The Indonesia Brackishwater Aquaculture Production Project

Completion Report

Research and Development Series No. 29
International Center for Aquaculture
Alabama Agricultural Experiment Station
Gale A. Buchanan, Director

November 1982
AID/ASIA-C-1177
Auburn University
Auburn University, Alabama

CONTENTS

PUBLISHED 11/82—1M

COVER PHOTO. Fish harvest from demonstration pond.

The Indonesia Brackishwater Aquaculture Production Project Completion Report

BRYAN L. DUNCAN[1]

INTRODUCTION

THIS REPORT presents the background, strategy, accomplishments, and remaining constraints of the Brackishwater Fishery Production Project (BFPP) of the Government of Indonesia (GOI).

The project purpose was to increase brackishwater pond (tambak) production in the provinces of Aceh and North Sumatra, and to create an organizational base upon which tambak area expansion can take place.

BACKGROUND

Brackishwater aquaculture in Indonesia is conducted in approximately 180,000 hectares of tambaks (ponds) constructed in mangrove forest associations and other lands located within the tidal-influenced coastal zone. These tidal lands in Indonesia are variously estimated to total 5 to 7 million hectares in area. This land is generally unsuited for agriculture and is exploited mainly for its timber and used for fishpond production. The area of tidal swamps in Aceh Province is estimated to be 75,000 hectares and in North Sumatra Province 50,000 hectares. At the beginning of the project in 1976 Aceh had an estimated 16,000 hectares of tambak, and North Sumatra 300 hectares. At project completion in 1981 Aceh had an estimated 24,000 hectares, and North Sumatra 400 hectares.

In 1974 the Directorate General of Fisheries (DGF) prepared a document entitled "Background Information and Project Idea for Brackishwater Pond (sic) in Aceh and North Sumatra," and asked AID assistance in its evaluation. USAID obtained the services of Dr. H.R. Schmittou, at that time technical advisor for a similar USAID/Auburn University project in the Philippines. Dr. Schmittou's recommendations were positive, and in June 1975, USAID contracted a team of consultants from Auburn University to assist USAID and the GOI with the project design. Auburn University was subsequently awarded a 2-year contract to provide technical assistance and commodities. Two technical advisors began language training in July 1976, and arrived in Indonesia to begin their work on October 26, 1976. One advisor (Dr. Michael C. Cremer) was assigned to the Aceh Provincial Fisheries Service and one advisor (Dr. Bryan L. Duncan) to the North Sumatra Provincial Fisheries Service.

In September 1978, technical assistance in Aceh Province was terminated on schedule. The North Sumatra portion of the project was extended an additional year. At the end of this extension an additional 2 years were requested by the GOI, and approved by USAID, to assist with area expansion (extensification).

[1]Associate Professor, Department of Fisheries and Allied Aquacultures and International Center for Aquaculture.

The duration of technical assistance to the project was 4 years and 10 months, with USAID grant assistance of approximately $900,000 and an equivalent amount of GOI counterpart funding.

RATIONALE

Project goals as envisioned by the GOI were expanded employment, increased food production, increased income, increased fishery exports, equitable distribution of development benefits, appropriate adjustments in sectoral occupations, and solutions to other socio-economic problems.

In the province of Aceh the GOI target group was the traditional, small-scale tambak farmer, who, through lack of accessibility to newer technology and management methods, achieved production levels which were only a fraction of what was possible at an appropriate level of intensification.

In North Sumatra, the GOI target group was the traditional, underemployed coastal fishermen who numbered approximately 55,000 on the east coast of North Sumatra and for whom conversion to coastal fish farming was viewed as desirable. Justification for this can be found in the quote below:

> "Virtually all the resources of the Malacca Strait are at least moderately heavily fished and increasing fishing either by increasing the number of fishermen, or by improving the efficiency of those now present, will increase the total catch considerably less than in proportion to the increase in effort, and for several stocks there may be little or no increase at all. For all stocks, any substantial increase in fishing will result in a significant drop in the catches of the fishermen already exploiting that stock. The workshop, therefore, believed that any positive measures to increase further the fishing intensity in the Straits of Malacca, except on those few stocks for which the opportunities for development have been clearly demonstrated (for example: further trawling surveys may show this to be the case in the deeper water of the northwestern approaches to the Strait), would be very undesirable" (UNFAO/UNDP Report of the Workshop on the Fishery Resources of the Malacca Strait - Parts I and II. March 29 - April 2, 1976, Jakarta).

Increasing competition for increasingly scarce resources resulted in social conflicts between the traditional fishermen and small trawlers (15 to 30 GT) which illegally encroached upon traditional fishing grounds within the 6-mile coastal zone reserved for small-scale fishermen.

Trawler operations surrounding the island of Sumatra were banned as of January 1, 1981, by Presidential Decree number 39, to reduce the fishing pressure on depleted fish stocks and eliminate social conflicts resulting from trawler operation. The immediate

result of the ban was a significantly reduced fish and shrimp catch. Prices of fish and shrimp in the local market increased considerably and jobs in the labor-intensive shrimp processing sector were lost. In the long run there is reason to believe the trawling ban may be effective in restoring depleted fish stocks. A trawling ban in the Philippines proved to be a suitable tool in tropical waters to allow heavily exploited fish stocks to recover ("Do trawling bans work in tropical waters?", ICLARM Newsletter Vol. 4, No. 1, January 1981).

Increased assistance for the development of tambaks with emphasis on shrimp production has been initiated by the GOI to partially offset catch declines resulting from the trawler ban, and in recognition of the steadily increasing fishing pressure in Indonesian waters and the importance of shrimp in generating foreign exchange and improving the incomes of tambak farmers. A country-wide shrimp hatchery development project is in early stages of implementation. The GOI plans to renovate 100,000 hectares of existing brackishwater ponds to permit intensive shrimp production, and to construct 31,000 hectares of new ponds. The scope of the present project was restricted to development of a pilot tambak area to serve as a model for a larger expansion effort.

The present project is also part of the GOI effort, for security and political reasons, to create a coastal zone of relative stability and prosperity.

An additional rationale of the present project was to increase fish consumption, which at 11.2 kilograms per capita per annum nationwide (16 kilograms for Sumatra) is far short of the 29.5 kilograms desired. "According to the National Food Conference held in 1968, an Indonesian needs 55 grams of protein per day to meet minimal nutritional requirements. Of this total 15 grams would come from animal protein consisting of 10 grams from fish and 5 grams from livestock. Ten grams of fish protein equals 60 grams of fish flesh per day (82 grams of whole fish per day), or 29.5 kilograms of whole fish per year." (The Development of Small Scale Fisheries in Indonesia, by A. Sidarto, EKI, Vol. XXV, No. 1, March 1977). While production of export quality shrimp generates income, low-value (small size) shrimp and production of fish in polyculture with shrimp for direct consumption by the fish farm household and for sale on the local market contribute to increasing per capita fish consumption.

A viable tambak industry will also provide off-farm employment opportunities in the marketing, processing and supply sectors. Many jobs were lost in this sector as a consequence of the trawler ban, and it is envisioned that many of these jobs could be restored by a viable tambak industry which now has high priority with the GOI.

STRATEGY FOR ACHIEVING PROJECT PURPOSE

The strategy for increasing brackishwater pond production was twofold: intensification of production in existing ponds in Aceh province, and construction of new ponds (area expansion or "extensification") in North Sumatra province. The former was achieved by introducing improved technology which has been successful in the Philippines and which had received limited testing in Indonesia. This improved technology includes fertilization, managed stocking, use of pesticides, minimization of fry losses during handling, and physical improvement of the tambak.

The means of delivering this newer technology was provided through training of government technicians and extension workers, and the construction of strategically located government demonstration stations. Financing for tambak owners for construction and operational costs was through a subsidized credit program. General technical assistance was provided by resident foreign advisors and short-term consultants who addressed specific problems.

SUMMARY OF PRESENT SITUATION, PROSPECTS, CONSTRAINTS AND RECOMMENDATIONS FOR REMOVAL OF CONSTRAINTS FOR BRACKISHWATER AQUACULTURE DEVELOPMENT IN NORTHERN SUMATRA

A. Present Situation

1. Rationale for tambak fisheries development.
   a. Coastal fishermen are poor with limited opportunity for alternative employment. Income is low and fluctuates drastically with the season.
   b. East coast waters are fished at or near maximum sustainable yield, indicating limited potential for expansion of capture fisheries. This situation may improve as a result of the trawler ban of 1980.
   c. Government ban on trawler operations is drastically reducing shrimp production with consequent reductions in foreign exchange earnings and employment (trawler crews, marketing, and processing sectors). Because of this GOI has increased assistance to tambak development.
   d. GOI desires a coastal zone with social stability and relative prosperity for political security concerns.
   e. Per capita fish consumption in project area is considerably below desirable levels.
   f. There appears to be considerable production potential in intensification of existing ponds and area expansion.
2. Accomplishments of present brackishwater production project.
   a. Establishment of eight government aquaculture demonstration, training, and production facilities.
   b. Production increases of more than 100 percent.
   c. Administrative experience within the fisheries services for brackishwater aquaculture development.
   d. Formal training and on-the-job experience for project technical staff.
   e. Creation of awareness and interest in the public sector and government agencies in brackishwater aquaculture development.
   f. Training for fish farmers and those interested in participating in tambak area expansion activities.
   g. Surveys of tidal swamplands and identification of sites with potential for tambak development.
   h. Construction of a 68-hectare area expansion pilot project.
   i. Shrimp and milkfish culture yield trials demonstrating economically sound productions.
   j. Field trial station designed, site selected, and funding provided.
   k. GOI participation in the project at district, provincial, and national levels.

B. Prospects for brackishwater aquaculture development in northern Sumatra (Provinces of Aceh and North Sumatra)

1. Tidal swamp land available for possible area expansion is estimated to be 100,000 hectares.
2. Area of intensification of production is about 24,000 hectares.
3. World and local shrimp demand, and local fish demand are increasing while production from capture fisheries has declined.

4. Milkfish culture technology is well-established and high productions are possible, as demonstrated by project.
5. Shrimp culture technology is sufficiently well-established for acceptable, economic productions from semi-intensive operations, as demonstrated by project.
6. A high degree of interest among coastal villagers.
7. A high degree of interest by the provincial governments.
8. A high degree of interest and commitment by GOI as evidenced by present plans for country wide intensification (100,000 hectares) and expansion (31,000 hectares) of brackishwater aquaculture.

C. Constraints

1. Insufficient skilled and experienced manpower.
2. Inadequate budget support to attain project objectives.
3. Insufficient shrimp post-larvae.
4. Inadequate knowledge of potential area for expansion.
5. Weak milkfish marketing structure.
6. Socio-economic baseline data lacking.
7. Fry distribution and fingerling production facilities lacking.
8. Inexperienced pond construction contractors.

D. Recommendations for Removal of Existing Constraints

1. Present manpower should be increased in number, and the skills that they possess upgraded. It is expected that solving the manpower problem will contribute towards removal of other constraints. It is proposed that the provincial level brackishwater aquaculture development unit establish teams that work together closely under the leadership of a GOI fulltime project manager/team coordinator. One of the below team leaders will also function as counterpart to the GOI project manager/team coordinator, and chief-of-party of the technical advisors. It is assumed that the team leaders described below will be expatriots, as the required skills will probably not be available within the country.

a. Engineering team

This team will consist of a qualified pond engineering expert as team leader assisted by two or three individuals with engineering/technical training. The engineering team will be responsible for field surveys, identification of potential tambak sites, site evaluation (soil, topography, tide, etc.), physical design of tambak projects and government brackishwater aquaculture facilities, participation in contractor selection, and direct on-site supervision of all construction activities. The team must have at its disposal facilities and equipment to perform its work.

b. Tambak management team

This team will consist of a team leader who is academically qualified (research experience) and experienced in practical field work. He will be assisted by two or three individuals with strong aquaculture backgrounds. The tambak management team will be responsible for working with PFDU (Provincial Fisheries Demonstration Unit) field staff to design overall management and production schemes for area expansion projects; plan, implement and monitor PFDU production, demonstration, and extension activities; for fry and shrimp post-larvae distribution; for fingerling production; and direct responsibility for the operation of the field trial facility. This team will be fully equipped to perform its functions.

c. Socio-economic team

This team will consist of a qualified agricultural/aquacultural economist as team leader, preferably with some experience and knowledge of cooperatives. He will be assisted by individuals with backgrounds appropriate to the tasks to be performed. This team will be responsible for: obtaining baseline socio-economic information in communities where tambak expansion activities are to be undertaken; performing economic analysis to be incorporated into plans for specific tambak area expansion efforts; assisting the bank in designing an appropriate credit scheme and monitoring its implementation; assisting tambak farmer cooperatives/associations in matters relating to their organization and function; and overall monitoring of economic and social performance of tambak area expansion.

2. ***A shrimp hatchery*** for northern Sumatra should be planned and developed as soon as possible to meet the demand for post-larvae and permit future tambak expansion. This should include long-term training of hatchery staff which will be essential to the operation of the hatchery.

3. It is recommended that a ***milkfish fry distribution and fingerling production center*** be constructed and operated by the fisheries service to support early stages of tambak area expansion and intensification, and to serve as a demonstration to encourage the private sector to take over this function.

4. ***Off-shore training*** for fisheries officials to the M.Sc. level is an essential part of a follow-on brackishwater aquaculture project. This must include support for intensive English language preparation. The contention that trainees should not train in countries with conditions or characteristics dissimilar to their native country is irrelevant to the trainees' needs, which are to gain the attitudes, technical information and problem-solving skills in their respective disciplines that will enable them to perform creatively and effectively in **any** environment. It is then highly desirable that the trainees undergo their training at appropriate institutions in the United States or other countries with equivalent educational standards, irrespective of similarities or dissimilarities with specific problems they will face upon returning home.

5. ***Improvement of construction*** methods is essential so that serviceable ponds are built and construction costs are lowered. Indonesian contractors and tambak farmers cooperatives or associations could be assisted by "master tambak builders" from the Philippines or Taiwan to demonstrate construction techniques and assist in supervising specific construction projects.

6. The implementation of the above recommendations can best be achieved by continued cooperation between GOI and USAID in a follow-on project. The preparation of a detailed project proposal should begin as soon as possible to minimize lag between termination of the present project and start-up of the proposed project.

a. Duration of proposed follow-on project - 5 years.
b. Budget estimates of major items for dollar funding.

1. Engineer, 60 man-months	$US 400,000
2. Biologist, 60 man-months.....	400,000
3. Economist/sociologist, 60 man-months	400,000
4. Commodities (vehicles, scientific and engineering equipment, etc.) ..	200,000
5. Off-shore training, 96 man-months	96,000
6. Other consultants, 24 man-months	96,000
Total	$US 1,592,000

PROJECT ACCOMPLISHMENTS

Nine objectives were established for the initial 3-year project period. These objectives were largely achieved. Seven new objectives were formulated for the final 2-year extension for North Sumatra. Project accomplishments were evaluated against these objectives in four formal reviews conducted by USAID during the life of the project. The initial objectives were:

1. Milkfish fry resources evaluated and improved capture and distribution methods instituted.
2. Fertilizer utilization by fish farmers increased.
3. Increased lending by GOI Bank Rakyat for fish pond production and development.
4. Provincial programs (demonstrations, training, and extension) made operational with technical assistance.
5. Trained staff functioning with technology and methodology for intensification outreach program.
6. Annual fish production from 4,800 hectares of existing tambaks doubled, from approximately 500 kilograms to 1,000 kilograms per hectare per year.
7. New employment created for agricultural and fishery families.
8. Increased number and greater development roles achieved for local producer associations.
9. GOI infrastructure in place and functional to handle remaining intensification and projected expansion.

Objectives for the final 2-year extension in North Sumatra were:

1. Three pilot project tambak small-holder estates totaling 300 hectares under development, and one pilot project operational.
2. Total credit of Rp. 195,000,000* to pilot project participants.
3. Plans finalized for construction of a field trial station.
4. Marketing study completed with recommendations for improving marketing situation.
5. Feasibility of pumping systems for tambak water management evaluated.
6. Shrimp hatchery feasibility study, and plans for follow-on initiatives completed.
7. Training opportunities provided for project manager to M.Sc. level, three PFDU managers to B.Sc. level and selected extension agents for short-term training.

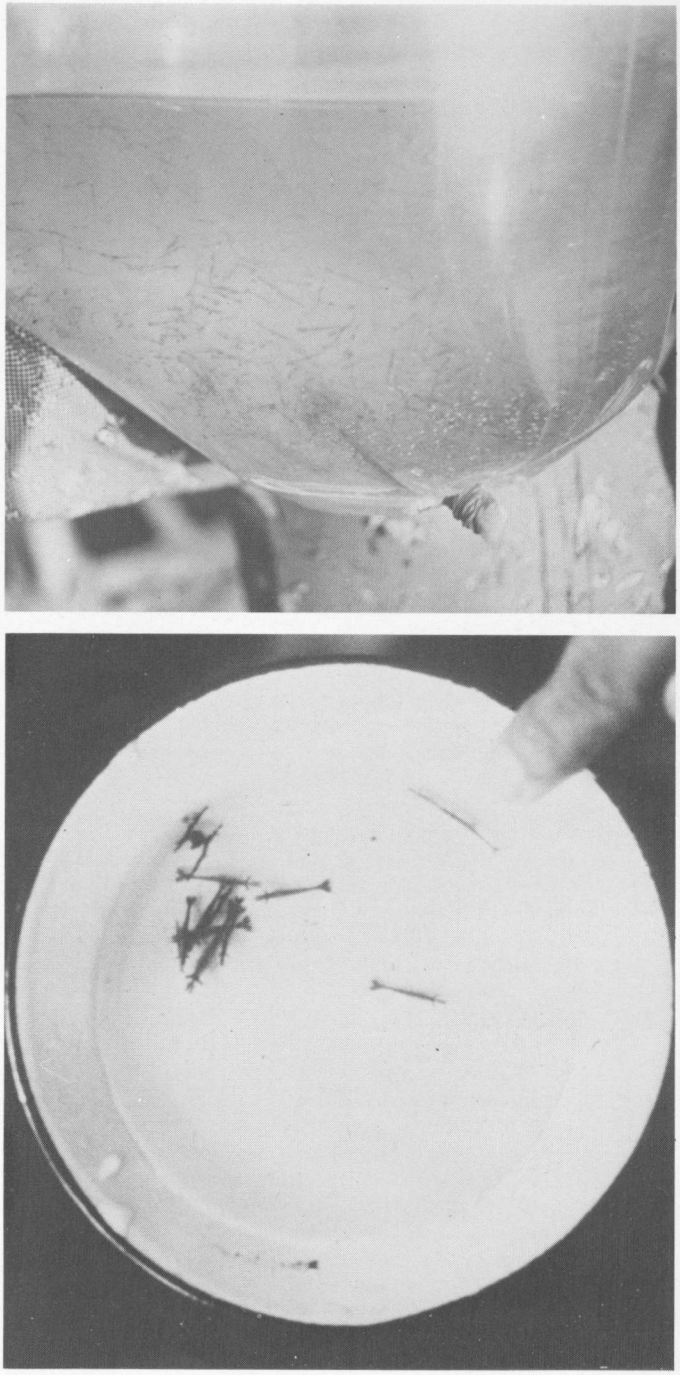
There were other project accomplishments which were not specified as objectives. Discussions of all project accomplishments follow.

Fry Resources

The goals under this objective were to increase the volume of milkfish fry catch sufficient to double pond production, and to improve handling and distribution methods so that 20 percent more of the captured fry reached the terminal market. A large number of fry are present in Aceh coastal waters, exceeding the local demand. Surveys confirmed the lack of milkfish fry in North Sumatra coastal waters, and the requirements for North Sumatra are met by Aceh.

Aceh Province: During 1977 and 1978 surveys were continuously conducted in Aceh to identify new milkfish fry capture grounds, determine seasonal availability and quantity captured, determine the fry needs of Aceh and the numbers of persons involved in the fry gathering industry. Seasonal occurrence of fry was determined to be April to June, and October to November, with the greater abundance during the April to June period. Milkfish fry collecting provided employment for an estimated 3,424 people during 1978. People of various occupations are engaged in this seasonal activity, including housewives (30 percent), full-time collectors (35 percent), and others.

*$1 = Rp. 625



Milkfish fry in plastic bag (top), and shrimp post-larvae for pond stocking (bottom).

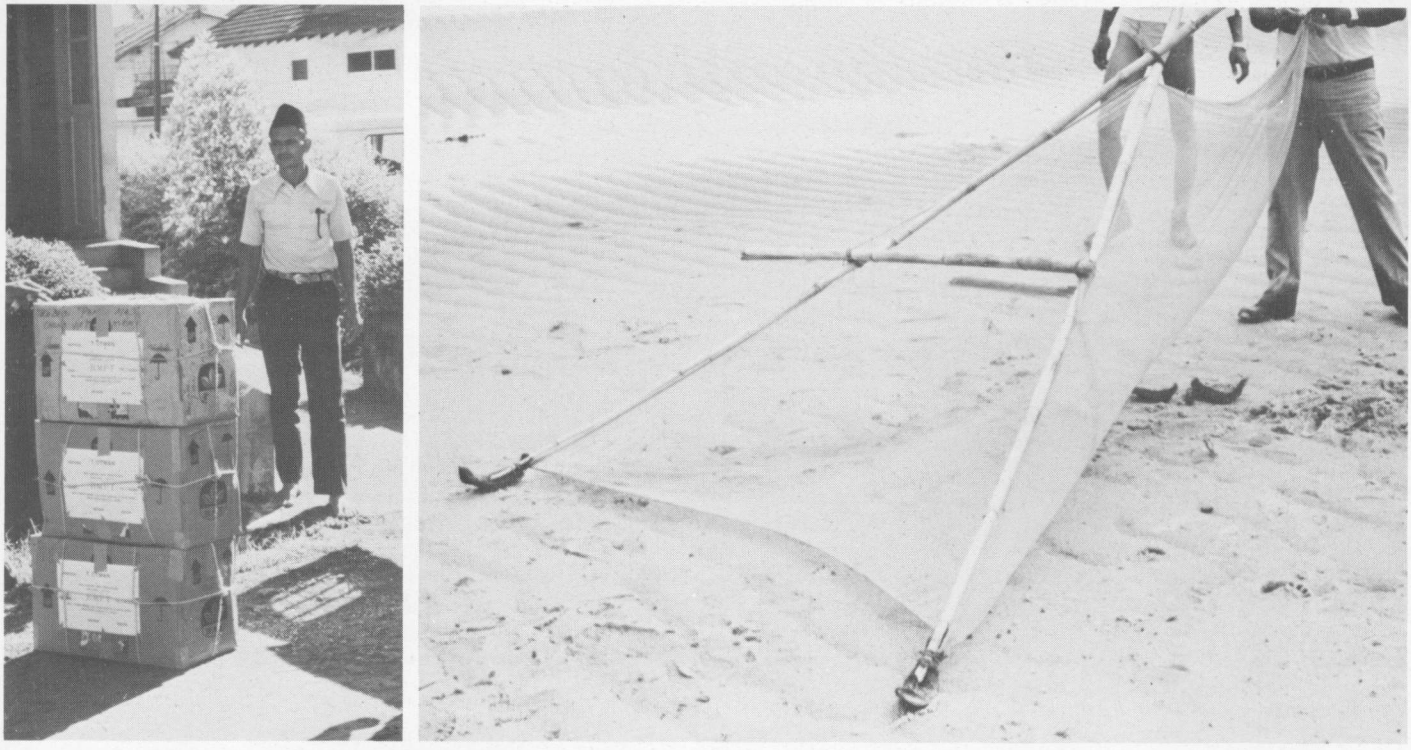
TABLE 1. MILKFISH FRY PRODUCTION

Year	Production*	Aceh requirement	Sold in Java	Sold in N. Sumatra
1978	121,000,000	72,000,000	1,500,000	127,000
1979	145,000,000		15,000,000	
1980	158,000,000		18,000,000	

*before approximately 40 percent mortality

In 1978 modified capture gear was demonstrated to improve fry collection, however the response was not favorable due to the higher cost of the gear and its larger size.

A workshop on fry handling and transporting was conducted in 1978. Improved handling, counting, and the use of oxygen inflated



Milkfish fry packed for air shipment (left), and fry and post-larvae gear (right).

plastic bags were demonstrated. This method tripled the carrying capacity per unit volume of water and where applied reduced mortalities from as high as 40 percent using traditional methods to 1-2 percent.

In 1978 a central fry market was established in Banda Aceh, and sale of surplus fry to Java was made for the first time. Fry were packed using the plastic bag/oxygen method and shipped by air to Java. Sales increased dramatically each year. A continuing problem is the unavailability of fry during the 6 or 7 off-season months of the year. There is thus a need for fry banks and/or a fingerling production/stunting industry. The technology for this is available.

Juveniles of several commercial species of shrimp were found in the course of surveys. The most abundant species were the white shrimp, *Penaeus indicus* and *P. merguiensis*, which are cultured by Aceh farmers for the local market and for export. *P. monodon* is also cultured, but is less than 10 percent of shrimp production from tambaks. Shrimp passively enter ponds in commercial quantities when water is added. Active stocking is generally not practiced. Shrimp passively entering "catching" ponds may be selected, however, and the desired species and number of shrimp subsequently stocked into growout ponds.

North Sumatra Province: Surveys to identify juvenile shrimp resources were conducted along the east coast from 1976 to 1978. The presence of the commercial species *Penaeus indicus, P. merguiensis, P. monodon* and *Metapenaeus* sp. was confirmed, but not in commercial quantities present in Aceh. Surveys were conducted sporadically as funding was available to identify *P. monodon* collecting grounds. This species was the focus in North Sumatra because of its excellent growth and survival in ponds, its high market demand and the ease of its identification by collectors at the post-larval and juvenile stages. Efforts to collect this shrimp in quantity along the east coast were not successful. In 1980 a survey to locate *P. monodon* post-larvae was begun on the west coast of North Sumatra. In April 1981 a 2-day survey in an isolated area (Pulau Pane, Tapanuli Tengah) yielded about 1,000 *P. monodon* post-larvae and juveniles; 5 days in May yielded 6,000, and 6 days in June yielded 60,000. These are commercial quantities, and efforts were made to organize collectors and provide them with gear and training to maximize exploitation of this new-found resource. It was clearly recognized, however, that exploitation of natural resources is a stop-gap measure only, and substantial progress in intensification and expansion of tambaks will depend upon hatchery production of shrimp post-larvae.

Fertilizer Utilization

An essential part of intensification of pond production is the utilization of inorganic fertilizers, especially those containing phosphorus and nitrogen. The project objective was to make inorganic fertilizer available to fish farmers for Rp. 120 per kilogram in quantities of about 900 tons per year.

Inorganic fertilizers were not available for fishpond use prior to August 1975 due to GOI policy. In October 1976, GOI policy change made inorganic fertilizers available for fish pond producers, at the subsidized prices used for other agricultural crops. Prices for urea and triple superphosphate were established at Rp. 70 per kilogram and diammonium phosphate at Rp. 90 per kilogram, substantially below the goal of Rp. 120 per kilogram. Presently, inorganic fertilizer is plentiful and readily available on the market. As of September 1978, 1,500 to 2,000 tons were used annually by Aceh farmers surpassing the project goal of 900 tons for both provinces. Significant quantities of inorganic fertilizer are not yet being used in North Sumatra.

Organic fertilizers, principally animal manures and rice bran, are important in maintaining pond fertility. As of September 1978, about 11,800 tons of cow manure were used annually in Aceh. In North Sumatra use was restricted largely to the government demonstration stations. In both provinces, however, organic fertilizer was in short supply. Even when available the cost and difficulty of transport is sometimes prohibitive. This problem will have to be addressed as fish pond activities increase.

Credit

The project design was based upon the assumption that credit would be made available to fish farmers for the purchase of inputs for intensification, and for pond construction and capital improvements. The GOI agreed to make available during the life of the project Rp. 1,841,540,000 for production inputs and capital improvements, with repayment over 3 and 5 years at 15 percent and 12 percent interest, respectively, with 1 year grace period.

Aceh: From the beginning of the project through July 1978, a total of Rp. 750,000,000 was granted for intensification of 2,005 hectares owned by 576 households. More credit could have been utilized had it been available. Up to and including April 18, 1981, a total of Rp. 3,000,000,000 had been granted to 2,362 households. The published rate for tambak loan default is 25 percent, however, interviews with bank officials revealed that the actual rate may be substantially higher. The reasons for this high default rate are not clear.

North Sumatra: Under the BFPP in North Sumatra credit utilization was insignificant until the fourth year of the project. Credit was allocated to provincial bank branches during these years but was largely unutilized. This situation was to be expected due to the lagtime characteristic of an area expansion project. In June 1980, about Rp. 70,000,000 was granted to 17 heads-of-household participants in the area expansion pilot project. The bank demonstrated flexibility in granting these loans by combining construction and operating capital in a single package at a low interest rate of 10.5 percent. The loan was for 5 years including 1 year of grace. The farmers participated in the loan program with informal assurance from the bank that it would be switched to the new and more liberal Rural Credit Program (up to 15 years repayment, 10.5 percent interest, grace period negotiable). A second area expansion project involving 12 participant households is being planned for which a credit package of Rp. 120,000,000 will be requested. The difference in cost of the two projects is principally attributable to site characteristics which require differing amounts of excavation, and availability of a larger amount of financing for the second project.

Provincial Fisheries Demonstration Units

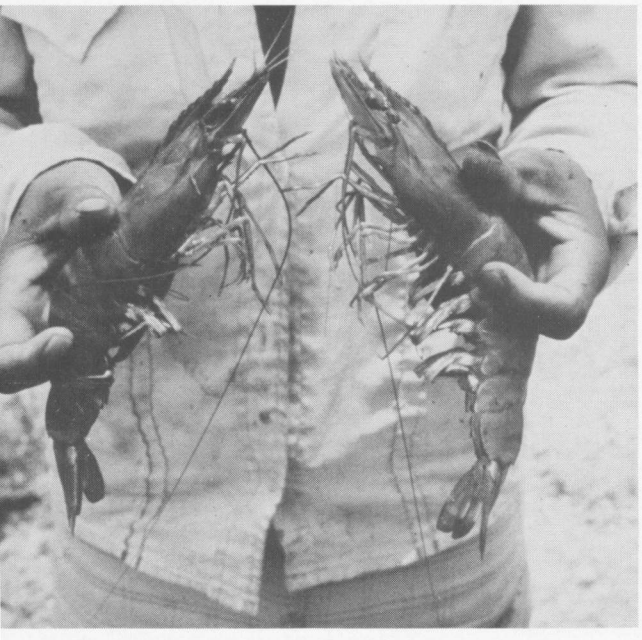
Central to BFPP strategy were the construction and operation of eight Provincial Fisheries Demonstration Units (PFDUs), five in Aceh and three in North Sumatra. The PFDUs range from approximately 5 to 8 hectares in water surface area, consisting of nursery, transition, and rearing ponds, in addition to a small house, an office/classroom building, storage buildings, generator sheds, etc. Assigned to each PFDU initially were a manager, an assistant manager, five extension agents and several laborers. The functions of the PFDUs were to conduct field tests and demonstrations of the new technology, conduct farmer training courses, serve as a base for extension agents, and provide work experience and training for fisheries staff.

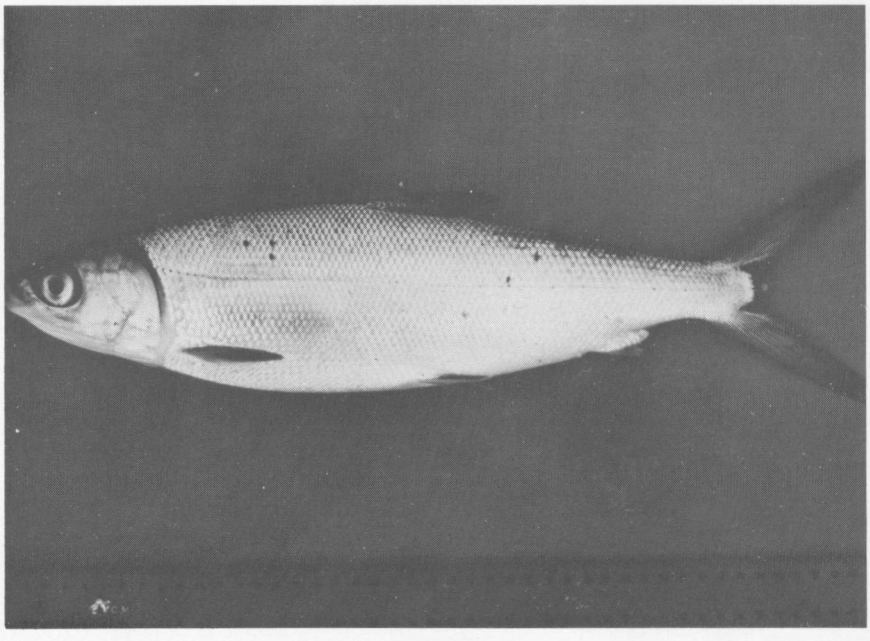
Aceh: Construction of five PFDUs in Aceh was completed by June 1977. Three of the PFDUs are owned by the GOI, and two were leased from fish farmers. By 1981 one of the leased PFDUs had been returned to its owner. During the 2 years (1976 to 1978) that the Aceh project received technical assistance, Rp. 45,757,000 was budgeted for PFDU operation. Milkfish production of 1,100 kilograms per hectare per year and shrimp *(Penaeus indicus* and *P. merguiensis)* production of 222 kilograms per hectare per 75 days were demonstrated at the PFDUs. A total of 654 farmers received 2,646 man-days of training at the PFDUs. Two 2-day workshops were conducted. Approximately 21,400 farmer contacts and 10,550 farm visits were made. At that time the tambak industry provided full-time employment for 7,423 fish farm owners, 2,300 owner family members, 2,560 fish farm caretakers, 500 shrimp processing workers and 150 marketing workers. About 3,433 fry collectors were employed on a seasonal basis.

A USAID/GOI evaluation team visited all PFDU sites in June 1981. While activities such as farmer training and culture trials were still being carried out in four of the original PFDUs, minimal activity was evident. All of the reasons for this were not clear and to some extent were different for each PFDU. Problems common to each PFDU appeared to be inadequate financing and staff, and inability of the provincial office to provide supervision due to inadequate funds for travel.

North Sumatra: Construction of two PFDUs was completed in May and June 1978, and the third in February 1979. Two of the PFDUs were gradually brought into operation as construction refinements

Marine shrimp, *Penaeus monodon* (left), and milkfish (right).



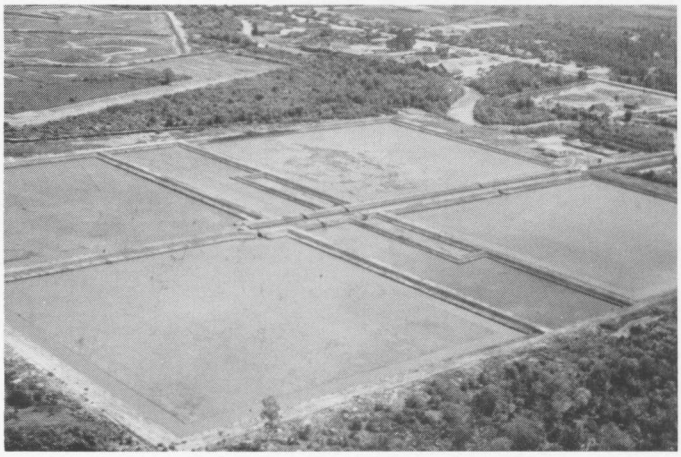


were made. One PFDU (Babalan) has not yet become operational due to severe construction problems resulting from poor site characteristics. Unfortunately the land was purchased by the GOI before site feasibility was adequately known and administratively there were no alternatives. It is doubtful that this PFDU will ever be operational unless very large sums of money are spent on its improvement.

Field trials were conducted in two of the PFDUs utilizing hatchery-produced *P. monodon* post-larvae. The highest productions of *P. monodon* alone were 129 kilograms per hectare per 153 days at a stocking rate of 15,385 per hectare in a 1.3-hectare pond with a survival rate of 20 percent. This trial gave the highest pondside crop value, Rp. 497,825 per hectare. The highest total shrimp production was 166 kilograms per hectare per 122 days (*P. monodon* 93 kilograms and wild shrimp, mostly *Metapenaeus* sp., 73 kilograms) at a stocking rate of 14,285 per hectare in a 0.7 hectare pond, with a survival rate of 9.6 percent and an average animal weight of 68.3 grams (*P. monodon*). The total shrimp value was Rp. 473,400 per hectare at pondside.

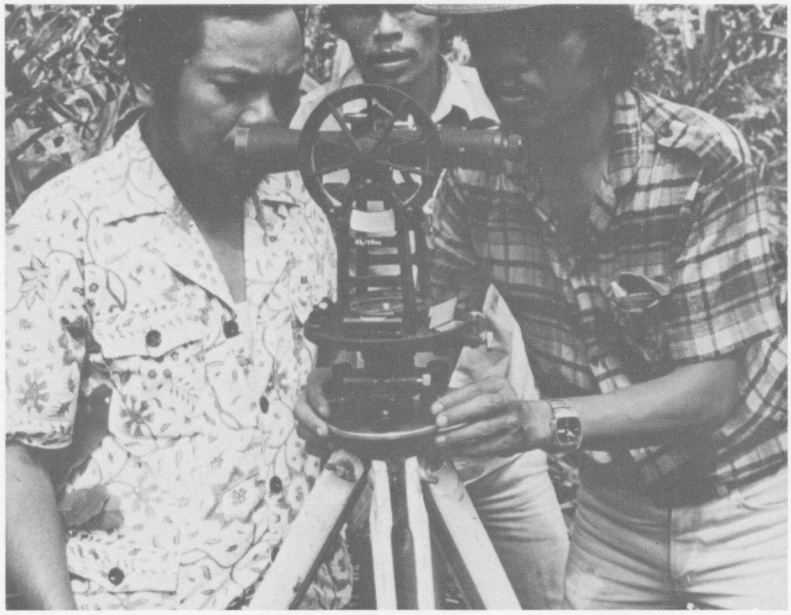
Milkfish field trials demonstrated a production high of 455 kilograms per hectare (309 grams average weight) in 104 days by stocking 4.3-gram fingerlings at 1,500 per hectare. Survival and growth rates were 98.5 percent and 2.9 grams per day, respectively.

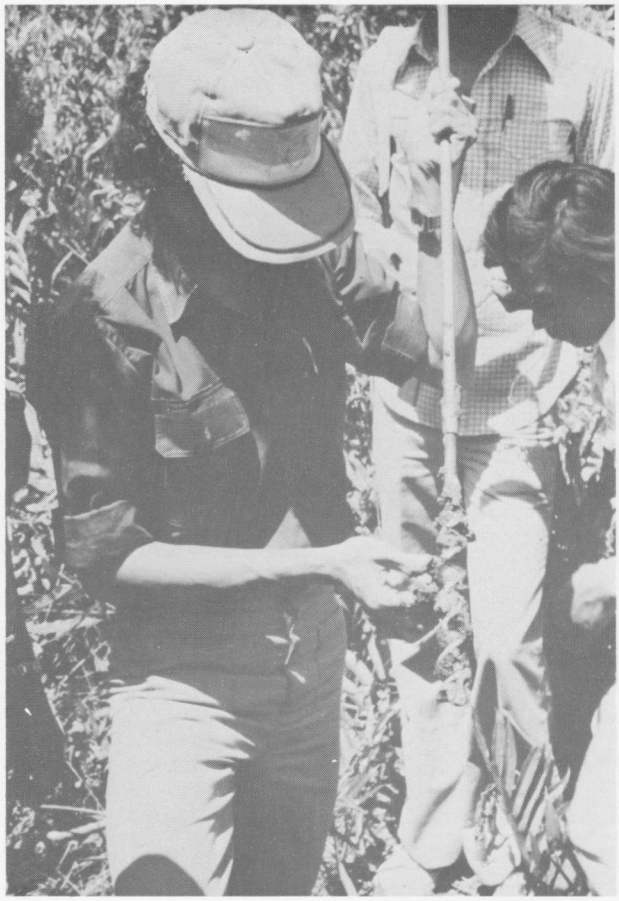
The above field trial results were extremely encouraging in view of the new ponds and inexperienced staff. The productions achieved were higher than those projected for economic analysis of area expansion.



Demonstration of fish sampling techniques (top), demonstration station in Sialang Buah, North Sumatra (center), and demonstration station in Pangkalan Dodek, North Sumatra, showing surrounding swamps (bottom).

THIS PAGE: In-country training for technical staff. FACING PAGE: Demonstration of fish smoking (left), graduates of training course for field extension agents (top right), and graduates of training course for pilot project pond owner/operators (bottom right).





Training

The BFPP provided long-term and short-term participant training. Four long-term participants completed M.Sc. degrees, two in the Philippines and two in the United States. These participants were selected from the Directorate General of Fisheries staff in Jakarta. Two additional M.Sc. slots were made available under the project extension for provincial level staff. However, failure of proposed candidates to qualify in English left these slots unfilled. Short-term, 3-month participant training in the Philippines was provided for two provincial fisheries staff. Two additional participants completed one-month study tours of aquaculture activities in the United States.

Early in the project 23 provincial staff received 3 months of training each at the Brackishwater Aquaculture Development Centre at Jepara, Central Java. During the project extension nine additional provincial staff received 20 months of training at Jepara.

In addition to the above, formal training for provincial staff was carried out at the PFDUs. This training was conducted by upper level provincial staff, some of whom had received training at Jepara, by the technical advisors, an Auburn University extension specialist (Dr. H.R. Schmittou), and other specialists such as bank credit program staff. Each of 56 provincial staff received an estimated 1.36 man-months of training. Training course subject matter was pond construction, fish culture techniques, extension methodology, and shrimp hatchery operation.

One hundred forty-one man-months of informal, on-the-job training were provided for extension agents at PFDUs early in the project. This activity was continued on a regular basis at some of the PFDUs.

A 2-week study tour to observe brackishwater culture activities in the Philippines and Taiwan was undertaken by one technical advisor and his GOI counterpart. A similar trip was undertaken by a group of 15 Indonesian fish farmers and GOI provincial and Jakarta fisheries staff.

Between 1976 and 1981, 585 candidate tambak farmers received 3,505 man-days of training. From a sampling of 60 trainees who expressed interest in becoming tambak farmers, 12 were fishermen, 21 were former fishermen (most of whom had become farmers), 10 were farmers with no fishing background, and the remainder were in miscellaneous village-based occupations.

Production

At initiation of the project, annual brackishwater pond production (principally milkfish) in Aceh averaged 490 kilograms per hectare per year for a total of 7,766 tons from 15,848 hectares. An end-of-project survey in Aceh in 1978 estimated production of 12,073 tons from 18,196 hectares for an average of 664 kilograms per hectare per year. This represented a net increase of 4,308 tons per year as a direct result of project assistance, which exceeds by 2,052 tons the project production goal of 2,256 tons. There was thus a 15 percent increase in area accompanied by a 36 percent increase in yield per hectare resulting in a total production increase of 56 percent. The Project Paper projected production increases up to 960 kilograms per hectare from 4,800 hectares for a 2,256-ton total production increase. This production goal was exceeded, but spread over the total tambak area and not limited to just the 4,800 targeted hectares. These unexpected production increases created marketing problems, which are discussed in detail below.

The 4,308 tons of new tambak production realized in Aceh provides 10 kilograms of fish per person for 430,800 persons, potentially increasing per capita consumption from the present 20

kilograms (in Aceh) to 30 kilograms (GOI minimum nutritional standard for wholefish consumption). This production represents additional income to tambak farmers of Rp. 1,292,400,000 (@ Rp. 300 per kilogram). Total USAID funding to the project during the period (1976 to 1978) when this production was realized, was Rp. 378,750,000 or Rp. 88 per kilogram for the fish production increase as a direct result of the project. This cost will be significantly reduced as longer-term aspects of the project pay off in North Sumatra and Aceh.

In 1981 the Aceh Fisheries Service estimated that there were 24,000 hectares of tambak in Aceh (a 50 percent increase over area at beginning of project), and annual production of 13,600 tons.

In North Sumatra significant production increases were not expected during the life of the project. This was due in part to the slow start-up of the project, but in a greater measure to the focus of North Sumatra activities on area expansion rather than intensification of the limited area of existing tambaks.

Fish Farmer Associations

In Aceh 14 new fish farm owner associations were formed during the project, as well as four district and one provincial federation of associations. The associations facilitate information exchange and extension education. At the end of the project in Aceh (1978) there were 78 associations (up from 64) and five federations (up from one) with membership of 3,135 farmers (up from 2,341), covering 7,220 hectares (up from 5,557). A government cooperative (KUD Mina) assists tambak farmers with marketing of produce and provision of inputs.

In North Sumatra there are four associations in various stages of organization for the purpose of area expansion. One of these associations, composed of 17 heads-of-household, is operating a 68-hectare area expansion pilot project.

Area Expansion

The single focus of the North Sumatra project was area expansion (extensification) as distinguished from intensification of existing ponds. According to published statistical data for North Sumatra for 1978 there were 449 hectares of tambak. This area included ponds that were used as traps, and uncleared land surrounded by dikes.

The decision was made early in the project to concentrate on area expansion at the expense of intensification for the following reasons: the provincial fisheries staff had limited ability and manpower and could not address both tasks; the problems of area expansion proved to be time consuming and difficult; early attempts to work with existing tambaks were thwarted by inability of the farmers to obtain credit for capital improvement and production inputs; area expansion had a greater long-term production potential than intensification; and it was felt that a careful and orderly approach to area expansion would draw the attention of local authorities who could assist in providing solutions to problems encountered by previous tambak development activities.

Project Paper estimates of area expansion were 1,700 hectares per year beginning in the third project year, and 5,600 hectares per year beginning in the seventh year after project initiation. It was realized shortly after the project began that these estimates were overly optimistic. The Provincial Fisheries Service therefore produced an outline tambak development plan for North Sumatra,

targeting construction of 2,100 hectares of tambak during Repelita III (the third 5-year plan of the GOI, from 1979 to 1983), including a total of 300 hectares of pilot demonstration tambaks in the three districts (Kabupatens) targeted for area expansion. In view of problems encountered and the unlikelihood of immediate further donor technical assistance, the target of 2,100 hectares may have to be revised downward.

Surveys: A major project activity was surveying tidal lands to determine their suitability for tambak area expansion. Surveys were concentrated in, but not limited to, four regions: the vicinities of Pangkalan Brandon (Kabupaten Langkat), Belawan (Kabupaten Deli Serdang), Bedagai (Kabupaten Deli Serdang), and Air Joman (Kabupaten Asahan). Potential expansion sites with a total area of approximately 1,050 hectares are presently under various stages of detailed survey, evaluation and construction. A 68-hectare pilot expansion project has been constructed in the Bedagai area, and has begun culture operations.

Approximately 14,385 hectares have been surveyed roughly. Of this total, 11,725 hectares were identified as having possible potential for tambak development (7,725 hectares of this requiring excavation or irrigation by pumping), and 2,720 hectares were considered to have no potential for tambak development.

Pilot Project: The Fisheries Service in North Sumatra was faced with the question of how to implement planned area expansion in a way that was effective, economic and orderly, as opposed to the unplanned, and rather haphazard method that has been traditional in other tambak areas. To answer these questions a pilot area expansion project was planned.

Current prices, costs, credit terms, and conservative projected productions suggested that 4-hectare family units would provide the minimum required net income during the critical credit repayment period. Minimizing construction costs required that multiple family-sized units be constructed simultaneously and contiguously to permit sharing of dikes, water-supply canals, maingates, and other infrastructure.

A site was selected and evaluated to the extent possible given the resources of the Provincial Fisheries Service. Thirty participants were chosen from among former training course participants, all of whom lived immediately adjacent or close to the proposed tambak site. A "phase I" project was designed for 17 family units.

The participants organized themselves into a formal association, and, with Fisheries Service assistance, obtained title to the land and negotiated a credit scheme with the bank. The bank agreed to fund the project provided a qualified contractor was utilized to do the construction. A cash flow analysis was performed by the bank with input from the Fisheries Service. On this basis a credit package of Rp. 45,000,000 was granted. This was later increased to Rp. 69,000,000 which included all land and land development costs, operation costs for the first year and a cost-of-living allowance for the farmers. Credit terms were 5 years including 1 year grace, and 10.5 percent interest. There was an unwritten understanding that the credit would be switched to a new and more realistic credit scheme (Rural Credit Program) then being prepared for implementation, which would lengthen the payback period to a maximum of 15 years, including a possible 3-year grace period. As of August 1981 BRI central office in Jakarta had not yet approved the change to the new scheme. If implemented, however, it will permit increasing the credit from the presently low figure of Rp. 1,014,706 per hectare to a maximum of Rp.2,500,000 per hectare.

Construction began in June 1979, and was completed in June 1980. Contractor performance was poor. From June 1980 to August 1981 the participants labored to improve the ponds. Six of the 17 units were stocked and have been operational since April 1980, and two units were harvested.

In addition to credit, the local government subsidized construction of main gates and improvement of the main canal at a cost of Rp. 7,000,000. The central government made available a Rp. 10,000,000 grant to seal the ponds along the main canal against excess seepage due to poor soil quality.

The present need of the project is an increase in the credit amount under the Rural Credit Project, and an engineering specialist to assist in planning the necessary improvements.

Economics of Area Expansion: In studying historical records it was learned that tambak construction has always been difficult and costly, primarily because of the high cost of excavation and the general unavailability of capital. Schuster (1952) estimated that 21 percent of the ponds in Java were unproductive because of insufficient excavation, and he felt that the prospects of improvement were not good unless government assistance was made available. Construction was often done gradually over a period of 3 years or more due to the lack of capital and technical deficiencies, delaying production until the fourth year, and thus further complicating an already precarious situation. Although costs remain high, prospects for faster and more economically and technically sound

Site selection for new ponds (left), preliminary survey for new pond site (center), and pond dike construction (right).



tambak construction are much better today. Capital availability for the small-holder has improved through liberal credit schemes subsidized by local and international financial development institutions. Construction techniques also are improved. The availability of international markets, especially for the shrimp portion of the crop, has improved the longer-term economic feasibility. What remains is the improvement and application of existing resources to plan and execute tambak area expansion in a way which is technically and economically sound. The prospective scale of area expansion is large enough to warrant careful consideration.

Budgets for projects A and B, which are described, are taken from actual tambak development plans developed for the provinces of North Sumatra and Riau. They represent unique situations which are not directly comparable due to differing construction requirements, earning potentials, costs, credit provisions, etc. Note that figures for project A reflect total cost for the 48-hectare small-holder estate, whereas project B figures reflect the cost for a single 4-hectare unit.

Project A (tables, pages 16-17) is a least-cost situation in which tidal range and land elevation is such that the only excavation required is to obtain soil for the dikes. The project is for a 48-hectare, 12-unit small-holder estate. Housing, as well as pond construction is provided under the capital investment item. Annual production increases are based upon a learning curve for improved management rather than increased inputs. The discount rate to estimate the net present value of costs and revenues is 15 percent. The net benefit cost ratio = 2.206. Development capital of Rp. 93,926,875 is amortized over 7 years with a 1-year grace period and annual percentage rate of 10.5 percent.

Expansion project B (tables, page 17) is also a 48-hectare, 12-unit small-holder estate. It is a higher cost situation in which excavation of 31 percent of the pond bottom to an average depth of 0.5 meter is required, and is financed under the credit scheme. Staged excavation of an additional 11 percent of the pond bottom would take place over a period of 11 years financed by the farmer, and production from this excavated area would contribute to payback over the life of the loan. Excavation of the balance would take place as the farmer has the resources. The maximum allowed credit of Rp. 10,000,000 per borrower under the Rural Credit Program is used with a payback of 12 years including a 3-year grace period, and interest of 10.5 percent. Housing is not included. The first 6 years of the project are the most critical, and an end-loaded repayment scheme was devised to ease the repayment burden in early years. The pond design includes soil depositories for excavation within the pond, upon which coconut trees will be planted. Coconut income does not assist the project in the early critical stages, however, because of the maturation lag-time of about 5 years. GOI subsidy for infrastructure is Rp. 30,000,000.

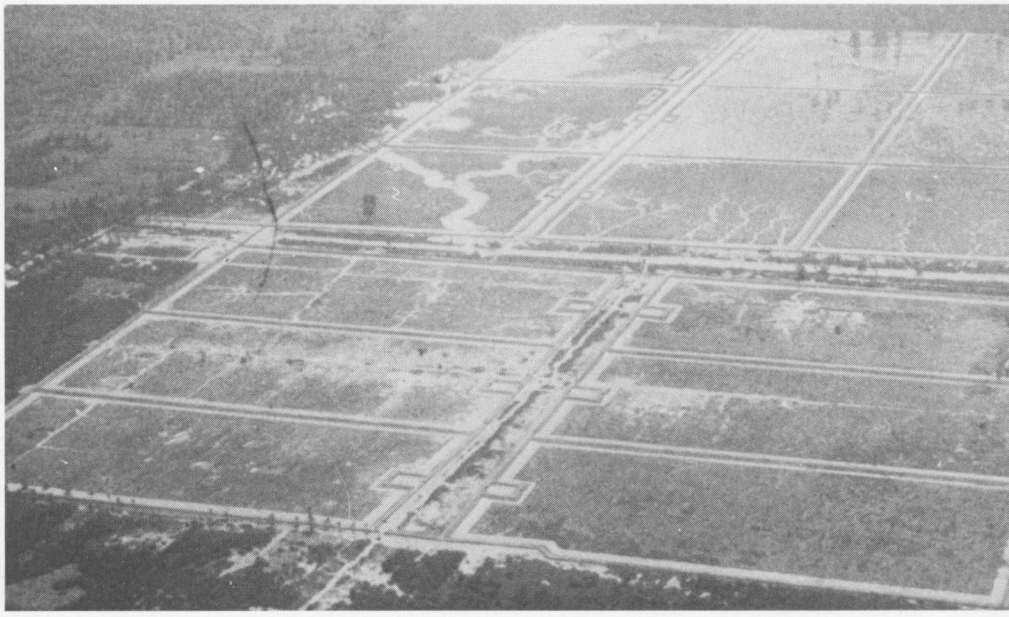
While the use of heavy equipment, where conditions permit its use, would help solve the problem of labor supply for pond construction, the cost may be higher than hand labor because of the lack of appropriate equipment, inadequate equipment maintenance and inexperienced operators. The use of heavy equipment together with hand labor, however, may be a requirement of large-scale area expansion activity, and means would have to be sought to ensure the effective and economic use of equipment.

Employment

Partial data on total tambak industry employment are available for Aceh, but baseline data for comparison with post-project employment are lacking. In addition to considerable temporary labor provided by pond construction and renovation activities, the tambak industry in Aceh provided full-time employment for approximately 7,423 fish farm owners, 2,300 farm owner family members, 2,560 fish farm caretakers, 500 shrimp processing workers, and 150 marketing workers. It is reasonably assumed that substantial new employment was created as a result of pond production increases, intensified collection and marketing of milkfish fry, and tambak area expansion by a reported 2,348 hectares. From 1978 to 1981 an additional increase of 6,000 hectares was reported by the Aceh Fisheries Service.

As a consequence of experience in North Sumatra it is estimated that the average labor requirement per four-hectare tambak unit is one family plus two man-months of annual labor per year. For pond construction 300 man-days is required per hectare for excavation (peripheral canal and dikes only), 125 man-days per hectare for clearing, and 10 man-days for gate construction. There is additional labor creation in the marketing, processing and input supply sectors, however, no means are available for quantifying these factors.

Pond gate construction (left), and pilot project ponds (right).



Field Trial Station

There is a need in the northern Sumatra project to obtain production data from controlled yield trials to determine productions possible under local conditions of soil, water and climate. This information is needed to support extension activities and provide data for budget projections for area expansion feasibility. Production trials would also provide additional learning experiences for project staff. Limited production trials have been conducted at PFDUs which were designed for demonstration, not field trials.

During the third year of the project a recommendation was made to construct a field trial facility. Over the next 2 years a site was selected and evaluated and the facility designed with the assistance of a consulting engineer with considerable experience in design of brackishwater ponds. Final drawings were prepared and Rp. 40,000,000 were made available by GOI for the first phase of development, consisting of fifteen 500-m^2 ponds, four 2,500-m^2 ponds, and buildings for laboratory, storage and housing.

Marketing

Project Paper estimates were that market demand was sufficient to absorb projected production increases resulting from the project in Aceh. Actual production increases, however, were nearly double the projections, and marketing difficulties were experienced by the fish farmers.

Efforts early in the project to locate export markets for milkfish were not promising. Visits to the Jakarta markets and discussions with officials there in 1978 established that demand was sufficiently high to absorb excess Aceh production. However, the attempt to establish marketing linkages was not successful.

In late 1980, a specialist from Auburn University (Dr. Gregory Sullivan) conducted a marketing study for milkfish and shrimp produced in tambaks in Aceh, and provided a comprehensive report of his findings. His recommendations focused on giving priority to market research in project analysis, providing an institutional framework at national and provincial levels for fish marketing, and expanding the role of tambak farmer associations in Aceh Province to include a direct involvement in marketing their produce.

The market for Aceh shrimp production is strong, both for local and export sale. Shrimp is thus an important tambak commodity, and there is a desire among tambak farmers to maximize production. The extent to which this can be done, however, is limited due to the unsuitability of some ponds (often too shallow) for shrimp culture, and limited natural occurrence of shrimp post-larvae in some areas.

Shrimp Hatchery

A shrimp hatchery for *Penaeus monodon* in the northern Sumatra area is regarded as essential to provide adequate numbers of shrimp post-larvae to shrimp producers. This is especially critical for North Sumatra province, as the economic feasibility of tambak area expansion will depend substantially upon the production of higher value shrimp.

Shrimp hatchery technology is established sufficiently to permit commercial scale operation, as has been demonstrated by the GOI hatchery at Jepara, Central Java. A hatchery for the northern Sumatra region would require a minimum production capacity of 5 million post-larvae per month. Construction cost would be approximately Rp. 300,000,000, and Rp. 200,000,000 would be required for annual operating expenses. The minimum skilled personnel needed would be one biologist technician, one maintenance technician and five skilled workers.

The French government has recently committed itself to assisting the GOI to develop a nationwide shrimp hatchery program to be funded by the Asian Development Bank.

Pumping Systems

The feasibility of pumping as opposed to excavation in high elevation/low tidal range areas was not thoroughly evaluated due to delays and problems with pump installation at the pilot project. The initial capital outlay for pumping appears to be much cheaper than excavation. However, continuing operational, maintenance and equipment depreciation costs must be considered and balanced against pond maintenance requirements incurred by excavation.

Pumping water from tidal channel to pond supply canal.

PROJECT REPORTS, REVIEWS AND PUBLICATIONS

(1) "ANNUAL REPORT - BRACKISHWATER FISHERY PRODUCTION PROJECT - INDONESIA", by Bryan L. Duncan and Michael C. Cremer, December, 1977.

(2) "TDY REPORT - INDONESIA BRACKISHWATER FISHERIES PRODUCTION PROJECT", by H.R. Schmittou, Auburn University, August, 1977.

(3) "MARKETING AND CREDIT PROBLEMS CONSTRAINING ATTAINMENT OF OUTPUT GOALS FOR BRACKISHWATER FISHERIES PRODUCTION PROJECT", by E.W. McCoy, Auburn University, August, 1977.

(4) PROJECT APPRAISAL REPORT (PAR), BRACKISHWATER FISHERIES PRODUCTION PROJECT, USAID, July, 1977.

(5) "FINAL REPORT - PHASE I - BRACKISHWATER FISHERY PRODUCTION PROJECT - INDONESIA", by Bryan L. Duncan and Michael C. Cremer, September, 1978.

(6) "EVALUATION OF MARKETING MILKFISH FROM LHOKSEUMAWAE TO JAKARTA, INDONESIA", by Michael C. Cremer, November, 1977.

(7) "TRIP REPORT - MILKFISH MARKETING SURVEY IN SINGAPORE", by Michael C. Cremer, August, 1978.

(8) "TAMBAK DEVELOPMENT PROGRAM FOR NORTH SUMATRA IN THE THIRD FIVE-YEAR PLAN", by Provincial Fisheries Service of North Sumatra, December, 1978.

(9) BRACKISHWATER FISHERY PRODUCTION IN ACEH AND NORTH SUMATRA. Proc. of Mangrove Forest Ecosystem Seminar, Jakarta, Indonesia. February 27 to March 1, 1978. pp. 162-164 by Bryan L. Duncan.

(10) "BRACKISHWATER AQUACULTURE DEVELOPMENT IN NORTHERN SUMATRA, INDONESIA", by Michael C. Cremer and Bryan L. Duncan. Research and Development Series No. 23, International Center for Aquaculture, Agricultural Experiment Station, Auburn University, Alabama. April, 1979.

(11) "REVIEW OF BRACKISHWATER AQUACULTURE PROJECT—SUMATRA", by D.D. Moss, Auburn University, February, 1979.

(12) "TRIP REPORT - BRACKISHWATER AQUACULTURE AND SEA FISHING NEAR MEDAN", by Donald K. Emmerson, Center for Southeast Asian Studies, University of Wisconsin, Madison.

(13) "ANNUAL REPORT - YEAR THREE - BRACKISHWATER FISHERY PRODUCTION PROJECT - NORTH SUMATRA, INDONESIA", by Bryan L. Duncan, October, 1979.

(14) "LAPORAN PROYEK PEMBINAAN PERIKANAN RAKYAT DAERAH ISTIMEWA ACEH (BRACKISHWATER FISHERY PRODUCTION PROJECT, TECHNICAL ASSISTANCE USAID)", by Dinas Perikanan Daerah Istimewa Aceh, 1979.

(15) PROJECT EVALUATION SUMMARY - BRACKISHWATER FISHERIES PRODUCTION PROJECT, USAID, 1979.

(16) BRACKISHWATER POND DEVELOPMENT IN SUMATRA, by B.L. Duncan. ICLARM Newsletter, Vol. 3, No. 4. October, 1980.

(17) "ADMINISTRATIVE REVIEW REPORT FOR BRACKISHWATER AQUACULTURE PROJECT AID/ASIA-C-1177", by E.W. Shell, Auburn University, December, 1980.

(18) "ANNUAL REPORT - YEAR FOUR - BRACKISHWATER FISHERY PRODUCTION PROJECT - NORTH SUMATRA, INDONESIA", by Bryan L. Duncan, November, 1980.

(19) PROJECT EVALUATION SUMMARY - BRACKISHWATER FISHERIES PRODUCTION PROJECT, USAID, 1980.

(20) "ECONOMIC ANALYSIS OF THE BRACKISH FISHERY PRODUCTION PROJECT", by Ernesto Lucas, USAID/Indonesia, 1980.

(21) "ANALYSIS OF THE STATUTE AND HOUSEHOLD RULES OF THE DIKE FISHERY PROJECT MANAGEMENT UNIT AT BEDAGAI", by Ernesto Lucas, USAID/Indonesia, 1980.

(22) "A MARKETING STUDY FOR MILKFISH AND SHRIMP FROM BRACKISHWATER TAMBAKS IN ACEH PROVINCE, SUMATRA, INDONESIA", by Gregory Sullivan, Auburn University, May, 1981.

(23) "REPORT OF AQUACULTURE ENGINEERING CONSULTANT", by Ricardo Hechanova, March, 1981.

(24) "THE INDONESIA BRACKISHWATER AQUACULTURE PRODUCTION PROJECT COMPLETION REPORT", by Bryan L. Duncan, August, 1981 (DRAFT).

(25) "AQUACULTURE TO PLAY IMPORTANT ROLE IN INDONESIA'S FUTURE", by Michael C. Cremer and Gregory M. Sullivan. Aquaculture Magazine, Vol. 3, No. 2, 1982.

PROJECT A. SCHEDULE OF FIXED COSTS (RUPIAH) - 48 HA SMALL-HOLDER ESTATE

Year	Amount of cap.[a] investment	Annual depreciation[b] equipment	Tax[c]	Maintenance[d] and repair	Total fixed costs
1.	Grace period		240,000		240,000
2.	22,638,400	300,000	240,000	1,878,536	25,056,936
3.	22,638,400	300,000	240,000	2,160,316	25,338,716
4.	22,638,400	300,000	240,000	2,484,364	25,662,764
5.	22,638,400	300,000	240,000	2,857,018	26,035,418
6.	22,638,400	300,000	240,000	3,285,571	26,463,971
7.	22,638,400	300,000	240,000	3,778,407	26,956,807
8.	-	300,000	240,000	4,345,168	4,885,168
9.	-	300,000	240,000	4,996,943	5,536,943

[a]Capital investment Rp. 93,926,000.
[b]Based on Rp. 600,000, depreciated over two years.
[c]Based on tax of Rp. 5,000 per hectare per year.
[d]Initially at 2% capital investment escalating at 15%/yr.

PROJECT A. SCHEDULE OF VARIABLE COSTS[a] (RUPIAH)

Year	Labor cost[b]	Cost of[c] fingerlings	Cost of[d] fertilizer	Cost of[e] pesticide	Total variable cost
2.	3,627,000	8,782,650	4,643,700	161,520	17,214,870
3.	4,171,051	10,100,048	5,340,255	185,748	19,797,101
4.	4,796,708	11,615,055	6,141,293	213,610	22,766,666
5.	5,516,214	13,357,313	7,062,487	245,652	26,181,666
6.	6,343,646	15,360,910	8,121,860	282,499	30,108,915
7.	7,295,193	17,665,046	9,340,139	324,877	34,625,255
8.	8,389,472	19,972,702	10,741,160	373,606	39,476,940
9.	9,647,892	22,968,607	12,352,334	429,646	45,398,481

[a]All costs escalating at 15%.
[b]At Rp. 90,000/ha.
[c]Milkfish @ Rp. 25 X 1950 (30% mortality) X 2 seasons X 40.38 ha.
Shrimp Rp. 6 X 10,000 X 2 X 40.38 ha.
[d]Organic fert. @ Rp. 25,000/ton X 3 ton/ha/yr X 40.38 ha; inorganic @ Rp. 100/kg X 20 kg/application X 20 appl/yr X 40.38 ha.
[e]Derris 2 appl/year X 4 kg/appl. X 500 kg. X 40.38 ha.

PROJECT A. PRODUCTION, PRICES, REVENUE OF TAMBAK PROJECT (RUPIAH)

Year	Production in kg/ha		Prices in Rp/kg[c]		Revenue from 40.38 ha		Total revenue 40.38 ha
	milkfish[a]	prawn[b]	milkfish	prawn	milkfish	prawn	
2.	600	150	1300 (800-1500)	3500 (2500-4500)	31,496,000	21,199,500	52,695,900
3.	642 (630-660)	173 (164-177)	1495 (920-1725)	4025 (2875-5175)	38,756,300	28,117,604	66,873,904
4.	687 (662-726)	198 (178-209)	1719 (1058-1894)	4629 (3306-5951)	47,686,882	37,009,996	84,696,848
5.	783 (695-799)	228 (194-246)	1977 (1217-2281)	5323 (3802-6844)	62,507,877	49,006,945	111,514,000
6.	837 (729-878)	262 (212-291)	2273 (1399-2623)	6121 (4373-7871)	76,822,990	64,757,487	141,580,000
7.	896 (765-966)	308 (231-343)	2615 (1609-3017)	7040 (5028-9051)	94,611,955	85,851,110	184,463,000
8.	958 (804-1063)	347 (252-405)	3007 (1850-3470)	8096 (5783-10,408)	116,322,000	113,440,000	229,762,000
9.	1025 (844-1169)	399 (274-478)	3458 (2128-3990)	9310 (6650-11,970)	143,124,000	149,999,000	293,123,000

[a]Based on 7% (5-10%) increase in yield.
[b]Based on 15% (9-18%) increase in yield.
[c]Based on 15% inflation rate.

PROJECT A. COSTS, REVENUE AND PROFITS AT CURRENT & CONSTANT PRICES (RUPIAH)

Year	Gross revenue	Gross costs	Gross profits	Net present value of: Revenue	Net present value of: Costs	Incremental profit
1.		240,000	-240,000		240,000	-240,000
2.	52,695,900	42,271,806	10,424,094	45,822,522	36,758,092	9,064,430
3.	66,873,904	45,135,817	21,738,087	50,566,279	34,129,162	16,437,117
4.	84,696,848	48,429,430	36,267,418	55,689,552	31,843,136	23,846,416
5.	111,514,000	52,217,084	59,296,916	57,175,300	29,855,288	27,320,012
6.	141,580,000	56,572,886	85,007,114	70,390,280	28,126,720	42,263,560
7.	184,463,000	61,582,062	122,880,000	79,748,400	26,623,600	53,124,800
8.	229,762,000	44,362,108	185,390,000	86,376,000	16,677,300	69,698,700
9.	293,123,000	50,935,424	242,180,000	95,822,400	16,650,800	79,171,600
			TOTAL:	541,590,000	220,664,000	320,926,000

PROJECT B. SCHEDULE OF FIXED COSTS-4 HA UNIT (RUPIAH)

Year	Capital investment[a]	Sluice gate depreciation[b]	Tax[c]	Maintenance[d]	Total fixed costs
1.	Grace period		20,000		20,000
2.	Grace period	69,000	20,000	200,000	289,000
3.	Grace period	79,350	20,000	230,000	329,350
4.	1,240,278	91,252	20,000	264,500	1,616,030
5.	1,240,278	104,940	20,000	304,175	1,669,393
6.	2,073,612	120,681	20,000	349,801	2,564,094
7.	2,073,612	138,783	20,000	402,271	2,634,666
8.	2,073,612	159,600	20,000	462,612	2,715,824
9.	2,490,280	183,540	20,000	532,004	3,225,824
10.	2,490,280	211,071	20,000	611,805	3,333,156
11.	2,490,280	242,732	20,000	703,575	3,456,587
12.	2,490,280	279,141	20,000	809,112	3,598,533
13.		321,013	20,000	930,478	1,271,491

[a]Capital investment Rp. 10,000,000/4 ha unit.
Repayment end-loaded at 10.5%/yr.
[b]Initial cost of sluice gate Rp. 300,000.
Depreciated over 5 years including 15% annual inflation.
[c]IPEDA tax @ Rp. 5,000/ha/yr.
[d]Initially at 2% of capital investment, escalating at 15% /yr.

PROJECT B. SCHEDULE OF VARIABLE COSTS - 4 HA UNIT[a]

Year	Labor[b]	Fingerling/ post-larvae[c]	Fertilizer[d]	Pesticide[e]	Total variable cost
1.					
2.	99,900	441,225	82,500	4,440	628,065
3.	114,885	507,409	94,875	5,106	722,275
4.	132,118	583,520	109,106	5,872	830,616
5.	165,623	738,153	138,019	7,428	1,049,223
6.	190,446	848,876	158,722	8,542	1,206,606
7.	219,036	976,207	182,531	9,823	1,387,597
8.	272,709	1,234,902	230,901	12,427	1,740,939
9.	319,616	1,420,137	265,536	14,291	2,019,580
10.	367,588	1,633,158	305,367	16,434	2,322,547
11.	454,958	2,065,945	386,289	20,789	2,927,981
12.	523,202	2,375,887	444,233	23,908	3,367,180
13.	601,682	2,732,212	510,867	27,494	3,872,255

[a]All costs escalating at 15%.
[b]At Rp. 90,000/ha.
[c]Milkfish fry @ Rp. 25 x 1,950 x 2 seasons x 1.11 ha
(1.21 ha by year 5, 1.31 ha by year 8, 1.41 ha by year 11).
Post-larvae @ Rp. 15 x 10,000 x 2 seasons x 1.11 ha, etc.
(as above).
[d]Rp. 25,000/ton x 3 ton/ha/yr. x 1.11 ha
for years 2 thru 4, etc. Inorganic
fertilizer Rp. 100/kg x 20 kg/application
x 20 applications/yr. 1.11 ha for years
2 thru 4, etc.
[e]Derris root, 2 applications/yr. x 4 kg/
application x 1.11 ha for year 2 thru 4, etc.

PROJECT B. PRODUCTION, PRICES AND REVENUE (RUPIAH)

Year	Production in kg/ha/year		Prices in Rp/kg[c]		Revenue from		Total
	milkfish[a]	shrimp[b]	milkfish	shrimp	milkfish	shrimp	
1.							
2.	600	200	900	4,500	599,400	900,000	1,499,400
3.	642	230	1,035	5,175	737,562	1,190,250	1,927,812
4.	687	264	1,190	5,951	907,458	1,571,064	2,478,522
5.	783	303	1,369	6,844	1,297,031	2,073,732	3,370,763
6.	837	349	1,574	7,871	1,594,100	2,746,979	4,341,079
7.	896	401	1,810	9,051	1,962,330	3,629,451	5,591,781
8.	958	461	2,082	10,409	2,612,868	4,798,549	7,411,417
9.	1,025	530	2,394	11,970	3,214,544	6,344,100	9,558,644
10.	1,097	530	3,753	13,766	3,956,254	7,295,980	11,252,234
11.	1,173	530	3,166	15,830	5,236,342	8,389,900	13,626,242
12.	1,255	530	3,641	18,205	6,442,932	9,648,650	16,091,582
13.	1,343	530	4,187	20,936	7,928,629	11,096,080	19,024,709

[a]7% increase in annual yield.
[b]15% increase in annual yield.
[c]15% inflation rate.

PROJECT B. GROSS REVENUE, COSTS AND PROFIT (RUPIAH)

Year	Gross revenue	Gross costs	Gross profit
1.		20,000	-20,000
2.	1,499,400	917,065	582,335
3.	1,927,812	1,051,625	876,187
4.	2,478,522	2,446,646	31,876
5.	3,370,763	2,718,616	652,147
6.	4,341,079	3,770,700	570,379
7.	5,591,781	4,022,263	1,569,518
8.	7,411,417	4,466,763	2,944,654
9.	9,558,644	5,245,404	4,313,240
10.	11,252,234	5,655,703	5,596,531
11.	13,626,242	6,384,568	7,241,674
12.	16,091,582	6,965,713	9,125,869
13.	19,014,709	5,143,746	13,880,963