A.I.D. EVALUATION SUMMARY PART I

(BEFORE FILLING OUT THIS FORM, READ THE ATTACHED INSTRUCTIONS) PD-AAZ-892

IDENTIFICATION DATA

A. REPORTING A.I.D. UNIT: S&T/AGR
(Mission or AID/W Office)
(ES#)

B. WAS EVALUATION SCHEDULED IN CURRENT FY ANNUAL EVALUATION PLAN? yes [X] slipped [ ] ad hoc [ ]
Eval. Plan Submission Date: FY 89 Q ___

C. EVALUATION TIMING PD-AAZ-892
Interim [X] final [ ] ex post [ ] other [ ]

D. ACTIVITY OR ACTIVITIES EVALUATED (List the following information for project(s) or program(s) evaluated; if not applicable, list title and date of the evaluation report)

Project #	Project/Program Title (or title & date of evaluation report)	First PROAG or equivalent (FY)	Most recent PACD (mo/yr)	Planned LOP Cost ('000)	Amount Obligated to Date ('000)
		FY-84			
936-4161	Reproductive Studies of Milkfish		1/90	4,850	4,850

ACTIONS

E. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

Action(s) Required	Name of officer responsible for Action	Date Action to be Completed
Incorporate relevant recommendations into annual work plan	S&T/AGR R.Neal	6/1/89

(Attach extra sheet if necessary)

APPROVALS

F. DATE OF MISSION OR AID/W OFFICE REVIEW OF EVALUATION: mo 4 day 1 yr 89

G. APPROVALS OF EVALUATION SUMMARY AND ACTION DECISIONS.

	Project/Program Officer	Representative of Borrower/Grantee	Evaluation Officer	Mission or AID/W Office Director
Signature Typed Name	R. A. Neal			
Date:	5/5/89		5/25/89	

H. EVALUATION ABSTRACT (do not exceed the space provided)

The reproductive studies of milkfish project seeks to develop milkfish hatcheries in an LDC setting. To accomplish this, the Oceanic Institute of Hawaii has developed a method to induce milkfish to spawn using hormone implants. They also have investigated better means of rearing milkfish larvae in cultured conditions. As a test animal, they utilized mullet, which has shown even greater promise for hatchery development than milkfish. The technology can be transferred to LDCs, as demonstrated most recently in Indonesia. Milkfish are cultured at present in only three LDCs, namely Indonesia, the Philippines, and the South Pacific nation of Kiribati. Taiwan also cultures milkfish.

This evaluation was conducted December 7 to 22, 1988, was chaired by Dr. Edward Donaldson, of the Department of Oceans and Fisheries of Canada, and was joined by Dr. Geoffrey Lawrence, of the U.S. National Marine Fisheries Service, of Narragansett, Rhode Island, and Dr. Phyllis Cahn, of Long Island University. The project had completed four years. An earlier evaluation was conducted, one year into the project, with positive result and recommendations. The team was composed by recognized experts in finfish reproduction and endocrinology, and larval rearing. The team reviewed project documents, work plans, progress reports, and publications. In addition, an evaluation of the economics of the milkfish industry and economic potential for application of this research was prepared for the team by Dr. Clare Idyll prior to the evaluation. Dr. Idyll reported the industry is in a decline; however, he was guardedly positive on potential for application of research results. He involved ICLARM in his discussions and literature review.

The team visited the site of the primary research, the Oceanic Institute of Hawaii; then the Taiwan National Fisheries Institute near Taipei, Taiwan; then the Tungkang Laboratory, site of cooperative milkfish research; then, the USAID Mission in Jakarta, including the GOI Research Council for Coordination of Fisheries;, and finally the cooperative research site in Gondol, Indonesia. The team was accompained by Dr. C.S. Lee, Principal Investigator, Dr. Paul Bienfang, Vice-President of the Oceanic Institute, and Dr. Lamarr Trott, S&T/AGR.

The evaluation team found the project to be on schedule, and to have accomplished most of its objectives, primarily artificial inducement of milkfish to spawn by implantation of slow-release hormones. Once the technology was developed, it was transferred to Taiwan and Indonesia. The team recommended continuation with the current work plan till EOP (January 14, 1989). The team also encouraged A.I.D. to consider extension of the project, considering at that time additional marine finfish species.

ABSTRACT

I. EVALUATION COSTS

1. Evaluation Team

Name	Affiliation	Contract Number OR TDY Person Days	Contract Cost OR TDY Cost (US$)	Source of Funds
Three team members travel		$15,000		Project
Honorarium to chairman		1,000		Project
Travel of L.Trott (RSSA)		5,000		RSSA

2. Mission/Office Professional Staff Person-Days (estimate) 0

3. Borrower/Grantee Professional Staff Person-Days (estimate) 42

COSTS

Project Purpose:

To develop means of artificially inducing maturation and spawning of captive milkfish in an aquaculture setting, to develop better methods of larval rearing of milkfish fry produced from such spawning, and to transfer this technology to LDCs. Limited training is also included, as is workshop development.

Evaluation Purpose and Methodology Used:

The external evaluation was conducted to provide a comprehensive examination of the technical performance and implementation of the project in accordance with the initial and modified scope of work in the grant agreement and extension with the Oceanic Institute since 1984. The evaluation determined the scientific accomplishments of the project, institutional interactions, and potential for accomplishment of objectives.

The external evaluation was conducted by a team that reviewed project documents, held oral discussions with researchers and collaborators, and conducted visits to research sites to determine degree of success, both in research objective attainment and collaboration.

A.I.D. EVALUATION SUMMARY PART II

J. SUMMARY OF EVALUATION FINDINGS, CONCLUSIONS AND RECOMMENDATIONS (Try not to exceed the 3 pages provided)
Address the following items:

- Purpose of activity(ies) evaluated
- Purpose of evaluation and Methodology used
- Findings and conclusions (relate to questions)
- Principal recommendations
- Lessons learned

Mission or Office: S&T/AGR

Date this summary prepared: 3/1/89

Title and Date of Full Evaluation Report:

Findings and Conclusions:

1) The team's report states, "In view (a) of the excellent progress that has been made both in research and development at OI particularly over the last year, (b) of the excellent progress that has been made in technology transfer in Indonesia, and (c) of the close and effective cooperative relationship that has been developed with Taiwan, the EEP has determined that the project has the clear potential to have a major impact on the culture of warm water brackish and marine finfish in LDCs."

2) The evaluation team felt that the present emphasis on milkfish with mullet as a test animal should remain till the EOP, and that additional species should be researched in potential extension.

3) The team felt that extension would be appropriate.

4) The team recognized the importance of the Technical Advisory Group, as well as the Principal Investigator, and suggested continuation of both.

Principal Recommendations:

1. "That serious consideration be given to the development of a project extension with OI which would build on current R & D strengths and on the current technology transfer successes.

2. That the technology transfer initiative in Indonesia be continued until the following criteria have been met.

a) Attainment of a high level of larval survival to stocking size from endocrine-manipulated spawners.

b) Successful maturation and spawning of the current F2 generation and rearing of the F2 larvae to stocking size.

c) Successful conduct of training sessions for regional extension officers.

3. That reproduction research, in addition to current endocrine studies, focus on environmental manipulation and the factors responsible for spontaneous maturation and spawning.

SUMMARY

4. That incubation and larval rearing research continue its focus on definition of optimal conditions for mass rearing at high survival rates using natural and artificial feeds.

5. That a regional international workshop be held to bring together LDC biologists and scientists from the developed countries to exchange information on techniques for controlled reproduction and larval rearing applicable to brackish and marine species and also to discuss the new biotechnologies that are expected to have a major impact on finfish culture over the next decade.

6. The EEP recognizes the important roles of Dr. I. Chiu Liao, Director General, Taiwan Fisheries Research Institute and Dr. Fuad Cholik, Director, Research Institute for Coastal Aquaculture, Indonesia, in the cooperative activities with Taiwan and in the technology transfer activities in Indonesia, respectively, and recommends that the attendance of both of these persons at all future TAG committee meetings be given a high priority.

7. The committee acknowledges the important role that TAG members Dr. Malcolm Gordon and Dr. John Hunter have played in the scientific direction of the project and recommends that they continue to be actively involved.

8. The committee recognizes that the Oceanic Institute placed as it is in the tropical Pacific Ocean is in a unique position within the United States in its capability to conduct research, development and technology transfer activities on aquacultured tropical brackish and marine finfish and recommends that USAID continue to work with OI during its current growth phase so as to further strengthen its role as a world class aquaculture research and development facility in order to meet USAID mission goals relating to production of additional high quality dietary protein in the LDCs.

9. No changes are currently needed in the Management Review Process. Results so far justify the strategy. Scientific management is cognizant of the unique nature and problems associated with research on living organisms.

10. The committee recommends that the various travel budgets be more specifically defined as there appears to be some overlap between them.

11. The EEP recommends that the OI team maintain its focus on milkfish and mullet for the duration of the current project. The team should then give serious consideration to extending its efforts on controlled reproduction and larval rearing to additional economically important brackish and marine finfish in a project extension proposal. Potential species include the seabass *Lates calcarifer*, the groupers *Epinephales* sp. and the sea breams.

12. The EEP recognizes the dedication of the young and enthusiastic program employees at OI and recommends that the staff could be strengthened in two ways. First additional career development could be provided for current employees and second an attempt could be made to bring in additional persons with specialized experience in addition to the principle investigator, e.g. university or government scholars on sabbatical leave.

13. The committee recognizes the key role of the program head, Dr. C.S. Lee in the successful development of this project and compliments him on the level of progress that has been achieved. We recommend that Dr. Lee continue in his role as the PI of this project.

14. A reorganization of reassignment of personnel within the finfish program should be considered to increase the international field activities of technology transfer or an additional qualified biologist could be hired for this purpose.

15. Specific research subjects need additional emphasis. These are nutritional requirements of maturing adults, the role of dopamine antagonists in induced ovulation, determination of egg quality, and most aspects of larval rearing. It would be valuable to add additional larval rearing expertise to the program in one or more of the following areas, physiology, biochemistry, nutrition, ethology."

ATTACHMENTS

K. ATTACHMENTS (List attachments submitted with this Evaluation Summary; always attach copy of full evaluation report, even if one was submitted earlier)

External Evaluation Panel Report

MISSION COMMENTS ON FULL REPORT

L. COMMENTS BY MISSION, AID/W OFFICE AND BORROWER/GRANTEE

The evaluation report has been reviewed by the Office of Agriculture of the Bureau for Science and Technology (S&T/AGR). It is agreed that the evaluation was a fair assessment of the scientific merits of the project. The evaluation followed the scope of work and answered all questions.

The AID project manager will incorporate the evaluation team's recommendations into the project's work plan, as appropriate, for the duration of the project (less than one year). The Office of Agriculture will review proposals received from the Oceanic Institute for subsequent project development in light of the evaluation team's recommendations.

Lessons Learned:

The Oceanic Institute was able to effect technology transfer just one month before the evaluation team's visit to Indonesia. Major credit for this goes to the scientists at the Gondol, Indonesia station. The GOI is genuinely interested in continuation of the project. Costs for their portion have been minimal ($28,000 so far, not including travel). Taiwan has also been very responsive, mostly funding the joint research on their own.

Cost-effectiveness is not addressed in the evaluation team's report, which is appropriate, as scientists judged research in a peer review context. Cost-effectiveness should be addressed in a separate financial management review.

The project is basically over-funded, but this is largely due to a 94.5% overhead, approved in the initial contract negotiations.

The Technical Advisory Group has been a major factor in directing the research design and approach.

Fisheries and Oceans Pêches et Océans

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Your File Votre référence

Our File Notre référence

January 16, 1989

Dr. Lamarr B. Trott
Senior Fisheries Advisor
Agency for International Development
Bureau for Science and Technology
Room 406E, SA-18
Washington, DC 20523

Dear Dr. Trott:

Please find enclosed the report of the External Evaluation Panel for the USAID Project titled "Studies on the maturation and spawning of milkfish in captivity". Contract No. DAN-4161-A00-4055-00 with the Oceanic Institute.

On behalf of my fellow panel members, I wish to thank you for the opportunity to participate in this evaluation and Drs. C.S. Lee and P. K. Bienfang of the Oceanic Institute for facilitating the site visits and meetings with project staff. If any further elaboration or clarification, of any aspect of the EEP report and its Appendices, is required the EEP would be pleased to oblige.

Yours sincerely,

Edward M. Donaldson, Ph.D., D.Sc., FRSC
Section Head
Fish Culture Research
Biological Sciences Branch

EMD/mb
cc: Dr. Phyllis H. Cahn
Dr. Geoffrey C. Laurence

Canada

XD-AAZ-~~886~~ 892-A

EXTERNAL EVALUATION PANEL REPORT

to the

United States Agency for International Development

Bureau for Science and Technology

Office of Agriculture

Renewable Natural Resources Division

on

STUDIES ON THE MATURATION AND SPAWNING OF MILKFISH IN CAPTIVITY

Contract No. DAN-4161-A-00-4055-00

With the Oceanic Institute, Hawaii

Dr. Phyllis H. Cahn

Dr. Edward M. Donaldson (Chairman)

Dr. Geoffrey C. Laurence

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EXECUTIVE SUMMARY

EEP members Dr. P.H. Cahn, Dr. Edward M. Donaldson (Chairman) and Dr. G.C. Laurence together with Dr. L. Trott, Dr. C.S. Lee and Dr. P. Bienfang conducted site visits at the Oceanic Institute and at project locations in both Taiwan and Indonesia between Dec. 7 and Dec. 21, 1988.

The unanimous assessment of the EEP is that, despite some initial set backs in selecting a suitable country in which to conduct the major technology transfer activities the project is now moving ahead rapidly in its research, development and technology transfer activities.

The panel expects that the project will reach its main goal of developing maturation, spawning and larval rearing technology for milkfish within the term of the current contract. Furthermore the panel considers that, based on current promising results, the technology transfer of milkfish seed production to Indonesia will be largely met during the term of the current contract and that it will be possible to organise a regional international workshop on reproduction, larval rearing and new culture biotechnologies within the term of the contract either in cooperation with the Taiwan cooperating agency, in a suitable LDC or at OI.

The significance on a world scale of the current success of the project both in R and D and technology transfer and the unique position of OI in its capability of conducting R and D applicable to the aquaculture of tropical brackish and marine finfish argues strongly for the submission of a renewal program by OI which would capitalize on both the recent success in closing the life cycle of both milkfish and mullet and also on the significant progress that has been made in technology transfer to Indonesia and in cooperative research with Taiwan.

INTRODUCTION

In Indonesia and a number of other countries in Southeast Asia, fish consumption accounts for over 50% of the animal protein consumed (Idyll 1988). Thus the continued availability of fish as a high quality protein source is crucial to the nutritional well being of the populations of these countries. Traditionally fish for consumption has originated from both the fishery on wild stocks and from aquaculture. It is now generally agreed that the world fishery catch from wild stocks has plateaued in the region of 80 million metric tonnes. As a result the focus has turned to extensive and intensive aquaculture as the only possible means for increasing the production of protein from aquatic organisms.

In Southeast Asia and the nations of the tropical Pacific region the milkfish Chanos chanos is a key brackish water teleost which has been cultured in parts of the region for several hundred years. Until recently its culture has depended totally on the seasonal collection of wild fry from inshore waters. This situation has 1) limited milkfish culture to the regions where wild fry are available 2) limited culture on a seasonal basis and; 3) prevented the implementation of selective breeding programs to improve production traits.

A second brackish water species the striped mullet Mugil cephalus is distributed even more widely in the warm brackish/marine waters of the world than the milkfish and is also valued as a source of protein in many countries from the Pacific to the Mediterranean. However, its culture like that of the milkfish is limited by the seasonal collection of fry from coastal waters.

The purpose of this external evaluation has been to review the accomplishments of the USAID project on milkfish reproduction titled "Studies on the maturation and spawning of milkfish in captivity" whose objective is to

develop "appropriate" technologies for the controlled reproduction and larval rearing of the milkfish using both milkfish and the striped mullet as experimental fish, and transfer these technologies into less developed countries (LDCs). The review panel was also asked to provide advice on future directions for the project utilizing the target species and to consider applications of the technology in other brackish and marine warm water finfish. The review encompasses both the research and development activities at the Oceanic Institute and the technology transfer activities in LDC's.

RESEARCH AND DEVELOPMENT AT OCEANIC INSTITUTE

Milkfish

Reproduction

Over 100 milkfish were brought to maturity and spawned with the help of hormonal implants. The spawning age was reduced from 10 years to 5 years of age, provided that the fish reached 3.5 kg total body weight. Over 20 milkfish in Taiwan, and in two LDC's the Philippines, and Indonesia, reached maturity and spawned under conditions similar to those at OI (hormone implants, fish 5 years old that reached a weight of 3.5 kg).

The appropriate parameters, or ranges of these parameters, where applicable, of the six or seven major environmental factors, such as photoperiod, temperature, salinity, dissolved oxygen, water quality, volume of water, stocking density, and nutritive components, found to be of primary importance for maturation and spawning, were identified, and used to achieve the success noted. For example, both sexes were found to mature at temperatures above 20°C, and temperatures above 27°C were ideal. Photoperiod was even more significant than temperature; when the day length reached 13.2 hours, a maximal percentage of females and males reached sexual maturity. Fluctuating

photoperiods were the best, especially a regime of 6L:18D, then 12L:12D, followed by 18L:6D. Seasonal factors were very important. The hormone therapy was most effective when it was started near the beginning of the natural breeding season. There was some success in inducing maturation out of season, by manipulating the environmental factors. This resulted in prolonging the length of the milkfish reproductive season, especially for the females. More work is needed on hormone dosage in the males. In Hawaii, milkfish in outdoor ponds normally mature and spawn during June, July and August. Using the techniques developed that combine hormone implants and environmental regulation, success was achieved from April through October. Even during November and December, partial success was obtained when the appropriate environmental parameters were simulated indoors, on hormonally implanted fish.

Steroid profiles on levels of serum gonadotropin, estradiol, and testosterone were monitored in the hormone implanted fish. These data permitted refinements of hormone implant techniques. The combination of 10 mg LHRH-a and 25 mg 17 -methyltestosterone (17 -MT) in a chronic implant, enhanced maturation of males and females. It is unrealistic at this time to predict what percentage accuracy was achieved with the refined techniques. This will be determined when scale-up is carried out on a much larger number of fish than can be accommodated with the present staff and facilities.

Associated with the refinement of the hormone techniques, there was much progress in assessing the stage of egg maturation at which hormone implanted females respond to the treatment. Egg diameters were determined by examining cannulated oocytes. When the average egg diameters were about 750 microns, females were ready for the hormone implants. Steroid levels monitored during this period of egg growth showed that as vitellogenesis terminated, serum

estradiol decreased, and serum testosterone increased. They found a critical period of about a week when there was the highest probability of inducing spawning using LHRH-a.

Larval rearing

Much progress was made in the methodology for milkfish larval rearing. Hatchery techniques were developed for the successful mass culture of milkfish larvae. Many of the protocols used were adapted from the mullet rearing program, with appropriate modifications. Of the eight larval rearing trials that were carried out during the 1988 breeding season, survival rates as high as 19.2-46.4% were achieved, as measured at harvesting by the 30th day post-hatching. This was achieved over a density range of 4.1-6.8 juveniles/ liter. At all salinities tested (5-40 ppt) hatching occurred, it was found that the highest percentage of normal larvae were produced at salinities ranging from 20-40 ppt. When eggs were incubated at different combinations of temperature and salinity, it was found that the optimal temperature range at a salinity of 35 ppt was 23-34.5°C, with the highest hatching rate at 25.5-28°C. Monitoring of embryonic dissolved oxygen consumption rates indicated that at salinities ranging from 20-35 ppt, there were no significant differences in oxygen consumption. If milkfish embryos, incubated at 27°C (& 35 ppt salinity) were transferred to lower temperatures such as 23-25.5°C, at the same salinity, the percentages of normally hatched larvae increased from about 53-60.6%. This is a very good survival rate, and it meets the requirement for a 20% improvement, as suggested in the logical framework tasks.

Mullet

Reproduction

The hormone implant technologies coupled with the environmental

manipulation developed for milkfish, was used successfully on mullet. As the daylength decreased below 11.3 hours, vitellogenesis started, and with the associated decreased temperature, eggs increased in size. This normally occurred at average daily temperatures below 27°C. Serum estradiol levels increased as the oocytes increased in diameter, as was found for milkfish, and these levels decreased at the end of vitellogenesis. Serum testosterone levels increased during egg growth, and remained high, even at the end of vitellogenesis. Very high LHRH-a dosages were needed for induction of mullet spawning, compared with milkfish. This may be related to the high levels of serum testosterone maintained throughout the period of egg maturation in the female mullet. Nevertheless, the mullet spawning was enhanced by using LHRH-a. When females with average egg diameters of 600 microns or greater were first given an injection of carp pituitary homogenate, followed by LHRH-a about 24 hours later, spawning success reached 94.1%. Also, fertilization and hatching rates were good.

Additional mullet data was obtained for testicular maturation. Serum testosterone and 11-ketotestosterone levels increased just before there was an increase in the number of ripe male fish. Also, when 17-methyltestosterone capsules were implanted into males during the non-breeding season, maturation occurred within a three week period. If a high dose of 17 MT was used once (19.7 +/- 17.6 ug/g body weight), males continued to spermiate for at least one year, with viable sperm capable of fertilizing spawned eggs.

It is unrealistic at this time to expect success with other species besides milkfish and mullet, using hormone implant technology because of staff and time constraints. This can be left for future testing.

Larval rearing

Larval rearing of mullet was studied: it was found that 10-30

larvae/liter was the optimal stocking density, using 5000 liter tanks, providing that 5-10 rotifers/ml were included, as well as 700,000 - 1,000,000 cells/ml of phytoplankton. Very high survival rates of 34.3% with a range of 19.1-52.2%, were obtained at 50 days post-hatching. Thermal tolerance limits of mullet eggs were between 18-32°C, with 25.5°C optimal for normal hatching. The salinity tolerance range was about 15-45 ppt, but at the optimal temperature of 25.5°C, the optimal salinity was 37.4 ppt, giving a 96.6% hatch rate of normal larvae.

The TAG recommended that the economic analysis to determine the feasibility of adapting new technology to LDC's, should not be done at this time. For the same reason, no work was done to determine the potential use of milkfish as baitfish in the S. Pacific these will be considered in the future.

TECHNOLOGY TRANSFER

The objectives of the project, were the control of milkfish reproduction in captivity, and the development of appropriate cost-effective intensive milkfish hatchery techniques in Indonesia, the Philippines and in Taiwan. Traditional milkfish aquaculture, based on the collection of wild fry, has been conducted in Southeast Asia for several hundred years, but streamlined maturation and spawning techniques in captivity were needed. Mullet (Mugil cephalus) reproduction is also important in these countries, and similar studies were pursued on this species based on its economic importance and suitability as a model species.

In this evaluation report, we will examine the effectiveness of the technology transfer efforts to the two LDC's noted with Taiwan helping to acieve the objectives. We determined whether these countries are adopting the resultant technologies and products, and whether the project workshops and

training led to successful project outputs and accomplishments.

Indonesia

It is important to remember that the milkfish project in Indonesia is about one year behind that in the other countries, because it was started later (1987). Milkfish project planning was initiated by Dr. C.S. Lee of OI jointly with Dr. F. Cholik, Director of the Research Institute for Coastal Aquaculture (RICA), who is located at the Maros Fisheries Research Station on the island of Sulawesi. The Gondol Station, in Bali, where the milkfish work is being done, is part of RICA.

Initially, several Gondol scientists went to OI for training, including Mr. Agus Prijono. When they returned to Indonesia, they implemented the hormone induction techniques learned in Hawaii. The work at the Gondol station is joint research between OI and the Bali scientists and involves about eight technical staff from each institution. One OI scientist oversees this work and visits Gondol monthly to be available for problem solving. When his is in Bali, he frequently lectures to the Gondol Station staff, on various topics relevant to the project such as fish endocrinology. For the milkfish broodstock projects, 88 broodstock, approximately four years old, were collected from private brackish water ponds in East Java and transported to the laboratory in plastic bags. There are now 81 of the fish remaining, after initial adjustment. Forty-seven fish have been sexed (36 females and 11 males). Two spawnings occured in LHRH-a and 17 -MT implanted fish. One of the spawnings (225,000 eggs spawned) resulted in a very high hatching rate (60%). It is now possible to induce maturation throughout the year. Initial larval rearing trials are underway, and training at OI in rearing techniques will be done in the near future. The staff at RICA is very enthusiastic and hardworking, and they have

achieved considerable success. They have already been approached by private companies which are interested in the application of this work. The only problem encountered of any significance was difficulty in communicating with OI. Recently arrangements were made for telex communication between OI and the Gondol Laboratory.

Milkfish seed supply for pond stocking is a native industry, primarily conducted by a large number of individual fishermen and their families who collect fry from nature during the breeding season. But artificial propagation is needed so that there will be sufficient fry for many purposes, including their future use as bait for the various offshore tuna fisheries.

A sub-facility of the Gondol station funded by the World Bank, is under construction at Negara on Bali, located about 80 kilometers from the Gondol Laboratory. Pond rearing of milkfish is planned for this sub-station which will enable studies on the culture and grow out of propagated fry and the grow out of F_1 milkfish to reproductive size.

Mullet is one of several other finfish projects, these include work on snapper, sea bass, and grouper. There are also projects on shrimp (Paeneus monodon), turtles, oysters and plankton rearing, underway at the Gondol station. Aspects of mullet reproduction, environmental manipulation, and larval rearing are under investigation.

Philippines

The milkfish project at the Naujan substation in the Philippines experienced many problems of a political nature, and was terminated after about one year or less. This was most unfortunate because the Philippine diet relies heavily on a fresh supply of milkfish. The IDRC funded project on milkfish reproduction in the Philippines involved the fish endocrinologists, Drs. Larry

Crim, and Nancy Sherwood who carried out one of the earliest LHRH-a induced maturation attempts. IDRC no longer is working there.

A Memorandum of Understanding (MOU) was implemented with SEAFDEC in the Philippines, and this cooperative agreement involved the use of Philippine stocks of milkfish for population genetics studies. These fish were collected and the work was completed in Hawaii at OI and at the University of Hawaii. Also, a study of maturation in tank - reared milkfish at the Naujan substation. To do the study, a site was constructed and eight (7 m diameter) canvas-lined tanks were made available for holding experimental brookstock. Here 35 milkfish, that had been previously fed with dietary 17 -MT were implanted with LHRH-a at monthly intervals starting in June 1985. After four months, the results were negative. Fresh broodstock were to be obtained, but this never occurred, and owing to the political problems the work there more or less terminated. Exchange of personnel for collaborative research, training and technology transfer, did take place. Mr. Alex Bocek of OI, who was fully trained in milkfish handling and hormone implantation techniques, went to work at the Naujan substation of SEAFDEC in the Philippines, in June 1985, for one year. Mr. Jesse Banno of SEAFDEC, Philippines, went to OI in April 1985, and is still working there on all aspects of milkfish maturation/hormone implantation, and larval rearing in the hatchery. He reported on his milkfish incubation and hatching experiments at the External Evaluation Panel meeting at OI in Hawaii. He determined that when using static water for rearing milkfish eggs, a stocking density of 50 eggs per liter gave the highest % hatching. Using 50 larvae per beaker he got the best survival, especially if low aeration (35 cc/min) was used.

Although Mr. Jesse Banno is still working at OI, the efforts in the

Philippines were terminated. It is hoped that they can be resumed some time in the future, in view of the importance of milkfish in the Philippine diet and economy.

Mullet was listed as a priority species for research in the Philippines, but techniques for induced spawning were not used there as yet, and it is not currently a target species for technology transfer.

Taiwan

The Tungkang Marine laboratory (TML) in Taiwan was responsible for collaborative studies on pond ecology and the effects of environmental conditions favoring spontaneous spawning. These studies were started in 1984, and much progress has been made. It was found that circulating the water by the use of paddle wheels improved environmental conditions in the pond. Culture methods used in Taiwan include both shallow water and deep water techniques. Stock manipulation procedures are unique. In order to obtain a higher yield, despite the cold winters, they start their cultures in May, with overwintered fingerlings. Fish are harvested when they are about 500 grams weight, which is the commonest market size in Taiwan, compared with smaller fish in Indonesia and the Philippines, where the market weight is about 300 grams.

Mr. Robin Chen, Technical Director of the TML, spent several months at OI, and received training in many of the techniques for the control of reproduction. He implemented this training when he returned to Taiwan, where considerable success was achieved. Commercial application of milkfish reproduction techniques in Taiwan was most impressive. Dr. Liao, who is Director of the Taiwan Fisheries Research Institute, the home base for TML, promoted the milkfish project. It was through his efforts that the collaboration agreements were made with OI for the 1988 research on milkfish in Taiwan. In

April 1988, an OI representative went to Taiwan to study the effects of fish age on responsiveness to hormone implants.

MANAGEMENT AND REVIEW PROCESS

The management review process at OI is the result of the background, strengths and philosophies of the 2 principle institutional officers. The president, with high level business management experience, insists on a practial goal oriented strategy, while the vice president for research, who is a scientist, serves as an interface between the programatic problems that the researchers face on a daily basis and their ability to meet the hard realities of management objectives in a timely manner.

The actual process of review is divided into 3 elements. The management team explains the objectives and overall time frame to the Principal Investigator. The P.I. is then required to implement a time management analysis schedule relative to the research components. The final review element is weekly meetings between the P.I. and the management team, primarily the vice president for research, to assess the progress towards management objectives.

The overall review process at O.I. is good. The only potential problem is proper mediation between the hard time elements of management objectives and the ubiquitous, unforseen problems that biologically oriented research always produces. The vice president for research of O.I., the prime reviewing contact with the P.I., seems well aware of these aspects of biological research.

TRAINING

Training associated with this program is divided into the education of personnel from LDC's in the proper application of technology transfer elements and conducting workshops and seminars.

The strategy for training people from LDCs is to bring them to OI for

extended time periods, send OI personnel into the field as instructors, or to monitor progress, and to produce instructional video tapes.

The two workshops held to date have been extremely successful. They served as a forum for many of the world's experts and the resulting publications are significant references. The workshops have been most cost effective.

There are considerable funds allocated to the training category in this program. So far, the training of LDC personnel does not seem commensurate with the funds allocated for this purpose. There is also the potential for budgetary overlap of these funds with other funded line items such as International Networking, Collaborative Research, and Travel.

OI does not have a policy regarding training of its employees or career counselling. However, some project employees have used this US AID funded research program as a basis for pursuing graduate level university degrees. This seems to be mutually advantageous to all concerned parties. Since OI benefits in the long term from graduate education with a more capable staff, it might be prudent for it to institute a formal policy regarding career development.

BUDGET

This program is supported by a substantial annual budget averaging between $1.2 KK - 1.4 KK per year. This represents a significant portion of the Oceanic Institute's current annual $4.5 KK budget. Total funding provided by US AID to the Oceanic Institute is $4.85 KK for the period 1984 through FY 1989.

An examination of the budget categories in combination with the on-site program review raises some questions regarding allocations and expenditures. First, the overhead charged by OI seems high (95%) considering the cost sharing involved. However, it is in line with overheads charged by similar organizations

to NSF. OI's salaries are relatively low and do not include employee benefits. The Finfish Project has an administrative assistant and secretary - clerical help. Both employee benefits and the administrative - secretarial functions are supported by USAID. These normally would be provided by the host institution given such a high overhead rate.

The funds in the workshop category of the budget have been well spent with the production of important proceedings. However, arrangements for workshop expenditures from the allocations for FY 88 and 89 need to be planned, justified and implemented.

Monies spent for expert guidance or review processes have been adequate and worthwhile. There is a category for consultants containing $15 - 30 K per year which is apparently exclusive of the Technical Advisory Group and External Evaluation Panel. It is not clear if these funds have been expended and they should be examined.

The travel monies are substantial but justified by Hawaii's isolation and the need to travel to LDC's in Southeast Asia and the Pacific. There is the potential for considerable overlap of travel funds with some other budget catagories, such as Collaborative Research, Networking Activities, and Expenses for Visiting Scientists, and strict accounting should be applied to these.

Funds for the budget categories, Support Facilities and Equipment, and Supplies (total $50 K per year), are generous for the type of research considering OI provides already existing capital aquarium facilities, has an existing seawater system and facilities maintenance group, and collects a significant overhead.

The Collaborative Research allocation of $80-90 K per year is large. This is an important aspect of the program and should be supported. However, it

is not clear how these funds are actually used. Only $28K has gone to Indonesia and the Taiwanese interaction should be reciprocal. This funding line item also needs to be cross-checked with the Travel, Equipment and Supplies for Collaborators, and Networking Activities categories for redundancy.

The Equipment and Supplies for Collaborators item is superfluous. USAID controls this, but it is duplicative and unnecessary.

Networking is an important activity but, again, the possibility for overlap with other categories is likely.

Overall, this project budget is generous and this has no doubt been the enabling factor for the 6 month no cost extension.

FUTURE DIRECTIONS

To date the project has made major progress in the development of maturation techniques for the milkfish and the mullet, and has successfully initiated technology transfer activities in Indonesia.

There are two key aspects to the future development of the project. The first is the furtherence of research and development activities focused on seed production and larval rearing of economically significant brackish and marine finfish. The second is the strengthening of the technology transfer activities to ensure that the innovative and appropriate technologies, which have been and are being developed, are successfully transferred into the LDC setting.

Research and Development

The future orientation of R & D activitives related to the project at OI should be to continue to develop a portfolio of research and development programs with an intergrated approach to the development of appropriate biotechnologies for the culture of brackish and marine finfish. In the area of induced maturation and spawning, the project should continue its two pronged

approach of developing both endocrine and environmental techniques for induction of gonadal development, naturation and spawning. In this area it would be valuable to determine whether the use of a dopamine antagonist such as domperidone in combination with potent analogs of LHRH or piscine GnRH offers benefits for the induced maturation and or spawning of brackish and marine species such as the milkfish and the mullet. Another possibility is the preparation and utilitization of biodegradable polymer rods containing an LHRH analog. With regard to environmental enhancement and regulation of spawning it would be very worth while to continue to investigate the role of temperature and photoperiod on maturation in these species, and combine this with a vigourous approach to the investigation of the factors which are conducive to "natural" maturation and spawning. Success in these areas would place the OI in a very strong position to provide technology for seed production for brackish and marine species to a number of LDCs. In the area of incubation and larval rearing it would be valuable to build on the existing R & D successes with further research on the scale up of larval rearing techniques, the use of "natural" algal production and exploration of the supplementation of living foods with synthetic substitutes.

In addition to the foregoing which build directly on the existing lines of R & D, it should also be recognized that the successful completion and closure of the life cycle in these species, in which traditional culture depends on the collection of wild fry, opens a whole new range of possibilities for the domestication of these species. These include:- determination of the heritablity of production characteristics, selective breeding and also monosex culture where one sex is of higher value or where it is desirable to produce a monosex broodstock. Further possibilities include, gamete preservation, chromosome set

manipulation, cloning of identical populations and development of transgenic fish having improved production characteristics.

Technology Transfer

Here as in the area of R & D it is very important for the project to continue to build on its successes. The first priority here is to continue the close collaboration with the Indonesian government at the Gondol Research Station for Coastal Aquaculture of the Central Research Institute for Fisheries (CRIFI). The recent successes with induced maturation and spawning of milkfish at this station are well recognised by the senior officials in Indonesia and it is important that the technology transfer effort here be sustained and strengthened by continuing the current effort on endocrine control and initiating or expanding work on larval rearing, environmental control of maturation and the development of a natural spawning broodstock. The F_1 generation of milkfish resulting from earlier USAID supported R & D at this station represent an extremely valuable national resource as they have undergone one complete cycle of domestication. It is important that this F_1 group be reared as domesticated broodstock in secure rearing facilities. Active technology transfer support from OI should continue until, 1) a high level of survival through larval rearing has been achieved from the existing spawners, 2) the F_1 milkfish have been successfully matured, spawned and their offspring successfully reared and stocked in grow out facilities. 3) technology transfer workshops have been held for extention agents from other regions of Indonesia. During on-site discussions, Indonesian officials also expressed a strong interest in extending the existing technology transfer activities to the mullets *Mugil tade* and/or *Mugil cephalus* and in extending technology transfer activities to the Research Institute for Coastal Aguaculture at Maros on the

island of South Sulawesi where the Research Institute for Coastal Aquaculture is headquartered (see Appendix 4). The review committee supports these suggestions from the Indonesian government with the proviso that the primary focus remain on the successful transfer of these technologies at Gondol. Gondol is a superb site for brackish and marine research and has excellent facilities built by the World Bank and equipped by USAID. Its only drawbacks are its distance from a major population center and the fact that it is not collocated with the aquaculture industry.

As the technology transfer activities at Gondol reach into the area of larval rearing it is important that consideration be given to having OI staff spend longer periods working with Indonesian biologists. Currently, for the induced maturation activities, OI staff spend approximately 2 days per month at Gondol, this is insufficient for the rapid and successful transfer of the larval rearing techniques and would also be insufficient for a strengthened program which includes environmental control and development of "natural" broodstock maturation. At Gondol there is opportunity to compare broodstock rearing in sea cages, onshore tanks supplied with pumped sea water and excavated ponds at the Nagara substation near Gondol, which is being constructed with World Bank funding.

Apart from the ongoing efforts in Indonesia other key considerations are the potential for technology transfer to other LDCs. This can be accomplished either by initiating new technology transfer projects in additional LDC's, by mounting of short term technology demonstrations or by organization of one or more workshops. These could be funded by mission buy-ins, by funding from the existing project or by a new submission which contains within it expanded technology transfer efforts. As indicated elsewhere in this report there are a

number of candidate nations in Southeast Asia and the Pacific where milkfish technology transfer would be possible including the Philippines, Thailand, Bangladesh, Sri Lanka and the LDC nations of the South Pacific. The possibilities for technology transfer of mullet culture are greater in number owing to the wide geographic distribution of the Mugilidae and include in addition to the above nations the LDCs of the Mediterranean especially Egypt.

RECOMMENDATIONS

General Recommendation

In view a) of the excellent progress that has been made both in Research and Development at OI particularly over the last year b) of the excellent progress that has been made in technology transfer in Indonesia, and c) of the close and effective cooperative relationship that has been developed with Taiwan, the EEP has determined that the project has the clear potential to have a major impact on the culture of warm water brackish and marine finfish in LDCs. In order for the project to realize the potential for a major and lasting impact of this type the EEP recommends that the project receive full support from USAID for the duration of the existing project and that very serious consideration be given to the development of a project extension which would take into account the specific recommendations of the EEP with regard to research, development and technology transfer.

Specific Recommendations

1. That serious consideration be given to the development of a project extension with OI which would build on current R & D strengths and on the current technology transfer successes.
2. That the technology transfer initiative in Indonesia be continued until the following criteria have been met.

a) Attainment of a high level of larval survival to stocking size from endocrine manipulated spawners.

b) Successful maturation and spawning of the current F1 generation and rearing of the F2 larvae to stocking size.

c) Successful conduct of training sessions for regional extension officers.

3. That reproduction research, in addition to current endocrine studies, focus on environmental manipulation and the factors responsible for spontaneous maturation and spawning.

4. That incubation and larval rearing research continue its focus on definition of optimal conditions for mass rearing at high survival rates using natural and artificial feeds.

5. That a regional international workshop be held to bring together LDC biologists and scientists from the developed countries to exchange information on techniques for controlled reproduction and larval rearing applicable to brackish and marine species and also to discuss the new biotechnologies that are expected to have a major impact on finfish culture over the next decade.

6. The EEP recognizes the important roles of Dr. I. Chiu Liao, Director General, Taiwan Fisheries Research Institute and Dr. Fuad Cholik, Director, Research Institute for Coastal Aquaculture, Indonesia, in the cooperative activities with Taiwan and in the technology transfer activities in Indonesia, respectively, and recommends that the attendance of both of these persons at all future TAG committee meetings be given a high priority.

7. The committee acknowledges the important role that TAG members Dr. Malcolm Gordon and Dr. John Hunter have played in the scientific direction of the project and recommends that they continue to be actively involved.

8. The committee recognizes that the Oceanic Institute placed as it is in the tropical Pacific Ocean is in a unique position within the United States in its capability to conduct research, development and technology transfer activities on aquacultured tropical brackish and marine finfish and recommends that USAID continue to work with OI during its current growth phase so as to further strengthen its role as a world class aquaculture research and development facility in order to meet USAID mission goals relating to production of additional high quality dietary protein in the LDCs.
9. No changes are currently needed in the Management Review Process. Results so far justify the strategy. Scientific management is cognizant of the unique nature and problems associated with research on living organisms.
10. The committee recommends that the various travel budgets be more specifically defined as there appears to be some overlap between them.
11. The EEP recommends that the OI team maintain its focus on milkfish and mullet for the duration of the current project. The team should then give serious consideration to extending its efforts on controlled reproduction and larval rearing to additional economically important brackish and marine finfish in a project extension proposal. Potential species include the seabass Lates calcarifer, the groupers Epinephales sp. and the sea breams.
12. The EEP recognises the dedication of the young and enthusiastic program employees at OI and recommends that the staff could be strengthened in two ways. First additional career development could be provided for current employees and second an attempt could be made to bring in additional persons with specialized experience in addition to the principle investigator, e.g. university or government scholars on sabbatical leave.

13. The committee recognizes the key role of the program head, Dr. C.S. Lee in the successful development of this project and compliments him on the level of progres. that has been achieved. We recommend that Dr. Lee continue in his role as the PI of this project.

14. A reorganization or reassignment of personnel within the finfish program should be considered to increase the international field activities of technology transfer or an additional qualified biologist could be hired for this purpose.

15. Specific research subjects need additional emphasis. These are nutritional requirements of maturing adults, the role of dopamine antagonists in induced ovulation, determination of egg quality, and most aspects of larval rearing. It would be valuable to add additional larval rearing expertise to the program in one or more of the following areas, physiology, biochemistry, nutrition, ethology.

APPENDIX 1

RESPONSES TO THE SCIENTIFIC ISSUES LISTED IN THE FORMAL SCOPE OF WORK

APPENDIX 1: RESPONSES TO THE SCIENTIFIC ISSUES LISTED IN THE FORMAL SCOPE OF WORK

1. **Is the project purpose, to develop field applicable techniques for inducing gonadal maturation in milkfish, spawning of milkfish and successful rearing of milkfish fry, being achieved?**

   At this stage, approximately four and one half years into the project it is clear that the project purpose is being achieved. Endocrine techniques for the controlled reproduction of milkfish have been developed and are being refined and field tested in both Taiwan and Indonesia. In addition there has been significant re ent progress at the Oceanic Institute in the development and adaptation of larval rearing techniques for milkfish. In addition to these primary achievements parallel successes have been attained in the reproduction and larval rearing of a second economically important species, the striped mullet Mugil cephalus.

2. **Is the project on schedule as outlined in the Cooperative Agreement and the annual work plans?**

   The main elements of the project as outlined in the cooperative agreement and annual work plans are basically on schedule. i.e. tasks 1-5, 9-10 of the cooperative Agreement extension dated 28 July '86. On the advice of the TAG group, research and development on task 6 - Application of the new technology to two additional families of fish. Task 7 - Economic adaptation and impact and task 8 - Milkfish as baitfish, were deleted from the work plan in order to tighten the focus of the project and ensure that success was achieved in the primary areas within the time frame.

3. **On the basis of a review of specific research activities, are the experimental design, research techniques and rate of progress satisfactory**

for the research activities undertaken?

In evaluating the rate of progress, consideration must be given to the nature of the work and time frame required, for the development of biological technologies. In particular in studies on fish propagation it is necessary to first of all develop the technology for maturation and induced spawning before research can be conducted on incubation, and this must in turn succeed before research can be conducted on larval rearing. When these factors are considered it is evident that significant progress has been achieved.

The review panel determined that the experimental approaches and designs and the research techniques utilized were appropriate and showed a significant level of innovative thought on the part of the investigators in conjunction with inputs from the TAG group.

4. **Are research results and techniques viable, particularly in relation to transferability in the LDC context?**

The research results and techniques developed are in the process of being shown to be viable in the LDC content. By conducting dose response studies the cost of using endocrine techniques to induce spawning in milkfish and mullet has been reduced to an economic level, and recent achievements in the environmental control of maturation in mullet should also be applicable in the LDCs, especially photoperiod manipulation. During 1988 in particular there has been rapid progress in the definition of optimal physical parameters for egg incubation and feeding parameters for larval rearing in both milkfish and mullet, and it is expected that this information and the associated incubation and larval rearing technologies will be successfully applied in the LDC context.

5. Are publications, manuals, and reports of project activities being properly developed and disseminated? Assess the quality of publications.

The project has been particularly successful in the dissemination of information through published reports. Specifically there have been 14 primary publications in refereed scientific journals, 5 full length publications and 4 short publications in conference proceedings. An additional 8 publications have been submitted for publication or are currently in press.

The project has also published a major state of the art document on milkfish aquaculture and has collaborated with IDRC in the organisation of a conference on finfish reproduction the proceedings of which are now in press.

6. Have the two workshops been appropriate and effective?

Should the focus of the proposed workshop be modified in any way?

The two workshops, the first in Taiwan, and the second in Singapore both contributed significantly to the exchange of information between researchers in the LDCs and the developed countries. The third workshop should focus on: 1) the new technologies that have been developed for the regulation of maturation and spawning 2) on technologies for larval rearing and 3) on experiences in the application of these technologies in the LDCs. In addition it would be beneficial to have presentations on the development and application of sex and growth control biotechnologies and on the integration of new technologies into viable production systems.

7. Are research personnel appropriate and are staffing and organisation adequate?

In general the research personnel are appropriate with an adequate mix of

professional and technical individuals. There are deficiencies in 2 areas of expertise, however. Namely larval physiology (a vacancy) and larval nutrition. A biochemist might be desirable. The staffing in terms of numbers seems more than adequate. There are currently 15 people and 1 vacancy involved in the program. This is as large or larger then most other research programs in the world involved in early life history associated studies. The structure of the Table of Organisation is good. The P.I. has a professional second in command as well as administrative and secretarial - clerical help. The remaining professionals and technicians are logically divided into 2 groups, one dealing with aspects of reproduction and one with rearing. Each is headed by a nominal group leader (although I is currently vacant). An organisational element dealing with the field aspects of technology transfer might be desirable as this program element is implemented. Currently, personnel from the other 2 groups are asked to go into the field every month, thus detracting from their work. A reassignment of personnel as aspects of the research change might be appropriate. There is one unusual aspect of OI personnel staffing philosophy and procedures that may be relevant and potentially negative to USAID long term committment to a working agreement. The O.I. encourages the employment of young personnel with low salary rates. This produces a dynamic but potentially volatile staff with the possibility of high turnover rates. This may affect continuity in a long term cooperative working agreement.

8. Are there identifiable gaps in the project research?

There are indentifiable gaps in the timing of research topics relative to the projected schedules as well as gaps in particular research subject areas. Although progress has been made and the quality of the research is

excellent, the whole larval rearing component and transfer of controlled reproductive technology to the field have been delayed relative to the proposal schedule. Gaps in specific research subject areas exist in nutritional requirements of adults associated with controlled maturation, aspects of egg quality, behavioral research of spawning adults, and most areas of the larval rearing component.

9. Identify any implementation problems or issues with regard to the research plan, budgets, dissemination of information, etc.

There are a number of implementation problems relative to the projected schedule. The larval rearing, although proceeding and scientifically sound, is behind schedule and slow in development.

The transfer of technology and methodology to LDCs, a primary USAID goal, is slow in developing. A lack of expertise or emphasis in the program has apparently resulted in no notable progress in nutritional requirements of maturing adults and egg quality research. Lack of appropriate methodology or techniques is preventing program personnel from determining gonadotropin profiles.

10. Has collaboration on research and extension of results been satisfactory, specifically with Taiwan and Indonesia? Are additional collaborative efforts desirable?

The nature of the collaborations with Taiwan and Indonesia by the USAID funded program at O.I. has been quite different for each country. Taiwan is not considered to be an LDC and has an extensive research history and developed milkfish aquaculture industry. Indonesia, on the other hand, is an LDC with a need for technology transfer to its culture efforts for milkfish. The Taiwanese collaboration is one of equal partner research

sharing with OI. OI has passed on its hormone implantation technology to Taiwan while the Taiwanese aquaculture research program at the Tungkang Marine Laboratory is conducting adult maturation studies coordinated with the OI basic research program. This collaboration is helped by the close ties the O.I. Principal Investigator has to the Taiwanese Federal Research structure. These interactions presently are supported equally by both parties. Any future joint research should be conducted on the same equal basis.

Indonesia is a true LDC. As such, its Milkfish Culture Program requires the development of basic research, the transfer of techology, and the allocation of support funds. OI is providing these and the Indonesians are producing results. Currently, broodstock representing the F1 generation from a natural spawning in ponds at the Gondol Station and fish purchased from East Java are being maintained. The hormone implantation technique developed at OI is being used by Gondol Station personnel and has resulted in successful spawnings. Attempts at larval rearing are also in progress. OI's interactions and transfer of technology as well as the Indonesian's enthusiasm and capability have been encouraging. The transfer of $28K from OI to Indonesia for support of the cooperation so far seems low. This should be reviewed for consideration of an augmentation of funds if justified.

11. Has the Technical Advisory Group been effective? Should its composition be changed?

The TAG has been very useful and probably one of the most cost-effective elements of the budget. It is composed of 2 elements of expertise-one concerned with basic research on controlled reproduction and larval rearing

(Drs Gordon and Hunter) and the other dealing with the transfer of technology to LDC's (Drs Liao and Dr Cholik). The success of the controlled reproduction research is the direct result of TAG recommentations, and the larval rearing research, although slow in development, is appropriate research because of TAG. The influence of the international members is harder to determine. Dr. Liao is an acknowledged and respected expert on the milkfish. He has recently assumed the position of head of Taiwanese fisheries research and therefore has heavy administrative responsibilites. His future role as a TAG member will most likely be one of influence by reputation.

Dr. Cholik, the Indonesian representative, has an enthusiastic interest in the project. He is knowledgable and committed. His participation in past meetings has apparently been a problem because of communication. If the biopolitical considerations of Taiwanese participation are not important, or if Dr. Liao is not available, then an alternate participant may be. Every effort must be made to insure that Dr. Cholik and Dr. Liao attend TAG meetings.

The EEP also recommends that Dr. Cholik visit Taiwan soon to see first hand commercial scale milkfish broodstock and hatchery installations.

12. Review and validate the Oceanic Institute's cost-sharing contribution under the Cooperative Agreement.

IO's cost-sharing contribution to this program is minimal. The only substantial contribution to this research that OI provides is the brainpower of its scientific staff. It seems that OI acquires maximal economic benefit from the research funding source with minor tangible institutional contribution. For example, OI pays lower than average professional and technical salaries, does not contribute to benefits of project personnel

(USAID provides this), and receives a high (95%) overhead. It may be argued that OI provides capital facilities and equipment but USAID has contributed and continues to contribute large sums of money in these catagories. Furthermore, there is generous support for travel and apparently underutilized funds for technology transfer, training and international networking. There is definitely a question of balance and equity here.

13. Review the extent to which project activities and outputs (as specified in the logframe) are likely to be achieved by the end of the current agreement.

All 10 of the issues listed in the logical framework for Reproduction Studies on milkfish (10 tasks involved) were completed. This included: for tasks 1-7, bringing the milkfish to maturity using hormonal implants; manipulation of environmental factors; monitoring steroid profiles and improved larval rearing methodology. Also included were mullet hormone implants and environmental regulation for enhanced maturation and spawning, and larval rearing.

For Task 8, Technology Transfer: Training, based on MOU's between OI and Indonesia, the Philippines, and Taiwan, for milkfish research, three representatives from these countries completed a training program. The program included training in milkfish production and implantation of the hormones. Also, seven scientists from the Peoples' Republic of China, received some training in various aspects of milkfish and striped mullet reproduction control. The Philippines program was terminated when political conditions there deteriorated.

For Task 9, Technology Transfer: Publications, the following were completed. A State-of-the-Art publication : "Aquaculture of milkfish

(Chanos chanos)", was published in 1986 by Oceanic Institute, HI. The proceedings of two workshops were published: one held in 1985 entitled, "Workshop on the Reproduction and Culture of Milkfish", published by Oceanic Institute and Tungkang Marine Laboratory; and a second one called "Singapore Workshop for the Induction of Spawning of Teleosts", published in November/December 1988, Aquaculture, vol. 74 (1 and 2). A third will be held sometime in 1989 (probably in Taiwan). Ten papers were published in refereed journals (primarily "Aquaculture"), on various aspects of mullet and milkfish reproduction. Several other articles are in press, submitted to "Aquaculture" and other refereed journals..

For Task 10, to expand existing research network of cooperators for reproduction, the Network for milkfish and mullet culture includes institutions in the developed (OI in Hawaii and Tungkang Marine Laboratory in Taiwan), and developing countries (Gondol Research Station) Indonesia; Southeast Asian Fisheries Development Center, Philippines; and the Fisheries Research Institute, Bangladesh). Also about 7 institutions in the Peoples' Republic of China are included in the Network.

14. Review project budget and expenditure reports to determine conformance met and adequacy for the current scope of work.

The budget and expenditure reports are on schedule and in conformance with the plans. In some cases monies were not spent on schedule, as for example in the case of approximately $4,500 of equipment money not yet used at the Gondol Fisheries Station in Bali. The money was insufficient for the purchase of the equipment needed, a photomicrography camera and an incubator tank. The lack of this equipment did not delay the progress of the work because the larval rearing part of the research was not ready to get

started. The major objective of the project, to transfer the technology to the user country, is about ready for implementation in Indonesia. That is, the Fisheries laboratory at the Gandol Station in Bali has mastered the LHRH-a hormone implantation technique, and achieved maturation and spawning of treated fish. The next step will start soon, training in larval and fry rearing.

15. Review and assess the Oceanic Institute's internal review process for monitoring research activities, financial control, and program planning and management.

According to information from various OI administrative officials, and comments from the Project Manager and the project staff, weekly staff meetings are held with the project personnel. At these meetings, attended by OI's President, Bill Rowland, VP, Paul Bienfang, and the Project Manager, Cheng Sheng Lee, and the various program staff, problems, plans and goals are discussed. The Institute uses a Time Management System as a tool to keep the programs on schedule.Also, the Program Managers for each Program, report directly to the OI VP Paul Bienfang. If any problems arise, they are aired, and guidance is given. Financial control is also the responsibility of Dr. Bien-fang.

16. Assess, to the degree possible, the cost-effectiveness of this kind of research program.

In view of the fact that graduate students are used extensively, wherever appropriate, on this project, the cost-effectiveness is high. The salaries given are, according to the VP of OI, what the market determines. However, because of the desirability of working in Hawaii, these seems to be a surplus of willing labour on the graduate student level. These people work

very hard for relatively low salaries, and put in many overtime hours without additional compensation.

The OI staff visit some of the LDC Fisheries Stations on a regular basis. While these trips are costly, when they are in the various countries, they set-up extensive networking for the project. Also, they give lectures to the staff, and this is very cost-effective.

17. Identify the potentially most appropriate program areas for Mission buy-ins.

While the OI milkfish project in Indonesia is not a USAID Mission project, but a centrally funded one, it has much potential for Mission buy-ins in the following program areas. Development of commercialization of the milkfish larval and fry rearing programs, based on improved techniques of feeding, and all aspects of rearing, including disease management, are aspects of the program that will be very appropriate for USAID-Mission buy-ins. If this is combined with commercialization of the hormonally induced maturation and spawning parts of the project, the entire package of the technology for the milkfish program can be made available.

18. Is the Oceanic Institute a member of any network; what kind of linkages have been established with other USAID projects, ICLARM or other international organisations, other donor programs, or other U.S. institutions?

OI is part of an international network in Aquaculture, and established close working relationships with many overseas laboratories including the Tungkang Marine Laboratory in Taiwan, which is serving as a collaborative institution for this project, and with the Taiwan Fisheries Research Institute whose Director, Dr. I.C. Liao also oversees the Tungkang facility. The South East Asian Fisheries Development Center (SEAFDEC) in the Philippines has a staff

member, Dr. Alfredo Santiago, who served on the project's Technical Advisory Group (TAG), and initially the project did some active research in the Philippines, until the political situation there deteriorated. Members of the International Center for Living and Aquatic Resources Management (ICLARM), in the Philippines, are also consulted from time to time, and they attended the workshop on "The Reproduction and Culture of Milkfish" held in Taiwan. As for any linkages with the Canadian International Development Research Center (IDRC), a workshop on "Fish Breeding" co-sponsored by IDRC-USAID, and planned and executed by OI, was held in Singapore 1987. Many Canadian as well as OI and Southeast Asian scientists participated and gave presentations. There has been some interaction with Japan, another donor country, via the Japan International Cooperation Agency, and in various capacities, including research collaboration, consultation, and some educational training of OI participants in the project. Other U.S. institutions that OI interacted with include: the Univ. Hawaii, the Univ. California, the Univ. of Notre Dame, and the National Marine Fisheries Service of NOAA, and others.

APPENDIX 2

GENERAL ITINERARY FOR EEP, DECEMBER 7-21, 1988

AND

AGENDA FOR EEP MEETING AT OCEANIC INSTITUTE, DECEMBER 8-9, 1988

ITINERARY OF EEP, DECEMBER 7-21, 1988

December 7 - evening meeting in Honolulu

December 8-9 - the evaluation team plus Dr. Malcolm Gordon will meet with staff, and review programs and facilities at the Oceanic Institute in Waimanalo, Hawaii.

December 10-12 - the team will travel to Tungkang, Taiwan, stopping in Taipei to discuss the project with Dr. I.C. Liao, a host country TAG member.

December 13 - the team will review programs and tour facilities of the Tungkang Laboratory, as well as tour milkfish farm locations in Southern Taiwan.

December 14-15 - the team will travel to Jakarta, Indonesia.

December 15 - the team will meet with USAID/Jakarta and RCCF/GOI.

December 16-17 - the team will travel to Gondol and review programs and facilities of the Gondol laboratory.

December 18-20 - the team will travel to Singapore and write the evaluation report.

December 21 - the team will return to their respective locations.

APPENDIX 3

LISTING OF PROJECT PUBLICATIONS

FINFISH PROGRAM PUBLICATIONS

Weber, G.M., and C.-S. Lee. 1985. Effects of 17α-methyltestosterone on spermatogenesis and spermiation in the grey mullet *Mugil cephalus* L. J. Fish Biol. 26: 77-84.

Lee, C.-S. and R. Hirano. 1985. Effects of environmental factors on the spawning cycle of sand borer, *Sillago sihama* (Forsskal). Prog. Fish Cult. 47(4): 21-26.

Lee, C.-S., C.S. Tan: u and L.W. Crim. 1985. Preparation of a luteinizing hormone-releasing hormone cholesterol pellet and its implantation in the milkfish (*Chanos chanos* Forsskal). Proceedings c the Workshop on the Reproductior and Culture of Milkfish, held in Taiwan, April 1985. p. 215-226.

Lee, C.-S. 1985. Environmental factors in milkfish reproduction. *In*: Reproduction and Culture of Milkfish. C.S. Lee and I.C. Liao (eds.). Published by the Oceanic Institute, HI, and Tungkang Marine Laboratory, Taiwan. pp. 99-114.

Lee, C.-S., C.S. Tamaru, C. Kelley, J. Banno, C.D. Kelley, A. Bocek and J.A. Wyban. 1986. Induced maturation and spawning of milkfish, *Chanos chanos* Forsskal, by hormone implantation. Aquaculture 52: 199-205.

Lee, C.-S. and G.M. Weber. 1986. Effects of salinity and photoperiod on 17α-methyltestosterone induced spermatogenesis in the grey mullet, *Mugil cephalus* L. Aquaculture 56: 53-62.

Lee, C.-S., C.S. Tamaru, C.D. Kelley and J.E. Banno. 1986. Induced spawning of milkfish, *Chanos chanos*, by a single application of LHRH-analogue. Aquaculture 58: 87-98.

Lee, C.-S., G.M. Weber and C.S. Tamaru. 1986. Effects of orally administered 17α-methyltestosterone on spermatogenesis in immature milkfish *Chanos chanos* Forsskal. J. Fish Biol. 29: 567-572.

Lee, C.-S. 1986. Reproduction. *In*: Aquaculture of Milkfish (*Chanos chanos*): State of the Art. C.S. Lee, M.S. Gordon and W.O. Watanabe (eds.). Published by the Oceanic Institute. pp. 57-76.

Kelley, C.D. and C.S. Lee. 1986. Artificial propagation. *In*: Aquaculture of Milkfish (*Chanos chanos*): State of the Art. C.-S. Lee, M.S. Gordon and W.O. Watanabe (eds). Published by the Oceanic Institute. pp. 83-116.

Lee, C.-S., C.S. Tamaru, J.E. Banno and C.D. Kelley. 1986. Influence of chronic administration of LHRH-analogue and/or 17α-methyltestosterone on maturation in milkfish, *Chanos chanos*. Aquaculture 59: 147-159.

Lee, C.S., C.S. Tamaru and C.D. Kelley. 1986. Technique for making chronic-release LHRH-a and 17α-methyltestosterone pellets for intramuscular implantation in fishes. Aquaculture 59: 161-168.

Tamaru, C.S. 1986. Population structure. Reproduction *In*: Aquaculture of milkfish (*Chanos chanos*): State of the Art. C.S. Lee, M.S. Gordon and W.O. Watanabe (eds). Published by the Oceanic Institute. pp.37-55.

Lee, C.-S., C.S. Tamaru, G.T. Miyamoto and C.D. Kelley. 1986. Induced spawning of grey mullet (*Mugil cephalus*) by LHRH-a. Aquaculture 62: 327-336.

Lee, C.-S., C.S. Tamaru, G.M. Weber. 1988. Studies on the maturation and spawning of milkfish, *Chanos chanos*, in a photoperiod-controlled room. J. World Aquacul. Soc. 18(4): 253-259.

Kelley, C.D., Lee, C.-S. and Tamaru, C.S. 1987. Acceleration of maturation and double spawning in one season in the grey mullet (*Mugil cephalus*) following chronic hormone treatment. Proceedings of the Third Symposium on Reproductive Physiology of Fish. pp. 204.

Lee. C.-S., Tamaru, C.S., and Kelley, C.D. 1987. The cost and effectiveness of CPH, HCG and LHRH-A on the induced spawning of grey mullet, *Mugil cephalus*. Proceedings of the Third Symposium on Reproductive Physiology of Fish. pp. 99.

Tamaru, C.S. amd Lee, C.-S. 1987. Testosterone and Estradiol-17β profiles of female milkfish, *Chanos chanos*, undergoing chronic LHRH-A and 17α-methyltestosterone therapy. Proceedings of the Third Symposium on Reproductive Physiology of Fish. pp. 218.

'amaru, C.S., Lee, C-.S., Aida, K., and Hanyu, I. 1987. Changes in serum testosterone and estradiol-17β levels in milkfish, *Chanos chanos*, undergoing chronic hormonal therapies. *In*: Proceedings of the First Congress of the Asia and Oceania Society for Comparative Endorinology (AOSCE). E. Ohnishi, Y. Nagahama, H. Ishizaki (Eds.). Nagoya University Corporation. Nagoya, Japan, November 4-7, 1987. pp. 361-362.

Iagiwara, A., A. Hino and R. Hirano. 1988. Comparison of resting egg formation among five Japanese stocks of the rotifer, *Brachionus plicatilis*. Nippon Suisan Gakkaishi 54(4), 577-580.

Iagiwara, A., A. Hino and R. Hirano. 1988. Effects of temperature and chlorinity on resting egg formation in the rotifer, *Brachionus plicatilis* O.F. Muller. Nippon Suisan Gakkaishi 54(4), 569-575.

amaru, C.S., C.-S. Lee, C.D. Kelley and J.E. Banno. 1988. Effectiveness of chronic LHRH-analogue and 17α-methyltestosterone therapy, administered at different times prior to the spawning season on the maturation of milkfish (*Chanos chanos*). Aquaculture 70: 159-167.

ozeki, Y. and Hirano, R. 1988. Effects of glutaraldehyde fixation on the body size of red sea bream (*Pagrus major*) larvae. Aquaculture 71: 265-269.

PAPERS SUBMITTED FOR PUBLICATION

Lee, C.S. and C.S. Tamaru. 1986. Application of LHRH-a cholesterol pellets to maturation of finfish -- milkfish. U.S. Dept. of Commerce. In press.

Lee. C.-S., Tamaru, C.S., and Kelley, C.D. 1987. The cost and effectiveness of CPH, HCG and LHRH-A on the induced spawning of grey mullet, *Mugil cephalus*. Aquaculture. In press.

Lee, C.-S. and C.S. Tamaru. 1987. Advances and future prospects in controlled maturation and spawning of grey mullet (*Mugil cephalus* L.) in captivity. (Submitted to Aquaculture for special Singapore Workshop Issue.)

Tamaru, C.S., C.-S. Lee, C.D. Kelley, K. Aida and I. Hanyu. 1987. Characterizing the stage of maturity most receptive to an acute LHRH-Analogue therapy for inducing milkfish (*Chanos chanos*). Aquaculture. In press.

Walsh, W. A., Swanson, C., Lee, C.-S., Banno, J.E. Ed.:. H. 1988. Oxygen consumption by eggs and larvae of striped mullet, *Mugil cephalus*, in relation to development and salinity. Submitted to J. Fish Biol.

Oozeki, Y., Ishii. T., and Hirano, R. 1988. Histological study of the effects of starvation on reared and wild-caught larval stone flunder, *Kareius bicoloratus*. Marine Biology. In press.

Tamaru, C.S., Kelley, C.D., Lee, C.-S., Aida, K. and Hanyu, I. 1988. Effects of chronic LHRH-a and 17a-methyltestosterone or LHRH-a + testosterone therapy on oocyte growth in the striped mullet, *Mugil cephalus*. Submitted to Gen. Comp. Endocrinol.

Tamaru, C.S., Lee, C.-S., Kelley, C.D., and Banno, J.E. 1988. Profiles of sex steroids from milkfish (*Chanos chanos*) during an annual cycle and undergoing chronic LHRH-a and/or 17α-methyltestosterone treatment. Submitted to Aquaculture.

APPENDIX 4

REPORT OF OI-RICA

MILKFISH MATURATION

PROJECT 1987-1988

REPORT OF
OI - RICA MILKFISH MATURATION PROJECT
1987-1988

BACKGROUND

Indonesia has 4.2 million hectares of tidal land which suitable for brackishwater fish production. Milkfish culture area in Indonesia covers 182,000 ha ponds which is roughly 65 % of the total area under aquaculture.

In Indonesia, milkfish production is believed as an appropriate means to increase animal protein consumption. The goverment's program for milkfish aquaculture are both extensification (expansion of area) and intensification (use of greater quantities and variety of input) to increase the supply, generate employment, and to improve the incomes and living standard of rural Indonesian. Also, milkfish can be used as bait for off-shore tuna fishing.

For those reasons, the demand of milkfish fry for aquaculture may increase in the future. By contrast, milkfish seed supply for pond stocking is still greatly dependent on natural collection. The supply fluctuates annualy and this leads to the destabilization of the milkfish farming industry. Effort to artificially propagate the milkfish have been undertaken to provide mean to increase the fry supply.

Spontaneous spawning without any prior treatment to the broodstock in captivity occured nine times between January 25 to April 13, 1985 in Gondol Station of the Research Institute for 200 adult milkfish derived from the spawning are being cultured at the station, at present.

Started in 1987, an Oceanic Institute (OI) - Research Intitute for Coastal Aquaculture (RICA) joint reseach on induced maturation of milkfish is being carried out at Gondol (Bali). The research is applying recent technique on induced maturation which was succesfully carried out at the Oceanic Institute of Waimanalo, Hawaii.

PROJECT PERIOD AND SCHEDULE OF ACTIVITIES

The memorandum of understanding of the joint research project was signed in Jakarta, Indonesia on April 13, 1987.

The project duration was for three years, started from April 1987 until March 1990. The first year schedule of activities could be seen on appendix 1.

US $ 28,000 budget had been funded for the first year activitis including salary, training, purchase of supllies and equipments, and local travel.

PROJECT STAFF

Eight staffs of RICA were assigned for the implementation of the project. These consist of four scientists and technicians, respectively. The former includes the director of RICA and the Head of Gondol Station. The Director of RICA is responsible for the overall project implementation, while the station head's ons responsibility to implement the dailly activities of the project. Names of the local staffs involved in the project are as follows:

DR. Fuad Cholik
Mr. Zafril Imran Azwar
Mr. Agus Priyono
Mr. Gede S. Sumiarsa
Mr. Dedi Rohaniawan
Mr. Agus Supriyatna
Mr. Gusti Putu Oka Suarjana
Mr. Putu Suarjana

Periodic visits of OI scientists to project location in Gondol to implant hormone, sex identification and observation of maturation stage of milkfish were conducted since August 1987. Up to November 1988, eighteen visits were carried out. Names of the OI scientists visited the project are as follows:

DR. Cheng-sheng Lee
DR. Clyde S. Tamaru
Mr. Cristopher D. Kelley
Mr. Garret T. Miyamoto
Mr. Jessie E. Banno
Mr. Aaron Moriwake
Mr. John Ginoza

PROJECT ACTIVITIES

Broodstock collection

Broodstocks were obtained from private brackishwater ponds (tambak) in Sidoarjo, East Java. The sites is about 400 km from Gondol. The site can be reached by boat and land transportation.

A total of 88 broodstocks were purchased and transported to project site. The fish weighing between 2.5 to 6 kg per fish were colected from shallow traditional milkfish ponds. Where the fish grows on natural food. The age of the fish approximately is 4 years old.

Collection of the broodstocks was carried out by total draining of the tambaks. The draining was done gradually.

By doing so, the fish folllows the receding waters and concentrate in the deeper part of the pond, i.e. in the peripheral canal. A sheet of screen made of bamboo slats was installed near the sluice gate. The width of the screen was as wide as the peripheral canal and about 2 m height. Two men pushing another sheet of bamboo screen slowly moving along the canal and reach another side of the gate. This operation concentrate the fish in front of the gate. The fish was then encircled by the bamboo screens. During high tide brackishwater flows into the pond, provide the fish with new aerated and relatively clear water. This stimulated the fish to swim against the current in the sluice gate. The concentrated fish was caught individually by using a piece of plastic bag of 60 cm wide and 100 cm long and a scoop net. The individual fish was forced to enter the bag containing water and immediatedly put into a fiberglass tank mounted on a boat. The water in the tank was aerated by diffused oxygen. By doing so, stress due to handling and physical damage to fish could be minimized.

Transport of Broodstock.

Eight trips were made to transport 88 adult milkfish from tambak in Sidoarjo to Gondol. The duration of each trip was 10-13 hours.

Three container, each of 0.5 m^2, were mounted on a wooden boat and filled with low salinity water (15-20 ppt) to a depth of 40 cm. Oxygen contained on oxygen bottle of 6 cubic-meters was supplied to each container via 6 airstones (2 pertemperatur at 25-27° C). Disolved oxygen was checked using YSI oxygen meter and kept between 5.0-10.0 mg/l.

After arriving at the landing place the fish was transfered into a canvas tank mounted on a truck. The canvas tank (of approximately 3.5 m^2) was , filled with low salinity water, to a depth of 40-50 cm. The tank was airated with oxygen from an oxygen bottle using four airstones. Pieces of ice wrapped in a small plastic bags were put inside the tank to keep the water 27° C.

Mortality during the collection and transport was minimal. Out of the 88 fish transported only one died at transport and none during collection.

Handling at Gondol Station.

Upon arrival at Gondol, the fish were transferred from the canvas tank on the truck into land based circular tanks. Catching the fish in the canvas tank was carried out by individually guided the fish to a plastic bag filled with sea water to avoid stress and mortality. The 88 fish were distributed into 7 tanks at the stocking density of 9 to 19 fish per tank.

The water in the holding tanks was changed at the rate of 100% per 24 hours using the flow through system. For the purposes of the aclimation of the fish water salinity in each tank had been decreased to 20 ppt, the day previous to the transportation, and maintained at this level for several days to allow fish to recover from stress during transportation. The adipose tissue covering the eyes of the fish shortly after released into tank became opaque for a week. But it healed by themselves. They were observed swimming around the surface of the water.

After salinity in each tank had been increased gradually to full seawater salinity level the fish was fed to station twice a day with comercial fish feed of 26 % protein contents at 3 % of total body weight.

Mortality of the broodstock was experienced due to mishandling. Seven fish jump out of the water, though the tanks were covered by net.

Maturation Experiment

The method applied in this experiment is induced maturation by hormone pellet implantation. This method has been succesfully applied in the maturation of milkfish at the Oceanic Institute of Waimanalo, Hawaii. The hormones used are LHRH analog and 17 Methyltestosteron.

The procedure taken in the implant of the hormone was initiated by anasthetized the fish with phenoxyethanol at 0.3 cc per liter sea water. The anasthetized fish, held underwater, was cannulated to observe the stage of egg development and sex identification. Furthermore, weight and length (total and standard) of the fish were meassured. The fish was tagged and then put into fresh sea water in the holding tank.

Fifteen months after broodstock collection, 47 fish were identified their sexes cannulation. Thirty six of them are females and the rest are males. Some of them has reached early stage of maturation (previt stage). Out of the 47 sexually identified broodstocks, 37 fish derived from hormone implanted fish and the rest are from control.

Results of the monthly observations indicate that percentage of matured fish is conclusively higher in the hormone implanted group than the control. The results also show that the highest percentage of matured fish in control group was 5% of the total number of broodstock, while in the treated group the highest percentage reached as high as 26% . This study also indicates that maturation of the observed fish taking place the whole year round. Sampling carried out from August to December 1987 resulted data showing that the highest number of fish with previt stage occured in September and December. From January to November 1988, the peaks occured in February, May, October and November. In September of 1988, the number of fish showing early maturity also high, though was not as high as of the said four months. The conclusion that may be drawn from the preserved data is the older the fish, the more matured fish that may be obtained.

Larval Rearing

Ovulation of matured females occured several times during this study. However, the eggs were not fertilized due to the unavailability of matured males.

On November 4 and 15, 1988, respectively two spawning had occured in the tanks. The first spawn produced about 85,000 eggs with a hatching rate of around 40% . The hatched larvae was found abnormal and died within 6 days. The second spawn released around 225,000 eggs with higher hatching rate, i.e. 60% . At present, the larvae, fed with algae, rotifers and artemia nauplii is still being reared in a concrete tank.

FINANCIAL

Total budget allocated for the first year of the project was US $ 28,066.50. This covers the funds spent by OI which was US $ 7,500 and US $ 20,566.50 by Gondol Station. Until October 1988 the amount of budget received by Gondol Station was Rp. 24,652,745 or approximately US $ 16,000. Thusly, there is a balance of around US $ 4,500.

The fund was spent for salary, broodstock purchase, fish feed, and other items as planned. However, some equipments such as photomicrographic camera, incubator tank, etc. could not be purchased due to technical reason.

TRAINING

Training of three RICA staffs have been carried at Oceanic Institute of Waimanalo, Hawaii. Two staffs for about two weeks training (mostly for orientation) and one staff for three months. The latter was trained on the induced maturation technique of milkfish.

COMMENTSS AND SUGGESTIONS

In general ,no major constraint was experienced during the implementation of the project. Training of local staffs as reported earlier could be carried out as planned. Likewise, other planned activities: broodstock purchase and maintenance, maturation and spawning experiments and expert visits to Gondol could also be carried out smoothly. Budget was also disbursed in due time, though a short delay was experienced at the beginning of the project implementation.

Communication between OI and RICA, most likely was one of the problem in the first year of the project. Due to remote location of Gondol and unavailability of communication facility such as telephone, telex, etc , delay of dissemination of information from OI to RICA and the reverse often was experienced. Invitation to RICA Director for attending the last TAG Meeting in Hawaii was received only three days before the commencement date of the meeting. Lately, the communication gap was resolved after the last visit of Dr. Lee. The program leader approved to use the project budget for telex leasing.

Maturation and spawning experiments have also been conducted as planned. Unfortunately results of the experiments were not so convincing.

Gonadal development was stimulated by the implant of hormone. However, the percentage of males and females matured was still low. Moreover, number of spawning was also minimal. Several factors likely to affect the implantation results. i.e. size and age of the broodstock and low quality feed. Stocking density of the broodstock should also be questioned.

Due to the said results of matured and spawning experiments, other activities as larval rearing experiment and local training could not be conducted at all.

The project, however is beneficial to RICA. The visits of OI experts to Gondol increased the capability of local scientist in the transport, handling and maturation technique of milkfish broodstock. The visits also created communication opportunity between the local staffs and foreign scientists.

Based on the previous discussion, RICA is proposing the following activities in the future:

1. To continue the research on induced maturation applying implantation technique accompanied by other treatments (feed, stocking density and environmental factors manipulation).
2. To start with larval rearing experiment as soon as the larvae is available.
3. To expand the research activities to grow-out experiment in tambak to generate more productive culture technique to increase fish production for consumption and tuna bait. This activities is proposed to be conducted in Maros.
4. To expand the researched commodities, especially that is culturable in brackishwater pond. Mugil and red tilapia may be suggested as the candidates.
5. To assign OI scientist on a longer term basis (3 to 6 months).

APPENDIX 5

LISTING OF PROJECT ACCOMPLISHMENTS

FROM PROGRESS REPORT

OCTOBER 1984 - DECEMBER 1988

ACCOMPLISHMENTS TO DATE

- Workshop on the Reproduction and Culture of Milkfish held April 22-24, 1985 at the Tungkang Marine Laboratory, Taiwan and proceedings published by the Oceanic Institute and Tungkang Marine Laboratory, ISBN 0-9617016-1-7, 226 pp.

- State-of-the-Art Document: Aquaculture of Milkfish (*Chanos chanos*). Published 1986, by the Oceanic Institute, HI, USA. ISBN 0-9617016-0-9, 284 pp.

- Singapore Workshop for the Induction of Spawning of Teleosts. Proceedings to be published as a special issue in *Aquaculture*, Vol. 74 (1 and 2), Nov./Dec. 1988.

- Redefined the annual reproductive cycle of milkfish and mullet in captivity:

  Determined steroid profiles that accompany maturation in milkfish.

  Correlated temperature and photoperiod with onset of maturation in milkfish.

  Determined steroid profiles that accompany egg growth and induced final maturation in striped mullet.

  Correlated temperature and photoperiod with the onset of maturation in female striped mullet.

- Development of chronic hormone treatments for influencing maturation in the milkfish and mullet:

  Tested the effectiveness of various LHRH-a and/or 17α-methyltestosterone combinations on the maturation of milkfish.

  Determined the response of ovarian steroids to the various chronic LHRH-a and/or 17-MT combinations.

  Examined the effectiveness of chronic LHRH-a + 17-MT treatment administered at different times prior to the start of the spawning season.

  Determined the effect of chronic LHRH-a + testosterone and LHRH-a + 17-MT treatment on egg growth in striped mullet.

  Demonstrated the effectiveness of 17-MT administered either orally or by implantation.

- Improved methods used to induce spawning of milkfish and mullet:

  Induced spawning of milkfish with a single application of LHRH-a.

  Defined the stage of maturation most receptive to an acute LHRH-a treatment for the induction of spawning in milkfish.

  Determined the minimum effective dose of LHRH-a.

  Induced spawning of mullet with LHRH-a alone or in combination with carp pituitary homogenate.

  Determined the most cost-effective method of hormonally inducing mullet to spawn.

- Hatchery techniques for the mass culture of milkfish and mullet larvae.

  Developed a mass culture technique for the intensive rearing of mullet larvae.

  Developed hatchery techniques for the mass culture of milkfish larvae.

  Described rates of oxygen consumption accompanying development of mullet embryos and larvae. Assessed abiotic factors (i.e. temperature and salinity) on oxygen consumption.

- Technology Transfer

  Field-tested developed chronic hormonal techniques at stations in the Philippines, Taiwan, and Indonesia.