ICLARM TECHNICAL REPORTS 3

Inputs as related to output in milkfish production in the Philippines

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and
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BUREAU OF AGRICULTURAL ECONOMICS, FISHERY INDUSTRY DEVELOPMENT COUNCIL,
INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

Frontispiece:

About 1920, Dr. Pio Valencia, a Tagalog practising medicine in Cebu, acquired an ancient fishpond on Mactan Island. He purchased a quantity of fry, stocked the pond, and at the close of season sold the fish for 500 pesos, to the great astonishment of the local people. This result was obtained without any improvement of the pond and shows the difference between chance stocking and intelligent planting of bangos fry. Later Dr. Valencia acquired more fishpond land and made extensive alterations and improvements until he has a fine modern plant. (Herre and Mendoza 1929)

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1982

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Cover: Part of the harvest of a farm in Negros Oriental, on its way to be packed in ice for shipment to Manila.

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Preface

Aquaculture or the husbandry of aquatic organisms has been practised in one form or another for many centuries. Yet much of aquaculture research has been limited to the bio-technical aspects of fish culture. Very little information, beyond costs and returns analyses, is available on the economics of aquaculture systems. These costs and returns studies are by and large descriptive in nature and shed little light on the potential for increasing profits by relating levels of input use to input and output prices.

This technical report deals with the production economics of the milkfish industry in the Philippines. It focuses on the estimation of input-output relationships, or production functions, as a methodology to determine the economic efficiency of milkfish producers. The study demonstrates that increased use of supplementary inputs will increase profits and thus provides statistical support for those private and government efforts to increase milk-fish production in the Philippines through the adoption of more intensive technology.

The study on which this technical report is based was a joint undertaking of the Bureau of Agricultural Economics (BAEcon), Ministry of Agriculture, and the Fishery Industry Development Council (FIDC), Ministry of Natural Resources, and the International Center for Living Aquatic Resources Management (ICLARM). All three institutions have a long standing interest in the aquaculture sector of the Philippines. BAEcon has conducted several farm and marketing studies since the early 1970's; FIDC has targeted the sector as the main source of increased production of aquatic products during the coming decades. ICLARM, as an international research organization, has been encouraging analytical research on aqua-culture economics since the inception of its program in 1979.

This report is the second in ICLARM's Technical Report Series that deals with milkfish; an earlier study analyzed the marketing of milkfish fry in the Philippines. With ICLARM financial support, a study of the milkfish resource system of Taiwan has been undertaken by the Research Institute of Agricultural Economics of National Chung Hsing University in Taichung. Another study currently being undertaken jointly by BAEcon, ICLARM and the Bureau of Fisheries and Aquatic Resources (BFAR), is examining constraints to the adoption of more intensive technology by milkfish producers in the Philippines.

BAEcon, FIDC and ICLARM are pleased to have been able to cooperate in this study of milkfish production economics, and hope that readers will find the study informative and useful.

JESUS C. ALIX, Director, BAEcon
ELIZABETH D. SAMSON, Executive Director, FIDC
RICHARD A. NEAL, Officer-in-Charge, ICLARM

Manila, March 1982

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Abstract

Chong, K-C., M.S. Lizarondo, V.F. Holazo and I.R. Smith. 1982. Inputs as related to output in milkfish production in the Philippines. ICLARM Technical Reports 3, 82 p. Bureau of Agricultural Economics, Quezon City; Fishery Industry Development Council, Quezon City and International Center for Living Aquatic Resources Management, Manila, Philippines.

The possibilities of improved economic efficiency and profitability of milkfish farming in the Philippines through the determination of optimum input combinations and optimum production or output level are reported in this study. Recall and record-keeping surveys were applied to 324 farms using supplemental inputs in seven Philippine provinces. The milkfish production model selected for general application was the Cobb-Douglas form. The study quantified the relative contributions of eleven inputs to milkfish output.

It is concluded that milkfish farming in the Philippines is not sufficiently intensive, although supplementary inputs are used. A potential exists for much higher output and profits by application of more inputs, especially in deeper ponds. The inputs which significantly explain milkfish output are stocking rates of fry and fingerlings, age of pond, miscellaneous operating costs, organic and inorganic fertilizers, and farm size. The optimum stocking rates for milkfish fry and milkfish fingerlings, and application rates for organic and inorganic fertilizers are also calculated. As expected, privately-owned milkfish farms are more efficient than government-leased farms. Larger farms are more efficient than medium and small farms. Climate also has a decided influence on milkfish yield.

The available economies of scale in Philippine milkfish culture offer great potential to policymakers and producers alike. Milkfish farmers should be encouraged to take advantage of the available scale economies. By appropriate reorganizing and restructuring of small units of production into larger units, production can be made more efficient and profitable. Bringing together small farms to form "tracts" of large farms need not involve changes in tenure status. A case for group farming is presented in this study and related to the Philippine government's scheme of fishpond estate development. Improvements to existing assistance programs are also discussed.

Chapter I
Introduction

In a country where fish is one of the main sources of animal protein, aquaculture or fish culture can be expected to play a comparatively big role in supplying fish needs, especially in view of the steadily rising prices of milkfish (*Chanos chanos* Forskal), the main cultured species (Fig. 1), and fish in general, and also the leveling-off of catches from capture fisheries. However, in the Philippines, aquaculture provides less than 10% of the total supply of fish in the country.

There are at present about 176,000 ha of brackishwater ponds devoted to milkfish husbandry in the Philippines. The 1973-1979 average milkfish production per year was about 115,000 metric tons (BFAR 1979). Based on this, the average yield is about 650 kg/ha/year. The low national average yield has been viewed as a perennial problem by the Philippine government. Past and present research on improved techniques of milkfish production have shown that the yields of Philippine milkfish ponds can be increased by at least threefold. In fact, such threefold increases in yields have been reported under field conditions. However, these yield performances are not yet widespread.

In the Philippines, for every 1 million fry stocked, farmers are able to harvest 83 tons only. This is in contrast to Taiwan where 142 tons are harvested for every 1 million fry stocked. The difference in yield is mainly due to the market size at harvest.

In the past, the main source of growth of milkfish production has come from the opening and expansion of new lands for milkfish production. A commonly cited estimate, made by visual means and ground surveys, is that about 400,000 ha of land are still available for brackishwater pond development. However, recent satellite imageries have shown that there are only a few areas left which can be brought into production. Current estimates suggest the remaining area may be no more than 125,000 ha.

Past government programs for aquaculture have been predicated on the grossly overestimated hectarage of land available for fishpond development. As such, production intensification methods were not actively promoted by the government and much less adopted by the milkfish farmers. In fact, a closer examination of the various credit programs by the government through the Development Bank of the Philippines and other

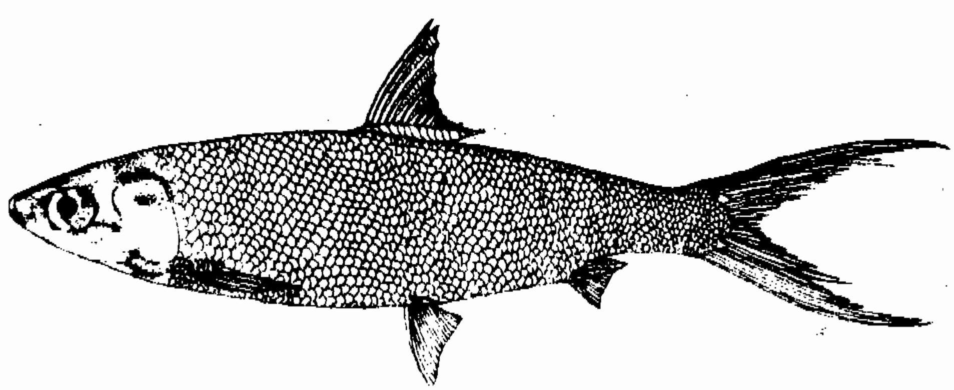

Figure 1. Adult milkfish.

institutions reveals the almost exclusive emphasis on loans for pond construction, development and improvement, and virtually none on loans for the purchase of supplemental inputs.

Because of this heavy infrastructure emphasis, it is not surprising that various investigators (Rabanal 1961; Tang 1967; Shang 1976; Librero et al. 1977; Chong 1980) have found that Philippine milkfish ponds are still largely underutilized. This fact, together with the recent satellite finding of limited expansion possibilities, indicates that a future shift in the pattern of production and resource use is likely. The problem will become one of attempting to increase the production of milkfish from a more or less fixed land base.

Efficiency (in the technical sense) and yields are closely related. De Wit (1979) asserts that "the increased efficiency of resource use in the course of time is closely correlated with an increase in yield per hectare and this suggests that further efficiency increases also may be induced by further yield increases." He further states that "the problem of agricultural research is not so much to determine the yield as a function of all possible input combinations but rather to find feasible combinations of inputs . . . Feasible combinations of these inputs are, of course, adapted to increasing knowledge and to changing economic conditions, . . . "

Supplemental inputs have to be used to improve the productivity of milkfish ponds (intensification of operations). However, the uncertainty of output response from such inputs affects a producer's decision on the use and rates of use of such inputs. The producer is naturally interested to know the risks (costs and benefits) involved in using inputs and the pay-offs he can expect.

OBJECTIVES OF THE STUDY

Few economic analyses, beyond costs and returns analyses, have been done on any form of aquaculture. This study was performed in view of the need for more rigorous analysis to enable more useful conclusions and recommendations to be made.

More specifically, the objectives were:

1. To estimate the input-output relationships of milkfish production for seven selected provinces in the Philippines (Fig. 2) and for the whole country.
2. To use the estimated production relationships to predict production levels from given levels of input application.
3. To determine the marginal productivities and returns of inputs used in different quantities and proportions.
4. To show the application, interpretation and use of production function analysis as a decision-making tool for aquaculture, for example, to show what output of milkfish will be obtained by different combinations of supplementary inputs.
5. To identify the factors which restrict the use of more inputs, especially productivity-increasing inputs which can help in improving output of milkfish.
6. To determine, within limits, the substitutability among relevant inputs of production, for example between organic and inorganic fertilizers, between fertilizers and land.[1]
7. To compare productivity differences in Philippine milkfish production by various criteria, such as province, climate type, tenure, size and age of pond.
8. To derive the optimum rates of application of the various inputs used in producing milkfish by using fitted or estimated function(s).

[1]Within limits, the use of fertilizers can be made to substitute for land in producing a given quantity of milkfish. Because of this, land and fertilizer are usually regarded as substitutes.

JUSTIFICATION OF THE STUDY

As more and more reliance is placed on aquaculture as a supplementary means of increasing food supply, and also as aquaculture is increasingly commercialized, it is necessary to find out more about the exact nature of the production process. Such information can lend itself to greater economic interpretation and application for all-round benefits. For example, the farmer as resource user and decision-maker, as well as the policymaker, can use information on the productivity and returns from the different inputs used in milkfish production to determine the quantity of the different inputs which should be used and how these inputs should be combined for maximum profits. Further, information on the marginal value productivity of inputs can suggest whether these inputs are used efficiently. The degree of economic efficiency and returns to scale can also be inferred from the study. Such findings suggest how resources may be reorganized, leading to greater benefits for all. Reorganization can be effected within farms, between farms and among provinces for increased efficiency.

Further, results of production function analysis can indicate which inputs give relatively higher returns or contribute the most to total output. In this way, if limited funds are always invested where the marginal returns are greatest, profits for the farm will be at a maximum. As such, the results of this study can be invaluable to milkfish farmers in the management of their aquaculture operations.

SOURCES OF DATA

Data to estimate production functions were obtained through a survey in seven provinces of the Philippines. Two methods of data collection were used, a recall survey and farm record-keeping. The latter minimizes recall bias, thus improving the reliability of the data collected.[2] The recall questionnaire is appended to this report (p. 73-82).

The provinces covered in the survey were, from north to south, Cagayan, Pangasinan, Bulacan, Masbate,[3] Iloilo, Bohol and Zamboanga del Sur (Fig. 2). Recall data were collected for the period from January to December 1978, while the farm record-keeping reference period was July 1979 to December 1980.

Proportional and stratified sampling was used in identifying the survey respondents. Proportional sampling procedure was necessary to obtain a representative set of data points. Climate zone, province and barangay were used as the strata in locating respondents. A minimum of 30 respondents per province was sought. The largest number of respondents, 81, was from Pangasinan (Table 1). In each barangay an almost complete census was taken.

Both methods of data collection benefitted from the extensive network of provincial and field offices of the Bureau of Agricultural Economics, which have radio communication with the Bureau's central office in Manila. Visits by their field officers facilitated call backs to check recall data. They also helped establish close rapport with pond operators during the record-keeping period.

In each strata, purposive sampling was used to obtain a homogeneous group of milkfish farmers using similar production method. Extensively operated farms using no supplementary inputs were not selected. Cross-sectional data from a range of farm sizes and rates of input use were obtained to meet the need for variability in sample points. Informa-

[2]The analysis and results of the farm record-keeping data are reported in "Average Cost Functions for Philippine Milkfish Farms" by Chong and Lizarondo (in preparation).

[3]Camarines Sur was originally chosen, but failed to yield sufficient respondents. Masbate was the most appropriate replacement under the circumstances.

Table 1. Sample breakdown by province and pond ownership.

Province	Private ponds	Government leased ponds	Total
Cagayan	26	1	27
Pangasinan	80	1	81
Bulacan	52	–	52
Masbate	13	18	31
Iloilo	43	10	53
Bohol	17	25	42
Zamboanga del Sur	16	22	38
Total	247	77	324

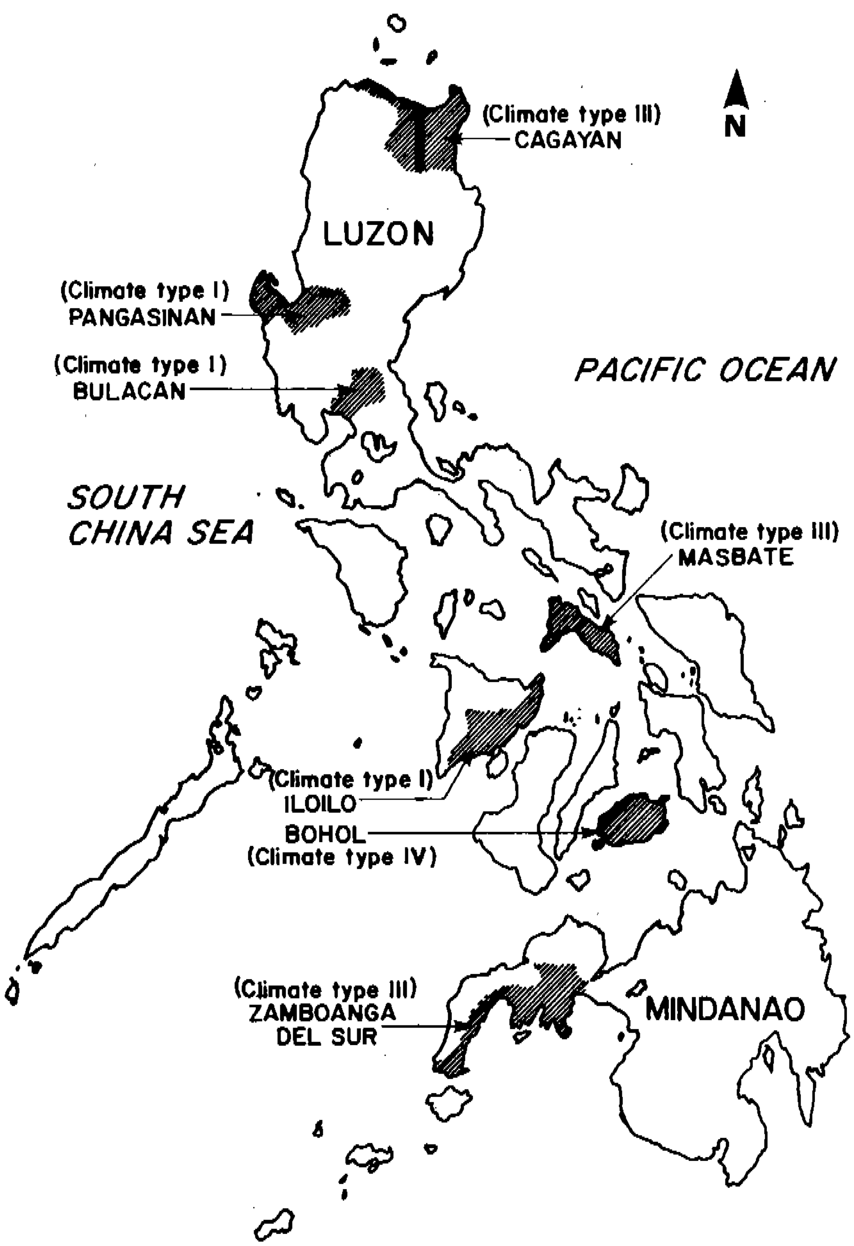

Figure 2. Map of the Philippines showing the climate types of seven provinces selected for survey.

tion collected is based on quantities actually used and not those available for use. Farms with a wide range of pond depth were included in the sample.

It was not possible however, to restrict the sample to farms which culture only milkfish. Some farms which cultivate milkfish and penaeid shrimp were also retained in the sample. The output and the corresponding value of the output of penaeid shrimp were, however, not considered in the analysis. Since 1978 was used as the reference period for the information collected, the 1978 price structure of inputs and output was also used.

Purposive sampling worked out well for the study because in none of the seven provinces was it possible to interview all the respondents listed or contacted, since pond ownership had changed hands several times. The survey group was constrained by the availability of cooperative milkfish producers. In each place the survey group had to canvass almost the whole area for prospective respondents.

Recognizing that data collection and data reliability are integral parts of the scientific method, close supervision of the 8-10 data collectors was provided. With the exception of two data collectors in each province, the same group of data collectors was used in the survey to maintain consistency. The same group was also involved in preparing the data for analysis to avoid errors in interpretation, coding, computation and analysis.

STRATIFICATION BY PROVINCE

Differences in productivity due to characteristics of the macro- and micro-environment (e.g., climatic, soil and water conditions) were recognized in the sampling procedure. The stratum from which each sub-sample was drawn reflected the common characteristics of milkfish production in that particular area. The province was taken as the relevant stratum. Each province selected embodies particular climatic, technical and economic conditions of production, and to a lesser extent, soil and water conditions.

Four types of climate can be distinguished.

Type I—two pronounced seasons, dry from November to April and wet during the rest of the year, e.g., Pangasinan, Bulacan, Iloilo.

Type II—no dry season, wet, maximum rain period from November to January (pronounced rainfall), e.g., Camarines Sur.

Type III—seasons not very pronounced, relatively dry from November to April and wet during the rest of the year, e.g., Cagayan, Masbate, Zamboanga del Sur.

Type IV—rainfall evenly distributed throughout the year, e.g., Bohol.

DIFFERENCE BETWEEN SURVEY AND EXPERIMENTAL DATA

In production function estimation, it is not always easy to obtain appropriate data. Two types of data are frequently used: one from field survey and the other from experiment. Common to both types of data are variables which may be difficult to measure. While data from controlled experiments are relatively homogenous, that is, there are no differences in the quality of inputs, results from analysis using experimental data have limited application. This is because experiments are of necessity conducted on a small scale and they seldom capture and replicate actual variations in field conditions. Consequently, their usefulness in national policy formulation is correspondingly limited. Surveys can be conducted over a wide geographical area, such that the results have broader application. Our survey of seven provinces in the Philippines has this wide coverage and variability.

Aspects of the BAEcon/FIDC/ICLARM milkfish project

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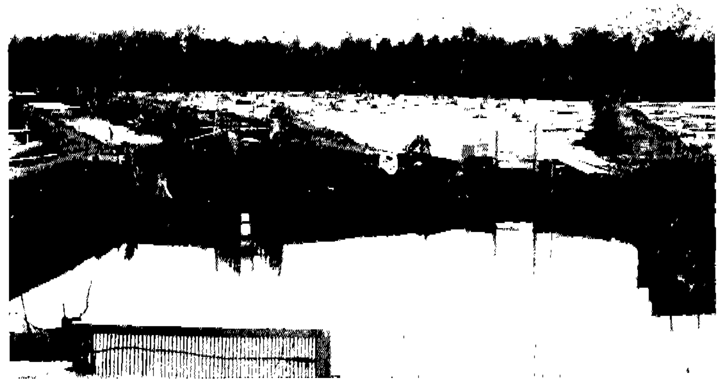

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1-4. Age of pond (input X_1) has an important bearing on productivity. Philippine milkfish ponds are in various stages of development and also in various states of disrepair. Older ponds are usually privately-owned and are concentrated near population centers.

5. No reliable method of fry counting has been developed. It is still a very laborious process involving at least 2 persons. Because of errors in counting, generalized from the density of a representative sample, errors in stocking rates are inevitable; these errors also extend to estimates of yield based on mortality and survival rates (X_2 and X_3).

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6. Acclimatizing fry to minimize stress (X_4) before releasing them into the ponds is not clearly understood among Philippine milkfish farmers.
7. Milkfish farming is very labor intensive (X_5).
8. Milkfish are herbivorous. Filamentous algae are often sown before stocking the ponds, but subsequent supplementary feeding is not common.
9-10. The importance of keeping farm records as a management tool is appreciated by very few farmers in the country (X_7).

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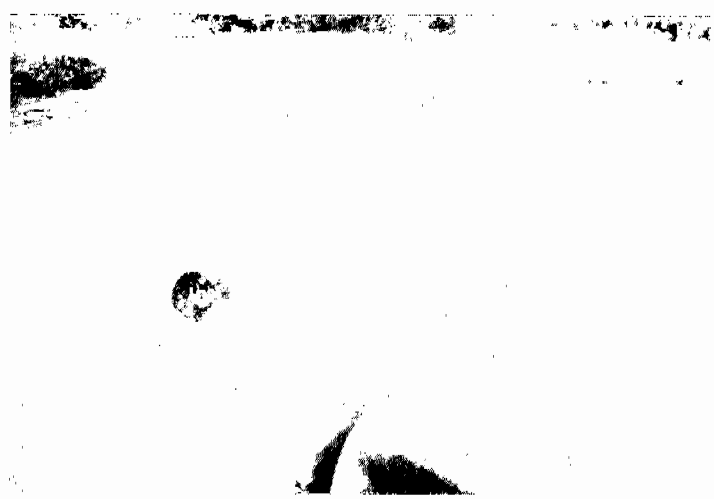

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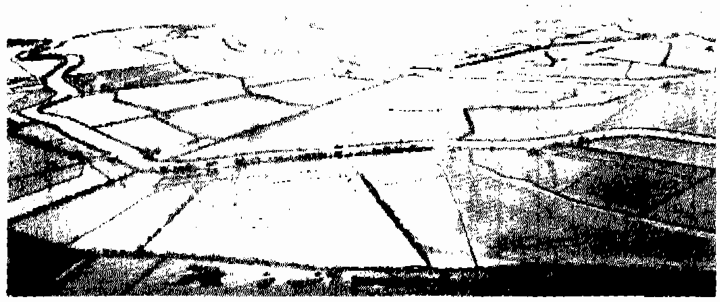
11. To apply pesticides to kill predators and food competitors, the ponds are drained and dried after harvest. Residual pesticides are then removed by flushing the pond with water. The authors found that pesticides were usually improperly applied (X_8).
12. Organic and inorganic fertilizers (X_9, X_{10}) are required to encourage the growth of fish food. Philippine milkfish farmers are not applying them in sufficient quantities to significantly affect milkfish yields.
13. Philippine milkfish farms are normally dug-out ponds along the coast. They range in size from a few hundred square meters to 250 ha (X_{11}).
14. A strong and well-built gate is absolutely essential for proper water control and management within the pond system.
15. Development communication is a two-way process: dialog between farmers and researchers is necessary for researchers to be aware of farmers' problems, and for research findings to reach the farmers. The extension agent can help to bridge the communication gap.



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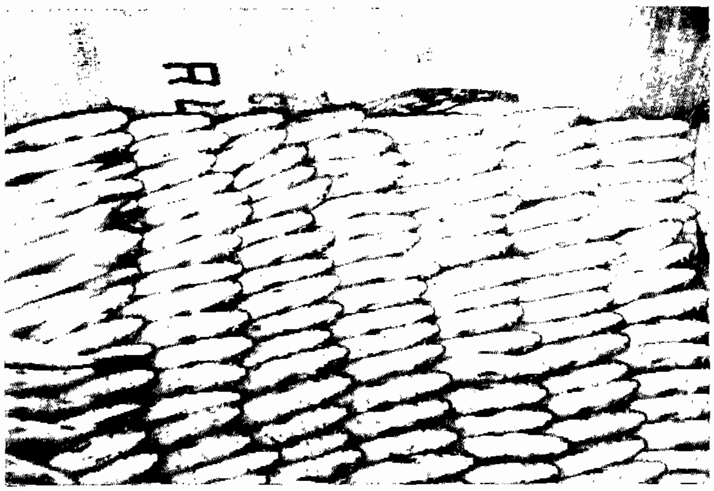
16. Most milkfish farmers are not aware of the value of soil analysis, which can pinpoint, e.g., whether liming is needed. **17-20.** Harvesting milkfish is usually done in the evening or early morning. There are 2 methods—gill-netting and herding the fish into a harvesting pond by using their behavior of swimming against the current. Harvested milkfish are increasingly being iced before shipment to the markets.



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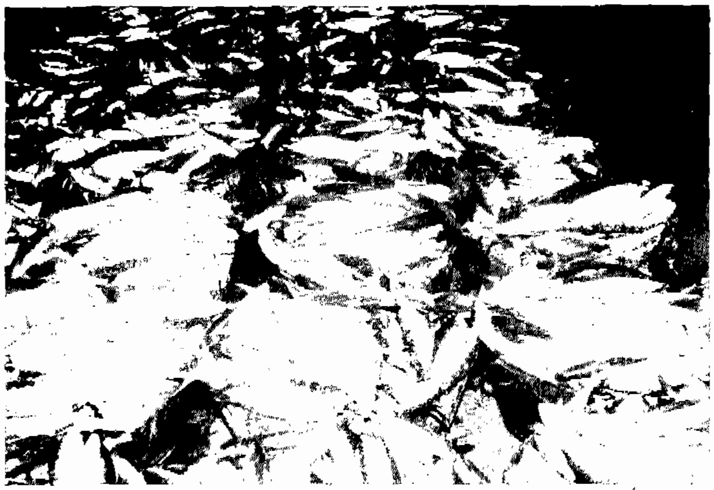

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Chapter II
Background Information

ECONOMIC IMPORTANCE OF MILKFISH AND MILKFISH FARMING

According to the 1921 Census of the Philippine Islands, the first fishpond was established in 1863 in the barrio of Concepcion, Rizal Province, by Mr. Domingo Cornel. Since then the milkfish industry has been witnessing increasing "commercialization" over the years. Today, milkfish is the main species of fish grown in brackishwater fishponds. According to the Bureau of Fisheries and Aquatic Resources statistics, fish production from fishponds in 1979 constituted 8.4% of the total fish production in the country or 11.4% of the total value of ₱10,536 million (Figs. 3 and 4).

The milkfish is classified as a first class fish in the Philippines (Aviguetero et al. 1979). In 1977/1978, the average *per capita* consumption of fish products (fresh, frozen, dried, smoked, salted and canned fish, crustaceans and molluscs) averaged 24.3 kg. Of this, milkfish represented 10%. Out of an annual *per capita* consumption of all first class fish of 5.6 kg, milkfish constitutes 45%.[4] This does not include those milkfish which bypass the traditional marketing channels. There are still many subsistence milkfish farms which remain outside the market economy but nevertheless still directly provide for the livelihood of these subsistence farmers.

In 1979, 325 tonnes of milkfish (frozen and canned), valued at over ₱4.5 million, were exported, mostly to the United States of America, Nauru, Canada, Thailand, Hawaii and Japan. Milkfish fingerlings are now being exported to Taiwan and Singapore (BFAR 1979). In 1979, over 2.2 million fingerlings were exported. Other secondary and tertiary economic activities stemming from the culture of milkfish are fry gathering and distribution, rearing of fry to fingerling size, milkfish marketing, distributing, processing and various ancillary trades and services. These provide business and employment opportunities for many who are directly and peripherally in the milkfish sector. Milkfish aquaculture has also boosted industrial activities such as canning and ice-making.

The Government of the Republic of the Philippines, through the Development Bank of the Philippines (formerly known as the Rehabilitation Finance Corporation), supports the development of the industry. Financial assistance is provided both to fishpond owners who want to improve their operations, and to those who wish to start milkfish culture.

The Government of the Republic of the Philippines and external assistance agencies attach some importance to the milkfish industry as can be gleaned from the following:

> The Development Bank of the Philippines as of September 30 this year (1979) financed 1,093 fishpond projects with a total area of 21,000 hectares worth ₱153.7 million under a credit line extended by the International Bank for Rural Development (sic). In an announcement, the Development Bank of the Philippines said 23 more projects involving ₱21.3 million in financing

[4]First class fish comprise milkfish, tuna, mackerel and others; while second class fish are such species as tilapia, sardines and others. Third class fish are mostly round scad, bonito, anchovy and others (Aviguetero et al. 1979).

are already in the pipeline while a third loan proposal is being negotiated with the International Bank for Rural Development (sic) involving the development of 7,500 hectares (Anon. 1979).

More importantly, milkfish farming provides employment to over 150,000 rural people who otherwise have very few means of livelihood—caretakers, hired laborers, fishpond administrators, managers and supervisors, fry gatherers, fry concessionaires and distributors, nursery pond operators and fingerling dealers and all other sundry middlemen (brokers, wholesalers, input suppliers, etc.). BFAR estimates that one man is employed per hectare of fishpond, such that there are at least 150,000 persons employed in the industry.

THE PHYSICAL ENVIRONMENT

The seven provinces (Fig. 2) selected for study reflect a north-south geographical distribution and orientation characteristic of milkfish production in those areas of the Philippines. Taken together, they represent the general picture of Philippine milkfish production.

Each of the seven selected provinces is a major milkfish production area in that region and climatic type. Table 2 points to the importance of each of the seven provinces in overall national milkfish production.

Most conditions of climate (with the exception of typhoons), soils (with the exception of acid sulphate soils), water and other natural environmental conditions in the Philippines are eminently favorable for the milkfish industry.

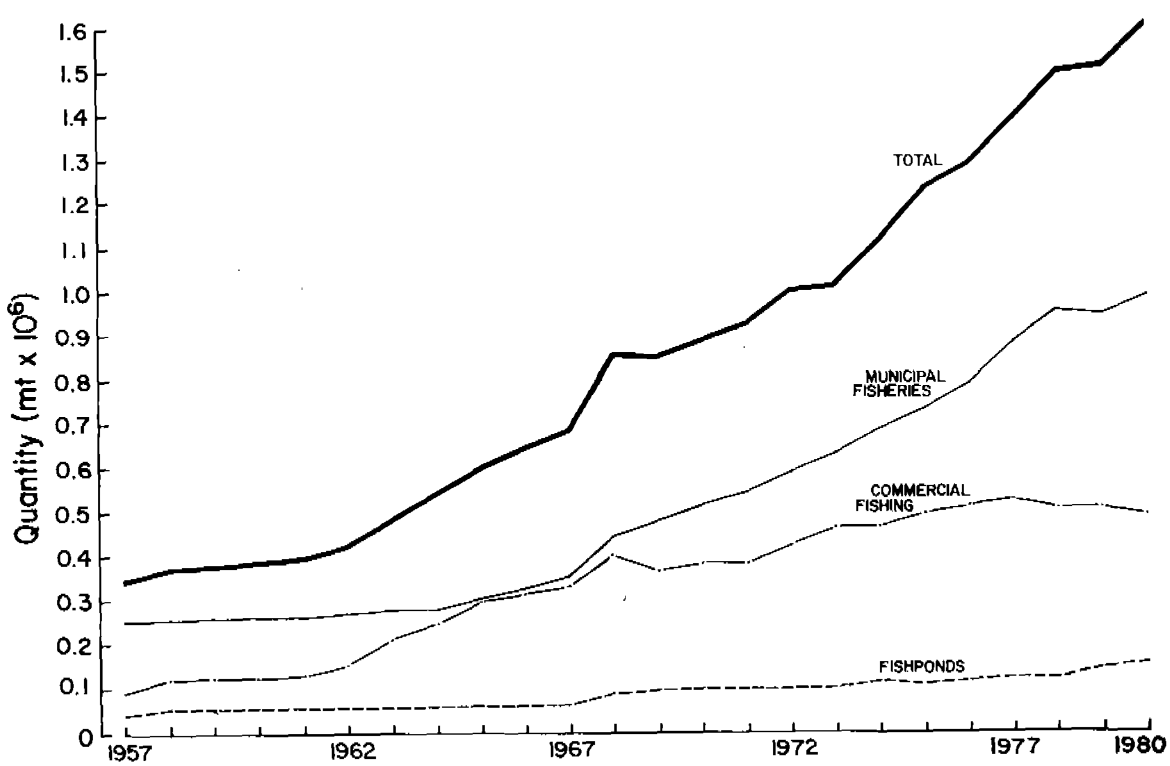

Figure 3. Philippine fish landings by types of fisheries, 1957-1979.

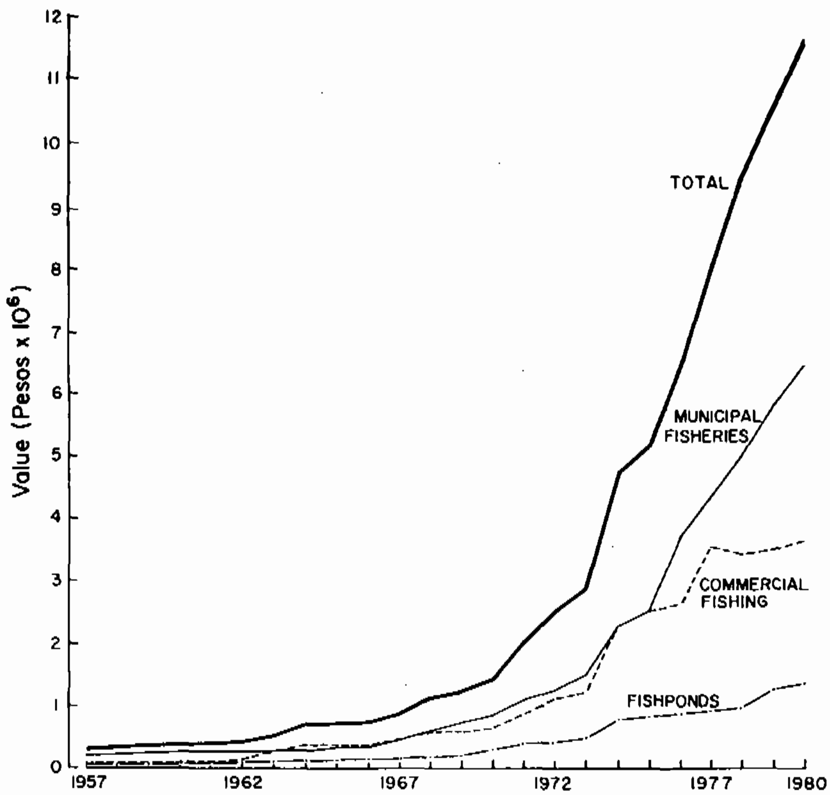

Figure 4. Value of Philippine fish landings by types of fisheries, 1957-1979.

Table 2. Average milkfish production (mt) by fishery regions and main production centers, 1975-1977.

Region	Regional average production	Highest producing province	Provincial hectarage (ha)*	Provincial average production	Regional percentage of country production	Province percentage of regional production	Province percentage of country production
I	7034	Pangasinan	9,534 (5.4)	6,685	6.4	95.0	6.0
II	151	Cagayan	806 (0.46)	137	0.1	91.0	0.1
III	23,718	Bulacan	16,173 (9.19)	14,016	21.4	59.1	12.7
IV	15,393	Quezon	16,415 (9.33)	6,836	13.9	44.4	6.2
V	2,846	Masbate	4,393 (1.98)	2,152	2.6	75.6	1.9
VI	40,426	Iloilo	17,388 (9.88)	19,353	36.5	47.9	17.5
VII	3,013	Cebu	2,727 (1.55)	1,398	2.7	46.4	1.3
VIII	3,470	Western Samar	3,798 (2.16)	1,377	3.1	39.7	1.2
IX	7,192	Zamboanga del Sur	16,279 (9.25)	6,783	6.5	94.3	6.1
X	2,131	Agusan del Norte	2,642 (1.50)	1,101	1.9	51.6	1.0
XI	2,133	Davao del Sur	1,777 (1.00)	729	1.9	34.2	0.7
XII	3,104	Lanao del Norte	2,690 (1.53)	1,659	2.8	53.5	1.5
National	110,611	—	—	—	—	—	—

Data adjusted according to revised classification of Fishery Regions.

*Figures in brackets represent provincial hectarage as a percent of national hectarage of 176,000 ha. Source: Fisheries Statistics of the Philippines, Bureau of Fisheries and Aquatic Resources, 1975-1977.

Although the fishponds could be adequately supplied with seawater from the ocean and freshwater from the hinterland, drainage and irrigation to refresh the pond water in most of the fishpond areas visited were observed to be inadequate. This arises mostly from illegal encroachment and silting of waterways. Illegal encroachment of waterways is usually in the form of extending fishpond sizes by constructing dikes or dams across small rivers, creeks and irrigation or drainage canals. This activity has also led to flooding in the surrounding areas, causing property damage and loss of milkfish. Philippine milkfish production is, therefore, mostly carried out in shallow, stagnant waters. The biological ramification of this is that oxygen and fishfood availability are much reduced.

Philippine milkfish ponds are in various stages of development. Established ponds are those over 20 years old, developed ponds are between 5 to 20 years old, and newly-developed ones are those less than 5 years old. The average sizes of the three types of farm ponds in the seven sampled Philippine provinces are shown in Table 3. In Indonesia, tambaks or milkfish ponds are not stocked with milkfish for the first 3 or 4 years (Korringa 1976). This is because of low initial yield. In Taiwan, tidal lands can be changed to very productive milkfish ponds and the annual yield should reach 2,000 kg/ha/year within about 5 years (Liang and Huang 1972). It can be inferred that there is a strong relationship between age of the pond and its productivity.

Acid sulphate soils, characterized by a high content of sulphur-based compounds that produce acidity on oxidation, are a problem in milkfish production, although most milkfish farmers do not recognize them as such. It is the chronic, sub-lethal effects of acidity that inhibit pond biota and result in low output of milkfish (BAC 1978). Although remedial measures have been worked out, much of this information is not reaching the milkfish farmers. Similarly, liming to condition the soil before filling the pond is not widespread, as revealed in this survey.

The industry suffers from intermittent setbacks from typhoons each year, beginning in June and continuing through September. Typhoons are very destructive to milkfish culture. Not only are valuable stocks of milkfish lost, but algal beds and other fishfood are also destroyed. Milkfish farmers report that algae and other fishfood do not thrive after a heavy rain. On the average, the Philippines experiences about 20 tropical cyclones each year with 145 rainy days. Damage to pond gates, embankments and other structures are

Table 3. Size distribution of sampled milkfish ponds in seven selected provinces.

	Average pond size (ha)[a]			
Province	Farm	Nursery pond	Transition pond	Rearing pond
Cagayan	4.51	0.18	0.56	4.25
Pangasinan	2.88	0.38	0.53	1.97
Bulacan	23.71	2.89	5.46	17.06
Masbate	23.83	0.50	2.22	22.39
Iloilo	37.47	1.81	5.91	30.20
Bohol	9.64	0.39	2.11	8.28
Zamboanga del Sur	14.64	0.57	2.30	13.09
Sample	16.27	1.02	2.95	13.27

[a]Note that average area of nursery and transition ponds is reported only for those farms using this type of layout. Consequently, farm size by province does not necessarily equal the sum of nursery, transition and rearing ponds. The survey results reveal that there are more farms without transition ponds than nursery ponds. These farms are mostly found in Cagayan (85%), Masbate (55%), Bohol (45%) and Zamboanga del Sur (58%). On the other hand, farms without nursery ponds are found in Bulacan (13.5%), Masbate (13%) and Pangasinan (10%).

additional losses borne by the milkfish producers, necessitating repairs and maintenance which are more frequent in typhoon-affected areas. Philippine milkfish ponds are also vulnerable to flooding, since they are excavated rather than built up from ground level with levees.

THE SOCIOECONOMIC AND CULTURAL ENVIRONMENT

Culturally, fish is important in the diet of the Filipino. Fishing and fish farming are important activities in the way of life. Yet fish farming has evolved haphazardly, without the benefit of sound technical planning or engineering advice. Any person having access to a suitable piece of land can develop it into a fishpond. In some parts of the country, elevation of pond bottom and height of the tides were not taken into consideration when the ponds were constructed. Because of this, some pond bottoms are exposed during low tides. Most ponds are shallow and with time have silted up. Pond preparation rarely involves deepening of ponds except for some rebuilding of trenches.

Fishpond designing, incorporating recent engineering information on pond layout, depth of water, water management and control has not taken place. Rehabilitation of worn-out or flood-damaged fishponds has at best been patch work. As a result, production costs are high, yields are low and net returns (profits) are correspondingly low.

Very few milkfish farmers keep any semblance of records. Those few that keep records have information only on the total costs of inputs purchased. These are recorded for those inputs purchased with out-of-pocket money and recorded only when remembered. Without properly kept records, it is not easy to evaluate the performance of the production operations. In this connection, it is obvious that a large percentage of the Philippine milkfish farmers are not aware of the value of management in production. Knowledge of basic farm management methods was lacking in most of the respondents in this survey. A majority of the respondents were, however, very interested in the ICLARM-BAEcon-FIDC Farm Record-Keeping Project as demonstrated by their support and willingness to pay for the blank farm record forms. Requests for additional record books are still received. Most did not know if it was advantageous to use inputs, such as fertilizers, in milkfish culture.

A significant number of the milkfish producers contacted for interview in the survey were among the relatively well-to-do members of their community. A similar observation was also made by Villaluz (1953). In Iloilo, it is said that the fishpond industry is a rich man's business (Ohshima 1973).

There is no doubt that Philippine milkfish producers are also among the more educated group of fish farmers in the Asian region. A considerable number of fishpond operators are either engineers, or legal or medical practitioners. In our sample, only six individuals or about 2% did not have any education. More than a third had college education. Iloilo has the highest number of milkfish farmers who are college-educated. In the rest of the provinces, the milkfish farmers are mostly elementary school-trained or high school graduates and a few are also college graduates.

There are more than 30 fishfarm producer associations in the country whose membership draws largely from the more successful and educated fish pond operators. Membership in the association is voluntary. Benefits of membership are varied depending on the degree of member participation and leadership. For the most part, these associations make representation to the government and serve as a source of information and meeting place for members. Buying and selling on behalf of members are only practised in one or two associations. The most common trade is bulk purchase of inputs, such as fertilizers.

It is also a characteristic trait of Philippine milkfish producers to rely on and leave to their caretakers the performance of routine but essential tasks such as regular checks for stress signs. This is especially needed for shallow ponds where sudden changes in water quality are likely, thus causing stress to the fish. To quote a successful milkfish farmer, "The best input for milkfish culture is the shadow of the milkfish producer across the pond water," implying that the owner himself must assume an active role. Many milkfish ponds, however, are owned or leased by absentee landlords.

TENURE PATTERNS

There are two major tenurial systems of milkfish ponds in the Philippines, private ponds and government-leased ponds. Private and government-leased ponds are also frequently sub-leased to other milkfish producers. The sample for this study consisted mostly of private ponds. About 27% were government-leased ponds. The tenurial status of the sampled farms is presented in Table 4.

It is extremely difficult to determine tenure status of productive farms from national statistics. While national statistics show approximately equal proportions of private and government leased milkfish farms, we found in the field that the hectarage recorded as productive under government leases is overestimated. It is common practice to record the whole area applied for as under production when in fact delays in pond construction or lease processing result in much of this land lying idle, often for many years. We believe that most of the pond-produced milkfish in the country comes from privately owned farms. In support of this point of view, our survey of farmers using supplementary inputs found that 73% of these farms were privately owned.

Prior to 1980, government-leased ponds were of two types: Fishpond Lease Agreement (FLA) which was for a period of 10 years, and Ordinary Fishpond Permit (OFP) which was good for one year. Both FLA and OFP were renewable. However, since 1980, both the FLA and OFP have been consolidated into one scheme for government-leased ponds which is valid for 25 years and renewable.

The nature of the lease arrangement affects the lessee's decision on the utilization of inputs. If it is short-term and non-renewable, lessee-operators seldom invest in inputs whose expected benefits span a longer period. Under such circumstances, they expect the owners to pay for the inputs unless an arrangement has been made for equitable sharing of benefits between owner and lessee.

Table 4. Percentage distribution of 324 fishpond areas by tenurial status, 1978.

Province	Private farms		Government-leased farms	
	Private	Leased private	FLA[1]	OFP[2]
Cagayan	41.7	0.2	58.1	0.0
Pangasinan	73.9	25.8	0.3	0.0
Bulacan	56.0	44.0	0.0	0.0
Masbate	35.5	7.9	45.1	11.5
Iloilo	61.9	22.5	15.1	0.5
Bohol	39.6	0.5	46.5	13.1
Zamboanga del Sur	25.2	29.5	37.6	7.8
Sample	51.3	21.2	23.4	4.1

[1]FLA = Fishpond Lease Agreement
[2]OFP = Ordinary Fishpond Permit

In general, the short-term nature of privately-leased ponds as well as government-leased ponds before 1980, and sometimes the uncertainty as to the legitimate lessee of government-leased land, can be viewed as contributing to the reluctance of these producers to use inputs. A piece of government land can have more than one applicant because application papers may have been filed either with the same government bureau in different localities or with different government agencies. Although this is not common, it nevertheless highlights the apparent lack of coordination among government bodies, which can cause confusion and discourage farmers from incurring expenses for production purposes.

Additionally, the inability of some farmers to provide the proper papers and documentation to support their tenure on government lands has led to low participation rates in government credit programs. Milkfish farmers interviewed requested the survey team to bring this problem to the attention of the government so that the processing of papers can be accelerated.

SIZE OF OPERATIONS

In general, the area of land available for milkfish farming is fixed for each producer in the short run. Milkfish farms of varying sizes are found in the Philippines. They range from a few hundred square meters to 250 ha. Table 3 shows that the average farm size in the whole country is approximately 16 ha. That table also reveals that the average size of farm holdings in Iloilo is greater than that of the other six provinces.

For purposes of this study, size of farm operations is defined as follows: a small farm has a total area of less than 6 ha, a medium-size farm has from 6 to 50 ha and a large farm is more than 50 ha. Most milkfish farms were either small or medium-size. Of the 324 sample farms, small farms accounted for 43%, medium farms 50%, and 7% were large farms (Table 5).

By tenurial status, Fishpond Lease Agreement (FLA) farms sampled average 20.5 ha. The average farm size under the Ordinary Fishpond Permit is 16.7 ha. Those leased from private individuals have a mean size of 16.1 ha. Titled or owner-operated farms average 16.2 ha. In Iloilo, owner-operated farms have the largest average size, 35.4 ha.

Table 5. Percentage distribution of small, medium and large milkfish farms in the survey sample, 1978.

Province	Small < 6 ha	Medium 6-50 ha	Large > 50 ha
Cagayan	85.0	15.0	0.0
Pangasinan	91.0	9.0	0.0
Bulacan	13.5	73.1	13.4
Masbate	6.5	87.1	6.4
Iloilo	13.2	60.4	26.4
Bohol	52.4	47.6	0.0
Zamboanga del Sur	18.0	82.0	0.0
Sample	43.0	50.0	7.0

The classification of sizes is based on the size distribution of farms in the sample. The Bureau of Census, as well as milkfish farmers themselves, were consulted for a size definition but no size definition is available for milkfish farms, unlike the situation in agriculture.

OUTPUT VARIATIONS

The survey data show that the average annual milkfish production per hectare is 761 kg. This estimated yield is higher than the reported national average of 650 kg/ha/year because the survey data consist of production data from farms using inputs only; those milkfish farms which did not use any inputs were excluded from the survey.

Output variations among milkfish farms provide a picture of the geographical differences in yield and use of inputs. To estimate the annual milkfish production per hectare, the total reported production was divided by the total active farm size, taking into account reported losses due to weather disturbances. Table 6 reveals the output gap among the seven provinces. Only Bulacan and Iloilo have yields above 1,000 kg/ha/year. The rest have yields which are less than 650 kg/ha/year. Even the average output of the high-yield farms (as defined) in Cagayan, Masbate and Zamboanga del Sur is lower than the average output among the low-yield farms in Iloilo and Bulacan.

Further analysis of the survey results shows that the larger the farm, the higher the per hectare yield, implying that there are economies of scale in milkfish production. Table 6 shows that small-scale producers with farms less than 6 hectares reported an annual average yield of 423 kg/ha. Medium-sized farms have an annual average yield of 580 kg/ha. Finally, the large farms or large-scale producers have average harvests of 1,056 kg/ha/year.

Large-scale milkfish farms (greater than 50 hectares) are encountered in only three of the seven provinces, namely Bulacan, Iloilo and Masbate. The reader is referred to Table 6 for further details on provincial yields as these relate to farm size as well as high and low yield farms. In analyzing individual performances of milkfish farms in each of the provinces surveyed, the wide variations and range in output are very obvious, both within and between provinces.

As a final note, it is interesting to see the proportion of milkfish farmers who produce less than 500 kg/ha/year and those who produce more than 1,000 kg/ha/year. At the national level, about 60% of the milkfish farmers interviewed produce less than 500/kg/ha/year; 21% are in the category of farmers who produce between 500 to 1,000 kg/ha/year while 19% produce more than 1,000 kg/ha/year (Table 7).

By province, Bulacan has the smallest percentage of milkfish farmers producing less than 500 kg/ha/year; about one third of the producers fall into this category. Those producers who can get more than 1,000 kg/ha/year number about 42% of the sample. Even

Table 6. Yield characteristics of sampled Philippine milkfish farms.

	Average production (kg/ha/year)					
Province	Average yield farms	High yield farms[1]	Low yield farms[1]	Small farms[2]	Medium farms[2]	Large farms[2]
Cagayan	253	424	153	296	239	–
Pangasinan	589	900	341	527	666	–
Bulacan	1,066	1,886	560	796	1,136	987
Masbate	95	432	35	337	113	16
Iloilo	1,110	1,616	621	433	905	1,195
Bohol	308	962	177	149	327	–
Zamboanga del Sur	204	427	116	163	207	–
Sample	761	1,429	266	423	580	1,056

Note: [1]High yields and low yields have been defined relative to the average yield of each province respectively. Those farms with yields above the calculated average yield are grouped as high yield farms and those that are below the average yield are grouped as low yield farms.

[2]Small farms are less than 6 ha, medium farms are 6 to 50 ha and large farms are greater than 50 ha.

Table 7. Distribution of surveyed milkfish farmers according to yield levels.

Province	Sample size	< 500	Percent of farmers 500-1,000 (kg/ha/year)	> 1,000
Cagayan	27	63	15	22
Pangasinan	81	51	33	16
Bulacan	52	29	29	42
Masbate	31	90	7	3
Iloilo	53	30	32	38
Bohol	42	88	10	2
Zamboanga del Sur	38	89	8	3
Sample	324	60	21	19

in Iloilo, where milkfish farmers are known to have the skills and knowledge to obtain higher output, 30% of the farmers are still producing less than 500 kg/ha/year. The proportions that can get yields of 500 to 1,000 and greater than 1,000 kg/ha/year respectively, are 32% and 38%.

In the rest of the provinces sampled, the picture is a very discouraging one. Masbate, Zamboanga del Sur and Bohol have large proportions of milkfish farmers who are producing less than 500 kg/ha/year; they are 90, 88 and 89%, respectively. In Cagayan and Pangasinan the figures are 63 and 51%, respectively.

Chapter III

Production Techniques and Net Returns

BASIS OF PRODUCTION

The most widely practised method of production is the use of a farm layout comprising nursery pond, transition and rearing (grow-out) ponds (Fig. 5). Milkfish eat naturally-occurring algae in the fishponds. Usually organic and/or inorganic fertilizers are added to enhance the primary productivity of the water, increasing the growth of algae and hence of the fish. Supplementary (direct) feeding of milkfish is not commonly practised in the Philippines except in Cagayan where chicken manures are scarce and rice bran abundant. It is normal practice, however, in Taiwan.

There are three kinds of algae suitable for milkfish food—filamentous, benthic and planktonic. Although plankton will grow in shallow and deep ponds, it is generally recommended as the sole feed only if pond depth exceeds 70 cm (Tang 1972). Since most Philippine ponds are shallower, it appears that milkfish rely primarily on filamentous and benthic algae for nutrition.

INPUT UTILIZATION: EXISTING PRACTICES

The use of inputs and input-mix are influenced to a large degree by a knowledge of what inputs to use, which inputs contribute the most to total output, what inputs are available to the producer in his area, and the prices of inputs. Although many milkfish

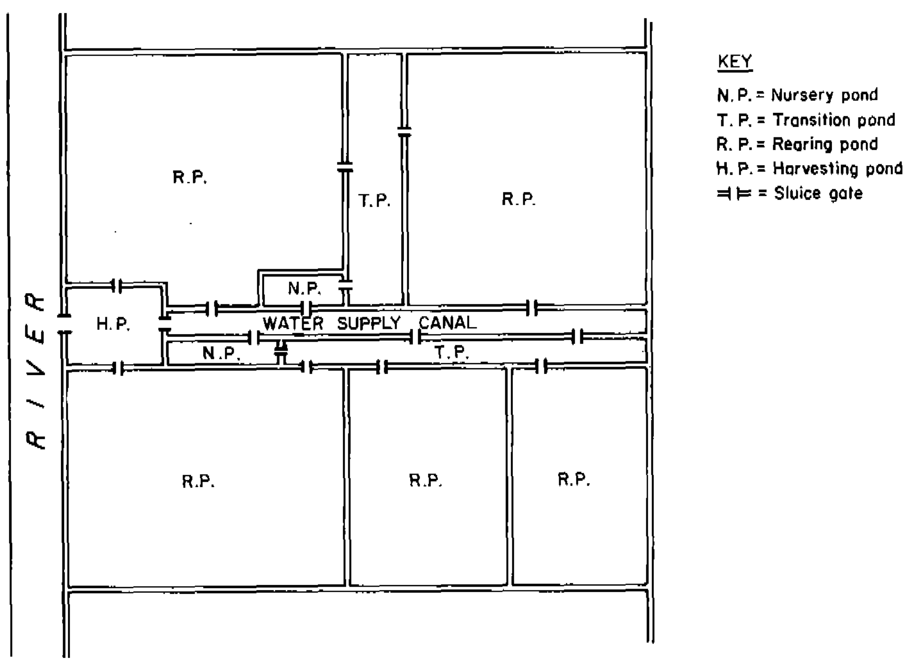

Figure 5. A milkfish farm layout showing nursery, transition and rearing ponds.

producers recognize the important role of such inputs as fertilizers in the production of milkfish, their use is not yet widespread.

Input utilization also varies between provinces and between farms within the same province. Iloilo is one of the few provinces where every milkfish producer uses inputs. This is in contrast to Cagayan, where most milkfish producers approached for interview do not use any inputs beyond labor, fry or fingerlings. In Pangasinan, milkfish producers claim that their ponds are still fertile and inputs are therefore not required. However, "lumut" or filamentous green algae are purchased as an input to be used in milkfish ponds. The buying and selling of lumut are quite common in some of the provinces surveyed.

Milkfish culture as practised in the Philippines is carried out with a very small inventory of inputs. The most commonly used inputs are chicken manure and labor. Other inputs, such as inorganic fertilizers and pesticides are not very widely used.

Note that the use of the terms "production intensification" or "intensifying production" means not only increases in stocking density but also all supplemental inputs. The means of eleven selected explanatory variables are shown in Table 8.

INPUT PRICE VARIATIONS

Input price variations are inevitable for several economic reasons, mainly differences in space, time, form (repacking in small units) and market conditions of supply and demand. Milkfish producers cited several problems in connection with the use of inputs. Except in Cagayan, milkfish producers complained of high input costs, especially of fertilizers and pesticides. Unlike agricultural farmers, milkfish producers receive no preferential treatment to encourage the use of supplementary inputs, and government price subsidy for inputs was cited by producers as a possible solution to this problem.

Because of input-output price variations from province to province, producers make differing decisions regarding added input use; it will be profitable to use an input only if the value of its marginal product exceeds its cost. For example, if the hypothetical value of the marginal output from an added kilogram of chicken manure is ₱0.30, it will be profitable for producers in Zamboanga del Sur to apply the added amount at a cost of ₱0.10/kg, but not for producers in Iloilo, where the cost is ₱0.57/kg.

Commercial dry pesticides are not commonly used. Their price varies little in most provinces. Tobacco dust is also used in two provinces, Bulacan and Zamboanga del Sur. The cost of liquid pesticides varies by a factor of two from Pangasinan (₱31.40/l) to Iloilo (₱66.00/l).

For supplementary feeds, which can be either rice bran, bread crumbs, broken ice-cream cones, booster feeds or hog mash, milkfish farmers pay ₱0.50 to ₱1.47/kg.

In 1978, the average price received by milkfish farmers surveyed was ₱6.29/kg. The national average retail price in the same year was ₱8.73, giving a marketing margin of ₱2.44 per kilogram of milkfish. Producers thus received 72% of the price paid by consumers. Among the provinces surveyed, farmers in Pangasinan reported the highest price received at ₱8.83/kg, and Bohol the lowest at ₱5.12/kg.

COSTS OF PRODUCTION

Annual costs of production were ₱3,394 per hectare in 1978 (Table 9). Table 11 provides the itemized cost breakdown of milkfish production. In all the provinces surveyed, small farms incurred highest per hectare costs of production (₱3,956). Farms between

Table 8. Survey means of explanatory variables and input prices by province, 1978.

Variable Province		Age of pond (year) X_1	Fry (pieces) X_2	Fingerlings (pieces) X_3	Acclimatization (hours) X_4	Hired labor (man-hours) X_5	Miscellaneous operating costs (₱) X_6	Milkfish culture experience (years) X_7	Pesticides (₱) X_8	Organic fertilizers (kg) X_9	Inorganic fertilizers (kg) X_{10}	Farm size (ha) X_{11}
1. Cagayan	$\bar{X}$	4.72 (5)	4,149 (5,767)	783 (627)	10.96 (11)	656.93 (8,448)	1,208.04 (3,176)	4.96 (5)	24 (49)	87.52 (249)	57.39 (65)	4.50 (9)
	$P_{\bar{X}}$*	–	0.06	0.48	–	–	–	–	–	0.11	1.56	–
2. Pangasinan	$\bar{X}$	22.36 (16)	6,362 (5,160)	3,400 (3,794)	15.93 (53)	286.41 (401)	881.45 (1,054)	17.59 (13)	89.97 (183)	269.51 (581)	165.33 (179)	2.88 (4)
	$P_{\bar{X}}$	–	0.10	0.22	–	–	–	–	–	0.15	1.57	–
3. Bulacan	$\bar{X}$	40 (18)	7,561 (6,287)	6,315 (2,992)	7.23 (11)	172.33 (328)	1,641.59 (1,666)	20.68 (17)	102.81 (141)	2,592.46 (7,626)	109.23 (144)	23.70 (23)
	$P_{\bar{X}}$	–	0.10	0.18	–	–	–	–	–	0.18	1.71	–
4. Masbate	$\bar{X}$	12.55 (8)	1,746 (1,952)	400 (1,884)	4.78 (6)	448.82 (834)	439.68 (814)	14.09 (11)	83.90 (87)	547.83 (373)	69.78 (63)	23.82 (20)
	$P_{\bar{X}}$	–	0.07	0.28	–	–	–	–	–	0.18	1.48	–
5. Iloilo	$\bar{X}$	28.70 (22)	8,528 (4,164)	6,282 (2,963)	6.08 (9)	127.23 (787)	1,066.76 (1,145)	18.68 (13)	36.54 (50)	2,627.14 (2,040)	270.54 (294)	37.66 (47)
	$P_{\bar{X}}$	–	0.09	0.20	–	–	–	–	–	0.57	1.67	–
6. Bohol	$\bar{X}$	10.43 (13)	3,136 (2,294)	–	20.05 (7)	578.02 (3,048)	779.22 (1,350)	11.81 (10)	51.11 (49)	856.64 (841)	109.44 (140)	9.63 (11)
	$P_{\bar{X}}$	–	0.05	–	–	–	–	–	–	0.29	1.63	–
7. Zamboanga del Sur	$\bar{X}$	14.89 (12)	1,904 (1,484)	–	50.34 (105)	207.66 (590)	531.27 (1,250)	14.05 (11)	34.74 (29)	1,031.53 (1,690)	33.87 (31)	13.75 (1)
	$P_{\bar{X}}$	–	0.10	–	–	–	–	–	–	0.10	1.71	–
8. Sample	$\bar{X}$	21.57 (19)	5,940 (4,921)	5,892 (3,197)	14.09 (42)	228.71 (238)	1,033.06 (1,663)	15.72 (14)	62.46 (123)	2,178.83 (4,305)	172.33 (194)	16.20 (26)
	$P_{\bar{X}}$	–	0.09	0.18	–	–	–	–	–	0.29	1.66	–

Note: Figures in parenthesis are the standard deviations.
*$P_{\bar{X}}$ is average price in pesos.

6 and 50 ha incurred the lowest per hectare cost (₱3,154), but even the larger farms (₱3,415) have lower costs than small farms (Tables 10 and 11). This pattern of economies of scale from small to medium farms but less so to large farms is also evident in the results of the production function analysis.

GROSS FARM RETURNS

Gross returns from milkfish production increased with the scale of operation. Table 10 shows that gross returns increased from ₱3,248/ha for small farms, ₱3,757 for medium farms, to ₱6,392/ha for large farms. In general, Bulacan milkfish farms reported the highest gross incomes; medium-sized farms in Bulacan grossed ₱8,099/ha.

Small farms as a whole were operating at a loss; the only exceptions were in Pangasinan. The average net loss of small farms at the national level was about ₱708/ha.

Medium farms in Masbate, Bohol, Cagayan and Zamboanga del Sur also incurred losses, with Masbate farms experiencing the heaviest losses of ₱1,251/ha. Table 10 shows that medium farms in Pangasinan, Bulacan and Iloilo were net earners of ₱3,042, ₱3,311 and ₱1,037/ha, respectively.

Table 9. Average per hectare costs and returns of milkfish production as surveyed in seven provinces, 1978.

Province	₱/hectare		
	Returns	Costs	Residuals
Cagayan	1,951	4,156	(2,205)
Pangasinan	5,206	3,036	2,170
Bulacan	7,457	4,320	3,137
Masbate	545	1,859	(1,314)
Iloilo	6,383	3,850	2,533
Bohol	1,577	2,536	(959)
Zamboanga del Sur	1,203	1,732	(529)
Sample	4,772	3,394	1,378

Table 10. Average per hectare costs and returns of milkfish production by farm size as surveyed in seven provinces, 1978.

Province	Small Farms			Medium Farms			Large Farms		
	Returns	Costs	Residuals	Returns	Costs	Residuals	Returns	Costs	Residuals
Cagayan	₱2,386	₱6,725	₱(4,339)	₱1,804[1]	₱2,583	₱(779)	₱ —	—	—
Pangasinan	4,688	3,304	1,384	5,845	2,803	3,042	—	—	—
Bulacan	4,692	5,929	(1,237)	8,099	4,788	3,311	6,732	3,720	3,012
Masbate	1,566[2]	3,551	(1,985)	652	1,903	(1,251)	89[2]	1,570	(1,481)
Iloilo	2,579	4,044	(1,465)	5,097	4,060	1,037	6,958	3,591	3,367
Bohol	739	3,814	(3,075)	1,676	2,387	(711)	—	—	—
Zamboanga del Sur	902	2,554	(1,652)	1,218	1,692	(474)	—	—	—
Sample	3,248	3,956	(708)	3,757	3,154	603	6,392	3,415	2,977

Note: [1]n = 4
[2]n = 2

Overall, only three provinces out of the seven surveyed showed profitable milkfish production—Bulacan, Iloilo and Pangasinan, where supplemental inputs are not only widely used but are also used in larger quantities. In contrast, producers in Cagayan, Masbate, Bohol and Zamboanga del Sur, where supplemental inputs are not widely used, incurred losses. It is worth reiterating that although inputs are not without costs, their application can be profitable.

As early as the late 1920s, the returns from milkfish production in some provinces were "so low that it is very evident the fish were raised at a lost (sic)." Also "if anything is charged for interest on the cost of the dikes, for time, and for labor, the owner would have been better off without a fishpond" (Herre and Mendoza 1929).

LIQUIDITY POSITION OF MILKFISH PRODUCERS

Theoretically, producers can be categorized into those who operate under a capital constraint and those who do not. The solution to the problem of determining the most profitable levels of inputs and output differs, depending upon the nature of the capital constraint. If no capital constraint exists, the producer maximizes profits when the marginal revenue from each added input equals its marginal cost, that is where the marginal product of each input equals the respective input-output price ratio. If a capital constraint exists, profits are maximized when the producer allocates inputs such that the return on the last peso spent on each input is equal. In the latter case, marginal revenues from each input will exceed the respective marginal costs.

In the Philippine milkfish industry, capital constraints appear to exist, but the level of participation of producers in government-sponsored credit programs is still low. This study establishes the relationships between marginal revenues and marginal costs, and thus provides an indication of whether or not milkfish producers are behaving as profit maximizers under varying assumptions regarding the nature of the capital constraint.

Table 11. Itemized shares of inputs (pesos) in Philippine milkfish production by farm size.

Input item	All farm sizes		Small farms		Medium farms		Large farms	
	Costs	%	Costs	%	Costs	%	Costs	%
1. Material input	(1,435)[2]	(42.27)	(899)	(22.77)	(1,004)	(31.84)	(1,890)	(55.36)
a. Stocking materials	520	15.32	444	11.24	375	11.91	712	20.86
b. Fertilizers								
i) Organic	403	11.86	151	3.82	322	10.20	492	14.42
ii) Inorganic	283	8.34	108	2.74	195	6.20	402	11.76
c. Pesticides	62	1.82	55	1.40	59	1.88	66	1.93
d. Supplementary feeds	167	4.93	141	3.57	52	1.65	218	6.39
2. Labor	(926)	(27.29)	(1,954)	(49.90)	(1,080)	(34.24)	(552)	(16.16)
a. Hired	690	20.34	764	19.31	851	26.99	458	13.42
b. Unpaid	236	6.95	1,190	30.09	229	7.25	94	2.74
3. Miscellaneous operating costs[1]	(1,033)	(30.43)	(1,101)	(27.84)	(1,070)	(33.92)	(973)	(28.47)
4. Per hectare costs[3]	3,394	100.00	3,956	100.00	3,154	100.00	3,415	100.00

Note: [1] Miscellaneous operating costs comprise costs of repair and maintenance provided by caretakers only, food for laborers, depreciation expenses, interest charges, leasehold fees, taxes and licence fees.

[2] Figures in parenthesis are subtotals of each category of inputs.

[3] Does not include opportunity costs of land or operator's own inputs such as labor and management.

Chapter IV

The Production Function Model

THEORETICAL BASE

Answers to questions as to the optimum level of production, the optimum stocking rate or the most profitable quantity of fertilizers to apply per unit of milkfish pond can be obtained from the theory of the "firm". A firm, in this case a farm, is a basic decision-making unit, having at its disposal a collection of inputs needed in the production of milkfish. Milkfish production involves a process whereby various land, labor and capital inputs such as milkfish fry or fingerlings, fertilizers, and labor services are combined to produce milkfish. As in any production process, there is a functional relationship between the inputs used in the production and output. This relationship is usually called a production function (see Heady and Dillon 1961 and Ferguson 1969 for detailed discussion).

A production function specifies all technically efficient combinations of inputs and output. It describes the maximum output which is forthcoming from given quantities of inputs, assuming a common technique of production. This functional relationship between inputs and output can be expressed in the generalized form:

$$Y = f(X_1, X_2, \ldots, X_n)$$

The equation states that the quantity of output Y, which can be produced depends upon the quantities of inputs $X_1, X_2, \ldots, X_n$ which are used, or applied to the pond. For example, Y is the quantity of milkfish produced and X_1 could be the amount of fertilizer applied, etc.

Once the equation has been estimated, the first partial derivative with respect to a particular input can be taken, giving the marginal product of the input so specified. Having obtained the marginal product, it can be compared with the input-output price ratio. When they are equal, optimum input level and combination can be said to occur. In other words, under optimization, the value of marginal product (added benefit) is equal to the input price (added cost). Mathematically, this relationship can be derived as follows:

$$Y = f(X_1, X_2, \ldots, X_n)$$

$$\frac{\partial Y}{\partial X_1} = f'(X_1, X_2, \ldots, X_n) = MP_{x_1}$$

$$MP_{x_1} \bullet P_y = P_{x_1}$$

$$MP_{x_1} = \frac{P_{x_1}}{P_y} \qquad \text{or}$$

$$VMP_{x_1} = P_{x_1}$$

where

MP_{x_1} = marginal product of input X_1
VMP_{x_1} = value of the marginal product of input X_1
P_{x_1} = price of input X_1 (e.g., milkfish fry)
P_y = price of output (milkfish)

The simple algebra above can be illustrated by means of a two-dimensional graph (Fig. 6). Maximum profits occur when the value of the marginal product and price for the input in question are equated.

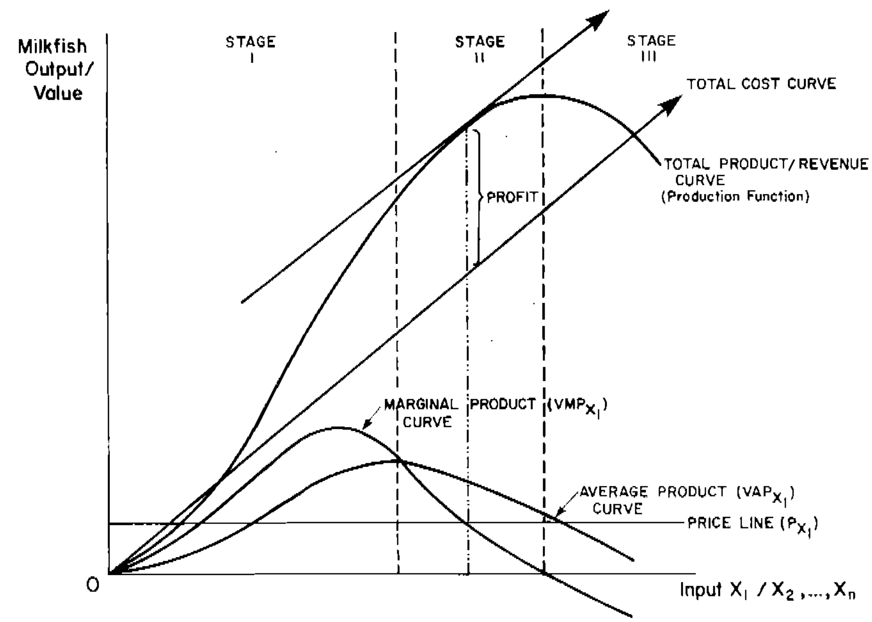

Figure 6. An input-output relationship or production function.

MODEL SPECIFICATION

A working familiarity of the milkfish production process is indispensable in identifying the key relevant variables in milkfish production function specification. The process of specification includes selection of explanatory variables and the appropriate functional form. Key relevant variables explaining or believed to explain milkfish output are singled out because it is impossible to incorporate all the possible explanatory variables in the model. Together with a knowledge of the physical, technological and biological relationships, an analytical model is accordingly specified.

Theoretically, each explanatory variable selected for incorporation into the model should be homogeneous. By this is meant that the variable is uniform in quality and is similar in all respects for all data points. However, from the practical point of view, this assumption has not always been easy to satisfy. Since it is difficult to incorporate all possible variables in explaining milkfish output, these left-out or non-specified variables are "captured" under the error term or residual. If a proxy, or dummy variable is also specified in the model, a part of the non-specified variables is also "captured" under this catch-all variable—either proxy or dummy variable, especially a time variable.

Specification bias can arise from omitting important explanatory variables. The extent of bias depends on whether the omitted variables are correlated with the included variables. There will be no bias if the omitted and included variables are not correlated. Conversely, bias arises if they are correlated.

In any modeling, it is well to consider the trade-off between the costs and returns of additional information. Similarly, in specifying a production function model, a choice has to be made between too much and too little aggregation of input categories. Fortunately, in production function modeling, there are certain rules which can simplify this decision. Although excessive aggregation of input categories results in the loss of information for decision-making, too much disaggregation of input categories into many inputs would considerably increase the costs of obtaining the additional details. It all boils down to whether the additional details or benefits are worth the additional costs. Also excessive disaggregation may result in loss of too many degrees of freedom. In our study, we limited our analysis to 11 explanatory variables.

The omission of key variables (such as fixed capital in this study) can affect the goodness-of-fit of the model. As discussed, it can result in specification bias of the estimated production coefficients to the extent that the omitted key variables are intercorrelated with the included variables. An examination of the residuals will indicate whether there are any omitted variables in the model. If there are omitted variables, the residuals will have non-zero mean and a systematic pattern. The analysis of the residuals will also indicate whether the functional form is correctly specified.

The production function model as specified in this study, using cross-section data, is different from the textbook or theoretical production function due to the type of data. Cross-section data collected from a sample of farms result in an "inter-firm" function whereas the textbook function is an "intra-firm" function, based on one firm only, such as an experimental farm, using time-series data.

In order to obtain parameters of physical production functions that approximate the true input-output relationship under investigation, it is first necessary to select, *a priori*, a mathematical or algebraic form which best describes the production process. Ideally, the mathematical function must reflect the relationship between output and input use in producing the output.

Several mathematical functions can be used, but there is no one function which has all the desired features. For instance, the simple power function, $Y = \alpha X^{\beta}$, is sometimes unacceptable because when $\beta > 0$ it implies that the yield is increasing continuously without reaching a limit. In most cases, this clearly violates the logic of the production process. A linear production function, $Y = \alpha + \beta X$, while it allows variation in the elasticities of production over the range of the data used, also does not portray diminishing returns. Another common mathematical form is the quadratic polynomial, $Y = \alpha + \beta_1 X_1 + \beta_{11} X_1^2$. This algebraic form is valuable in showing an input-output relationship which increases, reaches a maximum and then decreases. Unlike other functional forms, this is an easy curve to fit. Its main limitation is that it uses up twice as many degrees of freedom as functional forms where each explanatory variable is entered only once. The appropriate functional form of the production function can be determined statistically through the Box-Cox transformation (Box and Cox 1962). We did not apply this technique, but instead tested alternative functional forms for their 'goodness of fit.'

More complex functional forms are also available: exponential functions such as Spillman and Mitscherlich equations. Unlike the power and polynomial equations, the estimation of the exponential form suffers from a drawback, that is, statistical tests of significance cannot be calculated (Johnson 1953). Other more complex functional forms include cost and unit profit functions (Lau and Yotopoulos 1972) all of which require detailed data on input and output prices which we decided would be too difficult to collect using recall survey techniques.

The most commonly used functional form in agricultural production economics research is the Cobb-Douglas production function:

$$Y = \alpha X_1^{\beta_1} X_2^{\beta_2}, \ldots, X_n^{\beta_n}$$

or in log-linear form:

$$\log Y = \log \alpha + \beta_1 \log X_1 + \beta_2 \log X_2 + , \ldots, + \beta_n \log X_n$$

There are several advantages to using this particular functional form. First and foremost, the Cobb-Douglas equation is computationally simple. It is homogenous of "$\Sigma \beta_i$" degree. It is a power function which is linear in logarithmic form. Cobb-Douglas form is popular because of the ease in interpreting the elasticities of production and marginal products. The isoquants of the Cobb-Douglas production function are negatively sloped throughout and strictly convex for positive values. It has fixed or constant elasticities of production and linear isoclines which pass through the origin. These fixed and partial production elasticities do not vary over the range of the production function. But most important, the Cobb-Douglas formulation is thrifty on degrees of freedom when compared to other mathematical forms. In other words, a relatively small number of degrees of freedom is needed when estimating a Cobb-Douglas form of production function. This is a definite advantage for small samples.

The elasticities of production under the Cobb-Douglas form are easy to interpret because the estimated regression coefficients are related to the elasticities of production. Besides, these elasticities are independent of the unit of measurement of the explanatory variable or input. If the estimated regression coefficients are a mixture of positive and negative coefficients, then the value of, say, $\beta_9 < 1$, means that the marginal product of X_9 declines as input X_9 is increased. Similarly, if $\beta_9 > 1$, this means the marginal product of X_9 increases as X_9 is increased.

The Cobb-Douglas production function also implies substitutability among the various inputs (Heady 1946). However, the elasticity of substitution is unitary. Further, according to Heady (1946), the logarithmic transformation of the variables required under the Cobb-Douglas form also presumes, to a substantial degree, normality in the distribution of errors in the data.

An unconstrained Cobb-Douglas production function has one advantage over the other mathematical forms in that the unconstrained Cobb-Douglas form can take on any one of three types of relationship: increasing, constant and decreasing returns. It is not specified *a priori* like the linear form. Because of its mathematical properties, the linear equation can only represent a constant change in the dependent variable for each unit change in the independent variable, regardless of the magnitude of the independent variable. On the other hand, the Cobb-Douglas production function, because it can take on one of three types of relationship pointed out above, is better suited because the resulting production function estimated will best describe the data.

There are several limitations of the Cobb-Douglas production function that should be noted, however. First, the algebraic expression of the resulting input-output relationship of milkfish production cannot possibly account for all the technical relationships inherent in the production process. Neither can other mathematical functions. For example, the hypothesized inputs (e.g., fertilizers, hired labor) and the interaction term between any two inputs (e.g., organic and inorganic fertilizers), if included, can only pick up some of the variations in output, and the complementary and supplementary relationships among inputs and between inputs and output.

A second disadvantage of the Cobb-Douglas form is that the elasticity of production is constant throughout the entire range of the function. This means that it does not depict all three stages of production as found in textbook exposition, but only part of the entire production surface. The Cobb-Douglas form allows only an increasing total product. However, it does depict the production surface which is of interest in decision making, that is, stages I and II. This is not considered a serious drawback because stage III of the production function is not relevant for decision making in any case. Since the Cobb-Douglas form only maps a segment of the total product curve, it is prudent that neither output nor inputs be increased or decreased indefinitely. Accordingly, derivation of desired parameters has to be done within the segment mapped by the production function. Therefore, the Cobb-Douglas form is useful only if information on input productivities at their means is needed. Indeed, this is one of the purposes of the present study.

A third drawback is that if the sum of elasticities is less than 1.0 (unity), the Cobb-Douglas production function does not give a distinct peak. Finally, the elasticity of substitution among all inputs is constrained to 1.0. The elasticity of substitution refers to a situation where the two inputs can be substituted with each other. Zero and infinite elasticity of substitution refer to the case where the two inputs must be used in a fixed proportion (strict complements), and where the two inputs are perfect substitutes.

Attempts have been made in numerous studies to derive algebraic or mathematical forms of production functions which are both theoretically and empirically applicable (Garrod and Aslam 1977). Each alternative functional form has advantages, but each usually imposes certain limitations on the nature of the input-output relationship (Ulveling and Fletcher 1970).

In the final analysis, the selection of a mathematical function to describe a production process depends upon a knowledge of the workings of that process—the more information that is available the more accurate the mapping of the true relationship. Many "factors" can be identified which directly or indirectly affect the ultimate output of milkfish.

Chapter V

Milkfish Production Model

ALGEBRAIC FORM

Three algebraic forms of the production function model were initially estimated to determine their appropriateness and explanatory/predictive power. These were the linear, quadratic and Cobb-Douglas forms. The functional form of the milkfish production model chosen was that of an unconstrained Cobb-Douglas production function model.[5] This is of necessity an approximate modeling of the true production process because there exist variables that are presently known and measurable which may be important in milkfish production, but which have not been included. For instance, depth of pond and distance of pond from the main source of water are measurable but data were not available.

Milkfish production results from combining various inputs in a body of water. Within logical limits, it is true that without any one of these inputs, no milkfish would be forthcoming. Eleven inputs or explanatory variables were hypothesized to explain milkfish production in the country. Regression analysis (ordinary least squares method) was used to evaluate the relative influence of each of the eleven inputs or explanatory variables on the output of milkfish.

The basic model is shown below:

$$Y = \alpha_0 \; X_1^{\beta_1} \; X_2^{\beta_2}, \ldots, X_{11}^{\beta_{11}} \; \epsilon$$

or

$$\log Y = \log \alpha_0 + \beta_1 \log X_1 + \beta_2 \log X_2, \ldots, \beta_{11} \log X_{11} + \epsilon$$

where

X_1 = age of ponds (years)
X_2 = quantity of milkfish fry stocked (pieces)
X_3 = quantity of milkfish fingerlings stocked (pieces)
X_4 = acclimatization time before stocking (hours)
X_5 = hired labor (man-hours)
X_6 = miscellaneous operating costs (₱)
X_7 = milkfish culture experience of respondent (years)
X_8 = pesticides (₱)
X_9 = organic fertilizers (kg)
X_{10} = inorganic fertilizers (kg)
X_{11} = farm size (land in hectares)
α_0, β_i = production coefficients to be estimated
ϵ = error term distributed with mean zero and constant variance

The X_is or inputs are sometimes known as target variables which are subject to influence by the decision-maker (producer or policymaker). The β_is are actually transforma-

[5] Ferguson (1969) states that "in principle the variety of equations that may validly represent a production function is virtually limitless." Production function analysis, however, is not a substitute for budgeting, programming, or planning procedures which can provide relatively broader estimates of optimum resource use within a farm.

tion ratios of the various inputs used in milkfish production at different quantities. The model as presented above is an acceptable representation of the production relationships of milkfish culture.

The sign (positive or negative) attached to the parameters will depend upon economic logic. However, it is only in the quadratic form where signs can be explicitly attached in the specified functional form (e.g., $-\beta_i X_i^2$). The Cobb-Douglas form does not allow signs to be attached in the specified model, but these signs are produced in the estimation process. After estimation, one can therefore check the coefficients to determine if they have the expected positive or negative sign.

Of the eleven explanatory variables specified in the model, almost all can be amenable to policy-induced change in one way or another. The only exception is age of pond. There are two targets or instrument variables whose information can be useful to both the farmer and policymaker. The production coefficients, β_is or exponents of the Cobb-Douglas form, are the elasticities of production.

Estimating a production function calls for data on output and inputs, and the information has to be measured as accurately as possible. Faulty data have often been the source of poor fit and insignificant estimates. Recognizing the importance of accurate data, a brief discussion of all the variables used in estimating the production function is provided to give the reader a better appreciation of how they were obtained and measured. Problems of measurement are also briefly discussed. Ideally, all the variables should be measured in physical units. Sometimes, it is not entirely possible to do so, as was the case in the present study. Some of the variables are in value terms because of unlike units of measurement, e.g., liquid and powdered pesticides.

Total output (Y) refers to the quantity of milkfish (kg) harvested per farm or per hectare during the 1978 production year. Other byproducts, such as shrimp, tilapia and mullet, have been excluded from the total. Output includes the milkfish which are consumed at home, given away as gifts, and harvester's and caretaker's share. Wherever possible and when data permit, total output is adjusted for loss due to typhoon and floods.

DEFINITIONS OF EXPLANATORY VARIABLES

Following De Wit (1979), inputs can be classified into material inputs, management inputs and input of field work. Material inputs can be further distinguished into either yield-increasing inputs, such as fertilizers, or yield-protecting inputs, such as pesticides.

Profitable use of inputs is predicated on a knowledge of the response of milkfish output to the application of these inputs. Besides material inputs, management inputs and input of field work, other inherent characteristics of the pond environment and/or factors affecting its environment, such as age of the pond and weather, can be employed to explain milkfish output. Below is an overview of the eleven explanatory variables used in the model. They reflect the 1978 production practices found in each of the seven sampled provinces. In addition, other variables, such as supplementary feeding and liming, which are not specified in the model because they are not widely practised, are also discussed.

Age of pond (X_1):

Age of the milkfish pond has been incorporated as one of the explanatory variables to explain milkfish output because of the common observation that newly-excavated ponds are less productive. So far this observation is just an observation. The purpose of including this

Table 12. Age of sampled Philippines milkfish ponds in years.

Province	Newest	Oldest	Average age
Cagayan	2	27	5
Pangasinan	2	75	22
Bulacan	3	70	44
Masbate	3	31	13
Iloilo	4	100	30
Bohol	1	55	10
Zamboanga del Sur	1	49	15
Sample	1	100	20

variable is to document empirically its effect on milkfish output. The range of pond age in the surveyed provinces is shown in Table 12.

Fry and fingerling stocking rates (X_2 and X_3):

Milkfish fry occur along shallow coastal waters, tidal creeks and estuaries. Milkfish are believed to breed throughout most of the year, although peak spawning occurs in May and June. Correspondingly, the height of stocking activities is identified with these two months. Among the 324 milkfish farmers interviewed, 39% generally stock in May while about 25% do so in June. In two provinces surveyed (Iloilo and Zamboanga del Sur), stocking takes place every month. In the rest of the provinces, the inactive months when no stocking is carried out are January to February, and October to December. In Cagayan, stocking is carried out from March to June. Stocking of fingerlings displays a pattern similar to that of fry.

Although stocking density has to be based on a knowledge of the pond environment such as the fertility of the pond, types of fishfood available naturally, to be grown or to be added, (that is, the carrying capacity of the pond), the size of fry at stocking and the market size of the fish to be grown, a majority of milkfish farmers interviewed do not appear to understand fully the basis for such considerations. With a few exceptions, the stocking density is ultimately determined by the local availability of milkfish fry or the money at the producer's disposal.

Because of the different natural endowments and managerial abilities available on each farm, the optimum number of fry or fingerlings to stock a given unit of pond area is not known. As a result, there are wide variations in stocking rates. Over and beyond the arbitrariness of present stocking practices is the problem of counting. So far no accurate or reliable method of counting milkfish fry has been devised. The present method, visual assessment of the density of a representative sample, is far from reliable. Errors arising from this far from fool-proof method of counting are very common.

Of the total milkfish farms surveyed, 91% stock with fry and 13% use fingerlings (some milkfish farmers stock both fry and fingerlings). On a countrywide basis, stocking rates of fry range from a very low 50 pieces to an extremely high 33,000 pieces per hectare of pond. The very low stocking rate was observed in Masbate where the milkfish farmer was more concerned with shrimp production. The high density stocking was reported for Bulacan. Based on the survey, the average stocking rate is 5,922 pieces of fry per hectare. A similar figure was found for fingerling stocking rates. However, by province, the stocking rate of fingerlings was usually considerably lower than that of fry.

Milkfish fry mortality in the ponds is very high, averaging 50%. Fingerlings have a marginally higher recovery rate, about 60%. Table 13 provides a comparison of recovery rates in seven provinces in the Philippines.

In contrast to the frequent public outcry of fry shortage in the country, this survey shows that at the national level, only 13% of the farmers reported milkfish fry shortage and only 5% complained of high cost of milkfish fry. The price of milkfish fry averaged about ₱87/1,000 pieces.

Bulacan reported the lowest incidence of fry shortage. This is because Bulacan is the center of fry and fingerling transactions for the whole country. Zamboanga del Sur is reportedly also a milkfish fry surplus area, yet 20% of the milkfish farmers interviewed reported fry shortage and high cost of fry as two of the problems they faced. This is partly because the milkfish fry caught off Zamboanga del Sur are normally shipped out of the area, both legally and illegally by smuggling.

Table 13. Milkfish fry/fingerling recovery rates.

Province	Fry Stocking (pieces)	Fry Production (pieces)	Fry Recovery (%)	Fingerlings Stocking (pieces)	Fingerlings Production (pieces)	Fingerlings Recovery (%)
Cagayan	501,500	105,375	21	3,300	888	27
Pangasinan	1,366,170	488,676	36	154,650	55,378	36
Bulacan	5,896,000	2,936,000	50	3,741,000	2,406,254	64
Masbate	1,278,000	260,598	21	5,000	3,000	60
Iloilo	16,794,250	9,157,502	55	221,000	112,300	51
Bohol	1,266,000	433,302	34	–	–	–
Zamboanga del Sur	1,025,300	412,201	40	–	–	–
Sample	28,127,220	13,793,654	49	4,124,950	2,577,820	63

Based on 324 milkfish farms in seven provinces.

Acclimatization of stocking materials (X_4):

The importance of acclimatization of stocking materials to reduce unnecessary stress due to differences in salinity and temperature is well recognized by those experienced in fish culture. However, only 58% of Philippine milkfish producers practise any form of acclimatization. The acclimatization period varies widely from less than one hour to more than 24 hours. We measured hours of acclimatization as recalled by the producer.

Hired labor (X_5):

Although there is limited mechanization, Philippine milkfish farming is still largely labor-intensive. The different phases of production require heavy use of labor. Manpower requirements are provided by the milkfish farmers themselves, by the members of their families, caretakers and/or laborers hired by them either by contract or on a wage basis.

The measurement of labor presents a number of problems. This is because it is not easy to separate the productive use of labor from the non-productive uses. No data are available on such distinctions, even from the producers themselves. In general, caretakers hired on a monthly wage basis look after all aspects of pond operations. Additional casual labor can be hired if there is more work to be done than the caretaker can handle. Because the caretaker's time and services are available any time there is work to be done (stock), no effort is made to keep track of the work performed (flow). The same applies to the owner-operator's time in supervising and inspecting milkfish production activities. In this study, the labor component is therefore narrowly defined to include only the actual hired labor. Man-hours and costs are shown in Table 14.

Other categories of labor, including operator, family, exchange and contract labor, were excluded due to the intractable difficulties of measuring actual application of labor as opposed to simple availability.

Table 14. Hired labor utilization in sampled farms by province.

Province	Man-hours/ha/year	₱/man-hour
Cagayan	219	2.25
Pangasinan	84	1.72
Bulacan	184	2.58
Masbate	483	1.63
Iloilo	136	0.68
Bohol	472	0.72
Zamboanga del Sur	533	0.65
Sample	254	1.36

Miscellaneous operating costs (X_6):

The "miscellaneous operating costs" input category as defined in this study comprises the repair and maintenance costs of milkfish ponds carried out by caretakers only, food for laborers, depreciation expenses for tools and equipment, interest expenses, leasehold fees/rentals (if appropriate), taxes and license fees. This category of expenditures accounts for a large percentage of the total costs of milkfish production. At the national level, miscellaneous operating costs are about 22% of total costs.

The largest item in this category is the leasehold fee/rental paid by the milkfish operators at an average of ₱658/ha. This expense is common in three Luzon provinces: Pangasinan, Bulacan and Cagayan. Next in importance are interest charges, averaging about ₱459/ha. Close to ₱247/ha are spent for pond repairs and maintenance. Depreciation of tools and equipment accounts for another ₱136/ha. Taxes/licence fees and food for laborers amount to ₱70 and ₱49/ha, respectively. These total ₱1,619/ha. This total is different from the estimate for miscellaneous operating costs in Table 11, since the procedure used in estimation is different.

Milkfish culture experience (X_7):

Like all crops, milkfish respond to either management or neglect. By management is meant the proper use of production inputs to increase and protect the crop under a producer's supervision (Griliches 1957). For the purpose of this study, a proxy variable, namely, number of years of milkfish culture experience, was used to reflect the care and supervision given to the milkfish stock.

Based on the survey, the average milkfish culture experience reported by Philippine milkfish producers is about 16 years. Close to one third (31%) have an average experience of less than 5 years. Those who have from 6 to 20 years of experience constitute some 42%, of which only 15% have more than 15 years of experience.

Pesticides (X_8):

Pests and predators, which cause high mortality of fry and fingerlings and ultimately contribute to low yields, can be eliminated by the application of organic pesticides such as tobacco dust, derris roots and other raw materials containing saponin or rotenone. Chemical pesticides are also used. Aquatin is used to kill snails, polychaete worms and chironomid larvae, and is normally applied at one liter per hectare. Gusathion is used to eliminate unwanted fish species like therapon, tarpon, seabass, ten-pounder, gobies and tilapia. It is applied at the rate of ½ to 1 liter per hectare.

Organic and inorganic fertilization rates (X_9 and X_{10}):

The purpose of applying fertilizers or manures is to enrich the water column to support the growth of fish food. Out of 5,288 ha of fishponds surveyed, 76% are treated with organic fertilizers. Details are given in Table 15. The most common form of organic fertilizer is chicken manure, which is used in all the provinces surveyed. The rates of application range from 87/kg/ha/year (Cagayan) to 2,483 kg/ha/year (Bulacan, which has the country's largest poultry farms). Other organic manures like guano, hog manure, quail manure and nightsoil are also used, although infrequently.

About 86% of the producing fishponds in the country use inorganic fertilizers, from 30 kg/ha/year (Zamboanga del Sur) to 281 kg/ha/year (Iloilo). Some farmers (24%) use only inorganic fertilizers.

Table 15. Rates of organic fertilizer application in surveyed provinces of the Philippines, 1978 crop year.

Province	Area covered in survey (ha)	Organic fertilizers (kg/ha/year)	Percent of area using organic manure	Price (P/kg)
Cagayan	121.64	87.0	41.0	0.11
Pangasinan	233.39	288.0	38.0	0.25
Bulacan	1,232.80	2,483.0	97.0	0.18
Masbate	738.60	456.0	37.0	0.20
Iloilo	1,986.01	877.0	93.0	0.50
Bohol	404.75	1,150.0	58.0	0.13
Zamboanga del Sur	570.80	891.0	61.0	0.11
Sample	5,288.00	1,333.0	76.0	0.27

Some 47% of the milkfish producers interviewed use both organic and inorganic fertilizers. Organic fertilizers are used in greater quantity, partly due to their lower cost. However, in Pangasinan, manures are said to give an off-flavor to the fish. Some 8% of producers use organic fertilizers only.

Farm size (X_{11}):

Farm size as defined here includes only the developed portion of the farm.

EXCLUDED VARIABLES

Several inputs were not included in the model specification because their use is not widespread. These include supplemental feeds and liming.

When supplemental feeding is carried out, single-ingredient feeds are used. Some examples are rice bran, broken ice cream cones[6], bread crumbs and filamentous algae. Rice bran is by far the most common. Hog mash is used in Pangasinan. On a country-wide basis, only 22% of the total sample reported the use of supplemental feeds. Supplementary feeding expenditure is comparatively low, averaging ₱61/ha/year. Our 324 sample farms applied an average 19 kg/ha/year. Those 22% using supplemental feed applied an average 86 kg/ha/year.

Lime, generally as agriculture lime ($CaCO_3$), is used in fishponds as a soil-and-water conditioner. Liming is not carried out every year. Only about 3% of the sampled farmers practised liming in 1978, applying 96 kg per hectare of pond in Iloilo and 216 kg in Bohol.

Two other variables not included in the model due to difficulties in measurement were pond depth and distance from main water source.

ASSUMPTIONS OF THE STUDY

The assumptions of the model relate to both the theory of the firm and regression analysis. The theory of the firm assumes that the milkfish farmer is a profit-maximizer and has perfect knowledge of the input and output prices. The prices used for this analysis are fixed at a particular level; they refer to the 1978 price levels.

Philippine milkfish producers are also assumed to be single-product farmers, that is, milkfish monoculture is practised. It is further assumed that no output is forthcoming if no inputs are applied. The inputs used in milkfish production are assumed to be homogeneous and that there are no qualitative differences among inputs available in each province and across the seven provinces. In other words, the data or the variables of interest are assumed to be measured without error.

Further, work done by the milkfish operators (owners and lessees) in supervising and inspecting production operations is not considered in the model. It is treated as residual accruing to the operators for their labor and management.

The word *crop* or *production* as used in this study refers to the total quantity of milkfish harvested from the same batch of milkfish fry or fingerlings purchased and stocked to the time when every fish is harvested. In other words, it is assumed that no milkfish escaped harvest and that partial harvest did not constitute a crop. Within a production cycle, several harvests were made, and these were summed to reflect a single crop made from the same batch of fry. If stocking of fry was done more than once within the same crop year, then these quantities were added together to reflect the total milkfish fry stocked. Note that no account of the difference in size (weight) between fry and fingerlings was made. They are recorded as number of pieces stocked.

To account for beginning inventory and ending inventory, another rule of thumb used was that the fry stocked must benefit from the inputs applied during the relevant production period. On the one hand, in cases where the milkfish fry were purchased towards the end of the production period and brought forward to the next period (e.g., fry intentionally stunted for future use) they were excluded from the output estimated. On the other hand, milkfish stock which were grown in the relevant production period but were harvested at the beginning of the next period were included in the output estimated.

Unbiased and minimum-variance estimates of the regression coefficients are obtained if certain least squares-multiple regression assumptions hold true (Heady and Dillon 1961).

[6]The use of broken ice cream cones is limited to Bulacan, a province adjacent to Metro Manila.

These assumptions are applicable if the survey design is random sampling. Because one phase of our survey was based on purposive sampling, these assumptions were violated. Random sampling was not used throughout because it was impossible to construct an adequate sampling frame with the limited budget available. Even though purposive sampling was used in identifying a homogeneous group of farmers, it must be stated that in most provinces almost the entire population of those who used inputs was surveyed. An exhaustive search for milkfish farmers in each province was necessary to produce the final number of respondents. Because of its census-nature, it is felt that the ordinary least squares assumptions mentioned above have not been seriously violated.

Chapter VI

Production Function Results and Discussion

The following production functions are reported in this chapter:

- 2 national functions (1 per hectare; 1 per farm)
- 7 provincial functions
- 3 functions by climate type
- 2 functions by tenure status
- 3 functions by farm size

The last three categories of functions are to allow testing of the hypotheses that there are significant differences in output by climate, tenure status and farm size.

The results of production-function analysis are given in Table 16. The usefulness of the estimates of the various production coefficients are discussed in this section to provide more thorough understanding of the underlying input-output relationships.

Positive production coefficients and the calculated marginal physical products of the respective inputs imply that increases in output of milkfish can be accomplished by increasing the intensity of input use. Negative marginal products suggest that use of that particular input should be cut back to increase productivity. These production coefficients can also be interpreted as the production elasticities since the Cobb-Douglas algebraic form was used.

The estimated production coefficients in Table 16 show that productivity differences exist among provinces. The intercept or constant value indicates to an extent the efficiency of the production operations in each of the seven provinces. The magnitudes of the estimated production coefficients are larger for some provinces than others, indicating the kinds of responses of milkfish output to each of the inputs. There is indeed quite a diversity in the values of the intercepts and production coefficients. This diversity in the intercepts and coefficients can be partly explained by the differences in environmental conditions and overall managerial ability.

Selected production functions were used to demonstrate technical and economic relationships. Values of the respective inputs at their geometric means were substituted into the selected production functions to obtain the predicted milkfish yield response (to the input applied). The main interest in this study is in the statistical significance of the estimated production coefficients both in terms of their absolute values and their explanation of milkfish output variation. Finally, economic optima are calculated to show whether existing input combinations are efficient. From this, it can be shown whether or not profits can be increased by changing the level of input use.

FIT OF THE MODEL

In general, the Cobb-Douglas equation fitted the data well as indicated by the F values and R^2. With the exception of Cagayan, the F values are very significant in all cases as can be seen from the various tables. All the R^2 are also statistically significant. In some cases, their modest values are not unusual in regression analysis using cross-section data. In general, signs of the coefficients were of the expected direction. There appear to be no problems with dominant variables.

A revealing result of this study is that for the most part, inputs applied at the reported existing levels do influence milkfish output. The eleven variables hypothesized to explain variations in milkfish yield at the national level were found to explain more than 35% of milkfish output variation. The R^2 values for the provincial functions ranged from 0.39 to 0.90. The excluded variables, therefore, accounted for 10 to 61% of the variation in milkfish output. For this study, it was not possible to incorporate other explanatory variables which are known to be important in explaining milkfish output because of unavailable data. The fit of the model would have been improved if other variables had been included, such as distance to main source of water, pH of pond water and depth of pond. These aspects will be dealt with in a follow-up study undertaken during 1981/82, concerned with constraints to higher milkfish yields.

Since the purpose of this study is to examine the nature of the input-output relationships and the magnitude of the estimates of the production coefficients, all the coefficients will be reported even though some of them are not significant, as shown by low t-values.

In general, the magnitudes of the coefficients estimated for the production functions by province, climatic types, pond ownership patterns and farm size show slight variations among all the coefficients estimated for the same explanatory variable. There were few exceptions. The range of the magnitude of the estimated coefficients is from 0.56 to 1.11. Although the higher extreme is greater than 1.0, only three variables, X_2, X_6 and X_{11} (fry, miscellaneous operating costs and land) have values greater than 0.50. The rest have values of small, absolute magnitude.

For given provinces or the nation as a whole, coefficients for specific variables were similar in both the per-hectare and per-farm production functions (Table 16). This comparability between the two functions (with the exception, of course, of X_{11}-farm size), is discussed in reference to the results of the national production function. Subsequent discussion of results of the remaining functions (province, climate, tenure status, farm size), is focused on the per-hectare, rather than the per-farm specification.

From the various production functions estimated, selected production functions are singled out to derive broad economic and technical conclusions. In all cases, the selected production functions have sufficient degrees of freedom for statistical significance, and are stable with respect to the signs of their regression or production coefficients. The probability level used in accepting significant variables is either 1 or 5%.

NATIONAL MILKFISH PRODUCTION FUNCTIONS

National production functions were estimated on a per-farm and a per-hectare basis (Table 16). Of the 11 explanatory variables hypothesized to explain variation in milkfish output, 6 are significant in the per-hectare specification and 7 in the per-farm specification. Common to both specifications are age of pond, fry, fingerlings, miscellaneous operating costs, organic and inorganic fertilizers. The seventh is farm size (land). The following discussion focuses on the two national functions estimated on a per-farm and per-hectare basis. Each of the significant explanatory variables is discussed in turn, followed by a general discussion of the insignificant variables.

Table 16. Summary of estimated production functions (Cobb-Douglas) by province and country.

Explanatory variables	Philippines HA	Philippines FM	Cagayan HA	Cagayan FM	Pangasinan HA	Pangasinan FM	Bulacan HA	Bulacan FM	Masbate HA	Masbate FM	Iloilo HA	Iloilo FM	Bohol HA	Bohol FM	Zamboanga del Sur HA	Zamboanga del Sur FM
Intercept	7.01	10.91	7.96	16.60	17.80	19.90	258.80	290.20	0.69	0.73	36.70	82.20	0.37	0.50	0.53	0.29
Age of pond X_1	0.27*	0.28*	0.16	0.12	0.12	0.13	0.04	0.03	0.42	0.47	0.29*	0.30*	–0.12	–0.11	–0.04	–0.07
Milkfish fry X_2	0.18*	0.14*	0.08	0.15	0.14*	0.11*	0.12*	0.09*	0.31*	0.26*	0.13	0.05	0.73*	0.72*	0.65*	0.71*
Milkfish fingerling X_3	0.14*	0.10*	–0.10	–0.14	0.08	0.05	0.05	0.03	0.10	0.07	0.04	–0.01	–	–	–	–
Acclimatization X_4	0.05	0.04	0.45	0.45	–0.01	–0.01	0.28**	0.30*	0.13	0.16	0.01	0.02	0.03	0.02	–0.16	–0.18
Hired labor X_2	–0.01	–0.01	–0.06	–0.02	0.06	0.06	–0.06	–0.03	0.05	0.04	0.04	0.03	–0.01	–0.03	–0.04	–0.01
Miscellaneous costs X_6	0.17*	0.16*	0.40	0.24	0.08	0.08	0.07	0.07	0.59*	0.63*	–0.01	–0.01	–0.01	–0.02	0.25	0.27
Culture experience X_7	0.04	0.04	–0.34	–0.43	0.28**	0.30**	–0.07	–0.08	–0.50**	–0.56**	0.01	–0.00	0.08	0.10	0.00	0.00
Pesticides X_8	0.02	0.03	–0.10	–0.01	0.07	0.09	0.05	0.05	0.04	–0.02	0.03	0.06	0.08	0.10	0.00	–0.04
Organic fertilizers X_9	0.04**	0.03**	0.10	0.03	0.04	0.03	–0.05	–0.05	0.05	0.04	0.00	–0.01	0.04	0.02	0.07	0.05
Inorganic fertilizers X_{10}	0.12*	0.09*	0.06	0.07	0.01	0.00	–0.05	–0.06	–0.10	–0.02	0.10	0.07	0.01	–0.02	0.02	0.00
Farm size X_{11}	–0.02	0.57*	0.16	0.74	0.01	0.68*	0.12	1.11*	–0.09	0.07	0.16**	0.98*	0.07	0.31	–0.24	–0.15
R^2	0.39	0.77	0.22	0.56	0.40	0.77	0.40	0.79	0.79	0.77	0.43	0.90	0.44	0.81	0.49	0.55
F value	18.3	95.3	0.32	1.46	4.14	20.71	2.46	13.61	6.05	5.53	2.86	33.17	2.39	13.51	2.70	3.47
Economies of scale $(\Sigma\beta_i)$	1.00	1.47	0.81	1.20	0.88	1.52	0.50	1.46	1.00	1.14	0.80	1.48	0.90	1.09	0.51	0.56

Note: HA and FM refer to production functions estimated at the per hectare and per farm level respectively. More details are provided in Appendix Tables 1 to 14.
*Significant at 1%.
**Significant at 5%.

Age of pond (X_1):

Age of pond is a highly significant variable in explaining variations in milkfish output. Based on the national production functions, every 1% increase in age of pond contributes 0.27-0.28% to output, assuming that other inputs are held constant. The positive value of the coefficient is consistent with the general experience of milkfish producers, who assert that the older the ponds, the more productive they become. They attribute this to the organic matter build-up on the pond bottom, and the gradual reduction in acid-sulphate soil through pond draining, drying and leaching. Some producers have even attempted to shorten the aging period for the pond by incorporating mud press from sugar mills into their ponds, and claim that their milkfish ponds are positively affected. Mud press is the dirt accumulated from washing and processing the sugar cane brought in directly from the fields.

Milkfish fry (X_2):

Stocking rates of milkfish fry are highly significant in explaining milkfish output. This is to be expected since milkfish fry are the primary inputs in the production of milkfish. The estimated production coefficients for milkfish fry are 0.18 and 0.14 for the per-hectare and per-farm functions, respectively. Again, this implies that for every 1% increase in the milkfish fry stocking rate, a 0.14-0.18% increase in output can be expected, *ceteris paribus.*

Milkfish fingerlings (X_3):

Similarly, milkfish fingerling stocking rates are found to be significant in explaining milkfish output. For every 1% increase in stocking rate, an increase of 0.10-0.14% in output can be expected.

Miscellaneous operating costs (X_6):

Based on the estimated production coefficient for miscellaneous operating costs, an increase of 1% in expenditure of miscellaneous operating costs will increase milkfish output by 0.16-0.17%. Because miscellaneous operating costs cover a wide variety of items, such as repair and maintenance costs, food for laborers (but not wages), depreciation, interests, rentals, taxes and other fees, it is not easy to pinpoint the profitable use of additional expenditure on this input category, that is, which of the seven items to single out for additional expenditure. Miscellaneous operating costs as an input are, however, important in the production model because they represent 22% of the production costs of milkfish. Stated differently, if this expenditure is reduced by 1%, output will be reduced by 0.16-0.17%.

Organic and inorganic fertilizers (X_9, X_{10}):

The determination of the extent of substitutability can be done by comparing the value of the marginal product of each of the two inputs and their respective prices.

To some extent, organic fertilizers can be used in place of inorganic fertilizers in milkfish production or vice-versa. The estimated production coefficients for these two variables are significant, though small in absolute values, ranging from 0.03-0.04 for organic and 0.09-0.12 for inorganic fertilizers. While these results indicate the significant impact that fertilizer use can have on output on the average farm, the data collected indicate that the level of application generally practised is very low. On large numbers of farms, therefore, fertilizers are apparently not applied in large enough quantities to have an impact on output.

Farm size (X_{11}):

In the per-farm model, farm size contributes 0.57% to total output for each 1.0% increase in land area, its coefficient being significantly different from zero. Farm size is obviously an important factor in the increase or decrease of output.

Insignificant variables:

An insignificant variable is one for which the coefficient is not significantly different from 0; that is, increases in these inputs will have no significant impact on output. In some cases, however, these results may be due to difficulties in accurately measuring the inputs in question. For instance, the process of acclimatizing the seed stock (X_4) was found to be insignificant in explaining variations in milkfish output. Discussions with experienced farmers revealed that milkfish fry and fingerlings are very sensitive to changes in their environment. Small differences in temperature, pH, salinity and other water conditions result in shock and stress of the young milkfish. We would expect therefore that the number of hours of acclimatization would help to explain output variation. However, the insignificance of the coefficient implies that number of hours may not adequately measure the process of acclimatization.

Another variable found to be insignificant was hired labor (X_5), because it was narrowly defined as explained earlier and did not include all the labor employed on the farm. Hired labor was thus not a satisfactory measure of the total labor input, but total labor input may have a significant effect on output if accurately measured.

It is not altogether surprising to find that years of milkfish culture experience (X_7) are not significant in the model. Experience was chosen as a proxy variable for management. Although technical know-how is known to affect milkfish production, years of experience are apparently not an adequate measure of technical knowledge or management ability.

To an extent, this finding reveals that producers' experience is based primarily on knowledge of traditional methods of culture, and not on the more recent technology. Recent information on improved methods of production is apparently either not reaching the majority of milkfish producers, or not being adopted by them. Field observations show that information dissemination in the country could be improved to update producers' knowledge of improved techniques based on the increased use of supplementary inputs.

Lastly, the application of pesticides (X_8) to protect the milkfish from predators and pests has no significant effect on the final harvest. Incorrect or low levels of pesticide application have partly contributed to their insignificance. Predation on milkfish is reported as a common problem, yet measures taken to rid the ponds of predators are apparently not adequate.

In summary, of the 11 explanatory variables hypothesized to explain variation in milkfish output, the following were found significant: age of pond, stocking rates of milkfish fry and fingerlings, miscellaneous operating costs, organic and inorganic fertilizers, and farm size. Pesticides, milkfish culture experience, acclimatization and hired labor were not significant in explaining output.

All but three production coefficients (milkfish fry, farm size and miscellaneous operating costs) have values less than 0.50. The estimated production coefficients in the two national production functions are consistent with respect to the magnitudes, signs and significance levels.

PROVINCIAL MILKFISH PRODUCTION FUNCTIONS

To compare yields among the 7 provinces, a set of dummy variables (D_1-D_6) was first introduced to the basic model to account for locational differences. Iloilo Province was used as a base because a larger number of progressive milkfish producers are located here than in any other province in the country. The estimated provincial production functions and dummy variables used are shown in Tables 17 and 18. Separate provincial production functions are estimated (Table 16).

Inclusion of the provincial dummy variables significantly increased the predictive power of the production functions. The R^2 value of the per-farm function increased from 0.77 to 0.84 and the per-hectare function from 0.39 to 0.56. The F values also increased in both cases.

Coefficients of four out of the six dummy variables representing Cagayan, Masbate, Bohol and Zamboanga del Sur (D_1, D_4, D_5, D_6) were negative and significant, implying significantly lower yields in each case than that achieved in Iloilo. Because the coefficients for the dummy variables representing Pangasinan and Bulacan (D_2, D_3) were not significantly different from zero, this implies that yields in these two provinces are at par with those of Iloilo.

Individual production functions were also estimated for each province (Appendix Tables 1 to 14). The provincial functions are presented in the same format as the national production functions and their interpretation is similar.

Table 17. Estimated production function (farm) showing productivity differences among 7 provinces in the Philippines.

	Variable and description		Expected sign	Production coefficients	t value	Standard error	Significance level	Input mean $\bar{X}$	Estimated output at $\bar{X}$	Marginal product	Average price of input
1	Intercept (constant)		+	1.90	1.12	0.24	0.26		878		
2	X_1		+	0.03	0.55	0.05	0.58	12.84		2.06	–
3	X_2		+	0.56	10.25	0.05	0.001	3,543.00		0.14	0.09
4	X_3		+	–	–	–	–	–		–	–
5	X_4		+	0.05	1.47	0.03	0.14	3.74		11.76	–
6	X_5		+	–0.001	–0.03	0.01	0.97	123.26		–0.007	–
7	X_6		+	0.11	2.44	0.04	0.01	639.56		0.14	–
8	X_7		+	–0.02	–0.43	0.05	0.66	10.28		–1.71	–
9	X_8		+	0.03	1.14	0.02	0.25	27.79		0.95	–
10	X_9		+	0.01	0.83	0.01	0.40	630.44		0.02	0.29
11	X_{10}		+	–0.01	–0.33	0.02	0.74	74.77		–0.12	1.66
12	X_{11}		+	0.35	4.73	0.07	0.0001	6.16		49.94	–
13	D_1	C	–	–0.35	–3.17	0.11	0.001	–		–	–
14	D_2	P	–	–0.10	–1.15	0.08	0.25	–		–	–
15	D_3	BN	+	–0.03	–0.43	0.07	0.67	–		–	–
16	D_4	M	–	–0.26	–2.71	0.09	0.007	–		–	–
17	D_5	BH	–	–0.40	–4.38	0.09	0.001	–		–	–
18	D_6	Z	–	–0.33	–3.49	0.09	0.0006	–		–	–

R^2 = 0.84 F value = 101.45 DW = 2.01

D_1 to D_6 are dummy variables representing 6 provinces in the survey, Iloilo being the benchmark. C = Cagayan; P = Pangasinan; BN = Bulacan; M = Masbate; BH = Bohol and Z = Zamboanga del Sur.

Table 18. Estimated production function (hectare) showing differences in output among 7 provinces in the Philippines.

	Variable and description		Expected sign	Production coefficients	t value	Standard error	Significance level	Input mean $\bar{X}$	Estimated output at $\bar{X}$	Marginal product	Ave. price of input
1	Intercept (Constant)		+	2.86	1.95	0.23	0.05	–	593	–	–
2	X_1		+	0.03	0.58	0.05	0.56	12.84		1.39	–
3	X_2		+	0.52	9.62	0.05	0.0001	3,543		0.09	0.09
4	X_3		+	–	–	–	–	–		–	–
5	X_4		+	0.06	1.62	0.03	0.10	3.74		9.54	–
6	X_5		+	–0.003	–0.12	0.02	0.90	123.26		–0.01	–
7	X_6		+	0.11	2.40	0.04	0.01	639.56		0.09	–
8	X_7		+	–0.009	–0.17	0.05	0.86	10.28		–0.52	–
9	X_8		+	0.03	0.83	0.03	0.40	27.79		0.66	–
10	X_9		+	0.02	1.20	0.01	0.23	630.44		0.02	0.29
11	X_{10}		+	0.006	0.18	0.03	0.85	74.77		0.05	1.66
12	X_{11}		+	–	–	–	–	–		–	–
13	D_1	C	–	–0.37	–3.49	0.10	0.0006	–		–	–
14	D_2	P	–	–0.14	–1.93	0.07	0.05	–		–	–
15	D_3	BN	+	–0.04	–0.49	0.07	0.05	–		–	–
16	D_4	M	–	–0.28	–2.83	0.09	0.005	–		–	–
17	D_5	BH	–	–0.43	–4.82	0.09	0.0001	–		–	–
18	D_6	Z	–	–0.34	–3.71	0.09	0.0002	–		–	–

R^2 = 0.66 F value = 25.62 DW = 2.02

D_1 to D_6 are dummy variables representing 6 provinces in the survey, Iloilo being the benchmark. C = Cagayan; P = Pangasinan; BN = Bulacan, M = Masbate; BH = Bohol and Z = Zamboanga del Sur.

The results confirm those obtained with the use of dummy variables; that is, Iloilo, Bulacan and Pangasinan are the most productive milkfish producing provinces in the country. R^2 values are generally consistent with those obtained for the national functions, ranging from 0.40 to 0.79 for the per-hectare specifications, and 0.55 to 0.90 for the per-farm specifications. Only in the case of Cagayan is the R^2 value for the per-hectare estimation below this range, and this is most probably due to the very low levels of inputs applied in Cagayan fish farms. Most of the functions exhibit increasing returns to scale. Negative coefficients occur, but most are not significantly different from zero.

MILKFISH PRODUCTION FUNCTIONS BY CLIMATIC TYPES

Four climatic types describe the various Philippine provinces (p. 5). To account for yield variations by climatic types, three different production functions were estimated (Table 19). (No data were collected for climatic type II.)

Three out of the seven provinces included in the survey, Pangasinan, Bulacan and Iloilo, were of climatic type I. Each of the three provinces has its own production functions estimated separately. Climatic type III is represented by Cagayan, Masbate and Zamboanga del Sur while climatic type IV is represented by Bohol. The production function estimated by climate is not much different from those estimated separately for each province. How-

Table 19. Estimated production functions by climatic types.

	Climatic types		
Variables	I	III	IV
Intercept	38.80	2.36	0.37
X_1	0.19	0.10	–0.12
	(0.06)	(0.15)	(0.14)
X_2	0.09	0.21	0.73
	(0.02)	(0.07)	(0.19)
X_3	0.03	0.07	*
	(0.02)	(0.06)	
X_4	0.05	–0.01	0.03
	(0.04)	(0.09)	(0.08)
X_5	0.03	–0.02	–0.01
	(0.03)	(0.05)	(0.05)
X_6	0.08	0.41	–0.01
	(0.05)	(0.14)	(0.12)
X_7	0.06	–0.15	0.08
	(0.06)	(0.14)	(0.14)
X_8	0.07	0.01	0.08
	(0.03)	(0.09)	(0.14)
X_9	0.01	0.06	0.04
	(0.01)	(0.04)	(0.05)
X_{10}	0.04	–0.04	0.01
	(0.03)	(0.07)	(0.12)
X_{11}	0.13	0.07	0.07
	(0.04)	(0.13)	(0.13)
R^2	0.36	0.31	0.44
F-value	8.78	3.38	2.39

*No fingerlings were stocked in Bohol in 1978.
Figures in parentheses are the standard errors.

ever, the provincial production function reflects more closely the local conditions of production.

Milkfish farms in climatic type I were found to be more productive than those found in climatic types III and IV. Producers in climatic type IV are the least efficient. However, their low yields are not entirely due to the less favorable weather condition.

MILKFISH PRODUCTION FUNCTIONS BY TENURE STATUS

From the survey data, privately owned and operated milkfish farms constitute 73% of the sample while the rest are government-leased milkfish farms. A separate production function was independently estimated for private farms and government-leased farms to provide a basis for comparison between their respective efficiencies.

The average yield of the private farms sampled is estimated at 900 kg/ha/year while it is 253 kg/ha/year for the government-leased farms. It may be recalled that the national average output of milkfish farms using supplemental inputs is about 761 kg/ha/year.

As expected, privately owned and operated milkfish farms are found to be more efficient than government-leased farms. One reason is that government-leased farms are relatively new when compared to the privately owned farms. The estimated production coefficients for age of pond also bear this observation out. Table 20 presents both the

Table 20. Estimated production functions by tenure status.

Variables	Tenure status	
	Private farms	Government-leased farms
Intercept	15.56	0.42
X_1	0.27 (0.06)	0.12 (0.12)
X_2	0.13 (0.02)	0.53 (0.08)
X_3	0.07 (0.02)	0.33 (0.07)
X_4	0.07 (0.04)	−0.04 (0.06)
X_5	−0.02 (0.02)	−0.01 (0.04)
X_6	0.14 (0.05)	0.25 (0.10)
X_7	0.06 (0.07)	−0.07 (0.11)
X_8	0.02 (0.04)	−0.01 (0.88)
X_9	0.03 (0.02)	0.07 (0.03)
X_{10}	0.13 (0.03)	0.02 (0.06)
X_{11}	−0.02 (0.04)	0.17 (0.09)
R^2	0.34	0.58
F-value	10.78	8.10

Figures in parenthesis are the standard errors.

intercept values and age of pond coefficients for the privately owned and government-leased farms.

In addition, the relatively short-term nature of government-leases (before 1980) and the sometimes questionable ownership of these government-leased farms arising from the lack of proper supporting documents to show legal lessees, have also contributed to the observed inefficiency. Because of the lack of lessee papers, these producers are hesitant to fully develop their farms through capital improvement and application of inputs.

MILKFISH PRODUCTION FUNCTIONS BY FARM SIZE

As part of the objective to determine economies of scale, production functions by farm size were estimated to determine the relationship of efficiency and farm size. The data are grouped into three categories, farms of less than 6 ha (small), farms of 6 to 50 ha (medium), and farms of more than 50 ha (large).

An examination of the intercepts (Table 21) shows that the bigger the farms the more technically efficient they are, *ceteris paribus.* However, the summation of all the coefficients shows that while there are economies of scale to be obtained from small to medium farms, diseconomies of scale set in with farms larger than 50 ha. For two variables, farm size and miscellaneous operating costs, the coefficients are negative and they are significant. This shows that diminishing returns are occurring on large farms of more than 50 ha.

Table 21. Estimated production functions by farm size.

Variables	Farm size Small farms	 Medium farms	 Large farms
Intercept	13.00	11.30	81.20
X_1	0.22	0.24	0.37
	(0.09)	(0.08)	(0.12)
X_2	0.14	0.19	0.27
	(0.04)	(0.04)	(0.07)
X_3	0.11	0.15	0.19
	(0.04)	(0.04)	(0.05)
X_4	0.11	−0.06	0.02
	(0.06)	(0.06)	(0.11)
X_5	0.02	−0.01	0.02
	(0.03)	(0.03)	(0.06)
X_6	0.07	0.21	−0.32
	(0.08)	(0.07)	(0.13)
X_7	0.26	−0.10	0.11
	(0.10)	(0.08)	(0.12)
X_8	0.06	−0.02	−0.09
	(0.05)	(0.05)	(0.06)
X_9	0.06	0.03	0.38
	(0.03)	(0.02)	(0.09)
X_{10}	0.04	0.18	0.17
	(0.04)	(0.05)	(0.14)
X_{11}	0.74	0.86	0.45
	(0.11)	(0.13)	(0.27)
R^2	0.34	0.45	0.94
F-value	5.92	11.02	15.57

Figures in parentheses are the standard errors.

Also, the absolute values of the estimated coefficients for small farms are smaller, when compared to the medium and large farms, showing the scope for greater application of supplemental inputs in milkfish production.

Discussion

The regression results bring out the expected contrast among the different provinces in terms of output variations and, thus, efficiency levels. Milkfish farms in Bulacan and Iloilo are widely known for their higher output due to favorable climate (Guerrero and Darrah 1974), higher levels of know-how and, thus, higher levels of management.

With the exception of one coefficient (farm size), the production coefficients estimated are less than unity, implying that the marginal products for each input would decline as more of the particular input is used without increasing the other inputs at the same time. Additional doses of the input would only give rise to further diminishing marginal productivities.

The low absolute values of the production coefficients thus show that diminishing marginal productivities hold true only at the prevailing rates and levels of input application in existing ponds which are usually shallow. With such shallow ponds and the prevailing input use, the production function or frontier described is therefore lower than another if the ponds are deeper, either with prevailing input use or with greater quantities of inputs. With deeper ponds, higher marginal products can be expected. This is simply because with deeper ponds and higher levels of input application, a higher production function is described. Figure 7 illustrates the two production functions describing two pond-depth situations.

Essentially, there are two different production frontiers being described by the two situations. In the case of the deeper pond, an upward shift in the production frontier occurs which is not the same as moving along the same production frontier. Diminishing marginal returns set in only when one input is increased without simultaneously increasing all the other inputs along the same frontier. With a higher frontier individual marginal products are also higher.

Negative production coefficients which are statistically significant, as found in some of the production functions estimated, mean that when the use of an input is increased, output will decrease. This is consistent with the interpretation of the elasticity of production.

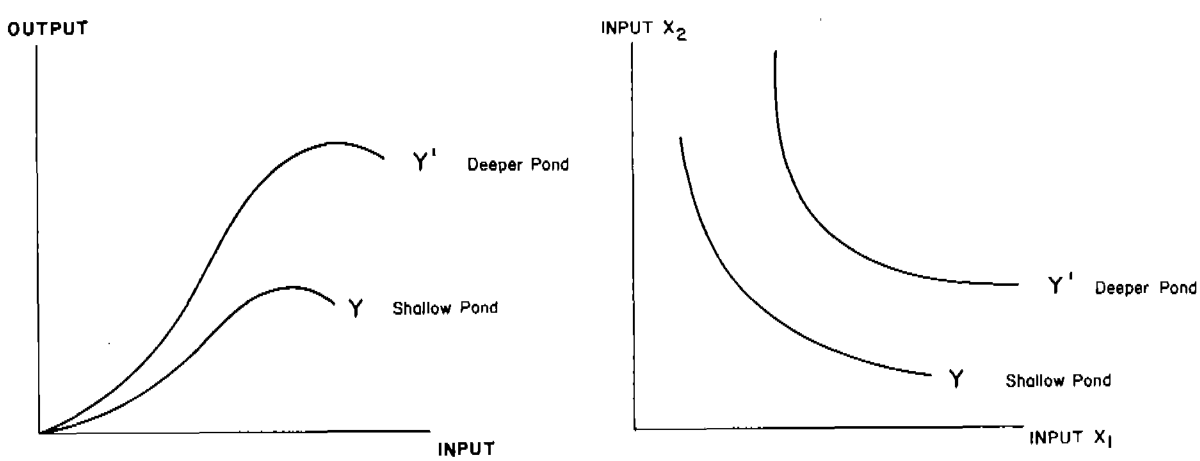

Figure 7. An upward shift in production frontier arising from the use of deeper ponds.

ECONOMIC OPTIMA

In order to realize maximum net returns, a producer must find out the rates at which to apply the various inputs. To do this, he will need to have information on the productivities of the inputs he used, and the prices of inputs and output prevailing in the factor and product markets. With the help of the estimated production functions, optimum input combinations can then be calculated. To determine the optimum input combinations, the value of the marginal products must be compared to the respective input price. If the value of the marginal product is greater than the input price, $VMP_{x_i} > P_{x_i}$, then the use of that input should be increased. If the value of marginal product is less than input price, the use of that input should be decreased. Similarly, if the values of marginal product and input price are equal, it means that use of that input is optimal.

In the Cobb-Douglas form of production function, marginal products of input application can be computed from the production coefficients and average products, or by differentiating the production function. In this study, the marginal product is calculated using the second method. Thus, marginal products are derived by differentiating the production function with respect to the specific input. Geometric means (as opposed to arithmetic means) of input values are substituted into the first differential to solve for the marginal products. Using arithmetic means of inputs would give biased marginal products.

Several examples will be provided to show how the economic optima[7] are calculated. Because not all input price information is readily available, economic optima are calculated only for a few selected inputs.

1. Optimum stocking rate:

The optimum stocking rate is calculated as follows, using the production function (Equation 1) estimated for the Philippines, the price of milkfish fry in 1978 and the price of market-sized milkfish in 1978:

$$Y = 10.9\, X_1^{0.28} X_2^{0.14} X_3^{0.10} X_4^{0.04} X_5^{-0.01} X_6^{0.16} X_7^{0.04} X_8^{0.03} X_9^{0.03} X_{10}^{0.09} X_{11}^{0.57} \qquad \text{(Equation 1)}$$

$$\frac{\partial Y}{\partial X_2} = 1.5\, X_1^{0.28} X_2^{-0.86} X_3^{0.10} X_4^{0.04} X_5^{-0.01} X_6^{0.16} X_7^{0.04} X_8^{0.03} X_9^{0.03} X_{10}^{0.09} X_{11}^{0.57}$$

Having obtained the $\frac{\partial Y}{\partial X_2}$ or the MP of the milkfish fry stocked, it is then equated to the input-output price ratio[8].

$$\frac{\partial Y}{\partial X_2} = \frac{0.36}{6.29} = 0.057$$

[7]Input application rates affect the fish stock in two ways: growth and mortality. Growth ceases and/or mortality sets in either at very low or very high application rates. The former arises from starvation; the latter from pollution. As application rates increase, growth and costs will increase, then costs will increase faster than growth (returns). In between, an optimum can be found.

[8]Based on four pieces to a kilogram of market size milkfish. Each milkfish fry cost ₱0.09, thus, 4 pieces of fry equal ₱0.36. The average price of milkfish was estimated at ₱6.29/kg in 1978.

That is,

$$1.5\, X_1^{0.28} X_2^{-0.86} X_3^{0.10} X_4^{0.04} X_5^{-0.01} X_6^{0.16} X_7^{0.04} X_8^{0.03} X_9^{0.03} X_{10}^{0.09} X_{11}^{0.57} = 0.057$$

Substituting geometric mean values of X_1 and $X_3 - X_{11}$,

$$X_2^{-0.86}\ (1.5)\ (2.04)\ (2.17)\ (1.05)\ (0.95)\ (2.81)\ (1.10)\ (1.10)\ (1.21)\ (1.47)\ (2.82) = 0.057$$

and solving for X_2:

$$113\, X_2^{-0.86} = 0.057$$

$$X_2^{-0.86} = \frac{0.057}{113} = 0.0005$$

X_2 = 6,790 pieces of milkfish fry per hectare.

Therefore, given the prevailing prices in 1978, the optimum stocking rate for the country as a whole is 6,790 pieces of milkfish fry per hectare per year.

The survey shows that the majority of Philippine milkfish farmers practise one cropping per year. The implicit assumption for this economically determined stocking rate is that the milkfish survival rate has already been taken into account in the input-output relationship through the raw data.

If this optimum stocking rate (6,790) is now compared to the arithmetic and geometric means of Philippine milkfish fry stocking rate of 5,940 and 3,540 respectively, it is obvious that Philippine milkfish farmers can profitably increase their present stocking rates. However, very shallow ponds probably cannot support additional fry. Stocking greater numbers of fry in deeper ponds will increase costs of production, but returns to the farm will increase more.

Another way to demonstrate the potential for increased profits is to show the inequality of the two sides of the relation between the value of marginal product (added benefits) and input price (added cost). This is shown below for fry:

$$VMP_{x_i} = MP_{x_i} \times P_y = P_{x_i}$$

$$0.11 \times 6.29 = 0.09 \times 4 \text{ pieces}$$

$$0.69 > 0.36$$

P_y is the price per kg of output (4 pieces per kg); P_{x_i} is the price per piece of fry. The left-hand side of the identity (added benefits) is greater than the right-hand side (added cost). Since the input-output price ratio is given or exogeneously determined,[9] nothing can

[9] In perfectly competitive markets, prices are taken as given at the farm level.

be done to influence prices. Only the left-hand side of the identity can be changed by the producer to affect its magnitude. This can be effected by increasing the stocking rate until the marginal product declines further due to diminishing returns. The milkfish fry stocking rate is deemed optimum when the equality is again restored.

For milkfish fingerlings, it can be shown that the left-hand side of the identity is smaller than the right-hand side implying excessive stocking rates for fingerling. By cutting back on the fingerling stocking rate, the marginal product of fingerlings will become larger, until the equality is restored again.

Based on the same production function, the optimum stocking rate for milkfish fingerlings is calculated to be 2,154 pieces per hectare per year. This economically determined stocking rate is about 60% lower than the national arithmetic mean stocking rate of 5,892 pieces or about 10% lower than the national geometric mean of 2,346. This means that the stocking rate of milkfish fingerlings can be cut back at current levels of input application if maximum financial returns are the objective of production. The most important thing to bear in mind is that the average level of input application cannot help to support a higher fingerling stocking rate.

The difference between the price of fry and fingerlings partly explains the optimal values obtained for fry (to increase) and fingerlings (to decrease). In 1978, milkfish fingerlings were twice as expensive as milkfish fry. The implication is that milkfish fry is the more economical stocking material. This may explain why only 13% of the sampled milkfish farmers use fingerlings as stocking materials.

More importantly, the calculation of the optimum stocking rates, based on 4 pieces of fish to a kilogram, has amply demonstrated the importance of size of fish at harvest. An additional market dimension which complicates this straightforward relationship is the market price in relation to size. In some markets, the bigger the fish the higher the price per kg, while in other markets, the relationship is inverse, that is, the bigger the fish the lower the price per kilogram. Thus, it is clear that once the input-output relationship has been estimated, the rates at which inputs are applied are also dictated by the prices of output as well as inputs, and whether the government is supporting the industry in terms of subsidies, price support or price ceiling.

Although it is true that each milkfish farm has its own individual production function, the production function estimated and presented above is the industry function in so much as it portrays the input-output relationship of the average farm in the industry. Therefore, the production function for any one particular farm may conceptually be obtained from this industry function in terms of the farm's ability to implement optimal values of the parameters in the industry (Aigner and Chu 1968). Most farms do not operate near the frontier production function. The production frontier shows the maximum attainable output for a given set of inputs.

2. Optimum fertilizer application rates:

a) Organic fertilizers

Using the same method as that used to determine optimum stocking rates, if the milkfish farmer takes into account the price of organic fertilizers and the price of milkfish, he would apply 1,750 kg/ha/year. Thus, according to the production function above (Equation 1), the average milkfish producer can increase his organic fertilizer application and in doing so will increase his output, returns and profits. The optimum organic fertilizer application rate is about 175% higher than the geometric mean (630 kg/ha/year) of current levels of organic fertilizer application in the country. This is consistent with the conclusion suggesting an increase in the stocking rate of milkfish fry, because the two inputs are complementary.

b) Inorganic fertilizers

Inorganic fertilizers should be applied at a rate of 1,124 kg/ha/year if the price of milkfish is ₱6.29 and the price of inorganic fertilizers is ₱1.66/kg. There is a need to distinguish between the price of inorganic fertilizers in terms of a kilogram of the fertilizers, including fillers, and the price of a kilogram of included nutrients (N-P-K). In addition, the type of inorganic fertilizer should also be considered explicitly, especially if these fertilizers are used in ponds suffering from acid sulphate soils or soils which are acidic. For example ammonium sulphate-phosphate is very acidic, and using this type of fertilizer would further compound the problem of acid-sulphate soils of existing ponds. The use of such "acidic" fertilizers would necessitate periodic liming to correct/restore the pond pH. This implies additional production costs which can be avoided if the proper fertilizers (less acid-forming) are used.

The point to be stressed from the brief discussion above is that input-use recommendations in the absence of explicit price considerations (and relating these to the marginal products of the respective inputs) are not useful from the management point of view. This is the basic difference between profit maximization and output (biomass) maximization.

Since the values of the marginal product of inorganic and organic fertilizers were 20.2 and 0.82 respectively, those milkfish farmers with limited capital would maximize their profits if they spend their limited operating capital on inorganic fertilizers first. This is because the returns from the additional unit of inorganic fertilizer would be greater than from the additional unit of organic fertilizer. Organic fertilizers would be used only when the returns from the last peso spent on inorganic fertilizers is equal to that of organic fertilizers.

As far as milkfish aquaculture is concerned, input subsidization or price support for inputs is unheard of in the Philippines. Input subsidization or price support can make the use of inputs profitable to private producers where before it is uneconomic (but at a cost to society).

Research to determine optimum input combinations and optimum output level must therefore recognize the presence or absence of such government support.

ESTIMATED OUTPUT

Equation 1 can also be used to predict or estimate the output of milkfish. The estimated output can be calculated at one of three points: at the point of maximum biomass production (physical measure) or total product; at the point of maximum profits (value measure) and thirdly, at the input means (in this case, the geometric means) of application. For this study, only the third method of calculation is used. These estimated outputs are reported in Tables 17 and 18 (p. 42, 43).

Chapter VII
Policy Implications

OPTIONS FOR DEVELOPMENT

The results of this study clearly show that Philippine milkfish producers are using insufficient inputs if the aim is to maximize profits. These are revealed by the nature of the response surfaces of milkfish output to inputs. The marginal analysis ($VMP_{x_i} = P_{x_i}$) strongly suggests the use of greater quantities of inputs. From these results, milkfish producers should be encouraged to apply more yield-increasing and yield-protecting inputs such as fertilizers and, whenever appropriate, to encourage the substitution of relatively costly inputs with less expensive inputs.

This study also found that there is a large degree of indifference or apathy on the part of most producers; that is, they do not appear to face economic pressure to produce larger quantities. In general, therefore, milkfish producers are not as growth-oriented as one would expect. Low perennial production is by and large a human factor problem.[10] If the Government of the Republic of the Philippines wishes to stimulate the productivity of the industry, this factor should be investigated fully in developing incentive programs.

To accomplish such improvements in productivity, it is necessary to have a strong and active extension service. Although there exists an extension service within the Bureau of Fisheries and Aquatic Resources, milkfish producers interviewed were of the opinion that it is inadequate. Compared to agriculture's 1 extension agent for every 305 farmers in 1979, aquaculture has 1 agent for every 50 fish farmers. However, the latter appear to have had little or no impact.

The government should also modify existing credit programs. Existing government credit programs tend to emphasize pond construction and development with little provision for the use of the loan to purchase supplemental inputs. Milkfish farmers complained that the proportion of loans allowed for the purchase of inputs is inadequate. They would like loans for the express purpose of buying supplemental inputs. Encouragingly, steps are presently being taken to correct this situation.

The presence of economies of scale, as revealed by increasing returns to scale of Philippine milkfish production, implies that it is advantageous to "consolidate" small farms into bigger farms. Because of the serious equity issue involved with consolidation, several alternatives are presented for the consideration of the relevant government bodies in order for Philippine milkfish farmers to benefit from economies of scale:

Option A: (Group farming)

Milkfish farmers with small farms can be encouraged to form a cooperative to oversee and manage their combined units of production. Change in tenure status is not necessary to bring this about. The cooperative can plan, program and manage the production of milkfish all at the same time, or stagger production to take advantage of market conditions (input

[10] A follow-up study conducted in 1981 and 1982 will determine the nature of this human or socioeconomic constraint to growth. Other constraints, involving physical, biological and institutional parameters, are also investigated.

and output markets), environmental conditions and socioeconomic mobilization of human and physical resources. Efficiency in production and marketing can thus be obtained.

Because of the presence of scale economies, investments and improvements to community-owned infrastructures and equipment can also be undertaken. Every member of the community of milkfish producers could benefit from such a collective action. A good example is the construction and maintenance of a dam to regulate water flow in the area. Deepening of silted waterways on which every farmer depends can also be undertaken on a group basis. This is because no farmer as an individual has the incentive to deepen a silted waterway which the whole community of farmers use. At any rate, the least benefit the member farmers would receive is the closer linkage fostered among them to lobby for government attention and assistance.

Under the Philippine Fishpond Estate Project scheme, a large area for milkfish production would be developed and subdivided among a group of families. Such contract fish farming has commenced in Zamboanga. The results of our input-output analysis have shown that there are economies of scale to be obtained and therefore point favorably in its direction and implementation.

It is argued, however, that instead of providing each family with a small farm unit to manage, the fishpond estate could remain a large tract operated on a cooperative basis with certain incentives for individualized "entrepreneurship and private attention." It is not intended that all production activities be carried out by the cooperative or undertaken on a cooperative basis. There are certain tasks which can be profitably done on a cooperative basis while others need "entrepreneurial attention, more akin to private motivations with the expectation of private gains." Thus, incentives to encourage this private motivation must be provided. A limiting factor in a scheme of this nature is the relatively higher investment cost per farmer.

Tasks such as pond preparation, maintenance and repairs of pond dikes, guarding the fish from pilferage, and fertilization can be done on a cooperative basis or collectively. However, such tasks as monitoring the health of the stock are more efficiently provided by the individual farmer. This is because the nature of the work calls for personalized or individualized attention.

Lessons from the experience (failures and successes) of aquaculture production on state farms, communes or cooperatives in China, Israel and Thailand, and the socialist countries of Europe can be invaluable in providing insights on managing a fish farming cooperative. An assessment of the potential of group farming for countries outside the traditional socialist bloc would certainly be worthwhile. As far as can be determined through preliminary literature search and personal communication, the significance of group farming to aquacultural development has never been systematically studied in non-socialist countries. Experiments in institutional innovation and reform may hold the answer to higher levels of productivity of small farms grouped together.

In agriculture, more and more research and development efforts on group farming are being undertaken in countries which are predominantly capitalist in nature. A recent review (Wong 1979) provides an excellent summary of experiences and potential for group farming in agriculture, which may provide insights into possible organizational approaches to group farming in aquaculture. The use and management of common resources for food production can open up new possibilities for increasing the supply of food and deserve investigation. The failures of cooperative mobilization of resources should especially be investigated and its role reexamined to determine how it can be made to work to improve the standard of living of small farmers. In the Philippines, an innovative program has already been launched in Mindoro Occidental to consolidate land holdings of 67 small farmers into a large tract of 166 ha of land under an "interim entrepreneur" to manage (Masaganang Sakahan, n.d.).

Option B: (Private expansion)

The milkfish producer may consider expanding his farm size to take advantage of economies of scale by buying other milkfish farms or acquiring new land for milkfish production. He can either acquire or lease additional ponds from other private milkfish producers or apply for government-leased lands.

Option C: (Rent out to others)

If the small producer is not able to expand his farm size to benefit from the economies of scale, he may consider hiring out his ponds to other milkfish producers. In this case, he would earn a rental income. The difference in profitability between the two situations needs to be taken into account. If he can get higher income from hiring out his ponds than managing his own farm, he should rent his ponds to other interested producers.

Option D: (Sell out)

Operators of small farms could be encouraged to sell their farms and leave the industry. In fact, small producers may eventually be forced out of business by bigger producers except where only subsistence production is carried out and the pond owner's desire is to keep the farm for real estate and for sentimental reasons.

PROSPECTS FOR GREATER PRODUCTION

In general, there are two ways to increase production, either by opening up new lands or by adopting production intensification methods using supplementary inputs. The industry has grown since 1952 by an annual average of 3.3% in hectarage expansion and 2.9% in production intensification (BFAR 1979).

Based on the milkfish production function for the whole country, increasing farm size by one percent would induce an increase in output of 0.57%. This is relatively large in comparison to the application of additional organic or inorganic fertilizers—0.03 and 0.09% for each additional one percent application of either organic or inorganic fertilizers. Of course, if other material inputs are added together with organic and inorganic fertilizers, the combined effect is larger. However, future growth of milkfish output will have to come from the use of more inputs rather than from opening up new areas of coastal land, since the latter may not be feasible in the future because of proposed moratoriums on mangrove conversion to fishponds. If these moratoriums are enforced, the cost of land relative to other inputs will increase. This shift in factor prices can be expected to encourage production intensification. That extensification continues to appeal to many producers is but an indication of the current low costs of acquiring additional land; certainly government lease fees are nominal. Both intensification and extensification entail added costs and while this study does not examine the costs and benefits of these alternatives, it can be stated that the economic incentives for intensification are likely to increase as land for milkfish farming becomes more scarce.

While our results show that the 'average' farm stocks less than the economically optimum number, there is a tendency among farmers who have the means to acquire large quantities of fry to overstock their ponds.

In a cultural and production setting such as found in the Philippines, where status of milkfish farmers is gauged by the large numbers of fry or fingerlings stocked and by farm hectarage, sheer numbers are often valued over productivity per unit area. In an already nutrient-poor pond environment stemming from low rates of input application, putting a high value on numbers as a tangible measure of "success" over productivity results in unnecessary waste of resources. It is, therefore, important to make Philippine milkfish farmers realize that stocking density has to be balanced with the carrying capacity of the ponds. This is an educational problem which the extension service can help to overcome. Although numbers are important, it is numbers balanced with available food in the ponds that ultimately count in productivity per unit area or per fry or fingerling.

RELEVANCE TO AQUACULTURISTS AND FISHERY BIOLOGISTS

Although the orientation of this study has been economic, much of the analysis and results can be of use to fish culturists and biologists in their research endeavors to improve cultural practices. This study has examined the various components or breakdown of the material inputs, physical/environmental "inputs," management and labor inputs. Six inputs were found to be significant in explaining output per hectare. These results can serve to pinpoint the areas where further research can help to improve cultural practices. The breakdown of the various input components also shows the costs associated with the use of inputs. The share of the total costs of an input in relation to the shares of the total costs of other inputs can also help aquaculturists and fishery biologists to find ways and means to reduce further the cost of production.

Milkfish producers in the rest of the country can benefit from the experience and knowledge of the producers in Iloilo where the most progressive fishfarmers are concentrated. In fact, some Iloilo milkfish producers have formed a group called the "Staff of Inland Fisheries Technology and Resource Speakers" whose purpose is to conduct mobile seminars on milkfish production technology (practices, techniques and trends in fishpond operations) in any part of the country. In addition, the local extension service can help to organize field trips or site visits to Iloilo milkfish farms for producers to observe operations. Field trips are a common extension practice in other countries to speed up technology transfer.

The results of the study can also be useful to individual milkfish farmers to properly evaluate and compare the performance of their production operations on a more commercialized and scientific basis. We have shown how a milkfish farmer can organize and manage his farm for greater profits.

As is true in any modeling work, no one single model can be used to characterize a production process. At best, it is an abstract representation of the real production process. For the purpose of this study, an unconstrained Cobb-Douglas production function model was selected. Numerous other mathematical functions were also used. The choice of an algebraic form imposes certain assumptions which can be advantageous and limiting.[11] To quote Heady and Dillon 1961):

> If the production logic, the correct mathematical form, were fully known and data were available for a segment of the (production) surface, the logical function could be fitted to the data . . . But if the production logic is totally unknown, the fitted function can only be a "statistical" function, and not a logical function. Hence, it can be used mainly to predict within the range of the observed data.

[11]This has been discussed in another section dealing with the features of the Cobb-Douglas algebraic form.

Apart from the error of estimate which arises solely from analyzing a sample (n) instead of the whole population (N), Cochran (1977) lists another three additional sources of error:

1. Error due to the failure to measure some of the units in the sample. According to Cochran, this may occur because of the failure to locate some respondents or the respondents' refusal to answer certain questions.
2. Error due to the measurement on a unit as memory recall bias.
3. Error due to poor editing, coding and tabulating of data.

All three sources of error have been kept to a minimum. Additionally, it was assumed that the observations of the variables are measured without error and that the observations are from a homogenous group of milkfish farms. Conscious attempts were made to obtain these goals. However, as is true for all data collected by survey means involving human subjects, errors arising from poor memory recall are common. Clearly, this violates one of the assumptions of the multiple regression technique. According to Heady and Dillon (1961), "errors of observation of some magnitude, will always be present." Besides the error due to recall, errors also arise from a lack of homogeneity of inputs especially in terms of qualitative differences. A good illustration is chicken manure. The quality of chicken manure with respect to the contents of nitrogen, phosphorus and other elements varies from one source to another, depending on the feed given to the chicken.

All the inputs identified in the model have some differences in quality. For example, although milkfish fry or fingerlings come very close to being a very homogenous input, the manner in which the fry or fingerlings are handled and transported determines to a large extent the quality of the seeds. Poor handling results in higher mortality and consequently lower production, and vice versa.

Another limitation concerns the nature of the results of the study; the findings of the study relate to a particular sample of milkfish farms. This, however, does not detract from its being useful as a guide to other milkfish farmers, policymakers and planners. Therefore, for predictive purposes (loosely defined), the following should be remembered: the reference period is 1978, the sample is drawn from seven provinces, the algebraic form is Cobb-Douglas, inputs are of different quality and only farms using supplemental inputs are included.

In addition, this study has not taken into consideration the initial weight of the milkfish fry or fingerlings stocked. As a result, the output reported due to growth (benefits arising from the use of inputs) is probably over-stated. This implies that the response of milkfish attributable to the use of the inputs identified in this model is also over-stated. Errors due to counting of milkfish fry by present means may further under/overstate the actual output response.

Additionally, it should be realized that the estimates have been made from a set of data involving sample variance, and while the probability test suggests that the estimated coefficients are significantly different from zero in some cases, care and caution should be exercised in interpreting them. Besides, it is known that different mathematical or algebraic forms can be fitted to the data giving widely contrasting answers.

Chapter VIII

Summary and Conclusions

This study was undertaken in response to a need for information on the productivity of inputs used in Philippine milkfish production. Based on the empirical results, Philippine milkfish ponds have available potential which is not yet realized. This is because, overall, milkfish ponds are not now being made to produce as much milkfish as the ponds are physically and economically capable of supporting. Higher output and profits can be obtained by intensifying production methods.

The survey data show that the average milkfish production per hectare from existing ponds using supplemental inputs is 761 kg/year. With proper husbandry and management, milkfish yield can be increased by a factor of 3 to at least 2 tonnes/ha/year. If, instead, increase in output were to come from hectarage expansion with existing practices, it would require at least 3 ha of land to produce 2 tonnes of milkfish, instead of 1 ha with proper management.

In this study, the concept of the production function describing a relationship between 11 inputs or explanatory variables and milkfish output has been employed. The analysis has focused on the allocation and transformation of inputs in milkfish production. Variables in the model which were significant in explaining output variation were age of pond, milkfish fry and fingerling stocking rates, miscellaneous operating costs, organic and inorganic fertilizers and farm size. Insignificant variables were acclimatization, hired labor, culture experience and pesticides. The higher profits that could be obtained by increasing stocking rates and fertilizer use were also demonstrated given the 1978 prevailing prices for these inputs and output.

Several algebraic forms of production functions were fitted to the data. The Cobb-Douglas production function, used to estimate input-output relationships by province, climatic types, pond ownership and farm size, fitted the data as revealed by the highly significant F and relatively high R^2 values.

Of the seven provinces surveyed, Iloilo, Bulacan and Pangasinan have the highest per hectare output. Milkfish production in these three provinces is clearly more efficient than in the other 4 provinces. A partial explanation of why productivity varies widely from province to province is the insufficient level of inputs used in the low yield areas. The three most productive provinces are also in the best climatic type (Climatic Type I) for milkfish culture. In the final analysis, however, it is largely the managerial and technical skills of the producers which make the difference.

Both the per-hectare and per-farm production functions clearly exhibit the presence of economies of scale in Philippine milkfish production. Recent literature on scale economies has suggested that economies of scale be exploited in those areas where it will benefit society. The available economies of scale should be tapped to further the development of milkfish aquaculture in the country, in particular, if benefits to existing small producers can be gained by some form of group farming.

Only interfarm production functions based on cross-sectional data have been estimated since lack of time series data precluded the estimation of intrafarm production functions. Interfarm functions cannot be regarded as truly representing any one particular farm. However, they can be viewed as representing industry production functions.

The estimated overall production functions will, nevertheless, have applications to existing farms in the country. In fact, Aigner and Chu (1968) state that the production function for any particular farm may conceptually be obtained from the industry function in terms of the farm's ability to implement optimal values of the parameters in the industry. Further, they argue that most farms operate below the frontier production function because of differences in technical and economic efficiency.

The analyses show that milkfish fry stocking rates can be profitably increased, while the stocking rates for fingerlings can be cut back. One possible explanation of why the stocking rates of fingerlings can be reduced is their relatively high price compared to that of fry. Secondly, fingerlings as stocking materials were shown earlier to be less desirable because of double-transplanting shock. Along with the higher stocking rates for milkfish fry, organic and inorganic fertilizer application rates can also be increased to increase profits.

Besides facilitating the management tasks and decision-making process of milkfish farmers, the results also provide government policymakers and planners concerned with aquaculture with information to help them formulate policies and programs to achieve the objectives of aquaculture development.

Finally, it is heartening to find out that the current 176,000 ha of Philippine milkfish farms can be made more productive and profitable. This is particularly encouraging because rural malnutrition and poverty still remain. By developing the full capacity of the 176,000 ha of milkfish farms, additional profits will accrue to producers at the same time that additional food will be made available. Underutilization of this resource system is contrary to sound economic development.

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Table 1. Estimated production function (Cobb-Douglas), sample means and marginal products for Cagayan.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
		Per farm basis										
Intercept	= 16.56											
Production coefficients		0.12	0.15	−0.14	0.45	−0.02	0.24	−0.43	−0.01	0.03	0.07	0.74
t-value		0.12	0.69	−0.73	0.83	−0.13	0.32	−0.68	−0.03	0.16	0.32	1.39
Standard error		1.03	0.21	0.19	0.54	0.17	0.75	0.64	0.28	0.21	0.20	0.52
Significance level		0.90	0.50	0.47	0.41	0.89	0.75	0.50	0.97	0.87	0.75	0.18
R^2		0.56										
Input mean ($\bar{X}$)	GM	3.69	2,746	870	6.10	835.62	2,239.3	3.47	24.82	105.18	71.98	1.25
	AM	4.72	4,149	783	10.96	656.90	1,208.1	4.96	23.99	87.48	57.39	4.50
Marginal product		10.45	0.02	−0.05	23.72	−0.007	0.04	−39.86	−0.13	0.09	0.32	194.77
Average price of input		–	0.06	0.48	–	–	–	–	–	0.11	1.56	–

F-value = 1.46 DW = 2.05

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 2. Estimated production function (Cobb-Douglas), sample means and marginal products for Cagayan.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
		Per hectare basis										
Intercept	= 7.96											
Production coefficients		0.16	0.08	−0.10	0.45	−0.06	0.40	−0.34	−0.10	0.10	0.06	0.16
t-value		0.15	0.41	−0.62	0.89	−0.42	0.57	−0.54	−0.29	0.38	0.28	0.35
Standard error		1.04	0.20	0.17	0.50	0.16	0.70	0.63	0.35	0.24	0.20	0.47
Significance level		0.88	0.68	0.54	0.38	0.68	0.57	0.57	0.59	0.70	0.78	0.73
R^2		0.22										
Input mean ($\bar{X}$)	GM	3.69	2,746	870	6.10	835.62	2,239.30	3.47	24.82	105.18	71.98	1.25
	AM	4.72	4,149	783	10.96	656.93	1,208.10	4.96	23.99	87.48	57.39	4.50
Marginal product		1.79	0.001	−0.02	3.05	−0.003	7.39	−4.06	−0.17	0.04	0.03	5.30
Average price of input		–	0.06	0.48	–	–	–	–	–	0.11	1.56	–

F-value = 0.32 DW = 2.08

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 3. Estimated production function (Cobb-Douglas), sample means and marginal products for Pangasinan.

		Per farm basis										
Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 19.9											
Production coefficients		0.13	0.11	0.05	–0.01	0.06	0.08	0.30	0.09	0.03	0.001	0.68
t-value		0.99	2.41	1.04	–0.15	1.22	0.95	2.17	1.35	0.98	0.01	5.53
Standard error		0.12	0.04	0.04	0.07	0.04	0.08	0.13	0.06	0.03	0.05	0.12
Significance level		0.32	0.01	0.30	0.88	0.22	0.34	0.03	0.18	0.32	0.98	0.0001
R^2		0.77										
Input mean ($\bar{X}$)	GM	16.92	5,786	1,815	4.72	95	510	13.33	35	240	97	1.64
	AM	22.36	6,086	3,144	10.81	613.11	562.14	17.59	75.84	269.54	113.80	2.88
Marginal product		8.79	0.02	0.03	–2.44	0.73	0.17	25.81	2.93	0.14	0.01	476.27
Average price of input		–	0.10	0.22	–	–	–	–	–	0.15	1.57	–

F-value = 20.71 DW = 1.64

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 4. Estimated production function (Cobb-Douglas), sample means and marginal products for Pangasinan.

		Per hectare basis										
Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 17.8											
Production coefficients		0.12	0.14	0.08	–0.01	0.06	0.08	0.28	0.07	0.04	0.01	0.01
t-value		0.98	2.79	1.41	–0.19	1.15	0.89	2.05	1.17	1.21	0.21	0.08
Standard error		0.12	0.05	0.05	0.07	0.04	0.08	0.13	0.06	0.03	0.05	0.09
Significance level		0.32	0.006	0.16	0.84	0.25	0.37	0.04	0.24	0.23	0.83	0.93
R^2		0.40										
Input mean ($\bar{X}$)	GM	16.92	5,786	1,815	4.72	95	510	13.33	35	240	97	1.64
	AM	22.36	6,362	3,400	15.93	286.41	881.45	17.59	89.97	269.51	165.32	2.88
Marginal product		8.04	0.03	0.05	–2.40	0.72	0.18	13.83	2.29	0.19	0.12	6.91
Average price of input		–	0.10	0.22	–	–	–	–	–	0.15	1.57	–

F-value = 4.14 DW = 1.70

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 5. Estimated production function (Cobb-Douglas), sample means and marginal products for Bulacan.

Inputs		Per farm basis										
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 290.2											
Production coefficients		0.03	0.09	0.03	0.30	−0.03	0.07	−0.08	0.05	−0.05	−0.06	1.11
t-value		0.24	2.79	0.95	2.48	−0.45	0.61	−0.66	0.86	−1.14	−0.63	5.78
Standard error		0.13	0.03	0.03	0.11	0.07	0.11	0.12	0.06	0.04	0.09	0.19
Significance level		0.18	0.008	0.34	0.01	0.65	0.54	0.51	0.39	0.26	0.53	0.0001
R^2		0.79										
Input mean ($\bar{X}$)	GM	32.79	7,287	3,426	3.61	129.36	1,164.07	13.87	42.86	2,108.76	68.56	15.15
	AM	40	7,561	6,315	3.06	586.80,	1,552.60	20.68	102.80	2,576.30	109.23	23.70
Marginal product		18.51	0.24	0.19	1,673.52	−4.90	1.20	−115.42	23.37	−0.44	−17.14	1,475.70
Average price of input		–	0.10	0.18	–	–	–	–	–	0.18	1.71	–

F-value = 13.61 DW = 2.17

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 6. Estimated production function (Cobb-Douglas), sample means and marginal products for Bulacan.

Inputs		Per hectare basis										
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 258.8											
Production coefficients		0.04	0.12	0.05	0.28	−0.06	0.07	−0.07	0.05	−0.05	−0.05	0.12
t-value		0.31	2.92	1.07	2.35	−0.60	0.63	−0.60	0.63	−1.00	−0.42	0.94
Standard error		0.13	0.04	0.04	0.11	0.09	0.11	0.12	0.07	0.05	0.11	0.13
Significance level		0.76	0.005	0.28	0.02	0.55	0.52	0.55	0.52	0.32	0.67	0.35
R^2		0.40										
Input mean ($\bar{X}$)	GM	32.79	7,287	3,426	3.61	129.36	1,164.07	13.87	42.86	2,108.76	68.56	15.15
	AM	40	7,561	6,315	3.06	586.80	1,552.60	20.68	102.80	2,576.30	109.23	23.70
Marginal product		0.79	0.01	0.009	50.55	−0.31	0.10	−3.29	0.76	−0.02	−0.48	5.13
Average price of input		–	0.10	0.18	–	–	–	–	–	0.18	1.71	–

F-value = 2.46 DW = 2.18

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 7. Estimated production function (Cobb-Douglas), sample means and marginal products for Masbate.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
		Per farm basis										
Intercept	= 0.73											
Production coefficients		0.47	0.26	0.07	0.16	0.04	0.63	−0.56	−0.02	0.04	−0.02	0.07
t-value		1.85	3.70	1.32	0.80	0.49	3.92	−2.37	−0.37	0.93	−0.39	0.29
Standard error		0.25	0.06	0.05	0.20	0.07	0.15	0.23	0.07	0.04	0.06	0.25
Significance level		0.08	0.001	0.20	0.43	0.62	0.001	0.02	0.71	0.36	0.70	0.77
R^2		0.77										
Input mean ($\bar{X}$)	GM	8.99	1,152	1,300	2.79	152.93	271.06	9.03	19.71	196.37	26.45	17.77
	AM	12.55	1,742	400	2.00	690.90.	399.00	14.09	83.90	605.00	69.87	23.82
Marginal product		21.14	0.09	0.02	23.24	0.11	0.94	−25.08	−0.41	0.08	−0.30	1.60
Average price of input		–	0.07	0.28	–	–	–	–	–	0.18	1.48	–

F-value = 5.53 DW = 1.92

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 8. Estimated production function (Cobb-Douglas), sample means and marginal products for Masbate.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
		Per hectare basis										
Intercept	= 0.69											
Production coefficients		0.42	0.31	0.10	0.13	0.05	0.59	−0.50	0.04	0.05	−0.10	−0.09
t-value		1.80	3.98	1.53	0.70	0.64	3.81	−2.28	0.37	0.81	−1.05	−0.47
Standard error		0.23	0.07	0.06	0.18	0.08	0.15	0.22	0.10	0.06	0.10	0.21
Significance level		0.08	0.0009	0.14	0.49	0.53	0.001	0.03	0.71	0.42	0.30	0.64
R^2		0.79										
Input mean ($\bar{X}$)	GM	8.99	1,152	1,300	2.79	152.93	271.06	9.03	19.71	196.37	26.45	17.77
	AM	12.55	1,742	400	2.00	690.90	399.00	14.09	83.90	605.00	69.87	23.82
Marginal product		16.12	0.10	0.03	16.11	0.11	0.75	−19.13	0.71	0.09	−1.29	−1.72
Average price of input		–	0.07	0.28	–	–	–	–	–	0.18	1.48	–

F-value = 6.05 DW = 1.98

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 9. Estimated production function (Cobb-Douglas), sample means and marginal products for Iloilo (farm).

Inputs		Per farm basis										
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 82.2											
Production coefficients		0.30	0.05	−0.01	0.02	0.03	−0.01	0.00	0.06	−0.01	0.07	0.98
t-value		2.71	0.75	−0.26	0.26	1.03	−0.14	0.00	1.33	−0.32	1.07	6.05
Standard error		0.11	0.06	0.05	0.06	0.03	0.09	0.11	0.04	0.02	0.06	0.16
Significance level		0.009	0.45	0.79	0.79	0.30	0.89	0.99	0.18	0.75	0.28	0.0001
R^2		0.90										
Input mean ($\bar{X}$)	GM	20.33	6,158	2,257	2.39	107.55	793.35	13.87	20.39	873.22	131.49	19.26
	AM	30.33	8,528	6,282	4.59	524.36	1,114.23	18.68	36.54	876.41	270.54	37.66
Marginal product		133.98	0.07	−0.04	76.27	2.61	−0.12	0	26.93	−0.11	4.99	463.93
Average price of input		–	0.09	0.19	–	–	–	–	–	0.57	1.67	–

F-value = 33.17 DW = 1.92

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 10. Estimated production function (Cobb-Douglas), sample means and marginal products for Iloilo.

Inputs		Per hectare basis										
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 36.69											
Production coefficients		0.29	0.13	0.04	0.01	0.04	−0.01	0.01	0.03	−0.003	0.10	0.16
t-value		2.62	1.47	0.49	0.07	0.90	−0.14	0.07	0.52	−0.11	1.30	1.96
Standard error		0.10	0.08	0.07	0.06	0.04	0.09	0.11	0.05	0.03	0.07	0.07
Significance level		0.01	0.15	0.62	0.94	0.37	0.89	0.94	0.60	0.91	0.20	0.05
R^2		0.43										
Input mean ($\bar{X}$)	GM	20.33	6,158	2,257	2.39	107.55	793.35	13.87	20.39	873.22	131.49	19.26
	AM	30.33	8,528	6,282	4.59	524.36	1,114.23	18.68	36.54	876.41	270.54	37.66
Marginal product		17.43	0.03	0.02	5.10	0.45	−0.02	0.88	1.81	−0.004	0.93	10.09
Average price of input		–	0.09	0.19	–	–	–	–	–	0.57	1.67	–

F-value = 2.86 DW = 2.02

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 11. Estimated production function (Cobb-Douglas), sample means and marginal products for Bohol.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
							Per farm basis					
Intercept	= 0.50											
Production coefficients		–0.11	0.72	–	0.02	–0.03	–0.02	0.10	0.10	0.02	–0.02	0.31
t-value		–0.77	3.58	–	0.28	–0.59	–0.19	0.71	0.85	0.54	–0.15	1.32
Standard error		0.14	0.20	–	0.08	0.04	0.12	0.14	0.11	0.04	0.10	0.23
Significance level		0.44	0.001	–	0.78	0.55	0.85	0.48	0.40	0.59	0.87	0.19
R^2		0.81										
Input mean $(\bar{X})$	GM	5.12	2,094	–	7.39	106.34	459.77	6.44	30.28	391.20	64.32	4.85
	AM	10.43	3,136	–	10.98	710.44	784.30	11.81	51.11	856.64	124.00	9.63
Marginal product		–5.06	0.08	–	0.64	–0.07	–0.01	3.66	0.77	0.01	–0.07	15.07
Average price of input		–	0.05	–	–	–	–	–	–	0.29	1.63	–

F-value = 13.51 DW = 1.96

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 12. Estimated production function (Cobb-Douglas), sample means and marginal products for Bohol.

Inputs		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
							Per hectare basis					
Intercept	= 0.37											
Production coefficients		–0.12	0.73	–	0.03	–0.01	–0.01	0.08	0.08	0.04	0.01	0.07
t-value		–0.81	3.68	–	0.32	–0.14	–0.09	0.56	0.51	0.69	0.10	0.53
Standard error		0.14	0.19	–	0.08	0.05	0.12	0.14	0.14	0.05	0.12	0.13
Significance level		0.42	0.0009	–	0.74	0.88	0.92	0.58	0.61	0.49	0.92	0.59
R^2		0.44										
Input mean $(\bar{X})$	GM	5.12	2,094	–	7.39	106.34	459.77	6.44	30.28	391.20	64.32	4.85
	AM	10.43	3,136	–	10.98	710.44	784.30	11.81	51.11	856.64	124.00	9.63
Marginal product		–4.05	0.06	–	0.70	–0.01	–0.004	2.18	0.46	0.02	0.03	2.51
Average price of input		–	0.05	–	–	–	–	–	–	0.29	1.63	–

F-value = 2.39 DW = 1.99

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 13. Estimated production function (Cobb-Douglas), sample means and marginal products for Zamboanga del Sur.

Inputs		Per farm basis X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 0.29											
Production coefficients		−0.07	0.71	—	−0.18	−0.01	0.27	0.001	−0.04	0.05	0.001	−0.15
t-value		−0.38	2.72	—	−1.30	−0.10	1.20	0.01	−0.38	1.17	0.01	−0.53
Standard error		0.18	0.26	—	0.13	0.08	0.22	0.20	0.09	0.04	0.07	0.27
Significance level		0.70	0.01	—	0.20	0.92	0.24	0.99	0.70	0.25	0.98	0.60
R^2		0.55										
Input mean ($\bar{X}$)	GM	8.77	1,317.00	—	9.41	68.82	399.71	10.01	13.42	604.25	28.50	10.42
	AM	14.89	1,904.00	—	17.03	496.10	544.20	14.05	34.81	1,031.50	33.87	13.75
Marginal product		−0.84	0.06	—	−2.02	−0.02	0.07	0.01	−0.32	0.01	0.004	−1.53
Average price of input		—	0.10	—	—	—	—	—	—	0.10	1.71	—

F-value = 3.47 DW = 2.23

Note: GM is the geometric mean; AM is the arithmetic mean.

Table 14. Estimated production function (Cobb-Douglas), sample means and marginal products for Zamboanga del Sur.

Inputs		Per hectare basis X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Intercept	= 0.53											
Production coefficients		−0.04	0.65	—	−0.16	−0.04	0.25	0.001	0.002	0.07	0.02	−0.24
t-value		−0.21	2.49	—	−1.21	−0.38	1.11	0.01	0.01	1.13	0.16	−0.91
Standard error		0.17	0.25	—	0.13	0.09	0.22	0.20	0.16	0.06	0.14	0.26
Significance level		0.83	0.01	—	0.23	0.71	0.27	0.99	0.99	0.26	0.87	0.37
R^2		0.49										
Input mean ($\bar{X}$)	GM	8.77	1,317.00	—	9.41	68.62	399.71	10.01	13.42	604.25	28.50	10.42
	AM	14.89	1,904.00	—	17.03	496.10	544.20	14.05	34.81	1,031.50	33.87	13.75
Marginal product		−0.60	0.06		−2.23	−0.07	0.08	0.01	0.02	0.02	0.10	−3.04
Average price of input		—	0.10	—	—	—	—	—	—	0.10	1.71	—

F-value = 2.70 DW = 2.21

Note: GM is the geometric mean; AM is the arithmetic mean.

CONFIDENTIAL

A Survey on Fishpond Production and Marketing in Selected Areas in the Philippines*

Name of Respondent ______________________ Name of Interviewer ______________________
Address ______________________ Date of Interview ______________________
Status ______________________

(Reference Period: 1978)

I. PRODUCTION

1. As a milkfish producer, what do you feel is your biggest problem(s) in increasing your income from milkfish production?

____
____
____

2. In the past year, what type of assistance have you received from either governmental or non-governmental group (e.g., advice, material, etc.)

Governmental	Non-governmental
______________	______________
______________	______________

3. Size of farm: ________ hectares

   a) Nursery pond ________ ha.
   b) Transition pond ________ ha.
   c) Rearing pond ________ ha.

4. Of the total area of your farm in No. 3, how many hectares were in active milkfish production in 1978?

   a) Developed (active production) ________ ha.
   b) Undeveloped (not in production) ________ ha.

5. Status of farm:

   a) Owned/Titled ______ ha.
   b) Leased:
      i) Private ______ ha.
      ii) Ordinary Fishpond Permit ______ ha.
      iii) Fishpond Lease Agreement ______ ha.
   c) Others ______ ha.

6. Age of Pond: ________ yrs.

*A joint undertaking of the International Center for Living Aquatic Resources Management (ICLARM), Fishery Industry Development Council (FIDC) and Bureau of Agricultural Economics (BAEcon).

7. Stocking and Harvesting: (Based on per farm per year)
(Production Period: from stocking to complete harvesting in rearing pond).

Dates of Stocking	J[1]	F	M	A	M	J	J	A	S	O	N	D	Source: (P = Private) (G = Government)
	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	
I. Stocking Material													
Bangus Fry													
Quantity (pcs.)													
Price/1,000 pcs.													
Bangus Fingerling													
Quantity (pcs).													
Price/1,000 pcs.													
Sugpo Fry													
Quantity (pcs.)													
Price/1,000 pcs.													
Sugpo Fingerling													
Quantity (pcs.)													
Price/1,000 pcs.													

How long did you acclimatize your fry/fingerlings before releasing them into the pond? ________ hours

[1] 1J means first half of January and 2J second half of January.

Stocking and Harvesting: (Based on per farm per year) (continued)
(Production Period: from stocking to complete harvesting in rearing pond).

Dates of Harvesting	J	F	M	A	M	J	J	A	S	O	N	D	Comments
	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	
II. Harvesting													
Bangus													
Qty. (pcs/kg)													
Price per kg													
Price per pc													
No. of pcs/kg													
Sugpo													
Qty. (pcs/kg)													
Price per kg													
Price per pc													
No. of pcs/kg													

8. Inputs (based on per farm per year) for milkfish only.

A. Material Inputs

Type of Input	Date of application	Total quantity	Unit	Kg/unit	Price per unit	Total value
Organic fertilizer						
1. Chicken manure						
2. Hog manure						
3. Guano						
4. Stable manure						
5. Sagana 100						
6. Mud press						
7. Others (specify)						
Inorganic fertilizer						
1. 1620						
2. 1846						
3. Urea						
4. Others (specify)						
Supplementary feed						
1. Rice bran						
2. Corn bran						
3. Copra cake						
4. Others (specify)						
Liming						
1. Lime						
Pesticides						
1. Endrin						
2. Gusathion						
3. Brestan						
4. Others (specify)						

B. Labor Inputs

Type of Labor	Date of work	Number of days	Number of workers	Hrs/day	Total man-hours	Total value	Contract work	Total man-hours	Total value
1. Operator									
Pond preparation									
Repair of dikes									
canals									
Fertilizing									
Stocking									
Feeding									
Harvesting									
2. Family									
Pond preparation									
Repair of dikes									
canals									
Fertilizing									
Stocking									
Feeding									
Harvesting									

3. Hired
   Pond preparation ______
   Repair of dikes ______
   canals ______
   Fertilizing ______
   Stocking ______
   Feeding ______
   Harvesting ______

4. Exchange
   Pond preparation ______
   Repair of dikes ______
   canals ______
   Fertilizing ______
   Stocking ______
   Feeding ______
   Harvesting ______

C. Miscellaneous Operating Cost Per Farm Per Year

1. Interest expenses ₱ ______
   (Operating capital) ______
2. Depreciation
   (pond structures, equipment and tools) ______
3. Maintenance and repair (fishpond structures,
   equipment, etc.) ______
4. Fuel ______
5. Leasehold fee/rental ______
6. Food for laborers ______
7. Commission for caretakers ______
8. Taxes ______

9. In addition to the inputs (e.g., fertilizer, feed, etc.) you use for milkfish production, what additional inputs do you use especially for your shrimp?

Types of Inputs	Date of application	Total quantity	Unit	Kg per unit	Total value	Price per unit	Price per kg

10. a) Who makes decision regarding quantity, kind and timing of application of production inputs, etc.?

______ Owner
______ Manager
______ Caretaker
______ Others (specify)

b) How many years of experience in bangus culture has he had? ______
c) Educational attainment ______

11. Fixed Costs/Resource Inventory

Table A

Farm Status	Area (ha)	Date acquired	Acquisition cost	Construction cost	Improvement cost (if any)
1. Privately owned					
2. Leased					
a. Government					
1. Leasehold (FLA)					
2. OFP					
b. Private					
c. Sub-leased					

Table B

Tools/Equipment Used	Number Owned	Number Rented	Date acquired	Total acquisition cost	Estimated life per unit*	Total maintenance cost	Total rental cost	Total depreciation cost
1. Banca								
a. Motorized								
b. Non-motorized								
2. Pump								
3. Chain saw								
4. Grass cutter								
5. Nylon net								
6. Shovel								
7. Bamboo poles with rake								
8. Long-handed fork								
9. Hand scythes								
10. Bolo								
11. Knife								
12. Sickles								
13. Other investments								
a. Caretaker's house								
b. Sluice gates								

*From acquisition to worn out.

12. Do you see a difference between maximizing output and maximizing net income/profit? Yes/No (Encircle one) Explain.

____

____

____

____

13. Disposition of Produce

Species	Total production (kg)	Marketed Volume (kg)	Marketed Value (₱)	Harvester's share Volume (kg)	Harvester's share Value (₱)	Given away Volume (kg)	Given away Value (₱)	Consumed Volume (kg)	Consumed Value (₱)
a. Bangus									
b.									
c.									

II. MARKETING

1. Marketing Investments

Item	Number Owned	Number Rented	Date acquired	Acquisition cost	Estimated life*	Maintenance cost	Rental cost
1. Vehicle							
a. Jeep							
b. Trucks							
c. Pick-up							
d. Boat/banca (motorized or non-motorized)							
2. Container							
a. Tub/banera							
b. Wooden box							
c. Basket							
d. Styrofoam							
3. Scale							
4. Building							
a. Storage							
b. Office							
5. Other equipment							
a. Office machines							
b. Water tanks							
c. Ice crushers							

*From acquisition to worn out.

2. Labor Cost for Marketing

Type of Input	Total no. of persons	Total no. of hours	Total cost (₱)	Comments
Labor (man-hours) e.g., sorting/grading, packaging, hauling, storage				
1. Operator				
2. Family				
3. Hired				
4. Exchange				

3. Transportation Cost (Delivery Expenses)

Species	Volume delivered (kg)	Total value (₱)	Total Cost: Transport	Total Cost: Handling
a.				
b.				
c.				

III. CHANNELS OF DISTRIBUTION/SELLING ARRANGEMENTS

1. Do you have any knowledge of the destination of your fishpond products?
   ( ) Yes ( ) No
   a. If yes, where? ____________

2. Who are your market outlets?
   ( ) Agent/Broker ( ) Retailer
   ( ) Wholesaler ( ) Consumer
   ( ) Wholesaler-Retailer ( ) Others, Specify ____________

3. Do you have any existing contract(s) or definite arrangement with a particular buyer/trader?
   ( ) Yes ( ) No

   a. If yes, what factors do you consider in making such arrangement? Rank choice accordingly.
      ( ) Good credit standing
      ( ) Honest
      ( ) Creditor/supplier of fry to collect payment for fry
      ( ) Regular Buyer
      ( ) Others, specify ____________

   b. To whom do you sell your produce? (Rank)
      ( ) Agent/Broker ( ) Exporter
      ( ) Wholesaler ( ) Institutional Buyer
      ( ) Retailer ( ) Others, specify ____________

   c. What factors are considered in choosing a particular buyer? Rank choice accordingly.
      ( ) Ability to pay
      ( ) One who easily agrees with your selling price
      ( ) Close friend/relatives
      ( ) Others, specify ____________

4. Do you encounter difficulties in seeking an outlet for your fish?
   ( ) Yes ( ) No

   a. If yes, enumerate such difficulties:
      ____
      ____
      ____

5. What is the manner of selling fishpond products in your area?
   ( ) Secret oral bidding (whispered)
   ( ) Open bidding
   ( ) Contract with regular buyer
   ( ) Others, specify ____________

6. Terms of Sale
   ( ) Cash and carry
   ( ) Cash on delivery
   ( ) Advance payment
   ( ) Consignment, specify period ______ (days)
   ( ) Credit (how many days?) ______
   ( ) Others, specify ____________

IV. PRICING

1. What are the factors considered in pricing fishpond products? Rank accordingly.
   ( ) Demand/supply condition
   ( ) Degree of freshness
   ( ) Size of fish
   ( ) Type of species
   ( ) Prevailing market price
   ( ) Others, specify ____________

2. Who determines the price of your fishpond products?
   ( ) Producer (owner)
   ( ) Agent/buyer
   ( ) Others, specify ______________________________

3. Are you aware of the prevailing prices of your product in the market/outlet?
   ( ) Yes ( ) No
   a. If yes, from whom do you get such price information?
      ( ) Agent/broker
      ( ) Buyer
      ( ) Others, specify ______________________________

V. MARKET STRUCTURE

1. During your last harvest how many buyers approached you? Please list them by name of person/institution.

Agent/broker	Buyer	Others

2. Do you consider the products of other operators superior to yours?
   ( ) Yes ( ) No

   a. If yes, what is the basis of your judgment?
      ( ) Locality differences
      ( ) Better degree of freshness
      ( ) Bigger sizes
      ( ) Others, specify ______________________________

3. Does sorting/grading help in attracting buyers?
   ( ) Yes ( ) No

   a. If yes, give the advantages
      ( ) It facilitates selling
      ( ) It increases volume of sales
      ( ) It increases average price received and if so, by how much? ______________________________
      ( ) Others, specify ______________________________

4. What are the rules/regulations/restrictions you have to comply with regarding your operations? Please specify corresponding amount/fee involved (per farm during the reference period 1978).
   a. Permits ______________________ ₱ ______________
   b. Certificates ______________________ ₱ ______________
   c. Licence ______________________ ₱ ______________
   d. Taxes ______________________ ₱ ______________
   e. Other fees ______________________ ₱ ______________
   f. What other restrictions? ______________________________

   a. Do any of these regulations pose as a hindrance or discourage one to be a fish producer?
      ( ) Yes ( ) No
   b. If yes, ask which and why? ______________________________
   ____

5. Do you have plans for expanding your fishpond operation?
   ( ) Yes ( ) No
   a. If yes, how?________________________
   b. If no, why not?________________________

VI. FINANCIAL STATUS

1. Do you have sufficient capital to finance your fishpond operation?
   ( ) Yes ( ) No

   a. If no, from whom do you get financial assistance?
      ( ) Relatives/friends
      ( ) Professional money lenders (merchants)
      ( ) Financial institutions (specify if government or private)

   b. Reasons for the choice of source of financial assistance (Rank)
      ( ) Familiarity with the source
      ( ) Accessibility
      ( ) No red tape
      ( ) Low interest rates
      ( ) Recommended by friends
      ( ) Others, specify ________________________

(Fill up the table as regard your latest loan)

Source	Type of loan	Amount of loan	Amount acquired	Date applied	Date acquired	Percent (interest)	Maturity

2. Are you able to meet your financial obligations in due time?
   ( ) Yes, totally
   ( ) Partially, specify reason ________________________
   ( ) No, why? ________________________

3. Indicate percentage of your loan for:
   ________ Construction of fishpond area (undeveloped)
   ________ Improvement of fishpond area
   ________ Repair of dikes, canals, etc.
   ________ Purchase of fry/fingerlings
   ________ Purchase of marketing equipment (trucks, refrigerated vans, freezer, etc.)
   ________ Others, specify ________________________

VII. OTHER INFORMATION

1. Cite your problems in marketing fishpond products. (Please rank according to importance)
   ____
   ____
   ____
   ____

2. In your opinion, what possible steps can the government take to improve the fishpond industry? (Please rank according to importance)
   ____
   ____
   ____
   ____

3. Was your farm affected by typhoon or unusual weather condition in 1978?
( ) Yes ( ) No

a. If yes, what was it and when did it happen?
____

b. Did you lose any fish and how much? ______________________________

4. When do you plan to stock your pond next? (specify months) ______________________________

5. Do you keep records of your operations? ______________________________

6. Would you be willing to cooperate in our record-keeping project?