify and expand the domestic and export markets. Studies should be conducted to determine the economics of growing larger sized tilapia (e.g. 500-800 g body weight) to encourage the export market.

4.2. Technology development

4.2.1. *Background*

To ensure the long term sustainability of the aquaculture sector in the Philippines, the government has encouraged the expansion of production in sheltered marine waters. Tilapia farming in salt water conditions has been identified by government planners and decision makers as an important investment for the future. In accordance with this policy, the Bureau of Fisheries and Aquatic Resources through its National Brackishwater Aquaculture Technology Research Centre has started studies on the culture of a salt-tolerant tilapia hybrid as an alternate aquaculture species for stocking salt water areas. The primary objective was to develop a production technology for adoption in brackish water as well as sheltered coastal marine waters.

4.2.2. *The culture of tilapia hybrids in salt water*

Introduction

Over the years, tilapia farming in the Philippines has been restricted to freshwater areas due to the non-availability of an adaptable species for culture in salt water environments. The Mozambique tilapia, which can tolerate high salinity waters, is considered a pest to fishponds by fish farmers due to its prolific breeding characteristics and low yields (Guerrero, 1994). The Nile tilapia species has fast growth rate, however, it cannot withstand high salinity water (over 15 ppt) over a long period.

Many studies on salinity tolerance characteristics of various tilapia species have been conducted and summarised in several reviews (Chervinski, 1982; Philippart and Ruwet, 1982; Payne, 1983; Wohlfarth and Hulata, 1983; Stickney, 1986 and Watanabe *et al.*, 1988). Their varying degrees of salt tolerance suggested the possibility of some tilapia species for culture in the saltwater environment (Villegas, 1990).

More recent studies have shown that a tilapia hybrid, a cross between female *O. niloticus* and male *O. mossambicus*, is more suitable for stocking brackishwater as well as marine coastal environments (Dureza, 1994; Salvador *et al.*, 1994; Guerrero, 1994). The hybrids grew fast and had higher growth rate than their parental sources (Kuo, 1969). Acclimatisation techniques of some tilapia hybrids have been studied and the general approach was to produce the hybrids from broodstock reared in freshwater environment and then acclimatised to salt water conditions (Watanabe *et al.*, 1985; Lightner *et al.*, 1988; Pruginin *et al.*, 1988; Suzuki, 1988; Hopkins *et al.*, 1982).

In view of the limited supply of milkfish fry outside the spawning period, there is a need to develop an alternative species for stocking brackishwater fishponds. This study was conducted to evaluate the technical feasibility and economics of culturing the tilapia hybrids (F_1 hybrid of female *O. niloticus* x male *O. mossambicus*) in saltwater conditions. The study was in line with the government's policy to develop alternative species and employment projects for coastal fishermen and fish farmers. The primary aim of the study was to develop a production technology for salt-tolerant tilapia hybrid for dissemination to marginal fish farmers and small-scale fishermen. This chapter presents the preliminary results of experiments conducted at the National Brackishwater Aquaculture Technology Research Centre of the Bureau of Fisheries and Aquatic Resources at Pagbilao, Quezon, Philippines.

Materials and methods

Study 1: Salinity tolerance test of tilapia hybrid fry (F_1 hybrid of female *O. niloticus* x male *O. mossambicus*)

Tilapia broodstock of *O. niloticus* (Egypt Strain) from captive stocks of the National Freshwater Fisheries Technology Research Centre, Munoz, Nueva Ecija and *O. mossambicus* from the National Brackishwater Aquaculture Technology Research Centre, Pagbilao, Quezon were used in this study. Upon arrival at the site, the broodstock were sterilised and acclimatised in plastic tanks (1000 L capacity) and then allowed to mature in 1.5 m x 1.0 m x 1.0 m hapa nets until they had grown to more than 100 g body weight. Matured broodstock were selected and stocked in 300 m^2 freshwater breeding ponds at a sex ratio of 1 male to 3 females. The breeding ponds were previously prepared by cleaning, drying, liming and manuring the pond bottom soil and then grown with natural food, *lab-lab*. Newly hatched fry weighing about 0.1-0.2 mg were collected and transferred to aerated glass aquaria (60 L capacity) which were previously filled with 40 L of fresh water. The fry were fed 30% of body weight, three times daily (0800 h; 1200 h and 1700 h) with commercially-formulated starter mash containing 30% crude protein. After about 2 to 3 days conditioning in glass aquaria, the fry were stocked directly into experimental aquaria at a density of 100 fry unit^{-1} at five different salinity levels (5 ppt; 10 ppt; 15 ppt; 20 ppt and 30 ppt) and two replications per treatment. The experimental animals were given supplementary feed daily in a plastic feeding ring. The experimental aquaria were cleaned of fish faeces and uneaten food every morning before the start of feeding. Fry survival was assessed after five days. Tests of significance on survival rates were made using Stat Graphic's multifactor analysis of variance.

Study 2: Culture of tilapia hybrids in pond-based net cages in brackishwater condition

The remaining tilapia hybrid fry from the first spawning period were collected and acclimatised to brackishwater pond condition by using the procedure and acclimatisation technique developed from Study 1. The newly acclimatised fry weighing about 0.1-0.5 mg were transferred in 300 m^2 nursery ponds and stocked at a density of 5000 pond^{-1}. The nursery ponds were previously prepared by cleaning, levelling, liming, drying, manuring and grown with natural food, *lab-lab*. The ponds were dressed with ammonium phosphate (16-20-0) fertiliser at a rate of 12.5 kg ha^{-1} week^{-1} to maintain the growth of natural food during the nursery rearing period. The hybrid fingerlings were harvested after 30 days of culture when they had grown to about 5-12 g body weight.

Meanwhile, eight experimental net cages measuring 1.0 m x 1.0 m x 1.0 m each were installed inside a 300 m^2 earthen brackishwater pond with a maximum depth of 1.2 m water. The net cages were closed at the top to prevent the escape of the experimental fish and then tied to wooden poles such that the bottom portion of the cages were about 0.20 m above the pond soil. The net cages were installed side by side forming two straight lines, 2 m apart. The pond was equipped with one inlet pipe and another outlet pipe on the opposite side to facilitate exchange of water during tidal fluctuations. Prior to installation of the net cages, the pond was cleaned and dried for at least 15 days to harden the pond bottom soil.

Tilapia hybrid fingerlings grown from the nursery ponds were harvested and sorted into two size groups (small and large). Only the larger fish (7.68 g ABW) were used in the grow-out experiment. The experimental fish were weighed individually and stocked directly into the net cages at four different stocking rates: 50 m^{-3}, 100 m^{-3}, 150 m^{-3} and 200 m^{-3}. The experiment was replicated twice. The fish were fed with formulated starter fish crumble during the first month, juvenile or grower fish pellet during the second month, and adult or finisher fish pellet on the third month of culture. The proximate nutrient composition of the tilapia feeds is shown in Table 4.5. The fish were fed manually to satiation (until the fish stop feeding) four times daily at 0800 h, 1100 h, 1400 h and 1700 h respectively.

Water depth was maintained between 1.0-1.2 m inside the pond and changed at least 40% daily when tidal fluctuation was appropriate. The net cages were cleaned with a brush every week to remove fouling organisms that clogged the net holes. Ten percent of the fish were sampled every 15 days to determine their growth rates. Water salinity and temperature were monitored daily. The experiment was terminated after 87 days due to mass mortality of the stocks after a heavy rainfall which caused a sudden change in pond water salinity and temperature. Growth and production data such as weight increase, growth rate, production and survival rate were collected. Tests for significance were analysed using Stat Graphics' multifactor analysis of variance and SPSS for windows' LSD test.

Table 4.5. Proximate nutrient composition of tilapia feeds

Composition	Starter crumble	Juvenile(Grower)	Adult(Finisher)
Crude protein	>30%	>28%	>26%
Crude fat	> 7%	> 6%	> 5%
Crude fiber	< 9%	<10%	<10%
Ash	<14%	<15%	<15%
Moisture	<13%	<13%	<13%

Notes: > - Not less than < - Not more than

Study 3: Culture of tilapia hybrids in marine net cages

Six units floating net cages measuring 1.0 m x 1.0 m x 1.0 m were used in this experiment. The net cages were closed at the top to prevent the escape of experimental fish during periods of strong wave action and inclement weather. The net cages were installed side by side into bamboo rafts which held them afloat. The bamboo rafts were anchored into bamboo posts strategically pushed into the soft seabed at each side corner of the rafts.

The remaining tilapia hybrid fingerlings produced for Study 2 were used in this study. Following the procedure used in previous studies, the hybrid fingerlings were collected from the nursery ponds and sorted into two size groups. The larger fish (7.68 g ABW) were packed in oxygenated plastic bags and transported by a motorised boat to the marine research site which is located about 5 km from the station. On arrival at the site, the experimental fish were acclimatised to normal sea water salinity of 32 ppt.

After acclimatisation, the fish were weighed individually and stocked in floating net cages at three stocking rates (100 m^{-3}, 200 m^{-3} and 400 m^{-3}) with two replications per treatment. The fish were observed daily for a week and any mortalities due to transport and acclimatisation stress were replaced. Mortalities occurring after one week were considered normal mortalities and were no longer replaced.

As in Study 2, the fish were fed to satiation at four times daily with formulated fish feeds such as starter crumble, juvenile pellet and adult pellet during the first, second and third months of culture respectively. The net cages were cleaned regularly with a brush to prevent the growth of fouling organisms. Stock sampling was done at intervals of 15 days, by weighing 10% of the stock. Water salinity and temperature were monitored daily. The experiment was terminated after 90 days of culture. Growth data, production and survival rates were analysed using Stat Graphics' multifactor analysis of variance and SPSS for windows' LSD test.

Results

Study 1. Salinity tolerance test of tilapia hybrid fry

The effect of salinity on the survival rate of tilapia hybrid fry is summarised in Table 4.6. Water salinity has a significant effect on the survival rate of tilapia hybrid fry (P=0.0001). A salinity of 30 ppt was unfavourable for stocking. However, no differences were found in survival rates at salinity levels of 5, 10, 15 and 20 ppt. The result indicated that the best entry point for acclimatisation of tilapia hybrid fry is less than 20 ppt.

Study 2: Culture of tilapia hybrid in pond-based net cages

The mean weight gain, growth rate, production, survival rate and FCR of tilapia hybrids when reared in pond-based net cages are shown in Table 4.7, while the weight development is shown in Figure 4.1. The mean weight gains of the fish stocked at different densities were not different from each other (P=0.1254). Treatment I showed the highest growth rate of 0.97 g day^{-1}, which was significant only from the lowest value of 0.74 g day^{-1} observed in Treatment III (P=0.1226) but was not different from Treatment II (0.75 g day^{-1}) and Treatment IV (0.78 g day^{-1}) respectively. Treatments III (9.28 kg m^{-3}) and IV (12.59 kg m^{-3}) showed a significant increase in production (P=0.0028), while Treatments I and II did not show any differences. Stocking rates of up to 200 m^{-3} had no observed negative effect on survival rate of hybrid tilapia when reared in pond-based net cages. The FCR values generally exhibited a decreasing trend with increasing stocking rates.

Table 4.6. Survival rate of tilapia hybrid fry at different salinity levels

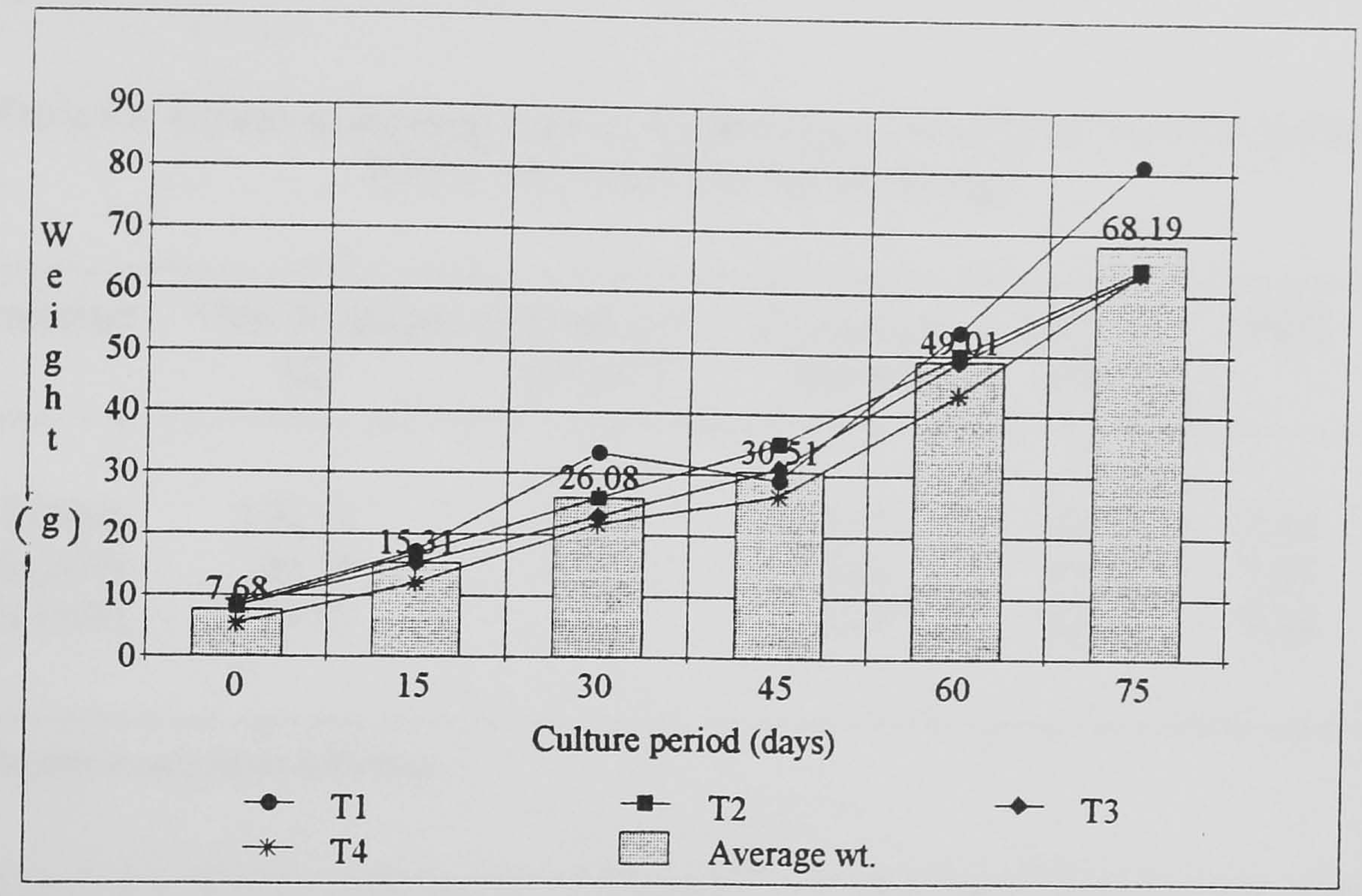
Treatment	Salinity level (ppt)	Survival rate (%) Replicate 1	Replicate 2	Mean
I	5	84	86	85
II	10	89	95	92
III	15	90	80	85
IV	20	81	79	80
V	30	0	0	0

Table 4.7. Growth, production and survival of tilapia hybrids in pond-based net cages

Treatment	Mean weight gain (g)	Growth rate (g day^{-1})	Production (kg m^{-3})	Survival (%)	FCR
I (50)	72.60	0.97*	3.99	98.0	2.86
II (100)	56.08	0.75	6.21	96.5	2.22
III (150)	55.20	0.74	9.28*	97.5	1.66
IV (200)	58.17	0.78	12.59*	99.0	1.89

* Denotes a significant difference

Figure 4.1. Weight development of tilapia hybrids in pond-based net cages (g)



Study 3: Culture of tilapia hybrids in marine net cages

The effects of different stocking rates on the growth , production, survival rate and FCR of tilapia hybrids when reared in marine net cages are shown in Table 4.8, while the weight development and average growth rate are shown in Figure 4.2. When the stocking rate was increased to 400 m^{-3}, no differences in the mean weight gains of the fish were found between the various stocking treatments ($P>0.05$). Average daily growth rates also showed no differences, although Treatment I with the lowest stocking density had the highest growth rate of 1.18 g day^{-1}. Average growth rate increased up to 2.13 g day^{-1} during the first 45 days of culture, and then slowed down to 1.68 g day^{-1} at 75 days of culture period. Comparison of production outputs showed, as expected, an increasing trend with higher stocking densities and the effect was significant between Treatments I and III ($P=0.0627$). As in Study 2, the FCR values decreased significantly with increasing stocking rate. The FCR values were

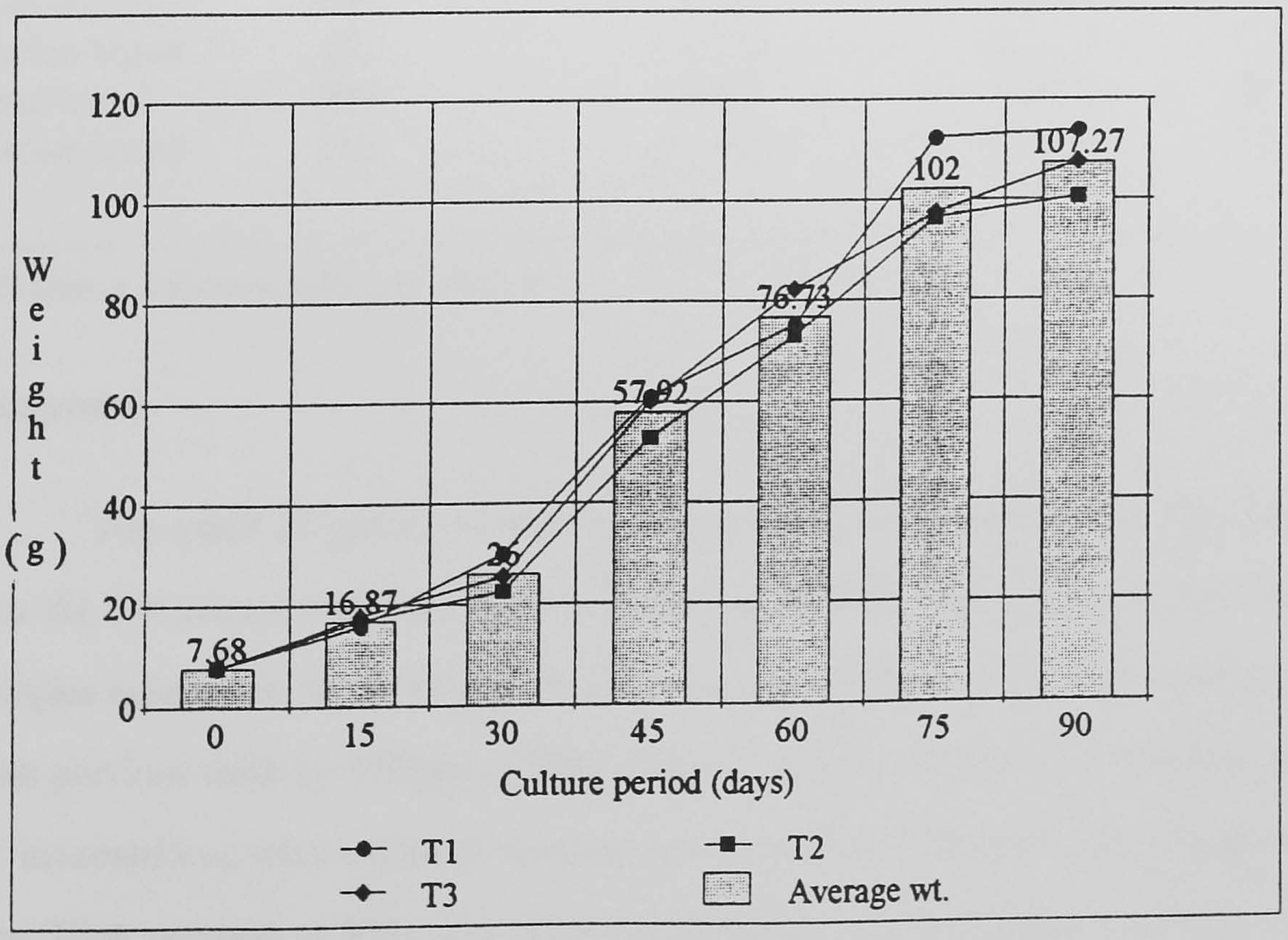
3.48, 2.91 and 1.96 in Treatments I (100 m^{-3}.), II (200 m^{-3}.) and III (400 m^{-3}.) respectively.

Table 4.8. Effects of stocking rates on the growth, production and survival of tilapia hybrids when reared in marine net cages

Treatment	Mean weight gain (g)	Growth rate (g day^{-1})	Production (kg m^{-3})	Survival (%)	FCR
I (100)	106.16	1.18	11.11	97.5	3.48
II (200)	92.79	1.03	19.16	95.0	2.91
III (400)	99.82	1.11	35.64*	82.5	1.96

*** Denotes a significant difference**

Figure 4.2. Weight development of tilapia hybrids when reared in marine net cages



A comparison of performance between pond-based and marine-based net cage culture of tilapia hybrids showed a significant difference between the two culture systems in terms of growth and production (Table 4.9). Growth of the hybrids cultured in marine-based net cages was higher (P=0.0121) irrespective of stocking rates. Production showed an increasing trend with higher stocking rates, and the effect was significant (P=0.0120) between the stocking rates of 100 m^{-3} (6.21 kg m^{-3}- 11.11 kg m^{-3}) and 200 m^{-3} (12.59 kg m^{-3}- 19.16 kg m^{-3}).

Table 4.9. Comparison of performance between pond-based and marine based cage culture of tilapia hybrids

Culture Type	Stocking Rate (fish m^{-3})	Growth Rate (g day^{-1})	Production (kg m^{-3})	Survival (%)
Pond-based	100	0.66	6.21	96.5
Marine-based	100	1.18*	11.11	97.5
Pond-based	200	0.68	12.59*	99.0
Marine-based	200	1.03*	19.16*	95.0

* Denotes a significant difference (P<0.05)

Discussion

The result of salinity tolerance test conducted on tilapia hybrid fry indicated that the fish cannot withstand direct stocking at salinities higher than 20 ppt. All fish samples exposed to 30 ppt (T_5) died within two hours of stocking. This result concurs with previous work by Villegas (1990), where F_1 hybrids of female *O. niloticus* x male *O. mossambicus* were unable to survive direct transfer to full seawater (32 ppt) at any age. High survival of 87% was observed following direct transfer to 20 ppt, and a sharp decline in survival occurred at 25 ppt (Villegas, 1990).

Hybrids between *O. niloticus* x *O. mossambicus* have been reported to tolerate higher salinities than pure *O. niloticus* (Watanabe *et al.*, 1985). Based on successive acclimatisation trials, improved survival rates were found when the fry were first stocked in a lower salinity level of 5 ppt, and then increased gradually by 5 ppt day^{-1} until the desired salinity level was attained. The result of the salinity tolerance test indicated the feasibility of mass producing tilapia hybrid fingerlings for stocking salt water areas.

The culture of tilapia hybrids in pond-based net cages under brackishwater conditions showed encouraging results. Acclimatised fingerlings grew well and survived in saline waters if they were given the proper management, nutrition and environmental conditions. The growth rates of tilapia hybrids from this experiment (0.74 - 0.97 g day^{-1}) were comparatively higher than the growth rate of pure *O. mossambicus* (0.127-0.188 g day^{-1}) reported by Manzano (1989) and the growth rate of pure *O. niloticus* (0.74 g day^{-1}) reported by Kuo (1969). This result concurs with previous studies that tilapia hybrids have better growth performance than their parents source (Hickling, 1967; Pruginin *et al.*, 1967; Yashouv and Halevy, 1967; Avault and Shell, 1967 and Kuo, 1969). Dureza (1994) reported higher growth rates of 1.0-2.0 g day^{-1} when stocked directly in brackishwater ponds at various stocking rates of from 6,000-8,000 ha^{-1}. Kuo (1969) also observed a higher growth rate (1.16 g day^{-1}) using hybrids of female *O. mossambicus* x male *O. niloticus*, as compared to 0.85 g day^{-1} using hybrids of female *O. niloticus* x male *O. mossambicus*, 0.74 g day^{-1} for pure *O. niloticus* and 0.59 g day^{-1} for pure *O. mossambicus*.

The higher growth rate, production and survival rate obtained from this experiment suggest the adaptability of tilapia hybrids for stocking in brackishwater environment. However, the experimental results do not provide enough information on the optimum stocking rate since the experiment did not observe critical biomass. The result suggests that the optimum fish biomass for pond-based cage culture of tilapia hybrids is beyond 12.59 kg m^{-3} provided the pond is cleaned and dried between stocking, has a minimum water depth of 1 m and a flow through water system. Further studies are required to establish optimum stocking rate, define water quality requirement and rate of water exchange, feeding requirement, FCR, economics of culture, and verify results in large-scale production.

Based on the foregoing results, a cost and return analysis of tilapia hybrid culture in pond-based net cages was prepared (Table 4.10). The analysis revealed that the technology is not financially viable when the production area is below 500 m^{-3}. Therefore, operating a one unit net cage (10 m x 10 m 1.5 m or 100 m^{-3}) is not financially viable irrespective of stocking rate. The break-even price to cover total costs in all stocking rates exceeded the selling price of 50 Pesos kg^{-1}. However, when the number of operational net cages is increased to five units, with a combined productive area of 500 m^{-3}, a stocking rate of 150 m^{-3} is financially viable (economy of scale due to labour efficiency). The break-even price to cover all costs was 39.21 Pesos kg^{-1} for a stocking rate of 150 m^{-3}. The stocking rate of 200 m^{-3} provided the highest profit of 58,489 Pesos $crop^{-1}$, however, the IRR (13.17%) was below the 15% opportunity cost of capital. Moreover, the B/C plus Capital cost was below one, indicating that it is not financially profitable. Assuming that one farm caretaker can maintain and supervise up to five net cages, then the optimum production in terms of RR, IRR and B/C ratios for the pond-based net cage culture of tilapia hybrid technology can be attained with five units net cages operating at a stocking rate of 150 m^{-3}.

Table 4.10. Cost and return analysis for operating a tilapia hybrid culture in pond-based net cages

Development cost (10 m x 10 m x 1.5 m)	One unit (Pesos)	Five units (Pesos)
Netting materials	4,500	22,500
Bamboo and wooden materials	2,500	12,500
Miscellaneous expenses	2,500	12,500
Pond and equipment (cost $cage^{-1}$)	2,500	12,500
Total	12,000	60,000
Depreciation cost (2 crops yr^{-1} x 3 yr)	2,000 $crop^{-1}$	10,000 $crop^{-1}$

A. Operating one (1) unit net cage (100 m^{-3})				
Stocking rate	50 m^{-3}	100 m^{-3}	150 m^{-3}	200 m^{-3}
Yield (kg $crop^{-1}$)[a]	399	621	928	1,259
Price (Pesos kg^{-1})	50	50	50	50
Gross sale (Pesos $crop^{-1}$)	19,950	31,050	46,400	62,950
Operating costs (Pesos $crop^{-1}$)				
Fingerlings (P0.50)	2,500	5,000	7,500	10,000
Fish pellet (P12 kg^{-1})[a]	13,694	16,543	18,486	28,554
Labour cost (P4,500 $month^{-1}$)	13,500	13,500	13,500	13,500
Miscellaneous (5% cost)	1,485	1,752	1,974	2,603
Total operating cost	31,179	36,795	41,460	54,657
Marketing cost (5% sale)	998	1,553	2,320	3,148
Direct cost	32,177	38,348	43,780	57,805
Interest on Capital (6% $crop^{-1}$)	1,931	2,301	2,627	3,468
Depreciation cost ($crop^{-1}$)	2,000	2,000	2,000	2,000
Total costs	39,359	46,203	52,195	67,804
Profit	(19,409)	(15,153)	(5,795)	(4,854)
Break-even production (kg)[b] to pay total cost	787	924	1,044	1,356
Break-even price to (Pesos)[b] cover total cost	98.64	74.40	56.25	53.86

B. Operating five (5) units net cage (500 m^{-3})				
Stocking rate	50 m^{-3}	100 m^{-3}	150 m^{-3}	200 m^{-3}
Yield (kg $crop^{-1}$)[a]	1,995	3,105	4,640	6,295
Price (Pesos kg^{-1})	50	50	50	50
Gross sale (Pesos $crop^{-1}$)	99,750	155,250	232,000	314,750
Operating costs (Pesos $crop^{-1}$)				
Fingerlings (P0.50)	12,500	25,000	37,500	50,000
Fish pellet (P12 kg^{-1})[a]	68,470	82,715	92,430	142,770
Labour cost (P4,500 $month^{-1}$)	13,500	13,500	13,500	13,500
Miscellaneous (5% cost)	4,724	6,060	7,171	10,314
Total operating cost	99,194	127,275	150,601	216,584
Marketing cost (5% sale)	4,988	7,763	11,600	15,738
Direct cost	104,182	135,038	162,201	232,322
Interest on Capital (6% $crop^{-1}$)[b]	6,250	8,102	9,732	13,939
Depreciation cost ($crop^{-1}$)	10,000	10,000	10,000	10,000
Total costs	120,433	153,140	181,933	256,261
Profit	(20,683)	2,110	50,067	58,489
Break-even production (kg)[c] to pay total cost	2,409	3,063	3,639	5,125
Break-even price to (Pesos)[c] cover total cost	60.37	49.32	39.21	40.71
Rate of return (RR)[d]	-	-	47.55%	42.30%
Internal rate of return (IRR)[e]	-	-	20.78%	13.17%
Benefit cost ratio (B/C ratio)[e]	-	-	1.28	1.23
B/C + capital cost	-	-	1.02	0.99

[a] Calculated from Table 4.7
[b] Calculated at 18% interest rate yr^{-1} (6% $crop^{-1}$ of 4 months) x working capital
[c] Adapted from Jolly and Clonts, 1993. Economics of aquaculture
[d] RR = Profit yr^{-1} over working capital (dev't. cost + first crop operating cost), adapted from Merrette and Sykes (1966). Capital Budgeting and Company Finance.
[e] Calculated at 2 crops $year^{-1}$ for 3 years and discounted at 15%

In Study 3, the culture of tilapia hybrids in marine net cages showed even more encouraging results. Irrespective of stocking rates, bigger fish and higher mean weight gain, growth rate and production were obtained compared to pond-based culture systems. The increased growth of the fish was probably due to improved water circulation and quality since water exchange in marine condition is enhanced by regular tidal currents and wave action. Growth rates (1.03 g day^{-1}- 1.18 g day^{-1}) obtained were within the range of growth rates (1.05-1.21 g day^{-1}) reported by Bautista *et al.*, (1988) in cage culture of tilapia hybrids (*O. aureus* x *O. niloticus*) in a freshwater lake.

The results suggest that the optimum stocking rate and biomass were beyond 400 m^{-3} and 35.64 kg m^{-3} respectively. Follow-up studies are necessary to confirm initial results. Better performance of tilapia hybrids was found in the marine net cages in terms of growth rate and production but no differences were found between marine net cages and earth pond net cages in terms of survival rate (Table 4.9). Production is enhanced considerably when stocking rate is increased whether the culture condition is pond-based brackishwater or marine-based sea water, provided environmental and nutritional conditions are met. Further studies are required to refine the culture technology, particularly the optimum stocking rate and biomass, feeding requirement and low-cost feeds, economics of culture and environmental effects.

A cost and return analysis for operating a one unit net cage (10 m x 10 m x 1.5 m) tilapia hybrid culture in marine conditions is shown in Table 4.11. The analysis revealed that the technology is viable at a stocking rate of 400 m^{-3}. The RR and IRR were 53.24% and 46.72% respectively. The break-even price to cover total cost of production (37.93 Pesos kg^{-1}) was below the selling price (50 Pesos kg^{-1}) of the fish at a stocking rate of 400 m^{-3}. The benefit cost ratios (B/C) are higher than 1, indicating that the technology is highly profitable. If one farm caretaker can supervise and maintain more than one unit net cage at the same period, then optimum production and profit will be attained when the operating net cage is more than one at a stocking rate of 400 m^{-3}.

Table 4.11. Cost and return analysis for operating a tilapia hybrid culture in marine-based net cages

Development cost (10 m x 10 m x 1.5 m)		One unit (Pesos)	
Netting materials		4,500	
Bamboo and floating materials		5,000	
Miscellaneous expenses		2,500	
Total		12,000	
Depreciation cost (2 crops yr^{-1} x 3 yr)		2,000	
A. Operating one (1) unit net cage (100 m^{-3})			
Stocking rate	100 m^{-3}	200 m^{-3}	400 m^{-3}
Yield (kg $crop^{-1}$)[a]	1,111	1,916	3,564
Price (Pesos kg^{-1})	50	50	50
Gross sale (Pesos $crop^{-1}$)	55,550	95,800	178,200
Operating costs (Pesos $crop^{-1}$)			
Fingerlings (P0.50)	5,000	10,000	20,000
Fish pellet (P12 kg^{-1})[a]	46,395	66,906	83,825
Labour cost (P4,500 $month^{-1}$)	13,500	13,500	13,500
Miscellaneous (5% cost)	3,245	4,520	5,866
Total operating cost	68,140	94,926	123,191
Marketing cost (5% sale)	2,778	4,790	8,910
Direct cost	70,918	99,716	132,101
Interest on Capital (6% $crop^{-1}$)	4,808	6,416	8,112
Depreciation cost ($crop^{-1}$)	2,000	2,000	2,000
Total costs	77,726	108,132	142,213
Profit	(22,176)	(12,332)	35,987
Break-even production (kg)[b] to pay total cost	1,603	2,139	2,704
Break-even price to (Pesos)[b] cover total cost	72.13	55.81	37.93
Rate of return (RR)[c]	-	-	53.24%
Internal rate of return (IRR)[d]	-	-	46.72%
Benefit cost ratio (B/C ratio)[d]	-	-	1.35
B/C + capital cost	-	-	1.10

[a] Calculated from Table 4.8
[b] Adapted from Jolly and Clonts, 1993. Economics of aquaculture
[c] Adapted from Merrette and Sykes, 1966. RR = Profit yr^{-1} over working capital
[d] Calculated at 2 crops $year^{-1}$ for 3 years and discounted at 15%

4.3. Tilapia development plan and strategies

4.3.1. *Background*

With the growing Philippine population, more fish protein will be needed to meet the nutritional requirement of the nation. The tilapia, because of its excellent farming qualities, is considered the most important warmwater aquaculture species for mass production. Today, tilapia farming in the Philippines is widely distributed and represents a big industry. Its investment viability is enhanced by the advancement in seed production technologies (e.g. SRT, GIFT, GMT) and the consumers acceptance as a food fish. The Philippines is endowed with vast water resources (fresh and marine) for the development and expansion of tilapia farming. The country's tropical climate provides excellent conditions for the production of tilapia such that it is now one of the largest producing nations in the world. Technically, the Philippines has the capability to increase and expand tilapia production. Suitable areas, expertise, manpower, feed manufacturers and financial institutions are available. Existing tilapia hatchery/nursery facilities are widely distributed throughout the country. Production technologies abound from extensive, semi-intensive and intensive culture systems whether in ponds, pens or net cages using monosexed or all male tilapia strains with fast growth rates. There is also great potential for the salt-tolerant tilapia hybrid as an alternative species to milkfish and shrimp in stocking unutilized brackishwater ponds.

The present domestic demand for fish tilapia is great. Due to the higher cost of meat (beef=150 Pesos kg^{-1}, pork/chicken=90 Pesos kg^{-1}) as compared to fish (60-80 Pesos kg^{-1}), the marketability and price of tilapia have increased greatly during the last five years. The increase in demand and the improvement of product quality may have caused the market price to go up to the advantage of the tilapia fish farmers.

The major problems that plague the industry are lack of good quality seed, inadequate extension services, environmental management and conservation issues and marketing. These are now being addressed by concerned government and non-government agencies such as SEAFDEC-AQD, ICLARM, PCAMRD and DA-BFAR. The main factor that hinders the growth and development of tilapia farming in the Philippines is the high cost of feeding. There is a need to develop an efficient culture technology (e.g. low-cost feed) to lower production costs. There is also a need to improve product quality (e.g. bigger size and packaging) to improve market price, and develop new value added products to penetrate the export market.

The strategic direction points to the proper utilisation and management of existing production areas through application of improved technologies, and the promotion and mass production of salt-tolerant tilapia hybrids for stocking under-utilised brackishwater ponds and sheltered coastal marine waters. Through this development plan, it is hoped that production from the present level of 81,182 t will increase to 135,000 t by the year 2001. It is calculated that about 2 billion tilapia fry are required to meet this production target, assuming that about 14,000 fry are needed to produce one tonne (1,000 kg x 7 fish kg^{-1} at 50% survival rate from fry to 150 g body weight) of marketable size tilapia.

4.3.2. *Objectives*

The general objective of this development plan is to increase production of tilapia over the next five years through the culture of salt-tolerant tilapia hybrids in some brackishwater ponds and sheltered marine coastal water areas throughout the country. The aim is to overcome declining production of tilapia and face the challenge of feeding the country's growing populace by the year 2000. The increase in tilapia production will contribute to the food sufficiency and security programme of the present administration. Since the projected fish deficit is large (Chapter I), the increase in tilapia production will be easily absorbed by the increasing market demand. The specific objectives of the plan are as follows:

(1). to establish hatchery and nurseries for the mass production of salt-tolerant tilapia hybrid fry and fingerlings for distribution to fish farmers throughout the country;

(2). to transfer the culture technology on salt-tolerant tilapia hybrids to fish farmers through out the country;

(3). to train fish farmers, hatchery/nursery operators, farm caretakers, technicians and extension officers on the culture of salt-tolerant tilapia hybrids;

(4). to increase production of tilapia by 10% annually through the culture of salt-tolerant tilapia hybrids through out the country.

4.3.3. *Implementing strategy and targets*

Strategies to accelerate the rapid development of the salt-tolerant tilapia hybrid culture throughout the country will be as follows.

(1). Establishment of hatchery/nurseries for salt-tolerant tilapia hybrids - Existing government farms and nurseries throughout the country will be tapped for the implementation of this plan (Figure 4.3). The existing government farms will be evaluated based on their suitability for the mass production of the salt-tolerant tilapia hybrid fingerlings. Some farms may have to be rehabilitated and upgraded before they can be utilised. There may be a need to establish new farm hatchery/nurseries in some areas which will require more seed supply for stocking grow-out units. As in milkfish, suitable and strategically located private farms will be selected and given input assistance to produce much of the fingerling requirements needed by the grow-out operators. The strategic areas, hatchery and nursery requirements and training targets for salt-tolerant tilapia hybrid culture development is shown in Table 4.12. A total of 25 coastal provinces from 11 administrative regions of the country was selected based on their proximity and accessibility to big cities as well as to the availability of suitable sites and entrepreneurs in these areas. Since profitability from tilapia is marginal (due to low price), production sites nearer to urban centres can be more advantageous to the fish farmers. A total of 19 existing government farms will be re-activated and 50 private hatchery/nursery farms will be established throughout the country. At least one government farm will be operated per region, while one private hatchery/nursery farm will be assisted for every province. The BFAR will provide good quality broodstocks to all participating fish farmers. During the first year of project implementation, about 112 million salt-tolerant tilapia hybrid fry and fingerlings will be required to support an increase in production of 8,000 t (14,000 fry to produce 1 tonne of fish). Initially, this target will be divided into 14 coastal regions of the country. Each government farm will produce 1 million fry annually, while the remainder will be produced by the private farms. In succeeding years, production from private farms will be intensified to meet the requirement of the fish growers. Tilapia fingerlings produced from the government farms will be sold to fish farmers based on prevailing market prices

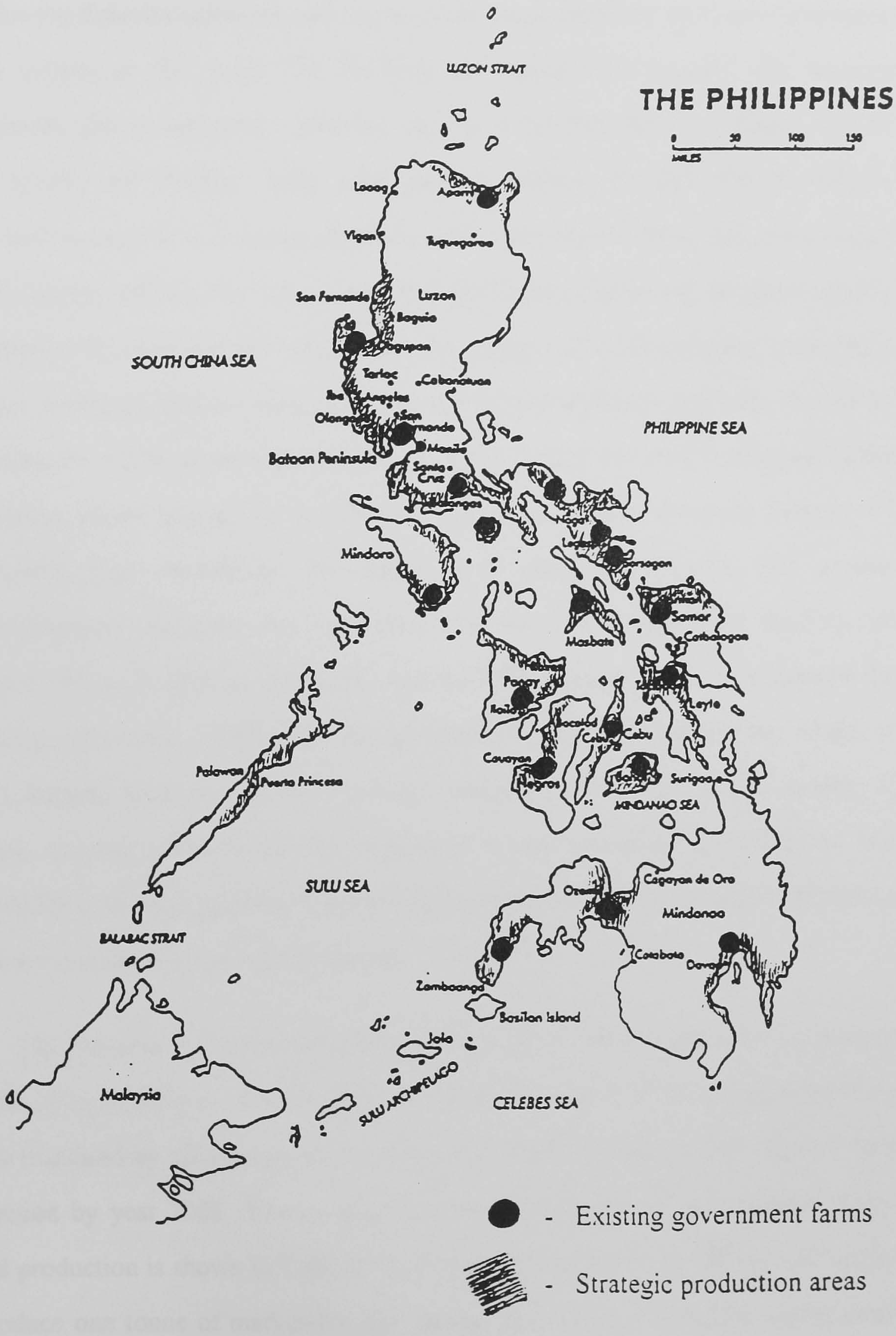
(2). Technology transfer - Strategies that will be used for technology transfer will be the usual training of end-users, the conduct of technical assistance and technology adaptation, verification and demonstration trials. Technology piloting will be intensified in key production areas throughout the country. Technology transfer will be accelerated by providing input assistance to targeted co-operators in the form of good quality broodstocks, fertilisers, feeds and technical assistance. Successful fish farmers will be rewarded (e.g. fellowship training or study tour to developed aquaculture areas, local and international) to encourage participation and recruitment of new co-operators. A total of 3,060 fish farmers will be targeted and assisted (2,200 for pond-based culture technology and 858 for marine-based technology) for a period of five years.

Table 4.12. Strategic areas, hatchery/nurseries and training targets for tilapia

Region	Strategic provinces for salt-tolerant tilapia production	Hatchery and nursery		Training programme		
		Gov't.[a]	Private[b]	EOs[c]	FF/FC[d]	
					Pond-based[e]	Marine[f]
I	Pangasinan	1	2	2	88	34
II	Cagayan	1	2	2	88	34
III	Bataan, Bulacan, Pampanga	1	6	6	264	103
IV	Batangas, Cavite, Mindoro Palawan, Marinduque, Quezon	3	12	12	528	206
V	Albay, Camarines (N&S) Sorsogon, Masbate,	4	8	8	352	138
VI	Capiz, Iloilo, Negros Occ	2	6	6	264	103
VII	Bohol, Cebu	2	4	4	176	69
VIII	Samar,Leyte	2	4	4	176	69
IX	Zamboanga	1	2	2	88	34
XI	Davao	1	2	2	88	34
XII	Lanao del Norte	1	2	2	88	34
	Total	19	50	50	2,200	858

[a] No. of targeted existing government farms and hatchery/nursery
[b] No. of targeted private hatchery/nursery farms to be established, two for each province
[c] No. of Extension Officers to be trained at 2 EOs per province
[d] No. of fish farmers (FF) and farm caretakers (FC) to be trained
[e] No. of fish farmers for pond-based net cage culture of tilapia, calculated at 500 m^2 $farmers^{-1}$ multiplied by 110 ha of pond area targeted for development in Table 4.13
[f] No. of fish farmers for marine-based cage culture of tilapia, calculated at 500 m^2 $farmer^{-1}$ multiplied by 85.81 ha of cage area targeted for development in Table 4.13

Figure 4.3 Strategic sites for the production and development of salt-tolerant tilapia hybrids



(3). Training programme - The intensive training of fish farmers' associations and co-operatives and the local government units will be used as a strategy to prepare them for the fisheries extension and management responsibilities after the termination of the project in five years. To facilitate the capacitation process, fish farmers associations and co-operatives who are already in the fish farming industry will be given priority for training. After each training session, the fish farmers will be supervised to conduct technology adaptation and verification trials in their own project sites. Extension officers who have completed the training course will be given specific co-operators for them to assist regularly in the conduct of stock sampling, monitoring of water quality parameters, data gathering and solving technical problems. A total of 3,315 trainees will be given training/seminar on the culture and seed production of the salt-tolerant tilapia hybrids for a period of five years, broken down as follows: 57 government farm technicians (19 farms x 3 personnel $farm^{-1}$), 150 private hatchery/nursery operators and caretakers (50 farms x 3 personnel $farm^{-1}$), 50 extension officers (2 EOs per province), and the 3,058 grow-out operators targeted for technology adaptation, verification and demonstration trials. To achieve this target, at least 5 training sessions will be conducted annually at 133 trainees per session. If possible, training sessions will be conducted in the provinces depending on the accessibility of the site. Regional trainers will be organised and developed to accelerate fish farmers' training in the regional levels.

(4). Increase in tilapia production - Tilapia production is projected to increase from 81,182 t in 1995 to about 84,000 t in 1996. Starting in 1997, tilapia production will be increased by 10% annually or a total of 51,000 t of salt-tolerant tilapia hybrid production by year 2001. The cumulative area development for salt-tolerant tilapia hybrid production is shown in Table 4.13. Assuming that about 14,000 fry are needed to produce one tonne of marketable size tilapia, then about 714 million salt-tolerant tilapia hybrid fry are required to meet the production target of 51,000 t by the year 2001.

Table 4.13. Cumulative area development for salt-tolerant tilapia hybrid production (Area in ha, Production in t)

Year		Brackishwater fishponds		Marine waters		Total increase	
		Area	Production	Area	Production	Area	Production
1996	(84,000)[a]						
1997	(92,000)[b]	40	1,856	17.24	6,144	57.24	8,000
1998	(101,000)[b]	80	3,712	37.28	13,288	117.28	17,000
1999	(112,000)[b]	160	7,424	57.73	20,576	217.73	28,000
2000	(123,000)[b]	280	12,992	72.97	26,008	352.97	39,000
2001	(135,000)[b]	440	20,416	85.81	30,584	525.81	51,000

[a] Calculated roughly at 3% growth rate from 81,182 t production in 1995
[b] Projected 10% increase in yearly production of salt-tolerant tilapia hybrids
Figures in parenthesis represent total cumulative increase in tilapia production from 1996-2001

Consequently, a total of 440 ha of brackishwater ponds will have to be converted into a pond-based net cage culture of salt-tolerant tilapia hybrid with a production potential of 9.28 kg m^{-3} or 185.6 t ha^{-1} yr^{-1} at 2 crops yr^{-1} (Table 4.7 and Table 4.10). Assuming that one hectare of brackishwater pond has a productive area of 2,500 m^{-2} cages, the project would require about 4 ha of brackishwater ponds ha^{-1} of pond-based net cages. On the other hand, about 86 ha of sheltered marine waters will be utilised for productive net cage culture of salt-tolerant tilapia hybrids with a production potential of 35.64 kg m^{-3} or 712.8 t ha^{-1} yr^{-1} at 2 crops yr^{-1} (Table 4.8 and Table 4.11). Assuming that one hectare of sheltered marine waters has a productive area of 5,000 m^{-2} net cages, the project would require about 2 ha of marine coastal waters ha^{-1} of marine-based net cages. Production sites will have to be strategically zonified and scattered in different localities to avoid possible effects of environmental pollution and diseases.

4.3.4. *Implementing agencies*

Existing government agencies involved in fisheries development, such as DA-BAR, PCAMRD, DA-RFOs, BFAR and LGUs will be in the best positions to implement this development plan since they have the existing facilities, manpower and regular budget to support R&D, extension and training activities. Specifically, DA-BAR and PCAMRD will provide the funds. BFAR can implement the R&D and training components. DA-RFOs can assist in training and technology transfer components, and the LGUs can handle the extension activities most particularly after the termination of the project in year 2001. Non-government organisations [e.g. Philippine Chamber of Fisheries and Aquatic Resources (PCFAR), Society of Aquaculture Engineers of the Philippines (SAEP)] can be tapped for the implementation of training and technology transfer activities.

4.3.5. *Time frame*

The implementation of this plan will be for a period of five years to start in 1997 and to end in 2001. The evaluation of strategic sites for the establishment of hatchery/nursery farms will precede all other activities during the first quarter of 1997. This will be followed by the implementation of training activities, establishment of hatchery/nursery units, technology adaptation/verification/demonstration trials, and extension activities in that order. The project shall be in full swing in the second year (1998) of project implementation.

4.3.6. *Inputs and expected benefits*

The implementation of this plan would mean the development of the salt-tolerant tilapia hybrid for stocking undeveloped salt water areas throughout the Philippine islands. More important is that the hybrid can be an important substitute for milkfish and shrimps in stocking brackishwater fishponds.

The development plan is designed to provide additional or alternative livelihood to coastal fisherfolks, particularly the marginal fishermen who are living near the coastline. The cage culture of tilapia hybrids in salt water areas could provide new job opportunities to new hatchery/nursery and grow-out operators, farm caretakers, part-time labourers and technicians. The projects will also open many additional jobs in related industries such as food processing and marketing, transportation, feed manufacturing, supplies and materials, etc.

The estimated budgetary requirements and direct benefits for the development of the salt-tolerant tilapia farming industry is shown in Table 4.14. The estimated development cost is about 6.78 billion Pesos, while the expected direct benefits is about 8.0 billion Pesos in five years. Direct employment that will be created by the plan is about 9,200 people, while total dependents is 45,900 people. Therefore, the implementation of the plan will affect directly about 55,080 Filipinos.

Other expected benefits are additional tax revenues from direct sale of fish products and income tax returns on new employment. The cage culture projects would generate additional supply of fish in the domestic market and reduce fish deficit. Hopefully, this would reduce fish imports and help the balance of trade. The utilisation of some undeveloped brackishwater fishponds and coastal marine waters will make them productive, thereby contributing to the food sufficiency and security programme of the national government. Lastly, the increase in fish production will contribute to the gross domestic product (GDP) of the country; improve health and nutrition of the Filipinos; and increase in trading activities which makes for a healthy and sound economy.

Table 4.14. Estimated budgetary requirements (Million Pesos) and direct benefits for the development of salt-tolerant tilapia farming industry in the Philippines, 1997-2001

Item	Budgetary requirement
<u>Inputs requirement</u>.	
Research/extension facilities and manpower	Existing
Evaluation of strategic areas (0.5 million x 11 Regions)	5.5
Research and Development (0.5 M x 25 Provinces x 5 yr)	62.5
Extension programme (TEV, 1 million x 11 Regions x 5 yr)	55.0
Training programme (3,325 trainees x P5,000/trainee)	16.6
Production inputs:	
Broodstocks (1.0 million x P5.00)	5.0
Fingerlings (2.0 billion x P0.50)[a]	1,000.0
Fish feed (143,000 t x 2.5 FCR x 12 Pesos kg^{-1})[b]	4,290.0
Ponds and equipment (440 ha x P150,000 ha)[a]	660.0
Nets/floats/bamboo (1.2 M x 85.81 ha)	103.0
Miscellaneous expenses (10%)	560.4
Contingency cost (10%)	616.4
Total budgetary requirements	6,780.4
<u>Expected benefits.</u>	
Gross value: Sale(143,000 t x 50 Pesos kg^{-1})	7,150.0
Land valuation (440 ha x 200,000 Pesos ha)	88.0
Tax revenues: Sale (7.15 billion Pesos x 10% tax)	715.0
Land (88 million Pesos x 1% tax)	1.0
Employment (3,216 farmers x P54,000 income yr^{-1} x 1%)	1.7
Total direct benefits (Pesos)	7,955.7
Direct additional employment and beneficiaries:	
Regular (3,060 farmers/hatchery operators/ caretakers)	3,060 People
Part-time (calculated at 2 persons per regular worker)	6,120 People
Family dependents (calculated at 5 persons per labourer)	45,900 People
Total	55,080 People

[a] Calculated from Table 4.13
[b] Calculated at an FCR of 2.5

5. GROUPER: OVERVIEW OF THE INDUSTRY, TECHNOLOGY DEVELOPMENT AND DEVELOPMENT STRATEGIES

5.1. Overview of the grouper industry in the Philippines

5.1.1 *Background*

The groupers are among the most commercially important marine food fish in the Philippines and Southeast Asia. The fish commands a high market value because of its good organoleptic qualities. They are farmed commercially in brackishwater fishponds and marine net cages. The fish grow fast and attain marketable size of about 500-600 g body weight in six to eight months depending on the environmental conditions (Chua *et al.*, 1980). The most important species cultured in Asia belong to the Genus *Epinephelus* (Table 5.1).

Table 5.1. Important species of groupers cultured in Asia

Species	Common name	Countries
Epinephelus malabaricus L.	Black-spotted grouper	Philippines, Thailand
Epinephelus salmoides Max.	Estuarine grouper	Malaysia, Philippines
Epinephelus tauvina Forskal	Brown-spotted grouper	Singapore, Kuwait
Epinephelus akaara T & S.	Red-spotted grouper	Japan, Hongkong, China
Epinephelus amblycephalus B.	White-spotted grouper	Hongkong, Philippines
Epinephelus bleekeri B.	Yellow-spotted grouper	Hongkong, Philippines
Epinephelus fuscoguttatus L.	Brown-spotted grouper	Indonesia, Singapore

Source: Duray, M.N. (SEAFDEC-AQD).

The culture of groupers in Asia, particularly Singapore, Hongkong and Malaysia, started during the 1970s. Production is mainly practised in floating net cages installed in marine coastal bays and estuaries. In the Philippines, it was only during the

1980s where grouper farming developed. The popularity of grouper for cultivation can be attributed to its fast growth rate, high market price and export value.

In 1993, the Philippines contributed about 10.3% (772 t) of the world's total aquaculture grouper production of 7,500 t. Malaysia was the leading country contributing 13.4%; followed by Thailand, 13%; Philippines, 10.3%; Hongkong, 8.4%; and Singapore, 2%. Table 5.2 shows the major producers of groupers in recent years. Since grouper is a high value fish, most of the production were exported to other Asian countries. Locally, there are no available data on the average per capita consumption of the fish.

Table 5.2. World aquaculture production (t) of groupers (Serranidae) between 1990 and 1993

Country	1990	1991	1992	1993	% Contribution in 1993
Malaysia	143	144	264	1,006	13.4
Thailand	415	355	916	1,000	13.3
Philippines	2,363	6,765	349	772	10.3
Hongkong	365	265	55	632	8.4
Singapore	153	153	233	147	2.0
Other Asia	2,206	1,229	1,125	3,942	52.6
Total	5,645	8,911	2,944	7,500	100.0

Source: Aquaculture production statistics 1984-1993. FAO Fisheries cir. no. 815, rev. 7. FAO, 1995.

The grouper industry in the Philippines is developing rapidly mainly due to its export potential. Many fish farmers have diversified to grouper production due to the collapsed of the shrimp industry in late 1980s. In view of this development, the Presidential Task Force on Science and Technology, Sectoral technical panel in Agriculture and Aquaculture in 1989, identified grouper as one of the eight commodities expected to contribute substantially to the country's Gross National

Product (GNP). The increasing demand for grouper encouraged local fish farmers to look for available production technologies. The major problems of the industry are the lack of grouper fingerlings and feed based on trash fish.

5.1.2. *Production performance and trend*

The bulk of grouper production in the Philippines comes from the municipal catch with a share of about 86% (12,878 t) of the total grouper production of 14,931 t in 1995 (BAS, 1996 and BFAR, 1996). Other production comes from commercial catch with a share of 9% (1,348 t) and aquaculture about 5% (705 t). Aquaculture production comes from brackishwater fishponds. In recent years, production in net cages has also been practised, especially in sheltered coastal bays and estuaries. At present, there are no available data on the total pond and cage areas engaged in grouper production. The Philippine production of groupers in recent years is shown in Table 5.3.

Table 5.3. Philippine production of groupers in recent years (t)

Year	Commercial	Municipal	Aquaculture	Total
1991	2,403	24,152	6,765*	33,320
1992	946	13,611	349*	14,906
1993	1,170	13,188	772*	15,130
1994	2,380	11,274	2,111**	15,765
1995	1,348	12,878	705**	14,931

Source: Fishery statistics 1986-1995. BAS, 1996.
* Aquaculture production statistics 1984-1993. FAO Fisheries cir. no. 815, rev. 7. FAO, 1995.
** 1994 and 1995 Philippine fisheries profile. BFAR, 1995/1996.

Aquaculture production of groupers in the Philippines fluctuated during the last five years, from a peak of 6,765 t in 1991, dropping to a low of 349 t in 1992 and then increasing to 2,111 t in 1994. The sudden drop in production in 1992 was due to the lack of seed supply for stocking, since some grouper fingerling are exported to neighbouring Asian countries. The island of Luzon and near-by island provinces, particularly areas covering administrative regions I to V, being near to Metro Manila markets and exporters, are among the major producers of groupers.

5.1.3. *Grouper price trend*

In the last decade, groupers have enjoyed a high price in the local market. This was because the bulk of the produce was exported to other Asian countries which pulled the local price up towards the export price. The domestic market price of groupers was higher than milkfish or tilapia. In 1995, market wholesale price of groupers was 108.37 Pesos kg^{-1} while milkfish and tilapia were 58.19 Pesos kg^{-1} and 42.39 Pesos kg^{-1} respectively.

The price of groupers has steadily increased in recent years from 62.10 Pesos kg^{-1} wholesale price in 1991 to 108.37 Pesos kg^{-1} in 1995, or an average annual increase of 18.63% (Table 5.4). Significant increases were observed in 1994 and 1995 when prices increased by 31.5% and 15.13% respectively. The positive annual increase in grouper price was due to lack of supply coupled with an increasing export market. The retail price also increased from 71.45 Pesos kg^{-1} in 1991 to 109.40 Pesos kg^{-1} in 1994, or an average annual increase of 16%. The price margin increased by an average annual rate of 21.7% between 1991-1995, indicating the increasing cost of the product. Since the fish has good organoleptic characteristics, the consumers were prepared to pay for the high market price.

Table 5.4. Market price of groupers in recent years (Pesos kg^{-1})

Year	Wholesale price	Retail price	Price margin	% Increase
1991	62.10	71.45	9.35	15.06
1992	70.32 (13.24)	78.28 (9.56)	7.96 (-14.9)	11.32
1993	71.57 (1.78)	81.10 (3.60)	9.53 (19.7)	13.32
1994	94.13 (31.50)	109.40 (34.90)	15.27 (60.2)	16.22
1995	108.37 (15.13)	-	-	-
Ave. annual increase	(15.41)	(16.02)	(21.70)	13.98

Source: Fishery statistics 1986-1995. BAS, 1996.
Figures in parenthesis represent annual growth rate.

5.1.4. *Markets for Philippine groupers: domestic and export*

The domestic market for groupers is normally the big hotels and seafood restaurants which are patronised by tourists and business groups. Chinese and seafood restaurants in big cities throughout the Philippines usually pay three to five times the normal price for live groupers weighing between 400 to 1000 g body weight. Other domestic markets are the elite groups of Chinese and rich Filipino businessmen who can afford to pay for this high value fish. People belonging to the middle class group also relish the fish on special occasions. Grouper, produced by commercial and municipal fisheries, is generally marketed in urban centres via several intermediaries such as fish broker/trader, wholesaler, retailer and consumer; while production from aquaculture is normally sold live to exporters and first class hotels and restaurants.

The demand for groupers, either in dead or live form, is large. A market survey conducted in 1993 by the Sea farming Research and Development Department (SRDD) of the Philippine Human Resources Development Centre (PHRDC), revealed that there was a whole year demand of groupers with the peak season in October to

March when most Philippine festivals are held. Live groupers are in greatest demand because of the seafood restaurants and export requirements. The survey also revealed that the seafood restaurants in Metro Manila alone required more than 3000 pieces of marketable size groupers (400-1200 g body weight) every month for their regular customers. Similarly, the demand from exporters was also great. The export markets for marketable size groupers are mainly Hongkong, Taiwan, Japan and Singapore. Live grouper fingerlings (5-7 cm body length) are also exported to Taiwan and Hongkong. Table 5.5 shows the buying price for live groupers within Metro Manila; the price varies depending on the size of the fish.

Table 5.5. Buying price of live groupers in Metro Manila, Philippines (1993)

Size range	Pesos	Pound sterling *
400 g	300 kg^{-1}	7.90 kg^{-1}
500 - 700 g	290 kg^{-1}	7.63 kg^{-1}
800 - 1000 g	250 kg^{-1}	6.58 kg^{-1}
1100 g	350 $fish^{-1}$	9.21 $fish^{-1}$
1200 g	450 $fish^{-1}$	11.84 $fish^{-1}$

Source: Potential of grouper culture. Gaffud *et al.*, 1993. PHRDC-SRDD.
*Conversion ratio (1993): GBP 1= 38 Philippine Pesos

5.1.5. *Production methods and practices*

Background

Grouper farming in the Philippines is a new industry. It started as an extraneous fish that entered milkfish ponds during tidal water exchange. Since the fish is carnivorous, it was regarded as a fish predator in milkfish and shrimp farms. The increasing demand for groupers in the 1980s caught the attention of some fish farmers who were then losing money in the shrimp farming business. Grouper culture started in brackishwater fishponds. However, the practise is very extensive, generally in combination with Mozambique tilapia which serve as the forage fish. In recent years, production of groupers in marine net cages has become popular with the availability of new technology. At present, the main practise is culture in brackishwater fishponds using either monoculture or polyculture methods. The culture of grouper is highly dependent on: the supply of wild fry and trash fish feed. The propagation technology for groupers is available, but mass production of fry to fingerlings is not yet viable. Artificial feed substitute for groupers has been developed in other Asian countries, but the cost of production is very high. The most economical food for groupers is trash fish. Grouper production in the Philippines has three phases, namely: fry collection, fry nursery and grow-out.

Fry collection from the wild

Grouper fry and fingerlings are collected from tidal rivers, estuaries and coastal bays. Their availability is seasonal although in some areas grouper juveniles are available all year round, with a peak between November and June. Grouper fry measuring 2-3 cm body length abound in estuarine areas particularly around the mouths of tidal rivers during the spawning season. The fry are collected by a fish net trap set at the mouth of the river as they are carried by tidal currents towards the shore. Grouper fingerlings measuring 5-12 cm body length are caught by baited hook and line, bamboo trap or dip net. Fingerlings caught with hook and line sometimes develop serious fungal and bacterial disease due to wounds inflicted by the hook.

Newly caught grouper juveniles are maintained in tanks or net cages until they are packed in oxygenated plastic bags and shipped to grouper fry traders. In some cases, the fish traders collect the fingerlings at the fishing ground at a pre-arranged market price. During times of abundant fry availability, the price of juvenile groupers dropped to 2.0 Pesos fish^{-1} from a normal price range of 5-10 Pesos fish^{-1}. Grouper fingerlings measuring 5-12 cm body length can command a price between 30-50 Pesos fish^{-1} depending on availability. Farmers who raise groupers on a commercial-scale normally purchase their seed from fry traders. Some small-scale growers buy their seed directly from the gatherers, normally at discounted price.

Nursery phase

In the Philippines, there are several methods practised by the fish farmers. Some farmers stock grouper juveniles in hapa nets installed inside earth ponds. Others stock juvenile groupers directly in a pre-prepared nursery ponds. In both cases, survival rate is very low, ranging from 0-20% depending on the management expertise of the fish farmer, quality of juveniles and climatic condition. Another practise is to buy only fingerling-sized groupers, measuring between 5-10 cm body length, for which the survival rate is almost 100%.

A recent development in nursery management is the use of several nursery net cages wherein grouper juveniles are sorted regularly to avoid cannibalism of smaller individuals. This method has been found to improve survival rate of grouper juveniles, however, it is labour intensive and involves too much handling. The stocking rate for juvenile groupers in the nursery net cages is 70-75 m^{-3}. The stocking rate is reduced to 60 m^{-1} after the fish reach between 5-7 cm body length. The fingerlings are harvested after about two to three months in the nursery.

Grow-out phase

The grow-out phase is done in earth ponds or net cages. The net cage can be either floating or fixed. The most popular method practised by fish farmers is the culture in floating net cages in protected marine coves and bays. The net cages are made of bamboo or wooden materials secured in styrofoam floats or plastic drums and carbuoys. The cages vary in size but the common measurements are 2.5 m x 2 m x 2 m, 3 m x 3 m x 3 m, and 5 m x 5 m x 4 m. Stocking rates in grow-out cages are 50-60 m^{-3} at an initial body size of 8-12 cm. During the growing period, the stocking rate is reduced to 40 m^{-3} once the fish reach 200-250 g body weight and lastly to 30 m^{-3} when the fish reach 400 g body weight up to harvest. Generally, the fish are harvested between 500-800 g body weight after a 6-8-month culture period.

In ponds, the practise is extensive polyculture with stocking rates varying from 2000-6000 ha^{-1} (Kohno *et al.*, 1988). The production level in ponds is very low compared to net cage culture. Efforts are being made to increase production in ponds through field testing of new methods and management techniques. Groupers are fed with chopped trash fish at 5-10% of the total fish body weight every two days. FCR is high, at about 4-5:1.

The net cages have several advantages compared to ponds, such as: high stocking rate and productivity, low development cost, low maintenance cost and continuous cropping. However, nets have to be cleaned and changed periodically, hence they are labour intensive. Furthermore, net cage culture in marine coastal waters is always susceptible to strong winds and typhoons.

5.1.6. *Issues and constraints of grouper industry in the Philippines*

Seed supply

A sudden increase of grouper fish farmers during the last decade has created a shortage of grouper fry and fingerling for stocking. Therefore, the expansion of the grouper industry is limited by the availability of the seed from the wild. This limitation becomes a mojor risk in the expansion of grouper production (Table 7.4). The problem is compounded by uncontrolled export of fingerlings to neighbouring Asian countries such as Taiwan and Hongkong, since the government does not have any law prohibiting the exportation of this species. Fish farming groups have urged the national government to prohibit such exportation, but with the recent implementation of the GATT (General Agreement on Tariff and Trade) law, this commodity has been liberalised by the government. At present the availability of grouper fingerlings is subject to price fluctuation. Previous studies on the breeding of groupers (*Epinephelus* sp.) have been conducted (Chen, 1979; Tseng et al., 1988 and SEAFDEC-AQD, 1990), but the survival rate from larval rearing to fingerling size of 5-7 cm body length is low (5%), making the technology unadaptable for private hatchery operations. For the grouper industry to expand, there is a need to intensify research on mass production of grouper fingerlings. There is also a need to identify species from wild stocks to be able to select only species that have potential for aquaculture production.

Feed supply and availability

Another major problem of grouper farming in the Philippines is the poor supply of trash fish feed. In the natural environment, groupers are carnivorous. They prefer to eat live food such as fish and crustaceans. In the cultured environment, the fish can be conditioned to feed on trash fish. However, the food conversion ratio is very high (FCR=5:1). Since small fish in the Philippines are also being consumed by the populace, either in fresh, dried, salted or fish paste, trash fish supply in the markets is limited. Furthermore, the utilisation of small fish for grouper food would affect the human needs for the same protein source, and is therefore not a productive and economical option. To sustain the growth of this industry, there is a need to develop an alternative feed for groupers other than trash fish. Previous studies on grouper feed substitute have been carried out in other Asian countries such as Singapore and Hong Kong, but the diet requires high protein levels so that the production cost is still very expensive. Studies on low-cost diets must be continued to develop an economical feed substitute. Studies on polyculture and biomanipulation studies should be encourage to improve production efficiency.

Mortality rate of grouper fry

Allegedly, there is an abundance of grouper fry (2-3 cm body length) collected by fry gatherers from estuaries during the spawning seasons. However, some fish farmers are reluctant to buy due to the low survival rate experienced at the nursery stage. The common practise, therefore, is to buy only fingerling-sized fish (5-7 cm body length) where the experienced mortality rate up to marketable size is minimal. More studies are required to develop a nursery technology for wild grouper fry. The nursery technology that will be developed, would maximise utilisation of wild fry supply whilst hatchery techniques are still being refined.

5.2. Technology development

5.2.1. *Background*

In response to the growing demand for grouper culture technology from fish farming groups, the National Brackishwater Aquaculture Technology Research Centre of the BFAR undertook several production-oriented studies aimed at improving survival rate and maximising pond production and economics per unit area. The clamour for grouper culture technology cropped up in view of the worsening condition of the shrimp farming industry in the late 1980s. Since the shrimp farms already exist, it is incumbent on the part of the government to find an alternative aquaculture species for diversification of production. Groupers, in view of its high market value and export potential, were identified by the previous administration as a priority species for aquaculture development.

5.2.2. *Culture of grouper (Epinephelus* sp.) *in brackishwater ponds*

Introduction

In response to the growing demand for grouper culture technology from the private sector, the Bureau of Fisheries and Aquatic Resources through its National Brackishwater Aquaculture Technology Research Centre conducted several production-oriented studies on grouper aimed at: improving the survival rate of wild fry; and developing nursery and grow-out culture management techniques in brackishwater ponds for dissemination to fish farmers. The studies were in line with the present administration's policy to encourage the development of export commodities. This thesis presents the preliminary results of experiments conducted at the station.

Materials and methods

Study 1. Sorting frequency study of grouper fry in nursery net cages

The experimental site used in this study was a 5000 m^{-2} earthen pond with a maximum water depth of 1.2 m and a flow-through water control system (one inlet and one outlet control gate). The pond was cleaned of debris and dried for one month prior to experimentation.

The experiment consisted of three treatments replicated three times in a randomised complete block (RCB) design. The treatments were as follows:

Treatment	Sorting frequency	Replication
I	Weekly	3
II	Bi-weekly	3
III	No sorting	3

Nine plastic net cages measuring 1 m x 1 m x 1 m each mounted on a wooden frame were suspended in floating PVC pipes. The net cages had 8-mm mesh and were installed 1.5 m apart in rows of three. The net cages were submerged 80 cm below the waterline. The whole experimental unit was anchored onto wooden posts which were fixed to the pond bottom. Additional net cages were installed every sorting period as required.

Grouper fry measuring 2-3 cm body length were procured from a grouper fry dealer. Grouper fry used in the experiment were a mixture of different species due to the difficulty in identifying the species. Upon arrival at the site, the fry were sterilised in 10-20% formalin for about 15-20 minutes, then acclimatised and conditioned in 250 L capacity plastic tanks for two weeks. Any dead fry due to transport, handling and acclimatisation stress were removed daily. The fry were fed with live fish, crustacean and insects larvae which were collected in brackishwater ponds.

Healthy and conditioned grouper fry were sorted and stocked in experimental net cages at a stocking density of 150 per cage. Only uniform-sized fry (1.29 g ABW) were selected for experimentation. The fry were fed to satiation thrice daily at 08.00, 12.00 and 17.00 h, respectively. During the first month, the experimental fish were fed with minced trash fish and crustaceans. In the second month, the fish were weaned with shredded trash fish. In the third and last month, the fish were given chopped trash fish.

Except for the control (Treatment III), the experimental fish were sorted regularly according to their assigned schedule, by manually separating the smaller ones. The smaller ones were transferred to another net cage to prevent them from being cannibalised by the bigger ones. Water depth inside the pond was maintained between 1.0-1.2 m and changed at least 40% daily when tidal fluctuation made it possible.

Physico-chemical parameters such as salinity, temperature and transparency were monitored twice daily between 08.00-09.00 h and 16.00-17.00 h, respectively. Test for significance on fry survival and growth rates were analysed using SPSS Windows LSD tests.

Study 2. Feeding rate study of groupers in pond-based net cages

The experimental site used in this study was an 8000 m^{-2} earthen pond with a maximum water depth of 1.5 m. The pond was cleaned of debris and dried for one month prior to experimentation.

Eight plastic net cages measuring 1 m x 1 m x 1 m each with wooden frame were installed 1.5 m apart in PVC raft. The plastic net cages having 8-mm mesh, were submerged 80 cm below waterline.

The experiment consisted of four treatments replicated twice in a randomised complete block (RCB) design. The treatments were as follows:

Treatment	Feeding rate (% BW)	Replication
I	5	2
II	10	2
III	15	2
IV	Satiation	2

Grouper fingerlings surviving from Study 1 were used in this experiment. Since the fingerlings were varied in size, they were sorted into three groups. The biggest and the smallest-sized groups were removed. Medium-sized fingerlings weighing between 9-41 g body weight were selected and stocked at a density of 40 per cage. The experimental fish were fed every other day (Chua *et al.*, 1982) with chopped trash fish based on their assigned feeding rates. At least 40% of pond water was changed daily when tidal fluctuation allowed. Water depth inside the pond was maintained between

1.0-1.2 m. At least 25% of the fish were sampled every month to determine their growth rate and adjust the feeding rate. Water salinity, temperature and transparency were monitored twice daily between 08.00-09.00 h and 16.00-1700 h, respectively. Production variables such as mean weight gain, growth rate, survival rate and net production were analysed using SPSS Windows LSD tests.

Study 3. Stocking density study in brackishwater pond

Nine earth ponds (300 m^{-2}) measuring 20 m x 15 m were used in this study. The experimental ponds were equipped with one inlet pipe and another outlet pipe on the opposite side to effect a flow-through water exchange during tidal fluctuation. The ponds were prepared (e.g. cleaned, levelled and limed) and dried for at least 15 days to harden the pond bottom soil prior to introduction of sea water.

A new batch of grouper fingerlings was taken from the nursery net cages of the National Brackishwater Aquaculture Technology Research Centre for this experiment. The experiment consisted of three treatments replicated three times in a randomised complete block (RCB) design. The treatments were as follows:

Treatment	Stocking rate (fish ha^{-1})	Density (fish $pond^{-1}$)	Replication
I	1,000	30	3
II	3,000	90	3
III	5,000	120	3

Grouper fingerlings weighing between 33-76 g body weight were stocked in the experimental ponds based on their assigned stocking rates. The fish were fed to satiation (Chua *et al.*, 1978) every two days. The food was given manually in small amounts until such time the fish stop feeding. At least 40% of pond water was changed daily when tidal fluctuation allowed. Water depth was maintained between 1.0-1.2 m using an electric water pump. At least 10% of the stock was sampled every month to assess the growth of the fish. Water salinity, temperature and transparency were monitored twice daily between 0800-0900 h and 1600-1700 h, respectively. Production variables such as mean weight gain, growth rate, survival rate and net production were analysed using SPSS Windows LSD tests.

Results

The effects of sorting frequency on the survival rate and growth rate of grouper fry are shown in Table 5.6 and Table 5.7 respectively. Sorting frequency produced a significant effect on the survival rate of the fry (P=0.001). Treatment I (weekly sorting) had the highest survival rate (76%) while Treatment III (no sorting) had the lowest survival rate (64.7%). The observed values between Treatments I and II were not statistically significant.

Table 5.6. Effect of sorting frequency on survival rate of grouper fry

Treatment	Frequency	Survival rate (%)			Mean
		$Replication_1$	$Replication_2$	$Replication_3$	
I	Weekly	74	79	75	76.0*
II	Bi-weekly	75	74	71	73.3*
III	No sorting	65	65	64	64.7

* Denotes a significant difference

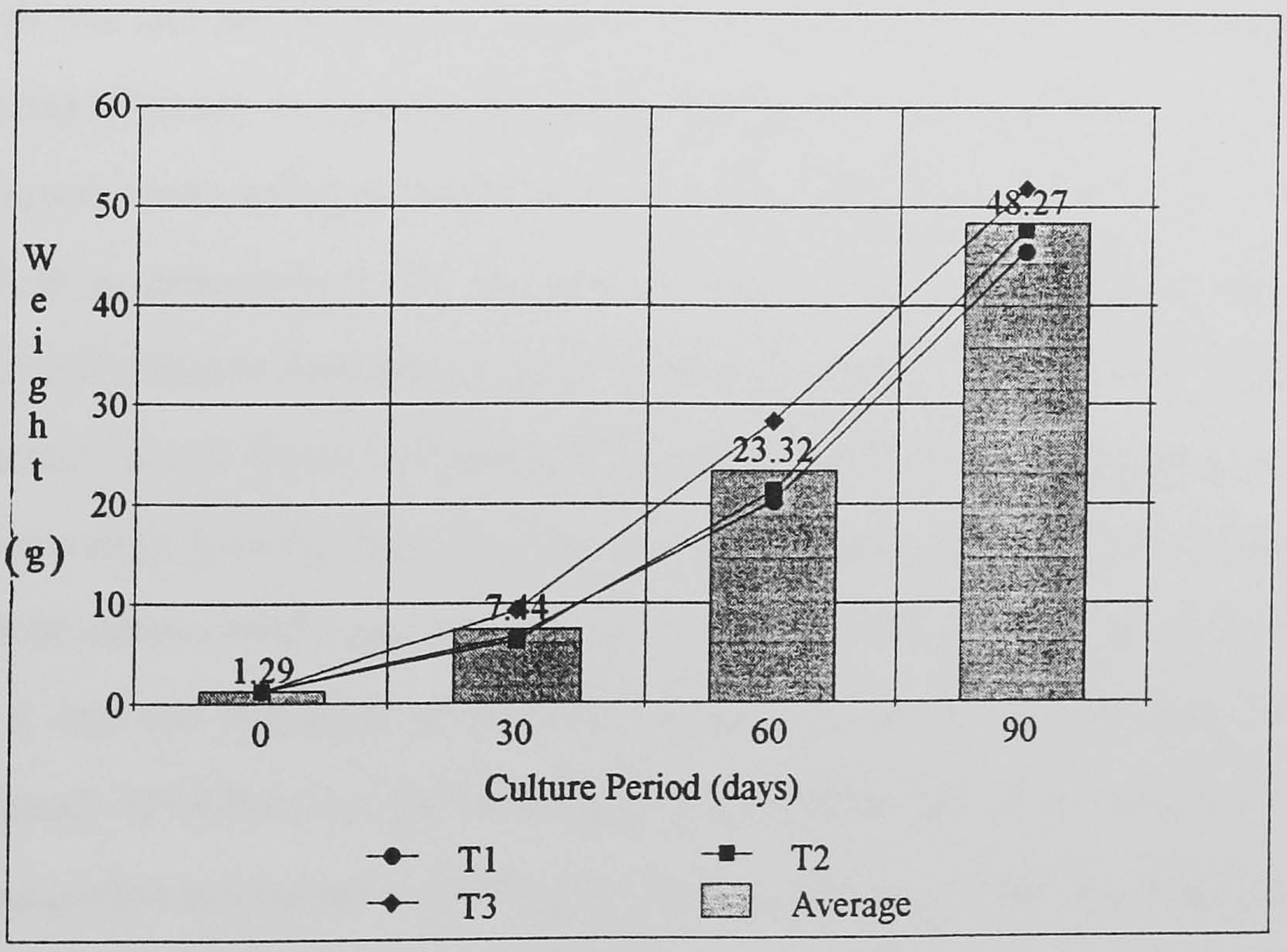
In terms of growth rate, Treatment III showed the highest at 0.63 g day^{-1} (P=0.0473), while growth rates between Treatments I (0.42 g day^{-1}) and II (0.48 g day^{-1}) were not significantly different. The result indicated that fry handling and cannibalism had an effect on the growth of grouper fry.

Table 5.7. Effect of sorting frequency on growth rate of grouper fry

Treatment	Frequency	Growth rate (g day^{-1}) Replicate$_1$	Replicate$_2$	Replicate$_3$	Mean
I	Weekly	0.35	0.42	0.49	0.42
II	Bi-weekly	0.43	0.42	0.60	0.48
III	No sorting	0.65	0.68	0.56	0.63*

*** Denotes a significant difference**

Figure 5.1. Weight increase of grouper fry raised in pond-based nursery net cages



The weight increase of grouper fry reared in pond-based nursery net cages is shown in Figure 5.1. The average weight increase in all treatments were 7.14 g, 23.32 g and 48.27 g during the first, second and third months of culture respectively. There was a significant increase in growth rate with increasing growing time (P=0.0001).

Average growth rates were 0.21 g day^{-1}, 0.53 g day^{-1} and 0.83 g^{-1} day during the first, second and third months of culture respectively.

Study 2. Feeding rate study of groupers in pond-based net cages

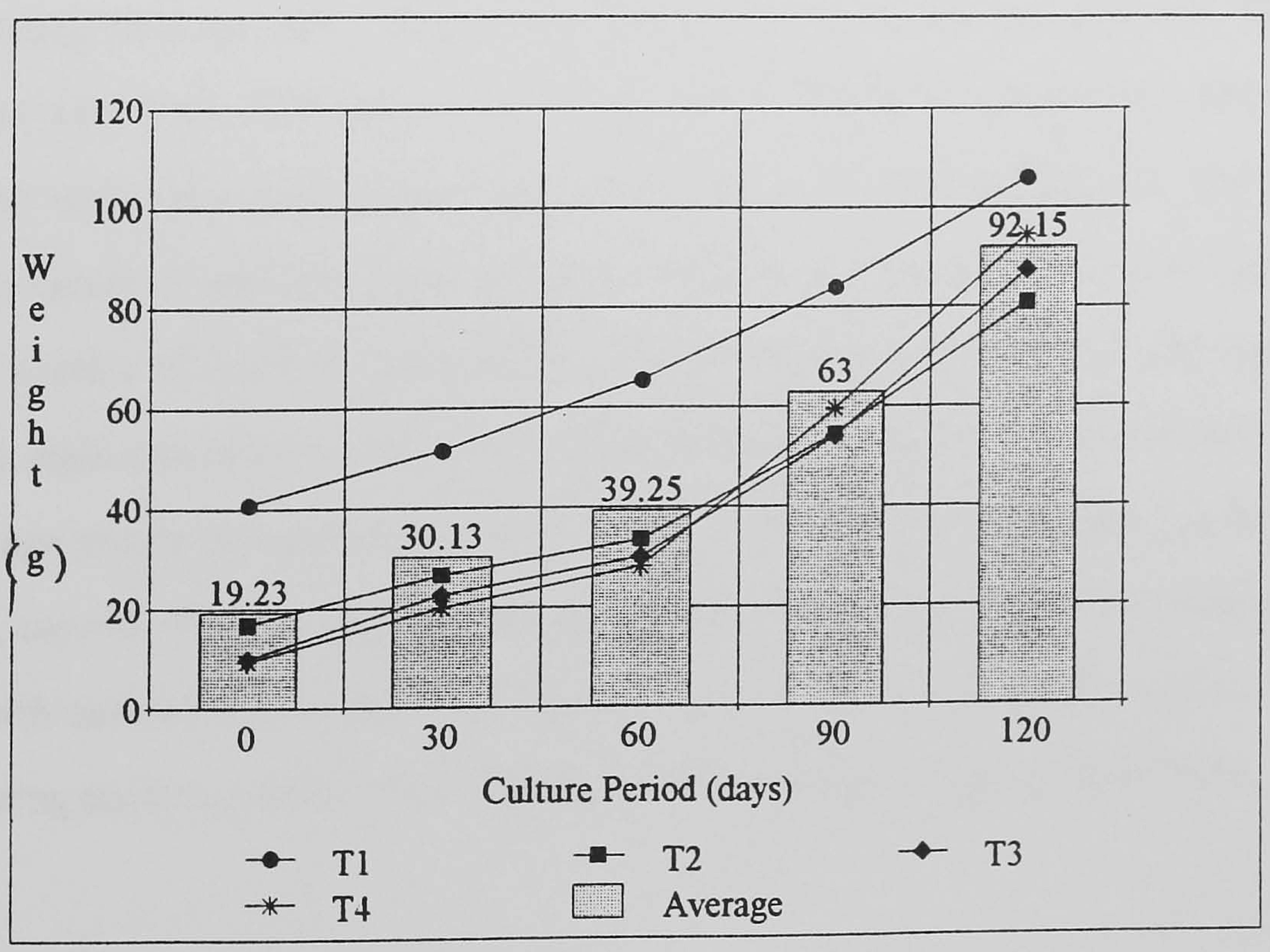
The effects of feeding rate on the culture of groupers in pond-based net cages is shown in Table 5.8. The mean weight gain, growth rate and net production between treatments were significantly different ($P<0.05$). Data indicated an increasing trend in the mean weight gain, growth rate and net production of groupers with corresponding increase in feeding rate. Satiation feeding (Treatment IV) resulted to highest mean weight gain (85.32 g), growth rate (0.71 g day^{-1}) and net production (3.34 kg m^{-3}). Growth rate and net production between Treatments III and IV were not statistically significant ($P>0.05$). Increasing the feeding rate had no observed effect on survival rate of groupers when reared in pond-based net cages. FCR values were 4.32, 4.62, 5.10 and 5.04 in treatments I, II, III, and IV respectively, and the values were not significantly different from each other ($P>0.05$). The growth increment of groupers fed at different rates is shown in Figure 5.2. The trend indicated an increasing growth rate with increasing growing time. Slowing down of growth was observed in the second month of culture which was may be due to frequent changes in pond water salinity since it was the beginning of the rainy season. However, growth rates increased significantly ($P=0.001$) on the third and fourth months of culture respectively. The average growth increments were 30.13 g, 39.25 g, 63.0 g, and 92.15 g during the first, second, third and fourth months of growth respectively. Average growth rates were 0.36 g day^{-1}, 0.30 g day^{-1}, 0. 79 g day^{-1} and 0.97 g day^{-1} during the first, second, third and fourth months of the culture period.

Table 5.8. Effects of feeding rates on growth, survival and FCR of groupers in pond-based net cages

Treatment	Mean weight gain (g)	Growth rate (g day^{-1})	Survival rate (%)	Production (kg m^{-3})	FCR
I (5%)	65.25	0.55	98.75	2.58	4.32
II (10%)	63.97	0.54	97.50	2.50	4.62
III (15%.)	77.32	0.65*	100.00	3.09*	5.10
IV (Sat.)	85.32*	0.71*	97.75	3.34*	5.04

* Denotes a significant difference

Figure 5.2. Growth increment of groupers reared in pond-based net cages



Study 3. Stocking density study of groupers in brackishwater ponds

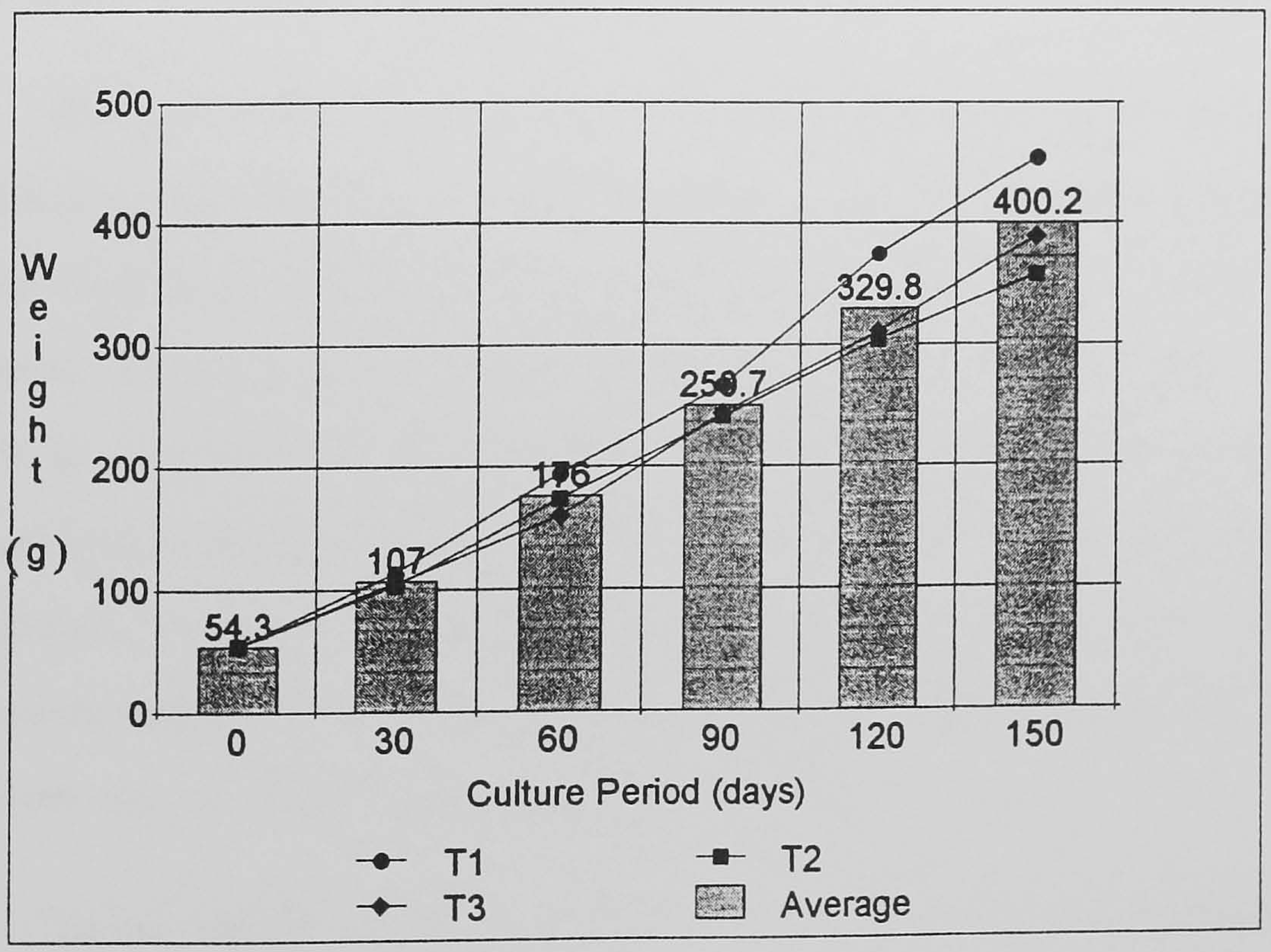
The mean weight gain, growth rate, survival rate, net production and FCR of groupers when reared in brackishwater ponds are shown in Table 5.9. The mean weight gain, growth rate, survival and FCR were not affected when the stocking rates were increased up to 5,000 ha^{-1}. Mean weigh gain (400.1 g) and growth rate (2.65 g day^{-1}) of groupers in Treatment I were higher than in Treatments II (302.9 g; 2.01 g day) and Treatment III (334.9 g; 2.22 g day) respectively. Net production of groupers in Treatments II (842 kg ha) and III (1,604 kg ha) was significantly higher (P=0.0015) than Treatment I (351 kg ha). Survival rates were high in all treatments (87.8%, 92.6% and 95.8% in Treatments I, III and III respectively). FCR values declined with increasing stocking rates, however, the values were not statistically different. The FCR values were 3.65, 3.49 and 3.07 in Treatments I, II and III respectively. These FCR values were very much lower than FCR values observed in Study 2. The growth development of groupers when reared in brackishwater ponds is shown in Figure 5.3. The weights of groupers increased for the five-month growth period, although there were slight decreases in daily growth rates on the third and fifth months of culture. The average weight increases were 107 g, 176 g, 250.7 g, 329.8 g and 400.2 g during the first, second, third, fourth and fifth months of culture respectively. The average daily growth rates were 1.6 g day^{-1}, 2.47 g day^{-1}, 2.41 g day^{-1}, 2.55 g day^{-1} and 2.51 g day^{-1} during the first, second, third, fourth and fifth months of culture respectively.

Table 5.9. Effects of stocking rate on the culture of groupers in brackishwater fishponds

Treatment	Mean weight gain (g)	Growth rate (g day^{-1})	Survival rate (%)	Production (kg ha^{-1})	FCR
I	400.1	2.65	87.8	351.3	3.65
II	302.9	2.01	92.6	841.5*	3.49
III	334.9	2.22	95.8	1,604.0*	3.07

* Denotes a significant difference

Figure 5.3. Growth development of groupers in brackishwater fishponds



Discussion

Study 1. Sorting frequency study on grouper fry

The sorting frequency study on grouper fry showed wide variation in growth and size of the experimental fish. Growth variation apparently started from the second week of nursery rearing, and the variation became more pronounced as the culture period progressed. This may have accounted for the high mortality rate in Treatment III (no sorting). It appears that bigger groupers (shooters) cannibalised the smaller ones even if the animals were given sufficient food (satiation). The wide variation in size of groupers even within a brood is believed to be due to their non-gregarious characteristic and nutritional deficiencies (Chen, 1979).

Groupers which were not sorted (Treatment III) had a higher growth rate compared to those that were sorted (Treatments I and II). The result suggests that regular handling of groupers may have affected their well being and normal feeding behaviour. This observation supports previous work of Tseng *et al.* (1988) and Chen (1979) on *Epinephelus* sp., that the fish have suspicious characters and are relatively non-gregarious carnivores. Sorting the fry every week was effective in controlling cannibalism, however, it was also labour intensive. The fry were very sensitive, particularly during the first month of nursery rearing, therefore, extreme care must be taken into account when feeding and sorting the fish.

To calculate the economic feasibility of operating a grouper fry nursery project, a cost and return analysis based on these experiments is shown in Table 5.10. Derivation is based on the minimum and maximum units a farm caretaker can maintain and supervise to be able to show economy of scale. The analysis showed that optimum

Table 5.10. Cost and return analysis for operating a grouper fry nursery project in pond-based net cages

Development cost (2 m x 2.5 m x 1.5 m)	One unit ($5\ m^3$)	Twenty units ($100\ m^3$)
Netting materials	400	8,000
Bamboo and wooden materials	450	9,000
Pond and equipment (cost $cage^{-1}$)	200	4,000
Miscellaneous expenses	150	3,000
Total	1,200	24,000
Depreciation cost (2 crops yr^{-1} x 2 yr)	300	6,000
Production output	$5\ m^3$	$100\ m^3$
Stocking rate (150 m^{-3})	750	15,000
Survival rate (76%)[a]	570	11,400
Price (Pesos $fish^{-1}$)	40	40
Gross sale (Pesos $crop^{-1}$)	22,800	456,000
Operating costs (Pesos $crop^{-1}$)		
Grouper fry (P10.00 $fish^{-1}$)	7,500	150,000
Fresh small fish(P50 kg^{-1})[b]	6,474	129,480
Labour cost (P4,500 x 3 months)	13,500	13,500
Miscellaneous (5% cost)	1,374	14,649
Total	28,848	307,629
Marketing cost (5% sale)	1,442	15,382
Direct cost	30,290	323,011
Interest on Capital (6% $crop^{-1}$)[c]	1,803	19,898
Depreciation cost ($crop^{-1}$)	300	6,000
Total costs	32,393	348,909
Profit	(9,593)	107,091
Break-even production (kg)[d] to pay total cost	751 pc	8,291 pc
Break-even price to (Pesos)[d] cover total cost	52.72	29.09
Rate of return (RR)[e]	-	64.58%
Internal rate of return (IRR)[f]	-	50% +
Benefit cost ratio (B/C ratio)[f]	-	1.41
B/C + capital cost	-	1.15
Pay back period (PBP)	-	1.5 yr

[a] Based from Table 5.6
[b] Composed of small fish and crustaceans which cost 5 times the ordinary trash fish (FCR=5)
[c] Total working capital = Dev't. cost + first crop operating cost
[d] Adapted from Jolly and Clonts, 1993. Economics of aquaculture
[e] Adapted from Merrett and Sykes, 1996. RR = Profit yr^{-1} over working capital
[f] Calculated at 2 crops $year^{-1}$ for 5 years and discounted at 15%

production and profit can be attained when operating a unit of 20 net cages. The rate of return (RR)) and internal rate of return (IRR) for operating 20 net cages were 64.58% and 33.96% respectively. Discounted benefit-cost ratios were higher than one, indicating that the project is profitable. The high profitability of the project is enhanced greatly by the high market price of grouper fingerlings (40 Pesos fish^{-1}). Grouper fingerlings weighing 25-50 g body weight are sold between 30-50 Pesos fish^{-1} (1000-1200 Pesos kg^{-1}) to grow-out operators or grouper fry exporters in Metro Manila. However, the technology is capital intensive. Initial capital requirement to cover development costs and the first cropping period is 331,629 Pesos (8,727 Pound Sterling at a conversion rate of 38 Pesos) which is outside the financial capability of small-scale fish farmers.

Study 2. Feeding rate study in pond-based net cages

Although the culture of groupers in marine cages is practised by some fish farmers, culture in pond-based net cages is not. In this study, four different feeding rates (5%, 10%, 15% and satiation feeding) were tested to determine growth and survival of groupers reared in pond-based net cage. The rations were given every two days between 1400-1700 h following procedure established by Chua *et al.*, (1978) in marine net cage culture of *Epinephelus salmoides*. The results indicate that the growth generally increased with a corresponding increase in feeding rate. The observed mean weight gain (64-85.2 g), growth rate (0.55-0.71 g day^{-1}) and production (2.58-3.34 kg m^{-3}) in pond-based net cages were generally lower than the reported mean weight gain, growth rate and net production of groupers cultured in marine net cages. Chen (1979) observed higher mean weight gain (700 g) of *E. tauvina* over a culture period of 180 days (6 months), or an average growth rate of 3.89 g day^{-1}. Chua *et al.* (1982), working on *E. salmoides* also observed a higher mean weight gain (500-600 g) over a

6-8 month culture period, or an average growth rate of 2-3 g day^{-1}. Tacon *et al* (1989) working on *E. tauvina*, reported higher average growth rate of between 0.84-2.42 g day^{-1} using different feeding types (e.g. trash fish, moist pellet). The observed net production of groupers in pond-based net cages (2.58-3.34 kg m^{-3}) was very much lower than production in marine net cages (23.8 kg m^{-3}) reported by Teng and Chua (1978). The observed survival rate (97.75-100%) and FCR (4.32-5.10) were within the range of survival and FCR values reported by other authors. Chen (1979) reported a FCR of 4.5 with *E. tauvina* in 180 days culture period. Tacon, *et al* (1989) reported a 3.53-4.16 FCR for *E. tauvina* in 156 days culture period. Teng, *et al* (1979) reported a lower FCR of 2.4 at a stocking rate of 60 m^{-3}, however, this was over a shorter culture period of only 90 days. Therefore, FCR values vary with different species and culture periods.

The lower mean weight gain, growth rate and net production experienced in pond-based net cage culture of groupers suggested water quality was inadequate to support the optimum growth of the cultured fish. In marine coastal water conditions, the constant flow of water current brings an adequate supply of dissolved oxygen and carries away the metabolic waste excreted by the fish, thus reducing the adverse effects of bad water quality (Hickling, 1962; Bardach *et al.*, 1972; MacCrimmon *et al.*, 1974). The result of this experiment suggests that the best feeding conditions for groupers is satiation feeding, supporting earlier observations by Chua *et al* (1978). More studies are required to establish optimum biomass, rate of water exchange, feeding management and economics of culture.

For the purpose of calculating the economic feasibility of operating a pond-based net cage culture of groupers, a cost and return analysis for operating a four units and a 10 units grouper net cage are shown in Table 5.11 and Table 5.12. It was assumed that one farm caretaker can supervise and maintain a minimum of unit with a four net cages (5 m x 5 m x 1.5 m) with a total production area of 100 m^3 and a maximum of 10 net cages with a total production area of 250 m^3. Since groupers produced from pond-based net cages are small-sized weighing 80-110 g body weight (Table 5.8, Figure 5.1), the best option is to sell them live to grow-out operators and exporters at 80 Pesos $fish^{-1}$ or 800 Pesos kg^{-1}. The analysis revealed that operating four units pond-based net cages of grouper grow-out is not financially feable under present conditions. The analysis also revealed that feeding to satiation will provide the potential farmer the maximum economic return on their investment when operating at 10 units net cages. Furthermore, operating at 10 units net cages per farm caretaker would provide the optimum production and profit. At satiation feeding, the rate of return (RR) and internal rate of return (IRR) for operating 10 units net cages were 42.31% and 38.26% respectively, while 25.74% and 4.85% for operating 4 units net cages respectively. The pay back period (PBP) when operating at 10 units net cages were 2.4 years for satiation feeding and 3.8 years for feeding at 15% BW. Benefit cost ratios (B/Cs) lower than one and internal rate of return (IRR) lower than 15% are considered not financially viable.

Table 5.11. Cost and return analysis for operating a four units 25 m^3 (5 m x 5 m 1.5 m) grouper grow-out in pond-based net cages

Development cost (5 m x 5 m x 1.5 m x 4 units)		Four units (100 m^{-3})		
Netting materials			10,000	
Bamboo and floating materials			10,000	
Pond and equipment (cost $cage^{-1}$)			8,000	
Miscellaneous expenses			2,000	
Total			30,000	
Depreciation cost (2 crops yr^{-1} x 3 yr)			2,000	
Total working capital	228,603	229,028	233,447	234,576
Production output (per crop)				
Feeding Rate (Table 5.8)	5%	10%	15%	Satiation
Stocking rate (40 m^{-3})	4,000	4,000	4,000	4,000
Yield (kg $crop^{-1}$)[a]	258	250	309	334
Price (Pesos kg^{-1})	800	800	800	800
Gross sale (Pesos $crop^{-1}$)	206,400	200,000	247,200	267,000
Operating costs (Pesos $crop^{-1}$)				
Fingerlings (40 Pesos $fish^{-1}$)	160,000	160,000	160,000	160,000
Trash fish (Pesos kg^{-1})[a]	11,146	11,550	15,759	16,834
Labour cost (P4,500 x 4 months)	18,000	18,000	18,000	18,000
Miscellaneous (5% cost)	9,457	9,478	9,688	9,742
Total	198,603	199,028	203,447	204,576
Marketing cost (5% sale)	10,320	10,000	12,360	13,360
Direct cost	208,923	209,028	215,807	217,936
Interest on Capital (6% $crop^{-1}$)	13,716	13,742	14,007	14,075
Depreciation cost ($crop^{-1}$)	5,000	5,000	5,000	5,000
Total costs	227,639	227,770	234,814	237,011
Profit	(21,239)	(27,770)	12,386	30,189
Break-even production (kg)[b] to pay total cost	286	286	292	293
Break-even price to (Pesos)[b] cover total cost	886	916	756	702
Rate of return (RR)[c]	-	-	10.6%	25.74%
Internal rate of return (IRR)[d]	-	-	0%	4.85%
Benefit-cost ratio (B/C)[d]	-	-	1.15	1.23
B/C + capital cost[d]	-	-	0.93	0.99
Pay back period (PBP)	-	-	9.4 yr	3.9 yr

[a] Calculated from Table 5.8
[b] Adapted from Jolly and Clonts, 1993
[c] Adapted from Merrett and Sykes, 1966. RR = Profit yr^{-1} over working capital
[d] Calculated at 2 crops yr^{-1} for 3 yr discounted at 15%

Table 5.12. Cost and return analysis for operating a ten units (5 m x 5 m x 1.5 m) grouper grow-out in pond-based net cages

Development cost (5 m x 5 m x 1.5 m x 10 units)			Ten units (250 m^{-3})	
Netting materials			25,000	
Bamboo and floating materials			25,000	
Pond and equipment (cost $cage^{-1}$)			20,000	
Miscellaneous expenses			5,000	
Total			75,000	
Depreciation cost (2 crops yr^{-1} x 3 yr)			12,500	
Total working capital	543,157	544,219	555,241	558,088
Production output (per crop)				
Feeding Rate (Table 5.8)	5%	10%	15%	Satiation
Stocking rate (40 m^{-3})	10,000	10,000	10,000	10,000
Yield (kg $crop^{-1}$)[a]	645	625	772	835
Price (Pesos kg^{-1})	800	800	800	800
Gross sale (Pesos $crop^{-1}$)	516,000	500,000	617,600	668,000
Operating costs (Pesos $crop^{-1}$)				
Fingerlings (40 Pesos $fish^{-1}$)	400,000	400,000	400,000	400,000
Trash fish (Pesos kg^{-1})[a]	27,864	28,875	39,372	42,084
Labour cost (P4,500 x 4 months)	18,000	18,000	18,000	18,000
Miscellaneous (5% cost)	22,293	22,343	22,869	23,004
Total	468,157	469,219	480,241	483,088
Marketing cost (5% sale)	16,125	15,625	19,300	20,875
Direct cost	484,282	484,844	499,541	503,963
Interest on Capital (6% $crop^{-1}$)	32,589	32,653	33,314	33,485
Depreciation cost ($crop^{-1}$)	12,500	12,500	12,500	12,500
Total costs	529,371	529,997	545,355	549,948
Profit	(13,371)	(29,997)	72,245	118,052
Break-even production (kg)[b] to pay total cost	699	680	694	698
Break-even price to (Pesos)[b] cover total cost	842	871	719	668
Rate of return (RR)[c]	-	-	26.02%	42.31%
Internal rate of return (IRR)[d]	-	-	13.46%	38.26%
Benefit-cost ratio (B/C)[d]	-	-	1.24	1.33
B/C + capital cost[d]	-	-	0.99	1.07
Pay back period (PBP)	-	-	3.8 yr	2.4 yr

[a] Calculated from Table 5.8
[b] Adapted from Jolly and Clonts, 1993
[c] adapted from Merrett and Sykes, 1966. RR = Profit yr^{-1} over working capital
[d] Calculated at 2 crops yr^{-1} for 3 yr discounted at 15%

Study 3. Stocking rate study in brackishwater ponds

The stocking rate study on groupers in brackishwater ponds showed encouraging results. The fish grew well and resulted to higher mean weight gain and average growth rate compared to results from Study 2. The fish attained mean weight gains from 334.9 - 400.1 g in the five month culture period at an average growth rate of 2.01-2.65 g day^{-1}. This growth rate was higher than the growth rates of 0.73-1.23 g day^{-1} reported by Manzano (1989). Furthermore, Manzano (1989) also reported lower production (139-182 kg ha^{-1}) and survival rate (84%) in a polyculture study of grouper (*E. tauvina*) and tilapia (*O. mossambicus*) in brackishwater ponds. The FCR values from this experiment (3.07-3.65) were lower compared to FCR values (4-7) reported by other authors (Chen, 1979; Tacon *et al.*, 1989) in marine net cage culture system. The presence of other factors in the ponds such as natural food (e.g. small fish, polychaete worms and crustaceans), wider space, hiding place (e.g. holes and stumps), and better water quality may have contributed to better nutrition and efficient feed conversion. In the natural environment, groupers were found to prefer live fish food and crustaceans (Tseng *et al.*, 1988). In this study, production was greatly enhanced with a corresponding increase in stocking rate. The result of this experiment seem to indicate that stocking rate and production can still be increased per unit area through stock manipulation (e.g. polyculture and biomanipulation techniques), improved pond water management and improved feeding regimes. Further studies are required to confirm initial results and establish optimum requirements for growth.

The financial feasibility of operating a one hectare grouper culture in ponds is shown in Table 5.13. It was assumed that one farm caretaker can maintain and supervise a one hectare grouper farm. Total working capital was calculated by adding the total development cost for the rehabilitation of ponds (ponds are already existing) and the first crop operating cost). Miscellaneous cost was increased to 10% since grouper pond culture requires frequent water change and maintenance of water depth through pumping. The analysis revealed that the pond culture technology was financially feasible at the stocking rate of 5000 ha^{-1}. In view of high capital investment in the rehabilitation of ponds and equipment (pump), stocking at lower densities (e.g. 1000 ha^{-1} and 3000 ha^{-1}) was not financially viable at a selling price of 300 Pesos kg^{-1} (Table 5.5). The rate of return (RR) and and internal rate of return (IRR) of grouper pond culture technology at 5000 ha^{-1} stocking rate were 59.20% and >50% respectively. The calculated benefit cost ratios (B/Cs) were higher than one, indicating that the technology is profitable. The pay back period (PBP) was 1.7 years.

Table 5.13. Cost and return analysis for operating a one hectare grouper culture in brackishwater fishpond

Development cost (Pesos ha^{-1})			
Pond improvement and repair		75,000	
Equipment cost (pump)		50,000	
Miscellaneous expenses		25,000	
Total		150,000	
Depreciation cost (2 crops yr^{-1} x 10 yr)		7,500	
Total working capital	232,843	339,075	448,916
Production output (Per crop)			
Stocking rate (fish ha^{-1})[a]	1,000	3,000	5,000
Yield (kg $crop^{-1}$)[a]	351	842	1,604
Price (Pesos kg^{-1})	300	300	300
Gross sale (Pesos $crop^{-1}$)	105,300	252,600	481,200
Operating cost (Pesos $crop^{-1}$)			
Fingerlings (P40 kg^{-1})	40,000	120,000	200,000
Trash fish (P10 kg^{-1})[a]	12,812	29,386	49,242
Labour cost (P4,500 x 5 mo)	22,500	22,500	22,500
Miscellaneous (10% cost)	7,531	17,189	27,174
Total	82,843	189,075	298,916
Marketing cost (5% sale)	5,265	12,630	24,060
Direct cost	88,108	201,705	313,976
Interest on Capital (6% $crop^{-1}$)	13,970	20,345	26,935
Depreciation cost ($crop^{-1}$)	7,500	7,500	7,500
Total costs	109,578	229,550	348,411
Profit	(4,278)	23,050	132,789
Break-even production (kg)[b] to pay total cost	776	1,130	1,496
Break-even price to (Pesos)[b] cover total cost	663.37	402.70	279.87
Rate of return (RR)[c]	-	-	59.20%
Internal rate of return (IRR)[d]	-	-	>50%
Benefit cost ratio (B/C)[d]	-	-	1.54
B/C + Capital cost[d]	-	-	1.17
Pay back period (PBP)	-	-	1.7 yr

[a] Calculated from Table 5.9.
[b] Adapted from Jolly and Clonts, 1993.
[c] Adapted from Merrett and Sykes, 1966. RR = Profit yr^{-1} over total working capital
[d] Calculated at 2 crops yr^{-1} for 10 yr and discounted at 15%

5.3. Grouper development plan and strategies

5.3.1. *Background*

There is great potential for grouper farming in the Philippines. A review of the industry showed that there is a current demand for the fish, both in the domestic and export markets. In view of foreign exchange prospects, the development of grouper farming industry is important to the economy of the Philippines. There is, therefore, a need to improve the present conditions to increase the aquaculture production.

The propagation technology for groupers (particularly *Epinephelus* sp.) has been developed, but at present it is not economically viable. Therefore, the technology is not yet adaptable to commercial hatchery operations. An alternative feed substitute for groupers has also been developed but the feed requires high protein level, and therefore entails a high production cost. Trash fish is at present the most efficient and economic feed for grouper farming.

The most strategic direction points to the proper utilisation and management of the existing grouper resources, while research and development on grouper seed production and feed substitute must be pursued.

5.3.2. *Objectives*

The primary objective of this development plan is to increase production of groupers through maximum utilisation of the existing wild resources (e.g. seed and trash fish). It is hoped that with the proper utilisation and management of the existing grouper resources, production can be increased by about 50-100% by the year 2000. The specific objectives of this development plan are to: (a) improve survival rate of wild grouper fry in the nursery phase; (b) improve growth rate and culture management techniques in nursery and grow-outs; (c) identify the quantity, spawning and fishing grounds of grouper fry and juveniles; (d) identify the volume, fishing grounds and species composition of trash fish feed; (e) disseminate improved grouper production technologies to fish farmers; and (f) increase production of grouper by 10% annually for five years.

5.3.3. *Implementing strategy and targets*

To achieve the above objectives, several development strategies must be undertaken:

(1). A physical survey of existing grouper resources (e.g. fry grounds, spawning grounds, fishing areas, production flow from fry catching to marketable fish) throughout the country should be conducted to determine seasonal abundance, quantity, availability, fishing methods, price, etc. The data will be useful in the planning and proper management of these resources. The survey will also identify which areas need strengthening and improvements. Potential spawning grounds for grouper development is shown in Table 5.14 while the potential areas for grouper production is shown in Figure 5.4.

(2). A physical survey of existing trash fish resources throughout the country should be conducted to determine species composition, fishing grounds, seasonal abundance, quantity, availability, fishing methods, price, and other uses of trash fish. The data will provide information on how to properly manage these resources as well as identify which areas in the production chain need improvements. Potential fishing grounds which will be surveyed are shown in Figure 5.5.

Table 5.14. Potential spawning grounds, production areas and training targets for grouper development

Region	Potential spawning grounds[a]	Potential production Provinces[b]	Training targets EOs[c]	Training targets Farmers[d]
I	Lingayen Gulf	Pangasinan, Zambales, La Union, Ilocos region	8	151
II	Babuyan Channel	Cagayan coastal areas,	2	38
III	Manila Bay	Bataan, Bulacan, Pampanga	6	113
IV	Batangas coast Tayabas Bay Lamon Bay	Batangas, Cavite, Mindoro, Palawan, Marinduque, Quezon	12	227
V	Ragay Gulf Lagonoy Gulf	Albay, Camarines (N&S), Sorsogon	6	113
VI	Sibuyan Sea Visayan Sea	Capiz, Iloilo, Aklan Negros Occ.	8	151
VII	Cebu coasts Bohol/Camotes seas	Cebu, Bohol	4	76
VIII	Samar Sea Leyte Gulf	Samar, Leyte	4	76
IX	Moro Gulf	Zamboanga	2	38
X	Agusan/Misamis coasts	Agusan del norte, Misamis coastal areas	4	76
XI	Davao Gulf, Cotabato coast	Davao, Cotabato, Surigao del Sur	6	113
XII	Panguil Bay	Lanao del Norte	2	38
ARMM	Sulu Sea	Sulu, Maguindanao	4	76
	Total	34 Provinces	68	1,286

[a] Potential spawning grounds to be surveyed
[b] Potential grouper production areas to be surveyed and targeted
[c] No. of Extension Officers to be trained at 2 EOs per Province
[d] No. of farmers to be trained at 1 farmer ha^{-1} of pond targeted for grouper dev't. in Table 5.14

Figure 5.4. Potential areas for grouper production in the Philippines
(Potential sites are shown in shaded areas)

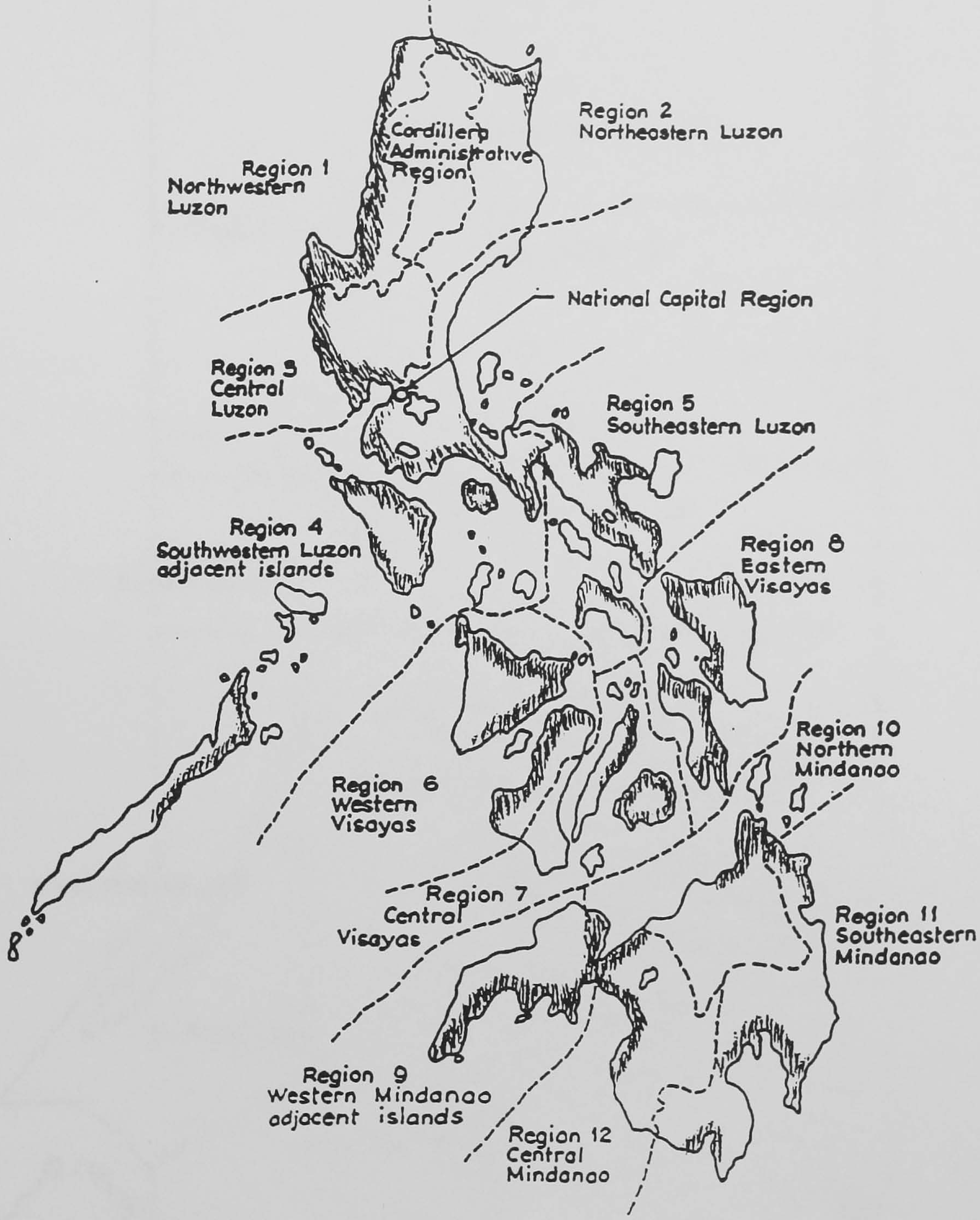
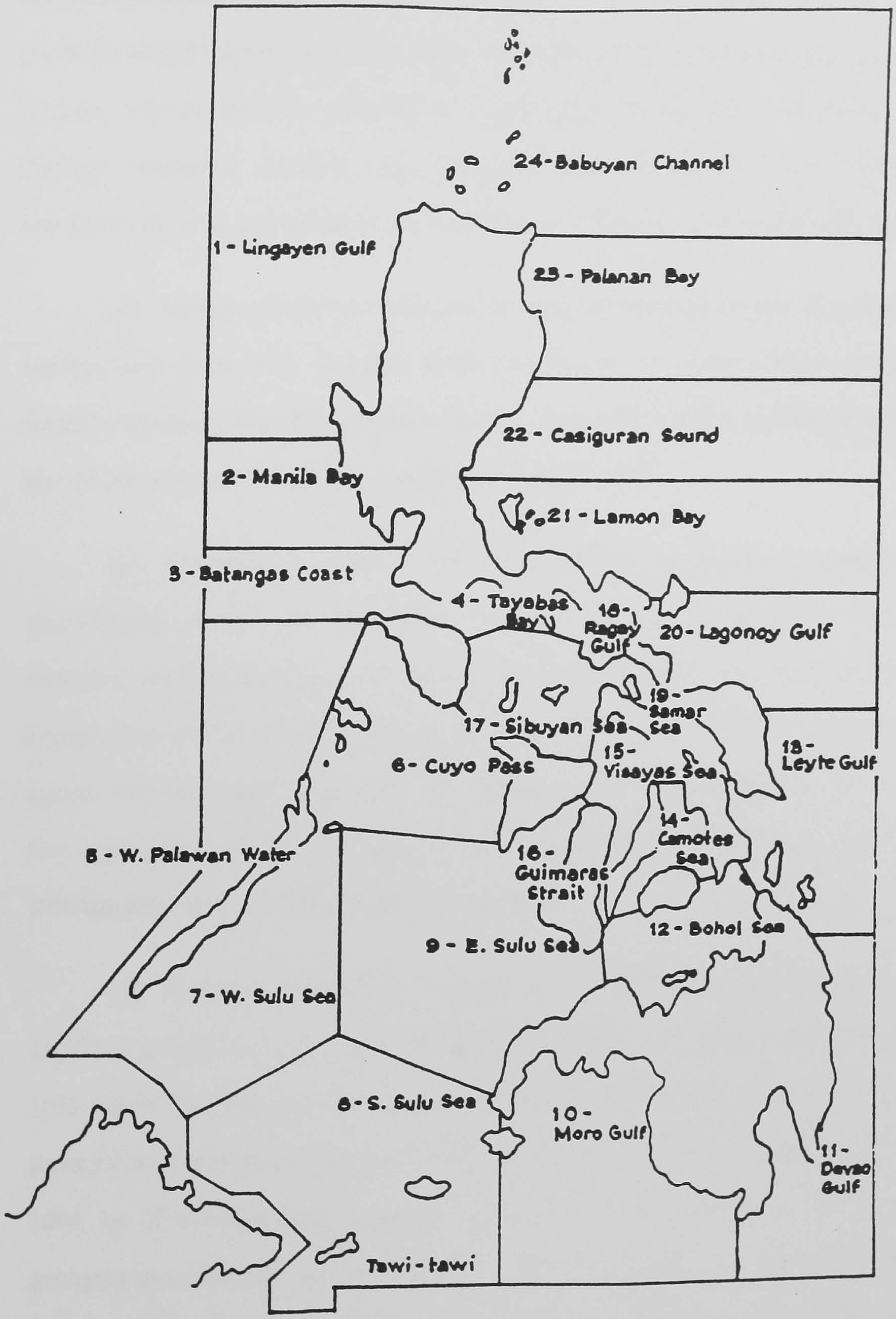


Figure 5.5. Potential fishing areas for trash fish food



(3). Studies should be conducted to improve the survival of wild grouper fry in the nursery phase. Fish farmers have experienced very low survival of grouper fry (2-3 cm body length) in the nurseries. Since wild grouper fry abound during the spawning seasons, efforts must be directed at maximising the utilisation of these resources through improved survival rate. Specific areas of concern are water quality management, feed and nutrition, fry handling, and diseases prevention and control.

(4). Studies should be conducted to improve the growth rate of groupers in the nursery and grow-outs. Specific areas of concern are water quality management, feeding management and stock manipulation. Polyculture and biomanipulation methods should be explored to increase production at lower cost.

(5). Technology transfer and dissemination of improved grouper culture technologies should be intensified through training, productivity enhancement seminars, on-farm research and technology demonstration, and input assistance (e.g. interest-free capital on nets, grouper fry). A total of 1,354 fish farmers and extension agents will be trained on grouper nursery and grow-out management for a period of five years (Table 5.14). The fish farmers will be given technical and input assistance with the help of government extension agents.

(6). Grouper production is projected to decline by 54.86% in 1996, from 14,931 t in 1995 to 6,740 t in 1996. In 1997, grouper production will be increased by 10% yearly for the next five years. The cumulative development area for grouper production is shown in Table 5.15. To support this production enhancement, a total of 1286 ha of brackishwater fishponds will have to be converted into the culture of groupers at a stocking rate of 5000 ha^{-1} with a production potential of 1.6 t ha^{-1} $crop^{-1}$ at 2 crops yr^{-1} (Table 5.9). By the year 2001, total grouper production is estimated to increase to 10,855 t. Assuming that a one tonne increase in grouper production would require 2,600 grouper fingerlings (1,000 kg x 2.5 fish kg^{-1} at 96% survival rate from fingerling to marketable size of 400 g), about 1.75 million grouper fingerlings will be required in the first year and 10.70 million grouper fingerlings will be needed to meet the production target by year 2001 (Table 5.16). Assuming that one hectare of brackishwater pond has an effective nursery net cage production area of 2,000 m^2, the grouper fingerling production component will require about 28.76 ha of ponds at a stocking rate of 150 m^{-3} and a survival rate of 76% (Table 5.6).

Table 5.15. Cumulative area development for grouper grow-out, 1997-2001

Year	Brackishwater fishpond development Area (ha)	Production increase (t)***	Total production (t)
1996			6,740*
1997	211	674	7,414**
1998	442	1,415	8,155**
1999	697	2,231	8,971**
2000	978	3,128	9,868**
2001	1,286	4,115	10,855**

* Calculated at 54.86 decline from 14,931 t in 1995.
** Production increased by 10% yearly.
*** Calculated at 1.6 t ha $crop^{-1}$ x 2 crops yr^{-1} (Table 5.9).

5.3.4. *Implementing agency*

Using the existing facilities and manpower resources of Fisheries agencies and research institutions (e.g. BFAR, DA-RFUs, LGUs, SEAFDEC-AQD and UP-BAC), the above projects can be implemented. Since these fisheries agencies and institutes have regular funds to support fisheries research and development and extension programmes, the budgetary requirements needed for the implementation of the above projects can be appropriated through standard operating procedure. Funding assistance, particularly on R&D and training programmes can be requested through international agencies such as FAO/UNDP, JICA, EEC, USAID who are engaged in aquaculture development programmes in Asia.

Table 5.16. Cumulative development for grouper fingerling production, 1997-2001

Year	Production increase (t)	Fingerling requirement (Millions)*	Fry requirement (Millions)**	Pond requirement (ha)***
1997	674	1.75	2.3	4.70
1998	1,415	3.68	4.8	9.89
1999	2,231	5.80	7.6	15.59
2000	3,128	8.13	10.7	21.86
2001	4,115	10.70	14.1	28.76

* Calculated at 2.5 fish kg^{-1} at 96% survival in grow-out x production increase
** Calculated at 76% survival rate in the nursery
*** Calculated at 150 fry m^{-3} x 2,000 m^3 effective production area ha^{-1} of pond

5.3.5. *Time frame*

The implementation of this plan will be for a period of five years to start in 1997 and to end in 2001. Survey of potential spawning grounds, production areas and fishing grounds will be conducted during the first quarter of 1997, while the training and pond improvement activities will start in the second quarter of 1997. Production and technology adaptation, verification and demonstration activities will commence in the second year (1998). The project should be in full swing in the second year of implementation.

5.3.6. *Inputs and expected benefits*

The estimated budgetary requirements and expected benefits of the grouper development plan is shown in Table 5.17. Total development cost is estimated to reach

606 million Pesos, while the expected direct benefits are over 2.0 billion Pesos in a period of five years. A total of 16,718 people are expected to directly benefit by this development plan. Other socio-economic benefits are additional employment and trading from related industries such as grouper fry gathering, net manufacturing, and trash fish food fishing and marketing; and the increase in foreign exchange earnings of the country which will help boost external trade.

Table 5.17. Estimated budgetary requirements and direct benefits (Million Pesos) for the development of grouper industry in the Philippines, 1997-2001

Item	Budgetary requirement
Inputs requirement.	
Research/extension facilities and manpower	Existing
Survey and data gathering (1 million per Region)	15.0
Research and Development (5 million yr^{-1} x 5 yr)	25.0
Extension program (1 million per Region)	15.0
Training program (1,354 farmers and EOs)	2.0
Production inputs:	
Grouper fry (14.1 million x 10 Pesos $fish^{-1}$)[a]	141.0
Trash fish feed(16,456 t x 10 Pesos kg^{-1})[b]	165.0
Netting materials (P400 x 400 units ha^{-1} x 28.76 ha)[c]	5.0
Bamboo and floating materials[c]	6.0
Equipment (water pumps)[c]	3.0
Ponds (1,315 ha x P100,000 ha)[d]	132.0
Miscellaneous expenses (10%)	50.0
Contingency cost (10%	55.0
Total budgetary requirements	606.0
Expected benefits.	
Gross value: Grouper fingerlings (10.7 million x 40 Pesos $fish^{-1}$)[e]	428.0
Marketable (400 g) grouper (4,115 t x 300 Pesos kg^{-1})[f]	1,235.0
Land valuation (1,314 ha x 200,000 Pesos ha)	263.0
Tax revenues: Sale (1.663 billion Pesos x 10% tax)	166.0
Land (263 million Pesos x 1% tax)	2.6
Employment (1,286 farmers x P54,000 income yr^{-1} x 1%)	1.0
Total direct benefits (Pesos)	2.095 billion
Direct additional employment and beneficiaries.	
Regular worker (1,286 new fish farmers)	1,286 People
Part-time (calculated at 2 persons per regular worker)	2,572 People
Family dependents (5 persons per labourer)	12,860 People
Total	16,718 People

[a] Calculated from Tables 5.10 and 5.15
[b] Calculated from Tables 5.9, 5.13 and 5.14
[c] Calculated from Table 5.10
[d] Calculated from Tables 5.14 and 5.15
[e] Calculated from Tables 5.13 and 5.15
[f] Calculated from Tables 5.13 and 5.14

6. SHRIMP: OVERVIEW OF THE INDUSTRY, TECHNOLOGY DEVELOPMENT AND DEVELOPMENT STRATEGIES

6.1. Overview of the shrimp industry in the Philippines

6.1.1 *Background*

Shrimp is among the highest value fishery products that are traded in the international markets. Because of its high export performance and world market demand, it has attracted a large number of fish farmers all over the world. In the Philippines, shrimp farming started as an incidental crop to milkfish some 50 years ago. As the demand and price of shrimp escalated over the years, fish farmers gradually shifted their production from milkfish to shrimp. Some milkfish ponds suitable for the farming of shrimp were converted into shrimp farming. Although the construction cost is very high, the output per unit of land more than compensates for the additional investment. However, the industry collapsed in the late 1980s due to disease which caused slowing of growth and eventual death to the affected stocks.

There are about 300 species of penaeid shrimp world-wide. However, only about eighty (80) species have commercial value of which twenty one (21) species are found in the Philippines (Apud, 1983). The giant tiger shrimp, *Penaeus monodon* Fabricius is the preferred species in the Philippines due to its fast growth rate, high survival rate, resistance to handling and consumer acceptability. Other shrimp species found to exist in brackishwater ponds are the white shrimp (*Penaeus indicus and Penaeus merguiensis*) and the endeavor shrimp (*Metapenaeus ensis*). Since the 1980s, the giant tiger shrimp has become a valuable export commodity that has consistently been one of the Philippines' major foreign exchange earners. In 1995, shrimp was the fisheries highest foreign exchange earner with an export value of 5.6 billion Pesos or US$ 218,652,000 (BFAR, 1996). Most of the Philippine shrimp export comes from ponds. In contrast, most of the world's shrimp production comes from capture fisheries.

The Philippines is one of the major producers of shrimp in the world. In 1993, the Philippines contributed 95,816 t representing 12% of the total world aquaculture production of 802,229 t (Table 6.1). Considering only the giant tiger shrimp production, Philippines ranked third only to Thailand and Indonesia in 1993 (Table 6.2).

Table 6.1. World aquaculture production of shrimp and prawn (t) in recent years

Year	1990	1991	1992	1993
World total	658,234	819,457	874,650	802,229
Philippines	53,989	51,434	78,397	95,816

Source: Aquaculture production statistics 1984-1993. FAO Fisheries circular no. 815, rev. 7. 1995

Table 6.2. World aquaculture production of giant tiger shrimp (t) in recent years

Year	1990	1991	1992	1993	% Share
Thailand	107,970	155,069	179,358	210,000	47.4
Indonesia	67,355	96,811	98,358	105,000	23.7
Philippines	47,591	45,740	75,996	86,096	19.4
Viet Nam	15,750	20,250	22,500	26,250	5.9
Others		4,148	15,215	15,782	3.6

Source: Aquaculture production statistics 1984-1993. FAO Fisheries circular no. 815, rev. 7. 1995

Shrimp farming practises in the Philippines can be classified into three main categories, namely: traditional extensive, semi-intensive and intensive. The traditional extensive and polyculture systems are the predominant methods being practised at present after the collapsed of the industry in late 1980s. Since the traditional extensive and polyculture systems require the lowest level of investment (e.g. pond development cost, feed, equipment), technical skill and management, the technology becomes viable.

A major research break-through in hatchery seed production of tiger shrimp in the 1970s has significantly eased the problem of fry supply. The main problem of the shrimp farming industry is the uncontrolled diseases in grow-out ponds which causes slowing down of growth and high mortalities of infected stocks. Despite the problem, however, the lucrative market for shrimp has continued to lure local shrimp growers to produce tiger shrimp even at a lower production levels. Therefore, total production has not changed much during the last five years.

6.1.2. *Production performance and trend*

Shrimp species cultured in the Philippines are tiger shrimp (*P. monodon*), white shrimp (*P. indicus* and *P. merguiensis*) and endeavor shrimp (*M. ensis*). The bulk of Philippine shrimp production is presently obtained from aquaculture farms with a share of 84%, although a small volume is contributed by capture fisheries (16%). The main species cultured in ponds was the giant tiger shrimp contributing 88,815 t (98.7%) of the total tiger shrimp production of 89,980 t in 1995. Recent Philippine shrimp production by sector is shown in Table 6.3. The Philippine Bureau of Agricultural Statistics listed two groups of shrimp as big and small. The bigger group is composed of tiger shrimp while the smaller group is comprised of white shrimp and endeavor shrimp. The statistics does not reflect the volume of species composition and therefore, the individual volume of white shrimp and endeavor shrimp cannot be determined.

Total production of shrimp has fluctuated in recent years, from a low of 66,583 t in 1991, increasing to a high of 113,921 t in 1993 and dropping to 107,819 t in 1995.

The general trend, however, is an increase by an average annual rate of 14.5%. The fall in 1994 and 1995 was mainly due to the decline in small shrimp production from the aquaculture and commercial sectors. Aquaculture production of big shrimp increased by an average annual rate of 20.67%. In 1993, there was 32,746 ha of brackishwater fishponds being used for the culture of shrimp. Since total production of shrimp in 1993 was 95,816 t, the average pond production of shrimp was 2.93 t ha^{-1} yr^{-1}.

Table 6.3. Philippine shrimp production (t) by sector, 1991-1995

Year	1991	1992	1993	1994	1995
Aquaculture					
Big	45,740	75,996	86,096	90,426	88,815
Small	5,694	2,400	9,720	2,221	1,641
Sub-total	51,434	78,396	95,816	92,647	90,456
Municipal					
Big	1,461	928	1,406	929	1,159
Small	12,702	17,353	15,866	14,930	15,528
Sub-total	14,163	18,281	17,272	15,859	16,687
Commercial					
Big	65	44	11	8	6
Small	921	721	822	827	670
Sub-total	986	765	833	835	676
Total					
Big	47,266	76,968	87,513	91,363	89,980
Small	19,317	20,474	26,408	17,978	17,839
Grand total	66,583	97,442	113,921	109,341	107,819

Source: Fishery statistics, 1986-1995. Bureau of Agricultural Statistics. 1996.

6.1.3. *Shrimp price trend*

The price of shrimp increased significantly during the period 1991-1995 (Table 6.4). The increase in prices can be attributed to the constant increase in operating expenses of the producers and traders (e.g. fuel, feeds). For shrimp growers, this positive price increases clearly indicates the high potential of shrimp. Wholesale price of giant tiger shrimp jumped from 148.72 Pesos kg^{-1} in 1991 to 197.84 Pesos kg^{-1} in 1995, or an average annual increase of 9.69%. Wholesale price of smaller shrimp also jumped from 75.65 Pesos kg^{-1} in 1991 to 108.96 Pesos kg^{-1} in 1995 at a rate semilar (9.72%) to big shrimp. The retail price and price margin for smaller shrimp increased more than for big shrimp indicating low supply and an increased demand for small shrimp products. Moreover, the increasing demand by the export markets may have caused local retail prices to increase. In view of the high market value and demand, the prospect for shrimp farming is always high.

Table 6.4. Market price of shrimp in recent years (Pesos kg^{-1})

Year	1991	1992	1993	1994	1995	% increase
Wholesale price						
Big	148.72	163.18	128.33	181.27	197.84	9.69
Small	75.65	83.30	87.94	91.04	108.96	9.72
Retail price						
Big	188.27	200.89	185.62	201.05	231.42	5.63
Small	98.92	97.80	107.41	116.54	142.38	9.84
Price margin						
Big	39.55	37.71	57.29	19.78	31.58	10.36
Small	23.27	14.50	19.47	25.50	33.42	14.66

Source: Fishery statistics, 1986-1995. Bureau of Agricultural Statistics. 1996.

6.1.4. *Market outlets for Philippine shrimp: Local and export*

The major shrimp species found in the domestic markets are tiger shrimp, white shrimp and endeavor shrimp. However, other shrimp species such as the freshwater prawn (*Macrobrachium* sp.) and marine shrimp (*P. semisulcatus, P. latisulcatus, P. japonicus* and *Acetes*) are also found. The shrimp is sold to wholesale or retail markets in whole body form, either fresh or iced. Domestic consumers prefer those ranging from 15-30 pieces kg^{-1} for tiger shrimp, 40-60 pieces kg^{-1} for white shrimp and 60-100 pieces kg^{-1} for endeavor shrimp. For bulk sales, the shrimp is iced and packed in Styrofoam containers (30-35 kg carrying capacity) at a normal ice to shrimp ratio of 1:1. The main domestic markets are the big hotels and seafood restaurants in the cities, particularly Metro Manila area.

The major export markets for Philippine shrimp are Japan, the United States of America and Korea. Minor exporting countries are Hong Kong, Guam, China, Canada, Trust Territory, Taiwan and Singapore in that order (Table 6.5). In 1994, Japan topped the list of the Philippine shrimp export with a share of 80.26%, followed by the USA (10.78%) and Korea (4.7%). The preferred shrimp species in the export markets are the tiger shrimp and white shrimp. The shrimp is shipped to international markets in frozen forms, either head-on, headless, shell-on or peeled. The USA and some European markets prefer shell-on and peeled frozen products at sizes ranging from 6-16 pieces kg^{-1}.

Table 6.5. Major export markets for Philippine shrimp (Million US$)

Country	1991	1992	1993	1994	% Share
Japan	203.75	161.27	190.55	196.45	80.26
USA	54.49	36.76	23.36	26.39	10.78
Korea	1.41	3.34	3.76	11.50	4.70
Hong Kong	0.87	1.77	0.77	2.46	1.00
Guam	2.44	1.65	1.60	1.98	0.81
China				1.62	0.66
Canada	1.81	1.18	1.08	1.06	0.43
Trust Territory	0.87	0.83	1.11	1.04	0.04
Taiwan	0.02	0.23	0.80	0.60	0.25
Singapore		0.34	0.25	0.44	0.18
Others	7.31	4.08	1.42	1.21	0.49

Source: Department of Trade and Industry (DTI), 1993. Philippines.

6.1.5. *Production methods and practices*

Background

Previous to the development of shrimp pond culture technologies in the 1970s, the supply of marketable-sized shrimp mostly came from trawling fisheries. Few shrimp is harvest in milkfish ponds only as secondary crop. In view of the market demand, initial attempts to culture shrimp in ponds were made in polyculture with milkfish. The development of the Japanese export market for the giant tiger shrimp in the 1980s fuelled the development of shrimp culture technologies and expansion of production areas through out the country. The investment viability of shrimp farming was further enhanced by the break-through achieved in seed production and grow-out technologies. Some brackishwater fishponds traditionally utilised for milkfish were converted into shrimp farming. Cultured shrimp is produced in three major phases, namely: broodstock development, hatchery/nursery and grow-out.

Broodstock development phase

Most shrimp hatcheries in the Philippines use wild broodstock and spawners which are caught in estuarine and off-shore waters by some passive gears and trawl fishing respectively. The wild spawners, although not abundant, occur throughout the year. Studies are now being conducted to develop broodstocks in pond conditions. In view of the scarcity of wild spawners, the price fluctuates during the periods of hatchery operations. At present, a gravid wild spawner costs about 500-1,000 Pesos. The normal practise is to induce the female broodstock to mature through unilateral eyestalk ablation (Primavera, 1983). Comparatively, wild spawners have higher fecundity than ablated spawners. In ideal conditions, wild spawners produce an average of 500,000 eggs compared to 200,000 eggs for ablated females.

Shrimp broodstocks are maintained in maturation tanks and fed with fresh mussel meat, squid and pellets. The tanks are cleaned of moulted shell and debris daily before feeding. Continuous water flow is maintained throughout the maturation period to ensure good water quality and minimise disease and mortality of the broodstocks. Tank walls are regularly scrubbed to remove dirt and fouling organisms. The broodstocks are checked regularly for their conditions. Ablation is done only when the broodstock is hard-shelled, never when newly moulted or ready to moult. Ablation is done by cutting either eye or pinching the eyeball and crushing the eyestalk. After ablation, spawning normally occurs after one to three weeks depending on the condition of the broodstock.

The ablated broodstocks are checked regularly to determine the degree of ovarian maturation. Females of Stages III and IV are removed from the maturation tanks and transferred to individual spawning tanks. Spawning normally takes place during the night between 2000-0600 h. Based on experience, not all spawners spawn while others spawn partially. The partial and non-spawning phenomena are believed to be associated with stress due to transport, handling, crowding, etc. (Primavera, 1980).

Hatchery and nursery phase

A significant boost to shrimp farming in the Philippines is the development of hatchery techniques. In the beginning, shrimp farmers relied exclusively on the wild stocks for stocking grow-outs. The shrimp fry are collected from estuaries and tidal rivers during spawning periods. However, in some areas the occurrence is seasonal and the quantity and quality is unreliable since the fry come in different sizes. With the establishment of private hatcheries throughout the country, the problem of seed supply has been reduced considerably. At present, the shrimp farming industry relies so much on the hatcheries for the source of seed materials. In 1995, there were more than 300 shrimp hatcheries existing throughout the Philippines, but only about 160 or 48% were operational. Other hatcheries were forced to close down operation in 1994 due to low fry demand and disease problems.

Ideally, shrimp hatcheries are located near the coastline where unpolluted sea water can adequately supply the hatchery requirements. Generally, the sea water is pumped into the hatchery through a series of sand filters to remove organisms, silt and other particles which are present in sea water. Air blowers or compressors are installed to aerate and circulate the water in the tanks.

There are several tank materials used for larval rearing, namely: concrete, fiberglass and marine plywood. Tank capacity depends on the projected production and capability of the hatchery operator. There are two basic techniques employed for larval rearing, either fertilised or unfertilised. The former involves the culture of natural food in the larval tanks by inducing plankton bloom through the application of fertilisers. This technique uses larger tanks with capacity ranging from 10-200 tonnes. Stocking density varies from 30-50 larvae L^{-1}. In the unfertilised method, algal food such as *Skeletonema, Chaetoceros* and *Tetraselmis* are grown in separate tanks for about a week and then harvested through a plankton net and fed to the shrimp larvae. This method uses smaller tanks ranging from 1-10 tonnes. The stocking density is 200 larvae L^{-1}. The larvae are harvested when they reach post larval stage (PL_5-PL_7). Average survival rate of the larvae up to post larval stage varies from a low of 30% to a high of 70% depending on the quality of the spawner, water quality and management expertise of the hatchery operator.

From the hatchery tanks, the post larvae (PL_5-PL_7) are transferred to the nursery tanks for further rearing. Stocking rate varies from 2,000-5,000 m^{-3}. Normally the fry are harvested at PL_{15}-PL_{25} or about 10-20 days culture period in the nursery tanks. Average survival rate ranges from 40-60% from PL_5 to PL_{25}.

The SEAFDEC-AQD has developed a low-cost backyard type shrimp hatchery system using local indigenous materials. At present, most successful shrimp hatcheries in the country are backyard type or small-scale production.

Recent advances in shrimp hatchery technology are: the development of a formulated larval feed as a supplement to natural food, improvements in disease diagnosis and the treatments of inflow waters, and the improvement in hatchery management techniques.

Grow-out phase

Shrimp grow-out technology has undergone series of changes over the years in response to the huge market demand for the product. There are three major culture systems being practised by the industry, namely: extensive, semi-intensive and intensive systems.

The extensive system depends completely on the natural food grown in the pond (e.g. lab-lab, algae) and on tidal fluctuations for water replenishment. Stocking density ranges from 5,000-40,000 ha^{-1}. Milkfish can be jointly cultured using a stocking rate of 500-2,000 fingerlings ha^{-1}. Production from polyculture system is roughly 100-500 kg ha^{-1} yr^{-1} of shrimp and 200-800 kg ha^{-1} yr^{-1} of milkfish.

The semi-intensive system requires supplementary feeding besides the natural food and the use of water pumps in addition to regular tidal water exchange. Stocking density ranges from 50,000-100,000 ha^{-1} with a corresponding higher production of 2,000-4,000 kg ha^{-1} yr^{-1} from each of two crops yr^{-1}.

The intensive system is virtually independent of nature, relying wholly on formulated feeds to sustain the growth of the shrimp and on pumps and aerators to maintain water quality in the pond. The stocking density is over than 100,000 ha^{-1} up to 400,000 ha^{-1} depending on the management and financial capability of the shrimp farmer. The system requires an intensive regimen of daily feeding, water exchange, cleaning and monitoring.

The shrimp farming industry experienced a decline in growth in the late 1980s, due to the prevalence of disease brought about by the intensive production system, and the problem has not yet been controlled. This situation triggered the closure of many intensive shrimp growers throughout the country. At present, the remaining shrimp farmers have reverted to the extensive polyculture and semi-intensive systems to minimise investment risk. Modification of culture management such as crop rotation (e.g. alternate cropping of milkfish and shrimp in polyculture or semi-intensive culture system) and stock manipulation (e.g. growing bigger post larvae in nursery before transferring in grow-out to shorten culture period) are now being promoted to minimise the effect of pollution and diseases.

6.1.6. *Issues and constraints of the Philippine shrimp industry*

Diseases

The Philippine shrimp farming industry is at present dormant or slowing down due to the unresolved prevalence of disease. Because of the current situation many shrimp growers have closed down production or diversified to the culture of other species (e.g. milkfish, groupers, mudcrab). Over the last seven years, intensive shrimp farmers have experienced lower production due to slow growth and survival rates of their cultured shrimp. Intensification of production led to environmental pollution and diseases. Research institutions have identified several shrimp diseases, but the most important are the *Monodon baculovirus* (MBV) and the luminescent bacteria (*Vibrio* sp.). The virus affect juveniles and adults and contamination of the cultured shrimp results to poor growth and eventual death. Studies are underway to prevent occurrence of the disease during the culture period. Meanwhile, the disease has resulted to higher FCR values, longer culture periods, higher operating cost and poor quality shrimp. Unless the disease problem is resolved, shrimp production will remain at low levels.

Environmental degradation

With the proliferation of shrimp ponds throughout the country, the coastal areas suffered high organic load to the detriment of the shrimp farming industry. At present, there are no guidelines on the number of hectares of shrimp farms that can be sustained in a particular area. Due to urbanisation, many of the tidal rivers and coastal areas are being polluted which affects shrimp farming. Associated with environmental degradation is the prevalence of diseases which resulted to low yields and unprofitable farming operations.

6.2. Shrimp technology development

6.2.1. *Background*

In view of the importance of the shrimp industry in the economy of the Philippines, the national government has identified shrimp as one of the priority species for aquaculture development under the Medium Term Fisheries Management and Development Programme (1993-1998). Since the current dilemma on shrimp diseases has not been resolved yet by research institutions, the government is faced with a challenge to develop an alternative technology to sustain shrimp production within ecological limits. In support to the above policy objective, the National Brackishwater Aquaculture Technology Research Centre of the BFAR conducted technology verification trials of the semi-intensive shrimp culture technology to determine its technical feasibility and economics under present conditions.

6.2.2. *Semi-intensive culture of shrimp (*Penaeus monodon*) in brackishwater fishpond*

Introduction

A technology verification on the semi-intensive culture of shrimp (*Penaeus monodon*) in brackishwater fishpond was conducted at the National Brackishwater Aquaculture Technology Research Centre farm facilities at Pagbilao, Quezon, Philippines. The study was undertaken in an effort by the government to find an alternative and a sustainable shrimp culture technology for dissemination to shrimp farmers which have been affected by shrimp diseases. The project was designed to enhance the productivity of the shrimp farming industry within ecological limits. The semi-intensive method which is characterised by low stocking rate (less than 100,000 ha^{-1}) and the use of natural resources (e.g. algae, tidal waters) has been found to be more environmentally friendly and an efficient technology. The primary aim of the project was to pilot-test and evaluate the technical and economic feasibility of the semi-intensive shrimp culture technology under present environmental conditions. The approach was to stock at lower density to minimise dependence on artificial feed but maximise the utilisation of natural food, thus reducing the effect of pollution and diseases. This report covers four cropping occassions and from what the production outputs and economics were analysed.

Materials and methods

A 7,000 m^2 earthen pond was used in this project. Prior to fry stocking, the pond was prepared following standard procedure. The pond was drained, cleaned of debris, levelled and sun-dried until the bottom cracked. Ammonium sulphate fertiliser (21-0-0) and hydrated lime were mixed at a ratio of 1:5 and then applied to the pond bottom soil at a rate of 300 kg ha^{-1} to kill unwanted fish species. Molluscicide was applied to kill small snails and crabs in the pond. Conditioning of the pond soil was done by applying 1,000 kg of hydrated lime. The pond was washed twice after 15 days from application of molluscicide. The pond was filled with tidal water to a depth of 80-100 cm and allowed to grow plankton for about 15 days. To enhance the growth of plankton, one bag (50 kg) of urea fertiliser (46-0-0) was broadcast evenly throughout the pond. The pond preparation process takes about 30-45 days depending on the climatic conditions.

Generally fry stocking was done early in the morning before 08.00 am , when the pond water was still cool to minimise stress. Hatchery-bred fry ranging from PL_{18}-PL_{20} were used in this project. The fry were purchased from a local shrimp hatchery and transported to the project site using oxygenated plastic bags. Upon arrival to the site, at least five fry bags were poured into white basins for the normal random counting to determine total number of stock. While random sampling was undertaken, the remaining fry bags were acclimatised to the pond water salinity and temperature by floating the oxygenated plastic bags in the pond for at least 10-15 minutes. If the salinity of pond water was higher or lower in the plastic bags by 5 ppt, the fry were acclimatised by gradually adding pond water into the fry bags. After fry counting and acclimatisation, the fry were released into the pond. In view of the discrepancy in hatchery fry counts and random fry counting at the project site, stocking rates in the four trial runs varied between 42,800-68,600 post larvae ha^{-1}.

To maintain the growth of plankton in the pond, a 1:1 mixture of urea fertiliser (46-0-0) and ammonium phosphate (16-20-0) fertiliser was applied every week at the rate of 12.5 kg ha^{-1}. The shrimps were allowed to feed on the natural food in the pond during the first 45 days of culture period. The shrimps were fed with supplementary shrimp pellets starting on the forty sixth day of culture up to harvest. The feeds and feeding scheme is shown in Table 6.6. The feeds were broadcasted evenly throughout the pond using a small wooden boat (banca). At least two feeding trays (1 m x 1 m nylon screen net formed by wooden framework) were placed on each side of the pond to check for feed consumption. Feed rations for the day were adjusted based on the appetite of the shrimp.

Table 6.6. Shrimp feeds and feeding scheme

Feed type (Pellet)	Growing stage (g)	Feeding rate (% BW)	Feeding Frequency (Times day^{-1})	Time (h)
Algae	0.01 - 5.0			
Grower	5.0 - 10.0	4	3	07.00/12.00/17.00
Finisher	10.0 - 20.0	3	4	07.00/12.00/17.00/22.00
Finisher	20.0 - above	2	4	07.00/12.00/17.00/22.00

Stock sampling was conducted after 45 days of culture period to determine the average body weight of the shrimp and the first feed ration was calculated. Stock samplings were conducted every 15 days thereafter to adjust feeding rate. During the early stages, the shrimps were sampled by collecting shrimps that fed on the feeding trays. When the shrimp reached 10 g and above, shrimp samples were collected at random using a cast net. Sample size consisted of at least 100 shrimps and the animals were weighed individually using a portable balance. The average body weight (ABW) of the shrimp were calculated by dividing the total weight of the shrimp by the total number of sampled shrimps.

Water exchange was carried out during spring tides that occurred every 15 days. The pond water was changed at least 50% daily for at least 4 consecutive days during spring tides. To effect good water exchange, fresh tidal water was always allowed at the inlet gate, while bad pond water was drained at the outlet culvert situated at the opposite side of the inlet gate. Water level was maintained between 80-100 cm during the culture period using a 2.5 hp electric water pump. To minimise water loss in the pond, control gates were soil sealed immediately after the last water change. Water salinity, temperature and turbidity were monitored daily.

To prevent the entry of pest and predators inside the pond, bamboo screens were installed at the opening of control gates. Another screen made of 2-mm mesh size polyethylene net was installed at the pond side enclosing the gate opening to serve as secondary line of defence in case an unwanted species penetrates the bamboo screen. Teaseed powder at the rate of 50 kg ha^{-1} was applied in the pond after 60 days of culture period to kill finfish that had gained entry into the net during their larval stages and had grown big in the pond. These finfish when not controlled, compete with the shrimps in food and space. The teaseed solution was prepared by soaking teaseed powder in water overnight in any convenient container. The teaseed solution was applied in the morning during sunny weather conditions by broadcasting evenly over the pond water. The teaseed solution kills only finfish but not crustaceans such as shrimps. The application of teaseed solution was scheduled during water change, so that the solution can be flushed within the next scheduled water drain.

The shrimps were harvested when they reached marketable size of about 30-40 g body weight. The pond was totally drained and the shrimps were harvested through a bag net which was attached to the drain gate. The remaining shrimps in the pond were then individually hand-picked. The harvested shrimps were washed with clean water and chilled in plastic tanks. The chilled shrimps were sorted according to size and quality. Soft-shelled, undersized, diseased and deformed shrimps were removed from the good shrimps and were classified as rejects. They were valued at 50-75% price of the good quality shrimps.

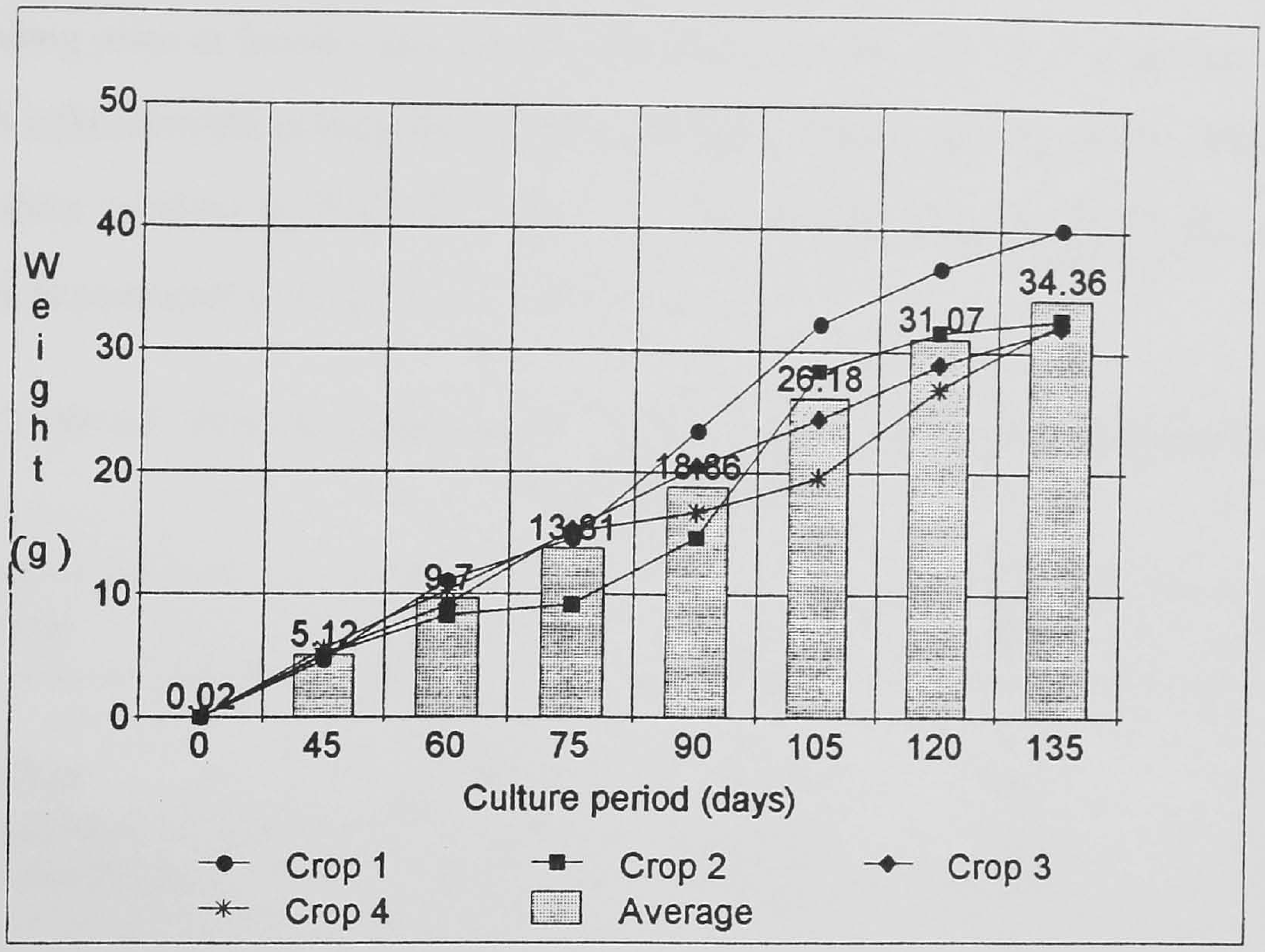
Result and discussion

Table 6.7 shows the production performance of the four cropping periods. Stocking rate ranged from 4.28 m^{-2}-6.86 m^{-2}, or an average rate of 6 m^{-2}. Culture period varied from 131 to 144 days, or an average of 138 days. The average final weight and growth rate of shrimps were 36.1 g and 0.27 g day^{-1} respectively in about 138 days culture period. Survival rate varied among the four crops, from a low of 38% (first crop) to a high of 93% (third crop). Production which was directly affected by the survival rate was highest in Crop 3 and lowest in Crop 1. The second and third crops showed a very high survival rates. Survival rate in the fourth crop period dropped to 54% due to frequent bad weather conditions (e.g. storms and typhoons) which caused disease contamination and mortalities to the shrimp stock. The feed conversion ratio (FCR) increased with increasing stocking density and culture period. Figure 6.1 shows the average weight increase of the shrimps taken during 15 day stock sampling intervals. The graph showed that the shrimps stocked at lowest density (Crop 1) grew faster than those of the other three crops.

Table 6.7. Growth rate, survival rate, production and FCR of shrimp (*P. monodon*) in brackishwater fishpond

Crop	Stocking rate (fry m^{-2})	Final weight (g)	Growth rate (g day^{-1})	Survival (%)	Production (kg ha^{-1})	FCR	Culture period (Days)
1	4.28	40.18	0.31	38	643.86	1.40	131
2	6.17	34.00	0.25	80	1,455.71	1.60	137
3	6.23	34.30	0.25	93	1,979.29	1.90	140
4	6.86	35.90	0.25	54	1,321.43	2.00	144
Ave.	6.00	36.10	0.27	66	1,350.00	1.73	138

Figure 6.1. Weight increase of shrimp (*P. monodon*) in brackishwater fishpond



Looking at the partial cost and return (direct operating cost vs gross benefit) statement of the production technology, all the four crops were profitable (Table 6.8). The highest return was obtained in the third crop period (71,780 Pesos) which had the highest survival rate (93%) and production (1,979.29 kg). The profit from the culture operation depended largely on the volume of production and the prevailing price of the commodity at the time of harvest.

Based on the average production results of the four crops (Table 6.7), a cost and return analysis for operating a one hectare shrimp farming project was prepared (Table 6.9). Under present conditions, the semi-intensive shrimp culture technology is financially viable. The rate of return (RR), internal rate of return (IRR) and benefit-cost ratios (B/C) indicated that the project was profitable under present environmental and economic conditions. The RR, IRR and B/C ratios were 56.82%, 42.70%, 1.68 and

1.24 respectively. Pay back period (PBP) was 3.63 years at one cropping per year. However, the initial capital investment was relatively high (309,500 Pesos ha^{-1}). The prevailing price at harvest and the survival rate were the two most significant factors which influenced the profitability of the production technology. The project also served as a show window for the fish farmers as well as a training ground for the station's technical personnel and on-the-job (OJT) trainees.

Table 6.8. Partial budget analysis of shrimp culture operations covering four cropping periods[a]

Cropping	I	II	III	IV
Yield (kg)	450.7	1,019.0	1,385.5	925.0
Ave. selling price (Pesos kg^{-1})[b]	130.9	129.8	132.0	142.6
Gross sale (Pesos)	59,011	132,265	182,887	131,889
Direct operating cost (Pesos)[c]				
Shrimp fry	13,500	19,482	20,700	21,885
Shrimp pellets	14,500	45,030	61,834	67,585
Fertiliser/Pesticide	2,755	2,595	3,125	4,035
Fuel/Power	4,000	3,356	6,462	1,540
Labour cost	4,000	8,000	11,800	16,000
Miscellaneous	2,000	10,249	100	1,450
Interest on operating loan (6% $crop^{-1}$)[d]	2,445	5,334	6,241	6,132
Total	43,200	94,226	111,107	108,327
Profit (Pesos)	15,811	38,040	71,780	23,562

[a] Marginal analysis adapted from Jolly and Clonts, 1993
[b] Actual market price of shrimp during time of harvest
[c] Actual operating expenses during the time of cropping
[d] Assuming that the budget will be borrowed from the bank

Table 6.9. Cost and return analysis for operating a one hectare tiger shrimp culture project in brackishwater fishpond

Capital cost of rehabilitation (Pesos ha^{-1})	
Pond improvement and repair	75,000
Equipment cost (pump)	50,000
Miscellaneous expenses	25,000
Total	150,000
Depreciation cost (1 crop yr^{-1} x 10 yr)	15,000
Total working capital (rehabilitation + first crop operating cost)	309,500
Production output (per crop)	
Stocking rate (fry ha^{-1})[a]	60,000
Yield (kg $crop^{-1}$)[a]	1,350
Price (Pesos kg^{-1})[b]	217
Gross sale (Pesos $crop^{-1}$)	292,950
Operating cost (Pesos $crop^{-1}$)	
Shrimp fry (P0.50 fry^{-1})	30,000
Shrimp pellets (30 Pesos kg^{-1})[a]	70,000
Labour cost (P4,500 x 2 x 5 months)	45,000
Miscellaneous expenses (10% of cost)	14,500
Total operating cost	159,500
Marketing cost (5% sale)	14,648
Direct cost	174,148
Interest on capital (6% $crop^{-1}$)	18,570
Depreciation cost (per crop)	15,000
Total costs	207,718
Profit	85,232
Break-even cost kg^{-1} shrimp produced (Pesos)[c]	153.87
Break-even price to cover operating cost(Pesos)[c]	118.15
Break-even production to pay operating cost (kg)[c]	735
Rate of return (RR)	56.82%
Internal rate of return (IRR)[d]	42.70%
Benefit-cost ratio (B/C)[d]	1.68
B/C + Total project cost[d]	1.24
Pay back period (PBP)	3.63 yr

[a] Adapted and calculated from Table 6.7
[b] Calculated from 9.69% price increase of tiger shrimp in 1991-1995 (Table 6.4)
[c] Adapted from Jolly and Clonts (1993)
[d] Calculated at 1 crop yr^{-1} for 10 years and discounted at 15%

6.3. Shrimp development plan and strategies

6.3.1. *Background*

The shrimp farming industry has a bright prospect given the proper direction and support by both the government and the private sectors. The industry has developed enormous resources such as pond and equipment facilities, technologies, hatcheries, feed manufacturers, processors and markets to be able to sustain production and growth. The shrimp product enjoys a high market value and world market demand which make the production technology financially viable even at lower levels of production. The shrimp farming industry is enhanced by the break-through in seed production technology such that the previous problem on seed supply is now a thing of the past. The main factor that hinders the growth of the shrimp farming industry in the Philippines is the current prevalence of shrimp disease as a result of production intensification during the last decade. At present, the extensive and polyculture systems are the predominant methods being practised by the shrimp growers since these techniques require lower levels of investment risk, technical skills and management. Recently, an analysis of the semi-intensive shrimp culture method revealed that the technology is technically feasible and financially viable under present environmental conditions. Since the semi-intensive method requires lower stocking rate and feed inputs, possible effects of pollution and diseases can be minimised, if not completely controlled. Moreover, as part of risk management, modification of culture through crop rotation and stock manipulation can be instituted to further neutralise any effects of pollution and diseases (Table 7.4).

The most strategic direction for the shrimp farming industry is the wise utilisation of existing pond resources through the adoption of environmentally friendly culture technologies, such as: low stocking density culture, crop rotation, stock manipulation through shorter culture period, polyculture and maximum utilisation of natural food, to contain possible effects of environmental pollution and diseases.

6.3.2. *Objectives*

The general objective of this development plan is to sustain the aquaculture production growth of the Philippine tiger shrimp through the dissemination and adoption of the semi-intensive shrimp culture technology throughout the country. The specific objectives are as follows:

(1). to intensify training of shrimp farmers, farm caretakers and technicians throughout the country;

(2). to conduct technology adaptation, verification, and demonstration trials of the semi-intensive shrimp culture technology in strategic areas of the country;

(3). to render technical assistance to shrimp farmers during the implementation of the project;

(4). to increase aquaculture production of tiger shrimp by 5% annually for the next five years.

6.3.3. *Implementing strategy and targets*

To achieve the above objectives, activities will be focused on the following implementing strategies:

(1). Training programme - A nation-wide physical survey will be conducted to determine the technological needs of the fish farmers, farm caretakers and extension agents/technicians. The survey results will provide information on the preparation of training course contents, training materials needed, approaches and methodologies, and budgetary requirements. Strategic production areas for shrimp are Regions I (Pangasinan, La Union), III (Pampanga, Bulacan), IV (Marinduque, Mindoro Occ., Mindoro Or., Quezon), V (Camarines Norte, Camarines Sur, Masbate, Sorsogon), VI (Aklan, Capiz, Iloilo, Negros Occ.), VII (Bohol, Cebu), VIII (Leyte, Western Samar), IX (Zamboanga), X (Agusan del Norte, Surigao del Norte, Misamis Occ.), XI (South Cotabato), and XII (Lanao del Norte); or a total of 26 provinces. At least 1,040 fish farmers will be trained for a period of four years at 40 farmers per province. Also, 52 extension agents will be trained (at 2 EOs per Province) to support the extension activities and about 20 farm technicians (2 persons per farm) for the technology piloting and demonstration activities; or a total of 1,112 trainees in four years. To achieve the above target, four training sessions will be organised each year with a maximum of 70 participants per session. The sessions will be conducted quarterly to allow enough time for planning and implementation. To accelerate the training of fish farmers at the regional and provincial levels, regional trainors (Training Specialists at least three per region) will be organised and developed through an intensive on-the-job training course on semi-intensive shrimp culture technology to be conducted at the BFAR National Brackishwater Aquaculture Technology Research Centre in Pagbilao, Quezon, Philippines. These regional trainors can then organise and implement training programmes at their respective regional areas, with technical and funding assistance from the national level. Another strategy that will be adapted is to give priority training to the officers and members of shrimp farmers associations and co-operatives so that after their training, they can serve as a model farmer and a resource person/technician (multiplier effect) to their respective members. The Training Section under the Fisheries Support Services Division of the BFAR will be tapped for the implementation of the training component since they have the logistics and expertise to handle the subject. The estimated budgetary requirement for the training programme will be about

1.4 million Pesos yr^{-1} at a cost of 5,000 Pesos per trainee, or about 5.6 million Pesos in four years.

(2). R and D programme - To achieve this objective, a nation-wide physical survey will be undertaken to locate existing shrimp farms throughout the country; and determine the status of production areas, production performance, level of technology and inputs used, suitability of farm site for shrimp farming and constraints to production. The survey results will provide valuable information in the selection of shrimp farmers and strategic areas for the nation-wide implementation of the semi-intensive shrimp culture technology adaptation, verification and demonstration trials. Moreover, Regional Fisheries Outreach Stations and Demonstration Fish Farms of the Department of Agriculture and Provincial Government Units throughout the country will be tapped for the conduct of R and D programme. These field stations will be evaluated and selected based on their suitability for the conduct of technology adaptation, verification and demonstration activities. Initially, about 10 potential government fish farm demonstration stations throughout the country will be selected. The stations are located in Regions I (1 farm), IV (2 farms), V (3 farms), VII (1 farm), VIII (1 farm), IX (1 farm) and XII (1 farm). There may be a need to establish more technology piloting and demonstration in some strategic private farms in the future. The stations will also serve as show windows for shrimp farming technology as well as training grounds for field personnel, technicians and trainees. The estimated budgetary requirement for the R&D component will be about 7.0 million Pesos yr^{-1} at 1 million Pesos per Administrative Region, or a total of 35.0 million Pesos in five year period.

(3). Extension programme - During the implementation of the project, follow-up extension activities will be conducted by extension agents and technicians to monitor regularly the progress of the project implementation. Government extension agents who have completed training on semi-intensive shrimp farming technology will be given targeted co-operators or clienteles for them to personally monitor and assist the shrimp farmers in the shrimp technology adaptation, verification and demonstration trials. The extension agents will assist the shrimp farmers particularly in the subject of fry stocking, stock sampling and monitoring of physico-chemical parameters, bookkeeping, and solving technical problems relative to the implementation of the project. Estimated budget for the extension programme is 3.5 million Pesos yr^{-1} at 0.5 million Pesos per region or 17.5 million Pesos in five years.

(4). Shrimp production target - Giant tiger shrimp production is projected to increase by about 20% between 1995 and 1996, from 88,815 t to 107,000 t. Starting in 1997, tiger shrimp production will be increased by an average of 5% yearly for the next five years. This production strategy will allow the shrimp farming industry to sustain its positive growth for the next five years while the R&D institutions are working to resolve and contain the effects of shrimp disease. The cumulative area development for tiger shrimp production is shown in Table 6. 10. A total of 21,898 ha of brackishwater ponds will have to be strengthened and re-activated for tiger shrimp production to support the 5% increase in production yearly up to year 2001. To minimise the effects of environmental pollution and diseases, the ponds will be operated for shrimp production only once a year at a stocking rate of 60,000 ha^{-1} and a production potential of 1.35 t ha^{-1} $crop^{-1}$ (Table 6.7). Moreover, the ponds will be alternately cropped with other species (e.g. milkfish, tilapia hybrid, grouper) through extensive polyculture method to further neutralise possible effects of pollution. Initially, about 238 million tiger shrimp fry will be needed to support a stocking rate of 60000 ha for 3,963 ha in 1997. Shrimp fry requirement will increase up to 1.3 billion to support stocking of 21,898 ha by the year 2001. Since the shrimp hatcheries are available (more than 150 hatcheries were operating in 1995, DOST), the problem of seed supply is not anticipated.

Table 6.10. Cumulative area development for aquaculture tiger shrimp production

Year	Production target (t)	Annual increase Prod'n (t)	Annual increase Area (ha)	Annual increase FR (m)	Cumulative increase Prod'n (t)	Cumulative increase Area (ha)	Cumulative increase Total FR (m)
1996	107,000*						
1997	112,350**	5,350	3,963	278	5,350	3,963	278
1998	117,968**	5,618	4,161	569	10,968	8,124	487
1999	123,866**	5,898	4,369	875	16,866	12,493	750
2000	130,059**	6,193	4,587	1,197	23,059	17,081	1,025
2001	136,562**	6,503	4,817	1,534	29,562	21,898	1,314
Total		29,562		4,453	85,805		3,814

* Projected at 20.6% increase from 88,815 t in 1995

** Projected 5% increase yearly for five years

FR = Shrimp fry requirement

m = in millions

6.3.4. *Implementing agencies*

Existing facilities and manpower resources of the government, particularly the BFAR, DA Regional Fisheries Units (RFUs) and Local Government Units will be tapped in the implementation of this development plan. The Fisheries Support Services Division of BFAR can implement the training component and assist in the implementation of the extension programme together with field extension agents of DA Regional Fisheries Units. Since the BFAR, DA and LGUs maintain and operate some research and field demonstration stations throughout the country, these government agencies can be tapped for the implementation of the R and D component. The budgetary requirements will be requested through the usual standard operating procedure. Since the primary inputs (e.g. ponds, hatcheries, farmers, manpower) are existing, the developmental cost for the implementation of the plan will be minimal.

6.3.5. *Time frame*

The implementation of this development plan will be for a period of five years commencing in 1997 to 2001. The fisheries budget appropriated for 1997 can be re-aligned to fund the initial phase (e.g. physical surveys) of the project activities. The physical surveys required for the training and R&D components will be conducted during the first quarter of 1997 so that training activities can start on the second quarter. Since the first three months of 1997 will be used for survey and planning purposes, the four training sessions programmed for 1997 can be spread during the second, third and fourth quarters. The R&D programme will commence right after the first training session, probably in the third quarter of 1997. Project implementation should be in full swing on the second year (1998) up to the fifth year (2001).

6.3.6. *Inputs and expected benefits*

The estimated budgetary requirements and expected benefits of the shrimp development plan is shown in Table 6.11. The development cost is estimated to reach 11.75 billion Pesos for five years. However, the expected direct benefits of the project development plan is over than 25.0 billion Pesos by the year 2001. A total of 284,674 people are expected to be directly benefited from this development activities. Most significant socio-economic impact of the project is the increase in foreign exchange earnings from the export sale of shrimp products and the increased trading and employment opportunities in other related industries particularly the feed and hatchery industries.

Table 6.11. Estimated budgetary requirements and direct benefits for the development of shrimp farming industry in the Philippines, 1997-2001

Item	Budgetary requirement (Million Pesos)
Inputs requirement.	
Research/extension facilities and manpower	Existing
Survey and data gathering (1 million per Region)	15.0
Research and Development (1 M x 7 regions x 5 yr)	35.0
Extension programme (TEV, 0.5 M x 7 regions x 5 yr)	17.5
Training programme (1,112 farmers/technicians at P5,000)	5.6
Production inputs:	
Shrimp fry (3.814 billion x 0.50 Peso fry^{-1})[a]	1,907.0
Shrimp feeds (85,805 t x 1.73 FCR x 30 Pesos kg^{-1})[b]	1,453.3
Ponds and equipment (21,898 ha x P150,000 ha)[c]	3,284.7
Miscellaneous expenses (10%)	671.8
Contingency cost (10%	739.0
Total budgetary requirements	8,128.9
Expected benefits.	
Gross value: Sale of shrimp (85,805 t x 217 Pesos kg^{-1})	18,620.0
Land valuation (21,898 ha x 200,000 Pesos ha)	4,379.6
Tax revenues: Sale (18.62 billion Pesos x 10% tax)	1,862.0
Land (4.379 billion Pesos x 1% tax)	438.0
Employment (1 person ha x 21,898 ha x P54,000 income yr^{-1} x 1%)	11.82
Total direct benefits (Pesos)	25,311.00
Direct additional employment and beneficiaries.	
Regular workers (1 person ha^{-1} x 21,898 ha)	21,898
Part-time workers (2 persons per regular worker)	43,796
Family dependents (5 persons per worker)	218,980
Total	284,674

[a] Calculated from Tables 6.10
[b] Calculated from Tables 6.10 and 6.7
[c] Calculated from Table 6.9

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

Given the proper government support and direction under the present environmental and economic atmosphere, the Philippine aquaculture industry has great potential for growth and development. The aquaculture sector is a dynamic and growing segment of the Philippine economy. Tremendous progress in production and technology has been achieved in the past ten years. However, the country is experiencing a fish production shortfall which the aquaculture sector is expected to play a very important role in supplying, thus, in the overall fisheries development it will become a significant source of protein and employment opportunity for Filipinos in the next decade.

The Philippines has the capability for aquaculture development. The country has the principal attributes necessary for aquaculture growth and expansion. The nation is endowed with important aquaculture species (e.g. shrimp, grouper, milkfish, tilapia) and ideal climatic conditions for raising fish on a commercial scale. It has large existing aquaculture farms (e.g. ponds, cages, pens) and extensive potential inland and marine water resources (e.g. lakes, reservoirs, swamps, sheltered coastal bays and coves) for expansion and diversification. Advanced aquacultural technologies and expertise are available which have evolved from a tradition of aquaculture. This study has shown that there are improved aquaculture production technologies (e.g. milkfish - semi-intensive and net cage cultures, salt-tolerant tilapia hybrid culture in net cages, pond culture of grouper, semi-intensive shrimp culture) which are technically feasible and financially viable under present economic and environmental conditions. There are large numbers of fish farmers distributed throughout the country. These farmers have the experience and financial capabilities to dramatically increase aquaculture production given the proper environment for growth. The Philippines enjoys close and easy access to major export markets such as Japan, Hong Kong, USA and Europe which can be tapped for expansion. The country also has various local and foreign institutions (e.g. SEAFDEC-AQD, ICLARM, DA-BFAR, LB, ADB) that can play a vital role in the development of the aquaculture sector. Fisheries credit is available to support renovation, improvement and operation of aquaculture farms, although in the past there were only few takers due to stringent requirements by the lending institutions. The government gives high priority to aquaculture development such that fisheries policies and priority thrusts are geared towards improving the productivity of aquaculture areas through the promotion and adaption of high yielding technologies within ecological limits. Seed caught from the wild are the main source for aquaculture production, except for shrimp and tilapia which are mass produced in the hatcheries. Research efforts are geared towards the mass production of milkfish fry and grouper fingerlings to solve the problem of seed supply in these important aquaculture species.

Although these factors give the Philippines a significant advantage for aquaculture development, there are a number of constraints that must be overcome for the country to attain the maximum benefit from the potential for aquaculture.

(1) Seed supply and quality - The most serious constraints to the growth and development of aquaculture in the Philippines is the limited supply of quality seed for stocking grow-outs. For example, milkfish and grouper farming depend mainly on the supply of wild fry and fingerlings. Shrimp hatcheries have experienced low fry survival due to the prevalence of diseases. Despite the availability of hatchery technology for the salt-tolerant tilapia hybrids, there are no available fingerlings for stocking grow-outs. Unless the problem of seed production is resolved, there can be no real and stable growth in production of these important aquaculture species or strains. Therefore, to accelerate the rapid development and growth on these species, R&D

efforts must be intensified to mass produce quality fry and fingerlings in the hatchery. Meanwhile, the most strategic option for milkfish development is for the government to pursue a short-term importation of milkfish fry from other Asian countries to sustain growth of the farming industry. On the other hand, the most strategic option for grouper development is the proper management and utilisation of existing grouper resources by improving survival rate of wild grouper fry in the nursery phase, and for the government to restrict exportation of grouper fry and fingerlings to boost the grouper farming industry in the country.

(2) Feed supply and quality - The feed industry in the Philippines is at an early stage of development. Feed ingredients, particularly fish meal and soy bean, are imported from other countries making the price of local feed very expensive. Normally in aquaculture, feed costs constitute from 50-70% of the total production cost depending on the species. This makes aquaculture intensification a very risky option. Moreover, due to inadequate supply of reasonably priced commercial feed, imported low quality feed proliferated in the market, thus increasing the risk for environmental pollution. There is, therefore, an urgent need to develop cost-efficient feed of better quality out of local materials to lower production costs and reduce the effect of environmental pollution. Perhaps, another strategy to lower feed cost is to encourage the fish farmers to formulate their own feed at a lower cost. This strategy can be done by intensifying training programme on feed formulation, and by forming fish farmers into co-operatives so that their chances for credit approval is high.

(3) Government policies - Although in general, there are adequate government policies and legislations supporting the accelerated development of the aquaculture industry in the Philippines, more could be done to stimulate accelerated growth and development through intensified technology transfer (e.g. technology adaptation, verification and demonstration trials of improved aquaculture technologies in strategic

production areas throughout the country), training of fish farmers, farm caretakers and extension agents, and tax incentives to new entrepreneurs and small-fish farmers (e.g. lower income tax on sales during the first one or two years, lower interest rates on aquaculture credits, subsidised tariff on imported goods used in aquaculture industry such as fish meal and soy bean).

(4) Marketing and post-harvest - Although there are well established fish processors and exporters in the Philippines, many others do not operate at quality levels that will meet international standards. These inefficient companies will continue to affect the reputation of Philippine exports unless they are closely monitored by the government and improvements are made in their operations. Moreover, it is important that value-added products, particularly the non-traditional export products such as milkfish and tilapia, should be promoted and encouraged by both the government and the private sectors to improve market value and expand and diversify domestic and export markets, thus improving the market price and marginal profit of the fish farmers on these species. There is a need for the government to set policy standards on aquaculture products in the local markets to create better pricing mechanism and product competitiveness.

(5) Environmental degradation and disease - This will become a very serious threat to the growth and expansion of the aquaculture sector in the future if the problem is not properly managed during the present stage of development. There is a need to promote and encourage the species diversification and integrated culture system. For example, polyculture and crop rotation methods must be practised in aquaculture areas which have been affected by environmental pollution and diseases to allow the environment to absorb the organic load discharged from aquaculture operations. In freshwater lakes and coastal marine waters, there is an urgent need for the government to establish developmental zones throughout the country to define

production areas in terms of the distance of fish cages and allowable number of fish cages per unit area (Beveridge, 1984) to minimise if not totally neutralise any effects of pollution and diseases.

(6). Grow-out ponds and farm management skills - Although there are vast numbers of brackishwater ponds available for aquaculture development (e.g. 239, 323 ha in Table 2.1) in the Philippines, only about 101,194 ha (42.3%) are productive areas (32,746 ha for shrimp and 68,448 ha for milkfish production) while about 138,129 ha (57.7%) are either undeveloped or unutilised. Since most of the brackishwater ponds are shallow and traditionally built (e.g. low and small dikes, large ponds), some rehabilitation works must be done to make them ideally suitable for the adaption of new improved aquaculture technologies. Under present economic conditions, the estimated cost for pond improvements is between 100,000 to 150,000 Pesos ha^{-1}. With the improvement of grow-out ponds, fish farmers' knowledge and skills must also be upgraded to the improved farm culture technologies through intensive technology transfer and training. Although there are plenty of fish farmers who are well experienced in fish farming, there is a shortage of highly qualified individuals with the capability to manage commercial-scale grow-out operations. As growth in the industry begins to accelerate, the shortage of qualified fish farm managers and manpower will become more acute unless there is a major effort to improve existing fisheries educational system and upgrade fisheries training facilities of government agencies and research institutions.

(7). Aquaculture credit - Although there are institutions that provide credit to aquaculture projects, there appears to be some difficulties in the availment of loans due to stringent procedures and high interest rates required by the bank. Moreover, there is a shortage of affordable short and medium-term credit system for the small and medium-scale fish farmers, which is essential to finance working capital and new investments. Unless, an affordable credit scheme is made available to qualified small and medium-scale fish farmers and entrepreneurs, growth in the aquaculture industry will be limited to a relatively small group of rich fish farmers who do not require access to credit.

(8). High mortality rate - There exists a technological deficiency in the production chain in some brackishwater aquaculture species such as grouper fry and milkfish (e.g. grouper fry survival in the nursery phase is 0-20%, milkfish fry from 20-50%). Since the production of these species are presently influenced by the supply of seeds from the wild, efforts must be directed to maximise the utilisation of the wild resources through improvement in survival rate of wild fry. Unless, the propagation techniques for milkfish and grouper are perfected, there can be no substantial development on the farming industry of these species.

7.2. Conclusions

Despite the constraints, the overriding conclusion of this study is that aquaculture development in the Philippines, particularly the brackishwater sector, has enormous growth potential, and that this potential provides great opportunities for local fish farmers, fish processors and exporters, and other domestic and foreign investors. This conclusion is based primarily on the tremendous socio-economic benefits that can be derived from the implementation of the aquaculture development plans (Table 7.1). Summing up all the benefits that can be derived, the long range impact on the national economy would more than outweigh the inputs the government has to make to develop the brackishwater aquaculture industry. Notable benefits that can be derived are as follows.

(1) Contribution to Gross Domestic Product (GDP) - The socio-economic impact of the whole brackishwater aquaculture development activities can be seen in

terms of its relative contribution to the gross domestic product (GDP) of the country. Aside from generating income and employment to large numbers of Filipinos, the increase in fish food supplies to the domestic markets (e.g. milkfish, tilapia), and to exports (e.g. grouper, shrimp) will contribute significantly to the fish deficiency problem of the country. It will also generate substantial foreign exchange needed for external trade and thus, reducing fish imports and foreign trade deficit and improve the economy of the nation. For example, in five years a total of 616,966 t of additional fish supply can be produced for the domestic markets, while the foreign exchange earnings that can be generated from the export of shrimps and groupers will be about 19.845 billion Pesos (equivalent to about GB£ 522 million).

(2) Direct additional employment - Specifically, the implementation of the development plans would mean additional full-time jobs to about 31,438 people, and 62,876 part-time workers assuming that one regular worker needs at least two helpers during fish stocking, harvesting and marketing activities. Assuming that each worker supports a family of five persons, total dependents that will benefit from the project is about 355,650 persons. The total additional number of Filipinos that would directly benefit from the brackishwater aquaculture development activities is estimated at 450,000. This number does not include other people that will be employed in related industries such as in feed manufacturing, fry production , trading and marketing which is also expected to be enormous.

(3) Tax revenues - The potential increase in tax revenues from the development activities is estimated at 4.70 billion Pesos over five years. A significant amount of 4.234 billion Pesos would be generated from the direct sale of aquaculture products, followed by land tax (452 million Pesos) and income tax from direct additional employment (18 million Pesos).

Table 7.1. Significant socio-economic benefits from brackishwater aquaculture development in the Philippines, 1997-2001

Benefits	Milkfish	Tilapia	Grouper	Shrimp	Total
Additional fish supply (Domestic markets)					
Quantity (t)	225,966	143,000	428,000		616,966
Value (Million Pesos)	14,914	7,150	428		22,492
Foreign exchange earnings					
Quantity (t)			4,115	85,805	89,920
Value (Million Pesos)			1,235	18,610	19,845
Value (Million GB£)			33	490	523
Direct additional employment and dependents					
Full-time worker	5,194	3,060	1,286	21,898	31,438
Part-time worker	10,388	6,120	2,572	43,796	62,876
Dependents	77,910	45,900	12,860	218,980	355,650
Total	93,492	55,080	16,718	284,674	449,964
Additional tax revenues					
Direct sales tax	1,491	715	166	1,862	4,234
Land tax	10	1	3	438	452
Income tax	3	2	1	12	18
Conversion of unutilised areas into productive farms					
Area (ha)	5,194	526	1,314	21,898	28,932
Value (Pesos)	1,039	105	263	4,380	5,787
Trained and skilled manpower					
Fish farmers	3,108	3,208	1,286	1,040	8,642
Extension officers	112	50	68	52	282
Farm technicians	80	57	0	20	157
Total	3,300	3,315	1,354	1,112	9,081
Increase in feed production					
Quantity (t)	451,932	357,500	16,460	148,443	974,335
Value (Pesos)	5,423	4,290	0.165	4,453	14,166
Increase in seed production					
Quantity (Million)	2.26	2,000	14.1	3,814	5,830
Value (Pesos)	2,260	1,000	141	1,907	5,308

(4). Other economic benefits - Other expected socio-economic benefits from the implementation of the development plans are the conversion of 28,932 ha of unutilised areas into productive farms valued at 5.787 billion Pesos; the utilisation and recycling of organic waste (e.g. chicken manure) as fertilisers in fishponds; improved health and nutrition of Filipinos due to increased utilisation of fish protein; and the production of 9,081 trained and skilled manpower. The training of fish farmers, caretaker, extension officers and technicians on improved culture techniques will enhance their technical experiences and managerial skills. This will in turn encourage development of new, innovative and cost-efficient technologies, thus, producing better quality products at lower production cost for the benefit of the consumers. Moreover, the brackishwater aquaculture development activities will spur the development of other support industries such as feed manufacturing, processing and export companies, and fry collection and production. The expected increase in feed production is 974,335 t with a value of 14.166 billion Pesos in five years. The expected increase in seed production is 5.83 billion with a value of 5.308 billion Pesos in five years. Lastly, the increased earnings generated in the industry are recycled back to the economy in terms of more spending on goods and services which will make for a sound Philippine economy.

7.3. Strategies for brackishwater aquaculture development

The implementation of the brackishwater aquaculture development programme will be for a period of five years commencing in 1997 to 2001. The overall timetable of activities is given in Table 7.2. During the first and second quarter of 1997, all planning activities, organisation, regional consultations (this will be employed as a strategy to get feedback and commitments of local government units, regional

Table 7.2. Timetable of development activities, 1997-2001

Activity	Start	Finish
1. Planning, organisation and budget preparation	1997 (1st qtr)	1997 (2nd qtr)
2. Regional co-ordination, consultation, identification of training needs, site survey and selections	1997 (1st qtr)	1997 (2nd qtr)
3. Signing of MOA/commitments by participating government agencies and fish farms	1997 (2nd qtr)	1997 (2nd qtr)
4. Rehabilitation and improvement of farm sites (government and private farms)	1997 (2nd qtr)	1997 (4th qtr)
5. Budget approval and annual release of funds	1997 (1st qtr)	2001 (4th qtr)
6. Training of fish farmers, caretakers, technicians, hatchery operators and extension officers	1997 (2nd qtr)	2001 (4th qtr)
7. Technology transfer: adaptation, verification, pilot-testing, demonstration trials (R&D)	1998 (1st qtr)	2001 (4th qtr)
8. Intensification of aquaculture production by fish fish farmers (milkfish, tilapia, grouper, shrimp)	1998 (1st qtr)	2001 (4th qtr)
9. Extension services (project monitoring, follow-up visits and technical assistance to fish farmers	1998 (1st qtr)	2001 (4th qtr)
10. Monitoring, evaluation and status reporting (Quarterly)	1998	2001
11. Transfer of fisheries extension and management to LGUs, Fisheries co-operative/associations, NGOs	2002 and beyond	

personnel and fish farmers), co-ordination, budget preparation, surveys, site selection, pond rehabilitation and data gathering will be implemented. All other activities such as training, research and development, production and extension, will start in the second or third quarter of 1997 and continue until the end of the project in year 2001. Regular monitoring and evaluation of project activities will be employed as a strategy to analyse unanticipated constraints during the implementation phase and plan alternative course of action. After year 2001, government responsibility for aquaculture extension and development will be gradually relinquished to the private sector (e.g. Fish farmers co-operatives/associations, NGOs) and the local government units (LGUs).

In general, the Department of Agriculture is the main government agency responsible for carrying out the programmes of agriculture and fisheries including the development of the aquaculture industry. Consistent with the objectives of the Medium Term Fisheries Management and Development Programme (MTFMDP) of the Department of Agriculture-Bureau of Fisheries and Aquatic Resources, the strategic policies and directions for aquaculture development are directed at increasing production within ecological limits. For the aquaculture sector, one of the specific objectives is to double aquaculture production from 1.2 to 2.4 t ha^{-1} yr^{-1} through the promotion of improved and high yielding aquaculture technologies.

To stimulate growth and rapid development of the industry, strategies for the development of the brackishwater aquaculture sector must be focused on the following issues: (a) Maximum utilisation of existing fishery resources through the rehabilitation and improvement of unproductive and unutilised brackishwater fishponds throughout the country, expansion of production areas to sheltered marine coastal waters, improvement of survival rate of wild fry (e.g. milkfish, grouper), and proper management of existing fry grounds and nurseries particularly milkfish and grouper which are limiting factors for production. (b) Increasing the productivity of existing fish farms through intensive technology transfer (e.g. conduct of technology adaptation, verification, field-testing and demonstration in strategic aquaculture production areas throughout the country), training and productivity enhancement seminars, and extension services. (c) Intensive investment in R&D to mass produce good quality seeds of milkfish, salt-tolerant tilapia hybrids, grouper and shrimp for a whole year period. (d) Intensify market and export promotions of export species (e.g. grouper and shrimp) to non-traditional markets such as Europe and other developed Asian countries (e.g. Korea, Singapore). (e) Increase investment in processing and post-harvest to develop value-added products of traditional (e.g. shrimp, grouper) and non-traditional export products (e.g. milkfish, tilapia) of international quality standard to expand and diversify markets of these species. and (f) Investment in feed production and distribution to increase supply and accessibility of good quality feed in the domestic markets throughout the country. (g) Conduct environmental studies to contain possible effects of pollution and environmental damage from aquaculture operations.

Specifically, strategies and directions for the sustainable growth and development of the brackishwater aquaculture sector with emphasis on milkfish, salt-tolerant tilapia hybrid, grouper and shrimps are as follows.

Milkfish

(1) Promotion and adaption of the semi-intensive milkfish culture technology in brackishwater fishponds through out the country through intensive training of fish farmers, technology transfer and extension services.

(2) Expansion of milkfish production in sheltered marine coastal waters through field-testing and promotion of the milkfish net cage culture technology.

(3) Establishment of milkfish fry bank and nurseries in strategic milkfish production areas throughout the country to improve fry and fingerling distribution and accessibility to milkfish growers.

(4) Development of cost-efficient feed for milkfish using local materials to lower production cost and improve fish farmers profitability.

(5) Development of value-added product for milkfish (e.g. smoking, drying, canning, fish fillets) to expand and diversify domestic and export markets.

(6) Conduct environmental studies on the possible effects of fish cage culture development and determine allowable limits in certain body of water (e.g. strategic developmental zones, distance between cages, allowable number of cages per unit space, mesh size, structural design).

(7) Refinement of milkfish propagation technology to mass produce milkfish fry in the hatchery at lower cost.

(8) Pursue short-term importation of milkfish fry from other Asian countries such as Taiwan and Indonesia to support a sustainable production, growth and development of milkfish farming industry.

Tilapia

(1) Mass production of salt-tolerant tilapia hybrids for stocking brackishwater and marine water areas, and as potential alternate species for shrimps and milkfish in stocking brackishwater ponds.

(2) Expansion of tilapia production to unutilised brackishwater ponds and sheltered marine coastal waters through field-testing and promotion of the salt-tolerant tilapia culture technology.

(3) Development of low-cost feed for tilapia using local materials to lower production cost and improve farmers income per unit area and capital.

(4) Export market promotion and development of value-added products to improve market value of tilapia and profitability of culture

(5) Continue R&D on salt-tolerant tilapia breeding and genetics to develop hybrids with faster growth performance.

Grouper

(1) Assessment and management of grouper fry grounds throughout the country.

(2) Improvement of survival rate of wild grouper fry in the nursery phase, and improvement of growth rate and production in grow-out units.

(3) Field-testing and promotion of grouper culture in ponds (monoculture and polyculture) to improve feed efficiency and production per unit area.

(4) Development of low-cost alternative feed for grouper out of locally available technology. For example, studies on biomanipulation methods (polyculture of groupers with some forage fish) must be conducted to determine optimum requirements and economics.

(5) Refinement of grouper propagation technology to mass produce fingerlings in the hatchery/nursery at lower cost.

(6) The government should initiate legislation to ban the export of grouper fingerlings to other Asian countries to enhance the local grouper farming industry.

Shrimp

(1) Promotion and technology transfer of the semi-intensive shrimp culture and crop rotation technologies (e.g. first crop, shrimp; second crop, milkfish).

(2) Export market promotion and expansion in non-traditional markets (e.g. Europe, USA).

(3) Establishment of shrimp laboratory and diagnostic centres in strategic shrimp production areas throughout the country to assist shrimp growers in the identification and prevention of diseases.

(4) Intensify R&D efforts on the development of shrimp broodstocks in ponds to minimise dependence from wild stocks.

(5) Intensify R&D efforts on prevention and control of shrimp diseases.

The principal initiative for the holistic development of the brackishwater aquaculture sector must come from the private sector (e.g. fish farmers, hatchery operators, processors, feed manufacturers) which are in the best position to make essential improvements and innovations in their production and management practices. Therefore, the participation of the private sector, with particular emphasis to existing fisheries co-operatives and associations (e.g. fish farmers co-operative, shrimp producers associations, Philippine fish processors and exporters associations) and non-government organisations (e.g. CFAR, SAEP, ADFI), should be strengthened and expanded in all aspects of aquaculture. Formation of fish farmers co-operatives and associations will be encouraged, particularly in areas which have no existing co-operatives, to facilitate technology transfer and credit assistance. Intensive training of fish farmers and farm caretakers should be emphasised and given priority to make them self-reliant after the project implementation in the year 2001. For example, fish farmers should be involved in the planning and implementation of technology verification and adaptation trials in their respective farms, or fish farmers should be involved in study tours/visits to successful aquaculture farms and projects. However, progress will depend upon close co-ordination and co-operation with the government who makes and sets policies that will encourage private initiative.

Regardless of the methods, approaches and strategies that will be used in the development process, there are at least three important factors which the government can play a vital role in the successful implementation of the brackishwater aquaculture development programme. These are improved access to credit, training and extension and fish farmers investment incentives.

(1) Credit - To stimulate rapid investments in the aquaculture industry, the government must devise a scheme that will induce financial institutions to lend on

attractive terms at lower interest rates to prospective borrowers (e.g. fish farmer, hatchery operators, feed manufacturers, fish processors). For example, the government will support exemption of fishponds from the Comprehensive Agrarian Reform Law or CARL (this law provides that one farmer can only own from 5-7 ha of land which is allegedly not conducive for short-term investment), and the strengthening of the Fishpond Lease Agreement or FLA (government land leased to farmers for 25 years renewable for another 25 years) as a negotiable instrument (collateral) in the application for aquaculture credits.

(2) Training and extension services - The apparent lack of skilled and qualified manpower can be gleaned from inadequate training facilities and technically skilled technicians and trainors (Training Specialists). There is a need for government to strengthen existing fish farm demonstration and training facilities throughout the country, most particularly in strategic aquaculture areas to develop technically skilled technicians and trainors. Intensified field-testing and implementation of technology adaptation, verification and demonstration trials in government outreach and fish farm demonstration stations and selected fish farmers association and co-operatives will be used as a strategy to develop competent and qualified field technicians. Technical training courses utilising highly experienced and professional technicians must be given high priority. Primary emphasis should be given to hands-on and on-the-job (OJT) training methods to provide practical experience to trainees. Non-government organisations (NGOs) which are existing and active in the Philippines (e.g. Chamber of Fisheries and Aquatic Resources, Shrimp producers association) should be tapped for training and transfer of improved farming technologies.

(3) Fish farmers' incentives - It is also essential for the government to develop incentive scheme for aquaculture production to improve efficiency and profitability. For example, the government may allow tax reduction for high fish producers, tax

exemption on imported aquaculture supplies/material/equipment (e.g. brine shrimp, soybean meal, fish meal, DO meter), or exemption (reduction) from sales tax of export products. The government should encourage fish farmers productivity by providing input assistance (e.g. free interest on fry, feeds, fertilisers) and rewarding successful farmers (e.g. government recognition award for top fish producer of the year, free fellowship training or study tour for successful fish farmers). The exemption of fishponds from CARL could be a permanent incentive that would boost fish farmers initiative to invest more in fish farming business.

7.4. Risks discussion and species prioritisation

For purposes of identifying and defining the important factors and problems associated with aquaculture development, a logical framework for the development of the brackishwater aquaculture sector in the Philippines is presented in Table 7.3. While the logical framework provides in summary the target objectives, outputs and inputs that must be accomplished, it also identifies the assumptions and risks that must be overcome and managed in order to meet the desired objectives. For this project, the most important risks that are likely to affect the accomplishment of targets are the natural calamities (e.g. strong typhoons, floods), technical (e.g. seed supply and quality, feed supply and cost), environmental impact (e.g. pollution, diseases), financial (e.g. project cost, budget), social risk (e.g. conflict in the use of water resources for aquaculture) and institutional (e.g. government priority). Although these identified risks cannot be totally avoided, proper planning and management can minimise its negative effects during project implementation. Since the Philippine government may not have adequate funds to support the continuous development of the brackishwater aquaculture sector, there is therefore, a need to prioritize the species in terms of its worth and risks (Table 7.4). Under the present political and economic environments, tilapia and milkfish have favourable conditions in view of their low project costs and high socio-economic returns. However, more efficient and better quality feeds must be developed to minimize feed costs and improve the profitability of the tilapia and milkfish culture technologies. On the other hand, grouper and shrimps require high capital investments and therefore, not within the financial and managerial capability of the small fish farmers. Moreover, milkfish and grouper have low chances of success if their seeds supply from the wild are not enough to sustain the projected increase in production. Shrimp has a high chance of success if the disease problem is contained and managed in the future. Assuming that the effects of typhoons, floods, conflicts, pollution and diseases can be minimised and/or controlled through proper management, the risk assessment indicates that the priority species for development is tilapia followed by shrimp, milkfish and grouper in that order. As part of risk management, the following strategies must be considered. To avoid natural calamities, fish production must be confined during the first, second and third quarters of the year since strong typhoons and floods normally occur during the last quarter. The last quarter must be programmed for pond drying, repair and cleaning. On the other hand, to minimise the effects of environmental pollution and diseases, aquaculture production must be limited to 2 crops yr^{-1} to allow the environment to process and absorb the organic waste from aquaculture operations. In ponds, the practice of crop rotation and alternate croppings (e.g. first crop-semi-intensive culture of shrimp or milkfish, second crop-extensive/polyculture system of shrimp, milkfish, tilapia or grouper) is highly recommended. The establishment of developmental zones for marine cage culture operations, widely spread allowing enough distance between each cage, will minimise the effects of pollution and diseases. It will also avoid conflicts in navigation and fishing grounds for small-scale fishermen.

Table 7.3. Logical framework for brackishwater aquaculture development in the Philippines

Summary	Indicators	Means of verification	Assumptions and risks
A. National objectives	National indicators	National statistics	Wider assumptions and risks
1. Increase food fish supply for domestic consumption	1. Increase in aquaculture production from 1.2 national average to 2.4 t $ha^{-1}yr^{-1}$ 2. Increase in domestic consumption 3. Decrease in fish deficit	1. BFAR, BAS, NSO 2. Market price index 3. Record of fish landings 4. FAO fisheries statistics	1. Farm sites, technology, markets, manpower and seeds for stocking are available 2. Increase in production can be readily absorbed by the current fish shortage and demand 3. Fish consumption will increase due to increasing population growth 4. Environmental pollution and diseases can be controlled through proper farm management 5. Propagation techniques for seeds will be improved and commercialised
2. Increase in gross domestic product (GDP) and gross national product (GNP)	1. Increase in aquaculture revenues (e.g. gross sale, income, tax, marketing) 2. Increase in aquaculture employment and other services 3. Increase in foreign exchange earnings 4. Decrease in fish imports 5. Increase in export value	1. DTI, NSO, BFAR, BAS 2. Bureau of Internal Revenue 3. FAO fisheries statistics 4. Market price index	1. Market prices of fish will not fall below the current price level 2. Employment will increase with development and improvement of new farm sites 3. Product quality will improve to meet international standard 4. New value-added products will be developed 5. New markets will be explored and penetrated
3. Provide socio-economic benefits to small-scale fish ....farmers and other beneficiaries	1. Improved health and nutrition and life quality of fish farmers and the Filipino people 2. Increase in income and spending activities on goods and household appliances of fish farmers 3. Increase in the use of community services by fish farmers (e.g. hospitals, schools, markets)	1. Municipal records 2. School records 3. Hospital and health centre records 4. Survey of fish farmers household	1. Improve the income level of fish farmers 2. Improve the working conditions and hygiene practices of fish farmers 3. Improve the quality of life of the fish farmers 4. Improve the technical proficiency, competitiveness and employment opportunity of fish farmers

		Specific records	Specific assumptions and risks
Milkfish			
1. Increase milkfish production through adaption of improved techniques and development of new farm sites	1. Increase in milkfish production by 10% annually for five years 2. Increase in milkfish domestic consumption 3. Increase in area of developed milkfish farms (e.g. 5,000 ha of developed brackishwater ponds and 194 ha of sheltered marine waters in 5 yr)	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. Record of fish landings 4. Site survey and inspection	1. Farm sites, technology, markets, manpower and seeds for stocking are available 2. Import of milkfish fry from other Asian countries will be pursued by the government 3. Increase in milkfish production can be easily absorbed in the domestic market 4. Water pollution, diseases, typhoons, floods, and conflicts can be avoided or minimized through proper planning and management
2. Improve supply distribution of milkfish fry and fingerlings through establishment of fry bank and nurseries	1. Increase in the number of milkfish fry bank and nurseries in strategic areas through out the country (e.g. 83 fry bank/nurseries in 5 years) 2. Increase in the number of fry/fingerlings produced	1. Site survey and inspection 2. Report of accomplishments 3. Quarterly status reports 4. BFAR annual report 5. Provincial/Municipal records	1. Milkfish fry from the wild are available during spawning seasons 2. Private milkfish nursery operators are available and interested 3. Government demostration fish farms are available and suitable for nursery operations
3. Intensify technology transfer of semi-intensive and marine ....net cage culture technologies through the conduct of training and technology adaptation, verification and demonstration trials	1. Number of trained fish farmers and technicians (e.g. 3,300 trainees in 5 years) 2. Number of technology adaptation, verification and demonstration trials conducted 3. Number of fish farmers given technical assistance 4. Number of successful fish farmers adapting the improved milkfish technologies	1. Provincial/Municipal records 2. BFAR records 3. Report of accomplishments 4. Site survey and inspection	1. Training and extension funds, facilities, supplies, equipment and expertise are available 2. Fish farmers and technicians are interested and willing to learn the improved technologies 3. Fish farmers have the financial capability to adopt the improved technologies 4. Present economic conditions will not change to affect financial viability of the project
Salt-tolerant tilapia hybrid			
1. Increase tilapia production through the culture of saltwater-tolerant tilapia hybrids in pond-based and marine based net cages	1. Increase in tilapia production by 10% annually for five years 2. Increase in tilapia domestic consumption 3. Increase in the number of developed areas utilized for saltwater-tolerant tilapia hybrid production (e.g. 440 ha of brackishwater ponds and 86 ha of sheltered marine waters in 5 yr)	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. Record of fish landings 4. Site survey and inspection	1. Farm sites, technology, markets, manpower and fish farmers are available 2. Saltwater-tolerant tilapia hybrid fingerlings are readily available when needed 3. Low-cost feed for tilapia will be developed and commercially available 4. Water pollution, diseases, typhoons, floods, and conflicts can be avoided or minimized through proper planning and management

	Specific indicators	Specific records	Specific assumptions and risks
2. Mass produce saltwater-tolerant tilapia hybrid fry and fingerlings through establishment of fry hatcheries and nurseries	1. Number of saltwater-tolerant tilapia hybrid fry hatcheries/nurseries established (e.g. 69 hatcheries/nurseries in 5 years) 2. Number of saltwater-tolerant tilapia hybrid fry and fingerlings produced	1. Site survey and inspection 2. Report of accomplishments 3. Quarterly status reports 4. BFAR annual report 5. Provincial/Municipal records	1. Farm sites, technology, expertise and funds are readily available when needed 2. Private hatchery/nursery operators are available and interested 3. Government demostration fish farms are available and suitable for nursery operations
3. Intensify technology transfer of saltwater-tolerant tilapia ....hybrid culture technologies through the conduct of training and technology adaptation, verification and demonstration trials	1. Number of trained fish farmers and technicians (e.g. 3,315 trainees in 5 years) 2. Number of technology adaptation, verification and demonstration trials conducted 3. Number of fish farmers given technical assistance 4. Number of successful fish farmers adapting the saltwater-tolerant tilapia hybrid culture technologies	1. Provincial/Municipal records 2. BFAR records 3. Report of accomplishments 4. Site survey and inspection	1. Training and extension funds, facilities, supplies, equipment and expertise are available 2. Fish farmers and technicians are interested and willing to learn the culture techniques for salt-water-tolerant tilapia hybrids 3. Fish farmers have the financial capability to adopt the culture technologies 4. Present economic conditions will not change to affect financial viability of the project
<u>Grouper</u>			
1. Increase grouper production through the culture of grouper in ponds and development of new farm sites	1. Increase in grouper production by 10% annually for five years 2. Increase in grouper export volume and value 3. Increase in the number of developed areas engaged in grouper production (e.g. 1,286 ha of new ponds developed for grouper in 5 yr)	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. Record of fish exports 4. Site survey and inspection 5. Department of Trade and Ind.	1. Farm sites, technology, markets, manpower and seeds for stocking are available 2. Export of grouper fingerlings to other Asian countries will be banned by the Government 3. Increase in grouper production can be easily absorbed in the export market 4. Seed supply from the wild will be enough to sustain increase in production target
2. Improve survival and growth rates of wild grouper fry in the nursery phase through adaption of improved nursery managementtechniques	1. Increase in the number of grouper fry bank and nurseries in strategic areas through out the country 2. Increase in the number of fry/fingerlings produced	1. Site survey and inspection 2. Report of accomplishments 3. Quarterly status reports 4. BFAR annual report 5. Provincial/Municipal records	1. Grouper fry and fingerlings from the wild are abundant during spawning seasons 2. Private grouper nursery operators are available and interested 3. Improved nursery management techniques for grouper are available and commercially feasible

3. Intensify technology transfer on improved grouper nursery ....management and grow-out techniques through training and technology adaptation, verification and demonstration trials	1. Number of trained fish farmers and technicians (e.g. 1,354 trainees in 5 years) 2. Number of technology adaptation, verification and demonstration trials conducted 3. Number of fish farmers given technical assistance 4. Number of successful fish farmers adapting the improved grouper technologies	1. Provincial/Municipal records 2. BFAR records 3. Report of accomplishments 4. Site survey and inspection	1. Training and extension funds, facilities, supplies, equipment and expertise are available 2. Fish farmers and technicians are interested and willing to learn the improved technologies 3. Fish farmers have the financial capability to adopt the improved technologies 4. Present economic conditions will not change to affect financial viability of the project
<u>Shrimp</u>			
1. Increase shrimp production through the adaption of semi-intensive shrimp culture technology and reactivation of existing shrimp farms throughout the country	1. Increase in shrimp production by 5% annually for five years 2. Increase in shrimp export volume and value 3. Number of hectares of reactivated shrimp farms (e.g. 21,898 ha of brackishwater ponds throughout the country in 5 yr)	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. Record of fish landings 4. Site survey and inspection	1. Farm sites, technology, markets, manpower and quality seeds for stocking are available 2. Present shrimp disease will be controlled and managed 3. Increase in shrimp production can be easily absorbed in the export market 4. Water pollution, diseases, typhoons, floods, and conflicts can be avoided or minimized through proper planning and management
2. Intensify technology transfer of semi-intensive shrimp culture ....technology through the conduct of training and technology adaptation, verification and demonstration trials	1. Number of trained fish farmers and technicians (e.g. 1,112 trainees in 5 years) 2. Number of technology adaptation, verification and demonstration trials conducted 3. Number of fish farmers given technical assistance 4. Number of successful fish farmers adapting the semi-intensive shrimp culture technique	1. Provincial/Municipal records 2. BFAR records 3. Report of accomplishments 4. Site survey and inspection	1. Training and extension funds, facilities, supplies, equipment and expertise are available 2. Fish farmers and technicians are interested and willing to learn the improved technologies 3. Fish farmers have the financial capability to adopt the improved technologies 4. Present economic conditions will not change to affect financial viability of the project through proper planning and management

		Project records	Output assumptions and risks
1. Sustainable production from brackishwater aquaculture	1. Increase in volume of fish produced from brackishwater aquaculture	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. FAO fisheries statistics 4. Site survey and inspection	1. Ideal conditions will prevail 2. Typhoons, floods, pollution and diseases will be managed and will not affect production 3. Government policies and economic conditions will not change
2. Increase in revenues	1. Increase in gross sale of fish from aquaculture 2. Increase in foreing exchange earnings 3. Increase in tax revenues	1. Department of Trade and Ind. 2. Bureau of Internal Revenue 3. FAO fisheries statistics 4. Fisheries statistics, BAS	1. Market price and demand will not change 2. Production targets and projections are correct
3. Employment and other services	1. Increase in the number of fish farmers employed 2. Increase in the number of people employed in related industries (e.g. feeds, marketing)	1. Site survey and inspection 2. National Statistics Office 3. Department of Labour 4. Records of LGUs	1. Development plans and targets will be implemented 2. Small fish farmers will be employed
4. Improved infrastructure facilities (e.g. ponds, demostration farms, ...training facilities, equipment) and trained manpower (e.g. EOs and fish farmers)	1. Number of trained fish farmers and technicians 2. Number of ponds and demo farms improved and rehabilitated 3. Improved extension services and training programme 4. Number of successful fish farmers adapting the improved milkfish technologies	1. Provincial/Municipal records 2. BFAR records 3. Report of accomplishments 4. Site survey and inspection	1. Training and extension funds, facilities, supplies, equipment and expertise are available 2. Fish farmers and technicians are interested and willing to learn the improved technologies 3. Fish farmers have the financial capability to develop their farms 4. Trained farmers and technicians will remain in the fish farming industry
5. Utilisation of unproductive sites and organic waste	1. Number of hectares of ponds and sheltered marine waters developed and established 2. Volumeof organic waste (e.g. chicken manure as fertilizers in ponds) recycled and utilised utilized for saltwater-tolerant tilapia hybrid	1. Philippine fisheries profile 2. Fisheries statistics, BAS 3. Provincial/Municipal records 4. Site survey and inspection	1. Farm sites and organic waste are available 2. Unproductive sites are available and not being utilised for other purposes 3. Developmental zones will be established to manage pollution and diseases
6. Improved health and nutrition by fish farmers and Filipinos	1. Decrease in malnutrition and sick patients 2. Increase in healthy people in the community	1. Provincial/Municipal records 2. Hospital/Health centre records	1. Fish protein is cheaper and more accessible compared to other sources of protein 2. Filipinos will eat more fish

1. Capital costs: land dev't. and improvement, infrastructure facilities and equipment	1. Budget allocations, releases and disbursements 2. Bank transfer 3.Delivery checks and verification	1. Accounting records 2. Report of disbursements 3. Provincial/Municipal records 4. Site survey and inspection	1. Workplan and budget duly approved 2. Budget disbursements are made available as needed 3. Timing of commissioning critical
2. Maintenance and operating costs: surveys, supplies and materials, personnel services, transportation, fuel, etc.	1. Delivery checks and verifications 2. Payment vouchers and official receipts 3. Approved programme of works and projects	1. Accounting records 2. Inventory reports 3.Accomplishement reports	1. Release of supplies and materials are on time 2. Workplans and budget duly approved 3. Project personnel are available when needed
3. Technology transfer: training, technology adaptation, verification and demonstration trials and extension programme	1. Training designs and programme 2. Budget allocation and approval 3. Approved R&D project proposals 4. Approved extension programme and activities	1. Site survey and inspection 2. Training reports and records 3. Accomplishment reports 4. Status and progress reports	1. Funds are readily available as required 2. Ideal conditions will prevail 3. Targets are attainable

Table 7.4. Risk assessment and species prioritisation

Criteria	Milkfish	Tilapia	Grouper	Shrimp
Seed supply	High	Low	High	Low
Feed cost	Manageable	Manageable	High	High
Market demand/acceptability	Low	Low	Low	Low
Technology/suitability	Low	Low	Low	Low
Project cost	Low	Low	High	High
Financial viability	High	High	Low	Low
Socio-economic	High impact	High impact	Low impact	High impact
Government priority	High priority	High priority	Low priority	High priority
Environmental pollution	Low	High	Low	High
Potential diseases	Low	High	High	High
Typhoons and floods	Manageable	Manageable	Low	Low
Conflicts with navigation and fishing grounds	Manageable	Manageable	Low	Low
Chance of success	Low	High	Low	High
Prioritisation	3	1	4	2

Legend:

Low - Low risk

High - High risk

Manageable - can be minimized or controlled

7.5. Recommendations

In addition to the recommendations already discussed in previous paragraphs, other important recommendations that must be pursued by both the government and the private sectors are as follows.

(1) Export promotion - The government and the private sector should launch a strong promotional campaign on aquaculture products particularly those that have high export value (e.g. grouper, shrimp) to increase awareness of the consumers on the product quality, and improve the image of Philippine exports. In addition to the current export markets, new and non-traditional markets must be penetrated.

(2) Post-harvest and marketing - Value-added products and technology packaging must be given priority in research and development to expand and diversity the markets and enhance the profitability of the fish farmers. For example, value added products on non-traditional export such as milkfish and tilapia should be developed to increase the demand and value of the product (e.g. canning, smoking, fish fillets, fish nuggets/crackers, improved packaging technique). On the other hand, new and improved packaging techniques on traditional export such as shrimp and grouper should be explored. The existing local quality standards on fish processing must also be improved to meet the international standard. This will enhance product competitiveness in the world market and increase market demand of the aquaculture products. The introduction of post-harvest products as a community-based project in coastal communities, will increase womens' participation (particularly fishermen and fish farmers wives) in fisheries development.

(3) Feed - The feed industry will be crucial to the expansion of the aquaculture industry, and it cannot develop unless the government facilitates the importation of

essential ingredients (e.g. fish meal and soybean meal) and the private manufacturers to develop cost-efficient and quality feed formulation. Therefore there is a need for the government to reduce, if not totally eliminate, the impediments or restrictions in the importation of necessary feed ingredients and other essential items directly related to aquaculture production. Meanwhile R&D efforts on cost-efficient feed must be pursued to develop low-cost and efficient feed out of local materials.

(4) Environmental degradation - Intensification of aquaculture production led to environmental pollution and diseases. Therefore, the fish farmers must learn to adapt only environmental friendly technologies for the sustainability of the aquaculture industry. The government must undertake environmental studies to determine the impact of aquaculture to the water environment and formulate policy guidelines to address the problem even before it can allow any aquaculture development in a particular area. Unless the problem on environmental pollution is not properly managed in the early phase of development, the potential risk of diseases from aquaculture is high and will eventually stop the growth of the aquaculture industry. There is a need to diversify into other species (e.g. salt-tolerant tilapia hybrid) for possible integration (polyculture) with major species such as shrimp, milkfish and grouper. Stock manipulation (e.g. regular transfer of fish from one pond to another to shorten culture period) and crop rotation (alternate practise of extensive and semi-intensive systems) methods must be strongly pursued by the government and the fish farmers as a sustainable production strategy to contain pollution and diseases. Expansion of production to sheltered coastal marine waters must be encourage to minimise pressure in the inland water areas. Both the government and the private sectors should conduct a nation-wide educational campaign on environmental issues, particularly with the fish farmers, consumers and fisherfolks, to create awareness on the negative effects of pollution, as well as environmental management and

conservation. All research efforts related to the above aspects must be encouraged by the government with the end product of developing sustainable and environmental friendly production technologies.

(5) Technology transfer beyond year 2001 - Since the government could not possibly sustain the continued cost of technology transfer, there is a need to train the private sector to assist in this endeavour, and perhaps assume some of the responsibilities of fisheries extension beyond the implementation of the project in the year 2001. There is also a need to train the LGUs by involving them in the planning and implementation of research activities at the farmers site, so they can assist in the transfer of technology most particularly after the project implementation. Intensive training of fish farmers associations/co-operatives must be given high priority to make them self-reliant and can be utilised to lead in the transfer of technology beyond the project implementation. Formation of fish farmers co-operatives should be encouraged and the existing ones must be strengthened to facilitate dissemination of information and access to credit. For example, the co-operative can provide technical services (e.g. seminar, workshop, training, consultations), maintain and share infrastructure facilities and equipment and assist members in outside business transactions (e.g. marketing, credit). Lastly, co-ordination with NGOs should be strengthened so that they can also be utilised for technology transfer beyond the project life.

REFERENCES

ADB. (1992) Key indicators of developing Asian and Pacific countries. Economic and Development Resource Centre, Asian Development Bank, Manila, Philippines, volume 23.

ADB-NACA. (1991) *Fish Health Management in Asia-Pacific*. ADB agricultural department report series no. 1. Asian Development Bank-Network of Aquaculture Centre in Asia-Pacific. Bangkok, Thailand.

ACPC. (1996) Fisheries credit in perspective. Paper presented at the second national fisheries workshop on policy planning and industry development, February 6-9, 1996, Puerto Azul, Cavite. Agricultural Credit Policy Council, Philippines. Unpublished report.

Anonymous. (1996) It's official: RP population now 68,614,162. Philippine Daily Inquirer, September 6, 1996, as cited from the National Statistics Office, Metro Manila, Philippines.

Angeles, R.V. (1992) Export prospects of tilapia. In: R.D. Guerrero III and D.DG. Fernandez (eds) *Tilapia Farming in the Philippines: Recent Developments.* Proceedings of the second national symposium and workshop on tilapia farming, November 21-23, 1991, CLSU, Munoz, Nueva Ecija. p. 53-67.

Apud, F., Primavera, J.H. and Torres, P.L. Jr. (1983) *Farming of Prawns and Shrimps.* Extension manual no. 5, SEAFDEC-AQD, Tigbauan, Iloilo, Philippines.

Avault, J.W. and Shell, W.E. (1967) Preliminary studies with *T. nilotica* x *T. mossambica. FAO Fish. Rep.* 44, (4): 237-242.

Aypa, S.M. (1993) Status and advances of aquaculture in the Philippines. Paper presented at the workshop/convention of the Chamber of Fisheries and Aquatic Resources, October 1993, Manila, Philippines. 15 pp.

BAR. (1989) *National Agricultural Research and Extension Agenda, 1988-1994.* Bureau of Agricultural Research. Department of Agriculture, Quezon City, Philippines.

BAR. (1995) *National Fisheries and Aquatic Resources Research Agenda.* Bureau of Agricultural Research and Philippine Council for Aquatic and Marine Research and Development, Philippines. 53 pp.

Bardach, J.E., Ruther, J.H. and Melarney, W.O. (1972) *Aquaculture: the Farming and Husbandry of Freshwater and Marine Organisms.* John Wiley and Sons, New York.

BAS. (1993) Fisheries statistics. Bureau of Agricultural Statistics. Department of Agriculture, Quezon City, Philippines.

BAS. (1996) Fisheries statistics, 1986-1995. Bureau of Agricultural Statistics. Department of Agriculture, Quezon City, Philippines. 40 pp.

Bautista, A.M., Carlos, M.H., Acosta, B.O. and Valera, P. B. (1988) Cage culture of *Oreochromis aureus* and *Oreochromis niloticus* hybrids in Laguna Lake, Philippines. *J. Aqua. Trop.*, 3:77-82.

Benitez, L.V. (1984) Milkfish nutrition. In: J.V. Juario, R.P. Ferraris and L.V. Benitez (eds) *Advances in milkfish biology and culture.* Island Publishing House, Manila, Philippines. p. 133-143.

Beveridge, M.C.M. (1984) Cage and pen fish farming: carrying capacity models and environmental impact. *FAO fisheries technical paper* no. 255. 131 p.

BFAR. (1987) *Main report.* Proceedings of the national conference on fisheries policy and planning, March 16-20, 1987, Baguio City, Philippines. Bureau of Fisheries and Aquatic Resources, Quezon City.

BFAR. (1993a) Medium term fisheries management and development programme. A component of the Medium Term Agricultural Development Plan, 1993-1998, Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines. 22 pp.

BFAR. (1993b) 1992 Philippine fisheries profile. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines. 44 pp.

BFAR. (1995) 1994 Philippine fisheries profile. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines. 43 pp.

BFAR. (1996a) 1995 Philippine fisheries profile. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines. 47 pp.

BFAR. (1996b) Report of the second national fisheries workshop on policy planning and industry development, February 6-9, 1996, Puerto Azul, Cavite. Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines.

Camacho, A.S. and Lagua, N.M. (1987) The Philippine aquaculture industry. In: J.V. Juario and L.V. Benitez (eds.) *Perspective in aquaculture development in Southeast Asia and Japan.* Proceedings of the seminar on aquaculture development in Southeast Asia. SEAFDEC-AQD, Iloilo, Philippines. p. 91-116.

Chen, F.Y. (1979) Progress and problems of net cage culture of grouper (*Epinephelus tauvina* Forskal) in Singapore. *Proceedings World Mariculture Society.* 10:260-271.

Chervinski, J. (1982) Environmental physiology of tilapias. In: R.S.V. Pullin and R.H. Lowe-McConnel (eds.) *The biology and culture of tilapias.* ICLARM conference proceedings, International Centre for Living Aquatic Resources Management, Manila, Philippines. p. 119-128.

Chiu, Y.N., Estilo, V.J., Sumagaysay, N.S. and Sastrillo, M.A.S. (1988) Effects of supplementary feeding, increased stocking rates and aeration on milkfish yields in brackishwater pond. University of the Philippines in the Visayas. Unpublished paper.

Chua, T.E. and Teng, S.K. (1978) Effects of feeding frequency on the growth of young estuary grouper, *Epinephelus tauvina* Forskal, cultured in floating net cages. *Aquaculture,* 14:31-37.

Chua, T.E. and Teng, S.K. (1980) Economic production of estuary grouper, *Epinephelus salmoides* Maxwell, reared in floating net cages. *Aquaculture,* 20:187-228.

Chua, T.E. and Teng, S.K. (1982) Effects of food ration on growth, condition factor, food conversion efficiency and net yield of estuary grouper, *Epinephelus salmoides* Maxwell, cultured in floating net cages. *Aquaculture*, 27:273-283.

Cruz, P.S. (1994) Shrimp farming in the Philippines: culture practices and problems. Paper presented at the ASEAN-EEC Aquaculture Development and Co-ordination Programme (AADCP) Component 3 workshop on strategy for technology transfer in aquaculture, November 14-18, 1994, Puerto Azul, Cavite, Philippines. 30 pp.

Dickson, J.O. (1993) Status of deep-sea fishing industry including Pacific operations. Paper presented at the first workshop/convention of the Philippine Chamber of Fisheries and Aquatic Resources (PCFAR), Metro Manila, Philippines.

Dieta, R.E. (1992) A study on the development of aquaculture in the Philippines with emphasis on milkfish farming. MSc dissertation, University of Hull, U.K. 81 pp.

DOST. (1994) Achieving international competitiveness through technology development and transfer. Department of Science and Technology, Philippines. Unpublished report. 142 pp.

Duray, M.N. (undated) Status of the breeding and seed production of grouper. Southeast Asian Fisheries Development Centre-Aquaculture Department, Tigbauan, Iloilo, Philippines. Unpublished report.

Dureza, L.A. (1994) Hatchery and culture of tilapia hybrids in brackishwater fishponds. *Tilapia farming: genetic improvement and advances on culture technology.* In: L.G. Villacorta and L.A. Dureza (eds.) Proceedings of the third national symposium and workshop on tilapia farming, November 25-27, 1993. University of the Philippines in the Visayas, Iloilo City, Philippines.

DTI. (1993) World exports of shrimps and prawns. Department of Trade and Industry, Manila, Philippines. Unpublished report.

FAO. (1993) Aquaculture production, 1985-1991. *FAO Fisheries Circular* No. 815, Revision 5. Fishery information, data and statistics service. FAO Fisheries Department, Rome. 213 pp.

FAO. (1995) Aquaculture production statistics, 1984-1993. *FAO Fisheries Circular* No. 815, Revision 7. Fishery information, data and statistics service. FAO Fisheries Department, Rome. 186 pp.

Felix, S.S. (1973) Bangus culture in fish pen. Bureau of Fisheries and Aquatic Resources, May 1973, Manila, Philippines. Unpublished paper. 23 pp.

FNRI. (1987) Third national nutrition survey. Food and Nutrition Research Institute, Manila, Philippines. As cited by the Bureau of Fisheries and Aquatic Resources in 1995 Philippine fisheries profile.

Eknath, A.E. (1994) The project of genetic improvement of farmed tilapias (GIFT): from modest beginnings to an international network of genetics in aquaculture. *Tilapia farming: genetic improvement and advances on culture technology.* In: L.G. Villacorta and L.A. Dureza (eds.) Proceedings of the third national symposium and workshop on tilapia farming, November 25-27, 1993, University of the Philippines in the Visayas, Iloilo City, Philippines. p. 9-13.

Gaffud, S.B. and Nipales, C.B. (1993) Potentials of grouper culture. Philippine Human Resources Development Centre (PHRDC), Sea farming Research and Development Department (SRDD), Dagupan City, Philippines. Unpublished paper. 13 pp.

Guerrero, R.D. III. (1994) recent developments on tilapia farming in the Philippines. *Tilapia farming: genetic improvement and advances on culture technology.* In: L.G. Villacorta and L.A. Dureza (eds.) Proceedings of the third national symposium and workshop on tilapia farming, November 25-27, 1993, University of the Philippines in the Visayas, Iloilo City, Philippines.

Guerrero, R.D. III. (1996) Status of national research for inland fisheries and aquaculture. Paper presented at the second national fisheries workshop on policy planning and industry development, February 6-9, 1996, Puerto Azul, Cavite, Philippines. Unpublished report. 8 pp.

Hickling, C.F. (1962) *Fish culture*. Faber and Faber, London : 295 pp.

Hickling, C.F. (1967) Fish hybridisation. *FAO Fish. Rep.* 159(1):162-179.

Hopkins, K.D. and Cruz, E.M. (1982) The ICLARM-CLSU integrated animal-fish farming project: final report. *ICLARM Technical Report*, 5:96 pp.

Jolly, C.M. and Clonts, H.A. (1993) *Economics of aquaculture*. Food Products Press. An imprint of The Haworth Press, Inc. Binghamton, NY. 319 pp.

Juliano, R.O. (1987) Fisheries education: issues, problems and recommendations. In: *Proceedings of the National Conference on Fisheries Policy and Planning*. March 16-20, 1987, Baguio City. BFAR, Quezon City, Philippines. Volume 3.

Juliano, R.O. (1990) Priorities and strategies for fisheries research and development for the year 2000. In: I.C. Pagsuberon (ed.) *Proceedings of the National Science and Technology Week Celebration*. Los Banos, Laguna. DOST, Philippines.

Juliano, R.O. (1996) Aquaculture in the Philippines: situation, issues and problems, action plans and recommendations. Paper presented at the second national fisheries workshop on policy planning and industry development, February 6-9, 1996, Puerto Azul, Cavite, Philippines. 35 pp.

Juliano, R.O. and Hirano, R. (1986) The growth rate of milkfish, *Chanos chanos*, in brackishwater ponds in the Philippines. In: J.L. Maclean, L.B. Dizon and L.V. Hostillos (eds.) *The First Asian Fisheries Forum*. Asian Fisheries Society, Manila, Philippines.

Kohno, H., Duray, M. and Juario, J. (1988) State of grouper (Lapu-lapu) culture in the Philippines. *SEAFDEC Asian Aquaculture*, 10(2): 4-8.

Kuo, H. (1969) Notes on hybridisation of tilapia. Joint Comm. Rural Reconstr. (Chinese-American). *Fish. Ser.*, 8: 116-117.

Lacanilao, F. (1993) Philippine fisheries research system. In: F.B. Davy (ed.) *Resources Allocation to Fisheries Research in Asia*. Asian Fisheries Society, Manila, Philippines.

Lavilla-Pitogo, C.R., Leano, E.M. and Paner, M.G. (1996) Mortalities of pond-cultured juvenile shrimp, *Penaeus monodon*, associated with dominance of luminescent bacteria, *Vibrio harveyi*, in the rearing environment (Abstract). Paper presented at the second international conference on the culture of penaeid prawns and shrimps, May 14-17, 1996, Iloilo City, SEAFDEC-AQD, Philippines.

Lightner, D., Redman, R., Mohney, L., Dickenson, G. and Fitzsimmons, K. (1988) Major diseases encountered in controlled environment culture of tilapia in fresh and brackishwater over a three-year period in Arizona. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) *The Second International Symposium on Tilapia in Aquaculture*. ICLARM conference proceedings 15. Department of Fisheries, Bangkok, Thailand and International Centre for Living Aquatic resources Management, Manila Philippines.

MacCrimmon, J.Z., Stewart, J. and Brett, J.R. (1974) Aquaculture in Canada: the practice and the promise. *Bull. 188, Fish. Res. Bd. Canada*, Ottawa. 84 pp.

Mane, A.M. (1979) Cage culture of tilapia in Laguna de Bay. In: Technical consultation on available aquaculture technology in the Philippines, February 8-11, 1979, Iloilo, Philippines. SEAFDEC-AQD/PCARR. p. 320-324.

Manzano, V.B. (1989) Polyculture of grouper (*Epinephelus tauvina)* and tilapia (*Oreochromis mossambicus*) in brackishwater ponds. In: E.A. Huisman, N. Zonnelveld and A.H.M. Bouwmans (eds.) *Aquaculture Research in Asia: Management Techniques and Nutrition*. Proceedings of the Asian seminar on aquaculture organised by IFS, Malang, Indonesia, November 14-18, 1988. p. 171-181.

Merrett, A.T. and Sykes, A. (1966) *Capital Budgeting and Company Finance*. The Camelot Press Ltd., London. 184 pp.

Nelson, J.S. (1984) *Fishes of the World*. Second edition. A Willey-Interscience Publication. New York.

NSCB. (1995) National accounts of the Philippines. National Statistics Co-ordination Board. Manila, Philippines. Unpublished report.

NSO. (1992) 1992 Philippine yearbook. National Statistics Office, Manila, Philippines. 1449 pp.

Otubusin, S.O. and Lim, C. (1985) The effect of duration of feeding on survival, growth and production of milkfish, *Chanos chanos* Forskal, in brackishwater ponds in the Philippines. *Aquaculture*, 46: 287-292.

Pascual, F.P., Sumagaysay, N.S. and Borlongan, I.G. (1991) Modular method of rearing milkfish with artificial feed. In: S.S. De Silva (ed.) *Fish Nutrition Research in Asia*. Proceedings of the fourth Asian fish nutrition workshop. Asian Fisheries Society, Manila, Philippines. p. 159-167.

Payne, A.I. (1983) Estuarine and salt-tolerant tilapias. In: L. Fishelson and Z. Yaron (eds.) *International Symposium on Tilapia in Aquaculture*. Tel Aviv University, Tel Aviv, Israel.

PCAMRD. (1991) Prospects for semi-intensive milkfish culture. Training material on semi-intensive milkfish culture, February 26-27, 1991. Philippine Council for Aquatic and Marine Research Development, Taguig, Metro Manila, Philippines. Unpublished paper.

PCAMRD. (1995) An analysis of the R&D investment for the fisheries sector. Philippine Council for Aquatic and Marine Research Development, Policy paper no. 1, Metro Manila, Philippines. 53 pp.

PCARRD. (1982) State of the art: milkfish research. Philippine Council for Aquatic Resources Research and Development. *Fisheries Series No. 3*. Los, Banos, Laguna, Philippines.

Philippart, J. Cl. and Ruwet, J.Cl. (1982) Ecology and distribution of tilapias. In: R.S.V. Pullin and R.H. Lowe-McConnell (eds.) *The Biology and Culture of Tilapias*. ICLARM conference proceedings, International Centre for Living Aquatic Resources Management, Manila, Philippines. p. 15-59.

Pillay, T.V.R. (1990) *Aquaculture Principles and Practices*. Fishing News Book. Blackwell Science, Oxford. 575 pp.

Pollock, B. (1995) Fisheries management in the Philippines: a brief review. Paper presented at the second national fisheries workshop on policy planning and industry development, February 6-9, 1996, Puerto Azul, Cavite, Philippines. 16 pp.

Primavera, J.H. (1980) Sugpo (*P. monodon*) broodstock. SEAFDEC Technical consultation on prawn. Southeast Asian Fisheries Development Centre-Aquaculture Department, Tigbauan, Iloilo, Philippines. Unpublished report.

Primavera, J.H. (1983) Broodstock of Sugpo, *Penaeus monodon* Fabricius. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Pruginin, Y., Rothband, S., Wohlfarth, G., Helevy, A., Moav, R. and Hulata, G. (1967) All male broods of *T. nilotica* x *T. aurea* hybrids. *Aquaculture*, 6: 11-21.

Pruginin, Y., Fishelson, L. and Koren, A. (1988) Intensive tilapia farming in brackishwater from an Israeli desert aquifer. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) *The Second International Symposium on Tilapia in Aquaculture*. ICLARM conference proceedings 15. Department of Fisheries, Bangkok, Thailand and International Centre for Living Aquatic resources Management, Manila Philippines.

Rabanal, H.R. (1995) Aquaculture extension services review: the Philippines. *FAO Fish. Cir. No. 892*, Food and Agriculture Organisation of the United Nations, Rome. 57 pp.

Salvador, R.C., Salvador, A.A. and Bacalando, N.Y. (1994) Seacage culture of sex-reversed tilapia hybrid in Northern Samar. *Tilapia farming: genetic improvement and advances on culture technology*. In: L.G. Villacorta and L.A. Dureza (eds.) Proceedings of the third national symposium and workshop on tilapia farming, November 25-27, 1993, University of the Philippines in the Visayas, Iloilo City, Philippines.

Santos, L.M. and Lacanilao, F. (1991) Fisheries education in the Philippines: a review of curricular programs. In: H.C. Liu and S.Y. Yeh (eds.) *Fisheries Education and Training in Asia: Second Workshop Proceedings*. Proceedings of the second workshop on fisheries education and training in Asia, Academia Sinica, Taipei, Taiwan, R.O.C., October 23-25, 1991. Asian Fisheries Society, Manila, Philippines.

Schuster, W. (1960) Synopsis of biological data on milkfish: *Chanos chanos* Forskal. *FAO Fisheries Synopsis No. 4*, Food and Agriculture Organisation, Rome, Italy.

SEAFDEC-AQD. (1990) Annual Report 1989. Southeast Asian Fisheries Development Centre-Aquaculture Department, Tigbauan, Iloilo, Philippines.

Smith, I.R. (1981) The economics of the milkfish fry and fingerling industry of the Philippines. *ICLARM Technical Report 1*. International Centre for Living Aquatic Resources Management and Southeast Asian Fisheries Development Centre-Aquaculture Department, Manila, Philippines.

Stickney, R.R. (1986) Tilapia tolerance of saline waters: a review. *Prog. Fish-Cult.*, 48 (3): 161-166.

Sumagaysay, N.S. (1989) Prospects of intensive milkfish culture. Southeast Asian Fisheries Development Centre-Aquaculture Department, Tigbauan, Iloilo, Philippines. Unpublished paper.

Sumagaysay, N.S., Chiu-Chern, Y.N., Estilo, V.J. and Sastrillo, M.A.S. (1990) Increasing milkfish (*Chanos chanos*) yields in brackishwater ponds through increased stocking rates and supplementary feeding. *Asian Fish. Sci.* 3: 251-256.

Suzuki, K. (1988) Salinity ranges related to sperm motility and propagation response in some tilapiines. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) *The second international symposium on tilapia in aquaculture*. ICLARM conference proceedings 15. Department of Fisheries, Bangkok, Thailand and International Centre for Living Aquatic resources Management, Manila Philippines.

Tacon, A.G.J., *et al.* (1989) The food and feeding of seabass *Lates calcarifer*, grouper *Epinephelus tauvina* and rabbitfish *Siganus canaliculatus* in floating net cages at the National Sea farming Development Centre. Technical paper 13, FAO/UNDP Sea farming Development Project INS/81/008, Lumpung, Indonesia.

Tayamen, M.M., *et al.* (1993) AADCP training manual on tilapia culture. Working paper, ASEAN-EEC Aquaculture Development and Co-ordination Programme, Component 3, Manila, Philippines. 71 pp.

Teng, S.K. and Chua, T.E. (1978) Effects of stocking density on growth of estuary grouper, *Epinephelus salmoides* Maxwell, cultured in floating net cages. *Aquaculture*, 15: 273-287.

Teng, S.K. and Chua, T.E. (1979) Use of artificial hides to increase the stocking density and production of estuary grouper, *Epinephelus salmoides* Maxwell, reared in floating net cages. *Aquaculture*, 16: 219-232.

Tseng, W.Y. and Ho, S.K. (1988) *The biology and culture of red grouper: a practical manual*. Chien Cheng publisher, Kaohsiung, Republic of China.

Villegas, C.T. (1990) Evaluation of the salinity tolerance of *Oreochromis mossambicus, Oreochromis niloticus* and their F_1 hybrids. *Aquaculture*, 85: 281-292.

Watanabe, W.O., Kuo, C.M. and Huang, M.C. (1985) Salinity tolerance of the tilapias *Oreochromis aureaus, Oreochromis niloticus* and *O. mossambicus* x *O. niloticus* hybrid. *ICLARM technical report 16.* Council for Agricultural Planning and Development, Taipei, Taiwan and International Centre for Living Aquatic Resources Management, Manila, Philippines. 22 pp.

Watanabe, W.O., Ellingson, L.J., Wickland, R.I. and Olla, B.L. (1988) The effects of salinity on growth, food consumption and conversion in juvenile, mono-sex male Florida red tilapia. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) *The second international symposium on tilapia in aquaculture*. ICLARM conference proceedings 15. Department of Fisheries, Bangkok, Thailand and International Centre for Living Aquatic resources Management, Manila Philippines. p.515-523.

Westlund, L. (1995) Apparent historical consumption and future demand for fish and fishery products-exploratory calculations. International conference on sustainable contribution of fisheries to food security, Kyoto, Japan, December 4-9, 1995. Food and Agriculture Organisation of the United Nations, KC/FI/TECH/8.

Wohlfarth, G.W. and Hulata, G. (1983) Applied genetics of tilapias. *ICLARM Studies and Reviews 6*. International Centre for Living Aquatic Resources Management, Manila, Philippines. 26 pp.

Yashouv, A. and Halevy, A. (1967) Studies on growth and productivity of *T. aurea* and its hybrid Ghan-Shannel in experimental ponds at Dor. *Bamidgeh* 9(1): 16-23.