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INLAND FISHERIES PROGRESS

IN THAILAND

1972

by

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INTRODUCTION

Dr. E. W. Shell and Dr. R. T. Lovell visited Thailand during the period October 1 - October 28, 1972 at the request of USOM and the Royal Thai Department of Fisheries. The purpose of the visit was to advise officials of the Department and to provide training sessions in various aspects of inland fisheries development. The two-man team visited a total of 11 fisheries stations in the Northeast, the North and the Central Plain. They were accompanied on these visits by several representatives of the Inland Fisheries Division.

This report was prepared for the purpose of assisting USOM evaluate the progress that is being made toward optimizing fish production in the country and to recommend future action by the Department of Fisheries for reaching that goal.

The section providing a synopsis of physical and biological data on the various Units and Stations which has been included in previous reports has been eliminated from this one. Although there have been minor changes in personnel and equipment at some of the Stations since the 1971 report was prepared, it was felt that the number of changes was not sufficient to merit including those 60 pages of detailed information again this year. This report also reviews recommendations made in previous reports beginning with the report by Swingle resulting from his visit in 1957.

ITINERARY

October 1 — Arrived Bangkok

October 2 — Conferences with Director of Inland Fisheries, Director-General of the Department of Fisheries and USOM.

October 3 — Reviewed research projects of Aquaculture Unit at Bangkhen Station, discussed the importance of review of project outlines in research planning, reviewed research of Survey Unit and discussed the role of survey-type information in management of public waters. Worked with Nutrition Research Group on problems related to pelleting of experimental rations.

October 4 — Discussed with the Survey Unit at Bangkhen Station the role of stocking, sanctuaries, gear restrictions and closed seasons in the management of large reservoirs, community reservoirs and irrigation tanks. Demonstrated technique of determining water stability of pelleted fish feeds.

October 5 — Worked on repair and evaluation of laboratory equipment at Bangkhen Station. Discussed pollution research needed with the Pollution Unit. Demonstrated the use of the microhematocrit centrifuge and discussed the use of the instrument in fish pathology for the Fish Disease Unit. Formulated and mixed moist feeds that could be preserved by fermentation.

October 6 — Discussed with the Survey Unit at Bangkhen Station the potential for trout stocking in Thailand and dangers involved. Reviewed data obtained from a study of the fish sanctuary of Bung Borapet Reservoir. Discussed the role of regulations in fishery management and the problem of enforcement of regulations. Discussed with the Nutrition Research Group, fish feed formulations that would result in lower ration costs and improved nutritional value.

October 7 Visited a Pla Duk Dan farm (Clarias batracus) and a Pla Salid (Trichogaster pectoralis) farm south of Bangkok.

October 9 Reviewed hatchery production, fingerling distribution, research projects and extension work at Nong Khai Station.

October 10 Reviewed research projects at Ubon Ratana Reservoir Station. Discussed methodology used in fish biology studies. Discussed the setting of priorities on research in large reservoirs.

October 11 Reviewed hatchery, research and extension activities at Khon Kaen and Maha Sarakham. Reviewed research projects at the Northeast Center. Discussed the role of the Northeast Center in solving problems related to fishery management in the Northeast.

October 12 Lectured at Khon Kaen Station to biologist from the Northeast on the following subjects:

1. Role of research in increasing food fish production and income.
2. Principles of research planning
3. Design of production experiments
4. Nutrient requirements of fish
5. Sources of nutrients in feedstuffs
6. Design of fish nutrition experiments

October 13-14 Reviewed hatchery, research and extension activities at Nakhon Ratchsima and Chai Nat Stations. Visited farmers growing fish in cages attached to houseboats.

October 15 Reviewed the data collected before and during the draining of Bung Borapet Reservoir. Discussed the further evaluation of the draining project and the management of reservoir. Visited a farmer who produces Pla Sawai (Pangasius sutchi) fingerlings by pituitary injection and who grows the species for market.

October 16 Reviewed hatchery, research and extension activities at Tak Station.

October 17-18 Traveled by boat from Bhumiphol Dam to Amphur Hod, south of Chieng Mai. Enroute discussed reservoir management and relevant research with biologists.

October 19 Reviewed hatchery, research and extension activities at Chieng Mai Station. Visited waterfall in edge of mountains to evaluate possibilities for trout culture. Visited ponds constucted by Police for producing fish to be given to Hill Tribes.

October 20 Repeated series of lectures given on October 12 at Khon Kaen to biologists from the North Region assembled at Chieng Mai Station.

October 24 Reviewed hatchery production, fingerling distribution and research projects of the Pattani and Prachuap Khiri Khan Stations with Station personnel visiting in Bangkok. Reviewed progress of project with Dr. Johnson of the Rockefeller Foundation.

October 25 Repeated series of lectures given at Khon Kaen and at Chieng Mai Stations for biologists at Banghen and from the South.

October 26 Visited with the Deputy Director General of the Fisheries Department. Discussed with Station personnel visiting Bangkok research projects of the Prachuap Khiri Khan and Chantiburi Stations. Reviewed work of the various extension groups and discussed the role of extension in aquacultural development. Visited commercial feed processing company to obtain information on prices of feed ingredients and processing capabilities. Visited Technology and Processing Laboratory of Department of Fisheries.

October 27 Discussed the problems of inland fisheries development with the Undersecretary of Agriculture. Reviewed the results of the visits to the various stations with the Research Reveiw Committee of the Inland Fisheries Division. Discussed proposed changes in research administration and establishing priorities for research in aquaculture and in large and small reservoirs. Discussed the implications of visit with Drs. Riggs, Fowler and Stone of USOM. Visited with Drs. Denning and Johnson of the Rockefeller Foundation.

RECOMMENDATIONS

1. The Research Review Committee of the Inland Fisheries Division should accept more responsibility for review, coordination and supervision of research efforts on the various stations. Many errors noted in the design and conduct of a number of production experiments could have been avoided by a more strenuous review procedure. The Committee should also take a more active role in deciding research priorities and in actual planning of experiments.

2. Research to develop effective cultural systems for the major food fishes which utilize resources (feeds, fertilizers, ponds and markets) available to farmers should continue to receive the highest priority.

3. It is recommended that in the design and conduct of future production research that considerable attention be given to the following aspects of the experiments:

   a. Number of fish stocked
   b. Duration of the experiment
   c. Size of fish stocked
   d. Control of poachers and prevention of fish kills
   e. Control of reproduction in Pla Nin (T. nilotica)

4. Less research emphasis should be directed toward learning to spawn new species of fish with pituitary injection. Once it is possible to spawn the primary food fishes, more attention should be directed to learning to grow the recently spawned fish to stocking size with low mortality rates.

5. The Bangkhen Fisheries Station processes pelleted fish feeds for all of the Department of Fisheries research stations in Thailand. The physical quality of the pellets is inadequate for research use because of lack of steam required in pelleting feeds. It is recommended that funds be provided for puchasing a steam generator capable of producing 30 lbs. of steam per hour as described in this report.

6. Research should be intensified to develop feed formulations and feeding methods for Pla Duk Dan (C. batrachus), Pla Sawai (P. stuchi) and Pla Nin (T. nilotica) and Pla Nai (C. carpio).

7. Technology studies with farm-cultured freshwater fish should be conducted to develop preserved fish products for human consumption such as fermented fish. In this respect, the Inland Fisheries Division should seek cooperation with the Fish Technology Diivision of the Department of Fisheries and Fish Products Technology Laboratory at Kasetsart University.

8. The present fingerling stocking policies of the Division should be reviewed to determine methods of increasing the contribution of stocked fish to the food supply of Thailand; especially of those fish stocked in swamps, irrigation projects and village reservoirs.

9. The Division should encourage the development of a viable fish fingerling production industry in the country. Private fish farmers should be encouraged to develop the methodology and technology necessary to produce and distribute large numbers of fingerlings for stocking.

10. The Village Reservoir Program should be viewed as one means of replacing part of the swamp and flood fisheries that may be lost as a result of flood control and irrigation development schemes.

11. Considerable research effort is needed to develop management methods for Village Reservoirs that will allow harvest of fish over a longer period of time and that will provide for greater return of stocked fish to the fishermen.

12. The research project to determine the effect of draining and refilling Bung Borapet Reservoir should be continued, although it is hoped that the continuation of the project will not be as disruptive of the entire fisheries program of the country as was the initiation of the project.

13. The use of gill nets, trap nets and seines should be legalized in Bung Borapet Reservoir and research should be initiated to determine the most effective sizes of these types of gear.

14. Strong consideration should be given to the eventual elimination of the sanctuary in Bung Borapet Reservoir.

15. Data should be collected on the amount of effort required to make the present catches in the large reservoirs.

16. Estimates should be obtained of the amount of fish being consumed by fishermen and farmers living on and adjacent to the large reservoirs that do not go into normal commercial channels.

17. Primary emphasis of research on the large reservoirs at this time should not be on biology of species or on limnology but rather on methods of aiding the fishermen to increase his catch with less effort and to obtain a fair price for his catch.

18. An in-depth review and evaluation should be made of inland fisheries extension and its relationship to fisheries research and to fishermen and fish farmers.

19. A thorough review is needed of the information that is being provided to fish farmers to ascertain whether it is accurate and whether it is being presented in a manner that can be understood and followed by the farmers.

20. The Mission of the Biological Survey Unit should be changed to include research of an applied nature. It is suggested that this Unit be given the responsibility of coordinating the management research previously recommended on swamps, village reservoirs and irrigation projects and of actually conducting much of the research.

21. USOM should provide fellowships for two biologists to study abroad for Ph.D.'s in aquaculture. On their return they should be assigned to the Office of the Chief of the Division to aid in the coordination and supervision of the aquaculture research program. It is not recommended that these men replace the Research Review Committee but rather that they serve as staff support for the Committee.

22. Some means should be found to increase the level of training of the Faculty of Fisheries at Kasetsart University and that an effort be made to involve the Faculty in research to solve problems in inland fisheries.

23. It is recommended that the program of review and instruction by outside consultants be continued. Emphasis for future reviews and instruction should be on research planning, extension methods and management research for large reservoirs, swamps, village reservoirs and irrigation projects.

REVIEW OF RECOMMENDATIONS OF PREVIOUS REPORTS

Dr. H. S. Swingle (1957) prepared the first report on the Fisheries Program of Thailand by an Auburn University staff member. He visited Thailand in 1957 at the invitation of the Director-General of Fisheries. His report summarized the status of inland and brackish water fisheries in Thailand and recommended a number of measures that should be taken to improve the Inland Fisheries Division and to increase the service of the Division to the people.

The next report in the series was produced by Swingle and Moss. They visited the country in 1968 at the request of USOM-Thailand to survey the inland fisheries. In this report they suggested that USOM provide consultant and advisory services to the Department of Fisheries.

H. S. Swingle and R. O. Smitherman (1969) were the first Auburn staff members to visit Thailand to provide consultant and advisory services at the request of USOM. Each year since 1969 at least one group of consultants has gone to Thailand at the request of USOM. Each group has focused on problems affecting the effectiveness of the fisheries research and extension programs. Each visit has resulted in the writing of a report detailing the problems, and the progress encountered and suggesting courses of action for improving the capability of the Inland Fisheries Division to solve their own problems. A list of the reports follows:

1. H. S. Swingle, 1957. Report to Department of Fisheries, Bangkok, Thailand
2. H. S. Swingle and D. D. Moss, 1968. Report of Fishcultural Investigations in Thailand.
3. H. S. Swingle and R. O. Smitherman, 1969. Report on Extension and Research at the Fisheries Stations of Thailand.

4. H. S. Swingle and R. O. Smitherman, 1969. The Marine and Coastal Stations of Thailand.

5. H. S. Swingle, G. B. Pardue, R. O. Smitherman, D. D. Moss, H. R. Schmittou and W. A. Rogers, 1970. The Inland Fisheries Program of Thailand.

6. H. S. Swingle and Ray Allison, 1970. The Inland Fisheries Progress in Thailand.

7. H. S. Swingle and E. W. Shell, 1971. Inland Fisheries Progress in Thailand.

The reports prepared by Auburn staff members have covered a variety of subjects and have included a number of recommendations; however for purposes of summarization most of the recommendations can be loosely organized into several general subject matter groups. The recommendations will be summarized in the following sections.

Management of the Fisheries of the Rivers, Swamps and Reservoirs

When Swingle (1957)1/ first visited Thailand, there was relatively little interest in fish culture, except to culture fingerlings for release into rivers, swamps and irrigation reservoirs. There were relatively few farmers in the country growing fish for food. Most of the work of the small fisheries staff was on the fish and fisheries of rivers, swamps and irrigation tanks. Several of Swingle's recommendations in that first report concerned the research required to provide information needed to manage those waters.

Relatively little attention was given to the management of natural or public waters in later reports. Swingle and Moss (1968) called attention to the potential loss of a large portion of the important flood fisheries in the Central Plain as a result of irrigation and flood control projects and they suggested that compensating measures could be taken by constructing small dams

1/ The citations refer to the reports listed above.

across swamps to maintain the water level so that the swamps could be managed intensively for fish production. Swingle and Allision (1970) suggested that an effort be made to determine the inland fisheries catch for the country as a means of demonstrating the importance of the inland catch to the food budget of the country.

Village Reservoir Program

Each report beginning with 1969 (Swingle and Smitherman) emphasized the importance of the Village Pond or Reservoir Program. The program was described in detail in that report. It was suggested that USOM participate in the development of these reservoirs throughout the country. Swingle and Shell (1971) urged that considerable research effort be devoted to learning to manage these waters. They also called attention to the major problems that should be solved in order to manage those waters effectively.

Research Facilities

Each of the reports has urged that research facilites be expanded. It was suggested that a central research facility be located at Bangkhen Station near Bangkok and that the number of ponds available for research there be increased. It was also recommended that regional research centers be established at Sakol Nakorn, Kohn Kaen and Chieng Rai. Bangkhen Station was suggested as the site for establishing a laboratory for research on fish feeds and feeding and a laboratory for research on fish pathology (Swingle, et al, 1970).

The shortage of research equipment at several stations was noted in earlier reports. It was recommended that USOM aid in the purchase of this equipment including two Jeeps and one truck per station.

The 1969 report by Swingle and Smitherman recommended that the water supplies at Sakol Nakorn and Bangkhen be improved. Because of leaking ponds they suggested that the Ubon Rajthani Station be moved to a more suitable site nearby.

Aquaculture

Because of the potential for fishculture in Thailand, much attention has been given to fish culture in the reports. In 1957, Swingle suggested that testing of native species for potential in fishculture be started and that a study of methods of growing rice and fish together also be initiated. In every report since 1957 it has been recommended that research effort on every phase of fish culture be increased to determine the best species of fish to grow using inorganic and organic fertilizers and feeds. In the 1970 report, Swingle and Allison suggested that experiments be conducted on the use of various species of fish that could be grown in combination that would utilize more fully both the natural foods produced in fishculture ponds and the processed feed added to the ponds. Swingle and Shell (1971) recommended that priority be given to research to develop reliable culture methods for the following species of fish:

Pla Mor Thai, Anabas testudineus
Pla Soong-Hue, Aristichthys nobilis
Pla Duk Dan, Clarias batrachus
Pla Duk Uey, Clarias macrocephalus
Pla Choa-Hue, Ctenopharyngodon idella
Pla Nai, Cyprinus carpio
Pla Lin-Hue, Hypophthalmichthys molitrix
Pla Bu Sai, Oxyeleotris marmoratus
Pla Sawai, Pangasius sutchi
Pla Nin, Tilapia nilotica

Research Organization and Procedures

In his 1957 report, Swingle suggested the use of project outlines for all research projects. He recommended that these outlines be prepared by the Project Leaders and that they be discussed in detail with other biologists before beginning the research. Swingle and Moss (1968) recommended that the Department of Fisheries develop a procedure whereby the faculty of the College of Fisheries at Kasetsart University could be involved in research to solve practical fisheries problems.

Several of the reports have recommended that the entire aquaculture research program be coordinated from the Division Office in Bangkok. It was suggested that because of the relatively small number of ponds available for research at any one station, without coordination of research efforts, rapid progress would be impossible.

One report recommended that two fellowships be provided by USOM for study at the Ph.D. level. When these workers returned they would be responsible for improving and coordinating the research program.

Hatcheries and Hatchery Management

Swingle and Moss (1968) suggested that only half of the ponds available would be needed to produce fingerlings for stocking if improved hatchery methods were used and wiser use was made of the fish produced. Other reports have also recommended more intensive management of hatchery ponds.

Swingle and Allison (1970) recommended that fingerlings be grown in cages and that rice fields might also be used for this purpose. Because of the high rate of loss resulting from stocking small fingerlings in reservoirs already containing fish, Swingle and Shell (1971) recommended that methods be developed for producing larger fingerlings.

Training

Most of the reports have recommended that the Division implement plans for additional training for its technical people. Swingle (1957) recommended that the biologists be brought together each year to discuss problems and to "learn new things". Later reports have suggested periodic short courses conducted by Thai specialists and consultants from Auburn University for all research and extension personnel. Several reports recommended that USOM provide a number of fellowships for study abroad for biologists. At least two of these fellowships should be for the Ph.D. The fellowships should be awarded so that biologists would be trained in supporting areas such as fish nutrition and fish pathology, as well as in the traditional areas of limnology, fisheries biology and fisheries management.

Extension

Several reports discussed the important role to be played by extension in the development of fisheries and aquaculture in the country. The reports also stressed the need for additional training for all extension workers.

Swingle and Smitherman (1969) noted that one of the major problems with the extension effort was lack of information to extend. They recommended more research effort to develop practical methods and procedures for fish cultures. They also reported the need for research demonstration ponds where the correct methods of producing fish could be demonstrated, and that extension personnel should be assigned to the research stations so they would be aware of the advances being made in aquaculture.

Swingle and Shell (1971) suggested that extension work be reorganized to eliminate duplication of effort and poor coordination. They also recommended that extension manuals be rewritten so that they are more attractive and useful to the farmer and to include recent advances in fish farming.

Several reports recommended that USOM aid the extension effort by providing Jeeps and trucks for transportation for extension workers.

Publications

Beginning with Swingle's (1957), each report has included the suggestion that some of the results of research projects be translated into English for publication in International Journals. It was suggested that all research reports presented in the Annual Reports of the various stations have a summary in English.

USOM and the Inland Fisheries Division have made considerable progress implementing many of the actions recommended in the various reports. A few of these accomplishments are described below.

USOM has provided Jeeps and trucks for many of the Stations. They have also supplied considerable equipment for Laboratories and Stations throughout the country. A number of fellowships have been provided for Thai fishery biologists to study in the U.S. for advanced degrees. USOM has provided funds each year since 1969 for 2 or 3 consultants from Auburn University to visit the country to review the progress made in the Inland Fisheries Program and to provide instruction and advice on several aspects of aquaculture.

The Inland Fisheries Division has initiated the use of project outlines for all research projects and has established a Research Review Committee to evaluate the proposals. The Division has constructed a number of additional ponds to be used as hatchery and research ponds at almost every station and although fund are limited, the construction of ponds is continuing. The Village Reservoir Program is being advanced as rapidly as possible with the funds available. With machines provided by USOM, the Division is pelleting experimental rations and distributing them to the various Stations for research on nutrition. Although much additional work is needed, considerable progress has been made in developing procedures that farmers can use for the culture of a number of native and introduced fishes. Farmers in many parts of the country are already using methods developed through research on the Stations. Improved hatchery management prodedures are being used at all of the Stations. More fingerlings for stocking are being produced each year. As a result of improved hatchery management, more ponds are being made available for research.

There is little doubt that as a result of the cooperation between USOM and the Inland Fisheries Division plus the technical contributions provided by the staff of the International Center for Aquaculture at Auburn University, the Division is more nearly capable of solving its own problems than it would have been without this cooperative effort. Although a number of problems still exist, the Division is making significant progress toward its goal to develop and manage inland fish as a significant national resource.

REVIEW OF THE AQUACULTURE RESEARCH PROGRAM

Introduction

During the visit to Thailand, aquaculture research being conducted at each station was reviewed. Research at eight stations was reviewed during visits to these stations. Research conducted at an additional seven stations was reviewed during discussions with heads of stations and biologists from those stations invited to conferences at Khon Kaen, Chieng Mai or Bangkhen.

Research project leaders at most of the stations had prepared summaries of their projects prior to our arrival. Most of the research projects were discussed in detail. All aspects of the projects were discussed including the purpose of the project, the objectives and results. Where there were obvious problems in experimental design or in experimental procedures these were discussed.

A total of 43 aquaculture research projects were reviewed in detail. This number includes only those projects completed between October 1, 1971 and Septmeber 30, 1972, or projects in which significant information was obtained during that period. The number and type of projects reviewed at each station are presented in Table 1.

Table 1. Aquaculture Research Projects Completed at Different Stations[1/]

Station	Field of Research					
	Production	Breeding	Biology	Nutrition	Diseases	Totals
Bangkhen	7	4	4	5	3	23
Chai Nat	0[2/]	1	0	0	0	1
Chantiburi	2	0	0	0	0	2
Chieng Mai	2[3/]	1	0	0	0	3
Chieng Rai	0[4/]	0	0	0	0	0
Maha Sarakam	2	0	0	0	0	2
Nakon Sawan	1	0	0	0	0	1
Nong Kai	2	0	0	0	0	2
Nakorn Rajsima	0	0	0	0	0	0
Pattani	2	0	0	0	0	2
Prachuap Khiri Khan	1	0	0	0	0	1
Surin	2	0	0	0	0	2
Tak	0	1	0	0	0	1
Udorn Thani	1	0	0	0	0	1
Totals	24	7	4	5	3	43

1/ Includes projects completed in 1971-1972 or of projects on which significant information has been collected.

2/ Three projects initiated but all were terminated without results.

3/ Includes one project for which only partial data are available.

4/ One project initiated but was terminated without results.

More than half of the projects were conducted at Bangkhen. Except for Bangkhen where 23 projects were completed, the average number of projects completed was 1.3 per station. Table 2 includes data on the number of biologists, the number of ponds and the area of ponds at each station. At Bangkhen the average of projects completed per biologist was 3.8. In the remainder of the stations the average production of completed research projects per biologist was 0.6. In terms of research productivity per biologist, Bangkhen was some six times as productive as the other stations. Many of the projects at Bangkhen were of relatively short duration but the duration of projects alone does not account for the difference in productivity.

There are differences between stations in the number of pond units, earthen and concrete, available for research (Table 2). Bangkhen has a large number (130) of small concrete ponds which are used in nutrition and disease experiments; however, a number of stations have more earthen ponds.

All stations produced fingerlings for distribution to farmers. This activity competed to some degree for the use of ponds, labor and equipment; however, except in the case of the smaller stations such as Nakorn Rajsima the use of ponds for producing hatchery fish did not completely prevent their use for research.

There is considerable research emphasis at Bangkhen. The presence there of a biologist with graduate training in aquacultural research contributes to the emphasis on research and to the research productivity of the station. As more biologists with graduate degrees return to Thailand from the U.S. and are assigned to work at the various stations it is expected that the research

Table 2. Number of Biologists, Ponds and Area of Ponds at each Station

Station	Number of Biologists1/	Number of Ponds		Area (rai) of Ponds	
		Earthen	Concrete	Earthen	Concrete
Bangkhen	6	32	130	15.80	10.50
Chai Nat	2	56	26	15.10	0.40
Chantiburi	2	31	5	172.00	0.03
Chieng Mai	2	38	39	14.96	0.24
Chieng Rai	2	14	27	6.29	0.39
Khon Kaen	2	56	41	30.40	0.16
Maha Sarakam	3	21	13	5.12	0.12
Nakon Sawan	3	16	2	6.45	0.57
Nong Kai	2	44	20	22.00	0.12
Nakorn Rajsima	2	13	14	2.12	0.26
Pattani	2	56	20	10.50	0.12
Prachuap Khiri Khan	2	43	0	43.88	-----
Sakon Nakorn	3	41	43	19.16	0.41
Surin	2	36	20	11.00	0.35
Tak	4	31	30	11.88	0.16
Ubon Ratchathani	2	10	61	1.80	3.73
Udon Thani	2	19	52	6.07	0.32

1/ Number does not include the Head of the Station.

productivity at all stations will increase.

Table 1 also contains information on the type of research projects conducted at each station. The classification is somewhat arbitrary but does provide a general basis for evaluating projects. The following table summarizes the data from Table 1.

Type of Project	Percentage of Projects
Production	55.8
Breeding	16.3
Nutrition	11.6
Biology	9.3
Disease	7.0

As the data in the table indicate most of the research effort was on production. Although most of the research has been in production, it should be increased in the future. Until research-proven methods that fish farmers can use are available, considerably more effort should be devoted to production research.

Considering only the 24 production experiments, the following table summarizes the type of experimental unit in which the experiments were conducted.

Type of Experimental Unit	Number of Experiments
Ponds	16
Cages	4
Rice Fields	2
Pens	1
Raceways	1
	24

As indicated in the previous table most of the research was conducted in ponds. Cage culture, especially along the major rivers, has some potential

Table 3. Species Used in Aquaculture Research

	Type of Research					
	Production	Breeding	Biology	Nutrition	Diseases	Totals
Pla Mor Thai						
Anabas testudinaeus	0	0	0	1	0	1
Chironomus sp.	1	0	0	0	0	1
Pla Nuan Chan						
Cirrhinus microlepis	0	1	0	0	0	1
Pla Duk Dan						
Clarias batrachus	3	0	0	0	0	1
Pla Duk Uey						
Clarias macrocephalus	1	0	0	0	0	1
Pla Choa-Hue						
Ctenopharyngodon idella	1	0	0	0	0	1
Pla Takok						
Cyclocheilichthys enlopes	1	0	0	0	0	1
Pla Nai						
Cyprinus carpio	5	2	1	3	0	11
Pla Mortan						
Helostoma temminckii	0	0	1	0	0	1
Labeo rohita	1	0	0	0	0	1
Labeo bicolor	0	1	0	0	0	1
Pla Kapong						
Lates calcarifer	1	0	0	0	0	1
Macrobrachium rosenbergi	2	0	0	0	0	2
Pla Chon						
Ophicephalus striatus	1	0	1	0	1	3
Pla Bu Sai						
Oxyeleotris marmoratus	1	0	1	0	0	2
Pla Thepa						
Pangasius sanitwongsei	1	0	0	0	0	1
Pla Sawai						
Pangasius sutchi	3	1	0	0	0	4
Pla Tapak						
Puntius daruphani	0	1	0	0	0	1
Pla Morted						
Tilapia mossambica	1	0	0	0	0	1
Pla Nin						
Tilapia nilotica	8	0	0	1	0	9
Totals	31 1/	6	4	5	3	49

1/ More than one species used in some experiments.

for future development, but the primary need now is to develop reliable pond culture methods as quickly as possible. Future research should continue to emphasize experiments in ponds, but research in cages should be continued.

Table 3 includes information on the various species of animals utilized in research. Altogether experiments were conducted on 18 species of fish. Almost half of the experiments were conducted on two species, Pla Nai, C. carpio (11 experiments) and Pla Nin, T. nilotica (9 experiments). It is interesting that neither of these fish are native to Thailand; however they do bring a good price in the markets. In most cases these species sell for a higher price than any of the native species.

Only two of the native species were used in more than three experiments. Pla Sawai, P. sutchi was used in four experiments and Pla Duk Dan, C. batrachus was used in five experiments.

The amount of research effort devoted to the two non-native species is a function of the present economic value of those species. Present economic value is only one criterion to be used in assigning research priorities. There are others that should be considered. For example, there are few species of fish in the world that have the potential of Pla Duk Dan, C. batrachus for production of protein per unit volume of water. The value per kilo of this species may be somewhat lower than for Pla Nai or Pla Nin, but those species have only a fraction of the potential for protein production. More research effort should be directed toward developing effective culture techniques and feeds for Pla Duk Dan that can be applied throughout Thailand. Now, the culture of the species is confined to the coastal area south of Bangkok because the supply of trash fish used as feed is available only there.

Most of the 24 production research projects involved the use of only a single species (Monoculture). Only five of the experiments were devoted to polyculture. It has been demonstrated many times that the use of polyculture leads to higher total production of fish. In many cases, the addition of a secondary species to a culture system may actually increase the production of the primary species of the culture with little additional cost. In such cases, the production obtained from the secondary species may be obtained virtually "free-of-cost". These fish may, in turn, be sold at a lower price, which hopefully might place them in the price range where poor people can afford to purchase them. More experiments should be devoted to polyculture in the future.

Fish Production Research

To this point, this review has been primarily concerned with some of the quantitative aspects of the program. The quantitative aspects of the program are important, but of greater importance is the quality of the research program. One experiment designed and conducted in such a way as to provide significant information on a question of importance is more valuable than any number of poorly designed and conducted experiment. It is somewhat difficult to evaluate the quality of a research program, but an evaluation must be attempted if there is to be any improvement in the program.

Standards by which an experiment can be evaluated are difficult to develop; however, it is somewhat less difficult to evaluate production experiments than other types of aquaculture experiments because the primary aim of this type of research is to develop methods for producing the maximum weight of fish of harvestable size per unit area of water. A production experiment that fails to result in high production of fish of harvestable size may be considered to be a poorly designed and/or poorly conducted.

For an evaluation of the quality of research, 18 production experiments were considered. Some characteristics of these experiment were as follows:

	Number of Experiments with:	
Species	Feeding	Fertilization
Pla Nai (*C. carpio*)	3	2
Pla Sawai (*P. sutchi*)	6	-
Pla Nin (*T. nilotica*)	3	4

Criteria used in evaluating production experiments are presented in Table 4. Fish smaller than the harvestable sizes listed are consumed in Thailand, but these are the minimum harvestable sizes that can be marketed without taking a reduction in price. Most of the Pla Sawai on the market, for example, are large fish taken from the rivers. These fish are too large for a single buyer; consequently they are cut into relatively small pieces before being sold. Farm-produced fish must also be large enough that they can be cut into similar sized pieces as those fish from the rivers. Farm-produced fish less than approximately 1000g would be too small for this purpose. Many of the Pla Nai are purchased to be cooked whole, Chinese style. A 500g fish is acceptable for preparation in this way. Fish of 200-300g would not be.

Table 4. Minimum Harvestable Sizes and Minimum Production for Acceptable Experimental Results.

Species	Minimum Harvestable[1/] Size	Acceptable Production With Feeding	Acceptable Production With Fertilization
Pla Nai (*C. carpio*)	400 g	200 kg/rai (1250 kg/ha)	56 kg/rai (350 kg/ha)
Pla Sawai (*P. sutchi*)	1000 g	450 kg/rai (2812 kg/ha)	100 kg/rai (625 kg/ha)
Pla Nin (*T. nilotica*)	200 g	560 kg/rai (3500 kg/ha)	192 kg/rai (1200 kg/ha)

1/ The minimum harvestable depends to some extent on local market conditions, on who will utilize the fish and how it will be prepared.

Experiments designed or conducted in such a way so that the fish produced are significantly smaller than those sizes listed would represent poor use of research resources. The production criteria are conservative estimates of results already obtained with these fish either in Thailand or in other countries. Research that results in production significantly less than those listed would not contribute much information on aquaculture.

The results of the evaluation of the experiments are presented in Table 5. In only 2 of 18 production experiments were fish of harvestable size produced in sufficient quantity to conclude that the experiment contributed useful information. In an additional experiment, fish of harvestable size were produced but production was too low. In four experiments, production was acceptable, but the fish were too small. Of the 18 production experiments, 11 experiments resulted in virtually no information that fish farmers might use. The experiments in which little or no information was obtained involved the use of over 40 ponds and 32 cages and required a major portion of the time of 11 biologists.

There were a number of reasons why the experiments resulted in poor results. Some of the reasons are summarized as follows:

Stocking rate too high--This error was made in 8 of the 18 experiments. In these cases, the stocking rate was so high that it would have been virtually impossible to have grown the fish to harvestable size. For example, in a series of experiments with Pla Sawai (P. sutchi), the fish were stocked at a rate of 2 fish/m^2 (3200/rai, 20,000/ha). If all of those fish had grown to the harvestable size of 1000 g each, the standing crop would have been 3200 kg/rai (20,000 kg/ha). Assuming a feeding rate of 2% for fish of that size, at

Table 5. Number of Experiments with Acceptable Criteria

Criteria	Pla Nai (*C. carpio*)	Pla Sawai (*P. sutchi*)	Pla Nin (*T. nilotica*)	Totals
Experiments in which fish were of harvestable size but production was unacceptable	1	0	0	1
Experiments in which production was acceptable but fish were not of harvestable size	0	4	0	4
Experiments in which fish were of harvestable size and production was acceptable	0	0	2	2
Totals	1	4	2	7

the time the fish reached a weight of 1000g each, 64 kg of feed per raii (400 kg/ha) would be required each day. This rate of feeding would have exceeded by a factor of eight, the maximum safe feeding rate for fish in standing water ponds. In those experiments, total production was acceptable. The average standing crop at draining was 473 kg/rai (2956 kg/ha); however, none of the fish were larger than approximately 180g after 9 months in the pond.

Experimental period too short--In 5 of the 18 experiments the experimental period was much too short. In one experiment involving Pla Nai (C. carpio), the experiment lasted for 60 days. At the end of this period the fish were only a little larger than when they were stocked. In four other experiments, it would have been virtually impossible for the fish to have reached harvestable size in the experimental period.

Stocked fish too small--Size of fish to stock is related to the length of the experimental period. If small fish are stocked, the period required to reach harvestable size is much longer than if larger fish are stocked. In four, experiments, fish were stocked at such a small size that they could not grow to a harvestable size in an experimental period of reasonable length. In one experiment, Pla Nin (T. nilotica) were stocked at a length of 4.7 cm into a pond with Pla Chon (O. striatus) which had previously been stocked at a length of 16.8 cm. The objective of the experiment was to allow the Pla Nin to reproduce. Then the Pla Chon would feed on those young fish. Unfortunately, the size of the Pla Nin brood stock was so small that most of them were eaten by the Pla Chon.

Lack of a control for reproduction--This error was repeated in 5 of the 7 experiments involving Pla Nin (T. nilotica). In those five experiments, total production was acceptable, but the percentage of marketable fish produced in the experiments was too low. There were so many small fish available that the original stock of fish did not grow well.

Stocking rate too low--This error was evident in two experiments. In those cases the fish were stocked at such a low rate that although they grew at an acceptable rate, total production was too low.

Death of fish or loss to poachers--Two experiments resulted in little or no information because of the death of all the fish in one experiment and such variable survival in the other that conclusions were impossible.

As noted previously, relatively few of the production experiments completed in 1971-1972 resulted in information that can be used by fish farmers. A more effective review of project outlines by the Research Review Committee should result in better experiments. A number of the problems in the experimental designs noted earlier should have been pointed out by the Committee after reviewing the project proposals.

If possible, members of the Committee should also help with the planning of projects before the formal proposals are prepared. This Committee should also establish research priorities. For example, fish farmers in Thailand are enthusiastic about the production of Pla Nai (*C. carpio*) and Plan Nin (*T. nilotica*) because of the market price of these species. Developing effective cultural systems which utilize resources (feeds, fertilizers, ponds and markets) available to farmers should receive highest priority. A similar recommendation was made by Swingle and Shell (1971).

The lack of an adequate library at most of the Stations also contributed to some of the problems observed in the research. Many stations have only a few textbooks or books of a general nature. Biologists attempting to prepare a Review of Literature of a Project Outline have virtually no literature to review. It would be much too expensive to provide each station with even a small library, but some mechanism is needed to provide biologists with books and journals related to their area of research. At least when a project outline is being prepared, the biologists should have access to a library even if it is necessary to travel to Bangkok to use one. The Review Committee should not approve a project outline without an appropriate "Review of the Literature". Many of the errors encountered in the experiments would have been avoided with even a cursory review of the literature.

Breeding Research

At this stage of development of aquaculture in Thailand, too many projects are being conducted in breeding. Almost all of these experiments are on spawning fish by pituitary injection. Now that the Pla Sawai (*P. sutchi*) can be spawned by injection, methods are available for spawning most of the major culture fishes in Thailand. These methods should be refined until an adequate supply of fingerlings of all cultured species are available. Spawning of new species should be de-emphasized and more emphasis should be placed on learning to grow the fry of the important food fishes that can already be spawned to stocking size in large numbers. Research on the spawning of additional species can be justified at this stage only if it has been clearly demonstrated that the fish in question has significant culture potential.

Fish Nutrition Research

It is rarely economical to grow fish for food without adding supplemental feed or fertilizer to the culture system. This is especially true as commercial fish production becomes more intensive and where it is desireable to get high yields per hectare.

Successful fishculture means that fish foods from natural and artificial sources are economically converted into fish flesh that is acceptable to man as food. With poor sources of food the fish do not make economical gains, grow slowly or do not reach acceptable harvest size. In most commercial fish farming operations observed in Thailand the fish were poorly nourished. Farmers stocking Pla Nin (T. nilotica) and Pla Nai (C. carpio) used poor or no fertilization practices and used supplemental feeds such as rice or rice bran which are probably inferior in physical condition and nutritional quality. Pla Sawai (P. sutchi) in cages, which received no natural food, were fed only rice by-products and small amounts of waste from the family diets. A commercial Pla Duk Dan (C. batrachus) farmer was apparently operating profitably but his feed conversions were 6.1 kg of moist feed, or 2.4 kg of dry feed, per kg of weight gain. Improved physical condition and nutritional quality of the feed could improve his conversion to below 2.0 and enhance water quality.

Poor nutrition was one apparent cause of low survival of newly hatched fry at several stations. Natural zooplankton is generally insufficient nourishment for intensive populations of small fry, consequently, acceptable supplemental feeds and suitable feeding practices are needed.

A nutritious, pelleted supplemental fish feed was developed at the Bangkhen Station which is referred to as the Bangkhen No. 1 and has the following formula:

Fishmeal	23%	Protein--approximately	33 %
Soybean meal	27%	Fat-- "	7.7%
Rice bran (fine)	35%	Fiber-- "	6 %
Broken rice	15%	Cost-- "	2 Baht/kg

The addition of a complete vitamin premix will make this formula adequate for feeding fish in artificial environments. The vitamin-supplemented formula is the Bangkhen No. 2.

The physical properties of the pellets prepared from the above formula are poor. The pellets crumble during transport and disintegrate quickly when placed in water; hence, determination of actual feed conversion is confounded when the feed disperses in the water instead of being eaten by the fish.

It was suggested that a modification of the above formula, by increasing broken rice to 25% and reducing rice bran to 25%, would provide for a more water-stable pellet with the existing pellet-making facilities at Bangkhen. With the addition of a good steam generator, the present Bangkhen No. 1 formula may be adequate for good quality pellets.

Fine rice bran is nutritionally superior to broken rice and is generally more favorably priced; hence, as much rice bran as possible should be used as long as physical quality of pellets is not reduced.

Several mills in Bangkok are processing pelleted feeds for poultry or livestock. A mill that was visited has equipment and sources of feed ingredients for making good fish feeds. The primary feedstuffs available are broken rice,

rice bran (fine and coarse), corn, milo, soybean meal and fishmeal. Estimated prices of feedstuffs in Bangkok in November, 1972, were as follows:

	Baht per kg	Baht per protein unit
Fishmeal (55% protein)	3.3-3.8	.060-.069
Soybean meal (solvent, 44% protein)	2.5-2.7	.057-.061
Fine rice bran (with polishings)	1.1-1.4	
Broken rice	1.1-1.3	
Corn	1.1-1.3	

One feed manufacturer indicated that soybean meal is generally a lower priced protein source than fishmeal and is more consistent in supply and quality. Fishmeal reportedly varies considerably in quality and price. If the price per protein unit for soybean meal is consistently and decidedly lower (over 10% lower) than that for fishmeal, then soybean meal should be increased in the Bangkhen No. 1 formula and the percentage of fishmeal reduced. However, the level of fishmeal should not be reduced below 16% of the feed mixture. Based on the above price information, the present amounts of fishmeal and soybean meal in the Bangkhen formula should probably be maintained.

The Banghken Station processes the Bangkhen No. 1 formula as a pelleted fish feed that is supplied to all of the Fisheries Research Stations in Thailand. The feed is nutritionally adequate but physically inferior because of the poor stability of the pellet for transport and for feeding in water. The poor structure of the pellet is caused by insufficient moisture and heat being incorporated into the mixture of ingredients during the pelleting process. The Bangkhen Station has two excellent pellet mills but the capacity of the steam generator is much too low to provide the necessary steam for the daily pelleting operation. A steam generator should be purchased that will produce 30 pounds (136 kg) of steam per hour.

The Auburn survey team recommends that funds be provided to purchase a larger steam generator for the Bangkhen Station. Specifications for the equipment are as follows:

> Chromalex, Electric steam boiler. Model CMB 10-L. With built-in high pressure feed, steam production capacity of 30 lbs. or steam per hour at 100 p.s.i. 208 or 240 volts, 3 phase, 9 kw.
>
> Manufactured by: Automatic Steam Products, Inc.
43-20 34th St.
Long Island City, N.Y. 11101
>
> Available from: Automatic Steam Products, Inc.
1907 Second Avenue
Los Angeles, California 90018

The cost of the boiler is approximately $900. The cost of crating and shipping plus any spare parts needed might increase the total cost to $1500.

This equipment should be installed as soon as possible. In the spring of 1973 a Thai student trained at Auburn will be returning to the Bangkhen Station with a M.S. Degree who has special training in feed formulation and pellet processing. With his experience and the improved feed processing facilities, the Fisheries Department should be able to satisfactorily make the variety and quantity of experimental feeds need for their research programs.

A number of nutrition experiments have been conducted in Thailand. Some have produced useful information while others have not because of lack of water stability of pelleted feeds, fish not conditioned to type of feeds or feeding methods used in the experiment, inadequate diet formulations, and underfeeding or excessively overfeeding.

The major areas where information on fish feedings is needed are the following:

<u>Feed Formulation and Feeding Methods for Pla Duk Dan</u> (<u>C. batrachus</u>)--Studies have indicated that this species accept moist feeds readily but conversions from dry pellets have not been favorable. Dry, pelleted feeds will be more economical to process and handle for commercial operation, and should allow for more efficient feed utilization. Preliminary food preference studies need to be made to determine whether or not this fish can be fed pelleted feeds. If large fingerlings will not accept pelleted feeds, perhaps small fry can be conditioned to dry feeds. On the assumption that Pla Duk Dan will accept pelleted feeds and good quality pellets can be made, the following treatments should be investigated with fish densely stocked in earthen ponds:

1. Bangkhen No. 1 pellets fed at 3% of bodyweight per day
2. Bangkhen No. 2 pellets (No. 1 plus complete vitamin premix) fed at same rate.
3. Bangkhen No. 2 formula fed as moist feed (rice cooked) at same rate on dry basis as the pelleted feed.
4. A conventional or control feed as used presently by farmers containing 66% ground trash fish, 16.5% rice bran and 16.5% cooked broken rice.

Future experiments may be used to evaluate ingredient substitutions, optimum protein levels, optimum feeding rate and frequency and adequacy of Bangkhen No. 1 formula with various vitamin supplements for artificial environments. Of immediate concern is food for small fry. One important cause of high mortality among recently hatched fry is undernutrition. Nutritionally complete (vitamin-supplemented) feeds, in either dry or moist form and in small particle size, should be offered to the fry approximately 72 hours after hatching, depending upon rate of absorption of yolk sac, several times daily. Pollution of the water should be avoided by allowing water to flow continuously through the tank or pond.

Feed Formulation and Feeding Methods for Pla Sawai (*P. sutchi*)-- Commercial growers feed moist feeds containing essentially cooked rice, rice bran, minced aquatic plant (*Ipomea*) and sometimes trash fish to Pla Sawai. This may be supplemented with waste from the family diet. Brood fish receiving the dry pelleted Bangkhen No. 1 feed in ponds grew and reproduced satisfactorily, indicating that this species can probably utilize pelleted feeds satisfactorily. Experiments to obtain information for making recommendations for commercial feeds for this fish should be conducted. Since commercial feeders are now using exclusively moist type feeds, modifications of moist feeds should be investigated. The following feeding regimes should be evaluated for Pla Sawai:

1. A control diet similar to the conventional feed, containing 67% rice bran, 30% cooked rice, and 3% *Ipomea*
2. A diet containing 10% fishmeal, 62% rice bran, 25% cooked rice, and 3% *Ipomea*.
3. A diet containing 20% fishmeal, 52% rice bran, 25% cooked rice, and 3% *Ipomea*.
4. A diet containing 20% trash fish or other animal waste such as poultry or livestock offal, 52% rice bran, 25% cooked rice, and 3% *Ipomea*.
5. The Bangkhen No. 1 pellets.

All diets should be fed on an equal dry matter basis, equivalent to 3% of the weight of the fish daily. The above comparisons should demonstrate the relative value of fish or animal protein in the conventional-type Pla Sawai feeds, as well as the conversion of dry pelleted feed. If the fish are fed in earthen ponds at moderate stocking rates, so that natural food is available, the vitamin supplement and aquatic-plant may be deleted from the feeds.

Feeding Pla Sawai fry should be studied. Over 90% young fry usually die probably due to undernutrition of the newly hatched fish. The new fry are generally fed zooplankton, however, unless the fry are in an earthen pond, this source of food is usually inadequate. The fry should be fed hourly on highly nutritous moist or dry feed for the first 2 to 3 weeks. The fish should be in a tank with flowing water to prevent pollution.

Feed Formulation and Feeding Methods for Pla Nin (*T. nilotica*)--Because it is such an efficient feeder in the pond environment, Pla Nin may not require such a high protein supplemental feed as the Bangkhen pellet. Although there is a substantial amount of information in the literature on the culture of this species, several feeding regimes should be evaluated for application in earthen pond culture under the specific conditions in Thailand. These include the following:

1. Initial pond fertilization and the Bangkhen No. 1 pellet fed at 3% bodyweight.
2. Initial fertilization and rice bran in meal form fed at 3%.
3. Initial fertilization and rice bran with cooked rice fed as a moist feed fed at 3% of dry ingredients.
4. Initial fertilization and rice bran mixed with cooked rice and 10% fishmeal fed as a mixed moist feed fed at 3% of dry ingredients.
5. Initial fertilization and a low-protein pellet (18-20% protein) containing rice bran, broken rice and fishmeal fed at 3%.

Ingredient substitutions in feeds should later be studied in order to determine least-cost ration. The essentiality of vitamin supplementation in feeds for Pla Nin in cages, raceways or pens should be evaluated because the fish is an effective plankton feeder and may be able to get sufficient micronutrients from planktonic organisms.

Feed Formulation and Feeding Methods for Pla Nai (*C. carpio*)--Pla Nai have responded poorly to pellet feeding, primarily because they are slow feeders and the pellets probably disintegrated appreciably before being consumed. A great amount of information is in the literature on worldwide culture of common carp. Satisfactory feeding recommendations for monospecies culture of common carp in Thailand can probably be developed from available information in the literature. However, because carp derive considerable nourishment from natural food, the productivity of ponds in Thailand under various fertilization and stocking conditions would justify feeding experiments with carp. At low stocking rates carp grow well on solely grain or grain byproducts, however, when desired production gets to 1000 kg and above per hectare, protein-rich feeds become necessary. Thus, feeding studies with carp under various stocking systems, using high-protein pellets and also lower quality cereal products should be conducted in fertilized ponds at some time in the future.

FISH PROCESSING AND TECHNOLOGY

Fresh fish have limited keeping quality. To extend distribution, fish must be preserved. Freezing and canning are expensive. Dehydration is weather dependent and generally reduces the acceptablility of most fish. In many areas of Thailand, especially the Northeast, fermented fish are highly acceptable. With some species, good fermentation processing produces a product with good flavor, texture and preservation properties.

The Government Fisheries Technology Laboratory of the Marine Fisheries Division is doing research on fermentation processing of several freshwater fishes. Pla Mortan (*Heleostoma temminckii*) is considered the best freshwater species for fermenting. Pla Duk Dan (*C. batrachus*) and Pla Chon (*O. striatus*) appear to have good fermentation properties. Low fat fish seem to ferment best. The fermentation process consists of putting two parts dressed fish and one part salt in containers and allowing to set for 2 weeks, then adding 10% carbohydrate in form of ground rice or byproduct and allowing the mixture to ferment for approximately 3 months. Other freshwater fish species which can be produced in intense cultures should be evaluated for fermentation preservation. These may include, Pla Sawai, Pla Nin, and Pla Nai.

The director of the Technology Laboratory indicated an interest in working with freshwater fish. This should be encouraged, especially with the species which have the greatest potential for intensive culture in Thailand.

FINGERLING PRODUCTION AND STOCKING

It is important that some consideration be given to the hatchery program because the number of ponds available for research is dependent to some extent on the number required for the production of fingerlings for distribution to farmers, to swamps and to community ponds.

Data on the production of fingerlings in 1971-1972 are presented in Table 6. The data does not include production of fingerlings at Bangkhen, Nakorn Sawan and Udorn Thani. These data were inadvertantly omitted in discussions at the various station.

The data presented in Table 6 are interesting in a number of respects. More Pla Nai (C. carpio) were produced than any other species. There were 5,722,495 fingerlings of this species produced; however, only 2,936,395 of the fish (51.3%) were actually distributed. A slightly higher percentage of the Pla Nin (T. nilotica) fingerlings were distributed. Only 24.4% of the Pla Salid (T. pectoralis) fingerlings were distributed.

The production and distribution data may be mis-leading in a number of respects. For example, the number of fingerlings reportedly produced may represent the number of recently hatched fry produced rather than the numbe of "stockable" fingerlings produced. The larger number is doubtlessly preferred when reporting station accomplishments for administrative purposes; although only a fraction of those fish may be alive when they reach a size for

Table 6. Number of Fish of Various Species Produced and Distributed[1/]

Species	Number Produced	Number Distributed
Pla Nai *C. carpio*	5,722,495	2,936,395
Pla Nin *T. nilotica*	4,869,629	2,634,470
Pla Salid *T. pectoralis*	726,897	177,850
Pla Tapien Khao *P. goninotus*	695,770	542,105
Pla Khang Lai *T. melanopleura*	53,470	13,000
Pla Lin-Hue *H. molitrix*	667,000	60,120
Pla Soong-Hue *A. nobilis*	598,000	96,744
Totals	13,333,261	6,466,687

1/ Does not include data from Bangkhen, Nakorn Sawan and Udorn Thani.

stocking. The number of fish distributed are also misleading in that the data include fish that are stocked in natural swamps and streams that likely contribute little to fish production in Thailand.

If the data on production and distribution are accepted, it is evident that over 50% of the fish produced last year were not distributed. In other words, production exceeded demand by approximately 50%. A similar conclusion was also evident in the data on production and distribution presented by Swingle and Shell (1971). Approximately 50% of the resources devoted to the production of hatchery fish (ponds, labor, feed, etc.) could have been devoted to other purposes without reducing the supply of fish below the demand. In some cases the production could be reduced even more than 50%. Approximately 75% of the Pla Salid were not needed for stocking.

The stocking of fish in natural swamps and reservoirs utilizes a large portion of the fingerlings produced at the various stations. At almost all of the stations at least 25% of the fingerlings distributed were stocked in those public waters. At a number of stations over 50% of the fish distributed were stocked in public waters.

The return to fishermen of fingerlings stocked in swamps and reservoirs is extremely low. Results from experiments completed in 1972 indicate that less than 10% of the fish stocked in those waters are taken by fishermen. When the number of stocked fish taken by fishermen from the public waters (swamps, village ponds and reservoirs) are added to those fish received by farmers and this total is compared with the number of fish produced by the Stations, it would appear that a large percentage of the production of the Stations are of little benefit in producing more food in Thailand.

The question of over-production of fish for stocking commercial private ponds leads to a further consideration--the question of whether the government should produce fish for stocking at all. In the beginning stages of an aquacultural enterprise it may be necessary for the government to distribute fingerlings. For example, to develop a culture for a new species, it may be necessary for the government to produce and distribute fingerlings, but as quickly as practical this responsibility should be shifted to the private sector. In fact, where aquaculture is a well-developed industry the fingerling producers make a significant contribution to the economic development of the entire industry. In the United States, fingerling production has been one of the most profitable aspects of the channel catfish (Ictalurus punctatus) and rainbow trout (Salmo gairdneri) production industries.

The Fisheries Division should provide information on fish culture techniques, spawning, nutrition, disease control and distribution methods to fingerling producers. These services should enable the fingerling dealers to provide a valuable service to the entire industry. A number of farmers are already producing fingerlings, but the supply is still relatively small relative to the demand.

There are a number of reasons why a government should not attempt to produce fingerlings for farmers. To begin with, if all costs are considered, the cost of government-produced fingerlings will be 30% to 50% greater than for fish produced by the more efficient fingerling producers. The production costs of fish for stocking are relatively high in any country because of the high "overhead" (cost of buildings, libraries, visitor centers, flower beds, administrative costs, etc.) and production of unneeded fish would further increase the cost. Also, it is virtually impossible to eliminate "political stocking" of government fingerlings--the stocking of fish as a result of political pressure rather than on the basis of need or on the basis of contribution that the fingerlings might make to the fish needs of the country. Further, government hatcheries tend to be less responsive to the needs of the fish farmer. The private fingerling producer has a vested interest in the success of the fish farmer. His future market depends on how well the farmer succeeds; consequently he is very much concerned with producing good fingerlings. Government hatcheries are usually not very responsive to the needs of farmers. The future activities of government hatcheries are only indirectly related to the services which they provide.

The government should be responsible for providing fish for public waters such as natural swamps, community ponds and irrigation projects; however, even for the stocking of these waters it would probably be cheaper to purchase the fish from a private hatchery.

Fingerlings being held in tanks were observed at a number of stations. These fish were being held until fish farmers came to purchase them. Many of the fish had been in tanks for a long period of time and were in a starved condition. At one station fingerlings were observed "rubbing" themselves against the bottom of the tank. Microscopic examination revealed a moderate infestation by an external protozoan parasite. The distribution of weak or parasitized fish to fish farmers should not be allowed. Starved fish are more susceptible to disease, to predators and to death during transportation. One of the basic requirements for the culture of a species of fish is a predictable supply of strong, disease-free fingerlings. Fish farmers will certainly not be encouraged to continue to grow fish if they continue to receive fingerlings that survive poorly and grow slowly in their ponds.

In visiting the various Stations, it was noted that a wide variety of procedures were being used to produce and distribute the same species. In considering the production statistics for the various Stations, it is obvious that some of these procedures are more reliable than others. In the future, if the Division intends to continue to produce fingerlings, an effort should be made to determine the best procedures for producing and distributing a species of fish and these procedures should be used by all of the stations. Probably a manual of procedures should be prepared for use at all of the stations.

RESEARCH ON THE MANAGEMENT OF SWAMPS, COMMUNITY RESERVOIRS AND IRRIGATION RESERVOIRS

Research of the management of swamps, community reservoirs and irrigation reservoirs is important in Thailand. The flooded swamp fisheries historically have been very important to the country. With the development of irrigation and flood control schemes, the swamp fisheries will diminish in importance unless the swamps remaining can be managed to produce more fish than before.

The construction of Community Reservoirs will replace some of the swamps that will be eliminated and will provide potential sources of fish where there were relatively few fish before. The construction of these reservoirs, especially in the Northeast, will provide a source of fish for an area that because of the relatively low rainfall and long dry period has relatively few sources of fish all year. Good management methods are needed for these reservoirs.

Some research has been conducted on the management of the communtiy reservoirs. Swingle and Shell (1971) reported on the results of research on two of these reservoirs. A number of these community ponds have been constructed, but records were available on only three of them in 1971-1972. Past research has demonstrated that up to approximately 100 kg of fish per rai (625 kg/ha) can be produced in these ponds in 8 to 10 months. The ponds are stocked with fingerling fish and then fertilized with inorganic fertilizers.

Although preliminary research has demonstrated the potential for fish production in these small reservoirs, considerable research remains to be done. Most of the reservoirs already contain predatory fish at the time the fingerling fish are stocked or the predators enter the reservoirs later during floods; consequently when the fingerling fish are stocked many of them are eaten by the predators. Fishermen usually recover less than 10 percent of the fish that are stocked. The mortality rate is so high that an unusually high stocking rate must be used to be sure that enough fish will survive to give good production. In cases where the mortality rate is less than expected, the reservoir is over stocked and the fish grow poorly.

Research is needed to develop methods of increasing the survival rate either by controlling the predator population or by stocking larger fingerlings. The best method would be to control the predators, but this method may be impractical. The use of larger fingerlings would be an easier method but would be more expensive because of the added cost of producing larger fingerlings.

The data on survival may be somewhat incorrect. The data is obtained by counting all of the fish that the fishermen catch when the reservoir is opened to legal fishing. There is, however, a certain amount of illegal fishing that takes place throughout the growing period before the reservoir is opened. The amount of illegal fishing varies from reservoir to reservoir. An estimate of the number of fish removed illegally is badly needed if a good management system is to be developed.

With the present management system, the reservoir is opened for fishing after a growing season of 8 to 9 months. People from the surrounding area converge on the reservoir and use virtually every type of gear to remove fish. Most of the fish are removed in a 2 or 3-day period. So much mud and silt are stirred up as a result of the seining, netting, etc. that many of the remaining fish are killed.

There are a number of problems with managing a common-use resource such as these reservoirs, but some better method should be devised than the one used now. Under the present system, fresh fish are available from the reservoir for only 2 to 3 days per year. During the harvest period people probably take many more fish than can be effectively utilized. Preservation methods are not available to most of the "one-time-per-year" fishermen that will make it possible to keep the excess harvest.

A method of management should be devised that will allow more or less continuous harvest or that will allow harvest to be spread over a somewhat longer period of time than 2 or 3 days. Such a method would probably require multiple stocking or stocking more than one time per year and stocking larger fingerlings that would not be readily eaten by the predators. Also some control over harvest methods will probably be needed. If the harvest is to be extended over a period of time the smaller fish in the population must be allowed to grow to a larger size before they are removed. Certainly the practice of allowing fishermen in large number to wade through the reservoir stirring up mud and silt would have to be curtailed.

Research on the management of village reservoirs should be better coordinated. Now, three stations are conducting research separately, stocking different species and using different stocking rates. With so few experiments it would be much better if there was a basic experimental design with each station assuming responsibility of a segment of the over-all experiment.

RESEARCH ON BUNG BORAPET RESERVOIR

Bung Borapet Reservoir was drained approximately 15 years ago in an attempt to improve the fishery. Unfortunately, there were so few biologists available for work in Thailand at that time that not enough data could be collected to fully evaluate the effect of the draining on the fish population or on the fishery.

The reservoir was drained again in 1972. This time a concerted effort was made to obtain enough information about the fish and the fishery to make possible a realistic before-and-after evaluation of draining as a management technique.

The reservoir could not be completely drained. A mud bar across the outlet prevented removal of the water from the old stream channels and other deeper areas of the reservoir.

The primary purposes for draining and refilling the reservoir was to determine the affect of this technique on: (1) the standing crop of fish (2) intra- and interspecific population (3) the aquatic weed population (4) the rich organic "mud" on the bottom of the reservoir and (5) the fishing population around the reservoir.

To study the reservoir before and during the draining, several units were established to collect various types of data. The units were as follows:

(1). Fish population study
(2). Fish landing statistics
(3). Fish habitat and distribution
(4). Population dynamics
(5). Brood fish collection
(6). Taxonomy
(7). Fishing gear
(8). Aquatic weed survey

(9). Aquatic weed control
(10). Fish toxicant bioassay
(11). Fishery and socio-economic survey
(12). Registration

The fish population survey unit completed its work during the period January 11 - March 14, 1972. In that period, 26 rotenone samples were taken in the reservoir. The standing crop as estimated by those samples ranged from 2.4 kg/rai (15.0 kg/ha) to 106.4 kg/rai (665.0 kg/ha). The average standing crop was 36.4 kg/rai (227.5 kg/ha). Altogether 83 species were taken in the samples. The population composition was as follows:

Species group	Percentage of population by weight
Carps	40.4
Catfishes	26.5
Murrels	6.4
Miscellaneous	26.6

During the draining period, April 4 - May 15, 1972, 168,751 kg of fish were removed by fishermen. Using an area of 132,000 rai as a basis, the total catch is equivalent to 1.3 kg/rai (8.1 kg/ha). If the standing crop and harvest data are correct, only 3.6% of the fish in the reservoir were taken during draining.

The catch composition was as follows:

Species group	Percentage of catch by weight
Carps	32.0
Catfishes	13.9
Murrels	11.8
Miscellaneous	32.0

It seems highly unlikely that only 3.6% of the fish would have been harvested. Either the standing crop data, the catch data or both are incorrect. Catch data were obtained by stationing clerks at nine major fish landing sites around the reservoirs during the draining period. As the fishermen brought the fish to the landings they were weighed. The estimate of the total catch is certainly less than actual catch but probably represents not less than 75% of the actual. Some fish were landed at other than the nine stations but apparently not a large quanitity.

The apparent low recovery rate of fish during draining creates several problems for the evaluation of the technique for future use. The first problem is whether or not the estimate of standing crop prior to draining is correct. If not the "before and after" evaluation will be of little value. If the estimates of the standing crop and of the landings are correct then it is important to determine what happened to the remainder of the fish. Obviously some of them remained in the old channels and some them escaped to the river below as the reservoir was drained. If most of the 36.4 kg/rai of fish remained in the deep channels, then as the reservoir refills, the population will simply re-inhabit the same areas as before and the fish population would be little changed. If, however, most of the 36.4 kg/rai of fish escaped, the remaining fish will serve as brood fish for a rapidly expanding population that may for a time be considerably different from the population at the time of draining.

Fishermen were required to register in order to fish during the time the reservoir was being drained. A total of 4835 fishermen did so. The catch per registered fisherman during the 42-day period in which draining took place was 34.9 kg or a little less than 1 kg per day.

The gear utilized in harvesting fish from the reservoir were not very efficient. Long nets (seines and gill nets) were not allowed. Most fishermen fished with cast nets which are a relatively inefficient for capturing fish in large quantities.

Bung Borapet Reservoir was created for the purpose of providing a sanctuary for fish. Originally it was supposed to be fished little if at all. Gradually portions of the reservoir have been opened over the years until less than one-third of it is a sanctuary and even within that sanctuary there is a considerable amount of illegal fishing. Swingle in 1957 suggested that the sanctuary served no useful purpose.

The 26 rotenone samples taken in the reservoir prior to draining were located so that 11 of them were taken in the sanctuary area and 15 outside the area. The average standing crop in samples inside the sanctuary was 36.46 kg/rai (227.88 kg/ha). The average standing crop in samples outside the sanctuary was virtually identical.

The economic value of the standing crops inside and outside the sanctuary were also compared. The value/rai for the five highest priced fish in the reservoir Pla Sawai (P. sutchi), Pla Chalat, (Notopterus notopterus), Pla Mang (Pontioplites proctozysron), Labiobarbus siaminsis and Pla Takok (C. enoples) were determined for each of the 26 samples. The average value in samples inside the sanctuary was 22.87 Baht/rai ($7.12/ha) and in samples outside the sanctuary, the value was almost identical.

Gill nets with 3, 5 and 8.0 cm stretched mesh were fished inside and outside the sanctuary. Because of an unusually high catch in nets set at one location inside of the sanctuary the average catch was a little higher for nets set inside; however, the degree of overlap in the catches was so great that the difference in averages is probably meaningless.

Data on the standing crop, economic value and gill net catches indicate that there is little difference in the fish populations inside and outside the sanctuary.

There are some differences in the relative abundance of some species in the two areas, but these differences are more likely the result of the fact that the water in the sanctuary is deeper than outside.

There is little evidence to indicate that the sanctuary is of any benefit in the management of the reservoir. The sanctuary has been in existence for approximately 40 years and there _ little evidence that it has had any effect on the fish population. There appears to be little biological basis for continuing it. Policing the sanctuary is a constant problem and the cost of patrolling it is relatively high. That law enforcement problem would be eliminated if the sanctuary were removed.

Even though part of the reservoir has been open to fishing in the past, restrictions on the type of gear that could be used has limited the effectiveness of the fishery and has encouraged the use of illegal gear. Fishermen can use only cast nets, hook and line and small traps. The use of gill nets, trap nets and seines is illegal. The restrictions on gear has resulted in the use of fishing methods that are detrimental not only to the fish population but also to the fishermen and their families. The use of insecticides, electrofishing and explosives are detrimental to the fish population because they are almost totally unselective. All sizes of fish are taken, even the smallest. These fishing methods are also extremely dangerous to the fisherman. The fisherman that use the methods seem to feel that if they are forced to be law violators in order to catch enough fish to pay for their effort that they might as well use some method that will guarantee a large quanitity of fish.

The gill net, seine and trap net are effective gear for catching fish, and by regulating the size of mesh they can be made selective for various sizes of fish.

They are effective enough that fisherman can expect to catch enough fish to pay for his labor and earn at least a small profit; yet they can be regulated so that the juvenile forms of the various species can be protected. Legalizing these types of gear would probably increase the income of the individual fishermen and at the same time encourage the use of legal fishing methods.

If gill nets and seines are made legal, considerable research will be needed to determine the minimum size mesh that should be used. This research will be complicated somewhat because the fishery involves so many species of fish. The proper management of one species may require one mesh size, while the management of another species may require a different mesh. Some good information has already been obtained by the Population Dynamics Unit on the selectivity of 3, 5 and 8.0 cm (stretch mesh) gill nets. Information also is needed on the selectivity of larger nets. Nets up to 14.0 cm (stretched mesh) should be fished experimentally.

Research should also be conducted to obtain information that will be useful to the fishermen in fishing with gill nets and seines. Different types of net (monofilament vs. woven) should be evaluated to determine the most effective one when initial cost, maintenance cost and catch per unit of effort are concerned. Information will be needed by the fishermen on the best methods for setting nets (floating or sinking), whether to fish perpendicular or parallel to shore and on the effect of season on the fishing efficiency of the nets.

The information gathered in 1972 on Bung Borapet will be of relatively little value unless additional information is obtained after the reservoir is refilled. The fish population survey unit will need to repeat the same scheme of sampling to used prior to draining. Because of the large amount of variation between samples, a large number of samples will have to be taken again in order to reach a conclusion on whether changes that are observed after refilling are real or only apparent because of sampling error.

The group working with fish habitat and distribution will need to repeat the same sampling schedule after the lake has refilled to determine whether the distribution of fish has changed. One of the main reasons for draining was to determine the effect of this technique on the aquatic plants in the reservoir. The pre-draining survey provided a wealth of information on the distribution, abundance and species associations of aquatic plants in the reservoir. A number of additional surveys over a period of several years might be needed to determine the effect of the draining and refilling.

The initiation of the research project on Bung Borapet required the services for several months of virtually all of the biologists of the country and interfered seriously with progress on other research projects. The continuation of the work on Bung Borapet should be scheduled, if possible, so as not to interfere with other research.

RESEARCH ON LARGE RESERVOIRS

Continuing research on large reservoirs is being conducted primarily at two locations in Thailand. The Station at Tak conducts research on Bhumiphol Reservoir and the Stations at the Northeast Center in Khon Kaen and at Ubon Ratana Reservoir conduct research on that reservoir.

Bhumiphol Reservoir

Only two projects were completed at Bhumiphol Reservoir in 1971-1972. One project was concerned with the spawning grounds of six species of fish. In another project, the food and feeding organs of three species of fish were studied. Almost no research was being conducted on the fishery of the reservoir. Relatively good data on the total catch of fish going into commercial channels are available for the reservoir. Clerks are stationed at the major fish landing on the reservoir to take records on the catch. No effort has been made to determine the amount of fish consumed locally that are not weighed. A creel survey should be designed to estimate that quantity.

The catch has been relatively constant since 1965 at approximately 800,000 kg/year. There are virtually no data available on the amount of effort required to catch this quantity of fish. Data on total catch are important from an economic point of view, but without an estimate of the effort associated with the catch, the data are of less value for management purposes. Increases or decreases in catch of a species may be more readily explained if the effort associated with those changes are known.

In the future some estimate of the catch per unit of effort should be obtained for the species of major importance in the reservoir. These estimates could be obtained relatively easily by a creel survey procedure.

In the future, less research emphasis should be given to the biology of species in the reservoir. If resources are limited, most of the research effort should be directed toward improving the lot of the fishermen. Research to determine where fish are located and how to catch them is of immediate benefit to the fishermen. There is relatively little that can be done to alter the biology of a species in a reservoir, but often there are many things that can be done to help the fishermen catch more fish and to do so more cheaply.

Most of the research effort on a new reservoir with a developing fishery should be devoted to answering the following questions:

1. How many and what size of fish is the fisherman catching and how much effort does it take to catch that amount of fish?

2. What information does the fishermen need to increase his income and to increase the amount of fish he supplies to the market?

3. Is the fishermen using the most effective gear for catching fish?

4. If he has the most effective gear, is he fishing it in the most effective manner?

5. Does the fisherman know the best locations to fish?

6. Are there valuable stocks of fish in the reservoir either other species or other sizes of the same species that the fisherman is not exploiting?

Research on the basic biology of species should be undertaken when there is an apparent need to know more about the species in order to harvest it more effectively or to protect if from over-exploitation. Few countries have sufficient resources, biologists and money, to allow them to study biology of native fishes for academic reason.

Several limnology projects are in the planning state for Bhumiphol Reservoir. It is suggested, however, that limnology studies should be given a low priority on the reservoir until more is known about the fishery. Until most of the questions noted above have been answered, little effort should be spent on limnology. Even if the limnological characteristics are well know, there is virtually nothing that can be done to change or to manage them. In some cases limnological information may be used to explain why some fish are found only in certain locations at a certain time, but information of this type is supplemental only to a good knowledge of the fishery of a reservoir.

Ubon Ratana Reservoir

Research by the station at Ubon Ratana is also oriented toward a study of the biology of the species in the reservoir, however, considerable emphasis is given to the population dynamics of the various species. Some of these types of studies are valuable in the management of a species.

Data on total catch are also collected at Ubon Ratana, but there is relatively little information on the effort required to make the catch. Data in the amount of effort spent fishing the reservoir should be collected in the future. Also an estimate should be obtained of the quantity of fish that are consumed without being included in the statistics.

There were a number of problems noted in research at Ubon Ratana that should be corrected in future research. Length-frequency studies on a species over a period of time may provide valuable information on the growth of the species and may be used as a basis for ageing fish of younger age classes; however, because of the selectivity of certain types of gear, especially gill nets, length-frequency data must be interpreted with caution. In the research at Ubon Ratana, length-frequency graphs were constructed from data collected with several types of gear including rotenone sampling. Combining data from several types of gear might be possible, but the additivity of such data must be demonstrated conclusively before doing so.

Similar problems were also noted with food habits studies. Data from several collections of a species over time and from a wide range of fish sizes were combined. Food habits generally vary with season and with size of fish; consequently a study of food habits of a species should take these factors into consideration.

The same comments made about the choice of priorities for work at Bhumiphol Reservoir are also applicable to research at Ubon Ratana. Information on the biology of a species may be important in its management, but usually not until a considerable amount of information has been obtained on the characteristics of the fishery for that species. Good information on a fishery is usually necessary before a biologist can know what species to study or what aspects of the biology of a species should be studied. The first priority for research on a new reservoir is to study the characteristics of the fishery.

EXTENSION

Problems resulting from the organization of extension activities in the Inland Fisheries Division in Thailand were discussed by Swingle and Shell (1971) in a previous report. Those problems still exist. An unfortunate result of the organization of extension activities is the apparent dichotomy of purpose of research and extension activities. At many of the Stations, the two groups are largely unaware of the activities of each. At some Stations research workers are requested not to work with farmers. Demonstration research projects in farmers ponds are not encouraged.

Unless research proven information on fish culture is extended to the farmer then funds spent on research are largely wasted, and unless the information extended to farmers is good practical information the funds spent on extension are largely wasted. In addition, unless the extension man provides good information and advice, he quickly earns the lasting distrust of the farmer. Obviously, the research man and the extension man cannot effectively function independently of each other. They should function as members of a team. Steps should be taken to see that the two groups are brought closer together in the future.

In an earlier section some special problems related to aquacultural research were described. In surveying the information that extension workers are providing farmers if is obvious that there are problems in this area also. It appears in many cases that the farmers are being provided incorrect information or information so vague that it could not be used as a basis for producing a crop of fish. For example, the following is a summary of information provided by extension workers at one of the Stations on stocking and feeding Pla Nai in ponds.

Stocking: Stock Pla Nai (*C. carpio*) at a rate of 1 fish/m^2
Feeding: Feed rice bran, broken rice, peanut cake, termites, and lemna (plants). These are local products. The rate of feeding and amount of feed will vary from pond to pond depending on the availability of material.

If the instructions above are followed by a fish farmer, the results would probably be unsatisfactory. A stocking rate of 1/m^2 for Pla Nai is much too high. Assuming a survival rate of 90% which is a reasonable rate for larger fingerlings, a 1 rai pond would contain 1440 fish (9000/ha). Further, assuming that these fish reached a minimum harvestable size of 500 g each the pond would contain 720 kg of fish (4500 kg/ha) at the time of harvest. Fish this size would require an amount of feed each day equivalent to approximately 2% of their body weight; consequently in the last days before harvest, if the fish were to keep growing, 14.4 kg of feed (90 kg/ha), would be required per day. Once the feeding rate reaches 6.4 kg/rai/day (40 kg/ha) the amount of organic wastes (feces, wasted feed, dying algae) in the pond becomes so great that the dissolved oxygen may be depleted resulting in a fish kill.

If a Thai fish farmer was to stock at a rate of 1/m^2, it is likely that his fish would never reach the minimum harvestable size unless the mortality rate of stocked fingerlings was at least 50%, or it is likely that he would kill his fish from overfeeding.

Records were obtained from a few fish farmers in the Northeast. The results obtained illustrates the point discussed above.

Size of pond:	1 rai
Date stocked:	June 2, 1971
Species stocked:	Pla Nai
Number stocked:	2000 (1.25/m^2)
Size stocked:	4-6 cm
Date drained:	May 12, 1972
Number recovered:	1322 (66% survival)
Weight recovered:	320 kg/rai (2000 kg/ha)
Average weight recovered:	248 g/fish
Feed used:	Broken rice and rice bran

None of the fish in this pond reached the minimum harvestable size of 500g. If it had not been for the fact that 43% of the stocked fish died, the average weight would have been even less than 248g each.

A 248g fish would be utilized in a country where fish is important in the diet, but because of the intra-muscular bones in Pla Nai, a fish of that size would bring a relatively low price on the market. The Thai people apparently do not like Pla Nuan Chan Thale (Chanos chanos), because of the number of bones in the flesh. They are willing to accept Pla Nai even with the bones and they will pay a good price for it (12-15 Baht/kg) but only if they can get fish large enough that the bones can be easily removed while eating. If the fish farmer is to be successful he must provide the fish that the market wants. High production is of little value if all of the fish are too small for the consumer.

In another farmer's pond the following results were obtained:

Size of pond:	1.52 rai
Date stocked:	June 15, 1971
Species stocked:	Pla Nai
Number stocked:	2500 (1.03/m^2)
Date drained:	February 25, 1972
Number recovered:	1427 (survival 57%)
Weight recovered:	599 kg (394 kg/rai, 2465 kg/ha)
Average weight recovered:	420 g/fish
Feed used:	Rice bran and broken rice

Fortunately, in this case, 43% of the stocked fish died so that the remaining fish grew almost to the minimum harvestable size of 500 g each by the time the pond was drained. Also fewer fish were stocked in this pond than in the previous one (1645/rai compared to 2000/rai).

The instructions provided on feeding are much too general to be of any value. If fish are to grow at a profitable rate, they must receive each day specific amounts of protein, fat, carbohydrate, vitamins and minerals. These nutritional requirements can be met with relatively low quality local products, but the farmer will need some rather specific information on how much of each should be fed to meet those needs. As the fish grow the amount of feed required increases, but the percentage of bodyweight required each day decreases. The farmer should be provided with rather specific instructions on the changes in the rate of feed required as the fish grow.

Growing a crop of fish in a pond requires considerable inputs in the form of capital and labor. Farmers cannot afford to utilize resources, nor can bankers afford to lend the amount of money required to grow a crop of fish unless there is a high probability of success. If the instructions presented above are indicative of the type of information that is being extended to the farmers, the probability of success is hardly high enough to justify confidence. Obviously, extension workers should be provided with better information by the research workers and the extension workers should provide that information to the farmer in a form that he can understand.

THE BIOLOGY SURVEY UNIT

The primary responsibility of the Biology Survey Unit has been the making of hydrobiological and fishery surveys in rivers, community fish ponds, irrigation tanks, small reservoirs and large reservoirs. The surveys involve qualitative and quantitative studies of the water, the plankton, the aquatic plants, the fish food organisms, and the fish fauna. These surveys have provided significant information about the living things in the waters of Thailand. It is doubtful whether any other country in Asia has accumulated as much information on their natural waters.

The Survey Unit could contribute significantly to the task of producing more fish in Thailand by increased involvement in research to develop management methods for community ponds and irrigation tanks. The importance of this researcl and some problems that should be solved were discussed in a previous section. No other group has that responsibility. The small amount of research that is being conducted on these bodies of water is by the individual Stations near them. The Survey Unit should coordinate all of the research projects on these small reservoirs and should be responsible for much of the actual research.

Even with a complete qualitative and quantitative description of the living things in a river or a large reservoir, there is little that can be done to change those living things; there is little that can be done to change the relative or absolute abundance of those living things for man's benefit. Because of the size of a large river or a large reservoir there are few management techniques available. Village reservoirs and irrigation tanks can be managed. They can be stocked, fertilized, the fish fed and drained. The fish populations can be manipulated at least to some degree. Research funds should be spent to learn how to manage things that can be managed.

TRAINING

One of the major causes of the problems encountered in evaluating the research is the level of training of the biologists designing and conducting the experiments. Most of them have only the B.S. and like B.S. degree recipients in any country, including the United States, they simply are not prepared for a career in research. There is not sufficient time in a 4-year undergraduate curriculum to make a man a competent research scientist. In the United States, we generally feel that a level of training and experience associated with the Ph.D. is necessary for a productive career in research. Considering the level of training, the Thai biologists are doing a creditable job with their research efforts and in time would probably learn enough from their mistakes to develop a good research capability. Unfortunately few countries have either the time or resources to allow the development of research capability through trial and error.

It is anticipated that as more biologists with graduate training and experience in experimental design return to Thailand to participate in the research program, that there will be a significant improvement in the quality of research. The increase in the level of training will certainly result in an increase in the quality of research, but we should not expect a really spectacular improvement until these returning students have gained some research experienc Even students with the M.S. degree have had relatively little research experienc at graduation. In the United States one would not expect a new inexperienced graduate with the M.S. degree in Agricultural Economics, Agronomy and Soils, or Animal Husbandry to conduct a significant amount of original research. In 18 months, the usual training period for a USAID trainee, it is not possible to make a competent researcher out of any student; although we make a considerable amount of progress toward that goal for both American and foreign students.

The Thai biologists with M.S. degrees will make a significant contribution to the research program there, but there is also a need for at least a few men with Ph.D. degrees in the organization. With 2 or 3 men with the higher degree attached to the Office of the Head of the Division of Inland Fisheries to coordinate research, to review research project proposals, to advise biologists on research planning and to suggest priorities in research for the country, the entire research program of the country should be improved. This same recommendation was made in the 1970 report by Swingle, et al, and there is currently one biologist from the Inland Fisheries Division studying for the Ph.D. at the University of Michigan. He is majoring in Fishery biology. Two additional Ph.D. students should be sent abroad for training in aquaculture.

The addition of a few Ph.D.'s to the staff of the Division should result in improving the quality of research in the Division, but for the orderly development of a true research capability in Thailand, the School of Fisheries at Kasetsart University must be involved. Currently, relatively little research is conducted by the University faculty. The level of training of the faculty is relatively low. There is not a single Ph.D. trained in fisheries or aquaculture. Further, there are almost no aquacultural research facilities available for research on campus. Although there is friendly relationship between the faculty and Fisheries Division staff, there seems to be virtually no participation by faculty in the solution of inland fisheries problems. Until the faculty of the College of Fisheries becomes involved in some manner in problem solving through research, it is not likely that students trained there will be research oriented. In discussions with the Dean of the College it was understood that funds from a loan from the World Bank was available for improving the faculty. Some of these funds might be used for curriculum planning and improvement, but most of it should be used to train a number of Ph.D.'s abroad in inland fisheries management and aquaculture.