OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : TA/AGR, Dr. P. M. Roedel

DATE: April 22, 1977

FROM : TA/RES, Miloslav Rechcigl

SUBJECT: Milkfish Project Issues

We have just received and reviewed the second draft of the proposed research project titled, "Research and Implementation of Milkfish Propagation". We note the extensive modifications that have been made as a result of our review of the first proposal and our meetings concerning issues raised at that time. We find this proposal to be satisfactory in terms of methodology and the program to be undertaken. There remains, however, a couple of issues brought up by the latest project review (18 March 1977) that should be addressed before the proposal is sent to R&DC and RAC:

1. More details concerning the cooperation between the Oceanic Institute and other foreign and domestic fish culturing programs should be clarified and detailed in order to avoid duplication of research activity.

2. The spawning of milkfish is the project's number one priority and that other aspects of the project (i.e. race determination, tracking, establishing cryogenic units, etc.) should not continue until the number one priority is achieved.

3. The confirmation of several geographical races of milkfish could possibly interfere with the potential technology transfer to the LDC's.

cc: TA/PPU:CMolfetto

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UNITED STATES GOVERNMENT

Memorandum

TO : TA/RES, Mr. Miloslav Rechcigl **DATE:** April 25, 1977

FROM : TA/AGR/F, Richard Neal RAN

SUBJECT: Milkfish Project Issues

In response to your memo of April 22, 1977 I would like to address each of the three issues raised.

1. I believe details concerning cooperation with other fish culturing programs are described adequately on pages 12, 19 and 20 of the Project Paper; however, additional information follows:

In the area of milkfish reproduction only two other institutions have significant activities. SEAFDEC in The Philippines is conducting surveys of spawning grounds, tagging and studies of handling and holding procedures, all closely coordinated with the Oceanic Institute's work. This cooperation will be the basis of the expanded O.I. activity in The Philippines. The Tungkong Fisheries Research Station in Taiwan is working with the artificial propagation of milkfish in close cooperation with O.I. In both cases O.I. is clearly in the leadership position with milkfish as it has been with mullet for several years.

Information is being exchanged with other groups mentioned on p. 12 in The Philippines, Hawaii, India, Indonesia, Thailand and Japan.

The O.I. freely publishes its research findings and communicates with research groups around the world which are involved with fish reproduction. The facilities are open to visitors and many opportunities for information exchange are pursued with the numerous scientific visitors attracted to the O.I. by their outstanding research contributions. O.I. staff members attend and participate in scientific meetings in the fisheries field.

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There is little problem of duplication of research activity because of the small number of research efforts directed toward milkfish reproduction and the close contact between O.I. and those efforts.

2. I disagree with the interpretation of the project as indicated by your issue number 2. The spawning of milkfish is number one priority and is treated as such in the research plan. The other activities are being continued as necessary parts of the total program because they are supportive of the spawning work. For example, the race determination work has already led to information that there are apparently different races with different reproductive cycles. One race matures at 4 years of age rather than at 5 or 6 years. Some of these cycles will be easier to duplicate or induce in captivity than others. Continued studies should lead to identification of the "best" race for use as a domesticated milkfish.

spawning

race

The tracking work is contributing to our knowledge of racial differences, of spawning behavior and of environmental requirements for spawning and maturation. These data are directly supportive of studies of holding methods for maturing adults (an essential part of domestication) and of environmentally controlled spawning.

tracking

holding methods

The cryogenic storage of sperm will enable scientists to fertilize eggs spawned "out of season" experimentally when ripe males are not available. The final test of egg viability is normal development of the zygote. This research will enable more frequent evaluation of maturation and spawning procedures with females.

cryogenic

To defer work on these aspects of the problem until after successful spawning has been achieved would only delay progress toward ultimate objectives. Research to gain a better understanding in these areas ought to proceed pari passu so that the whole range of scientific and technical problems can be resolved as early as possible and thus avoid the delay in developing a comprehensive system, which can generate a reliable flow of milkfish fry.

integrated package development

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In summary I believe a well rounded, but properly proportioned research approach to this particular problem is better than a narrow single-channelled approach.

3. The study of milkfish races is important for just this reason! We must have a better understanding of the differences between races. Although it is likely that a hormonal approach to spawning would be applicable to all races, it is possible that an environmental approach which works with a race domesticated in Hawaii would not work in the Philippines with another race. Of course the race domesticated first may be the standard milkfish breed used worldwide by fish farmers.

We do not believe these issues require further resolution prior to submission of the project to R&DC, and urge an early submission of the proposal for further review so that any revisions deemed necessary can be made prior to RAC review.

Attachment:a/s

R E S E A R C H P R O J E C T P A P E R

April 11, 1977

A. PROJECT SUMMARY

1. Basic Identification and Fiscal Data

Project Title: RESEARCH AND IMPLEMENTATION OF MILKFISH PROPAGATION

New or Extension: Extension

Contractor and Address: Oceanic Institute
Waimanalo, Hawaii 96795

Principal Investigator: Colin E. Nash, Ph.D.

Duration: Currently Authorized: January 13, 1975 - January 12, 1978
Extension: January 13, 1978 - January 12, 1980.

Total Estimated Cost: $1,440,409
Cumulative Obligation Through Current Year: $528,369
Current Year: $248,532
FY 1 (4) $463,097
FY 2 (5) $448,943

A.I.D. Project Manager and Sponsoring Office: TA/AGR(Fisheries)
P.M. Roedel

2. Abstract

Fish are traditionally the major source of animal protein for the peoples of Southeast Asia and other LDC's. Fish farmers rely on the natural annual production of juveniles which each year decreases. Artificial breeding of certain brackishwater fish, particularly milkfish and mullet, and propagation of fry in hatcheries are vital for the future supplies of seedstock for the farmers.

Support for fisheries projects in the LDC's by the international development agencies has recently been renewed with the emphasis on a strong technical base implementing "packaged technology".

This project concerns the development of breeding techniques for the milkfish, production of fry, design of hatcheries and hatchery technology, and production in the field. Technical barriers are being positively attacked by concentrating on key research areas; for example, reproductive physiology, pathology, behavior, and nutrition. Technical development is being conducted in Hawaii, with field application intended first for the Philippines.

This project paper is based on a proposal developed by the Oceanic Institute, reviewed and modified by TAB and jointly developed to its present form.

B. EXPANDED NARRATIVE STATEMENTS

1. General Background and Rationale

a. Background Information

Fisheries are one of the few food-producing industries whose growth rate has kept ahead of the rate of population increase since World War II. In order to maintain present per capita consumption, however, fish production will have to reach 107 million tons annually by 1985. If consumption increases are to be sustained without irreparably depleting stocks and endangering prized species, much greater reliance must be placed upon controlled fish production (aquaculture) as an ever-increasing complement to wild fish capture.

Fish supply about 10 percent of the animal protein and three percent of the total protein in human diets worldwide. However, while in "high-calorie countries" it constitutes 6.7 percent of animal protein supplies, in "low-calorie countries" (i.e., the LDC's) it supplies 21 percent. In parts of Southeast Asia, fish constitute a major source of animal protein in the diets of many people--50 percent or more in most countries of the area--whereas in other parts of the world, such as the Balkans, Central America, the Near East, and landlocked countries such as Bolivia, Paraguay, Nepal, Afganistan and most of the Sahelian countries, fish often represent as little as one percent of all animal protein consumed. In many countries, aquaculture has until recently been all but unknown, but in none are there insuperable, long-term barriers to its development.

Total world fish production in 1974 was 69.8 million metric tons (mmt), an increase of over 350 percent since 1948. Inland waters supplied 9.5 mmt, or nearly 14 percent of the world harvest. About 63.7 percent of total production was used directly for human food, and 36.3 percent was converted into fishmeal, oil or for uses such as fish flour, margarine, cooking fats, industrial uses, and livestock and poultry feed.

The world's largest fish producers in 1974 were: (1) Japan 10.773 mmt, (2) Russia 9.235 mmt, (3) China (mainland) 6.880 mmt, (4) Peru 4.149 mmt, (5) USA 2.743 mmt, and (6) Norway 2.644 mmt. Seven developing countries are among the top 14 nations; they are: (1) India 2.255 mmt, (2) Korea (north and south) 2.240 mmt, (3) Thailand 1.626 mmt, (4) Indonesia 1.341 mmt, (5) Philippines 1.291 mmt, (6) Chile 1.126 mmt, and (7) Vietnam (north and south) 1.080 mmt.

Fish production is the cheapest and nutritionally one of the highest quality sources of animal protein. The protein content of fish is comparable to that of beef, pork, and lamb, and it is an excellent source of calcium. But most importantly, fish production has an unmatchable feed-conversion ratio. In steers,

1,000 grams of feed produce a weight gain of 163 grams; the rates of gain with chicken flesh are substantially better. But with tilapia, catfish and probably many unexplored types of fish, the weight gain approaches 1,000 grams - - i.e., a 1:1 ratio of flesh to feed.

Long-range demand outlook for fish is difficult to predict. Present consumption patterns are highly country and culture specific with an important factor being historic availability of supplies. Experience is too limited for conclusions on the degree of acceptability of fish in previously non-fish-eating societies but does suggest affirmative responses. The demand outlook is encouraging. Income elasticities of demand for livestock products in LDC's are high. With increases in the price of conventional livestock products, high-quality protein sources such as fish become more attractive - - particularly among low-income consumers. Furthermore per capita fish supplies from conventional capture sources may be expected to decrease and their relative production costs to increase.

Finally, at the opposite extreme from most forms of livestock production, fish-farming systems can be highly supportive of ecological values, via three relationships:

1. Increasingly, fish production systems are being built on waste materials as primary feed sources, ranging from the normal organic residues in contaminated streams to animal (including fish) excrements, and other organic byproducts. Conversely such wastes from other animals are a principal source of environmental contamination.

2. Pond fish production is a concomitant of good surface water management designed for erosion control and other conservation purposes.

3. By increasing animal protein production on a highly land-intensive basis, aquaculture can remove pressure of overgrazing by land animals, a most direct source of ecological destruction in most LDC's.

b. Project Extension

The program objective is to breed the milkfish, *Chanos chanos*, in captivity and to raise the fry from the egg, undertaking any research and development which may be necessary to attain that goal. During the 2-year life of this program progress has been made in a number of important areas. This progress in the critical areas of capturing adults, maturing adults, handling live fish, and inducing spawning has brought the state of the art to a point where achievement of the program goal is a realistic probability. Progress to date is outlined in the following paragraphs.

Procedures for capturing and handling the fragile wild breeding fish have been improved. Evidence suggests the need to minimize handling, to use fish with oocytes of 0.7 mm diameter or above, and to inject once immediately upon capture. Experience suggests low-level injections are perferable, possibly followed by artificial stripping; however, control of stress is essential.

Work on health care and husbandry continues to be productive. The handling techniques developed to reduce stress have been beneficial. In addition to previous information on the stress of the adult fish during capture, autopsies have revealed incidences of blood clots. Wild fish have also shown evidence of gastritis, particularly when taken from the heavily polluted coastal areas.

fish captured

Significant experience has been gained in procedures for holding experimental populations for maturation and spawning experiments. The resident population of fish on site numbers 50 adult fish, 65 subadult fish, and about 100 0-group juveniles. Over 89 adult fish were caught during the second year, but losses were sustained. One entire tank of 12 fish was lost by mechanical accident following storm damage; several adult fish were poached; and others died during experimental treatment.

captive adults

Captive adult fish have been conditioned for twelve months in manipulated environmental conditions (18L/6D) at 25% C, but failed to show any oocyte development. The diet of the captive stock has been changed for one with a higher protein composition in an effort to improve this performance.

hormone injection

In summer of the second year of the project, seven mature fish were captured and deemed ready for spawning inducement. Following the results of the first year with doses of salmon gonadotropin SG-G100 at levels similar to those used for the grey mullet, Mugil cephalus, six of the fish were injected with a low priming dose. One was deliberately not injected. Only one of the injected fish hypophysated? completely and released eggs. One fish receiving several small injections died. The eggs of the rest of the fish went atretic.? These preliminary trials have provided a basis for expanded experimentation when greater numbers of experimental animals become available.

race identification

Eye lens protein analyses continue to give evidence of racial differences in milkfish from around the Pacific Islands and the work has been reinforced with isozyme identification from various tissues. In addition over 250 adult fish have now been examined for statistical morphology to provide a basis for identification of races.

The electronic tag for use in tracking adult fish has been developed and tested, is now being miniaturized and a number are being developed for testing in the next breeding season.

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The project has benefited from international cooperation in many elements of milkfish knowledge. An extensive bibliography on the milkfish is being assembled; morphometric data are being pooled; and there are beneficial exchanges of data on physiology, reproduction, and general handling.

A total of five publications relevant to the project have been prepared and three published. The other two are in press.

Progress to date has been satisfactory, and the prospects for solving the problem during the next 2 years are encouraging. The Oceanic Institute through this research has not only made significant progress on this particularly difficult and complex problem, but has assumed a prominent leadership role in the field and is now in position to make a breakthrough of major importance. If AID support is not continued the momentum of this activity will be lost as well as much of the technical expertise of this team pertaining specifically to milkfish.

AID Role

The substantial increase in the budget over last year is attributable to a substantial increase in the personnel required to focus necessary attention on this research, the travel and personnel requirements related to additional field work in the Philippines, and new holding facilities to increase available numbers of experimental adult fish. Although important progress has been made with about 39 man months of effort, the completion of the research will require an increased level of scientific input (about 156 man months) because of technical and logistical difficulty of the research.

Budget Increase

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2. Research Purpose and Expected Products

a. Purpose

The purpose of this project is to learn how to increase the potential for effective controlled production of young milkfish upon which mature fish production by small farmers must be based.

b. Objectives and Expected Products

The overall objective is to learn how to supply an adequate and predictable quantity of juvenile fish to the fish farmers. Specific objectives are:

(1) To induce spawning of milkfish in captivity economically and do so over long periods.

(2) To discover specific pathological effects of stress and handling and to prevent or overcome these effects.

(3) To learn how to increase egg production and the larvae survival rate.

(4) To learn how to increase hardiness of larvae and juveniles.

(5) To develop handling techniques for juveniles that will assure low mortality in the farmers' pens.

Present fish-farming practice is largely based on collection of wild juveniles from natural sources, a costly, unpredictable, and ultimately destructive approach. Collection of milkfish juveniles by such countries as the Philippines, Indonesia, and Taiwan is enormous, estimated at 160 million per year for Taiwan alone. It is estimated that the annual production of 2,000 metric tons of mature grey mullet in Taiwan involves an annual collection of 10,000,000 juveniles from coastal waters. Japan has set an annual catch limit of 31 million juvenile yellowfish; a similar limit on young eel catch has caused Japanese eel farmers to scour the world for seedstock. Crude calculation suggests that the modest goal of doubling farm fish production, to some 15 million tons per year, might require capture of some 100 billion juveniles per year, under the optimistic assumption of a one-third survival rate to maturity. Natural populations unquestionably cannot sustain juvenile catches of this magnitude.

Although an interrelated set of factors are involved, the technical constraints to managed juvenile fish production fall into two categories: brackishwater parent fish which reproduce only in the sea, and excessive mortality of very young fish larvae. The first problem must be solved if brood fish are to reproduce under man-controlled conditions, and to find the solution to the second problem--or indeed to any kind of production of seedstock fish in captivity. Since such research is somewhat species specific, it will be necessary to investigate most parameters for the milkfish even though much of this is known for the mullet.

Cause mortality

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Research, largely by the principals of this project, primarily with mullet species, has gone a long way toward establishing feasibility of solving the first type of problem. In this project what has been learned will be applied to the milkfish. They have been able to induce spawning over much longer than normal periods by manipulating such external environmental parameters as water quality, diet, hygiene, temperature, salinity and light. Salinity alone appears to be the principal factor causing fish to go to sea for breeding purposes. Regularly induced spawning has been achieved by use of salmon hormones. The investigators have found considerable promise from use of human hormones, and the very much cheaper hormones from several other mammals. However, a number of environmental variables appear strongly to influence physiological changes in the pituitary gland and to stimulate gonads to time-controllable maturity. This study would clarify those variables in quantitative relationship to their effects on reproduction. Once these relationships can be sufficiently understood and controlled continuous fish larvae production systems can be established. With other support research will be consistent on the mullet to complete the understanding of how to husband the fish to market and in broods.

Salinity on breeding

Similarly, the principals in the project and others have made considerable strides toward understanding the biological mechanisms, and their relationships to environmental factors, which result in the extremely high mortality ratios of fertilized eggs and fish larvae. Relationships to larvae survival of a large number of variables--especially temperature, salinity, pH, oxygen, light, and food supply--have been observed and catalogued. The principals in the project have observed a key variable to be the osmo-regulatory system of the larvae, by which body fluid balances are maintained. In fact, it would appear that several of the other noted variables are associated with survival not so much directly as via their effect on body fluid supplies. Clearly quantity and type of food intake and salinity of the environmental water have direct bearing on body fluids during the first critical days when the larvae are unscaled and most mortality is effected. Simply stated, it is their hypothesis that it is primarily through finding means of supplying "drinking water" of the right types and quantities, through the right means and at the critical times that the excessive mortality can be reduced.

Larva survival

To the extent possible during fish breeding, a selection will be made of brood fish of propensity toward higher larvae survival rates and other good breeding qualities.

larva/fish parent

If the two sets of problems outlined above can be solved, controlled production of juvenile seedstock fish can be made a relatively modest cost component of the entire aquacultural enterprise. The numbers of larvae produced per fish are so enormous that the numbers of brood fish required for continuous production would be relatively small. Also, rearing of larvae to the size now normally captured as fish stock would require relatively modest-scale facilities in relationship to the ultimate mature fish production enterprise.

ground on this

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The study will determine factors and procedures necessary to reduce mortality and improve performance of the juveniles through delivery to fish farmers and subsequent production activities.

3. Relevance and Significance of Proposed Work to A.I.D.

a. Significance

The high priority given by the Agency to improve nutrition, particularly of low-income groups, needs no reiteration. Development of highly efficient aquacultural systems very directly and importantly serves that objective. Aquaculture of this type in Southeast Asia and in the Philippines is normally highly labor intensive and thus provides a realistic opportunity for increasing protein availability to rural and urban poor of the region while at the same time increasing income to the small producers. Land used for fish culture can be space essentially unused for food production---marshes, land with saltladen soils, brackish and saltwater streams, estuaries and sea shelves. Many of the suitable sites are public lands or waters available to the rural poor who own no land. The most rapid recent expansion of milkfish farming has been labor intensive pen culture in natural waters utilizing bamboo cages, and requiring little capital. Fish production is well suited for small pond and small land holdings as well, and with high labor inputs yields as high as 24,000 lbs. of fish per acre have been achieved.

In addition to the general benefits of fulfilling a major aquaculture void, a successful project will first contribute significantly to local and then national domestic need for animal protein which cannot be met by land animal production. In the long term such a project would contribute to maintaining low and stable prices of fry or juveniles, and subsequently harvested fish. The planning and development of hatchery and nursery centers are the national priority of many countries which are dependent on aquatic animal protein to meet minimal population requirements, and which are facing annual shortages because of natural and environmental influences.

The Agency has recognized, through its Fisheries Division in the Technical Assistance Bureau (Agriculture), and in its Overseas Missions, the importance of integrating modern technical research and development in aquaculture with the traditional practices of subsistence fisheries in the LDC's. The opportunities for increased gain are substantial, but the technology has to be "packaged" before application in the field.

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b. Side Effects

Environmental side effects are predominantly beneficial. There is the minimum tradeoff with land animal production as aquaculture mostly occupies non-agricultural land, but does compete for fertilizer and, in some cases, raw materials for feed. Aquaculture is labor intensive in certain seasons, but is similar to agriculture for the rest of the year. Aquaculture complements the utilization of agricultural waste, a problem presently affecting modern intensive aquaculture, but not rural agriculture of the LDC's where the two have been integrated for centuries.

Any aquaculture projects closely complement the other concerns of the Agency as they are directly concerned with food and energy requirements, and the status of the poor in the LDC's. Primarily aquaculture is concerned with the production of directly utilizable aquatic animal protein in the immediate vicinity of a needy village community, and by methods which have been traditional to the community for many decades. There is the added benefit of labor and income both to the individual and to the community.

4. Relation to Existing Knowledge

The countries of Indonesia, the Philippines, and Taiwan are the three main centers of milkfish culture. The traditional practices in Indonesia (about 350 kg/ha per annum) and the Philippines (600 kg/ha) are less productive than the new techniques for management currently being developed in Taiwan (over 2,000 kg/ha). However, for all three nations the main constraint is the nonavailability of the young fry, and this is very evident in Taiwan which for many years imported fry from the other two countries. In the Philippines, the annual deficiency of fry is estimated to be over half a billion, and in Taiwan the need is of lesser magnitude but still numbering in the millions.

The current interest in milkfish has therefore added to the very scant background knowledge of the species. Most of the literature contains references to farming practice and fertilizer application, and general biology and natural history. Only in the last few years has specific information been added due to some independent studies on breeding and holding adult stock in the Philippines, Taiwan, and Hawaii. Currently, egg and larval surveys are being conducted in Thailand and South India, and there is a UNDP-supported project involving milkfish in Indonesia.

Without making specific references, information is now being accumulated rapidly in the following areas. Note that reference to Hawaii mostly indicates Agency-sponsored work.

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a. Behavior and Bio-ecology in Nature

Taxonomic data is being accumulated from a number of sources which indicate racial differences. This is being reinforced by electrophoresis of eye lens proteins and isozymes. Migratory pathways of the adults are being followed by telemetry, together with oceanographic conditions and preferences of the fish for spawning. Age and growth data are being collected universally in addition to feeding requirements.

migration

b. Egg and Larval Surveys

Plankton surveys from milkfish regions are being reviewed for eggs and larvae of milkfish. Predominantly these took place in Southeast Asia, but new surveys are being planned. The need is to define spawning grounds and to verify or deny unsupported observations.

define spawning grounds

c. Maturation and Reproduction

Data on reproductive physiology of the fish are all recent. Work is predominantly being conducted in Hawaii, Taiwan, and the Philippines. Details are being provided on gonad development for both males and females. Preliminary induced spawning is being attempted at all three places with hormones.

AID physiology

d. Egg Incubation and Larval Rearing

Only very old information is available on egg incubation and early larval rearing. New data await the success of induced spawning. Rearing of fry after the yolk-sac stages is well established and traditional but can be improved by better handling and distribution techniques.

e. Predators, Pathology, and Physiology of Stress

Nothing existed on milkfish pathology or physiology of stress in the literature until recently. Present work is being conducted in Hawaii and the Philippines. Information of a general nature was available on parasites.

f. Hatchery Technology

The technology for hatchery production of brackishwater fish species of interest to LDC's is being developed in Hawaii, Taiwan, and Israel.

5. Relation to Other Related Projects

The project directly complements other Agency activities in fish culture integrating the emphasis on brackishwater fish with that of the freshwater fish

projects undertaken by the International Center for Allied Aquacultures at Auburn University, Alabama. With the support of the Auburn Center, the Agency has concentrated strongly on improving the freshwater fisheries of Central and South America, and in Africa. Support to the Agency by the University of Rhode Island for coastal zone fisheries and production economics add to the Agency's increasing emphasis on aquaculture development.

Auburn U

These three institutions maintain close contact on fisheries topics, particularly in working on areas of key constraints.

The International Center of Auburn through its involvement with the Agency-backed University of the Philippines Inland Fisheries Project, is involved in pond management for improving milkfish production. and is undertaking studies on fish migration.

Through its support of the Oceanic Institute in Hawaii, the Agency is indirectly assisting the joint cooperative program developed by the International Development Research Center and the Southeast Asian Fisheries Development Center in the Philippines. Contributors to the program are individuals from projects supported by the Taiwan Fisheries Research Institute, the University of the Philippines, the Philippine Council for Agriculture and Resources Research, the Philippine Bureau of Fisheries and Aquatic Resources, the Hawaii Institute of Marine Biology, the Central Fisheries Research Institutes of India, the Shrimp Culture Research Centre of Indonesia, Thailand Department of Fisheries, and the Ichthyological Society of Japan. Many of these projects are backed by funds from international development agencies.

Finally, and most important, the Agency interest in aquaculture closely parallels the objectives of the newly established International Center for Living Aquatic Resources Management. The new organization has a strong interest in the production of aquatic animal protein through the propagation and farming of the brackishwater fishes important to the LDC's. Many of the brackishwater fish species have similar breeding problems. The culture of milkfish in Hawaii and elsewhere will be of direct importance to the entire brackishwater fish and farming movement. The core of technical personnel supported by the Agency in Hawaii can be the nucleus of a technical group applying research and technology to a much wider range of brackishwater species and coastal aquaculture production problems working in association with the broader objectives of ICLARM.

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6. Research Project Design and Methods

a. Design Procedure and Tasks

The research project design and methods of approach for most of the contract have been specifically identified in the first contract (AID/TA-C-1189). As has been demonstrated in both the annual reports and in scientific publications resulting from the initial phase of this research correct experimental procedures have been stressed and experimental designs facilitating statistical analysis of results are used routinely. In instances where only a few experimental animals have been available only preliminary trials have been possible. These trials have lead to the establishment of appropriate ranges of parameters to be examined in later properly designed experiments.

The research tasks to be addressed under this contract are as follows:

(1) Establish broodstock in captivity.

- (a) Collection of increased numbers of mature fish in season (at sea).
- (b) Collection and growing-on greater numbers of immature fish (from brackishwater ponds).
- (c) Collection of migratory fish (from known runs).
- (d) Development of broodstock husbandry.
- (e) Holding, handling and sampling large fish.
- (f) Identification of broodstock individuality.
- (g) Year-round breeding through environmental control.

(2) Establish conditions for spawning.

- (a) Determination of natural spawning conditions (through location of spawning sites).
- (b) Simulation of spawning conditions in laboratory (by environmental control).
- (c) Attempt spawning without hormone treatment (by behavioral responses).

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(3) Induce spawning by hormone injection was to:

(a) Define the optimum induced spawning procedure (for salmon gonadotropin, specifying correct time for treatment, dosage, dose rate, response, etc.).

(b) Determine cost effectiveness of readily available hormones.

Experiments will include:

i. Determine natural reproductive physiology (for both sexes) from immaturity.

ii. Determine responses to hormone treatment.

iii. Test reactions to salmon pituitary gonadotropin.

iv. Test reactions to other cheaper hormones.

(4) Improve survival of larvae in laboratory.

(a) Nursery I (Day 0 - Day 21*) development Definition of Nursery I rearing procedure with recommended facilities, food and food density, rearing density, water quality and external environmental conditions etc.

(b) Production high survival (%) from available eggs.

(5) Increase hardiness of larvae to juvenile stage.

(a) Nursery II (Day 21 - Day 50*) development Definition of Nursery II rearing procedure with recommended facilities, food and food density, rearing density, water quality and environmental conditions.

Juveniles larger and healthier than those caught and distributed by the existing farming operators and expected products.

(b) Economics of operations--low cost of juveniles.

* An estimated stage differentiation.

(6) Improve handling and husbandry of juveniles.

(a) Improve collection of juveniles from Nursery II facilities.

(b) Develop safe transportation methods.

i. Develop safe procedures for mass collection and transportation of nursery stock.

ii. Recommend optimum economic transfer method for fry distribution.

The new contract proposes to extend the project with the following specific tasks in years FY 04 and FY 05.

(7) Conduct practical pathological treatment to eliminate handling stress and mortalities and reduce diseases of captive stocks.

(a) Routine examination or autopsy of all fish for background pathology,

(b) Conduct diagnostic tests using modern histological and biochemical clinical methods,

(c) Pursue related research toward practical application for the hatchery and the farmer.

(8) Commence tracking and tagging operations in the field.

(a) Examine existing plankton collections in Hawaii and conduct systematic plankton survey.

(b) Capture, tag, and track adult fish and synchronize plankton tows,

(c) Conduct large tagging trials in the Philippines.

(9) Conduct experimentation on breeding in the field.

(a) Assemble annually a team to work in the field responding to individual seasonal availability in the Pacific Islands and Southeast Asia,

(b) Design field units for a mobile task force investigating breeding locations.

(10) Establish a cryogenic unit.

(a) Collect and preserve sperm.

(b) Test periodically for viability.

(11) Begin hatchery development.

(a) Site selection survey.

(b) Engineering drawing and design.

(c) Construction planning.

b. Tasks, Targets, and Milestones

See Figure 1.

c. Resources Required

The staff resources required are those which would constitute a multidisciplinary team of scientists, technologists, engineers, and practical culturists. Briefly, the elements are:

i. Reproductive physiology-requiring a Ph.D. team leader supported by three research assistants concentrating on physiology, histology, biochemistry, cryogenics, and hormone studies.

ii. Fish culture - requiring a Ph.D. team leader with a research assistant responsible for research projects in larval bioenergetics, larval nutrition, environmental regulations, and rearing facilities; together with a research associate responsible for production and husbandry, supported by three technicians and/or fishermen.

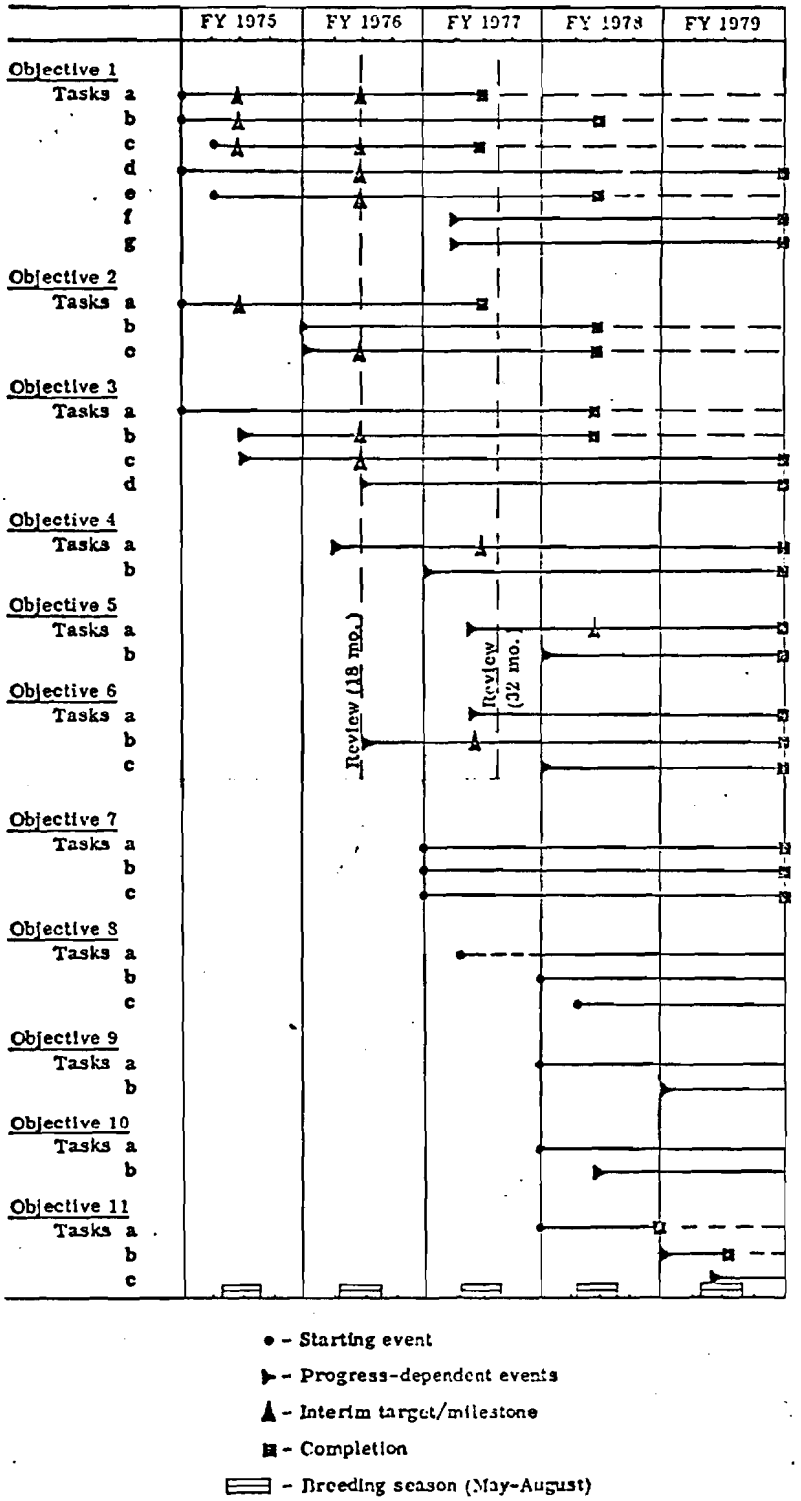

Figure 1. Project time chart.

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iii. Pathology — requiring a Ph.D. team leader and a research assistant responsible for the health and care of the fish and research aspects related to the project.

iv. Engineering — requiring a certified engineer team leader supported by a junior engineer for equipment development, hatchery technology, and implementing hatchery development.

v. Coordination and direction — requiring a Ph.D. project leader to coordinate the teams to be directly involved in at least one aspect of the research, and for overall responsibility for field application.

Overseas cooperation would be necessary by at least one technical aquaculture group. Liaison between the group(s) would be made through the Agency centers and some of their established technical support. For example, in the Philippines, the work could be linked through the UP.IFP Project funded by the Agency and involving Auburn University aquaculture staff as technical advisers.

AID Mission Support

The cost of continuing the project which was established first in 1975 (FY 01) into 1978 and 1979 (FY 04 and 05), including the addition of five new elements to the original six elements, is $912,040.00.

7. Contribution to Institution Building

In most developing countries, existing aquaculture centers are extremely small with limited facilities for research or pilot-scale operations. Few have interdisciplinary teams of workers or the equipment for advanced research. Consequently, few are able to undertake the long-term research and development programs which keep a team together. Even in countries like the United States, where funding is much easier comparatively, it is recognized that excessive diffusion of research funds negates the quality and intention of the work.

The high-priority research problems in aquaculture in most regions of the world have been formulated many times by expert groups. Within the limits of the available funding resources, a few existing institutions in the developed world are attempting to undertake work on some of the problems. Recognizing that none of the existing institutions have the capability to carry out research on all or even a number of the problems, there is a need to establish a few centers of scientific and technical expertise with a critical mass of staff and facilities. These centers will concentrate their efforts on major problems of general regional and

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inter-regional importance, implementing the results in cooperation with institutions in the LDC's through demonstration and training; that is, by developing the packaged technology in technically advanced countries and applying it directly in the field.

The increased support of this project by the Agency will help create a technical group capable of backstopping a number of seed production programs. It will increase the overall competence and efficiency of the personnel, and assure more effective utilization of equipment, facilities, and instrumentation. As a result, it will provide the Agency with another center of competence in aquaculture and fisheries, together with the International Center for Allied Aquaculture at Auburn University and the University of Rhode Island, capable of applying present and future Agency projects in the LDC's.

8. Plans for Utilization

The principal utilization potential lies in a country-by-country effort to select key opportunities for aquacultural development and tying them appropriately for technical support to these institutional expertise centers, once the aspects limiting the husbandry of the fish are learned. TAB is investing a major effort in support of this effort, particularly toward effecting the necessary integration of effort and experience among the research centers and between them as a group and the aquacultural programs of individual LDC's.

The LDC's interest in aquaculture is growing rapidly. One aggressive country effort is underway in the Philippines under the general technical assistance tutelage of Auburn University. If economic or marketing problems become central. Oceanic will solicit Rhode Island's cooperation.

Brazil is developing, also with assistance from Auburn a research and development center which Brazilians hope can be a center of support for aquaculture in abutting countries if not, indeed, for the oontinent. Colombia, Vietnam, Laos, and others have active growing programs.

The Rockefeller Foundation has established an international center to concentrate on problems in aquaculture and artisanal fisheries, and the International Development Research Center of Canada is supporting pilot-level production and training aspects of fish farming in the Philippines. These are all complementary projects to the present efforts by the Agency.

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9. Research Competence and Resources

The staff and research approach to aquaculture by the Oceanic Institute are both interdisciplinary. The program proposed by the Institute will fulfill the basic research and development priorities for all aspects of juvenile milkfish production and distribution. The present work is fundamental to the effectiveness of Auburn and Rhode Island in saltwater and brackishwater production systems.

The Oceanic Institute supported a five-year study on the artificial propagation of the grey mullet, Mugil cephalus, supplying one-third matching funds to annual grants from the Office of Sea Grant (U.S. Department of Commerce, NOAA). The support was terminated on July 31, 1975. The overall cost of the program has been $906,900. The Office of Sea Grant considered that the Oceanic team achieved its goal of developing induced spawning techniques and improving larval survival to a stage where the methods could be transferred and utilized for other more commercial species. Work on this species is being continued on funds provided by the International Center for Living Aquatic Resources Management to implement mullet hatchery technology in the LDC's.

grey mullet

The aquaculture team at the Institute is recognized internationally as a leading authority on induced spawning and artificial propagation of brackishwater species, particularly the mullet. Letters from people in both developed and developing nations come continually to the Institute asking for training and instruction in the methodology.

O.I problem solving

Other recognized experts in the field are the staff of the Tungkang Fisheries Research Station in Taiwan, with whom the Institute staff has worked closely over the years. The two organizations have produced the majority of technical reports and procedural manuals on the artificial propagation of a brackishwater fish.

Few other aquaculture organizations could take on the artificial propagation program for milkfish without major investment and relocation of key and experienced personnel.

Dr. H. Burr Steinbach, until recently Dean of the Graduate School of Woods Hole Oceanographic Institution, serves as President of the Oceanic Institute. Dr. Colin E. Nash, Director of Research, and Dr. Ching-ming Kuo, head of the Aquaculture Division, under whom the research project will be carried out, have extensive research experience in the problems addressed by this project. They will be supported by other senior researchers including Albert C. Smith, Ph.D., M.D., and Guy N. Rothwell, Jr., B.S., C.E.

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The Oceanic Institute's physical facilities are modest but adequate, consisting of a cluster of wooden framed buildings of various sizes adjacent to the sea in Waimanalo Hawaii. Its 3,600-square-foot principal laboratory houses aquaria, larval, chemistry. microbiology, histology, microscopy, and controlled water-temperature laboratories. Other buildings contain an electronics lab. photoperiod lab, office space, library, and training facilities.

The Institute obtained in 1976 an appropriation from the State of Hawaii for $300,000 to complete a fish hatchery for marine and brackishwater propagation. Plans are being completed and construction will start in 1977. This will be a key focal point for fish culture work in the Pacific and has direct relevance to the aquaculture needs of LDC's everywhere.

10. Overall Cost Estimates (combined Hawaii and field projects)

See following tables.

FISCAL 1978

	Salaries & Overhead	Capitol Items	Supplies	Travel Local & US	Travel Overseas	Publications	Consultants	TOTAL
1. Broodstock	58,113	16,750	7,000	2,000				83,863
2. Spawn Conditions	10,397		500					10,897
3. Induced Spawning	98,625	9,450	3,600	800		500		112,975
4. Larval Survival	30,178		1,600					31,778
5. Larval Rearing	30,178		1,500					31,678
6. Husbandry	23,043		3,000					26,043
7. Pathology	58,281	4,900	3,500	800		1,000		68,481
8. Tracking	37,327		8,500		4,800	500	2,500	53,627
9. Field Breeding	10,291		500		3,300		1,500	15,591
10. Cryogenics	10,301	1,700	1,700					13,701
11. Engineering	10,063		1,100		3,300			14,463
	376,797	32,800	32,500	3,600	11,400	2,000	4,000	463,097

FISCAL 1979

	Salaries & Overhead	Capitol Items	Supplies	Travel Local & US	Travel Overseas	Publications	Consultants	TOTAL
1. Broodstock	41,507	6,000	6,500	2,300		500		56,807
2. Spawn Conditions	5,499							5,499
3. Induced Spawning	95,692	1,500	3,000	1,600		500		102,292
4. Larval Survival	45,888		1,000					46,888
5. Larval Rearing	40,362		500					40,862
6. Husbandry	33,266		2,000					35,266
7. Pathology	58,286	500	2,000	800		1,000		62,586
8. Tracking	39,828		1,000	800	3,500	500	2,500	48,128
9. Field Breeding	13,236		1,000		3,500		1,500	19,236
10. Cryogenics	10,301		1,800					12,101
11. Engineering	12,078		3,200		3,500	500		19,278
	395,943	8,000	22,000	5,500	10,500	3,000	4,000	448,943

11. Work Plan and Contract Budget

Item 1 - Establish Broodstock in Captivity

a. Collection of mature fish in season (at sea)

We have so far collected by various means a total of 120 adult milkfish, of which 50 survive. Adult milkfish will continue to be collected from coastal bays and harbors in Hawaii using well-developed capture and transport methods. Capture at sea, while not now possible with present gear or staff, will be pursued in cooperation with NMFS and other agencies which have greater resources (e.g., large ships).

Continued efforts to improve handling methods of adult fish will be made. Specific work will be directed toward improving survival of the fish during transport by using anesthesia, temperature, and salinity. A further reduction in stress levels would be expected to increase survival of wild adults and juveniles above the present 50% level. A doubling of the number of adult fish from the present 50 is a primary goal of the capture program.

b. Collection and growing-on of immature fish (from brackishwater ponds)

We have collected (with no significant losses) 100 first-year-class juveniles, plus an additional 100 subadults. Immature fish will continue to be taken whenever encountered. Methods to ensure high survival of adults and juveniles will be improved further. Collection of these fish will be primarily from fishponds. Juveniles and fry will be stocked in ponds at O.I. for growing out to ensure a satisfactory supply of research and broodstock animals for the next program years. Present stocks of juvenile and subadult milkfish will be doubled pending increased pond capacity.

100 Juveniles
100 Subjuveniles

c. Collection of migratory fish (from known runs)

Liaison with the fishing community in Hawaii has been established and O.I. will continue to exploit information regarding spawning and migratory patterns of the milkfish. Collection of fish from migratory pathways in Hawaii will be expected when and if such runs have been identified.

d. Development of broodstock husbandry

Diet requirements will be defined through laboratory and growout experiments. Cooperation with other laboratories such as HIMB which currently have necessary facilities for laboratory analysis will occur. A satisfactory prepared feed for milkfish is expected. Growout trials in ponds will be conducted at O.I. and, as opportunities arise, in association with various pond owners throughout the State. Disease and parasite control will be an important aspect of the husbandry work. Prophylactic methods have been developed and will be further

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defined. This portion of the work is closely linked to the pathology program and will be emphasized. A manual will be written, with a preliminary draft available for review on 1 March 1978.

Pathology manual 1 March 1978

e. Holding, handling and sampling large fish

Restraining Box

Further development of techniques and methods to handle adult milkfish so as to reduce stress and eliminate injury and mortality will be made. Adult fish (>3 kg) are present handled by hand using a restraining box developed during 1976. This device restricts movement and facilitates weighing, tagging, gonad sampling, and hormone injection without anesthetization. Continued improvements will be expected.

f. Identification of broodstock individuality

fin clipping tags segregation

Two years' experience with physical segregation, fin clipping, and plastic identification tags has shown that while fin clipping has short-term utility, a combination of segregation and tagging is necessary in the long term. Work with plastic tags will continue, leading to recommendations for tag type and method of application.

g. Year-round breeding through environmental control

spawning control

Regimes for the extension of the reproductive cycle throughout the year by environmental control will continue to be developed. Definition of environmental parameters required for spawning will enable us to more critically control the maturation of the fish out of season. Behavior of broodstock animals will continue to be studied in the laboratory under photoperiod and temperature control.

Item 2 - Establish Conditions for Spawning

a. Determination of natural spawning conditions (through location of spawning sites)

An electronic fishtag has been developed, and data on inshore currents in Hawaii have been compiled. Subject to the success of the tagging trials scheduled for summer 1977, and/or to obtaining notice of observations of a milkfish spawning event, a small-scale survey of the physical, chemical, and biological properties of the spawning location will be made by O.I. personnel. The results will be used directly in adjusting the appropriate parameters of the various induced spawning experiments.

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b. Simulation of spawning conditions in laboratory (by environmental control)

Experiments on induced gonadal development by manipulation of environmental conditions (photoperiod of 18L/6D, water temperature of 26° C) were conducted from January 1976 to December 1976. Two sets of salinity (32 °/oo and 10-12 °/oo) were examined. Inadequacy of nutritional supply to these experiments was identified as a serious problem. It is planned to emphasize nutritional and physical conditions in future experiments. The conditions for gonadal maturation will be refined as the attempts continue. The overall results will be reported at the end of 1979. If environmentally induced maturation proves possible, the best conditions for gonadal development will be established.

c. Attempt spawning without hormone treatment (by behavioral responses)

Observations on the possibility of spontaneous spawning of milkfish in confinement have been made in 1975 and 1976. No positive indication was obtained. The attempts will be continued by modification of physical conditions whenever mature females are available. The priority of breeder usage will be given to the hormonal induced spawning in order to achieve artificial propagation of milkfish fry as soon as possible. Once the possibility of spontaneous spawning in captivity has been observed, the results will be reported.

Item 3 - Induce Spawning by Hormone Injection

a. Define the optimum induced spawning procedure (for salmon gonadotropin, specifying correct time for treatment, dosage, dose rate, response, etc.)

The responsiveness of mature females to salmon pituitary gonadotropin has been examined since 1975. Various injection schedules and dosages were tested. The response of treated females were followed individually. Asynchronism of egg hydration was observed and premature spawnings were repeatedly obtained. It is anticipated that human chorionic gonadotropin will be more effective to induce spawning, if fully ripened eggs can be assured. The technique of artificial fertilization will be examined. To test this possibility, a group of three O.I. staff is planning to join the SEAFDEC/IRDC team at Pandau, Philippines, in April 1977. All the results will be reported and a procedural manual of induced breeding of milkfish will be published for technology transfer use.

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b. Determine cost effectiveness of readily available hormones

As a standard induced spawning technique is established, search for alternative normones and/or drugs will continue. Feasibility of any available hormones will be examined on the basis of effectiveness and cost.

Research on the mullet is continuing. The results are readily applicable to the milkfish.

Item 4 - Improve Survival of Larvae in Laboratory

a. Nursery I (Day 0 - Day 21*) development
Definition of Nursery I rearing procedure with recommended facilities, food and food density, rearing density, water quality, and external environmental conditions, etc.

Nursery methods will be developed for Nursery I using, as a starting point, the methods proven successful in rearing grey mullet larvae. Similar food items and densities will be varied to accommodate milkfish requirements in a multivariable investigation of water quality and nutritional parameters.

If this investigation is successful, experiments to test artificial foods for larval rearing will be conducted and food requirements will be defined. Cooperation with the NMFS and other workers in nutrition is anticipated to provide alternative feeds at less cost than is now possible with live foods.

b. Production high survival (%) from available eggs

The procedures developed for Nursery I will be implemented to demonstrate a technical ability to successfully raise milkfish larvae with high survival.

Survival rates of mullet using both extensive and intensive rearing methods range from 2.5% to 20% by day 21. These methods will be applied to milkfish larval-rearing efforts, with the goal of similar survival rates.

Item 5 - Increased Hardiness of Larvae to Juvenile Stage

a. Nursery II (Day 21 - Day 50*) development
Definition of Nursery II rearing procedure with recommended facilities, food and food density, rearing density, water quality and environmental conditions

As for Nursery I, nursery methods will be developed to be utilized in rearing Nursery II milkfish to juvenile stage. These methods will expand upon

*An estimated stage differentiation.

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current literature and observations on the rearing of milkfish larvae at the Oceanic Institute and elsewhere.

Evidence suggests that milkfish larvae differentiate at the third week after which they are able to feed on algal foods. As with Stage I larvae, work will be directed toward defining the best food species, densities, fry density, and water quality requirements. The goal for this work will be juveniles which are larger and healthier than wild stock and of a consistent size for stocking.

b. Economics of operations--low cost of juveniles

When rearing procedures have been outlined sufficiently, a cost evaluation will be made to explain and improve upon cost functions in rearing milkfish.

Item 6 - Improve Handling and Husbandry of Juveniles

a. Improve collection of juveniles from Nursery II facilities

Improvement of juvenile collection from Nursery II facilities will be based upon consolidation techniques now being evaluated for mullet larvae. These will include physical crowding mechanisms, use of phototaxis on both the juveniles and food organisms, and directional currents and salinity gradients.

b. Develop safe transportation methods

Current handling and collecting techniques in Taiwan, Indonesia, and the Philippines will be reviewed. Methods employing least cost and ensuring greatest survival will be examined and compared with known tolerances and requirements of the fry. Further definition of life support requirements will be made. Equipment and procedures developed or adapted will be reported on.

Item 7 - Conduct Practical Pathological Treatment ($ 68,481 & 62,586)

a. Routine examination or autopsy of all fish for background pathology.

All milkfish, whether ocean or pond captive or fish maintained on site, will be routinely autopsied. In addition to standard autopsy procedures with body organs, particular attention will be paid to new pathogens. Records of such will continue to be filed with the Smithsonian Institution (as presented in 1976). Information of a general pathology nature will be published, possibly in the form of information leaflets. End results (though continual) will be an extensive description of naturally occuring pathogens which effect milkfish of all ages and origins.

b. Conduct tests using modern clinical methods.

New methods for detecting pathogens will be developed using relevant medical techniques. Continued attention will be paid to the pathogens known or thought to be relevant to the condition of nervous stress, as reported in 1976. Treatments will be applied to both newly caught and resident fish, and also tested during specific experiments designed to encourage stress among resident stocks. The results will be published as developed. End results (though continual) will be substantial pathological data on the stress factors of milkfish and other brackishwater fish, and a practical improvement in the handling capabilities of live adult milkfish for captivity and breeding. A target milestone by the end of the project would be a 50% survival factor during induced breeding handling.

c. Pursue all related research toward practical application for the hatchery and the farmer.

Undertake basic research where it will be relevant to the safer handling and maintenance of milkfish. Cooperative work will be maintained with the pathology laboratory of St. Francis Hospital, and the Hawaii College of Tropical Agriculture. Material for research has and will continue to be derived from both captive and wildstock of all age groups. End results (though continual) will be substantial pathological research data reported as it develops. Results of a practical nature will be interpreted and printed as information leaflets.

Item 8 - Commence Tracking and Tagging Operations in the Field. ($ 53,627 & 48,128)

a. Examine existing plankton collections in Hawaii and undertake new tows.

Extensive plankton collections exist at the Hawaii Institute of Marine Biology, the NMFS Honolulu Laboratory, and the University of Hawaii Department of Marine Biology.

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Plankton + milkfish larvae Jan 1978

These collections will be examined to determine if they have been recorded sufficiently site and time specific to give clues to milkfish spawning grounds in Hawaii. If this looks promising, an attempt will be made to identify milkfish eggs and larvae in selected samples, and to relate the data developed to geography, season, and ocean currents. The results of this work will be reported in a paper on or about January 1978. During the summer of 1977, tows will be made near Kaneohe Bay to look for milkfish eggs and larvae from this year's season. Results will be reported on or about January 1978, along with data above.

b. Capture, Tag, and Track Adult Fish and Synchronize Plankton Tows.

Development of the electronic tag circuitry is complete, and it is planned that 50 will be made up by summer 1977. Ten of these will be expended during the summer spawning period during trials in Kaneohe Bay to develop techniques for attachment and tracking. The goal is to achieve successful tracking of at least one school of milkfish including tagged individual(s), to identify the environmental parameters of spawning locations. Proof of accomplishment will be our ability to maintain contact with the tag(s) for a period of several hours, and stated parameters at spawning locations.

If the tracking trials succeed in following a seaward-migrating school, transects will also be made across the prevailing currents with plankton nets in an attempt to intercept fertilized milkfish eggs to learn more of egg incubation and coastal movement of larvae.

c. Conduct Large Trials on Location in the Philippines.

March 1978

The accomplishment of this item will depend very largely upon arrangements with and cooperation by existing organizations in the Philippines. No detailed plans have yet been formulated for this item. We expect that a memorandum outlining a planned field operation will have been written, circulated among the interested organizations, and approved by March 1978, leading to field operations beginning in that year.

Item 9 -. Conduct Experimentation on Breeding in the Field. ($ 15,591 & 19,236)

a. Assemble Annually a Team to Work on Location in the Field, Responding to Individual Seasonal Demands in the Pacific Islands and Southeast Asia.

In April 1977 three members of the Institute team are being sent at the expense of the project to work with the SEAFDEC/IRDC team at Pandan, Philippines. In

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March 1977 a staff member of the Hawaii Institute of Marine Biology was commissioned to visit Palau in the Trust Territory to make preliminary observations on reported lunar spawnings of milkfish. If these missions are successful, each year at the appropriate time, staff members will be sent to these and other locations to collect mature fish on the threshhold of spawning, and subject them to many 'spot-check' injections, using gonadotropins, HCG, and prostaglandins, etc. The results will be data which will set the ranges for controlled experimentation on captive fish. Observations on spawning will also direct construction of future facilities for captive fish (that is, large units for schooling behavior). The program will also provide strong linkages with other units in the field (SEAFDEC and MMRC) and other international programs (IDRC).

b. Design Field Units for a Mobile Task Force Investigating Breeding Locations.

If reports of accessible spawning schools in the Pacific Islands are confirmed, the objective will be to collect and transport fertile eggs and emergent fry in large quantities back either to Hawaii, Palau or the Philippines. A small portable field unit and personnel will be prepared to undertake such a mission(s). Success will be accepted if live eggs or larvae are transported to a major fish culture base. The end result (though continual) will be material to advance other program sub-projects (#4). Another end-result might be a major source of large numbers of active fry for such countries as the Philippines or Taiwan.

Item 10 - Establish a Cryogenic Unit ($ 13,701 & 19,278)

a. Collection and Preservation of Sperm.

Although experiences with other fish indicate that running males can be found at most times of a natural breeding season, the numbers (50) of males involved might not be adequate to cover all eventualities. Cryogenic methods for storing fish sperm have improved sufficiently to be practiced by the project without extensive research into techniques. A small cryogenic unit will be established to collect and preserve sperm from male milkfish. Sperm viability will be recorded by standard observations and tests on live fish if possible. End results will be directions for the collection and storage of sperm for milkfish, technical publications, and a stock pile of sperm.

b. Periodic Testing for Viability

As an investment for a long term sperm bank, the stored sperm will be spot-checked and logged for viability using standard observations and spot checks on live females. Trials on shipment of sperm will be conducted in assocation with

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SEAFDEC in the Philippines. The end results will be recommendations for sperm banks (should the practice prove feasible), and their use with genetic programs at hatcheries. The data will be published.

Item 11 - Hatchery Development ($ 14,463 & 19,278)

a. Site Selection Survey

At this time it is not possible to state with an assurance, where or when a milkfish hatchery will be constructed or by whom. The responsibility of the engineering group is therefore to gather engineering information from what ever source, and to assemble a design memorandum containing appropriate site selection criteria, hatchery schematics including space requirements, tankage volumes, water supply and management schematics, and as much detail as possible on such aspects of brackish/saltwater fish hatchery design as are not site-specific. At present, we envision the first "edition" of this memorandum as complete at the end of June, 1978, and available for review and responses by other workers in the field at that time. A seond edition would be published in June, 1979.

June 1978
June 1979

b. Engineering Drawing and Design

This is properly accomplished by professionals in the country of interest, if such exist, aided by consultation from our engineering group. Because of the nebulous nature of the eventual hatchery locations, size, owner, etc., we have provided only modest allowances of time (2 man months/year) for this category. The bulk of the actual consultation costs should be defrayed from the appropriation for hatchery design and construction, which is outside the scope of the present contract.

c. Construction Planning

Working with the International Center for Living Aquatic Resources Management (ICLARM), the Institute is preparing a Hatchery Design Guide for the breeding and propagation of grey mullet and (potentially) other brackishwater fish. The Institute will be using this guide to implement construction of a hatchery in a developing country as part of ICLARM's program in aquaculture. The project proposes to update this Design Guide using the most recent techniques (if available) for the milkfish. A Guide for milkfish propagation might therefore be available by January 1980.

milkfish guide 1980

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12. Management Considerations

Oceanic Institute shall maintain appropriate contacts with AID on both technical and other contractual matters affecting the carrying out of this project. Questions involving technical matters, funding and managerial decisions will be referred to the Fisheries Division in the Bureau for Technical Assistance (TA/AGR/F). Other routine matters will be handled directly with the Office of Contract Management (SER/CM).

Periodic project reviews and evaluations will be scheduled at mutually agreeable times with the concurrence of the TA/AGR/F Staff.

Oceanic Institute will continue to provide annual reports to AID and to provide occasional scientific and technical reports to interested scientists and institutions.

13. Internal and External Reviews

Reviews have been held in May 1966 and March 1977. Copies of reports resulting from these reviews are attached. Reviewers were generally complimentary and agreed with the importance of this research. Oceanic Institute has been responsive to the criticisms of the first review team and the proposal for continuation reflects responses to the second review. Specifically, new holding facilities are being constructed to increase the numbers of experimental adult animals available, major emphasis is being placed on development of hormone spawning techniques, and research activities will be conducted in the Philippines with races of fish most valuable to fish farmers under local environmental conditions. This step will significantly increase the availability of experimental animals since spawning times in Hawaii and the Philippines are different.

14. Proposing Office General Approval

The project has a very high rating from the Sponsoring Office with respect to the importance of the research to the rural poor in LDC's, the quality of the research conducted so far under the contract, the significance of the research findings, and the probability of additional contributions of major consequence.

The Sponsoring Office expects a rapid acceleration of the research with the fourfold increase in personnel. The promising nature of results obtained thus far has encouraged the assignment of additional manpower to the project, and this office supports the need for such an increase.

The highest priority should be placed upon perfecting techniques for hormonal inducement of spawning and the aquisition of sufficient adult fish to complete this phase of the research. Most other activities are supportive of this role and are, therefore, also important. Efforts to track adults to their spawning grounds using radio tags do not have the high priority assigned to the hormone spawning work but are, nevertheless, an important part of the research on spawning inducement through environmental control.

15. Minority Personnel and Women

The complement of staff involved in the project, either full or part-time is twelve. Of these, two are female Oriental technicians who are responsible for laboratory work.

The male staff includes one Japanese, one Chinese, one Hawaiian, one Jew, and six Caucasians. The project also involves local fishermen principally Orientals and Hawaiians hired according to their ability to deliver live adult fish.

Of the total Institute staff, some of whom provide administrative and clerical services associated with the grant as overhead, eleven of the thirty are female.

16. Environmental Statement

The research being conducted has no adverse environmental effects. With the fish farming likely to result from this research the environmental side effects are predominantly beneficial. There is the minimum tradeoff with land animal production as aquaculture mostly occupies nonagricultural land, but does compete for fertilizer and in some cases, raw materials for feed. Aquaculture is labor intensive in certain seasons, but is similar to agriculture for the rest of the year. Aquaculture complements the utilization of agricultural waste, a problem presently affecting modern intensive agriculture but not rural agriculture of the LDC's where the two have been integrated for centuries.

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1975 to FY 1980
Total U.S. Funding $1,440,409
Date Prepared: April 8, 1977

Project Title & Number: Research and Implementation of Milkfish Propagation

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To promote fish farming thereby increasing availability of food and opportunities for employment for the rural poor.	Measures of Goal Achievement: 1. Increase of production of low-priced fish in LDC's. 2. Increased consumption of fish by the rural poor. 3. Increased employment of poor in fish farming activities.	1. Fishery statistics. 2. Economic studies of fish farming and product distribution. 3. Observation of use of new technology in LDC's.	Assumptions for achieving goal targets: 1. Land and labor resources for increased saltwater fish farming are available. 2. Fingerling supplies from wild stocks are inadequate and limit production. 3. Hatchery procedures will be used when practical technology is available. 4. Appropriate extension work will make technology available.
Project Purpose: To develop dependable methods for maturing and spawning milkfish and for rearing fry to a size suitable for stocking.	Conditions that will indicate purpose has been achieved: End of project status. 1. Description of methods of handling adults. 2. Demonstration of methods for holding and maturing adult fish in captivity. 3. Description of practical techniques for inducing spawning on demand. 4. Description of methods for rearing fry.	1. Data collected during research and demonstration activities. 2. Acceptability of results for publication in scientific journals. 3. Project reviews.	Assumptions for achieving purpose: That research approach is valid. That method similar to those used with other fish (e.g. mullet can be developed within given time frame.
Outputs: Publications describing methodology and techniques for holding maturing, spawning milkfish and for rearing fry.	Magnitude of Outputs: Minimum of 5 scientific and/or technical reports with at least 500 copies of each report being made available through publication in scientific journals and widespread distribution of reprints in appropriate LDC's	1. Observed publication of report. 2. Discussions and feedback with the scientific community.	Assumptions for achieving outputs: 1. Research results will be published and distributed. 2. Appropriate extension mechanisms are operating.
Inputs: Scientific manpower Supplies Equipment Travel funds	Implementation Target (Type and Quantity) 156 man months per year as budgeted	Contractors Annual Report Project management records Audit reports	Assumptions for providing inputs: Proposal is funded as requested.

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COLIN E. NASH, Ph.D.
Vice-President and Director of Research
The Oceanic Institute

Academic

Leeds University, Yorkshire, B.Sc., 1959.
Leeds University, Yorkshire, Ph.D., 1962.

Experience

Vice-President, The Oceanic Institute, 1973 - present.
Director of Research, Oceanic Institute, 1972 - present.
Co-Director, Aquaculture Division, Oceanic Institute, 1971 - 1973.
Assistant Principal Officer, Fish Farming, for White Fish Authority, 1970.
Research Officer and Project Head for aquaculture in discharges from electricity generating plants, for White Fish Authority, 1966 - 1970.
Research Officer and Deputy, Plaice propagation hatchery development, White Fish Authority, 1963 - 1966.
Research Fellow, International Wool Secretariat, London, 1962 - 1963.

Affiliations

American Fisheries Society
Challenger Society
Smithsonian Institution
World Mariculture Society

National and State Services

Consultant, U.S. AID (RED).
Delegate, South Pacific Islands Fisheries Development Association, 1971 - 1972.
Delegate, South Pacific Commission, 1971 - 1972.
National Oceanographic and Atmospheric Administration (NOAA), Aquaculture Survey Steering Committee Member, 1973.
Governor's Advisory Panel for Marine Resource Development, Aquaculture Sub-Committee Member, 1972 - 1974.
Consultant, Aquaculture, Office of Sea Grant, 1973-present.

Editorial Board

Aquaculture, Elsevier Publishing Co., Amsterdam.

Colin E. Nash, Ph.D.

Publications

Shelbourne, J. E. and C. E. Nash. 1966. Sea fish culture in Britain. Proc. Nutr. Soc. 25(2):133.

Nash, C. E. and J. E. Shelbourne. 1967. Power station effluent as an environment for flatfish culture. I.C.E.S. Fisheries Imp. Comm. CM E:10.

Nash, C. E. 1968. Power stations as sea farms. New Scientist 40(623):368.

Nash, C. E. 1969. Thermal addition - planning for the future. Chesapeake Science 10(3 & 4):279-296.

Nash, C. E. 1970. Marine fish farming, Part I. Mar. Pollution Bull. 1(1):5.

Nash, C. E. 1970. Marine fish farming, Part II. Mar. Pollution Bull. 1(2):28.

Nash, C. E. 1970. Marine fish farming. North Ayrshire Coastal Development Comm. Report for the Public Enquiry at Ayrshire, Scotland.

Nash, C. E. 1972. Power stations and fish farming. Everymans Nature Reserve, Chapter IV. Ed. Eve Dennis, David & Charles, Newton Abbott, England.

Nash, C. E. and Z. H. Shehadeh. 1973. Current propagation techniques for selected marine teleosts, pleuronectes, scopthalmus and coryphaena species. Presented at Northwest Regional Meeting of American Fisheries Society, Portland, June 1972.

Kuo, C-M., Z. H. Shehadeh and C. E. Nash. 1973. Induced spawning of captive grey mullet (Mugil cephalus L.) females by injection of human chorionic gonadotropin (HCG). Aquaculture 1:429-432.

Shehadeh, Z. H., C-M. Kuo, and C. E. Nash. 1973. Establishing brood stock of grey mullet (Mugil cephalus L.) in small ponds. Aquaculture 2:379-384.

April, 1974

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Colin E. Nash, Ph.D.

(Publications - continued)

Nash, C.E. 1973. Automated mass production of Artemia salina for hatcheries. Aquaculture 2:289-298.

Kuo, C-M., Z.H. Shehadeh and C.E. Nash. 1974. A procedural guide to induce spawning in grey mullet (Mugil cephalus L.) Aquaculture 3:1-14.

Nash, C.E., C-M. Kuo and S.C. McConnell. 1974. Operational procedures for rearing larvae of the grey mullet (Mugil cephalus L.) Aquaculture 3:15-24.

Kuo, C-M., C.E. Nash and Z.H. Shehadeh. 1974. The effects of temperature and photoperiod on ovarian development in captive grey mullet (Mugil cephalus L.) Aquaculture 3:25-43.

Nash, C.E. 1974. Residual chlorine retention and power plant fish farms. Progr. Fish-Cult. 36:92-95.

Nash, C.E. and J.R. Sylvester. 1974. Thermal tolerance of eggs and larvae of Hawaiian striped mullet (Mugil cephalus L.). Trans. Am. Fish Soc. (in press).

Sylvester, J.R., C.E. Nash and C.R. Emberson. 1974. Preliminary study of temperature tolerance in juvenile Hawaiian mullet (Mugil cephalus) Progr. Fish-Cult. 36:99-100.

Nash, C.E. and C-M. Kuo. 1974. Hypotheses for problems impeding the mass propagation of grey mullet and other finfish. Paper presented at IBP/PM International Symposium on the Grey Mullets and their Culture, Haifa, Israel, June 1974. Also, Aquaculture 5:119-133, 1975.

Kuo, C-M. and C.E. Nash. 1974. Recent progress on the control of ovarian development and induced spawning of the grey mullet (Mugil cephalus L.) Paper presented at IBP/PM Int'l Symposium on Grey Mullets and their Culture, Haifa, Israel, June 1974. Also, Aquaculture 5:19-29, 1975.

July 1975

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Nash, C.E. 1974. Potential for the development of aquaculture in the Indo-Pacific region. 16th Session of Indo-Pacific Fisheries Council, Jakarta, Indonesia, October-November.

Lee, J.H., C.E. Nash, and J.R. Sylvester. 1975. Effects of mirex and methoxychlor on striped mullet, Mugil cephalus L. EPA Grant No. R 802348. Report No. EPA-660/3-75-015.

Sylvester, J.R., C.E. Nash, and C.R. Emberson. 1975. Salinity and oxygen tolerances of eggs and larvae of Hawaiian striped mullet, Mugil cephalus L. J. Fish Biol. 7:621-629.

Sylvester, J.R., C.E. Nash. 1975. Thermal tolerance of eggs and larvae of Hawaiian striped mullet, Mugil cephalus L. Trans. Am. Fish. Soc., Vol. 104, No. 1:144-147.

Nash, C.E., T. Joyner, and R.D. Mayo. 1976. Seeding the Southern Ocean with salmon - an ocean range management program. Report to ICLARM.

June 1976

BEST AVAILABLE COPY

Colin E. Nash, Ph.D.

Restricted Papers for the White Fish Authority

** Senior Scientist and Author; * Senior Scientist and Joint Author
+ Joint Author

** Plaice rearing at Hunterston and Carmarthen Bay electrical generating stations, 1966.
** Dover sole rearing at Hunterston nuclear generating station, 1966-1968.
** Plaice rearing at Hunterston, 1968.
** Plaice rearing at Hunterston, 1969.
** Turbot fattening at Hunterston, 1969.
** The influence of water temperature on the growth of the plaice and Dover sole at Port Erin, Isle of Man, 1965.
* Survival of young Dover sole fed with liver supplement, Hunterston, 1970.
* Chlorination and its detection for a power station fish farm.
* Residual chlorine retention in relation to flow rate in a fish tank.
* The development of tank rearing facilities for marine flatfish.
* Design of ancillary services at a power station fish farm.
* The potential of the ormer (abalone) in marine fish farming, Hunterston, 1968.
* The measurement of water flow into a fish tank, Hunterston, 1969.
* The production of Artemia salina nauplii, Hunterston, 1968.
* An instrument for the measurement of dissolved oxygen in a marin fish farm, Hunterston, 1968.
* Production technique and costing for plaice at a power station fish farm, Hunterston, 1970.
* A synopsis of the marine fish cultivation programme, 1964-70.
+ Hydrography and management of the Ardtoe inter-tidal pool, May 1968-April 1970.
+ Plaice rearing in a sheet polyethylene floating tank, Ardtoe 1967.
+ Plaice rearing in a prototype floating cage for sheltered water, Ardtoe 1967.
+ Plaice rearing in a netting enclosure and floating cage, Ardtoe 1968.
+ Hatching of plaice at Ardtoe, 1969.
+ Plaice rearing in a prototype floating sea-cage, Ardtoe 1969.
+ An incidence of pop-eye disease at Ardtoe, 1968.
+ Design, construction and operation of a netting enclosure.
+ Design, construction and operation of small floating cages.
+ Design, construction and operation of large floating cages.

April, 1974

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CHING-MING KUO, Ph. D.
Head, Aquaculture Division
The Oceanic Institute

Academic

National Taiwan University, Taipei, B.S., 1958.
Scripps Institution of Oceanography, University of California, San Diego, Ph.D., 1970.

Positions and Experience

Head, Aquaculture Division, Oceanic Institute, 1972 - present.
Research Associate, Aquaculture Division, Oceanic Institute, 1970 - 1972.
Post-graduate Research Biologist, Scripps Institution of Oceanography, 1970.
Research Assistant, Scripps Institution of Oceanography, 1964 - 1970.
Teaching Assistant, Department of Zoology, National Taiwan University, 1960 - 1964.
Research Biologist, Institute of Fishery Biology, National Taiwan University, 1960.

Publications

Kuo, C-M. 1965. The physiology of some teleost fishes, part I. Study on the sexual maturity of Silver Carp, Hypophthalmichthys molitrix C. & V. Rept. Inst. Fish. Biol., 2(1):46-52.

Kuo, C-M. 1964. Morphology of Yellowfin Tuna. China Fish., No. 138, pp 2-7 (in Chinese).

Kuo, C-M. 1964. Behavior of Yellowfin Tuna. China Fish, No. 139, pp 2-7 (in Chinese).

Shehadeh, Z.H., C-M. Kuo, and K.K. Milisen. 1973. Induced spawning of grey mullet (Mugil cephalus L.) with fractionated salmon pituitary extract. J. Fish Biol. 5:471-478.

Shehadeh, Z.H., C-M. Kuo, and K.K. Milisen. 1973. Validation of an in vivo method for monitoring ovarian development in the grey mullet (Mugil cephalus L.) J. Fish Biol. 5:489-496.

October 1976

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Ching-Ming Kuo, Ph. D.

(Publications - continued)

Kuo, C-M., Z. H. Shehadeh and K. K. Milisen. 1973. A preliminary report on the development, growth and survival of laboratory reared larvae of the grey mullet (Mugil cephalus L.) J. Fish Biol. 5:459-470.

Shehadeh, Z. H., C-M. Kuo and C. E. Nash. 1973. Establishing brood stock of grey mullet (Mugil cephalus L.) in small ponds. Aquaculture 2:379-384.

Kuo, C-M., Z. H. Shehadeh, and C. E. Nash. 1973. Induced spawning of captive grey mullet (Mugil cephalus L.) females by injection of human chorionic gonadotropin. Aquaculture 1:429-432.

Kuo, C-M., C. E. Nash and Z. H. Shehadeh. 1974. The effects of temperature and photoperiod on ovarian development in captive grey mullet (Mugil cephalus L.). Aquaculture 3:25-43.

Kuo, C-M., C. E. Nash and Z. H. Shehadeh. 1974. A procedural guide to induce spawning in grey mullet (Mugil cephalus L.) Aquaculture 3:1-14.

Nash, C. E., C-M. Kuo and S. C. McConnell. 1974. Operational procedures for rearing larvae of the grey mullet (Mugil cephalus L.). Aquaculture 3:15-24.

Nash, C.E. and C-M. Kuo. 1974. Hypotheses for problems impeding the mass propagation of grey mullet and other finfish. Paper presented at IBP/PM International Symposium on the Grey Mullets and their Culture, Haifa, Israel, June 1974. Also in Aquaculture 5:119-133, 1975.

Kuo, C-M. and C. E. Nash. 1974. Recent progress on the control of ovarian development and induced spawning of the grey mullet (Mugil cephalus L.). Paper presented at IBP/PM International Symposium on the Grey Mullets and their Culture, Haifa, Israel, June 1974. Also in Aquaculture 5:19-29, 1975.

October 1976

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GUY N. ROTHWELL, Jr.
Senior Engineer
Oceanic Institute

Professional/Academic

Registered civil and structural engineer, Hawaii 1961.
Loyola University, Los Angeles, B.A. Philosophy, 1950.
UCLA, completed undergraduate engineering curriculum, 1959.
University of Hawaii, completed courses in ocean engineering.

Positions and Experience

Senior Engineer, Oceanic Institute, 1970 - present.
Project Manager (planning, conceptual design, EIS and construction contract drawings) for ocean related projects including light draft harbors and a fish hatchery.
Principal investigator of Open Ocean Fish Enclosure Study.
Task Force member of ICLARM Southern Ocean Salmon Project.
Chief Engineer of MOSES, Floating City Development Studies, Offshore Coal-fired Electrical Power Generation, OTEC Platform Study; responsible for conceptual and preliminary engineering design, coordination with consultants and technical supervision of engineering staff.

President and Chief Engineer, Pacific Submersibles, Inc., 1967 - 1970.
A Hawaiian Company which operated the research submersible NAIA. Projects included marine biology research, bottom surveys, development and testing of undersea products, oil field and pipeline surveys, and militairy ordnance recovery in Hawaii, the Gulf of Mexico and the Gulf of Suez. Developed several electro-mechanical work systems for the submersible, including remote manipulators, a large object recovery device, and an oil field work jig for servicing undersea well heads. The latter system has been awarded American and foreign patents.

Partner, Guy Rothwell & Associates, 1963 - 1967. Engineering Consultants; heavy engineering structures including waterfront structures, undersea pipelines and cables; a nuclear reactor refueling facility; and several underground facilities resistant to nuclear weapons.

Chief Engineer, Rothwell, Lester & Phillips, Architects and Engineers, 1961 - 1963. Structural design of large buildings, waterfront structures, and harbors; operated a hydraulic model laboratory for the State of Hawaii in connection with harbor design projects.

43

Structural Engineer, Paderewski, Mitchell & Dean, San Diego, Cal., 1959 - 1961. Broad range of engineering structures: hospitals, schools, hotels, apartment buildings, industrial structures.

Structural Designer, Daniel, Mann, Johnson & Mendenhall, Los Angeles, Cal., 1956 - 1959. Missile launching facilities, large commercial, aseismic design of high-rise buildings.

U.S. Air Force, 1951 - 1956. Discharged in 1953 as staff sergeant to receive commission as 2d Lt. USAF. Separated in 1956 as 1st Lt.

Patents

On remotely controlled Underwater Work Systems Apparatus & Methods:

American	- 366615
British	- 1282858
Venezuelan	- not available
New Zealand	- 159564
Pending:	Canada and Japan.

Special Qualifications or Experience

Qualified SCUBA diver
Qualified submersible pilot

Instrument Design and Construction (unpublished)

MARS, multi-channel Beta particle counter for in-situ determination of sinking rate of ^{14}C-labeled phytoplankton. 1976, Oceanic Institute.

Inertial motion sensing package for model tests in connection with OTEC platform study. Vertical gyro reference, triaxial accelerometer, pressure proof case, weight 11 lb. Remote digitizing and logging equipment can receive data by wire or FM telemetry. 1976, Oceanic Institute.

Lightweight, field programmable equipment for operating and logging data from a multi-sensor oceanographic probe. Provides high quality data, has operated from a small outboard craft in surf. 1975, Oceanic Institute.

Direct digitizing data logging system, 24 channel, wind, velocity, and structures response. 1970, Oceanic Institute.

44

Surface-following wave measuring buoy. 1972, Oceanic Institute.

Flicker/fusion apparatus for clinical research and diagnosis of brain damage. 1971, Oceanic Institute.

Vibration sensing, recording, and spectral analysis apparatus for investigation of building motions. 1965, Guy Rothwell & Associates.

Multi-channel wave measurement and recording system for small amplitude waves. 1964. Guy Rothwell & Associates.

Publications

Principal author or co-author, over a period of twenty years, of a large number of major and minor pieces of engineering documentation, such as proposals, conceptual designs, preliminary engineering reports, research reports, environmental impact statements, construction contract drawings and specifications, etc. Clients have included the U.S. Air Force, U.S. Navy, Army Engineer Corps, Federal Aviation Agency, U.S. Department of Commerce, State of California, State of Hawaii, and many private clients.

45

ALBERT CARL SMITH, Ph.D., M.D.
Marine Pathologist

EDUCATION

University of California, Los Angeles, B.A. Zoology
University of Southern California Medical School, 3 years
University of Hawaii Graduate School, Zoology, 1 year
Santa Monica City College, University of California Los Angeles extension, and Kerckhoff (California Institute of Technology) Marine Laboratory--summer sessions
University of California, Irvine, Graduate School in Biology, Fall, 1965-1966, Ph.D. in Biological Science
University of Hawaii, John A. Burns School of Medicine, 1973-1975, M.D.
Saint Francis Hospital - University of Hawaii, John A. Burns School of Medicine, July 1975 - June 1976, Pathology Research Fellowship

EXPERIENCE

Resident, Department of Pathology, Saint Francis Hospital - John A. Burns School of Medicine, University of Hawaii, Honolulu, 1976-present.
Pathology Research Fellow, Department of Pathology, John A. Burns School of Medicine, University of Hawaii, Honolulu, 1975-1976.
Chief Consultant, Hawaii BioMarine, Honolulu, Hawaii, 1973-present.
Associate Professor of Biology, Division of Natural Science, University of Hawaii, Hilo, 1969-1973.
California Department of Fish and Game, Long Beach, research on molecular genetics of fishes, 1971, 1970, 1965-1966, 1963, 1962, 1961.
Program Director in Pathology, Aquatic Sciences, Inc., Boca Raton, Florida, 1969.
Research Associate and Instructor, Department of Population and Environmental Biology, University of California, Irvine, 1966-1967.
Research Assistant to Dr. Grover C. Stephens, Chairman, Department of Organismic Biology, University of California, Irvine, 1966.
Lab Technician (II) to Dr. R. L. Taylor, Assistant Research Pathologist, University of California, Irvine, 1964-1965.
Studied electrophoresis of blood and urine for Cancer Research Institute, Orange County General Hospital, 1964.
Tested actions of new drugs on lab animals of Allergan, pharmaceutical firm, 1963.
Assistant to Senior Scientists, Eniwetok Marine Biological Lab, University of Hawaii, 1959.
Teaching Assistant in Zoology, University of Hawaii, 1958-1959.

June 1976

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Publications

- Smith, A.C. & van Weel, P.B., 1960. On the Protease and Amylase Production in the Mid-Gut Gland of Young and Mature African Snails. Experientia, 16:60-62.

- Smith, A.C., 1962. The Electrophoretic Characteristics of Albacore, Bluefin Tuna, and Kelp Bass Eye Lens Proteins. Calif. Fish Game, 48:199-201.

- Smith, A.C., 1963. Variant Hemoglobin and Electrophoretic Whole Blood Studies in Two Tunas and Three Other Fish Species. Calif. Fish Game, 49:44-49.

- Smith, A.C., 1965. Intraspecific Eye Lens Protein Differences in the Yellowfin Tuna, Thunnus albacares. Calif. Fish Game, 51:163-167.

- Smith, A.C., 1966. Electrophoretic Studies of Soluble Protein from Lens-Nuclei of Bluefin Tuna, Thunnus thynnus, from California and Australia. Amer. Zool., 6:577.

- Smith, A.C., 1966. Electrophoretic Studies of Eye Lens Protein from Marine Fishes, Doctoral Dissertation, Dept. of Organismic Biology, University of California at Irvine; Dissertation Abstracts, 28, 1968.

- Taylor, R.L. & Smith, A.C., 1966. Polypoid and Papillary Lesions in the Foot of the Gaper Clam, Tresus nuttalli. J. Invert. Path., 8: 264-266.

- Smith, A.C., 1967. Serological Studies of Kelp Bass, Paralabrax clathratus. Calif. Fish Game, 53:197-202.

- Smith, A.C. & Goldstein, R.A., 1967. Variation in Protein Composition of the Eye Lens Nucleus in Ocean Whitefish, Caulolatilus princeps. Comp. Biochem. Physiol., 23:533-539.

- Smith, A.C. & Taylor, R.L., 1968. Tumefactions (Tumor-Like Lesions) on the Foot of the Moon Snail, Polinices lewisii. J. Invert. Path., 10:263-268.

- Smith, A.C., 1968. Effects of Sodium Chloride Concentration on Solubility and Electrophoretic Characteristics of Protein from the Eye Lens Nucleus in a Yellowfin Tuna (Thunnus albacares) and in a Desert Wood Rat (Neotoma lepida). Comp. Biochem. Physiol., 27:543-549.

- Smith, A.C. & Taylor, R.L., 1968. Digestive Gland and Integument Lesions Associated with Malnutrition in a Ghost Shrimp, Calianassa affinis. J. Invert. Path., 12:1-6.

- Smith, A.C., 1969. Protein Variation in the Eye Lens Nucleus of the Mackeral Scad (Decapterus pinnulatus). Comp. Biochem. Physiol., 28: 1161-1168.

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4. Smith, A.C., 1969. Effects of Urea on Solubility and Electrophoretic Characteristics of Protein from the Eye Lens Nucleus in Bigeye and Skipjack Tunas, and in Menpachi. Comp. Biochem. Physiol., 29:251-258.

5. Smith, A.C., 1969. An Electrophoretic Study of Protein Extracted in Distilled Water and in Saline Solution from the Eye Lens Nucleus of the Squid, Nototodarus hawaiiensis. Comp. Biochem. Physiol., 30: 551-559.

6. Smith, A.C. & Little, H.F., Liver Lesions Produced by Hydatid-Like Cysts in an Elasmobranch, the Electric Ray (Torpedo californica).

   A. Full-length version: 1969. Mar. Biol., 3:136-142.
   B. Short version: 1969. Nat. Cancer Inst. Monogr., 31:251-254.

7. Peterson, G.L. & Smith, A.C., 1969. Intraspecific Variation in the Soluble Nuclear Eye Lens Proteins of the Sandbar Shark, Carcharhinus milberti (Müller and Henle). Comp. Biochem. Physiol., 31:679-684.

8. Smith, A.C., 1969. Pathology in the Aquatic Environment. Mar. Tech. Soc. J., 3:65-66.

9. Smith, A.C., 1970. Electrophoretic, Solubility, and Thermostability Differences in Proteins of Eye Lens Nuclei From Two Closely Related Fish Species, the Yellowfin Tuna and the Bigeye Tuna. Comp. Biochem. Physiol., 33:1-14.

10. Smith, A.C., 1970. Permeability of the Eye Lens Capsule of the Bigeye Tuna to Nuclear Eye Lens Proteins. Comp. Biochem. Physiol., 34:101-108.

11. VanArman, J. & Smith, A.C., 1970. The Pathobiology of an Epibranchial Bopyrid Isopod in a Shrimp, Hippolysmata wurdemanni. J. Invert. Path., 15:133-135.

12. Smith, A.C. & Goldstein, R.A., 1971. Natural Agglutinins Against Sea Urchin Sperm in Hemolymph of the Crab, Cardisoma quanhumi. Mar. Biol., 8:6.

13. Smith, A.C., 1971. Protein Differences in the Eye Lens Cortex and Nucleus of Individual Channel Rockfish, Sebastolobus alascanus. Calif. Fish Game, 57:177-181.

14. Smith, A.C., 1971. The Soluble Proteins in Eye Lens Nuclei of Albacore, Bluefin Tuna and Bonito. Comp. Biochem. Physiol., 39: 719-724.

15. Smith, A.C., 1971. Genetic and Evolutionary Analysis of Protein Variation in Eye Lens Nuclei of Rainbow Trout (Salmo gairdnerii). Intern. J. Biochem., 2:384-388.

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26. Smith, A.C., 1971. Absorption of Water and Nuclear Lens Protein by Nuclear Lens Tissue. Pac. Sci., 25:566-568.

27. Smith, A.C., 1972. Lens Iso-Percipitin in Yellowfin Tuna (Thunnus albacares). Comp. Biochem. Physiol., 42:497-499.

28. Smith, A.C. & Taylor, R.L., 1972. Preliminary Results of Marine Pathology Study off the Florida Coast. Mar. Tech. Soc. J., 6:51-52

29. Smith, A.C., 1972. Reacting Components in Mixtures of Nuclear Lens Extracts from Yellowfin Tuna (Thunnus albacares). Program, 52nd Annual Meeting, Amer. Soc. of Ichthyologists and Herpetologists, Boston, Mass., June 18-23, 1972.

30. Smith, A.C. & Clemens, H.B., 1973. A Population Study by Proteins from the Nucleus of Bluefin Tuna Eye Lens. Trans. Amer. Fish. Soc., 102:578-583.

31 Smith, A.C., Taylor, R.L., Chun-Akana, H., & Ramos, F., 1973. Intestinal Tumor in the Sea Cucumber, Holothuria leucospilata. J. Invert. Path., 22:305-307.

32. Smith, A. C., 1975. Search Among Marine Invertebrates for Eosinophils Useful in Medical Research. Abstracts of Papers, VIIIth Annual Meeting, Soc. for Invertebrate Pathology, Corvallis, Oregon, August 18-22.

33. Ramos, F. & Smith, A. C., 1975. Protein Differences in the Lens Nucleus from the Desert Woodrat (Neotoma lepida). Psychological Reports, 37:219-222.

34. Smith, A. C. & Taylor, R. L., 1975. Immunoglobulins or Similar Substances in Invertebrate Body Fluids: A Preliminary Study. Aquaculture, 6:295-299.

35. Smith, A. C., in press. Catalase in Fish Red Blood Cells. Comp. Biochem. Physiol.

36. Smith, A. C., in press. Reactions of Fish Red Blood Cells with Mucus and Sera from Other Fish(es). Calif. Fish Game.

37. Smith, A. C. & Hartley, F. K., in press. Keloid in the Gray Reef Shark, Carcharhinus amblyrhynchos. Pac. Sci.

38. Smith, A. C. & Ramos, F., in press. Occult Hemoglobin in Fish Skin Mucus as a Possible Indicator of Early Stress. J. Fish Biol.

39. Taylor, R. L. & Smith, A. C., in press. Proposal for a Center for Marine Pathology. Arch. Path.

40. Smith, A. C., ~~submitted m.s.~~ in press. Immunologic Reactions of the Sea Cucumber, Holothuria cinerascens, to Serum from the Milkfish, Chanos chanos.

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41. Smith, A.C., submitted m.s. Formation of Specific Binding Activity in Fish Lens Protein.

42. Smith, A.C., submitted m.s. Hypersensitivity and Desensitization in the Sea Cucumber, Holothuria cinerascens.

43. Smith, A.C., submitted m.s. Hepatoma in Tilapia, Tilapia mosambica.

44. Smith, A.C. & Smith, D.J., in press. Diseases of Man and Marine Animals. Sea Grant Newsletter, University of Hawaii.

45. Smith, A.C. & Smith, D.J., in press. Man's Evolutionary Roots in the Sea. Sea Grant Newsletter, University of Hawaii.

H. BURR STEINBACH, Ph. D.
President
The Oceanic Institute

Academic

University of Michigan, B.A., 1928.
Brown University, M.A., 1930.
University of Pennsylvania, Ph.D., 1933.

Experience

President, The Oceanic Foundation, 1974 - present.
Dean of Graduate Studies, Woods Hole Oceanographic Institution, 1968 - 1974.
Professor and Chairman, Department of Zoology, University of Chicago, 1957-1968; Professor of Zoology, University of Chicago, 1968-1971.
Consultant, Institute for Defense Analysis
Consultant, Presidne'ts Science Advisory Committee
Visiting Professor, National Taiwan University, 1966.
Visiting Professor, University of Hawaii, 1964.
National Science Foundation Divisional Committee Chairman, 1954-1959.
Guggenheim Fellow, 1955-1956.
Assistant Director, National Science Foundation, 1954-1954.
Professor, University of Minnesota, 1947-1957.
Associate Professor, 1942-1946; Professor, 1946-1957, Washington University.
Assistant Professor, Columbia University, 1938-1942.
Assistant Professor, University of Minnesota, 1936-1938.
Instructor, University of Minnesota, 1935-1936.
National Research Council Fellow, University of Chicago, 1933-1934.
Instructor, Zoology, University of Pennsylvania, 1930-1933.
Assistant, Physiology and Biochemistry, Brown University, 1928-1930.

Member of the Corporation, Marine Biological Laboratory, Director and President, 1966-1970.
Member of the Corporation, Woods Hole Oceanographic Institution.
Member of the Executive Committe and Trustee, Chicago Zoological Society, 1966-1968.
Biophysical Society, Charter Council Member
American Society of Zoologists, President, 1959-1959.

April, 1974

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H. Burr Steinbach, Ph. D.

(Experience - continued)

Physiological Society.
Society for General Physiologists, President, 1956-1957.
Member, Founding Committee AIBS (Executive Secretary).
AIBS Curriculum Study, 1958-1963.
Chairman, Division of Biology and Agriculture, N. R. C., 1958-1963.
Member, Physiological Study Section, NIH, 1958-1959.
Member, Heart Council, NIH, 1959-1963.
Member, Science Information Council, NSF, 1966-1968.
Member, Sino-American Committee on Scientific Cooperation (NAS-NRC)
Chairman, Pacific Science Board, NRC, 1967-1970.
Member Advisory Committee, Sea Grant, NSF, 1968.
Editorial Board, Physiological Zoology
Managing Editor, Biological Bulletin, 1942-1950.

H. Burr Steinbach, Ph. D.

Publications

1931. with I. R. Taylor. Respiratory metabolism during pupal development of Galleria mellonella (bee moth). Physiol. Zool. 4:604.

1933. The electrical potential difference across living frog skin. J. C. C. P. 3(1), April.

1933. Injury potential s in scallop muscles. J. C. C. P., 3(2), June.

1935. Diffusion potentials in colloidal systems. J. C. C. P., 7(2), Dec.

1935. Diffusion potentials in scallop muscles. J. C. C. P. 7(2), Dec.

1937. Potassium and chloride in Thyone muscle. J. C. C. P. 9 (3), April.

1937. Potassium in frog skin. J. C. C. P., 10(1), June.

1940. with the assistance of Jack Auringer. Electrolytes in Thyone muscles. J. C. C. P. 15(1), Feb.

1940. Sodium and potassium in frog muscle. J. Biol. Chem. 133(3), May.

1940. Chemical and concentration potentials in the giant fibers of squid nerves. J. C. C. P., 15(3), June.

1940. The distribution of electrolytes in Phascolosoma muscle. Biol. Bull. 78(3), June.

1940. Electrolyte balance of animal cells. Cold Spring Harbor Symposium.

1941. The role of the injured surface in the production of the injury potential of frog muscle. Physiol. Zool., 14(1), Jan.

1941. Chloride in the giant axons of the squid. J. C. C. P. 17(1), Feb.

1942. with M. L. Gabriel. Zoology in 1941. Chem. Eng. News 20:Feb 26.

1942. with D. Nachmansohn. On the localization of enzymes in nerve fibers. Science 95: Jan. 16.

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H. Burr Steinbach, Ph. D.

(Publications - continued)

1943. with A. Glenn Richards and Thomas F. Anderson. Electron microscope studies of squid giant nerve axoplasm. J.C. C. P. 21(2), April.

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REVIEW OF THE RESEARCH PROGRAM RESEARCH IN ARTIFICIAL PROPAGATION OF MILKFISH CONDUCTED BY THE OCEANIC FOUNDATION FOR AID

BACKGROUND

This review was held at the Oceanic Institute, Waimanalo, Hawaii on May 6 and 7, 1976, in accordance with the terms of the contract between AID and the Oceanic Foundation (now Oceanic Institute) entered into on January 13, 1975.

This contract, AID-TA-0-1189, is in the amount of $498,532 for the 3-year period ending January 12, 1978. Of this sum, $250,000 was alloted initially. The balance, $248,532, was to be provided if funds were available and "contingent upon ... favorable AID review and evaluation of the results of the program after 18 months." The review was actually held after 16 months to avoid a session during the spawning season.

The original research proposal, which was submitted to the AID Research Advisory Committee on 16 October 1974, covered a 5-year study at a total cost of $870,000. Whether the contract will be extended for two additional years will be determined by a second review which, under the terms of the contract, is to be held after 32 months.

The review team consisted of:

Philip M. Roedel, Fisheries Advisor, AID, Washington, D. C.,
H. R. Schmittou, Fisheries Advisor, USAID Mission, Manila, Philippines,
James A. Storer, Office of Marine Resources, NOAA, Rockville, Md.

The principal Oceanic Institute staff participants in the review were:

H. Burr Steinback, President
Colin J. Nash, Director of Research
Ching-Ming Kuo, Head, Aquaculture Division
Guy N. Rothwell, Jr., Senior Engineer
Albert C. Smith, Marine Pathologist

SUMMARY FINDINGS

The team agreed that the work being done is in accordance with the terms of the contract, that it is generally on schedule, and that the timetable for the next year remains valid. The project projections for the proposed years 4 and 5 will require careful scrutiny at the second (final) review of the existing contract. The project staff, while small in numbers, is obviously extremely competent professionally. There are some questions with respect to certain aspects of the work which are addressed in the report. The program as a whole, however, is sound and fully deserving of continued AID support. The team endorsed Oceanic's request for additional funds ($30-35,000) for pathology work and recommended that the program be funded for its third year at no less than the level indicated in the contract.

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PURPOSE OF THE RESEARCH

The program objective set by AID for the contractor was to breed the milkfish, Chanos chanos, in captivity and to raise the fry from the egg, undertaking any research and development which might be necessary to attain that goal.

Specific objectives are:

a. To induce spawning of milkfish in captivity economically and over long periods.

b. To increase the survival rate of eggs and larvae.

c. To increase the hardiness of juveniles.

d. To develop handling techniques for juveniles that will assure the lowest possible mortality.

The original proposal from Oceanic Foundation proposed research, design, and construction of low-cost pens and enclosures for aquacultural production of brackish-water fish. The revised research project excludes any work on pens and enclosures for commercial production.

PROJECT PLAN

The review team agreed that the Institute is carrying out the research program in a very satisfactory fashion. The original plan was well conceived, the staff has been able to adhere to it, and Oceanic expects to be able to achieve its objectives within the allocated time. This is not due simply to an automatic adherence to the original plan but rather to the staff having periodically examined the plan to determine its continuing validity and productivity, as well as their progress under its terms.

STAFF

The team was impressed with the attitude, enthusiasm and general approach of the staff. It is a talented group of professionals who seem to work very well together, stimulate one another, have respect for each other's special area of competence, thereby achieving a good degree of interaction and esprit de corps. The leadership provided by Colin Nash appears to be most effective,

The breadth of approach is exemplified by the role of Dr. Smith who took his doctorate in biology but more recently obtained his MD. With that unique training he can bring to his fish pathology work the training and interest of a physician. He is, for instance, pursuing a number of

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by-products of his pathology research that may have significant medical application. Such a result that would, of course, increase the pay-off of the project. This broad capacity of the staff is to be highly valued and bodes well for the continued health of the Institute and for its potential not only in aquaculture but as well in other activities.

The staff tends to be academically and intellectually oriented, yet it maintains a strong practical orientation manifested in such ways as in efforts to reduce the cost of feed.

The team had, however, some concern that the staff might be overly academically oriented, with not enough contact with practical fishermen or practicing aquaculturists. In that sense there was a feeling that the staff feels itself to be something of an "intellectual elite" and that it wishes to keep it that way.

RELATIONSHIPS WITH OTHER ORGANIZATIONS

The staff was well aware of the activities of the other institutions working in the fisheries field with AID support -- Auburn University and the University of Rhode Island. They were quite open to the possibilities of closer cooperation with either or both, at the same time pointing out quite correctly that such cooperation could more easily be effected with the University of Hawaii.

However, they appear to be quite selective in their relations with other professionals at that University. While the staff seems to have associated regularly with some groups, they have almost no contact with others, particularly social scientists, including economists. They should exert a greater effort in this direction.

FUNDING

The Institute is operating on a very tight budget, but should be able to carry out the work as scheduled in the contract. It is essential that the full $249,000 budgeted for the third year be obligated in FY 1977, and equally essential that certain studies of stress be funded immediately. Cost is estimated at $30-35,000. (Note: The budget was augmented by $30,000 on June 22, 1976).

As we have noted, the project proposal presented to the AID Research Advisory Committee called for a 5-year study at a cost of $870,000. The contract finally let covered the first three years only for which approximately $500,000 was budgeted. Requirements beyond the third year are to be considered by the review to be made "after 32 months". If the project is to continue, this review will in fact have to be made after about 28 months (e.g. in May 1977) to permit the Agency sufficient time to process extension documents, this assuming the board so recommends.

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Oceanic noted in the executive summary of its annual report for 1975 that the essentially similar 5-year program for gray mullet cost $1-3/4 million including capital construction. It believes that the milkfish work will require funding support of the same order of magnitude -- perhaps $1 million exclusive of construction.

SPECIFIC ~~COMMENTS~~ Objectives

Sexual Maturity and GSI

The following is based on a comment from one of the board members: So little is known about the biology of milkfish that it is not valid to make concrete comparisons between two apparent subpopulations. There are some important apparent differences in spawning biology between milkfish in Hawaii and in Southeast Asia such as:

1. Reported minimum sizes of sexually mature fish in SEA are almost 5 kg while Hawaii fish are 2.5 to 3 kg.

2. SEA fish apparently spawn over a long season with only a relatively few females gravid at any given time while Hawaii fish apparently all develop and spawn within a short season during July and early August.

3. Reported minimum spawning temperatures for SEA fish have been 28°C while waters around Hawaii do not exceed 26°C.

Another apparent difference of possible significance is in gonad weight relative to total body weight — GSI. The most developed Philippine fish studied had GSI values of 5 to 7 for males and 8 to 12 for females, while GSI's for both sexes in Hawaii were only approximately 3.3 during peak development (based on available data).

The Board suggests that the Staff should consider what the apparent differences mean and what importance they may have.

Supplemental Feed

Oceanic is using feeds to supplement natural growth of vegetation in the tanks and pools. An example of the supplemental feed reported consists of:

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Wheat middlings	55.0%
Cottonseed meal	14.0
Soybean meal	14.0
Tuna meal	14.0
Propylene glycol	1.4
Visorbin	1.4
Vitamin pre-mix	0.2

A Board member points out that total protein in this feed could not be more than 20% and animal protein not more than about 9%; carbohydrates are high and fats, vitamins and minerals are low. Supplemental feeds for fish should be high in protein (30% or more) and low in carbohydrates. The feed may not be nutritionally adequate for developing breeders especially since there appeared to be very little natural foods available in Oceanic tanks and ponds. The fish may not be able to get enough nutrients, especially protein to develop sex products and especially viable products.

The team suggests that Oceanic begin using some of the proven nutritionally complete trout diets. Since little is known about milkfish nutrition, it would appear Oceanic could collaborate profitably with a fish nutritionist.

Electronic Tagging

Oceanic intends to locate milkfish spawning grounds by tracking from a boat a released gravid female equipped with an electronic tag. The odds for success of this method seem extremely small. For example, the spawning grounds may be as much as 300 km from the Hawaii beaches where the larvae and postlarvae are collected.

Other troublesome factors include:

1. The problem of selecting and preparing the specimen for tagging.

2. The possibility if not probability that handling stress will cause altered behavior to a point where these tagged fish will not move immediately to the grounds for spawning, will spawn outside of the normal spawning grounds, will lose their eggs to atresia or premature release.

It seems to the team that in addition to electronic tagging, upcurrent sampling of larvae and eggs be used to locate spawning grounds. Theoretically, larvae development would become less developed as sampling progressed upcurrent away from shore.

Some advantages of these methods are that:

a. There is a greater chance index for success than with the electronic tagging method;

b. It would be less expensive than electronic tagging;

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c. It will provide valuable information on development of wild eggs and larvae for use in artificial spawning studies; and

d. It will provide information on the environment in which eggs and larvae exist between spawning grounds and shore, as well as just the spawning grounds.

One team member has suggested to Oceanic that they consider mass tagging as a possible preliminary to electronic tagging. This could provide valuable information on distribution, range, migration habits and subpopulations. Releases of mass-tagged milkfish should be considered in a broad geographic area including Indonesia, Philippines, and Taiwan as well as Hawaii and possibly other Pacific Islands. The tagging program requires especially careful consideration before final plans are made for the 1977 spawning season.

Milkfish Pathology Project

It became apparent in 1975 that naturally-occurring organic disease and stress induced by confinement could seriously affect the outcome of the entire program. Consequently, in October 1975, Oceanic made a formal application to AID for supplementary funding so that it could itensify the work being carried out by Dr. Smith. This includes studies of basic pathology and studies of diseases that manifest themselves under condition of contamination. In the latter case, Oceanic hopes to develop a fundamental understanding of the stress state and how to cope with it. Preliminary work is promising.

The team fully endorsed this project and believed it should be adequately funded. As noted under "Funding", the budget was augmented by $30,000 in June, 1976.

FUTURE WORK

The study as authorized will provide answers to only part of the questions no matter how successful the scientific work may be. Oceanic can with its present staff and facility develop the laboratory techniques needed for artificial propagation. However, with its present physical facilities, Oceanic cannot carry out pilot production operations designed to field-test the techniques that are needed as an intermediate step leading to the design and operation of large-scale production hatcheries. There is a real question as to whether, even if the facilities in Hawaii were expanded, the work should be done there. The team feels, as does the staff, that this should be carried out in South East Asia where production operations will ultimately take place.

This question requires full consideration at the second review team which will determine where and in what form the project will continue.

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WILLIAM F. ROYCE
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(206) 523-4383

18 March, 1977

Mr. Philip Roedel
AID, Department of State
Washington, DC, 20523

Dear Phil:

Herewith is the final copy of the review of Project 931-0526, Artificial Propagation of Milkfish.

Drs. Schmittou and Storer have seen and approved the draft of 11 March but I have made some minor corrections of grammer and spelling which they have not seen. I presume that they will approve of this copy.

Sincerely yours,

Bill

cc Schmittou
Storer

FELLOW, AMERICAN INSTITUTE OF FISHERY RESEARCH BIOLOGISTS
FELLOW, INTERNATIONAL ACADEMY OF FISHERY SCIENTISTS

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Review of Project 931-0526
Artificial Propagation of Milkfish
March 2-4, 1977

This is a project conducted by the Oceanic Foundation of Waimanalo, Hawaii under Contract No. AID/TA-C-1189 dated January 13, 1975. The contract was estimated to cost $498,532 during its three-year period ending January 12, 1978. The initial allotment was for $250,000 for the work through January 12, 1977 but this was amended to $263,089. The third year of operations, January 13, 1977 to January 12, 1978, was budgeted at $248,532. This and a small cost overrun have brought the total contract cost to $528,369 for the period January 13, 1975 to January 12, 1978.

The original proposal prepared in 1974 was for a five-year project in the total amount of $870,000. Now the Oceanic Institute proposes a fourth-and-fifth-year of work, budgeted at $463,097 and $448,943 respectively, which will bring the total contract cost to $1,440,409.

This review, the second such outside review, was held at the Institute on March 2-4, 1977. The review team consisted of:

William F. Royce, Fisheries Scientist, Seattle, WA

H. R. Schmittou, Associate Professor, International Center for Aquaculture, Auburn University, Auburn, Alabama.

James A. Storer, Office of Marine Resources, NOAA, Rockville, Maryland.

The principal Oceanic Institute staff participants in the review were:

Richard W. Power, President

Colin J. Nash, Director of Research

Ching-Ming Kuo, Head, Aquaculture Division

Guy N. Rothwell, Jr., Senior Engineer

Albert C. Smith, Marine Pathologist

The first review, which was conducted on May 6 and 7, 1976, found in summary as follows:

"The team agreed that the work being done is in accordance with the terms of the contract, that it is generally on schedule, and that the timetable for the next year remains valid. The project projections for the proposed years four and five will require careful scrutiny at the second (final) review of the existing contract. The project staff, while small in numbers, is obviously extremely competent professionally. There are some questions with respect to certain aspects of the work which are addressed in the report. The program as a whole, however, is sound and fully deserving of continued AID support. The team endorsed Oceanic's request for additional funds ($30-35,000) for pathology work and recommended that the program be funded for its third year at no less than the level indicated in the contract."

The second review team was charged with the primary tasks of evaluating the progress on the contract and assisting with the

technical specifications for an extension of the contract from January 13, 1978.

PURPOSE OF THE RESEARCH

The program goals set by AID for the contractor were to breed the milkfish, Chanos chanos, in captivity and to raise the fry from the egg, undertaking any research and development which might be necessary to attain those goals.

The more specific goals for the first three years have been:

a. To induce spawning of milkfish in captivity economically and over long periods.

b. To increase the survival rate of eggs and larvae.

c. To increase the hardiness of juveniles.

d. To develop handling techniques for juveniles that will assure the lowest possible mortality.

The proposed goals for the extended contract in years four and five include all of the above and also the following:

e. Conduct practical pathological treatment.

f. Commence tracking and tagging operations in the field.

g. Conduct experimentation on breeding in the field.

h. Establish a cryogenic unit for preservation of sperm.

i. Plan production hatcheries.

Project Plan and Management

As noted above (i.e. Purpose of the Research) the review team fully supports the purpose of the research. It also concludes

that the previous activities carried out under the project, and building upon the earlier work with mullet, have been intelligently conceived and carried out, and they provide a good basis for the concluding phase of this contract.

The review team emphasizes the need for the highest priority in this project to be assigned to goal a.--to induce the spawning of the milkfish--because this problem has proven to be especially difficult and because achieving the other goals will either depend on control of the spawning or will be easier because there is much more information available. For example, the technology of handling larvae larger than about 12 mm. length and all of the later stages is well known because these problems have been widely studied using larvae collected in the wild. The practices of the farmers can, no doubt, be improved but this is a task requiring application of the technology--not its development. The new goals of conducting pathological treatment and experimenting with breeding in the field will probably provide important information relative to the control of spawning but the other goals seem to the review team to be of ancillary importance at this time.

The team would urge, that in these remaining months of the project, the staff be vigilant in reviewing and evaluating activities to ensure that they are the best means of achieving the stated objectives. In this regard, it is important that

activities in themselves do not get justified as objectives. This process of re-evaluation is especially critical in these next few months while there is still time available for pursuing alternatives if they are desirable.

The review team requested that the Oceanic Institute provide reasonably specific operating plans for the extension to years four and five. Such a shift from more general plans at the beginning of a large complex project is normal. After some experience is gained and the problems defined, specific objectives should be stated and operations planned accordingly.

Staff

Any research project such as this is only as good as the staff and, as in the previous review, this team is much impressed by the caliber of the scientific staff and its director, Dr. Nash. Individually, they are highly competent, well-trained and well-motivated. It is a tribute to this director that the staff works well together as an interdisciplinary unit.

Futher, it is no doubt true that the ability to keep the staff together in the face of moderate salaries and inadequate fringe benefits (n.b. only last year was a health insurance program initiated for staff members and there is as yet no retirement program though this is now being actively investigated by the President) speaks well for the respect and confidence that this staff have in the Director.

The review team was gratified to see the interest in the project review manifested by the newly appointed president, Mr. Richard Power, and felt that not only his interest but his experience in organizational management would prove to be most helpful to the Institute and this project.

We would point out that the staff working on the project is wholly scientific in training and orientation. There are obvious and natural reasons for this but it does lead to an absence of the "practical fisherman" expertise within the staff. There has been some remedying of this situation within the last year by virtue of the contact with fish-pond operations in Hawaii that came about as a result of the State supported pond survey. Likewise the contacts that will be made as a result of the pilot plant construction and operation for mullet breeding (supported by the State) will have a useful impact on the whole program of this Institute.

In view of the necessary limitation on the number of staff that can be employed, it is hoped that the Institute will make the fullest possible use of expertise that exists within the Islands both in the academic field and especially in the non-academic world. In this connection it might be useful to tap the knowledge of the NMFS staff in Hawaii who have, among other things, a wide range of experience in the theory and application of tagging and tracking procedures and also are the major

source of knowledge and data on the circulation of the sea near the Hawaiian Islands.

Relationships with Other Organizations

The geographic situation of the Institute raises some very real problems in trying to establish and strengthen meaningful contacts with institutions and organizations outside the Islands. (Though as we have noted above, we feel that even in Hawaii in the case of the National Marine Fisheries Service a genuine state of friendly relations has not been carried to its fullest use). Clearly some of these contacts have been sought out by the staff as in the case of Dr. Smith seeking collaboration of the Smithsonian Institution for some of his pathology findings.

The team senses that the contact with the other institutions engaged in fisheries research program funded by AID (i.e. University of Rhode Island and Auburn University) are slight and casual in nature. This is to be regretted, though to some extent understandable.

Institutional contacts are important not only in the immediate pursuit of the research objectives but also in making sure that research work is oriented toward avenues for its practical application. In this regard it is assumed that the sort of "family relationships" that exist between the Institute and ICLARM (International Center for Living Aquatic Resource Management) will ensure close cooperation between the two,

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and that the Institute will be fully "plugged into" the full range of institutional relationships that are expected to be a part of the evolving ICLARM in Southeast Asia. However, other organizations and programs in the area of the project's eventual applications, warrant continuing contact such as SEAFDES (Southeast Asian Fishery Development Commission), the FAO regional commissions in the region, i.e.--the Indian Ocean Fishery Commission, and the Indo-Pacific Fisheries Council, the UNDP/FAO regional projects that are affiliated with these bodies, as well as several within country organizations in Taiwan, Indonesia, and Philippines. Furthermore, it should be emphasized that as the range of activities of these organizations increases, particularly SEAFDEC and ICLARM, the cooperation among them will become essential to avoid duplication and to ensure complementarity in programs.

Large Holding and Culturing Facilities

A relatively serious if not limiting constraint to the milkfish propagation project is OI's lack of adequate fish holding and rearing facilities. Good use is being made of six rubber-lined earthen pools and a number of fiberglass tanks including several fiberglass-lined beer vats. These facilities are excellent for certain uses, but are too small for holding either large fish or large numbers of fish. The six rubber-lined pools are the largest of the facilities but they are

each only approximately 75 square yards in areas--too few and too small to adequately meet the needs of this and OI's other projects. The major problems of the small number and area of facilities are:

(1) The physical limitations to the number and size of fish that can be held,

(2) The restricted flexibility in what may be done with fish in those facilities,

(3) Crowding of fish is necessary so natural foods, perhaps essential to proper gamete production, are absent or in low abundance.

(4) The small environments are subject to rapid and extreme charges adverse to health and life of the fish.

Larger facilities would be more easily managed as far as providing and maintaining an ideal living environment as well as providing physical space for greater numbers of fish than now possible.

OI presently plans to use ponds of cooperative fish farmers as holding facilities. At best this is a poor alternative to having their own facilities. Even with ideal cooperative arrangements, OI would not have complete control over the facilities and water environments and would not have preferred use and management flexibility--an undesirable situation considering the high value of brood fish.

The Races of Milkfish

Milkfish occur over large areas of the tropical Pacific and Indian Oceans. They live most of their lives close to the shore and since their larvae are found close to shore when only a few weeks old they must have many spawning areas. Further it must be assumed that there can be little, if any, genetic interchange between widely separated populations, i.e. there are probably many races that are more or less different genetically.

It will be difficult to identify and describe the races because the spawning area of each must be known. The Institute has bound some promising morphological and chemical techniques of identifying races and is working on some tagging techniques that may be useful in tracking fish to their spawning grounds. Such techniques will be useful scientific contributions but are not likely to contribute much to the overall knowledge of the racial structure of the milkfish.

Priorities

The scientists from the Institute and the review team are completely agreed that control of the spawning process in the milkfish is the first priority and this must succeed before some other parts of the project are undertaken. Fortunately, it will be possible for the staff to work with spawning milkfish in the Philippines in April and then in Hawaii in June and July. The findings of the earlier efforts can be applied to the second.

If the efforts to control this spawning are unsuccessful in 1977 the staff will attempt to determine the causes of the failure and devise corrective action. They will then have other opportunities early in the fourth year of this project to apply improved techniques.

The review team feels that the identifications of race and the efforts to track adults are probably not essential to the project and, if needed, the funds could better be used in the items concerned with control of spawning.

Further the items (Nos. 10 and 11) concerned with application of the research findings should not be commenced until successful and reproducible methods of controlling spawning have been developed.

Future Work

In order to achieve fully the ultimate goal of using the technology developed by this project it is clear that much will remain to be done after the next two years of work by the Institute.

First, the technology suitable for culturing the Hawaiian milkfish may require modification when applied to other races of milkfish. Hawaii is at the edge of the range of milkfish and the ocean conditions there are not typical of the condition found where milkfish are abundant. The Hawaiian milkfish grows and matures at different rates than

the milkfish of the Philippines or Indonesia and whether these differences are important to consider in their cultural technology is not yet known.

Second, the application of the technology to the existing large and complex milkfish culture system is certain to embody most of the problems of transferring technology to less developed areas. If, as we expect, the spawning process and early larval development of the milkfish are brought under control then it will be essential to plan adequately the technology transfer. We suggest that the procedures for such planning be examined and a suitable conference be scheduled for late in calendar year 1978.

Such needs raise serious questions about the role and nature of Oceanic Institute, its range of interests and staff as well as its location. Some of these questions can perhaps be answered as the cooperative arrangements with ICLARM are realized in the next years. Perhaps also, a part of the answer will be provided by the evolving overall thrust of the Institute and the extent, for instance, that it develops a strong commitment for programs of interest to Hawaii, or alternatively, the extent to which it maintains a predominant interest in aquaculture. In any event, the Institute and AID will have to be considering these matters as the final phase of this immediate project is spinning out.

Submitted March 18, 1977

SUMMARY OF RAC RECOMMENDATIONS TO A.I.D.

PROPOSALS REVIEWED AT THE OCTOBER 17-18, 1974 MEETING

1. Program for Applied Research on Fertility Regulation (PARFR) (Extension)- Northwestern University. Duration of extension 3 years; estimated additional cost, $2,052,549. Connell, Carter, Linder, Merrill. 1/

Recommendation: That the proposed extension be approved with the following amendments: (1) removal of the Family Planning Demonstration Center, (2) more active recruitment among foreign students currently in this country as potential grantees upon their return to their home countries, and (3) A.I.D. staff make every effort to lower the percentage of funding going into administration.

2. Nitrogen Fixation by Legumes as a Major Factor for Food Production in Less Developed Countries (New)-University of Hawaii. Duration: 3 years; total estimated cost $900,000. M. Peterson, Heady, Milner, Whitney.

Recommendation: That the project be approved with recommendation that the AID staff negotiate further relative to the following matters: (1) greater input of time of the principal staff; (2) greater participation of scientists from developing countries including financing, if necessary; (3) narrowing initial objectives to those which can be achieved during the initial life (3 years) of the project, namely, to food legumes and oil crops; (4) greater attention to the interaction of this project to cropping systems in developing countries; (5) budget reduction for the initial 3-year program; and (6) that the RAC Subcommittee be advised of the plan of action with reference to the sequence of research activities and an explanation of how this will be expanded to the field activities.

3. Adapting Simulation Models to Agricultural Sector Analysis (Extension)-Michigan State University. Duration of extension: 18 months; estimated additional cost, $697,753. Heady, Ruttan, Hagen, Wittnebert.

Recommendation: That the proposed extension be approved as a terminal contract under the conditions that: (1) by March 1, 1975 the MSU team provide AID with documentation of important policy and developmental alternatives for Korea, and agreed upon with Korean officials, to be simulated in the remainder of the project; (2) the model emphasize major economic relationships and subsectors which can be quantified and analyzed for

1/ RAC Review Subcommittee, Chairman underscored

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major policy decisions to be made over the next three years; (3) the emphasis be shifted to economic modelling as the end and systems science as the means; (4) more full-time MSU economists be added to the project and represent the major portion of the staff; and (5) that sufficient evidence (including names of persons and their organizations and academic qualifications, along with a calendar of expected attainment) be provided indicating that Koreans will be sufficiently able to operate and further adopt the model by July 1, 1976.

4. Artificial Propagation of Milkfish and Fish Enclosure Development (New)-Oceanic Foundation, Hawaii. Duration: 3 years; total estimated cost, $450,000. Wittnebert, Adams, Ludington, Schweigert.

Recommendation: That project be approved with the following provisos: (1) the enclosures work be deleted; (2) the project design should be seriously reviewed by the AID staff; (3) mullett breading be carried to its natural conclusion; and (4) the project be closely monitored including periodic site visits and comprehensive reviews at the 18 month and the 32 month points of project life.

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RAC Meeting
Oct. 17-18, 1974

Project Review

Agriculture

Artificial Propagation of Milkfish and Fish Enclosure

Development -- Oceanic Foundation, Hawaii

Mr. Frederick Wittnebert, Chairman of the Subcommittee composed of Dr. Adams, Mr. Ludington, and Dr. Schweigert, made the following report. It should be noted that a revised Project Statement has been submitted to the RAC under a changed title as indicated above. Mr. Wittnebert reviewed some background in the field of acquaculture, through the recommendations of the Consultative Group in 1973, to the Oceanic Foundation proposal submitted to AID in 1974.

The Subcommittee review indicated that: (1) A majority agreed that there was great potential for gain in the broad area of aquaculture R&D; (2) this proposal was deemed to be deficient in various respects: (a) the scope and work plan, (b) the supporting information provided, and (c) the proposed contractor. The project criticisms were communicated to the AID Office of Agriculture with a meeting held October 6, 1974 to review these criticisms with the proposed project leader, Dr. Colin Nash, of the Oceanic Foundation. The meeting was held in the office of Dr. Adams in Wilmington, Delaware and included Dr. Leon Hesser, Dr. Colin Nash and Mr. Wittnebert. Dr. Schweigert and Mr. Ludington were invited but were unable to attend. The project statement was withdrawn for the purpose of making improvements in the presentation for this October RAC meeting. The revised proposal is the result of this effort. The indicated modifications will limit the main thrust of the project to the development of a capability for producing, in captivity, milkfish specifically and will include a provision for the establishment in the field of a "seed-stock" producing and distributing pilot operation -- all with the view to satisfying initially the Philippine's milkfish farming needs for such a capability. Additionally, the revised proposal may include provision for: (1) wrap-up work on the development of a mullet breeding capability, and (2) open-water enclosure development work.

Mr. Wittnebert reported on his visit to the Auburn University aquaculture activities, the Central Luzon State University, and his briefing by the Philippine Government people concerning their food needs. He concluded that (1) the Philippines already have a substantial subsistance-type milkfish pond farming operation, (2) the government is keenly interested in expanding that operation, and (3) this objective is being severely hindered by limitations in the supply of the necessary milkfish fingerlings, which cannot as yet be raised in captivity and the natural supply is being

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distributed at prohibitively high prices. Hence the need for the development of the subject proposal.

Subcommittee review of the revised proposal shows improvement, but certain questions still remain: (1) Where does the mullet breeding work now stand? What must yet be done to get it to a fish-farm supply; pilot-stage? Why should this not be done before milkfish breeding work is undertaken? (2) What exactly will be the nature of the linkages made with Auburn and Rhode Island; and the Rockefeller Foundation? (3) Who else has done work on breeding these kinds of brackish water fish? Why should this type of work not be done by them? Additionally, a majority of the Subcommittee favored deletion of the enclosure development work on the basis of its being irrelevant and too in depth.

Dr. Adams stated that he wished to express a philosophy based on 10 years of work in aquaculture and 5 years of operating a mullet hatchery. There is undoubtedly a potential for the development of culture methods for marine and brackish water fish, but the magnitude, the species, and the geographic location are big questions. However, he agreed that some public effort could well be put into this area. Areas of confusion include: (1) Oversell: they will never contribute more than 20% of the world's protein needs; (2) Time and dollar trade-offs: this is possible only within narrow limits; natural time may indicate that less dollar input over a longer time may be best; (3) Conflict between the research and development philosophies: research designs can focus on specific answers, but production requires a sequence of steps all of which must be contributory: (4) Economics: modeling based on assumed parameters may be of very limited value; this work should not be oriented towards international commerce, but rather subsistance farming; and (5) Intensive versus extensive controls: modify the natural system as little as possible.

Dr. Adams agreed with the subcommittee chairman's recommendations that the cage-enclosure component was extraneous and open-ended, a bio-engineering problem which will never be completed to meet the diversity of conditions, and therefore, should be deleted. The mullet project should not be dropped, but should be pushed through to practical operation.

Mr. Luddington commented on his twenty years of observing enthusiasm for food programs which subsequently failed for good and practical

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reasons. He recommended that this project be further limited to concentrate on a single variety of fish with follow-through to demonstrable feasibility for commercial utilization. Steps would include: (1) demonstrated ability to get fish eggs on demand, (2) hatching, (3) effective raising of fingerlings, and (4) logistics from bench top to pilot plant to commercial scale production capability. The mechanics of moving the volumes of water required and the supply of food represent severe practical problems.

Dr. Schweigert commented on fish breeding activities at UCLA where he has been responsible for coordinating this work for the past four years. The rhetoric on the potential impact has been overdone. There is need for a wide diversity of relatively rare technical skills to be focussed on the marine problems. The enclosure system may be a sequential aspect to follow the demonstration of capability for producing the juvenile fish, not a major research effort, and should be put on hold for the initial project. As a function of basic assumptions he believes that the project is not too well designed scientifically. He recommends holding the project to 3 years with an intensive review and a site visit before further work is authorized.

Dr. Heady pointed out that there are inconsistencies in the budget presentation. Dr. Milner asked how many possible contractor groups are there?

Dr. Hesser indicated that TA/AGR is seeking a technical specialist in aquaculture for their staff, and apologized for the late submission of the revised Project Statement. The reasons for focussing on milkfish are (1) that the mullet work of the Oceanic Foundation will probably reach their objectives by June under other financing, (2) there is a high degree of interchangeability between the milkfish and mullet, and (3) the milkfish is importantly related in the Philippines to the work of Auburn for the Mission. The Israelis have done work on brackish water fish breeding, and the Oceanic Foundation has been in close coordination with this work.

Dr. Long acknowledged concern for the natural parameters in this area. He agreed to deletion of the enclosure work in view of this project being reviewed at the end of 3 years in terms of the need for such work. The milk-fish-mullet issue makes this project meaningful only in context of other work going on in parallel. This research must be related to operationalizing factors. In the

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Philippines the work on milkfish is most likely to be a successful approach. There will be concentration on the practical aspects. There is concern for strengthening the emphasis on the economics of aquaculture in the complex of contractual and grant work in this area. All evidence indicates that the production of fingerlings in an economic manner is a key constraint. This happens to be the activity in which the Oceanic Foundation is specializing. They will be working in close cooperation with the University of Hawaii and the Fisheries Center.

Motion: The RAC recommends that the project be approved with the following provisos: (1) the enclosures work be deleted; (2) the project design should be seriously reviewed by the AID staff; (3) mullet breeding be carried to its natural conclusion; and (4) the project be closely monitored with comprehensive reviews based on site visits at the 18th month and the 32nd month points of project work.

Moved by Wittnebert, Seconded by Adams

Vote: Unanimous approval.

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PROJECT STATEMENT

A. PROJECT SUMMARY

STATISTICAL:

Project Title:	Efficient Production of Fish Seed Stock and Design of Open Water Fish Enclosures
New or Extension:	New
Contractor:	Oceanic Foundation, Waimanalo, Hawaii
Amount: *	Total: for 5 years $870,000 for 3 years $450,000 FY 1975 funds $250,000
Duration:	Five Years
Project Leader:	Dr. Colin E. Nash Vice President and Director of Research
Principal Investigator:	Dr. Ching-Ming Kuo Director, Aquaculture Division
Project Managers:	Leon Hesser, TA/AGR Erven J. Long, AA/TA

NARRATIVE:

This project is directed at removing two primary constraints to development of efficient aquacultural industries; the lack of: 1) efficient systems of production of juvenile fish to supply the necessary seedstock for fish farming, and 2) low cost and effective cages or pens for production of fish in enclosures in open water such as streams, lakes, estuaries and sea shelves. Because they are quantitatively more important in the LDCs, and the Oceanic Foundation's expertise is more directly experienced with them, the sea-breeding, brackish water species will be given the most immediate attention in the project. (Specifically, central attention will be given to Milkfish, the principal species of the Philippine aquacultural industry.) Present aquaculture production requires capture of literally billions of tiny juveniles each year: a costly, unpredictable and ecologically destructive practice which the project seeks to make unnecessary, Fortunately, the sea breeding fish are the more difficult biological models, so adaptation of findings of this study to fresh water species, by Oceanic Foundation or other aquaculturists, should be rather easy.

Fish production in mesh-like enclosures in open waters -- often using waste materials as a principal feed supply -- has been proved highly successful experimentally, but constrained seriously by lack of inexpensive, durable, enclosures conducive to prosperity of the fish. A relatively minor portion of this project will be directed at removing this constraint.

The staff and research approach are interdisciplinary, and the project will be very closely integrated with work at Auburn and Rhode Island Universities, and with major AID sponsored LDC aquacultural programs.

*See attached for discussion of the budget.

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The project will be thoroughly reviewed at the end of 18 months and 32 months, with no commitments for support beyond 24 months and 36 months unless confirmatory action is taken by AID at the respective reviews.

B. EXPANDED NARRATIVE STATEMENT

BACKGROUND INFORMATION

Fisheries are one of the few food-producing industries whose growth rate has kept ahead of the rate of population increase since World War II. In order to maintain present per capita consumption, however, fish production will have to reach 107 million tons annually by 1985. If consumption increases are to be sustained without irreparably depleting stocks and endangering prized species, much greater reliance must be placed upon controlled fish production (aquaculture) as an ever-increasing complement to wild fish capture.

Fish supply about 10 percent of the animal protein and three percent of the total protein in human diets worldwide. However, while in "high-calorie countries" it constitutes 6.7 percent of animal protein supplies, in "low-calorie countries" (i.e., the LDCs) it supplies 21 percent. In parts of Southeast Asia, fish constitute a major source of animal protein in the diets of many people -- 50 percent or more in most countries of the area -- whereas in other parts of the world, such as the Balkans, Central America, the Near East, and landlocked countries like Bolivia, Paraguay, Nepal, Afghanistan and most of the Sahelian countries, fish often represent as little as one percent of all animal protein consumed. In many countries, aquaculture has until recently been all but unknown, but in none are there insuperable, long-term barriers to its development.

Total world fish production* in 1971 was 69.7 million metric tons (m.m.t) an increase of over 350 percent since 1948. In 1972 there was a slight decline to 65.6 mmt. Inland waters supplied 9.5 mmt, or nearly 14 percent of the world harvest. About 63.7 percent of total production is used directly for human food, and 36.3 percent is converted into fishmeal, oil or for uses such as fish flour, margarine, cooking fats, industrial uses and livestock and poultry feed.

The world's six largest fish producers in 1972 were*; 1) Japan 10.248 mmt., 2) Russia 7.756 mmt., 3) China (mainland) 7.574 mmt., 4) Peru 4.768 mmt., 5) Norway 3.163 mmt., and 6) USA 2.650 mmt. Next in order of importance are seven developing countries; 1) Korea (north and south) 2.139 mmt., 2) Thailand 1.679 mmt., 3) India 1.637 mmt., 4) Chile 1.487 mmt.,

*The statistical information in this section was obtained largely from the 1972 Yearbook of Fisheries Statistics, Volume 34, FAO-UN, and from "A Proposal for the Creation of an International Center for Living Aquatic Resource Management" prepared by John A. Pino of the Rockefeller Foundation in May, 1974.

5) Indonesia 1.268 mmt., 6) Philippines 1.149 mmt., and 7) Vietnam (north and south) 1.078 mmt.

Fish production is the cheapest and nutritionally one of the highest quality sources of animal protein. The protein content of fish is comparable to that of beef, pork, and lamb, and it is an excellent source of calcium. But most importantly, fish production has an unmatchable feed-conversion ratio. In steers, 1,000 grams of feed produce a weight gain of 163 grams; the rates of gain with chicken flesh are substantially better. But with tilapia, catfish and probably many unexplored types of fish, the weight gain approaches 1,000 grams -- i.e., a 1:1 ratio of flesh to feed.

Long-range demand outlook for fish is difficult to predict. Present consumption patterns are highly country and culture specific, with an important factor being historic availability of supplies. Experience is too limited for conclusions on the degree of acceptability of fish in previously non-fish eating societies, but does suggest affirmative responses. The demand outlook is encouraging. Income elasticities of demand for livestock products in LDCs are high. With increases in the price of conventional livestock products, high quality protein sources such as fish becomes more attractive -- particularly among low-income consumers. Furthermore, per capita fish supplies from conventional capture sources may be expected to decrease and their relative production costs to increase.

SIGNIFICANCE TO AGENCY GOALS

The high priority given by the Agency to improved nutrition, particularly of low income groups, needs no reiteration. Development of highly efficient aquacultural systems very directly and importantly serves that objective. Properly designed, it has important additional values of key importance to the Agency. First, it is extremely land intensive; production as high as 24,000 lbs. of fish per acre has been achieved. (And this project, though supportive of such pond culture, focuses on production on land space essentially completely unused for food production -- the streams, estuaries, and sea shelves.) Also, aquaculture is normally highly labor intensive. It can be -- though is not automatically -- relatively capital unintensive. It will be the goal of this project to further this latter objective insofar as the research has any differential implications in this respect. The Agency has recently focused research and program attention on the economic aspects of aquaculture. Research is currently underway on the economic feasibility of different fish species in various LDCs. Central to these investigations is concern for cost and return statistics, capital intensity, consumer demand for the product and institutional necessities for successful aquaculture in the LDCs.

Finally, at the opposite extreme from most forms of livestock production, fish farming systems can be highly supportive of ecological values, via three relationships.

1. Increasingly, fish production systems are being built on waste materials as primary feed sources, ranging from the normal organic residues in contaminated streams to animal (including fish) excrements, and other organic byproducts. Conversely, such wastes from other animals are a principal source of environmental contamination.

2. Pond fish production is a concomitant of good surface water management designed for erosion control and other conservation purposes.

3. By increasing animal protein production on a highly land intensive basis, aquaculture can remove pressure of over-grazing by land animals, a most direct source of ecological destruction in most LDCs.

The major component of this project is to develop effective, controlled means of producing the young fish upon which mature fish production enterprises must be based. The lack of an adequate, predictable supply of juvenile fish is probably the most serious technical barrier to rapid expansion of fish production. Present fish farming practice is largely based on collection of wild juveniles from natural sources, a costly, unpredictable and ultimately destructive approach. It is estimated that the annual production of 2,000 metric tons of mature grey mullet in Taiwan involves an annual collection of 10,000,000 juveniles from coastal waters. Japan has set an annual catch limit of 31 million juvenile yellowfish; a similar limit on young eel catch has caused Japanese eel farmers to scour the world for seedstock. Collection of Milkfish juveniles by such countries as the Philippines, Indonesia and Taiwan is enormous, estimated at 160 million per year for Taiwan alone. Crude calculation suggests that the modest goal of doubling farm fish production, to some 15 million tons per year, might require capture of some 100 billion juveniles per year, under the optimistic assumption of a one-third survival rate to maturity. Natural populations unquestionably cannot sustain juvenile catches of this magnitude.

DESCRIPTION OF THE PROJECT

A. Juvenile Fish Production

Although an interrelated set of relationships is involved, the technical constraints to managed juvenile fish production fall into two categories: those which cause the parent fish to reproduce only in the sea, and those which cause excessive mortality of very young fish larvae (often as high as 99.8 percent). The first category of problems must be solved if the brood fish are to reproduce under man-controlled conditions. This is necessary to solution of the second category of problems -- or indeed to any kind of production of seedstock fish in captivity.

Research, largely by the principals of this project, primarily with mullet species, has gone a long way toward establishing feasibility of solving the first type problem. They have been able to induce spawning over much longer than normal periods by manipulating such external environmental parameters as water quality, diet, hygiene, temperature, salinity and light. Salinity alone appears to be the principal factor causing fish to go to sea for breeding purposes. Regularly induced spawning has been achieved by use of salmon hormones. The investigators have found considerable promise from use of human hormones, and the very much cheaper hormones from several other mammals. However, a number of environmental variables appear strongly to influence physiological changes in the pituitary gland and to stimulate gonads to time controllable maturity. This study would clarify those variables in quantitative relationship to their effects on reproduction. Once these relationships can be sufficiently understood and controlled, continuous fish larvae production systems can be established.

Similarly, the principals in the project and others have made considerable strides toward understanding the biological mechanisms, and their relationships to environmental factors, which result in the extremely high mortality ratios of fertilized eggs and fish larvae. Relationships to larvae survival of a large number of variables -- especially temperature, salinity, pH, oxygen, light and food supply -- have been observed and catalogued. The principals in the project have observed a key variable to be the osmoregulatory system of the larvae, by which body fluid balances are maintained. In fact, it would appear that several of the other noted variables are associated with survival not so much directly as via their effect on body fluid supplies. Clearly quantity and type of food intake and salinity of the environmental water have direct bearing on body fluids during the first critical days when the larvae are unscaled and most mortality is effected. Simply stated, it is their hypothesis that it is primarily through finding means of supplying "drinking water" of the right types and quantities, through the right means and at the critical times that the excessive mortality can be reduced.

An important component of effort will be fish breeding, to develop brood fish of propensity toward higher larvae survival rates and other good breeding qualities. Health and hygiene factors will, of course, also require rigorous control and study.

If the two sets of problems outlined above can be solved, controlled production of juvenile seedstock fish can be made a relatively modest cost component of the entire aquacultural enterprise. The numbers of larvae produced per fish are so enormous that the numbers of brood fish required for continuous production would be relatively small. Also, rearing of larvae to the size now normally captured as fish stock would require relatively modest scale facilities in relationship to the ultimate mature fish production enterprise.

The study will also concern itself with hardiness and other factors related to the mortality and performance of the juveniles through delivery to fish farmers and subsequent production activities.

The work will necessarily be interdisciplinary, requiring contributions of pathologists, geneticists, engineers and other specialists, provided by the Oceanic Foundation on a part-time basis to the project.

B. Enclosures for Open Water Fish Production

Although substantial aquacultural development in earthen closed water enclosures such as man-made or natural ponds can be anticipated, cultivation of fish in cages and pens in open water, such as rivers, estuaries and coastal shelves, also has great promise. Each satisfies a different need, is based upon different resource availabilities and will probably feature different types of fish. Although impossible to predict, certainly the probabilities favor growth of open water cultivation as being quantitatively the more important.

Many areas of potential for fish production exist as open bodies of water, in estuaries, bays, streams, large lakes and coastal shelves, where permanent construction is uneconomic and often impossible. Conversion to concentrated fish production of these wetlands as entire bodies introduces great technical and economic problems and in some cases would lead to ecological imbalance and adversely influence the offshore fisheries which depend on these areas for basic links in the food chain. Use of simple cages and pens as fish enclosures in these water areas can, however, be highly productive in terms of yield of fish. In some of these areas, organic refuse and live growth polluting the waters serve as a major feed source for suited fish species. Moving water, especially,serves to bring such food and oxygen to the fish and to remove the wastes inimical to their growth -- thus reducing ecological and environmental problems.

Excellent results have been obtained in experimental production of various aquacultural species in a variety of types of cages in open water. But a constant constraint to commercial adoption of the practice has been lack of such artificial enclosures having all the characteristics necessary to economic use. These include: low cost, durability, freedom from fouling with excrement or undesirable growth, adaptability to varying conditions, etc. Electronic and chemical barriers have also been explored. Dr. Colin Nash and staff engineers have done landmark work on enclosure design, working very closely with researchers in this field from Europe and Japan. A relatively minor proportion of the research project would be devoted to expanding this work, directing it to those species and situations with which AID aquacultural efforts become involved.

The design of pens and enclosures will concentrate on the three main factors of concern. These are:

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Husbandry factors, (such as nutritional needs, predator control, behavior and harvesting methods)

Environmental factors (such as bio-fouling rates, resistance to weather, ecological impacts)

Economic factors (such as cost to construct and deploy, availability of materials, cost to repair and maintain, life expectancy)

Any engineering solution must satisfy all the requirements implied in these factors, recognizing that all three are highly interactive. For example, the economic factor of materials/cost must be balanced against the environmental factor of bio-fouling. The cheapest material is of little value if it is attractive to fouling organisms or if it releases toxic chemicals or metallic ions into the environment, nor the best material relevant if unavailable or priced out of the reach of the ordinary fish farmer.

Particular attention will be paid to the testing of low cost materials readily available in tropical and sub-tropical regions, e.g., local timber, galvanized netting, fish netting. A key focus will also be on simple construction techniques manageable by typical, small scale LDC producers.

GENERAL OUTLINE OF PROJECT ACTIVITIES

Year 1

- Select suitable broodstock.
- Commence collection of physiological data on reproductive cycles, identify stages of eggs and sperm.
- Observe first reactions to hormones, particularly salmon pituitary gonadotropin as indicator, and test against it hormones from humans and pregnant mares, serum, Synahorin, and certain steroids.
- Study osmo-regulatory mechanisms, relating to fluid balance and survival of larvae.
- Develop larval rearing techniques following successful incubation of any fertilized eggs obtained.
- Identify individual brood fish reacting well to injection and with high quality eggs or sperm.

- Further the biochemical studies on egg and sperm quality.

- Begin accumulation of data on disease, identification of bacteria which contaminate eggs and larvae in aquaria, development of test controls.

- Design prototype enclosures following study of materials characteristics.

- Strengthen existing links with Auburn University and University of Rhode Island. Visit U.S. AID aquaculture project in Philippines, Tungkang Fisheries Institute in Taiwan and survey Japan's recent progress in cage and pen construction.

(Within three months develop detailed, time-phased work plan for three years.)

Year 2

- Extend the work begun in the first year; extend studies of disease.

- Upgrade levels of activity in larval rearing technology.

- Formulate mass propagation techniques using controlled data following studies in first year. i.e., larval density, food density, etc.

- Construct prototype pens and enclosures and test against engineering criteria.

- Exchange personnel with Auburn University, and apply results of the first year where applicable to the US AID aquaculture project in the Philippines.

(By the end of 16th month, submit report of work to date as basis for 18-month Project Review.)

Year 3

- Modify program as determined by 18-month Review. Tentative plans as listed below.

- Describe operational procedures for induced breeding, out of season spawning, egg incubation and larval rearing of specific target species.

- Commence full scale in situ testing of enclosures and pens.

- Design egg or juvenile receiving field units.

- Formulate methodology for identification and perhaps control of most limiting diseases.

- Intensify genetic studies using fish of known history in terms of gametocyte quality and breed hybridize.

(By end of 30th month submit report for review by end 32nd month for decision on whether project should be continued and, if so, nature of work program.)

Years 4 & 5

- Continuation of research projects determined by review.

- Intensification of all projects in the field, specifically enclosure construction and demonstration of construction, and of juvenile reception units.

CAPABILITIES OF THE CONTRACTOR

Oceanic Foundation's physical facilities are modest but adequate, consisting of a cluster of wooden framed buildings of various sizes adjacent to the sea in Waimanalo, Hawaii. Its 3600 square feet principal laboratory houses aquaria, larval, chemistry, microbiology, histology, microscopy and controlled water-temperature laboratories. Other buildings contain an electronics lab, a photo-period study lab, office space, library and training facilities.

Dr. H. Burr Steinbach, until recently Dean of the Graduate School of Woods Hole Oceanographic Institution, serves as President of Oceanic Foundation. Dr. Colin E. Nash, Ph.D., Director of Research and Dr. Ching-Ming Kuo, Ph.D., Head of the Aquaculture Division, under whom the research project will be carried out, have extensive research experience on the problems addressed by this project. They will be supported by other researchers indicated in the budget. (See attachments for detail.)

LINKAGES AND UTILIZATION

Increased Agency emphasis on aquacultural development will involve continuing, effective working relationships with the International Aquaculture Center at Auburn University (the world's premier center of pond fish production) the University of Rhode Island (featuring coastal zone aquaculture and fish production economics) and the contribution of this project,

should it be approved, to solving the indicated production problems. These three institutions have been in close contact, particularly in preparation of this proposal to focus on key constraints. Rockefeller Foundation is in process of appointing aquacultural expertise to its staff to relate to these three efforts, particularly this project. It has not determined specifically its course of action as it wishes to associate its efforts with those of AID, in the combination of integrated and complementary activities which mutual judgment indicates most favorable to worldwide aquacultural development. Close coordinating mechanisms of the involved U.S. institutions, including Rockefeller Foundation, will be developed upon conclusion of this proposed contract.

The LDCs' interest in aquaculture is growing rapidly. Badly needed as an interacting guide to research, especially to identify constraints beyond technical production problems, is one or more aggressive country efforts at developing a major fish production industry. Such an effort is underway in the Philippines under the general technical assistance tutelage of Auburn University. This project will direct its first attention at the species (Milkfish) most important in that country. If economic or marketing problems become central, we would hope to make Rhode Island's capabilities available. Brazil is developing, also with assistance from Auburn, a research and development center which Brazilians hope can be a center of support for aquaculture in abutting countries if not, indeed, for the continent. Colombia, Vietnam, Laos and Panama also have expressed desire for assistance. India had begun to develop major aquacultural research and development activities, with assistance from Auburn and Rhode Island, when our technical assistance relationships were discontinued. We trust this may be reinitiated.

Rockefeller Foundation has expressed interest in supporting a center in Fiji to concentrate on problems characteristic of that area.

As these and other programs in the less developed countries proceed, and their support needs from the indicated U.S. institutions take shape, special coordinating arrangements should be developed. It is hoped that this may draw participation by other donor countries, especially those with special expertise such as Israel, Taiwan, Belgium, Japan and China. The Technical Advisory Committee to the Consultative Group has undertaken special study of aquacultural opportunities and may in time recommend a structured network of research and development. At such time, the programs of three mentioned U.S. aquacultural institutions can be major research and expertise building blocks of such a network.

As mentioned, these three institutions will work together intimately and with AID and Rockefeller Foundation to identify and remove key constraints, and to evolve an expanding base of expertise. Each has extensive contact with aquaculturists in both developed and developing countries -- collectively, a very substantial latticework of intercommunication and contact.

The principal utilization requirement is the country-by-country effort of selecting key opportunities for aquacultural development and tying them appropriately for technical support to these institutional expertise centers. TAB intends to invest a major effort in support of this effort, particularly toward effecting the necessary integration of effort and experience among the research centers and between them as a group and the aquacultural programs of individual LDCs.

BUDGET*
(Year-Date Omitted)

Expense Item	% of Time	Year 1	Year 2	Year 3	Year 4	Year
Personnel						
Colin E. Nash, Ph. D.	0.2*+	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,00
Ching-Ming Kuo, Ph. D.	0.8*	20,000	20,000	20,000	20,000	20,00
Guy N. Rothwell	0.4 +	8,000	8,000	8,000	8,000	8,00
Pathologist	0.2*	5,000	5,000	5,000	5,000	5,00
Research Assistant	1.0*	11,000	11,000	11,000	11,000	11,00
Junior Engineer	0.4 +	5,000	5,000	5,000	5,000	5,00
Technician	1.0*	9,000	9,000	9,000	9,000	9,00
Research Assistant	1.0*	11,000	11,000	11,000	11,000	11,00
Junior Geneticist	1.0*	- - -	11,000	11,000	11,000	11,00
Total		74,000	85,000	85,000	85,000	85,00
Fringe Benefits (10%)		7,400	8,500	8,500	8,500	8,50
Total Personnel		81,400	93,500	93,500	93,500	93,50
Supplies		10,000	10,000	10,000	10,000	10,00
Overhead (62%)		56,700	64,200	64,200	64,200	64,20
Equipment		20,000	20,000	20,000	20,000	20,000
Travel		5,000	7,000	10,000	10,000	10,000
Total		$173,100	$194,700	$197,700	$197,700	$197,700
Cage Construction Junior Engineer Supplies Outside Contracts					60,000	60,000

* Budget is as submitted by Oceanic Foundation in their proposal, it will be re-oriented to FY 75 funding of $250,000, for three years at $450,000 and for five years not to exceed $870,000

* Aquacultural Research

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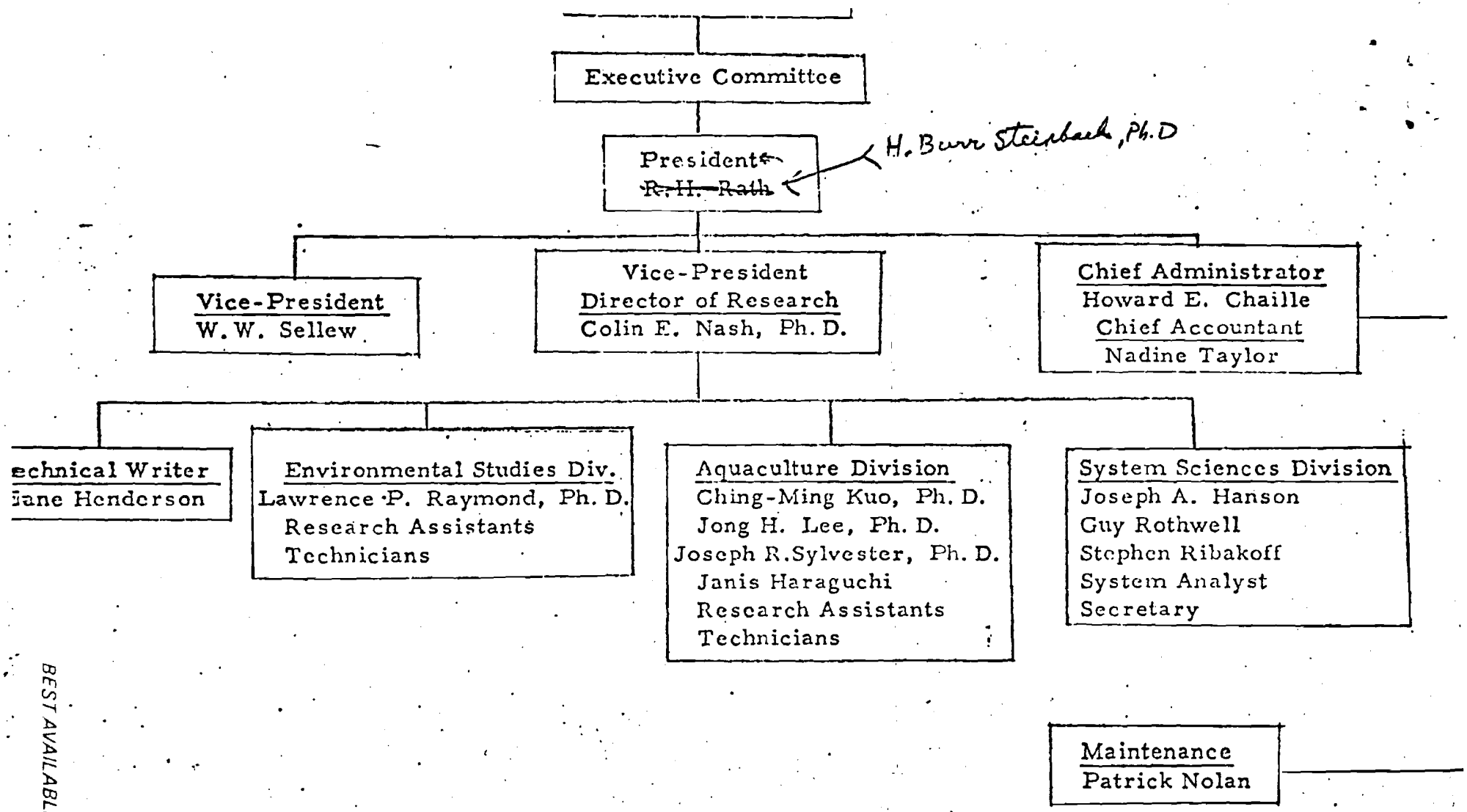

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- See Attached List.
* - H. Burr Steinbach, Ph. D., will assume Presidency as of January 1, 1974.

COLIN E. NASH, Ph.D.
Director
Oceanic Institute

Academic

Leeds University, Yorkshire, B.Sc., 1959.
Leeds University, Yorkshire, Ph.D., 1962.

Experience

Director, Oceanic Institute, May 1972 - present.
Co-Director, Aquaculture Division, Oceanic Institute, 1970-1972.
Assistant Principal Officer, Fish Farming, for White Fish Authority, 1970.
Research Officer and Project Head for aquaculture in discharges from electricity generating plants, for White Fish Authority, 1966-1970.
Research Officer and Deputy, Plaice propagation hatchery development, White Fish Authority, 1963-1966.
Research Officer, International Wool Secretariat, London, 1962-1963.

Affiliations

American Fisheries Society
Challenger Society
Smithsonian Institution
World Mariculture Society

National and State Services

Consultant, U.S. AID
Delegate, South Pacific Islands Fisheries Development Association
Delegate, South Pacific Commission
National Oceanographic and Atmospheric Agency (NOAA) Aquaculture Survey Steering Commmittee Member
Governor's Advisory Panel for Marine Resource Development Aquaculture Sub-Committee Member

Editorial Board

Aquaculture, Elsevier Publishing Co., Amsterdam

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Colin E. Nash, Ph. D.

Publications

J. E. Shelbourne & C. E. Nash. 1966. Sea fish culture in Britain. Proc. Nutr. Soc. 25(2):133.

C. E. Nash & J. E. Shelbourne. 1967. Power station effluent as an environment for flatfish culture. I. C. E. S. Fisheries Imp. Comm. CM E:10.

C. E. Nash. 1968. Power stations as sea farms. New Scientist 40(623):368.

C. E. Nash. 1969. Thermal addition - planning for the future. Chesapeake Science 10(3 & 4):279.

C. E. Nash. 1970. Marine fish farming, Part I. Mar. Pollution Bull. 1(1):5.

C. E. Nash. 1970. Marine fish farming, Part II. Mar. Pollution Bull. 1(2):28.

C. E. Nash. 1970. Fish farming. Proc. Inst. Food Sci. Tech. (U. K) 3(1):14.

C. E. Nash. 1970. Marine fish farming. North Ayrshire Coastal Development Comm. Report for the Public Enquiry at Ayr, Scotland.

C. E. Nash. 1972. Power Stations and fish farming. Everymans Nature Reserve. Chapter IV. Edit. Eve Dennis. Publ. David and Charles, Newton Abbott, England.

C. E. Nash & Z. H. Shehadeh. 1973. Current propagation techniques for selected marine teleosts, pleuronectes, scophthalmus and coryphaena species. American Fisheries Society.

C. M. Kuo & Z. H. Shehadeh & C. E. Nash. 1973. Induced spawning of captive grey mullet (Mugil cephalus L.) females by injection of human chorionic gonadotropin (HCG). Aquaculture 1(4):429.

Publications in Press

C. E. Nash. 1973. Automated mass production of Artemia salina for hatcheries. Aquaculture.

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Colin E. Nash, Ph. D.

Restricted Papers for the White Fish Authority

** Senior Scientist and Author
* Senior Scientist and Joint Author
+ Joint Author

** Plaice rearing at Hunterston and Carmarthen Bay electrical generating stations, 1966.
** Dover sole rearing at Hunterston nuclear generating station, 1966-68.
** Plaice rearing at Hunterston, 1968.
** Plaice rearing at Hunterston, 1969.
** Turbot fattening at Hunterston, 1969.
** The influence of water temperature on the growth of the plaice and Dover sole at Port Erin, Isle of Man, 1965.
+ Survival of young Dover sole fed with liver suppliment, Hunterston, 1970.
* Chlorination and its detection for a power station fish farm.
* Residual chlorine retention in relation to flow rate in a fish tank.
* The development of tank rearing facilities for marine flatfish.
* Design of ancillary services at a power station fish farm.
* The potential of the ormer (abalone) in marine fish farming, Hunterston, 1968
* The measurement of water flow into a fish tank, Hunterston, 1969.
* The production of Artemia salina nauplii, Hunterston, 1968.
* An instrument for the measurement of dissolved oxygen in a marine fish farm, Hunterston, 1968.
* Production technique and costing for plaice at a power station fish farm, Hunterston, 1968.
* Production technique and costing for plaice at a power station fish farm, Hunterston, 1970.
* A synopsis of the marine fish cultivation programme, 1964-70.
+ Hydrography and management of the Ardtoe inter-tidal pool, May 1968 - April 1970.
+ Plaice rearing in a sheet polyethylene floating tank, Ardtoe 1967.
+ Plaice rearing in a prototype floating cage for sheltered water, Ardtoe 1967.
+ Plaice rearing in a netting enclosure and floating cage, Ardtoe, 1968.
+ Hatching of plaice at Ardtoe, 1969.
+ Plaice rearing in a prototype floating sea-cage, Ardtoe, 1969.
+ An incidence of pop-eye disease at Ardtoe, 1968.
+ Design, construction and operation of a netting enclosure.
+ Design, construction and operation of small floating cages.
+ Design, construction and operation of large floating cages.

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HENRY BURR STEINBACH
Zoologist
Dean of Graduate Studies
Woods Hole Oceanographic Institution

Birth: October 7, 1905

B.A., University of Michigan, 1928
M.A., Brown University, 1930
Ph.D., University of Pennsylvania, 1933

Assistant, Physiology and Biochemistry, Brown University, 1928-30
Instructor, Zoology, University of Pennsylvania, 1930-33
National Research Council Fellow, University of Chicago, 1933-34
Instructor, University of Minnesota, 1935-36
Assistant Professor, University of Minnesota, 1936-38
Assistant Professor, Columbia University, 1938-42
Associate Professor, 1942-46; Professor, 1946-47, Washington University
Professor, University of Minnesota, 1947-57
Assistant Director, National Science Foundation, 1953-54
Guggenheim Fellow, 1955-56
National Science Foundation Divisional Committee Chairman, 1954-59
Visiting Professor, University of Hawaii, 1964
Visiting Professor, National Taiwan University, 1966
Consultant, President's Science Advisory Committee
Consultant, Institute for Defense Analysis
Professor and Chairman, Department of Zoology, University of Chicago, 1957-68; Professor of Zoology, University of Chicago, 1968-71
Dean of Graduate Studies, 1968 to present, Woods Hole Oceanographic Institution

Member of the Corporation, Marine Biological Laboratory, Director and President, 1966-70
Member of the Corporation, Woods Hole Oceanographic Institution
Member of the Executive Committee, and Trustee, Chicago Zoological Society, 1966-68
Biophysical Society, Charter Council Member
American Society of Zoologists, President, 1958-59
Physiological Society
Society for General Physiologists, President, 1956-57
Member, Founding Committee AIBS (Executive Secretary)
AIBS Curriculum Study, 1958-63
Chairman, Division of Biology and Agriculture, N.R.C., 1958-63
Member, Physiological Study Section, NIH, 1958-59
Member, Heart Council, NIH, 1959-63
Member, Science Information Council, NSF, 1966-68
Member, Sino-American Committee on Scientific Cooperation (NAS-NRC)
Chairman, Pacific Science Board, NRC, 1967-70
Member, Advisory Committee, Sea Grant, NSF, 1968
Editorial Board, Physiological Zoology
Managing Editor, Biological Bulletin, 1942-50

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CHING-MING KUO, Ph.D.
Senior Scientist, Aquaculture Division
Oceanic Institute

Academic

National Taiwan University, Taipei, Taiwan, B.S., 1958.
Scripps Institution of Oceanography, Ph.D., 1970.

Positions and Experience

Senior Scientist, Aquaculture Division, Oceanic Institute, 1972-present.
Research Associate, Aquaculture Division, Oceanic Institute, 1970-1972.
Post-graduate Research Biologist, Scripps Institution of Oceanography, 1970.
Research Assistant, Scripps Institution of Oceanography, 1964-1970.
Teaching Assistant, Department of Zoology, National Taiwan University, 1960-1964.
Research Biologist, Institute of Fishery Biology, National Taiwan University, 1960.

Publications

Kuo, C-M. 1965. The physiology of some teleost fishes, Part I. Study on the sexual maturity of Silver Carp, Hypophthalmichthys molitrix C & V. Rept. Inst. Fish. Biol., 2(1):46-52.

Kuo, C-M. 1964. Morphology of Yellowfin Tuna. China Fish., No. 138, pp 2-7 (in Chinese).

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Kuo, C-M., Z.H. Shehadeh and K.K. Milisen. 1973. A preliminary report on the development growth and survival of laboratory reared larvae of the grey mullet (Mugil cephalus L.) J. Fish Biol. (in press).

Kuo, C-M, Z.H. Shehadeh and C.E. Nash. 1973. Induced spawning of captive grey mullet (Mugil cephalus L.) females by injection of human chorionic gonadotropin. Aquaculture 1:429-432.

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2. 1933. The electrical potential difference across living frog skin. J.C.C.P., 3: (1), April.

3. 1933. Injury potentials in scallop muscles. J.C.C.P., 3: (2), June.

4. 1935. Diffusion potentials in colloidal systems. J.C.C.P., 7: (2), Dec.

5. 1935. Diffusion potentials in scallop muscles. J.C.C.P., 7: (2), Dec.

6. 1937. Potassium and chloride in Thyone muscle. J.C.C.P., 9: (3), April.

7. 1937. Potassium in frog skin. J.C.C.P., 10: (1), June.

8. 1940, with the assistance of Jack Auringer. Electrolytes in Thyone muscles. J.C.C.P., 15: (1), Feb.

9. 1940. Sodium and potassium in frog muscle. J. Biol. Chem., 133: (3), May.

10. 1940. The distribution of electrolytes in Phascolosoma muscle. Biol. Bull., 78: (3), June.

11. 1940. Chemical and concentration potentials in the giant fibers of squid nerve. J.C.C.P., 15: (3), June.

12. 1940. Electrolyte balance of animal cells. Cold Spring Harbor Symposium.

13. 1941. The role of the injured surface in the production of the injury potential of frog muscle. Physiol. Zool., 14: (1), January.

14. 1941. Chloride in the giant axons of the squid. J.C.C.P., 17: (1), Feb.

15. 1942, with M. L. Gabriel. Zoology in 1941. Chem. Eng. News, 20: Feb. 26

16. 1942, with D. Nachmansohn. On the localization of enzymes in nerve fibers. Science, 95: January 16.

17. 1943, with A. Glenn Richards and Thomas F. Anderson. Electron microscopic studies of squid giant nerve axoplasm. J.C.C.P., 21: (2), April.

18. 1943, with D. Nachmansohn, A. L. Machado and Sol Spiegelman. Localization of enzymes in nerves. II. Respiratory enzymes. J. Neurophysiol.,

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19. 1943, with Sol Spiegelman. The sodium and potassium balance in squid nerve axoplasm. J.C.C.P., 22: (2), October.

20. 1943, with Sol Spiegelman and N. Kawata. Rectification and injury potential in squid axons. Federation Proc., 3: (1), March.

21. 1944. with N. Kawata. The recovery of the cut surface of the scallop muscle. Federation Proc., 3: (1), March.

22. 1944. with S. Spiegelman and N. Kawata. The effects of potassium and calcium on the electrical properties of squid axons. J.C.C.P., 24: (2) October.

23. 1944. Osmotic behavior of frog sartorius muscles. J.C.C.P., 24:3

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25. 1945. with S. Spiegelman. Substrate-enzyme orientation during embryonic development. Biol. Bull., 88: (3), June.

26. 1945, with Florence Moog. Localization of adenlpyrophosphatase in cytoplasmic granules. J.C.C.P., 26: (175).

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28. 1946. Localization of acid and alkaline phosphomonoesterases in cytoplasmic granules. J.C.C.P., 28 (2), October.

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31. 1949. Calcium and apyrase system of muscle. Arch. Biochem., 22: (2), Jun

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34. 1951. Permeability. Ann. Rev. Physiol., 13.

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arl N. Hodges, Ph. D., Director, Environmental Research Laboratory, University of Arizona

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oyd MacNaughton, Chairman of the Board, California and Hawaiian Sugar Co.

ujio Matsuda, Ph. D., Vice President, University of Hawaii

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lexander Wylly, Ph. D., Director, Planning Research Corp.

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Robert H. Rath - Vice-Chairman
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John Craven, Ph. D.
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Jon Lindbergh
Boyd MacNaughton
Fujio Matsuda, Ph. D.
William McLean, Ph. D.

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Dr. Colin E. Nash - Vice President, Research Director
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Andrew T. F. Ing - Treasurer
Andrew T. F. Ing - Secretary
Nadine Taylor - Assistant Treasurer
Nancy Roberts - Assistant Secretary

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Discussion of the Budget

for

Efficient Production of Fish Seed Stock and

Design of Open Water Enclosures

The time schedule and amounts are meant to be only suggestive and preliminary.

AID has in mind a proposed figure of $470,000 to cover a three year program. An extension would be considered depending upon two factors: (1) the quality of research performed up to that point (three years) and determination of a need for further research and (2) a consideration of whether the program could be carried forward by organizations other than AID.

There would be a report of activities prepared at the end of 16 months for an intensive 18 month review, and a further report at the 30th month for a 32nd month review.

If it should be determined that an extension is to be made, the total amount would not exceed $870,000. The fifth year, if granted, would be for a relatively small amount.

The budget as submitted by the Oceanic Foundation is intended to serve only to give guidance as to types of persons involved.

It is only the Oceanic Foundation's first draft and is not definitive. A detailed work plan will be required within the first three months.

Project Review Report - RIGC (9/12/74)

Project: Efficient Production of Seed Stock and Design of Open Water Fish Enclosures - Oceanic Foundation, Waimanalo, Hawaii

Project Manager: James Urano, TA/AGR

Discussion Highlights:

Dr. Long called attention to a typographical error on the front page of the Project Statement in that the Total Amount for three years should read $450,000. This figure does not agree with the proposed budget following page 11, but represents a recommended level of expenditure which will need to be worked out in detail and agreed upon in any contract negotiations. It is proposed that there will be a report of activities prepared at the end of 16 months for an intensive 18 month review, and a further report at the 30th month for a 32nd month review. This means that this will be essentially a 3 year project subject to thorough review before any follow-on activities.

The Chair was taken by Carl Fritz, TA/PM, at Dr. Long's request so that he would be free to speak to the details and background of the project planning. Jim Urano discussed the Oceanic Foundation as a non-profit, research organization dependent on contract and grant funds. It is now independent of formerly associated tourist attraction activities. It has no ties with the University of Hawaii.

There was general discussion about the desirability of budget elaboration prior to being submitted to the RAC. There was agreement that this would be accomplished as much as possible in consultation with the Oceanic Foundation.

Mr. Gleason Rohlfs, SA/TD, asked about plans for the dissemination of information. Dr. Long stated that this should be viewed in the context of the several institutions involved in the program, namely Auburn University, the University of Rhode Island, The Rockefeller Foundation, and others. Training centers may be located in Fiji, the Philippines, and some other site. Bill Littlewood urged consideration of the East-West Center's program on training Asian entrepreneurs.

O. L. Mimms expressed the hope for emphasis on the consideration of economic and social aspects of the project. Dr. Long stated that the project research design should lend itself to the utilization of results for their economic implications. Rhode Island is also a real resource in the economics of estuarial versus inland aquaculture.

Jim Urano commented on the aspect of land use economics for areas not now in use. Dr. Long pointed out that there will need to be tradeoffs in the analysis of production economies and the areas of needs for the products. Further, from the point of view of genetic control there is need for domestication and controls which are not possible in the open sea.

Motion: That RIGC approves the proposal for presentation to the RAC. Moved by O. L. Mimms, seconded by W. Leake, approved unanimously.

COST REIMBURSEMENT TYPE CONTRACT

AGENCY FOR INTERNATIONAL DEVELOPMENT — CONTRACT TYPE

NEGOTIATED CONTRACT NO. AID/TA-C-1189

NEGOTIATED PURSUANT TO THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED, AND EXECUTIVE ORDER 11223 — AMOUNT $498,532.00

CONTRACT FOR: Research in artificial propagation of milkfish — Project No. 28p.

ISSUING OFFICE (Name and Address)	CONTRACTOR (Name and Address)
Central Operations Division Office of Contract Management Agency for International Development Washington, D.C. 20523	Oceanic Foundation NAME STREET ADDRESS Waimanolo, Hawaii CITY, STATE AND ZIP CODE
ADMINISTRATION BY Same as issuing office	COGNIZANT SCIENTIFIC/TECHNICAL OFFICE TA/AGR
MAIL VOUCHERS (Original & 3 copies) TO: Central Services Division Office of Financial Management, A.I.D. Washington, D.C. 20523	ACCOUNTING AND APPROPRIATION DATA PIO/T NO. 931-17-130-526-73-315766 APPROPRIATION NO. 72-11X1023 ALLOTMENT NO. 402-31-099-00-22-51
EFFECTIVE DATE January 13, 1975	ESTIMATED COMPLETION DATE January 12, 1978

TYPES OF BUSINESS (CHECK APPROPRIATE BOX(ES))

	SOLE PROPRIETORSHIP		SMALL BUSINESS
	PARTNERSHIP		LABOR SURPLUS AREA
	JOINT VENTURE		
X	CORPORATION, INCORPORATED IN THE STATE OF Hawaii (Non-profit)		

The United States of America, hereinafter called the Government, represented by the Contracting Officer executing this contract, and the Contractor agree that the Contractor shall perform all the services set forth in the attached Schedule, for the consideration stated therein. The rights and obligations of the parties to this contract shall be subject to and governed by the Schedule and the General Provisions. To the extent of any inconsistency between the Schedule or the General Provisions and any specifications or other provisions which are made a part of this contract, by reference or otherwise, the Schedule and the General Provisions shall control. To the extent of any inconsistency between the Schedule and the General Provisions, the Schedule shall control.

This Contract consists of this Cover Page, the Schedule of 11 Pages, including the Table of Contents and the General Provisions (form AID 1420-41C, dated _____).

NAME OF CONTRACTOR	UNITED STATES OF AMERICA AGENCY FOR INTERNATIONAL DEVELOPMENT
Oceanic Foundation	
BY (Signature of authorized individual)	BY (Signature of Contracting Officer)
TYPED OR PRINTED NAME Colin E. Nash, Ph.D.	TYPED OR PRINTED NAME R.J. O'Brien
TITLE Vice President - Director	CONTRACTING OFFICER
DATE January 13, 1975	DATE 13 JAN 1975

CERTIFIED A TRUE COPY THIS 5th DAY OF Feb. 1975

BY E. L. Annis

AID 1420-41A (7-72)

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COST REIMBURSEMENT TYPE CONTRACT

Contract No. AID/ta-C-1189

TABLE OF CONTENTS

The Schedule on Pages 1 through 11, consists of this Table of Contents and the following articles:

ARTICLE I - STATEMENT OF WORK

ARTICLE II - TECHNICAL DIRECTIONS

ARTICLE III - KEY PERSONNEL/POSITIONS

ARTICLE IV - PERIOD OF CONTRACT

ARTICLE V - ESTIMATED CONTRACT COST AND FINANCING LIMITATIONS

ARTICLE VI - BUDGET

ARTICLE VII - COSTS REIMBURSABLE

ARTICLE VIII - ESTABLISHMENT OF OVERHEAD RATES

ARTICLE IX - PERSONNEL COMPENSATION

ARTICLE X - SPECIAL PROVISION

ARTICLE XI - LOGISTIC SUPPORT

ARTICLE XII - ADDITIONAL CLAUSES AND MODIFICATIONS TO THE GENERAL PROVISIONS

GENERAL PROVISIONS

1. The General Provisions applicable to this contract consist of form A.I.D. 1420-41C entitled "General Provisions - Cost Reimbursement Type Contract," dated 9/74, which includes provisions 1 through 43, and form A.I.D. 1420-41D entitled "Additional General Provisions - Cost Reimbursement Type Contract," dated 9/74 which includes provision 1 through 15.

SCHEDULE

ARTICLE I - STATEMENT OF WORK

For a period as hereinafter set forth in the Schedule, the Contractor shall make available and employ its research and development facilities and personnel at the level of effort hereinafter set forth and shall perform the services set forth in Appendix A attached hereto.

ARTICLE II - TECHNICAL DIRECTIONS

Performance of the work hereunder shall be subject to the technical directions of the cognizant A.I.D. Scientific/ Technical Office indicated on the Cover Page. As used herein "Technical Directions" are directions to the Contractor which fill in details, suggest possible lines of inquiry, or, otherwise complete the general scope of the work. "Technical Directions" must be within the terms of this contract and shall not change or modify them in any way.

ARTICLE III - KEY PERSONNEL

The key personnel which the Contractor shall furnish for the performance of this contract are as follows:

Key Personnel	Title
Dr. Colin E. Nash	Project Leader
Dr. Ching-Ming Kuo	Principal Investigator

The personnel specified above are considered to be essential to the work being performed hereunder. Prior to diverting any of the specified individuals to other programs, the Contractor shall notify the Contracting Officer reasonably in advance and shall submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on the program. No diversion shall be made by the Contractor without the written consent of the Contracting Officer; provided, that the Contracting Officer may ratify in writing such diversion and such ratification shall constitute the consent of the Contracting Officer required by this clause. The listing of key personnel may, with the consent of the contracting parties, be amended from time to time during the course of the contract to either add or delete personnel, as appropriate.

ARTICLE IV - PERIOD OF CONTRACT

The effective date of this contract is the date of signature by the A.I.D. Contracting Officer designated on the Cover Page and the estimated completion date is three years thereafter.

ARTICLE V - ESTIMATED CONTRACT COST AND FINANCING LIMITATIONS

The Contractor will be reimbursed for the costs incurred by him in performing services hereunder in accordance with the applicable provisions of the Schedule and the General Provisions subject to the following limitation made in respect thereto:

A.	Total A.I.D. dollar funds available for payment and allotted to this contract. See clause of the General Provisions entitled "Limitation of Funds."	$ 250,000
B.	Estimated additional funds which may be provided if funds are available	$ 248,532
	TOTAL ESTIMATED CONTRACT COST	$ 498,532

C. Funding beyond A above is contingent upon the following: (1) Favorable A.I.D. review and evaluation of the results of the program after 18 months.

ARTICLE VI - BUDGET

The attached Budget sets limitations for reimbursement of dollar costs for individual line items. Without the prior written approval of the Contracting Officer, the Contractor may not exceed the grand total of Funds Available as shown in Article V-A above, nor may the Contractor exceed the dollar costs for any individual line item of the Budget by more than 15% of such line item.

ARTICLE VII - COSTS REIMBURSABLE

The United States dollar costs allowable under this contract shall be limited to reasonable, allocable and necessary costs determined in accordance with the Clause of the General Provisions of this contract entitled "Allowable Cost and Payment."

ARTICLE VIII - ESTABLISHMENT OF OVERHEAD RATE

Pursuant to the Clause of the General Provisions of this contract entitled "Negotiated Overhead Rates," a rate or rates shall be established for the period beginning January 1, 1975 and ending December 31, 1975. Pending establishment of final overhead rates for the initial period, provisional payments on account of allowable indirect costs shall be made on the basis of the following negotiated provisional rates applied to the base(s) which are set forth below:

	RATE	BASE	PERIOD
On Site	85%	Total direct salaries & fringe benefits	1/1/75 - 12/31/75

Postdetermined indirect cost rates for subsequent periods shall be established in accordance with the terms of the "Negotiated Overhead Rates" postdetermined clause of the General Provisions. The provisional rate of 85% shall constitute the maximum rate for the period 1/1/75 through 12/31/75.

ARTICLE IX - PERSONNEL COMPENSATION

A. Limitations

Compensation of personnel which is charged as a direct cost under this contract, like other costs, will be

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reimbursable in accordance with Article VII of the Schedule entitled "Costs Reimbursable" and General Provision No. 9 entitled "Allowable Cost, Fixed Fee and Payment," and other applicable provisions of this contract but subject to the following additional specified understandings which set limits on items which otherwise would be reasonable, allocable and allowable:

1. Approvals

Salaries and wages may not exceed the Contractor's established policy and practice, including the Contractor's established pay scale for equivalent classifications of employees, which will be certified to by the Contractor, nor may any individual salary or wage, without approval of the Contracting Officer, exceed the employee's current salary or wage or the highest rate of annual salary or wage received during any full year of the immediately preceding three years, provided that if the work is to be performed by employees serving overseas for a period in excess of one year, the normal base salary may be increased in accordance with Contractor's established policy and practice, but not to exceed 10 percent of base U.S. salary excluding benefits. There is a ceiling on reimbursable salaries and wages paid to a person employed directly under the contract of the maximum salary rate of FSR-1 (or the equivalent daily rate of the maximum FSR-1 salary, if compensation is not on an

annual basis), unless advance written approval is given by the Contracting Officer.

2. Salaries During Travel

Salaries and wages paid while in travel status will not be reimbursed for a travel period greater than the time required for travel by the most direct and expeditious air route.

3. Return of Overseas Employees

Salaries and wages paid to an employee serving overseas who is discharged by the Contractor for misconduct or security reasons will in no event be reimbursed for a period which extends beyond the time required to return him promptly to his point of origin by the most expeditious air route plus accrued vacation leave.

4. Merit or Promotion Increase

Merit or promotion increases may not exceed those provided by the Contractor's established policy and practice. With respect to employees performing work overseas under this contract, one merit or promotion increase of not more than 5% of the employee's base salary may, subject to the Contractor's established policy and practice, be granted after employee's completion of each twelve month period of satisfactory services under the contract. Merit or promotion increases exceeding

these limitations or exceeding the maximum salary of FSR-1 may be granted only with the advance written approval of the Contracting Officer.

5. Consultants

No compensation for consultants will be reimbursed unless their use under the contract has the advance written approval of the Contracting Officer; and if such provision has been made or approval given, compensation shall not exceed, without specific approval of the rate by the Contracting Officer, (1) the current compensation or the highest rate of annual compensation received by the consultant during any full year of the immediately preceding three years or (2) maximum daily salary rate of a Foreign Service Officer Class 1 whichever is less.

Note: The daily rate of a Foreign Service Officer Class 1 is determined by dividing the annual salary by 260 days.

6. Third Country and Cooperating Country Nationals

No compensation for third country or Cooperating Country nationals will be reimbursed unless their use under the contract is authorized in the Schedule or has the prior written approval of the Contracting Officer. Salaries and wages paid to such persons may not, without specific written approval of the Contracting Officer, exceed either the Contractor's established

policy and practice; or the level of salaries paid to equivalent personnel by the A.I.D. Mission in the Cooperating Country; or the prevailing rates in the Cooperating Country, as determined by A.I.D., paid to personnel of equivalent technical competence.

7. Work Week

a. Non-overseas Employee. The work week for the Contractor's non-overseas employees shall not be less than the established practice of the Contractor.

b. Overseas Employee. The work week for the Contractor's overseas employees shall not be less than 40 hours and shall be scheduled to coincide with the work week for those employees of the A.I.D. Mission and the Cooperating Country associated with the work of this contract.

B. Definitions

As used herein the terms "Salaries," "Wages," and "Compensation" mean the periodic remuneration received for professional or technical services rendered exclusive of overseas differential or other allowances associated with overseas service unless otherwise stated. The term "Compensation" includes payments for personal services (including fees and honoraria). It excludes earnings from sources other than the individual's professional or technical work, overhead or other charges.

ARTICLE X - SPECIAL PROVISION

A. In accordance with Additional General Provision No. 7 entitled "Personnel" whereunder the Contractor may not send individuals outside of the United States to perform work under the contract without the prior written approval of the Contracting Officer, the Contracting Officer does, hereby, provide said approval for those individuals required to travel outside the United States; provided, however, that concurrence with the assignment and/or travel of any and all said individuals outside the United States is obtained, in writing, from the Cognizant Technical Officer of A.I.D. prior to their assignment and/or travel abroad.

B. This approval by the Contracting Officer shall not apply to any other clause or provision of this contract which specifically requires Contracting Officer approval.

ARTICLE XI - LOGISTIC SUPPORT

Prior to making any visits to less developed countries, the Contractor will review his plans with the Office of Agriculture. He will also keep A.I.D. missions in countries to be visited fully informed of proposed visits, ask them to provide any advice they wish regarding timing and content of the visits and to participate if they desire, and he will inform the missions of the outcomes of consultations. Contractor

will make his own appointments and logistics arrangements directly. Upon completion of any project funded travel, a copy of the trip report will be provided to the Project Manager designated in Appendix A. The report format will be established jointly by the Contractor and the Project Manager.

ARTICLE XII - ADDITIONAL CLAUSES TO THE GENERAL PROVISIONS

A. Add General Provision No. 44 (Attachment A) entitled "Cost Accounting Standards."

APPENDIX A

ARTICLE I - STATEMENT OF WORK

A. Objective - To develop effective and controlled means of producing seed fish upon which mature fish production enterprises are based and to develop effective distribution systems.

B. Scope of Work

The Contractor shall be required to make available the required personnel to develop effective and controlled means of producing seed fish upon which mature fish production enterprises are based and to develop effective distribution systems. The primary goal of the project is to develop the artificial propagation of the milkfish in the shortest possible time. The goal will be attained by a direct assault on those aspects known to be necessary to achieve that end. In addition to the practical production, which will be evaluated by the cost effectiveness of juveniles produced each year, a number of specific research targets will need to be achieved in order to supply the detailed scientific information required for direct progress toward the overall goal as enumerated below:

1. Broodstock collection and holding.

a. A considerable number of broodstock will be captured for research material, to indicate husbandry requirements for holding adults, for illustrating their food requirements, and for providing a large gene pool for increasing the chances of good larval survival after breeding.

b. Each fish on site will be numbered by year, class and sex, and its life history recorded while it is in captivity, particularly details of spawning, subsequent fertility and survival and growth of its offspring.

c. Since the success of an artificial propagation system depends primarily on the quality and quantity of broodstock resources, large numbers of sexually mature individuals must be contained in good health under acceptable environmental conditions in order to reproduce and yield viable offspring.

d. Essential external conditions for broodstock fish requiring research, are suitable water quality, a nutritious diet, high standards of hygiene and limited physical disturbance, but most importantly the broodstock shall be exposed to the correct environmental parameters which influence the physiological changes in the pituitary gland and stimulate the gonads to seasonal maturity.

e. Many experiments with fish have used gonad development to interpret the effects of certain environmental regulators on the reproductive cycle. Among the factors concerned are temperature and photoperiod which initiate pituitary activity. The relative importance of each varies with different species of fish and shall be reflected in this study.

f. The project will apply the existing knowledge for maintaining captive Mugilidae in the most suitable environment for breeding

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to maintaining captive milkfish. It will concentrate on details of enclosure size, population density, health, sexual development, behavior and environmental controls and manipulation. The objective is to detail the conditions for holding large numbers of broodstock throughout the year, and to phase the spawning process to establish year-round production of fertilized eggs.

2. Induced breeding techniques.

a. The physical containment of fish and their maintenance in captivity for high survival are not generally difficult problems. Milkfish readily become domesticated, as testified by centuries of pond farming. They grow in captivity and are technically mature, but individual females will not undergo the final stages of gametogenesis and spawn in captivity. At present these stages need the artificial stimulus of hormone injection to complete the breeding cycle.

b. The project will use the induced breeding techniques already established for the Mugilidae and use partially purified salmon gonadotropin SG-G100. It will specify a technique, providing data on the critical time for injection, dose rate and frequency, subsequent development procedures and behavioral reactions. An important objective for induced breeding is to select a hormone which is widely available and to standardize its potency and establish spawning dosage against egg maturity.

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c. Finally, present induced spawning techniques are applied to stimulate the final stages of development.

3. Egg and sperm quality.

a. Egg and sperm quality will be judged by microscopic gross appearances and subsequent fertility. The minimum of histological examinations will be made to establish a sequential record of embryonic development to which all subsequent observations can be related. If poor larval survival is persistent, then detailed but short-term studies on the biochemical composition of the eggs will be necessary in order to establish that induced spawning does not influence development detrimentally.

b. Once egg and sperm quality are established, it is anticipated that there will be significant variations between individuals. Good fish will be marked for their capacity to produce good quality gametocytes and used individually year after year. An early start identifying good fish in this way will begin a genetic aspect of the program.

4. Egg incubation and larval survival.

a. Environmental controls during larval development have concentrated mostly on temperature, salinity, pH, oxygen and light intensity. They all influence the rate of incubation development and/or survival in some way.

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b. However, the success of the larval rearing technique and the need to become involved in short-term experiments will be judged by the annual production figures from the hatchery operation and from observations made during the process. If salinity changes are indicated then a series of short-term research experiments will be conducted to indicate the right saline regime for optimizing production. Similarly short-term experiments may be conducted for light intensity, water quality, food density and food regimes. (For example, it may be necessary to work on the changes in body fluids in varying salinities to establish the time at which the larvae can be exposed to lower salinities. The work will be performed in replicate aquaria and in an existing density column.)

5. Hatchery distribution.

a. Mass propagation is ineffective without satisfactory means to distribute the juveniles safely to the farms and the farmers requiring them.

b. Handling operations for young fish can be detrimental to their survival. Mishandling and overcrowding, thereby draining oxygen from the water used for transport, rapidly reduce their numbers. The final project for the mass propagation goal will be to test the best methods of transportation for the juveniles.

C. Project Reviews and Coordination.

1. Reviews will be at 18 months and again at 32 months. The

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outcome of the 18 months review will determine program direction in the third year and the outcome of the 32 months review will determine A. I. D. 's requirements with regard to this project.

2. All plans and operations shall be coordinated with the Cognizant Technical Office's project monitor.

3. The contractor shall be granted access to research results developed under other A. I. D. contracts in related areas.

D. Project Restrictions

During the life of this project, no research, design, nor construction of pens or enclosures for commercial fish production will be carried out. It is the understanding of the parties that for the period of this contract the Oceanic Foundation without charge to this contract will continue at its approximately present level of activity its research program on the mullet. If the effort under this program is to be suspended, or terminated in whole or in part, the A. I. D. project officer should be advised at least thirty (30) days in advance of the effective date of such occasion.

E. Work Plan

The foundation of the overall project for the production of fish seed is to establish a broodstock of mature milkfish in captivity. The immediate goal is a total of fifty fish and a capability to replace losses annually.

Three approaches to the problem will be made immediately (of which one will be through a linkage with an overseas center). An attempt will be made to

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capture spawning fish at sea at their natural spawning sites; another will capture the immature fish from fresh and brackishwater ponds and allow time to mature in captivity in seawater; the third will entail the trapping of migratory spawning fish as they move out of the freshwater areas and to relocate them in the sea but in captivity. The general care and maintenance of all these resources will contribute to the information on broodstock husbandry.

Subsequent work will provide information on holding, handling and sampling the broodstock. Each individual will be identified by the safest marking method (which will be determined), so that annual fertility and quality of gametes can be determined for long-term genetic studies and selection of the best breeding fish. Handling in captivity will also lead further into controlled manipulation for year-round breeding.

Indication of progress in establishing broodstock will be continuously monitored through such indications as survival in captivity, repeated spawning from individuals, growth of the spawning broodstock, and the development of criteria for broodstock maintenance that can be substantiated by repetition by other network institutes. Activities and alternatives to be explored so as to establish criteria for broodstock development are shown in the attached flow chart (2, 3, 4, 8, 9, 13, 16, 17, 20, 21, 25) during 1975 and to some extent during 1976.

The second major priority in the first two years is to define the conditions for spawning in captivity by determining the conditions on the natural spawning

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grounds. This will be achieved by using transponder tags to locate spawning fish on the natural grounds; determining the environmental condition of the grounds; and to simulate the conditions in the laboratory or the spawning tanks. Although hormone treatment is anticipated as being essential to complete spawning development for the immediate future, some work will be established for spawning fish without hormone treatment maintained in optimum conditions. The second objective of this priority area is to produce fertile eggs from fish in captivity with or without hormone treatment.

All fish captured, whether dead or alive, will contribute to the basic knowledge of the natural reproductive physiology of the milkfish which, at present, is almost unknown. This information is fundamental to the entire study and provides the background to all the induced and natural spawning responses. This third priority area is therefore dependent on the catching of (preferably mature) fish, but not totally dependent on live fish. The main objective of the third priority area is, however, to define the optimum induced spawning procedure for salmon pituitary gonadotropin and subsequently other cheaper hormones if necessary. This aspect is totally dependent on live fish from an established broodstock. This objective will be achieved when repeated successes with hormone treatment for spawning fertile eggs are recorded.

The activities to achieve spawning in captivity, while related to the establishment of the broodstock, also entail specific explanations also described on the flow chart (5, 6, 7, 10, 11, 22, 26) with the eventual selection of the best method

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and proccdures to obtain spawning of the broodstock.

The remaining three priority areas; improving survival of larvae, increasing hardiness of early juveniles, and improved handling and husbandry of juveniles; are all dependent on the production of fertile eggs as they involve work with larvae and juveniles.

The development of juveniles has been described as a two stage process, numbering I (0-20 days) and II (21-50 days), because this differentiation may be important to distribution.

The work, therefore, is divided into separate objectives for Nursery I and Nursery II production. The need for both is to increase the survival, recommend the rearing procedures with optimum growth rates, and to evaluate the economics of the subsequent distribution complexity.

The period from hatching to a hardy, juvenile state requires an estimated 21 days and is an extremely critical period requiring careful and fundamental investigation into such items as salinity variables, food density, and rearing density, as indicated by flow chart activities and numbers 12 and 18.

Nursery work as well as the development of optimum distribution methods and hatchery procedures whether from Nursery I or II will be carried out during FY 76 and will be planned to extend into 1977 if the results of the 18 months review indicate the need continuation. It is during these latter phases flow chart Nos. (14, 19, 23, 24, 27, 28) that the final system (29) is expected to be achieved, but may require the entire five year period to complete, subject to the results of the thirty-two month review.

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Table : Work Plan Outline 1975 - 1977 (Inclusive)

Program Area Objectives

1. ESTABLISH BROODSTOCK IN CAPTIVITY

   a) Collection of mature fish in season (at sea)

   b) Collection and growing-on of immature fish (from brackishwater ponds)

   c) Collection of migratory fish (from known runs)*

   d) Development of broodstock husbandry

   e) Holding, handling and sampling large fish

   f) Identification of broodstock individuality

   g) Year-round breeding through environmental control

2. ESTABLISH CONDITIONS FOR SPAWNING

   a) Determination of natural spawning conditions (through location of spawning sites)

   b) Simulation of spawning conditions in laboratory (by environmental control)

   c) Attempt spawning without hormone treatment (by behavioral responses)

3. INDUCE SPAWNING BY HORMONE INJECTION WAS TO:

   a) Define the optimum induced spawning procedure (for salmon gonadotropin, specifying correct time for treatment, dosage, dose rate, response, etc.)

   b) Determine cost effectiveness of readily available hormones.

   Experiments will include:

      1) Determine natural reproductive physiology (for both sexes) from immaturity

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2) Determine responses to hormone treatment

3) Test reactions to salmon pituitary gonadotropin

4) Test reactions to other cheaper hormones

4. IMPROVE SURVIVAL OF LARVAE IN LABORATORY

a) Nursery I (Day 0 - Day 21**) development
Definition of Nursery I rearing procedure with recommended facilities, food and food density, rearing density, water quality, and external environmental conditions, etc.

b) Production high survival (%) from available eggs.

5. INCREASED HARDINESS OF LARVAE TO JUVENILE STAGE

a) Nursery II (Day 21 - Day 50**) development
(Definition of Nursery II rearing procedure with recommended facilities, food and food density, rearing density, water quality and environmental conditions.

Juveniles larger and healthier than those caught and distributed by the existing farming operators and expected products.

b) Economics of operations -

Low cost of juveniles

6. IMPROVE HANDLING AND HUSBANDRY OF JUVENILES

a) Improve collection of juveniles from Nursery II facilities

b) Develop safe transportation methods

1. Develop safe procedures for mass collection and transportation of nursery stock.

2. Recommend optimum economic transfer method for fry distribution, from unknown operational costs and survival factor.

3. Restrict receiving facilities on farms.

Note ** - An estimated stage differentiation.

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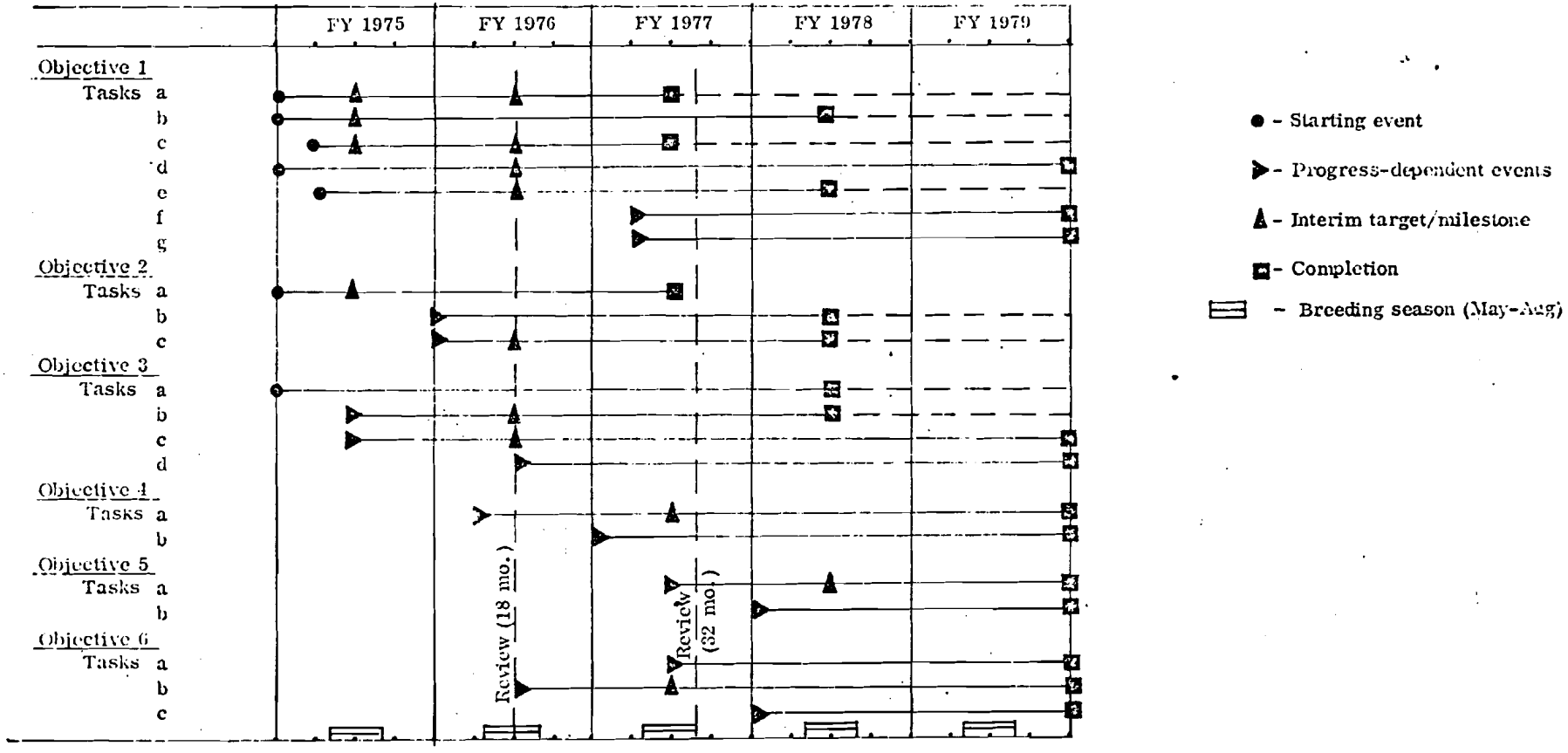
PROJECT TIME-CHART [FY1 - FY2]



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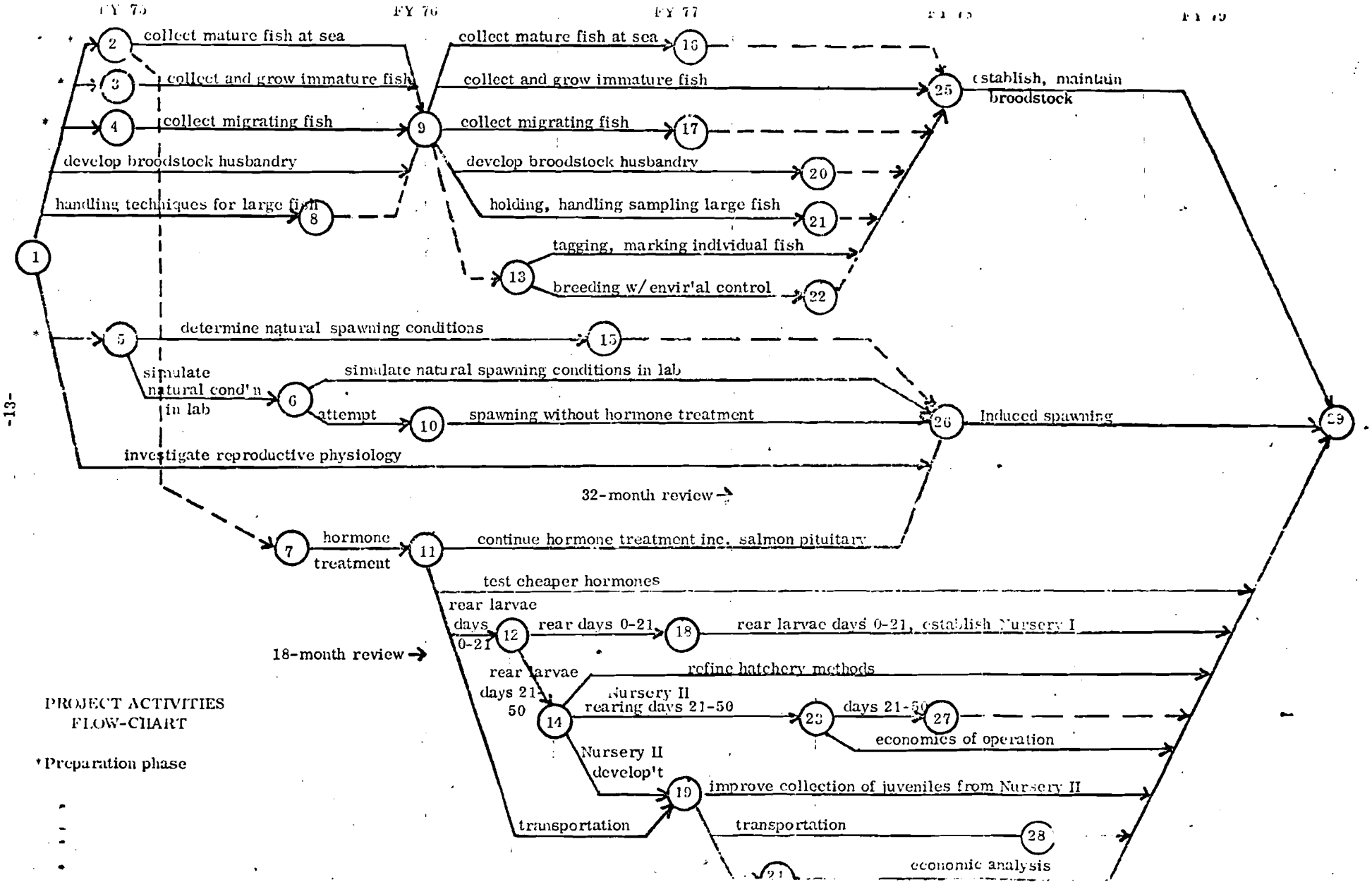

PROJECT ACTIVITIES FLOW-CHART

* Preparation phase

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Work Plan Linkages

In addition, specific areas of cooperation with other agencies planned for the project are as follows:

a) The Oceanic Foundation has signed an agreement to train technical staff from the SEAFDEC Aquaculture Center in the Philippines in the practice of induced spawning of mullet between January and March, 1975. The trainees will then return to put their knowledge to both mullet and milkfish breeding in the Philippines, under continued guidance from the Foundation. SEAFDEC have agreed to provide the travel expenses of the trainees. The Foundation will support the balance of the program from their own funds.

b) In addition to the development of a transponding fish tag for determining the natural spawning sites of milkfish, field work will be encouraged in both the Philippines and in Taiwan where greater resources of fish are available. The Foundation will work with the SEAFDEC Center in the Philippines and the Tungkang Fisheries Research Station to obtain information from extended use of the tag. The Director of the Rural Reconstruction program in Taiwan funded by the Rockefeller Foundation has agreed to this cooperation.

c) No migratory milkfish runs are evident in Hawaii and therefore the catching of migratory fish and retaining at sea has to be done elsewhere. The Foundation will work with the field stations of the SEAFDEC Center in the Philippines to supervise this work.

d) The U.S. Peace Corps stationed in the Philippines (and working mostly with the Bureau of Fisheries) have been making some preliminary efforts to catch and spawn adult milkfish with little success. The Foundation will work with the fisheries officers involved to try and improve their results.

e) The National Marine Fisheries Service in Honolulu recognizes the value of juvenile production for the progress of aquaculture. The laboratory has offered its assistance for the catching of milkfish broodstock. It will, if necessary, use its facilities to bridge the gap between the transfer of adults caught in the sea back to the laboratory; or support the construction of holding facilities within U.S. Government Property Areas, possibly of the U.S. Navy which has control over the entire Pearl Harbor region and which constitutes some of the best milkfish grounds.

f) Except for (a) above, which is already organized and funded separately by the Oceanic Foundation, expenditures for linkage field projects and trials are not covered by the present budget.

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F. Reports

Notwithstanding Clause 16 of the General Provisions, Contractor shall submit fifty copies of annual reports in English which will be required 45 days after the anniversary date of the contract. Guidelines for Preparation of the Research Annual Report are attached for your information. The reports shall be forwarded to:

Leon Hesser, Project Manager
Office of Agriculture
Bureau of Technical Assistance
Agency for International Development

Budget 1975 - 1977 (Inc.) Years 01 - 03

		Year 01	Year 02	Year 03	Total
1.	SALARIES (Man months)	46,060 (39½)	46,060 (39½)	106,800 (74½)	198,920 (153)
2.	FRINGE BENEFITS (8 %)	3,915	3,915	9,078	16,908
3.	CONSULTANT	5,000	0	5,000	10,000
4.	TRAVEL & TRANSPORTATION	3,500	5,500	7,500	16,500
5.	CAPITAL PURCHASES	35,000	4,500	11,500	51,000
6.	VEHICLES & SUPPLIES	6,000	5,342	9,908	21,250
7.	PUBLICATIONS	0	250	250	500
8.	OVERHEAD (85% of #1 and 2)	42,479	42,479	98,496	183,454
	TOTALS	141,954	108,046	248,532	498,532

Memorandum

ACTION

TO : AA/TA, Dr. Erven J. Long

THRU : TA/RDS, Dr. Miloslav Rechcigl

FROM : TA/AGR, Leon F. Hesser

DATE: February 27, 1976

SUBJECT: Amendment No. 1 to Oceanic Foundation Contract on Artifical Propagation of Milkfish

Problem: In conducting research on the Artifical Propagation of Milkfish Project No. 526, it was determined that the pathology of milkfish was a major constraint to achieving the project purpose. The current contract work plan with the Oceanic Foundation does not provide for research on this aspect of the milkfish.

Discussion: Disease is a fundamental problem in aquaculture. Milkfish also face this problem, and their diseases range from psychological to organic.

Emphasis often is on combatting specific diseases as they crop up, using drugs, etc; but while including this approach in the amendment, the Oceanic Foundation will emphasize basic situations predisposing and occurring before the possible onset of an overt pathological condition. Progress has already been made in this area, and it is of major importance in milkfish (as well as other species) aquaculture that not only should predisposing conditions to disease continue to be investigated, but that preventive measure be tested.

a. Rationale: The milkfish is raised and consumed throughout southeast Asia. The research grant awarded to the Oceanic Foundation in January 1975 recognized the importance of this fish to the region. However, it is apparent that certain pathological conditions will be involved attendant upon the necessary steps in handling and treating broodstock. In order to realize the potential of the artifical propagation of milkfish, these pathological conditions must be identified and solved.

b. Specific products: Research will be conducted on basic pathology and aquaculture-induced pathology. In the latter case it is expected to develop a method for identifying the existence of a certain disease and to test a proposed simple preventive measure.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

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c. Cost of the planned investigation is $35,800. Funds for this activity are available in the FY-76 budget from the unutilized Auburn Technical Assistance Project.

Recommendation: It is recommended that you approve an amendment for the pathology of milkfish to the existing contract.

Approved: Ernest J. Lory

Disapproved: _____

Date: March 26, 1976

Attachment:
Oceanic Foundation Proposal
October 1975

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5. ISSUED BY

Central Operations Division
Office of Contract Management
Agency for International Development
Washington, D.C. 20523

6. ADMINISTERED BY (If other than Block 5)

1/130-526

7. CONTRACTOR NAME AND ADDRESS — CODE — FACILITY CODE

Oceanic Foundation
Makapuu Oceanic Center
Makapuu Point
Waimanalo, Hawaii 96795

U. Hawaii

(Street, city, county, state, and ZIP Code).

8. ☐ AMENDMENT OF SOLICITATION NO. 7p.

DATED _____ (See block 9)

☐ MODIFICATION OF CONTRACT/ORDER NO. AID/ta-C-1169

DATED 1/13/75 (See block 11)

9. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in block 12. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.

Offerors must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended, by one of the following methods:

(a) By signing and returning _____ copies of this amendment, (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If, by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

10. ACCOUNTING AND APPROPRIATION DATA (If required)

NA

11. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS

(a) ☐ This Change Order is issued pursuant to FAA of 1961, as amended, and E.O. No. 11223

The Changes set forth in block 12 are made to the above numbered contract/order.

(b) ☐ The above numbered contract/order is modified to reflect the administrative changes (such as changes in paying office, appropriation data, etc.) set forth in block 12.

(c) ☐ This Supplemental Agreement is entered into pursuant to authority of _____

It modifies the above numbered contract as set forth in block 12.

12. DESCRIPTION OF AMENDMENT/MODIFICATION

The Contract is hereby amended as follows:

Add ARTICLE XIII - ADVANCE PAYMENT as shown on the attached pages.

CERTIFIED A TRUE COPY THIS 1st DAY OF May 1975

BY R. O. Hundstad

Except as provided herein, all terms and conditions of the document referenced in block 8, as heretofore changed, remain unchanged and in full force and effect

13. ☐ CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT ☒ CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN 6 COPIES TO ISSUING OFFICE

14. NAME OF CONTRACTOR/OFFEROR

BY _____ (Signature of person authorized to sign)

15. UNITED STATES OF AMERICA

BY _____ (Signature of Contracting Officer)

15. NAME AND TITLE OF SIGNER (Type or print)

William W. Sellew,
Vice President

16. DATE SIGNED

4/28/75

18. NAME OF CONTRACTING OFFICER (Type or print)

19. EFFECTIVE DATE

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ARTICLE XIII - ADVANCE PAYMENT

(1) Amount of Advance. At the request of the Contractor, and subject to the conditions hereinafter set forth, AID shall make an initial advance payment to the Contractor in an amount not to exceed $21,875. No advance payment shall be made (a) without the approval of the office administering advance payments (hereinafter called the "Administering Office" and designated in paragraph (9)(c) hereof) as to the financial necessity therefor; (b) in an amount which together with all advance payments theretofore made, shall exceed the amount stated in paragraph (9)(a) hereof; and (c) without a properly certified invoice or invoices. To request the initial advance payment, the Contractor shall submit Voucher Form SF-1034 and 1034(a) to the Agency for International Development, Office of Financial Management, Central Services Division, Washington, D.C. 20523.

(2) Use of Funds. The funds may be used by the Contractor solely for the purposes of making payments for items of allowable cost as defined in Article VI of this Contract, or to reimburse the Contractor for such items of allowable cost, and for such other purposes as the Contracting Officer may approve in writing. Any interpretation required as to the proper use of funds shall be made in writing by the Contracting Officer.

(3) Return of Funds. The Contractor may at any time repay all or any part of the funds advanced hereunder. Whenever so requested in writing by the Contracting Officer, the Contractor shall repay to the Government such part of the unliquidated balance of advance payments as shall in the opinion of the Contracting Officer be in excess of current requirements,

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or (when added to total advances previously made and liquidated) in excess of the amount specified in paragraph (9)(a) hereof.

(4) Replenishment and Liquidation. Following the initial advance payment, AID will periodically reimburse the Contractor in amounts equal to reported expenditures in order to replenish the advance funds on an imprest basis. Such replenishment shall be made monthly upon submission of documents prescribed in General Provisions Clause 9, entitled "Allowable Cost, Fixed Fee, and Payment", until such time as total reimbursements plus the initial advance payment equals the amount of total estimated cost stated in Article V of this Contract. Thereafter, vouchers for expenditures, which shall be marked "NO PAY" by the Contractor before submission, will not be reimbursed, but will be applied to liquidate the remaining outstanding advance. In the event that the total amount of such subsequent vouchers is insufficient to completely liquidate the outstanding advance, the Contractor shall, pursuant to General Provision Clause 9, entitled "Allowable Cost, Fixed Fee, and Payment", make repayment to AID of all unexpended portions of the advanced dollar funds which are not obligated under this Contract at the time of submission of the "final voucher". In the event that there are such outstanding obligations, a subsequent accounting with respect thereto shall be made in the same manner as prescribed by the said General Provision Clause 9.

(5) Default Provisions. Upon the happening of any of the following events of default, (a) termination of this Contract by reason of fault of the Contractor; (b) a finding by the Contracting Officer that the Contractor (i) has failed to observe any of the covenants, conditions, or warranties

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of these provisions or has failed to comply with any material provision of this contract, or (ii) has so failed to make progress, or is in such unsatisfactory financial condition, as to endanger performance of this Contract, or (iii) has allocated inventory to this Contract substantially exceeding reasonable requirements, or (iv) is delinquent in payment of taxes or of the costs of performance of this Contract in the ordinary course of business; (c) appointment of a trustee, receiver or liquidator for all or a substantial part of the Contractor's property, or institution of bankruptcy, reorganization, arrangement or liquidation proceedings by or against the Contractor; or (d) the commission of an act of bankruptcy; the Government, without limiting any rights which it may otherwise have, may, in its discretion and upon written notice to the Contractor, withhold further payments on this Contract. Upon the continuance of any such events of default for a period of thirty (30) days after such written notice to the Contractor, the Government may, in its discretion, and without limiting any other rights which the Government may have, take the following additional actions as it may deem appropriate in the circumstances:

(i) Withdraw all or any part of the balance of the advance payments by checks payable to the Treasurer of the United States and apply such amounts in reduction of advance payments then outstanding hereunder and in reduction of any other claims of the Government against the Contractor;

(ii) Charge interest on advance payments outstanding during the period of any such default at the rate of six percent (6%) per annum;

(iii) Demand immediate repayment of the unliquidated balance of

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advance payments hereunder; or

(iv) Take possession of and, with or without advertisement, sell at public sale at which the Government may be the purchaser or at a private sale, all or any part of the property on which the Government has a lien under this Contract and, after deducting any expenses incident to such sale, apply the net proceeds of such sale in reduction of the unliquidated balance of advance payments hereunder and in reduction of any other claims of the Government against the Contractor.

(6) Prohibition against Assignment. Notwithstanding any other provision of this Contract, the Contractor shall not transfer, pledge, or otherwise assign this Contract, or any interest therein, or any claim arising thereunder, to any party or parties, bank, trust company, or other financing institution.

(7) Representations and Warranties. To induce the making of the advance payments, the Contractor represents and warrants that:

(a) No litigation or proceedings are presently pending or threatened against the Contractor.

(b) None of the provisions herein contravenes or is in conflict with the authority under which the Contractor is doing business or with the provisions of any existing indenture or agreement of the Contractor.

(c) The Contractor has the power to enter into this Contract and accept advance payments hereunder, and has taken all necessary action to authorize such acceptance under the terms and conditions of this Contract.

(d) There has been no assignment of claims under any contract affected by these advance payment provisions or if there has been any assig-

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ment, such assignment has been terminated.

(e) All information furnished by the Contractor to the Administering Office in connection wich each request for advance payments is true and correct.

(f) These representations and warranties shall be continuing and shall be deemed to have been repeated by the submission of each invoice for advance payment.

(8) Covenants. During the period of time that advance payments may be made hereunder and so long as any such advance payments remain unliquidated, the Contractor shall not, without the prior written consent of the Contracting Officer, mortgage, pledge, or otherwise encumber, or suffer to be encumbered, any of the assets of the Contract now owned or hereafter acquired by it, or permit any pre-existing mortgages, liens, or other encumberances to remain on or attach to any assets of the Contractor which are allocated to the performance of this Contract and with respect to which the Government has a lien hereunder.

(9) Designations and Determinations

(a) Amount. The aggregate amount of the advance payment to be made hereunder (less the aggregate amounts paid or withdrawn pursuant to paragraph (3) shall not exceed $21,875.

(b) Interest Charge. No interest shall be charged for advance payments made hereunder, except interest during a period of default as provided for in paragraph (5).

(c) Administering Office. The office administering advance payments is designated as Office of Financial Management, AID.

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(10) Other Security. The terms of this Contract shall be considered adequate security for advance payments hereunder, except that if at any time the Administering Office deems the security furnished by the Contractor to be inadequate, the Contractor shall furnish such additional security as may be satisfactory to the Administering Office, to the extent that such additional security is available.

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MEMORANDUM

DATE: March 16, 1976

TO : AA/TA, Dr. Erven J. Long

FROM : TA/PPU, John N. Gunning

SUBJECT: Request for additional funds to increase scope of work in Artifical Propagation of Milkfish Project.

Subject activity was approved at a level of $450,000 for a 3 year research effort and finally contracted at a level of $498,532. TA/AGR is now requesting an amendment to the contract to increase the funding level of the contract by $35,800 to include a research effort on milkfish which had not been included in the original contract. Approval of TA/AGR's request would bring the total cost of the contract up to $534,332 or a 19% increase over the approved level. In accordance with Handbook #3, chapter 3, it is not necessary to obtain Mr. Murphy's approval.

We concur with the increase scope of work set forth in TA/AGR memorandum and recommend your approval.

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ATTACHMENT A

GENERAL WORK PLAN*

The program has to be envisaged as a series of steps, each representing progress to the ultimate goal of successful artificial propagation of milkfish and improving farming methods.

The program activities are therefore a logical sequence of events and hopefully successes which enable the objectives to be reached in the shortest possible time. During the process it is known from experience that short-term research projects will be necessary to enable the next step to be made. Such research projects will be undertaken at once. If an aspect of the work indicates a long-term research project, then action will be taken to obtain the support elsewhere. For example, problems with disease other than the basic control of bacteria will be pased to another center.

It is hoped that the progress of the study might pursue the following pattern within the given time frame:

Year 1 - Select suitable broodstock.

- Commence collection of physiological data on reproductive cycles, identify stages of egg and sperm.
- Observe first reactions to hormones, particularly salmon pituitary gonadotropin as indicator.
- Develop larval rearing techniques following successful incubation of any fertilized eggs obtained.
- Identify individual brood fish reacting well to injection and with high quality eggs or sperm as indicated by larval survival.
- Arrange a joint seminar with Auburn University and University of Rhode Island. Visit U.S. AID aquaculture project in Philippines, Tungkang Fisheries Institute in Taiwan and survey Japan's recent progress in cage and pen construction.

Year 2 - Upgrade levels of activity in larval rearing technology.

- Formulate mass propagation techniques using controlled data following studies in first year, i.e., larval density, food density, etc.
- Exchange personnel with Auburn University, and apply results of the first year where applicable to the U.S. AID aquaculture project in the Philippines.

Year 3 - Extension to be determined by 18 month review.

*A detailed work plan will be supplied to SER by Oceanic Foundation through TA/AGR in draft within six weeks of this date.

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ATTACHMENT B

Artificial Propagation

	Year 1	Year 2	Year 3	Year 4	Year 5
A. Personnel Salaries and Wages					
C.E. Nash, Ph.D. (20% time)	5,000	5,250			
C.M. Kuo, Ph.D. (80% time)	20,000	21,000		5 percent annual	
A. C. Smith, Ph.D. (20% time)	5,000	5,250		cost-of-living increases	
Two research assistants (100%)	22,000	23,100			
Technicians (one the first year, two the second year) (100%)	9,000	20,000			
Subtotal	61,000	74,600			
B. Fringe Benefits (10%)	6,100	7,460			
C. Combined Salaries + Benefits	67,100	82,060	86,160	90,470	95,000
D. Expendable Supplies	10,000	10,000	10,000	10,000	10,000
E. Permanent Equipment	20,000	20,000	20,000	20,000	20,000
F. Travel	3,500	5,500	7,500	7,500	7,500
G. Overhead (46% of A+B+C+D)	35,470	42,350	44,230	46,220	48,300
H. Contingency (10% of A-G)	13,610	15,990	16,790	17,420	18,080
TOTAL	149,680	175,900	184,680	191,610	198,880

Note: Budget above is suggested by TA/AGR and should be adjusted by Oceanic Foundation to conform to RAC Approval of funding of $250,000 first two years, and depending on 18 month review and a total of $450,000 for first three years. Further, RAC approval will need to proceed to a total of not to exceed $870,000 for five years.

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AID 1230-1X (7-71)

PIO/T

DEPARTMENT OF STATE
AGENCY FOR
INTERNATIONAL DEVELOPMENT

PROJECT IMPLEMENTATION ORDER/TECHNICAL SERVICES

1. Cooperating Country: WORLDWIDE 25-31566

2. PIO/T No. 931-17-130-526-

3. [X] Original or Amendment No. 7

4. Project/Activity No. and Title: The Artificial Propagation of Milkfish

DISTRIBUTION

5. Appropriation Symbol: 72-11X1023

6.A. Allotment Symbol and Charge: 402-31-099-00-22-57

6.B. Funds Allotted to: [ ] A.I.D./W [ ] Mission

7. Obligation Status: [X] Administrative Reservation [ ] Implementing Document

8. Funding Period (Mo., Day, Yr.): From 12/1/74 To 12/1/76

9.A. Services to Start (Mo., Day, Yr.): Between 12/1/74 and 12/15/74

9.B. Completion date of Services (Mo., Day, Yr.): 12/1/77

10.A. Type of Action: [X] A.I.D. Contract [ ] Cooperating Country Contract [ ] Participating Agency Service Agreement [ ] Other

10.B. Authorized Agent: AID/W

Estimated Financing $1.00=		(1) Previous Total	(2) Increase	(3) Decrease	(4) Total to Date
11. Maximum A.I.D. Financing	A. Dollars		250,000		250,000
	B. U.S.-Owned Local Currency			FUNDS [illegible]	[illegible]
12. Cooperating Country Contributions	A. Counterpart				1/6/75
	B. Other			SER/FM/CSD	

Mission References

14. Instructions to Authorized Agent

This PIO/T requests the Contract Office to negotiate a new contract with the Oceanic Foundation, Waimanalo, Hawaii to provide research services described in Block 19 herein for a 3-year period beginning approximately December 1, 1974. The estimated cost of this 36 month period is $450,000 and the estimated cost of the first 24 months thereof is $250,000, as approved by RAC on October 17-18, 1974. This PIO/T provides only for the first 24 months incremental funding. The balance of the funding should be provided subsequently subject to reviews and availability of funds. May be necessary to modify this work plan when a detailed work plan is submitted and reviewed by AID.

Attachments:
A. General Work Plan; B. Budget

15. Clearances – Show Office Symbol, Signature and Date for all Necessary Clearances.

A. The specifications in the scope of work are technically adequate
/AGR, H. Rice Date: 11/15/74

B. Funds for the services requested are available
TA/PM, C. Molfetto Date: 12/5/74

C. The scope of work lies within the purview of the initiating and approved Agency Programs
AGR: L. Hessel Date: 11/15/74
TA/AGR, G. Baird Date:
TA/AGR, R. Holmes Date: 11/15/74

D. TA/RIG, M. Recheigl Date: 11/27/74

F. TA/PM, Mary Mozynski Date: 12/5/74

For the cooperating country: The terms and conditions set forth herein are hereby agreed to

Signature and date:

17. For the Agency for International Development
Signature: John Gunning
Title: Chief, Program Div. TA/PM

18. Date of Signature: 12/[illegible]

Cover to Contract 1/6/75

OPO 867-77

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AID 1350-1X (9-70) PIO/T	Cooperating Country Worldwide	PIO/T No.	Page 2 of Pages
	Project/Activity No. and Title The Artificial Propagation of Milkfish		

SCOPE OF WORK

19. Scope of Technical Services

A. Objective for which the Technical Services are to be Used

To learn how to breed and rear juvenile milkfish in captivity in sufficient quantity to supply small farmer demands in LDCs at the "farm gate".

XXXXXXXXXX

The major components of the proposed program by the Oceanic Foundation are to develop effective and controlled means of producing seed fish upon which mature fish production enterprises are based and to develop effective distribution systems.

B. Description

The primary goal of the project is to develop the artificial propagation of the milkfish in the shortest possible time. The goal will be attained by a direct assault on those aspects known to be necessary to achieve that end. In addition to the practical production, which will be evaluated by the cost effectiveness of juveniles produced each year, a number of specific research targets will need to be achieved in order to supply the detailed scientific information required for direct progress toward the overall goal. (Continued)

C. Technicians

(1) (a) Number	(b) Specialized Field	(c) Grade and/or Salary	(d) Duration of Assignment (Man-Mont)
See Attachment B			

(2) Duty Post and Duration of Technicians' Services

Contractor's location in Hawaii and such other locations as the parties agree upon.

(3) Language requirements

English.

(4) Access to Classified Information

None conterplated at this time. .

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(5) Dependents ☐ Will ☐ Will Not Be Permitted to Accompany Technician

D. Financing of Technical Services

(1) By AID - $ 250,000 (2) By Cooperating Country –

20. Equipment and Supplies (Related to the services described in Block 19 and to be procured outside the Cooperating Country by the supplier of these services)

A. (1) Quantity (2) Description (3) Estimated Cost (4) Special Instructions

To be detailed by the contractor and TA/AGR and made a part of this PIO/T

B. Financing of Equipment and Supplies

(1) By AID – $ (2) By Cooperating Country –

21. Special Provisions

☒ A. This PIO/T is subject to AID (contracting) (PASA implementation) regulations.

☒ B. Except as specifically authorized by AID, or when local hire is authorized under the terms of a contract with a U.S. Supplier, services authorized under this PIO/T must be obtained from U.S. sources.

☒ C. Except as specifically authorized by AID/W, the purchase of commodities authorized under this PIO/T will be limited to the U.S. under Geographic Code 000.

☒ D. Other (specify): SPECIAL PROVISIONS - Prior to making any visits to LDCs, the Contractor will review his plans with TA/AGR. He will keep AID Missions in countries to be visited fully informed of proposed visits, ask them to provide any advice they wish regarding timing and content of the visits and to participate if they desire, and will inform the Missions of the outcomes of consultations. He will make his own appointments and logistics arrangements directly. Upon completion of any project funded travel, a copy the trip report will be provided to the TA/AGR Project Manager. The report format ~~will be established jointly by the Contractor and the~~ Project Manager.

(continued)

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22. Reports by Contractor or Participating Agency (Indicate type, content and format of reports required, including language to be used if other than English, frequency or timing of reports, and any special requirements)

Fifty (50) copies of annual reports in English will be required 45 days after the anniversary date of the contract. Guidelines for Preparation of the Research Annual Report are attached and should be an attachment to the contract.

Background Information (Additional information useful to Authorized Agent and Prospective Contractors or Participating Agency, if necessary cross reference Block 19.C(4) above.)

In addition to coordinating its plans and operations with the AID project monitor, it is expected that contractor shall have access to research results developed under other AID research and technical assistance contracts.

24. Relationship of Contractor or Participating Agency to Cooperating Country and to AID

A. Relationships and Responsibilities

Contractor shall coordinate its activities and plans through the AID Project Monitor and it is expected that contractor shall have access to research results developed under other AID research and technical assistance contracts.

B. Cooperating Country Liaison Official

Activities in any country will be cleared and coordinated through the AID Mission.

C. AID Liaison Officials

Dr. Leon F. Hesser, TA/AGR
Dr. Harold L. Rice, TA/AGR

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AID-1300-1X (7-69) CONTINUATION SHEET	DEPARTMENT OF STATE AGENCY FOR INTERNATIONAL DEVELOPMENT	[X] Worksheet [ ] Issuance	PAGE 5 OF ___ PAGES
		1. Cooperating County Worldwide	2.a. Code No.
FORM SYMBOL	TITLE OF FORM	2.b. Effective Date	2.c. [ ] Original OR Amendment No: ___
PIO/T		3. Project/Activity No. and Title The Artificial Propagation of Milkfish	

Indicate block numbers.

19 B

Use this form to complete the information required in any block of a PIO or PA/PR form.

1. Broodstock collection and holding. A considerable number of broodstock will be captured for research material , to indicate husbandry requirements for holding adults, for illustrating their food requirements, and for providing a large gene pool for increasing the chances of good larval survival after breeding.

Difficulties have been experienced by everyone working with milkfish in obtaining large fish which survive capture and subsequent handling. Present practices used by the Foundation have been to handle and sample the gonads of younger fish, getting them used to the technique as they mature.

Each fish on site will be numbered by year, class and sex, and its life history recorded while it is in captivity, particularly details of spawning, subsequent fertility and survival and growth of its offspring.

The success of an artificial propagation system depends primarily on the quality and quantity of broodstock resources. Large numbers of sexually mature individuals must be contained in good health under acceptable environmental conditions in order to reproduce and yield viable offspring.

Some essential external conditions for broodstock fish requiring research are suitable water quality, a nutritious diet, high standards of hygiene and limited physical disturbance. But most importantly the broodstock must be exposed to the correct environmental parameters which influence the physiological changes in the pituitary gland and stimulate the gonads to seasonal maturity.

Many experiments with fish have used gonad development to interpret the effects of certain environmental regulators on the reproductive cycle. Among the factors concerned are temperature and photoperiod which initiate pituitary activity. The relative importance of each varies with different species of fish .

The project will apply the existing knowledge for maintaining captive Mugilidae in the most suitable environment for breeding to maintaining captive milkfish. It will concentrate on details of enclosure size, population density, health, sexual development, behavior and environmental controls and manipulation. The objective is to detail the conditions for holding large numbers of broodstock throughout the year, and to phase the spawning process to establish year-round production of fertile eggs.

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AID-1300-1X (7-69) CONTINUATION SHEET	DEPARTMENT OF STATE AGENCY FOR INTERNATIONAL DEVELOPMENT	[X] Worksheet [ ] Issuance	PAGE 6 OF ___ PAGES
		1. Cooperating County: Worldwide	2.a. Code No.
FORM SYMBOL	TITLE OF FORM	2.b. Effective Date	2.c. [ ] Original OR Amendment No: ___
PIO/T		3. Project/Activity No. and Title: The Artificial Propagation of Milkfish	

Indicate block numbers.

19 B

Use this form to complete the information required in any block of a PIO or PA/PR form.

2. Induced breeding techniques. The physical containment of fish and their maintenance in captivity for high survival are not generally difficult problems. Milkfish readily become domesticated, as testified by centuries of pond farming. They grow in captivity and are technically mature, but individual females will not undergo the final stages of gametogenesis and spawn in captivity. At present these stages need the artificial stimulus of hormone injection to complete the breeding cycle.

The project will use the induced breeding techniques already established for the Mugilidae and use partially purified salmon gonadotropin SG-G100. It will specify a technique, providing data on the critical time for injection, dose rate and frequency, subsequent development procedures and behavioral reactions. An important objective for induced breeding is to select a hormone which is widely available and to standardize its potency and establish spawning dosage against egg maturity.

Finally, present induced spawning techniques are applied to stimulate the final stages of development.

3. Egg and sperm quality. Egg and sperm quality will be judged by microscopic gross appearances and subsequent fertility. The minimum of histological examinations will be made to establish a sequential record of embryonic development to which all subsequent observations can be related. If poor larval survival is persistent, then detailed but short-term studies on the biochemical composition of the eggs will be necessary in order to establish that induced spawning does not influence development detrimentally.

Once egg and sperm quality are established, it is anticipated that there will be significant variations between individuals. Good fish will be marked for their capacity to produce good quality gametocytes and used individually year after year. An early start identifying good fish in this way will begin a genetic aspect of the program.

4. Egg incubation and larval survival. Environmental controls during larval development have concentrated mostly on temperature, salinity, pH, oxygen and light intensity. They all influence the rate of incubation development and/or survival in some way.

However, the success of the larval rearing technique and the need to become involved in short-term experiments will be judged by the annual production figures from the hatchery operation and from observations made during the process. If salinity changes are indicated then a series

(Continued)

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19 B

of short-term research experiments will be conducted to indicate the right saline regime for optimizing production. Similarly- short-term experiments may be conducted for light intensity, water quality, food density and food regimes.

For example, it may be necessary to work on the changes in body fluids in varying salinities to establish the time at which the larvae can be exposed to lower salinities. The work will be performed in replicate aquaria and in an existing density column.

5. Hatchery distribution. Mass propagation is ineffective without satisfactory means to distribute the juveniles safely to the farms and the farmers requiring them.

Handling operations for young fish can be detrimental to their survival. Mishandling and overcrowding, thereby draining oxygen from the water used for transport, rapidly reduce their numbers. The final project for the mass propagation goal will be to test the best methods of transportation for the juveniles.

---

21 D

2. It is TA/AGR's understanding that work on mullet, well advanced at the Oceanic Foundation, will be continued on funds other than this project. It is considered essential to the success of this project that the mullet work be continued and should it not, AID should be notified prior to its termination.

3. Reviews will be at 18 months and again at 32 months. The outcome of the 18 months review will determine program direction in the third year and the outcome of the 32 months review will determine whether there is need for additional research in the fourth and fifth years and, if so, the funding level for the fourth and fifth years.

4. During the life of this project no research, design, nor construction of pens or enclosures for commercial fish production will be carried out.

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January 20, 1972

10p.

GUIDELINES FOR PREPARATION

OF THE

RESEARCH ANNUAL REPORT

The attached guidelines suggest the format and the detail for annual research reports that are required in all research contracts. The research contractor will submit thirty-five copies of the report with appendices to the A.I.D. Project Manager. The A.I.D. Project Manager will submit two copies to TA/RUR and two copies to the A.I.D. Reference Center.

The outline should prove useful to the contractor in preparing the report, and provide an improved basis for annual project reviews. The contractor is encouraged to develop a self-contained report as outlined below in approximately fifteen double-spaced pages. Additional material may be annexed as necessary for a comprehensive report. The fifteen page report is intended to provide a barebones statement of the effectiveness of research resources and methods in producing research results according to annual work plans, and the significance of these research results for the solution of the problem being addressed. Annexed material is essential for a critical review of assertions regarding findings, significance, etc.

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REPORT SUMMARY 1/

A. 1. Project Title and Contract Number:

2. Principal Investigator, Contractor and Mailing Address:

3. Contract Period (as amended): 2/ from _____ _____ to _____

4. Period covered by Report: from _____ to _____

5. Total A.I.D. funding of contract to date:

6. Total expenditures and obligations through previous contract year: 3/

7. Total expenditures and obligations for current year: 3/

8. Estimated expenditures for next contract year:

B. Narrative Summary of Accomplishments and Utilization

(In this space provide a concise statement of the principal accomplishments during (1) the period of the report and (2) life of the project in relation to research objectives and actual or potential operational significance.

This information does not substitute for a full discussion of the same points required in the body of the Annual Research Report as outlined below.)

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Identify significant problems or accomplishments in the progress of the project related to the volume, effectiveness, or scheduling of the manpower, equipment, travel, etc., made available by these expenditures.

Discuss significant changes or modifications in project management, in the staffing pattern, physical facilities, institutional environment, etc.

G. Work Plan and Budget Forecast for Coming Year

Taking into consideration the past year's progress and expenditures and the work remaining to be done over the life of the project, present a work plan and budget for the coming year.

1. anticipated accomplishments for the coming year.

2. procedures to be used and activities to be carried out.

3. significant factors that you anticipate that will promote or impede accomplishments.

4. a plan for dissemination and utilization of the expected results of the research in the U.S. and in LDCs as applicable.

5. a budget statement that shows planned expenditures for each of the major inputs (personnel, equipment, travel, LDC involvement, etc.) according to the major accomplishments, or work targets that are planned for the coming year's work.

H. Appendices

Reports of technical data and analyses (Par. D. 2)
A bibliographic list with abstracts of papers and publications (Par. E. 1)
A list of uses made of research findings and reports (Par. E. 1)
Other appendices as appropriate.

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1/ "Report Summary": Statistical Information (Item A) and the Narrative Summary of Accomplishments (Item B) should be reported on a single page. This page will be for general public use as well as project management purposes, and should be written for a general rather than a technical audience.

2/ Item 3 - Contract Period (as amended): Report the original date of the contract and closing date as prescribed by the contract or any amendment thereto.

3/ Items A 6-8: These items refer to expenditures including firm obligations by the contractor. Obligations are the contractor's legal but unpaid commitments, i.e., subcontracts, purchase orders, etc.; and other related accruals through the end of the reporting period. A "contract year" is one between anniversary dates of the contract.

ANNUAL RESEARCH REPORT

A. General Background

Prepare a concise statement that provides the background and rationale that led to the initiation of the project. This summary should state the nature and importance of the problem to which the research is addressed, and the rationale that links the research activity to the problem.

B. Statement of Project Objectives as Stated in the Contract

The purpose of this section is to record in a precise and concise way the objectives of the research project. The objectives as stated in the contract may have been interpreted, expanded or further defined in other documents and mutually agreed to by A.I.D. and the contractor. This section should reflect the contractual objectives as modified by these supplementary understandings.

C. Continued Relevance of Objectives

Does your research to date, or other circumstances, indicate a need for modification of project objectives as stated in the contract? If so, in what respects?

D. Accomplishments to Date

1. Findings: Provide a statement of the principal and significant findings and other accomplishments for the reporting period as they relate to the anticipated results in the year's work plan. (See material for the year similar to that requested in G.1. below for the coming year.)

Discuss the operational significance of the findings of the current year's research for attainment of project objectives as stated in Section B above. The discussion should include reference to existing knowledge, recent research findings by others, and cumulative findings and accomplishments of this project.

Also discuss side effects of the work, positive or negative. For example, do the findings to date suggest unexpected complications for the application of findings; do they suggest the need for more direct approaches to the problem than were originally anticipated; or is the research developing information and insights not expected in the scope of the work?

2. Interpretation of Data and Supporting Evidence:

Summarize briefly the evidence and analysis that support the findings cited above. To permit a critical analysis of the evidence and analysis, expand as necessary in an appendix to each copy of the report.

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3. Research Design: State briefly any significant modifications made in the research design prior to the current reporting period.

Are the present techniques, instruments or mode of inquiry appropriate and/or optimal for the study design? In view of the findings of the past year or your experience with the research measures employed, do you recommend modifying (1) the research design or (2) research techniques? For example, have there been special problems of data availability, sampling, data processing, or ineffective techniques? Have research findings revealed technical relationships that suggest a continuation of present methods or do they suggest a new approach?

E. Dissemination and Utilization of Research Results

1. Briefly describe efforts made under the contract to disseminate the results of the research project. Attach as appendices two lists: (1) a bibliographic list and an abstract not exceeding 200 words of papers and publications developed under the contract and (2) a list of short statements that identify each known use of materials produced by the project for seminars, conferences, translations, or as background material for speeches, policy statements, etc.

2. Cite evidence and cases known to you that findings of the research project are being used in LDCs, the U.S., or both, in training, direct application to the problem, etc.

3. Has the experience of the past year suggested new or more effective ways to expand the use of research results? If so, discuss the experience and as appropriate include proposed steps in the work plan (Item G below). Indicate whether your proposals can be carried out under current provisions of the contract, or would require new contract arrangements by A.I.D.

4. Discuss the extent and nature of considerations to involve LDC personnel and/or institutions as an appropriate activity of the project. If judged appropriate, discuss the kind and extent of LDC involvement in (a) planning the project, (b) the execution of the field work, (c) the analysis and reporting of results. Plans to involve LDCs in the future should be reflected in the work plan in Item G (4) below.

5. Under separate cover forward four copies of publications, seminar reports, translations and other materials representing efforts to disseminate results of the research project, and evidence of the results being utilized by LDC or U.S. people or institutions.

F. Statement of Expenditures and Obligations and Contractor Resources

Provide a statement of expenditures and obligations related to the budget plan for the year. This statement should show expenditure and obligations for each of the (1) major inputs (Personnel, equipment, travel, etc.) according to (2) the major accomplishments or work targets that had been planned for the year's work.

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Identify significant problems or accomplishments in the progress of the project related to the volume, effectiveness, or scheduling of the manpower, equipment, travel, etc., made available by these expenditures.

Discuss significant changes or modifications in project management, in the staffing pattern, physical facilities, institutional environment, etc.

G. Work Plan and Budget Forecast for Coming Year

Taking into consideration the past year's progress and expenditures and the work remaining to be done over the life of the project, present a work plan and budget for the coming year.

1. anticipated accomplishments for the coming year.

2. procedures to be used and activities to be carried out.

3. significant factors that you anticipate that will promote or impede accomplishments.

4. a plan for dissemination and utilization of the expected results of the research in the U.S. and in LDCs as applicable.

5. a budget statement that shows planned expenditures for each of the major inputs (personnel, equipment, travel, LDC involvement, etc.) according to the major accomplishments, or work targets that are planned for the coming year's work.

H. Appendices

Reports of technical data and analyses (Par. D. 2)
A bibliographic list with abstracts of papers and publications (Par. E. 1)
A list of uses made of research findings and reports (Par. E. 1)
Other appendices as appropriate.

GENERAL PROVISION NO. 44

COST ACCOUNTING STANDARDS

(a) Unless the Cost Accounting Standards Board has prescribed rules or regulations exempting the Contractor or this contract from standards, rules, and regulations promulgated pursuant to 50 U.S.C. App. 2168 (P.L. 91-379, August 15, 1970), the Contractor, in connection with this contract shall:

(1) By submission of a Disclosure Statement, disclose in writing his cost accounting practices as required by regulations of the Cost Accounting Standards Board. The required disclosures must be made prior to contract award unless the Contracting Officer provides a written notice to the Contractor authorizing postaward submission in accordance with regulations of the Cost Accounting Standards Board. The practices disclosed for this contract shall be the same as the practices currently disclosed and applied on all other contracts and subcontracts being performed by the Contractor and which contain this Cost Accounting Standards clause. If the Contractor has marked the Disclosure Statement to indicate that it contains trade secrets and commercial or financial information which is privileged and confidential, the Disclosure Statement will be protected and will not be released outside of the Government.

(2) Follow consistently the cost accounting practices disclosed pursuant to (1), above, in accumulating and reporting contract performance cost data concerning this contract. If any change in disclosed practices made for the purposes of any contract or subcontract subject to Cost Accounting Standards Board requirements, the change must be applied prospectively to this contract, and the Disclosure statement must be amended accordingly. If the contract price or cost allowance of this contract is affected by such changes, adjustment shall be made in accordance with subparagraph (a)(4) or (a)(5), below, as appropriate.

(3) Comply with all Cost Accounting Standards in effect on the date of award of this contract or if the Contractor has submitted cost or pricing data, on the date of final agreement on price as shown on the Contractor's signed certificate of current cost or pricing data. The Contractor shall also comply with any Cost Accounting Standard which hereafter becomes applicable to a contract or subcontract of the Contractor. Such compliance shall be required prospectively from the date of applicability to such contract or subcontract.

(4) (A) Agree to an equitable adjustment as provided in the Changes clause of this contract if the contract cost is affected by a Disclosure Statement change which the Contractor is required to make pursuant to (3), above. If the Contractor has not been required to file a Disclosure Statement but is required pursuant to (a) (3), above, to change an established practice, then an equitable adjustment shall similarly be agreed to.

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(B) Negotiate with the Contracting Officer to determine the terms and conditions under which any Disclosure Statement change other than changes under (4) (A), above, may be made. A change to a Disclosure Statement may be proposed by either the Government or the Contractor, provided, however, that no agreement may be made under this provision that will increase costs paid by the United States under this contract.

(5) Agree to an adjustment of the contract price or cost allowance, as appropriate, if he or a subcontractor fails to comply with an applicable Cost Accounting Standard or to follow any practice disclosed pursuant to subparagraphs (a) (1) and (a) (2), above, and such failure results in any increased costs paid by the United States. Such adjustment shall provide for recovery of the increased costs to the United States together with interest thereon computed at the rate determined by the Secretary of the Treasury pursuant to P.L. 92-41, 85 Stat. 97, or 7 percent per annum, whichever is less, from the time the payment by the United States was made to the time the adjustment is effected.

(b) If the parties fail to agree whether the Contractor or subcontractor has complied with an applicable Cost Accounting Standard, rule, or regulation of the Cost Accounting Standards Board and as to any cost adjustment demanded by the United States, such failure to agree shall be a dispute concerning a question of fact within the meaning of the Disputes clause of this contract.

(c) The Contractor shall permit any authorized representatives of the head of the agency, the Cost Accounting Standards Board, or the Comptroller General of the United States to examine and make copies of any documents, papers, or records relating to compliance with the requirements of this clause.

(d) The Contractor shall include in all negotiated subcontracts which he enters into the substance of this clause except paragraph (b), and shall require such inclusion in all other subcontracts of any tier, except that this requirement shall apply only to negotiated subcontracts in excess of $100.000 where the price negotiated is not based on:

(1) Established catalog or market prices of commercial items sold in substantial quantities to the general public; or

(ii) Prices set by law or regulation.

NOTE:

1. Subcontractors shall be required to submit their Disclosure Statements to the Contractor. However, if a subcontractor has previously submitted his Disclosure Statement to a Government Contracting Officer he may satisfy that requirement by certifying to the Contractor the date of such Statement and the address of the Contracting Officer.

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2. In any case where a subcontractor determines that the Disclosure Statement information is privileged and confidential and declines to provide it to his Contractor or higher tier subcontractor, the Contractor may authorize direct submission of that subcontractor's Disclosure Statement to the same Government offices to which the Contractor was required to make submission of his Disclosure Statement. Such authorization shall in no way relieve the Contractor of liability as provided in paragraph (a) (5) of this clause. In view of the foregoing and since the contract may be subject to adjustment under this clause by reason of any failure to comply with rules, regulations, and Standards of the Cost Accounting Standards Board in connection with covered subcontracts, it is expected that the Contractor may wish to include a clause in each such subcontract requiring the subcontractor to appropriately indemnify the Contractor. However, the inclusion of such a clause and the terms thereof are matters for negotiation and agreement between the Contractor and the subcontractor, provided that they do not conflict with the duties of the Contractor under its contract with the Government. It is also expected that any subcontractor subject to such indemnification will generally require substantially similiar indemnification to be submitted by his subcontractors.

(e) The terms defined in Sec. 331.2 of Part 331 of Title 4, Code of Federal Regulations (4 CFR 331.2) shall have the same meanings herein. As there defined, "negotiated subcontract" means "any subcontract except a firm fixed-price subcontract made by a Contractor or subcontractor after receiving offers from at least two firms not associated with each other or such Contractor or subcontractor, providing (1) the solicitation to all competing firms is identical, (2) price is the only consideration in selecting the subcontractor from among the competing firms solicited, and (3) the lowest offer received in compliance with the solicitation from among those solicited is accepted."

(End of Clause)

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