PD-AAT-875

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT DATA SHEET

1. TRANSACTION CODE: C (A = Add, C = Change, D = Delete)

Amendment Number: One

DOCUMENT CODE: 3

COUNTRY/ENTITY: Worldwide

3. PROJECT NUMBER: 936-4161

4. BUREAU/OFFICE: Bureau of Science and Tech, Office of Agriculture — 10

5. PROJECT TITLE (maximum 40 characters): Reproductive Studies on Milkfish

6. PROJECT ASSISTANCE COMPLETION DATE (PACD): MM 12, DD 31, YY 89

7. ESTIMATED DATE OF OBLIGATION (Under "B." below, enter 1, 2, 3, or 4)

A. Initial FY 84 B. Quarter 4 C. Final FY 88

8. COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY 84 B. FX	C. L/C	D. Total	LIFE OF PROJECT E. FX	F. L/C	G. Total
AID Appropriated Total	1,250		1,250	4,850		4,850
(Grant)	(1,250)	( )	(1,250)	(4,850)	( )	(4,850)
(Loan)	( )	( )	( )	( )	( )	( )
Other U.S. 1.						
Other U.S. 2.						
Host Country						
Other Donor(s)						
TOTALS	1,250		1,250	4,850		4,850

9. SCHEDULE OF AID FUNDING ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE 1. Grant	2. Loan	D. OBLIGATIONS TO DATE 1. Grant	2. Loan	E. AMOUNT APPROVED THIS ACTION 1. Grant	2. Loan	F. LIFE OF PROJECT 1. Grant	2. Loan
(1) ARDN	121 J	077		1,250		3,600		4,850	
(2)									
(3)									
(4)									
TOTALS				1,250		3,600		4,850	

10. SECONDARY TECHNICAL CODES (maximum 6 codes of 3 positions each): 319, 960, 876, 874, 079, 976

11. SECONDARY PURPOSE CODE: 141

12. SPECIAL CONCERNS CODES (maximum 7 codes of 4 positions each)

A. Code	BS	R/AG	NUTR	TECH			
B. Amount	485	3,395	728	2,425			

13. PROJECT PURPOSE (maximum 480 characters)

To refine newly developed methodology for maturing and spawning milkfish in captivity; develop new methodology for rearing larvae of milkfish; demonstrate dependable methods for maturation and spawning milkfish; and expand developed methods to mullet and other marine species, such as snappers, groupers, etc.

14. SCHEDULED EVALUATIONS: Interim MM 09 YY 87; MM 03 YY 89; Final MM 12 YY 89

15. SOURCE/ORIGIN OF GOODS AND SERVICES: ☐ 000 ☐ 941 ☐ Local ☐ Other (Specify)

16. AMENDMENTS/NATURE OF CHANGE PROPOSED (This is page 1 of a ____ page PP Amendment.)

To extend for three years and add $3,600,000.

17. APPROVED BY

Signature: [signature]

Title: S&T/FA Duane Acker

Date Signed: MM DD YY 1 AUG 1986

18. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION: MM DD YY

Tab B

PROJECT AUTHORIZATION

Country: Interregional

Project: Reproductive Studies on Milkfish

Project No: 936-4161

1. Pursuant to Section 103 of the Foreign Assistance Act of 1961, as amended, the centrally funded project, Reproductive Studies on Milkfish was authorized on June 15, 1984. That authorization is hereby amended as follows:

   a. The authorized final year of obligation is extended to FY 1988; and

   b. The authorized funding for the project is increased in the amount of $3,600,000 to $4,850,000 subject to the availability of funds in accordance with A.I.D. OYB/allotment process.

2. The purpose of this project is to: 1) refine newly developed methodology for maturing and spawning milkfish in captivity; 2) develop new methodology for rearing larvae of milkfish; demonstrate dependable methods of maturation and spawning milkfish; and 3) expand developed methods to mullet and other marine species, such as snappers, groupers, etc.

3. The agreement which may be negotiated and executed by the officer to whom such authority is delegated in accordance with A.I.D. regulations and Delegations of Authority shall be subject to the following terms and conditions, together with such other terms and conditions as A.I.D. may deem appropriate.

Source and Origin of Commodities, Nationality of Services

a. Commodities financed by A.I.D. under the project shall have their source and origin in the cooperating country* or the United States, except as A.I.D. may otherwise agree in writing. Except for ocean shipping, the suppliers of commodities or services shall have the cooperating country or the United States as their place of nationality, except as A.I.D. may otherwise agree in writing.

b. Ocean shipping financed by A.I.D. under the project shall, except as A.I.D. may otherwise agree in writing, be financed only on flag vessels of the United States.

* Each country where research, training, technical, or other assistance takes place under the project shall be deemed to be a cooperating country for the purpose of permitting local cost financing of goods and services for the activity being conducted in such country. Such activities may be undertaken in any country included in A.I.D. geographic code 935.

Duane Acker
Agency Director
for Food and Agriculture

Clearances:

S&T/AGR,	Richard Neal	RAN	date 7/24/86
	Elizabeth Roche		date 7/24/86
S&T/PO,	Vivian Anderson		date 7/31/86
	Gerald Gower		date 8/1/86
GC,	Stephen Tisa		date 7/28/86

MFPROPPA:7/23/86

Tab A

Reproductive Studies on Milkfish

Certification of the Procurement Plan

I certify that the procurement plan for this Project Paper (936-4161) was developed with full consideration of maximum involvement by minority and women-owned firms, historically Black colleges and universities and minority controlled PVOs in the provision of goods and services, and that the Project is not appropriate for minority or Gray Amendment contracting. We know of no minority institutions with an on-going program of the type required, or the requisite scientists and technical staff and facilities needed to implement this project. However, to ensure consideration of minority organizations as defined in the Gray Amendment, we will work with the Office of Procurement, and the Office of Small and Disadvantaged Businesses, to identify all potential organizations and institutions which may be available to work with the Oceanic Institute in the area of reproductive studies of milkfish.

Duane Acker
Agency Director,
for Food and Agriculture

MFPROPPA:7/23/86

1 AUG 1986

ACTION MEMORANDUM FOR THE AGENCY DIRECTOR FOR FOOD AND AGRICULTURE, BUREAU FOR SCIENCE AND TECHNOLOGY

FROM: Tejpal Gill, Acting Office Director, S&T/AGR

SUBJECT: Extension of Project 936-4161
Reproductive Studies on Milkfish DOC # 0002

Problem: Your approval is required to authorize a three-year extension of the "Reproductive Studies on Milkfish" project (936-4161) which requires an increase in the authorized life of project cost of $3,600,000 to a new total of $4,850,000 from the Agriculture, Rural Development and Nutrition Account, Section 103 of the Foreign Assistance Act of 1961, as amended. The Project Authorization is attached for your signature. (Tab B)

Discussion: Milkfish is the most important cultured marine fish in the world. Traditional methods for culturing of this fish have been practiced by farmers for hundreds of years in Southeast Asia; e.g., Indonesia, Philippines and Taiwan. However, these methods have resulted in a rather low yields. Higher yields (often 10 times higher) have been obtained through more intensive methods such as pen culture in the Philippines or pond culture in Taiwan. However, irrespective of method used, all of the juvenile fish needed to stock the ponds and pens are still gathered from the sea. This dependence on uncontrollable fry supply from natural fisheries is of great concern, and for years, studies have been aimed at inducing milkfish to reproduce in captivity with very little success.

The Oceanic Institute has pioneered in this very difficult technical area under this project. Research progress has led to demonstrations of successful new techniques for implantation of hormone-release capsules and for implantation/injection procedures for inducing maturation and spawning of milkfish in captivity. While considerable progress has been made, the research is not complete. Dependable methods for maturation and spawning on a routine basis have not been fully developed and the existing methods for inducement of maturation and spawning of milkfish have not been fully replicated in developing countries or with races of milkfish other than those available

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in Hawaii. In addition, the application of new methods developed for milkfish to other marine species offers a significant opportunity for an important contribution to salt water aquaculture technology.

The Oceanic Institute of Hawaii submitted a four-year unsolicited proposal for research on milkfish in January 1984. The proposal was reviewed by S&T/AGR and members of the Fisheries and Aquaculture Subcommittee of the Sector Council for Agriculture who recommended funding only the first two years of the proposal. The cooperative agreement was signed and became operational in July 1984. During this phase of the project, the Oceanic Institute developed the technology and demonstrated the techniques for enhancing the maturation and spawning of milkfish in captivity. In March 1986 the Oceanic Institute submitted a revised proposal for continuation and expansion of the research to fund the second phase of the research and development activities. (Tab C)

This proposal was reviewed by S&T/AGR and certain changes in the scope of work were recommended to the Institute in a letter from the Deputy Assistant Administrator for Research, Bureau for Science and Technology. (Tab C) The Institute responded by accepting the $3,600,000 level and recommending that the new funds be added to the existing cooperative agreement. (Tab C) The program description of the activities to be funded was collaboratively drafted by Dr. Lee and Mr. Dill of the Institute and Drs. Neal and Trott of S&T/AGR. The revised Program Description attached as Tab D.

In summary the research and development activities to be funded under the cooperative agreement during the three-year extension include the following activities:

1. Developing and evaluating technologies to shorten the time-span for gonadal maturation of milkfish in captivity.

2. Maximizing the production of fertilized eggs.

3. Developing semi-intensive and cost-effective culture systems for larval rearing.

4. Extending hormone technology to other finfish species.

5. Determining the feasibility of adopting new maturation technologies in LDCs.

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6. Studying the feasibility of using milkfish as baitfish.

7. Expanding existing and creating new networking relationships to disseminate and obtain information on fish reproductive technologies.

This three-year extension is consistent with the objectives of AID's Food and Agriculture Policy and Strategy to enable LDCs to become self-reliant in food and to assure food security. One clear way to achieve these objectives is to increase the availability of high protein foods in the LDCs. Fish have historically been vital to the well-being of many developing countries by providing basic nutritional needs and economic opportunities. The animal protein derived from fish has higher quality protein and a more desirable amino acid balance than that derived from livestock or poultry, and therefore does, under some circumstances, provide the most cost-effective way to increase animal protein intake.

Certification of the Procurement Plan: Certification that the procurement plan for this project was developed with full consideration of maximum involvement by minority and women-owned firms, historically Black colleges and universities and minority controlled PVOs in the provision of goods and services, and that the project is not appropriate for Minority or Gray Amendment contracting is attached as Tab A.

Method of Implementation: After evaluating the activities carried out under the current cooperative agreement in October 1985, and reviewing the unsolicited proposal submitted for the three-year extension, S&T/AGR has decided to continue to provide assistance to the Oceanic Institute under the cooperative agreement. The memorandum to the Office of Procurement which provides the rationale for accepting the Oceanic Institute's unsolicited proposal without consideration of other sources is attached as Tab E. This memorandum is required by Handbook 13, Chapter 1.B.2.f. Dr. Brady, the SAA/S&T, delegated authority to approve unsolicited proposal determinations to the agency directors on June 17, 1982.

S&T/AGR will provide $3,600,000 to fund this three-year extension of the cooperative agreement and project management will include technical and administrative support and oversight. An A.I.D. direct-hire employee will serve as project manager to assure that the objectives are achieved, facilitate acquisition of mission clearances, monitor project operations, approve certain administrative actions within the project, and maintain close liaison with the recipient.

The Technical Advisory Group will continue to serve during the extension period. Membership will continue to consist of milkfish researchers from Indonesia, Philippines and Taiwan, and others as deemed appropriate by S&T/AGR. The group will be convened semiannually or periodically (or individual members may be called upon at any time) by S&T/AGR to provide advice and guidance to S&T/AGR and the Oceanic Institute regarding the work under the cooperative agreement.

Environmental Considerations: This project will have little or no adverse impact on the environment. No genetic alteration of experimental fish will be undertaken during these studies. No foreign substances will be released into the environment and no undesirable effects on water, soil or air quality can be anticipated. The Environmental Threshold Determination is attached as Tab F.

Agency Policy: The project will be implemented in accordance with relevant Agency policies, including those on food and agriculture, development of human resources and institutional capabilities, and expanding the role of LDC scientists and institutions.

Justification to Congress: An Advice of Program Change has been prepared and will be sent to the appropriate Congressional Committees shortly.

Funding: S&T/AGR is requesting authorization for $3,600,000 of which $1,200,000 is to be obligated annually in FY 1986, FY 1987 and FY 1988. The cost estimates are appropriate for the planned level of effort described in the scope of work. The funds have been requested from PPC. As of this date, PPC has not indicated the level of funding which will be available in FY 1986.

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Recommendation:

1. That you sign the Certification of the Procurement Plan. (Tab A)

2. That you sign the attached Project Authorization approving the three-year extension and $3,600,000 of S&T funds for the "Reproductive Studies on Milkfish" project. (Tab B)

3. That you sign the Project Data Sheet. (Tab B)

4.. That you sign the memorandum to M/SER/OP, Ms. Kathryn Cunningham requesting that the cooperative agreement be awarded to Oceanic Institute without consideration of other sources. (Tab E)

3. That you sign the Environmental Threshold Determination and the Initial Environmental Examination. (Tab F)

Attachment:

Tab A - Certification of the Procurement Plan
Tab B - Project Authorization
Project Data Sheet
Tab C - Proposal received from Oceanic Institute
- Letter to Oceanic Institute from the Deputy Assistant Administrator for Research, Bureau for Science and Technology
- Letter from Ocean Institute to Deputy Assistant Administrator for Research
Tab D - Program Description
Tab E - Memorandum to SER/OP/ST
Tab F - Environmental Threshold Determination and Initial Environmental Examination

cc: S&T, Bradshaw Langmaid

Clearances:

S&T/AGR,	Richard Neal	RAN	date 7/24/86
	Elizabeth Roche	ERoche	date 7/24/86
S&T/PO,	Vivian Anderson	V.L.A.	date 7/31/86
	Gerald Gower	[illegible]	date 8/1/86
GC,	Stephen Tisa	[illegible]	date 7/28/86

MFAMEMO:7/21/86

Gill Tab C
SAT/AGR

THE OCEANIC INSTITUTE

Ref No. 0715-04
Action: Langmaid
As approp.
Due Date: —
Copies To: Grady
Brennan
Acker
Gill
Ch

July 9, 1986

Dr. Bradshaw Langmaid
Deputy Assistant Administrator
for Research
Agency for International Development
Washington, D.C. 20523

Dear Dr. Langmaid:

Thank you for your letter of July 2, 1986, confirming AID's intention to support the milkfish program at the Oceanic Institute at the level of $1.2 million per year for a period of three years. The Agency's appreciation of the work that the Institute has done during the past two years is most welcome.

Of the two alternatives you present in your letter regarding funding, we would prefer the extension of our existing cooperative agreement to begin July 16, 1986 at a level of $700,000 per year for three years, with the awarding of the companion grant at a level of $500,000 per year to begin in January or February, 1987, to run concurrently with the funded extension.

There has been some indication, however, that there is a possibility of extending and expanding our existing cooperative agreement to embrace the entire $1.2 million per year for three years beginning July 16, 1986. This would be our strong preference.

Dr. Lee and Mr. Dill will be in Washington the week of July 14 consulting with Dr. Gill and his staff regarding the details of the extension. It is our hope that the work will begin by the July 16th date.

If you have any questions, please call.

Sincerely,

W. C. Rowland
President

WCR/eh

cc: Senator Daniel Inouye

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AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

OFFICE OF THE
SENIOR ASSISTANT ADMINISTRATOR

JUL 2 1986

Mr. W. C. Rowland
President
The Oceanic Institute
Makapuu Point
Waimanalo, Hawaii 96795

Dear Mr. Rowland:

This is to summarize and build upon the discussion we had on June 19, 1986 in a meeting attended by Richard Collins, of Senator Inouye's staff, Jay Morris, the Deputy Director of this Agency, Tejpal Gill, of our Office of Agriculture, and Jan Dill and yourself from the Oceanic Institute.

The Agency for International Development (A.I.D.) recognizes the progress the Oceanic Institute has made on inducement of sexual maturation and spawning of milkfish. The Oceanic Institute has pioneered in a difficult technical area under the A.I.D.-supported project "Reproductive Studies on Milkfish," and research progress has led to demonstration of successful new techniques for implantation of hormone-release capsules and for implantation/injection procedures for inducing maturation and spawning of milkfish in captivity.

While we are encouraged by the progress made during this study and during the previous study supported by A.I.D., it is apparent that this research is not yet complete. Dependable methods for maturation and spawning on a routine basis have not been fully developed and the existing methods for inducement of maturation and spawning of milkfish have not been fully replicated in developing countries or with races of milkfish other than those available in Hawaii. In addition, the application of new methods, developed for milkfish, to other marine species offers a significant opportunity for an important contribution to salt water aquaculture technology. It is for these reasons that we are anxious to continue these research efforts.

The difficulties of controlling marine fish reproduction have long been an obstacle to expansion of aquaculture for some species, and the Oceanic Institute can make its greatest contribution, we believe, by completing the work with milkfish reproduction that is presently underway, then applying the results of this research to other marine fishes, especially the snappers and groupers. The Oceanic Institute is in a unique position to make this contribution.

We are prepared to consider providing $1.2 million each year over the period FY 87, 88, and 89 to enable you to complete this necessary research. I realize that this is less than requested in your proposal and is for a shorter term activity. Funding realities make this necessary. It also represents our judgment as to what is required to complete the research aspects of the proposal, which, in our view, is where the Institute can make its most significant contribution. When I outlined this approach at our meeting, you indicated that it posed some difficulties for you inasmuch as you had urgent funding requirements this fiscal year related to the start of your new grant proposal. In response, I said that if the FY 87 start we had proposed caused serious difficulties, we would be prepared to consider an alternative--specifically, a three-year extension and revision of the current cooperative agreement at a $700,000 level per year, subject to availability of funds, running from July 16, 1986 through July 15, 1989, and a new companion $500,000 per year cooperative agreement, subject to availability of funds, to be initiated during FY 87 and running for three years from FY 87 through FY 1989. In essence, this alternative represents the same amount of money for the same time period but separates your grant proposal into two segments so as to be responsive to your expressed need for some early funding in FY 86. Because this alternative was something which evolved from the conversation and neither of us had explored the idea in depth, it is described in somewhat more detail below.

First, we believe that the strategy your institution outlined two years ago, at the outset of the current project, would be most appropriate to follow for another three-year period. As we envision it, the current phase would be extended, and the Scope of Work expanded to include work orginally considered Phase II, such as larval dynamics. The funding for this extension and revision will be at the level of $700,000 for the year beginning July 16, 1986. Funding at the same level for two additional years is anticipated, subject to availability of funds. To bring the research to a satisfactory conclusion, future activities during this extension should specifically address the following ongoing objectives:

(1) replication of methods for inducing spawning on demand,

(2) describing the environmental factors influencing maturation and spawning,

(3) describing the nutritional factors influencing maturation and spawning,

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(4) demonstrating the applicability of your new methods for maturation of milkfish in LDCs, such as Indonesia and the Philippines,

(5) increasing overall understanding of the endocrinology of milkfish in relation to reproductive processes, and

(6) developing improved techniques for larval rearing.

Secondly, we would consider a new, related research activity under a companion Cooperative Agreement, specifically to further develop and test the maturation, spawning, and hatchery technologies developed for milkfish on other selected groups of marine fish with aquaculture potential. This activity would be funded at the level of $500,000 per year, subject to availability of funds, for a three-year period, beginning in FY 1987 and ending 30 Sept. 1989.

For the extension, you should continue to work with the cooperating institutions, i.e. the Tungkang Marine Laboratory in Taiwan, and SEAFDEC in the Philippines. Other LDC research institutions should also be included, as mutually agreed with the country concerned, the USAID Mission, the Oceanic Institute, and my representatives in our Office of Agriculture. Indonesia is a possible example.

For the companion Cooperative Agreement, the Oceanic Institute should develop relationships with other cooperating and AID-supported institutions to accelerate the refinement of this research. Possible examples are 1) joint funding of a milkfish workshop with IDRC, 2) cooperative bioassay research with the University of Hawaii, 3) economic analyses of hatchery development for milkfish and other species with the University of Rhode Island or ICLARM, and 4) cooperative studies with South Pacific nations involved in development of milkfish as a tuna bait.

In our experience, the successful application of this type of technology depends heavily on a truly joint undertaking between the concerned institutions in a developing country, U.S. researchers and USAID Missions. We believe that the field phase of the milkfish program must be such a joint enterprise. We would want to discuss with you how best to undertake that phase and the potential partners.

Please let me know which of these two arrangements is most satisfactory to you. We would need a revised grant proposal

from you under either proposal and are anxious to begin discussions with your technical staff on the necessary revisions and the work plans.

We are pleased to continue our cooperation with you in this important research.

Sincerely,

BL

Bradshaw Langmaid
Deputy Assistant Administrator
for Research

cc: Senator D. Inouye

Clearances:

S&T/AGR/RNR, TGill		date
S&T/AGR, FLi		date
S&T/PG, GCower		date
AA/ARE, CGreenleaf	(~~phone~~)	date 6/27
LEG, KKammerer	(info)	date
PPC/B, JHummon	(draft)	date 6/27
GC/CCM, KFries	(draft)	date 6/27
SER/AAM, KCunningham	(phone)	date 6/27
DA/ALD, DSmith	(info)	date

cc: S&T, R.C. Brady

Drafted by:S&T/AGR/RNR:RNeal:michelle:4/24/86:3957g
Revised: 5/30/86: rev: 6/4/86:johnnie:rev:michelle:6/24/86:
revised:6/26/86:myrtle:rvsn:6/27/86:BLangmaid:gt

FILE: AGR

Due: 4/2/86

ACTION: AA/S&T coord. reply fc
S&T signature

INFO: R/logs AA/AFR AA/ANE
AA/LAC AA/PPC

THE OCEANIC INSTITUTE

March 20, 1986

Mr. M. Peter McPherson
Administrator
Agency for International Development
Washington, DC 20523

Dear Mr. McPherson:

Attached is a formal proposal from the Oceanic Institute to continue and expand our collaboration with AID in aquaculture technology, particularly with finfish in coastal areas. This proposal is based primarily on our review of AID's policies and strategies of technology research, development and transfer in food production, and our achievements in the Cooperative Agreement entitled, "Studies on the Maturation and Spawning of Milkfish in Captivity".

As fully explained in our proposal, and taking into consideration the favorable findings and recommendations contained in the Report of the External Evaluation Panel, dated October 11, 1985, we envision a multi-year R & D project which will deal with a selected number of finfish species with potential for food production and export earnings in the developing countries. The project will employ a systems approach from investment through production to eventual distribution and consumption. Our proposal also involves cooperation with other fisheries research institutions, both in the U.S.A. and the developing world, in a networking approach to technology development and transfer in aquaculture.

In preparing our proposal, I have noted with great interest that AID's "Blueprint for Development" states a commitment to research which is characterized by (a) a problem focus, (b) a commitment to stay the course, and (c) selectivity based on the relevance of the research and the likelihood of achieving a major breakthrough. We also fully subscribe to the statement that, in order to effectively use AID's limited resources, you intend increasingly to allocate resources on the basis of competition among proposals directed at the key problems identified. I assure you that the Oceanic Institute shares these principles and strongly believes that this proposal meets these criteria and requirements.

605737

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Members of my staff will, of course, be ready to meet with your representatives to discuss this proposal in more detail. Our proposal is not set in concrete and we expect further negotiation regarding priorities, products, schedules and budgeting if it is accepted by you in principle. We do sincerely hope that the innovative and exciting multi-species systems approach incorporated herein will be maintained. I look forward to hearing from you at your earliest convenience.

Sincerely,

W. C. Rowland
President

WCR/ab

Enclosures

16

THE

OCEANIC INSTITUTE

A Proposal

on

The Expansion of Aquaculture Opportunities

In Developing Countries

Submitted to the

United States Agency for International Development

by

The Oceanic Institute
Makapuu Point
Waimanalo, Hawaii 96795

on

March 20, 1986

MAKAPUU POINT
WAIMANALO, HAWAII 96795
(808) 259-7951

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MILKFISH PROGRAM SYNOPSIS

PROBLEM:

The milkfish industry is one of the most important sources of low-cost animal protein for the peoples of Southeast Asia, and employs over a million people. Milkfish production is endangered by the inconsistent and decreasing supply of wild-catch juvenile fish for use as seed stock.

SOLUTION:

This will involve the production of seed stock in captivity by establishing a reliable method for maturation and spawning. This technology has eluded investigators for more than a decade. Such a development will permit, for the first time, a closed life-cycle production system with more effective controls and culture practices to increase yield and profitability of existing farms and open opportunities in new locations.

BREAKTHROUGH:

The Oceanic Institute, through the financing provided in its Phase I agreement with AID, has demonstrated the development of a technology for enhancing the maturation and spawning of milkfish in captivity, a feat never before accomplished. This technology was developed through the application of biotechnology. Additional experiments and trials are required for further verification, to be followed by field-testing. Management practice manuals will also be developed for hatchery managers.

A NEW APPROACH:

The OI proposal involves more than an extension of current research on a multi-species finfish basis. In some respects, it offers AID an exciting opportunity to adopt an innovative approach which will unify its fisheries efforts. These include:

- using systems approach to link the production process to processing, marketing and consumption;
- providing an end-user orientation for technology development and its commercial application;
- in addition to providing protein and income to the rural population and marginal farmer, by applying the technologies to higher value fish, the basis for commercialization on a significant scale through the private sector will be provided, thereby adding to a country's overall industrial development;

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- a package approach, involving close cooperation with the IBSNAT project at the University of Hawaii and the Pond Dynamics CRSP, is proposed for the development of methodologies for aquaculture sub-sectional analyses, feasibility studies and production modeling for decision-making; and last but not least,

- the approach calls for programmed coordination and collaboration with other AID fisheries contractors to produce useable results with near-term impact.

EXPECTED BENEFITS

Developing World

- improved nutrition and income for rural poor and small farmer;

- expanded and new mariculture industry resulting in increased employment and export earnings;

- expanded infrastructural support, e.g., processing, transportation, etc.

Domestic

- new and cheap supply of bait (milkfish) for fisheries industry

- technology can be used on other warm water species in coastal waters of the U.S., particularly Hawaii, California and the Gulf Coast, e.g., sea bass and snapper.

REQUIRED RESOURCES:

Our proposal covers a five year span and amounts to Phase II of a 10 year-plus effort to achieve the project purpose which, succinctly stated, is to increase the productivity of existing mariculture industries and establish new industries using selected finfish species existing in the coastal and inland brackish waters of the tropics and sub-tropics. (It is not without importance to note that because Hawaii is surrounded by such waters, the feedback of project results to our state will be very high.) Phase I which is funded through July 15, 1986, will involve $1.25 million in expenditures. For Phase II, i.e., the current proposal, the Institute estimates that $9.4 million will be required to finance necessary work programs over the next five years, including collaboration with institutions in developing countries.

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A Proposal

on

The Expansion of Aquaculture Opportunities In Developing Countries

Submitted to the

United States Agency for International Development

by

The Oceanic Institute
Makapuu Point
Waimanalo, Hawaii 96795

on

March 20, 1986

William C. Rowland
President

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Attachments
- Schedule of Activities and Budget
- Curricula Vitae of Key Personnel
- Statements of Support (to be submitted separately)
- Oceanic Institute's 1985 Annual Report (to be submitted separately)

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I. INTRODUCTION

A. AID's Objectives:*

The United States Government, through the Agency for International Development (AID), seeks a world in which extreme poverty, hunger, illiteracy and illness are essentially eliminated; a world in which free nations associate together on a basis of economic self-reliance. Within this lofty context, AID is concentrating its developmental efforts on key problems in the areas of real economic growth, reduction of hunger and undernourishment, an increase in life expectancy and reduction in infant mortality, increased education and skills, and relief from unmanageable population pressures.

B. AID's Approach to Development:

As an introduction to our proposal, it is also important to recognize that AID's approach to development, while emphasizing long-term development, does not ignore the need for immediate results to eliminate or ameliorate human misery. Nevertheless, AID is clearly concerned with development and not dependency. It seeks an expansion of productivity, income and employment leading to economic stability.

AID also seeks to bring about fundamental, systematic changes which go beyond impacts on a small group of direct beneficiaries. As such, AID has recently reoriented its approach to emphasize four basic programmatic components:

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* Information regarding AID policies and strategies has been extracted from "Blueprint for Development - the Strategic Plan of the Agency for International Development" and from publications and exchanges with members of the Committee for International Fisheries Research and Assistance Institutions (CIFRAI), an informal group of AID fisheries collaborators.

- policy dialogue (reform);
- institutional development and training;
- technology, including research, development and transfer;
- reliance on the private sector and market forces;

all leading to the promotion of self-sustaining development and progress toward goals shared by host governments.

Specifically in the area of technology, which is most relevant to this proposal, AID intends to be a leader in supporting the development and dissemination of new technologies which are appropriate to the needs and circumstances existing in the developing countries, i.e., research which is focused on their problems. Agriculture is the first of five critical research areas identified for major attention in the coming years, and increased attention is to be given to commercialization of technology rather than technology which will be dependent upon public budgets and donor support.

Finally, for our purposes here, we note that in addition to the problem focus, AID has a number of special initiatives which include: 1) a major program of economic assistance in Central America, 2) a special fund for economic policy reform in Africa, and 3) increased attention to urban areas while continuing AID's rural/agricultural emphasis. The Agency is also seeking ways to integrate women in development areas at all levels, including the project level.

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C. Sector Goals

Agriculture

The objectives of U.S. assistance in food and agriculture as stated in the AID policy paper Food and Agricultural Development (May 1982) are to enable countries to become self-reliant in food, assure food security and achieve sustained economic growth. These broad objectives are further supported by the sub-objectives of increased food availability and improved food consumption in both rural and urban areas.

Fisheries

Fisheries have historically been vital to the well-being of many developing countries by providing basic nutritional needs and economic opportunities. The animal protein derived from fish has a higher protein density per unit weight than that derived from livestock or poultry, and therefore could, under some circumstances, provide the most cost-effective way to increase animal protein intake. On the other hand, the over-harvesting of capture fisheries and the under-utilization of culture fisheries, combined with population pressures in the developing world, can result in a world-wide deficit of animal protein by the year 2000.

The sector goals of increased food availability and improved food consumption in developing countries can be achieved, in part, by AID's increased involvement in fisheries development, both capture and culture. Despite some long-term AID institutional support to several universities involved in fisheries, a number of field projects in aquaculture, and the recent award of two Collaborative Research Support Program (CRSP) agreements in "Pond Dynamics" and "Stock Assessment", the Agency, as yet, has

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not articulated a policy or strategy on fisheries. However, based on the existing fisheries portfolio, some recent problem-focused strategic planning undertaken by the Universities of Auburn and Rhode Island under respective cooperative agreements covering "fishery development support services" and "aquaculture", and discussions and exchanges between members of CIFRAI* on fisheries, the basic elements of a sub-sector strategy on fisheries are beginning to emerge.

In line with general AID strategies briefly listed above, it would appear that fisheries development assistance sponsored by AID will concentrate on four policy elements, i.e.:

- the improvement of country policies to remove constraints to fish production, marketing and consumption;
- the development of human resource and institutional capabilities, especially to generate, adapt and apply improved science and technology for fisheries development, and conduct research on fisheries problems in developing countries;
- the expansion of the role of developing country private sectors and the complementary role of the U.S. private sector in assisting this expansion; and
- the employment of all available assistance instruments in an integrated manner to provide food security.

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* This informal group of AID fisheries contractors currently includes the University of Rhode Island, Oregon State University, the International Center for Living Aquatic Resources Management, Auburn University, Oceanic Institute and the University of Maryland. AID and the National Marine Fisheries Service also participate.

Within the culture fisheries and, particularly relevant to this project proposal, brackishwater aquaculture, investment will concentrate on species that will increase food supply and maximize returns on investments. Fry populations will be managed at their respective spawning grounds or hatcheries to assure that 1) mother populations are not adversely affected; and 2) the supply of fry will be sustained. Finally, based on the incomplete planning to date, it is apparent that disruptions and adverse effects to the ecosystem for swamplands and estuaries will be viewed as a direct cost of developing those areas, and all fisheries development will adhere to environmental policies of both the recipient country and AID.

Problems

In completing this introductory section, which is intended to set the strategic and policy framework for the Institute's proposal, and given the absence of a comprehensive and approved AID fisheries strategy, it is useful to present here a very brief description of some of the major problems impeding aquaculture contributions to development. They are extracted and adapted from some experiences by long-term AID collaborators in aquaculture, particularly from a "Description of Problems", published by the International Center for Marine Resource Development of the University of Rhode Island, dated October 1985, and an unpublished paper by the International Center for Aquaculture, Auburn University, dated April 1985, on "First Approximation of Problem Statements".

(1) The first problem area concerns the low use of aquaculture (including mariculture) in developing countries. Important elements of this problem, some of which are susceptible to research and technical

assistance, include:

- Fish culture operations are considered to be high-risk ventures requiring an integrated industry;
- Mariculture operations, in particular, normally depend on the wild harvest of larvae to sustain production facilities;
- A lack of methodology and opportunities for conveying the rationale for aquaculture and creating awareness of its potential. National planners, development banks, economists, agriculturists and inland farmers often overlook fish culture as an alternative or supplemental animal crop;
- Need for refinement in methodology for sub-sector analysis and an aquaculture systems approach;
- Need for methodology for feasibility and marketing studies;
- The long-term time frame and commitment required for acceptance of new production systems and skepticism of entrepreneurs and farmers to public-sector endeavors; and last but not least,
- Counterproductive governmental agricultural policies.

(2) The second major problem may be described as the need for improved aquaculture production systems appropriate for the variations found in tropical and sub-tropical areas and the social/economic/cultural conditions in the developing countries. Some aspects of this problem are:

- Inadequate and inconsistent supply, quantity, growth and timeliness of seed supply;
- Absence of consistent methods for maturing appropriate species in captivity, i.e., no adequate method of maintaining or manipulating

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broodstock in spawning or fry production;

- Inadequate knowledge and methodology for hatchery and pond design and management requirements;
- Selection and supply of nutrients and their effective use;
- Tropical diseases; and
- Need for "appropriate" harvesting methods.

(3) An ineffective post-harvest processing and marketing system is also a problem in aquaculture. This may include:

- Inadequate means of preservation immediately after harvest;
- Poor transportation and road networks;
- Significant post-harvest loss due to spoilage and insect infestations;
- Inadequate distribution and marketing methods;
- Human resistance to change;
- Consumer preference/acceptance; and
- Seasonality of alternative sources.

II. THE OCEANIC INSTITUTE

In this section of our proposal, we will show the significant overlap between the objectives of AID and its approach to development and those of the Oceanic Institute. We will also indicate the relevance of our current work and staff capacities and interests to the proposal at hand.

A. Background and Purpose

The Oceanic Institute (OI) is a non-profit, private marine science center independent of state or federal agencies. Its purpose is to secure scientific and technical knowledge through applied research and develop-

ment, for the wise use of the ocean and its resources, and to share that knowledge with the peoples of the world.

The Institute was founded in 1960 as a division of the Oceanic Foundation, a three-part complex which included Sea Life Park, a public oceanarium, and Makai Range, an engineering facility. In 1973, the Foundation was reorganized, and the Institute assumed control of the entire 118-acre center. The Institute is governed by a Board of Trustees.

In its early years, much of the Institute's work was directed toward the study of marine mammals, especially their ability to withstand great changes in pressure and their sophisticated navigational and sensory systems. Studies of pollution and farming of marine fishes were also important undertakings in those formative years.

B. Today's Goals

The present goals of the Oceanic Institute are divisible into three main themes which, though distinct from each other, are often interrelated in projects and research. The present goals include:

(1) Increasing the production of food from the sea with its attendant responsibilities of protection and conservation, is a primary theme. Current projects fulfilling this objective include:

- Research and development in fish farming technology;
- Induced breeding and larval rearing of brackishwater and marine fish;
- Research in reproductive physiology of food fish;
- Development of hatchery techniques for mass production;
- Design of fish hatcheries;

- Application of aquaculture to enhance overfished stocks of marine animals;

(2) Improving mankind's compatibility with the aquatic environment, through an interest in both basic research and the practical needs of today's demanding society, is assuming greater importance in the Institute's affairs. Current activities associated with this goal include:

- Studies of energy flow in the marine environment;
- Research on photosynthesis - light relationships in the open sea;
- Phytoplankton ecology and fisheries recruitment;
- The effects of pollutants and effluents in coastal waters;
- Design and environmental planning for coastal developments;

(3) Finally, the Institute desires to preserve the heritage of the sea for future generations through education and management of existing resources. The projects in this third theme include:

- Evaluation of existing resources;
- Conservation and management;
- Development and management of new resources;
- Consulting and advisory services;
- Training and practical instruction;
- Publication of books and reports;
- Workshops and visitor tours;

C. Staff, Facilities and Funding

The Oceanic Institute has a staff of 64 with 13 postdoctoral researchers and over 20 technical personnel with either Bachelor's or Master's Degrees. Its research programs are supported by water quality,

algology and zooplanktonology laboratories. The Institute has its own 1,500 gpm seawater supply system, indoor and outdoor fiberglass and cement tanks, raceways of varying sizes and shapes and 3.1 acres of lined and unlined ponds.

To carry out its programs, the Institute relies mainly upon contractor support including private firms and foundations, and state, federal and international sponsors including the State of Hawaii, National Science Foundation, U.S. Army Corps of Engineers, the U.S. Department of Agriculture, the U.S. Agency for International Development, the Food and Agricultural Organization and UNESCO. The Institute also relies on the generosity of business firms, community leaders, trusts and foundations to finance uncovered staff development, laboratory improvements and construction, and certain innovative research.

D. Collaboration with AID

Aquacultural research has taken two paths in the Institute. The first involves shrimp, a high market-value species and the focus is on its commercial aquaculture in the U.S. The second program involves marine finfish, particularly milkfish and mullet, and the focus is on the food and nutritional needs of the developing world. Most of this latter program has been financed by AID, initially under a small five year grant beginning in 1973 and currently under a cooperative agreement for a two year term to begin the development of reproductive techniques of maturation and spawning of captive milkfish.

Originally contemplated in the AID project paper for four years, the cooperative agreement was only executed and funded for two years and the

expectations reduced accordingly. A Technical Advisory Group (TAG) was established to provide strategic and tactical support to the Principal Investigator. The project was limited entirely to maturation, spawning and larval rearing and the results are described in recent progress reports, minutes of the TAG, and the External Evaluation Panel Report dated October 11, 1985. The Panel's summary conclusions and recommendations included:

- Although the work the first year on (a) finding ways and treatments to induce gonadal maturation and spawning, and (b) establishing techniques for successful fertilization of eggs, larval rearing and fry culture, has been very successful, much more work is needed on the maturation/spawning problem to provide a stable technology which is transferable to developing countries. The maturation/spawning experiments need to be repeated in the second year of the project to verify the first year's results with a large number of fish.
- More attention to larval and fry culture can be considered in the second phase of the project.
- Generally, the majority of tasks outlined in the implementation plan were performed as scheduled.
- Staffing appears to be adequate provided that the research focus remains closely linked to the project objectives of maturation and induced spawning of milkfish.
- Further collaboration on research and dissemination of results is appropriate.

The Evaluation Panel does not specifically address the issue of extension, nor was it asked to, but their review and recommendations clearly imply at least two additional years of research, with increasing emphasis on larval and fry culture. The Oceanic Institute appreciates the excellent advice provided during the evaluation exercise and the reaffirmation of the validity of the research hypothesis and its probable early verification. However, in view of the achievements to date and the nature of the problem as related to AID's sector goals, we believe the foundation has been firmly established to initiate a more comprehensive, systematic and innovative approach to marine finfish aquaculture which will be explained next.

III. JUSTIFICATION OF PROPOSAL

A. Systems Approach

In our introduction to this proposal, we pointed out the considerable overlap between AID's objectives and the goals of the Oceanic Institute. We gave particular emphasis to the problems impeding the more effective contribution of aquaculture to development within the context of AID's development strategy. Our proposal is intentionally designed to facilitate a coordinated and systematic AID approach to assisting the developing countries solve or ameliorate many of those problems, particularly those whose solutions are susceptible to outside assistance and technology development. These fishery problems cannot be overcome overnight by AID alone and certainly not by us. On the other hand, we believe our proposal can serve as the catalyst for a systems approach, which is user-oriented, utilizing the differing strengths and experiences of the U.S. fisheries

community in an orchestrated and programmed effort to produce tangible results which lead to the expansion of the aquaculture industry, and, subsequently, increased socio-economic benefits for the rural and urban poor. We also believe that our Institute can play a unique and innovative role in this process.

B. Projected Impact on Selected Problems

Our proposal touches on many of the problems enumerated above, but is focused on coastal finfish species. Within this context, successful project achievement will have a significant impact on the following problems:

- The inconsistent supply of fry due to the uncontrollable and declining supply of mature broodstock from nature;
- Lack of a consistent method for maturing finfish in captivity;
- Lack of reliable methods of induced spawning;
- Absence of sound criteria for determination of egg quality and factors influencing egg quality;
- Lack of cost-effective hatchery techniques for marine finfish, including milkfish;
- Need for a reliable food organism (feed) production system;
- Absence of management strategies for suitable growout systems for small-scale fish farmers at different locations and conditions;
- Absence of production models for prediction and simulation.

It is evident that the future of the marine finfish aquaculture industry, given the inconsistent and declining fry supply for milkfish, depends on the ability to develop new broodstocks by using animals taken

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from production ponds and transferring them to defined environments in which they can grow to sexual maturity. Successful aquaculture depends on the routine control of maturation and spawning in enclosed culture systems. Under the current cooperative agreement, the Institute is well on the way to developing a stable technology to accomplish this for milkfish. This technology, with minor adjustments, can be applied to other fish species. It can also be used for high-value species such as sea bass and snapper which should not be overlooked. This work must be carried to its conclusion and utilized.

C. Expected Benefits

The project purpose, as explained below, concentrates on improving the productivity of existing finfish aquaculture industries and expanding it into new areas and species. To the extent this is successfully achieved or demonstrated, a number of socio-economic benefits are expected to result which become the principal justification for this proposal and motivate the Oceanic Institute's interest in this program. Coincidently, some of the expected benefits will also apply to the United States and other developed or industrialized countries. The development of the LHRH-a cholesterol pellet implantation technique at the Oceanic Institute, for example, has drawn interest from scientists in both the United States and Japan. Our findings on many aspects of milkfish culture will also serve as the baseline for future research on domestic species and the ready supply of milkfish will solve the bait problem for tuna fisheries. Th benefits may be summarily stated as follows:

- Increased production of low-value finfish will enable the rural and

urban poor to consume sufficient levels of protein to avert and/or alleviate malnutrition.

- Increased production of high-value finfish will provide a source of foreign exchange and stimulate industrial development.
- Full and part-time employment opportunities will be generated for the rural poor, including women, and the impact of declining wild fry catch on small fisheries and businesses will be eased or eliminated.
- The risk of establishing new industries will be reduced, encouraging the availability of venture capital.
- Expanded production will also stimulate infrastructural improvements in processing, packaging, marketing, transportation, and distribution systems providing additional employment and economic opportunities.

D. Important Assumptions

In justifying this proposal, the Institute seeks to obtain AID concurrence on the reasonableness of the following assumptions:

- To meet both internal and, in the case of high-value species, external, market demand for finfish species, existing ponds must use more intensive methods which produce higher yields.
- Among the options available for aquaculture in brackish water, investments in finfish production will be cost-effective.
- In the least developed countries, capital investment in hatcheries and growout systems may require public subsidy or management but in more developed countries, the private sector can assume a major

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role throughout the entire system.

- Providing a constant supply of fry will not only provide a stable basis for the finfish aquaculture industry where it already exists, but will permit its establishment in new areas.
- There is widespread interest and support of this effort on the part of several developing countries, including the Philippine, Indonesian and Taiwan governments, as well as other nations, including Japan, Australia, Germany, Canada and New Zealand. As the technology is developed and demonstrated, we assume that other coastal nations will be interested, particularly Egypt, sub-Sahara Africa, Central America and Mainland China. We will expect AID's assistance in locating and developing these potential linkages.

IV. PROJECT PURPOSE

A. Succinct Statement

As explained just above, the Oceanic Institute is proposing a new project with a more comprehensive overall purpose or objective than that included in the current cooperative agreement which is limited to developing field techniques for inducing gonadal maturation, spawning of milkfish and the successful rearing of milkfish fry. The following statement has not only been developed to extend the scope and coverage both in terms of species and geographic areas, but to place the project emphasis on the end-user, i.e., the farmer and the industry itself.

> Purpose: To develop, test and transfer appropriate technology and management practices to developing countries through a systems approach for increasing the

productivity of existing aquaculture industries and establishing new industries using selected finfish species existing in the coastal and inland brackish waters of the tropics and sub-tropics.

B. End-of-Project Status Indicators (EOPS)

This proposal will cover Phase II work on low-cost food and some high-value finfish species over a five year period beginning in mid-1986. At the time of project completion in 1991, the following expectations and indicators of project success appear reasonable:

- Controlled reproduction of milkfish and other important species through the commercial application of the hormone implantation technique;
- Operations manuals for milkfish farming which are accepted and used by fish farmers;
- Evidence collected on increased productivity from aquaculture industries formerly dependent on wild catch of fry and extensive growout;
- Private sector involvement, including cooperatives, in one or more new aquaculture ventures involving middle and small-size entrepreneurs/farmers.

V. PROJECT APPROACH

A. Baseline

By the end of the 1986 spawning season, we anticipate the following results:

- Preliminary results on development and laboratory testing of a

chronic hormone releasing pellet that controls the reproductive cycle of milkfish;

- Demonstrations of the potential applicability of this technology in Taiwan and the Philippines;
- Biologists from Taiwan and the Philippines trained in experimental design and methodology for reproduction of milkfish;
- Preliminary results on development and laboratory testing of induced spawning technology for milkfish;
- Scientific exchange of information on reproduction and culture of milkfish;
- Completion of the State of the Art Review and its publication and distribution.

B. Project Hypotheses

Based on our experience with the milkfish project, a reading of AID's strategies, priorities and preferred modes of implementation, and the lessons learned from similar aquacultural and agricultural development projects, we have designed our proposal and suggested activities with a number of hypotheses and assumptions intended to reduce risk and assure eventual success. They include:

- Biotechnology will be used successfully (i) in the manufacture of growth hormones, (ii) control of reproduction, and (iii) monosexual culture.
- AID and CIFRAI institutions will assist the Oceanic Institute in locating sites and collaborating countries for field testing.
- The technologies developed for the maturation/spawning, larval

rearing and fry culture, and the semi-intensive growout of milkfish is transferable, with minor modifications, to other finfish species.

- This will be specifically demonstrated with mullet and tilapia, a low-cost source of food and protein in the developing countries. At later stages of the project, it will also be demonstrated for seabass and snapper, high-value fish producing export earnings.
- A systems and life-cycle approach in the implementation of finfish aquaculture, i.e., the interaction of its major components -- including hatcheries, ponds, harvesting, processing and storage, packaging, marketing and consumer acceptance -- on yield and consumption is necessary to successfully achieve the project purpose.
- Along with the development of appropriate technology, culture practices, etc., methodologies must be developed which demonstrate and ensure the cost-effectiveness and social benefits of aquacultural investments by governments, development banks, and medium and small-size entrepreneurs/farmers.
- The finfish aquaculture industry is most likely to survive and grow, providing increased income, employment and food supply, through the maximum involvement of the private sector and with supportive public policies.
- A coordinated program for the development and transfer of appropriate technology will be indispensible in using the systems approach. This will require close collaboration with AID and its

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associated fisheries contractors through appropriate mechanisms. The Institute will seek assistance from other institutions in jointly producing or arriving at an effective division of effort in producing selected outputs and sub-outputs, particularly in relation to production modeling and the socio-economic aspects of aquaculture in the developing world.

- The existing network with SEAFDEC and TML will be extended as feasible to include collaborative linkages with other organizations in Asia, the South Pacific, Africa and Latin America, particularly in the Caribbean.

VI. PROJECT OUTPUTS

Introduction

For the purposes of presentation, subsequent management and budgeting, it is useful to categorize the proposed and on-going milkfish activities as follows: (A) controlled life-cycle culture of milkfish; (B) other desirable finfish species; (C) post-harvest components; (D) policy and socio-economic benefits; and (E) technology transfer. Within each category, to the extent possible, we will provide the following information: background, a statement of objectives, and a description of the experimental activities/tasks/work required to produce the intended results, i.e., outputs, and the time and resources requested.

Our ability at this time to provide this desired level of detail varies for each category and is strongest on the research. Under technology development, except for growout, the work is essentially a continuation and extension of work already in process and we can project

the requirements with reasonable certainty. Under management practices, considerable work has been undertaken by others or is in process, but it has not yet been brought together in a systematic and practical approach involving all the players and of particular use to the small and middle-size entrepreneur/farmer. Similarly, while there is recognition of the problems involved in government fisheries policies, or the lack of them, and need for better instruments of economic and cost analysis at the sub-sector and industry level and the great potential usefulness of production models, very little work has been done on the problems facing developing countries in aquaculture and on the species of finfish which are adaptable to culture. In both these cases, it is not possible or appropriate for the Institute to suggest a detailed or unilateral approach. Rather, we are proposing that the Institute, in close collaboration with AID and its other fishery partners, take the initial steps to get a coordinated and user-oriented systems approach started which will be compatible with or linked to other agricultural systems (see exhibit on "The Closed Fish-Farm Production System").

A. CONTROLLED LIFE-CYCLE CULTURE OF MILKFISH

Background

The work under this category will be organized around the major components of a closed life-cycle production system as follows:

Technology Development

- o seed production
- o juvenile production
- o fish production

Management Practices

- o hatchery
- o nursery
- o pond

Not all components will receive equal emphasis in this phase of the project but the systems approach requires that all aspects and their interactions be considered, in order to promote commercial application. In some cases, technology development will be dependent upon the results achieved in other system components and/or from non-project sources, e.g., Pond Dynamics CRSP. Where this is the case, we will try to flag such instances as "critical assumptions". In any event, the technology, principles and practices which are developed under this project will be adaptable to the site-specific and economic and social conditions in the tropics and sub-tropics.

TECHNOLOGY DEVELOPMENT

1. Seed Production

Objective

To control the seed production factors, i.e., time, quality and quantity, for cost-effective culture of milkfish

No longer will the entire production process be based on the uncertain supply of wild catch but, rather, can be scheduled to meet market demand (and employment availability), including quantity. The quality, i.e., producing healthy larvae with high survival and faster growth rates, can be improved and the efficiency of the system increased through maximum use of the broodstock.

Output No. 1 - Estimated completion date - 1989

Technology developed and tested for (a) shortening the time-span for gonadal maturation in captivity from approximately 10-11 years to about six years and (b) to provide eggs for fertilization on a scheduled, i.e., demand basis.

Hypothesis: Under usual culture conditions, stress and other environmental factors cause delays in the secretion of required hormone thereby lengthening the time period for maturation. By external application of LHRH-a, this process can be shortened by triggering the internal secretion of required hormones resulting in quicker gonadal maturation.

Summary Work Plan

An environment which produces minimal disturbances to the fish is necessary for reproductive maturity. Diet and adequate sex hormones also are important in the acceleration of maturation. The research plan includes the following:

- Verify the experimental results using combinants of LHRH-a cholesterol pellets plus liquid testosterone through tube implants;
- Evaluate whether photoperiod is a factor in determining maturation as measured by time, size and age;
- Determine through trials whether age or size is most important in gonad development;
- If size is critical, develop a diet (feed) for maximum maturation/growth;

- Based on results achieved above, develop an optimum combination or formula of amount and type of hormone and diet for accelerating maturation in milkfish.

Results to Date *

- A combination of LHRH-a pellets and liquid testosterone in a sample of 20 fish has accelerated the maturation process by (a) occurring earlier, i.e. in April instead of June and (b) at a higher rate, i.e., 90% of fish matured in June.
- Preliminary results of prolonged photoperiod imply a positive effect on maturation numbers (under one treatment) and indicate fish can mature under complete artificial lighting conditions.

Additional requirements

- A replication of the same hormone therapy experiment will be undertaken to achieve statistical satisfaction.
- Trials will be conducted for the hormone therapy on age and sex using different age and size groups to determine the minimum age and size of response.
- Conduct additional tests under variable photoperiods.
- Develop optimum formula.

Output No. 2 - Estimated completion date - 1988

Technology developed and tested for controlling and maximizing the production of fertilized eggs.

Hypothesis: Under captive conditions, spawning of milkfish has been

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* Hereafter, unless otherwise noted, results to date will refer to those achieved by the end of calendar year 1985.

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inconsistent and unreliable. Since the use of LHRH-a has produced promising results in controlling the reproductive process in other vertebrate species, it is hypothosized that control of milkfish spawning factors can be affected by its proper application.

Summary Work Plan

LHRH-a has proven to be successful in inducing final maturation and ovulation of milkfish but inconsistent in producing fertilization. We will focus on refining the LHRH-a technique rather than attempting induction with other exogenous hormones by carrying out the following activities and experiments:

- o Determine the optimal stage of maturation for spawning after receiving one application of LHRH-a (female). This will be accomplished by first staging, i.e. measuring, the egg diameter in the female and then inducing her to spawn with one dose of LHRH-a. This activity will be carried out repeatedly, using a number of females with varying initial egg diameters and comparing spawning success in relation to the initial egg diameter.
- o Determine the optimal dosage required for achieving spawning in the female. Using the optimum egg diameter established above, varying dosages of LHRH-a will be injected and the quantity of hydrated eggs released and the number of fertilized eggs produced will be recorded and analyzed.
- o Determine the optimal pretreatment of the male in spawning attempt. The male milkfish will be injected with different doses of LHRH-a before they are used for spawning attempts. Data will be collected

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and analyzed based on the success of fertilized spawning.

- o Determine the environmental conditions required for obtaining viable spawnings. More than 10 spawnings will be tried in three different sizes of facilities with a sex ratio of 1:1 or 1:2. After the 3 X 2 factor experiments are conducted, the optimal size facility and sex ratio can be verified.
- o Determine the difference in egg quality under different conditions, e.g., nutritional condition of broodstock, kinds and dosage of hormones, etc. A comparison of egg quality from different experimental conditions will be made and criteria for assessment will include fertilization and initial survivability before feeding.

Results to Date:

- o Preliminary results of Phase I experiments involving 50 spawning trials indicate that milkfish with an egg diameter of 800 um will respond to a single application of LHRH-a and release hydrated eggs. However, the fertilization of hydrated eggs did not occur consistently.
- o A single injection of 250 ug of LHRH-a given to a females with 800 um eggs and a unimodal size distribution results in spawning approximately 24 hours after injection.
- o After male receives one injection of 250 ug of LHRH-a, given at the same time female is injected, 40% of the 17 spawning trials resulted in fertilized eggs.
- o Sex ratio of two males to one female appears to be a requirement

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for obtaining fertilized eggs based on the limited trials to date. There also appear to be no differences based on the sizes of spawning tanks used.

Additional requirements

- o Replicate egg diameter experiments enlarging sample to approximately 100 spawning trials. They will be carried out during different months of the year and until a statistically sufficient number have been run. The histology of 800 um eggs will be compared for egg quality.
- o More experiments will be conducted to determine the minimum and optimal dosage for viable spawnings. Sufficient data will be collected to plot accurately the response curve of milkfish to varying dosages of LHRH-a.
- o The male pretreatment experiments will be repeated on a larger scale, 30 or more trials, until statistically significant data are provided on timing and quantity of dosage for optimum male response.
- o The environmental experiments will also be continued on a larger scale to provide statistically valid data for evaluat~~ing~~ whether the 2:1 sex ratio is valid and to determine whether an optimum ratio is dependent upon different factors, e.g., tank size and shape.

Output No. 3 - Estimated completion date - 1991

Technology developed and tested for semi-intensive and cost-effective culture system for larval rearing under

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conditions prevalent in developing countries.

Hypothesis: The principal constraints to the cost-effective production of milkfish larvae are (a) the lack of a consistent and economic supply of live food organisms, (b) low survival and growth rates and (c) ineffective rearing practices. These constraints can be overcome by the development of alternative or supplemental formulated feed sources and improved management practices including the use of hormones to reduce mortality and increase growth rates.

Summary Work Plan

Given the constraints of manpower and resources, the Technical Advisory Group recommended that work on larval rearing as originally planned be postponed until Phase II. This was also predicated on the basis that the reproduction research was not fully tested and validated. As indicated above, by mid-1987, statistically valid reproductive results will have been achieved to permit initiation of the larval rearing experiments.

- To refine live food production techniques, especially rotifers. This study will develop a procedure for producing a consistent supply of nutritionally enriched live food organisms. Different strains of algae will be cultured and fed to the rotifers. Production and nutritional value of the rotifers will be monitored. The procedure that produces nutritional rotifers consistently will be defined.
- To identify a cost-effective formulated feed that can supply sufficient nutrition to larvae. Several available artificial plankton species will be tested in an attempt to fully or partially

replace current larval live food organisms. The surviving larvae from different rearing strategies will be compared. Finally, a practical and less costly feeding regime for milkfish larvae will be developed.

- To improve larval survival and growth rates through the application of thyroid hormone, steroids or growth hormone. Experiments will be conducted using available chemicals, including thyroid hormone, steroids or growth hormone to test their influence on larval survival and growth.
- To design a methodology for a semi-intensive larval rearing system. A larval rearing system for milkfish will be designed and tested with an aim toward reducing the cost of hatchery production.

2. Juvenile Production

Objective

To establish baseline data on hatchery-produced fry for the purpose of proposing cost-effective nursery management practices.

There is no existing practical method for culturing hatchery-produced fry until they are ready for stocking in growout ponds. Current information on handling, storage and transportation comes from wild-caught fry. Some of these data may be applicable to hatchery-produced fry and can be used as a starting point to identify critical parameters, e.g. dissolved oxygen, stocking densities, etc.

Output No. 1 - Estimated completion date - 1989

Optimum stocking density established in the laboratory.

Summary Work Plan

Experiments will be conducted to compare the survival and growth rates at varying densities.

Output No. 2 - Estimated completion date - 1989

Preliminary parameters defined for water quality, e.g., temperature, salinity and pH.

Summary Work Plan

Using optimal stocking density, subject fry to varying parameters using survival and growth rates as criteria for selecting optimum water quality regime.

Output No. 3 - Estimated completion date - 1991

Feed regime defined for fingerling production systems.

Summary Work Plan

Experiments will be designed to compare the variables including type of feed (commercially available), amount and kind of fertilizer inputs, and no-feed or combination of the above factors. Survival and growth of fry will be used as the criteria for comparison of results and preliminary selection of optimum feeding regime.

3. Fish Production

Background

Two types of milkfish production are practiced among milkfish farmers; the traditional and the intensive culture systems. The traditional culture system (or shallow-water pond culture system) has been practiced for centuries in Southeast Asian countries. In this system, the pond is fertilized with organic or inorganic materials to initiate the growth of

benthic algae on which milkfish will then feed, transforming useless protein to a source of protein useful to humans. The system requires little energy for pumping water and no aeration.

Recently, the intensive culture system (or deep-water culture system) was developed and is being practiced in Taiwan. In this culture system, milkfish meet their nutritional requirements from ingesting formulated feeds. The unit production of milkfish has doubled or tripled production from the traditional method, however, the intensive system entails higher energy costs, a larger labor force and greater capital investment. The unit production cost is higher than in the former system, but the growout period is shorter. The product is available prior to traditional system harvest and hence commands a higher selling price. Both systems, therefore, have advantages and disadvantages.

In the two systems described above, milkfish is the monospecies. However, polyculture in milkfish ponds is very common and is justified by the production of a second crop as well as by the ability to control the pond ecosystem. The polyculture of milkfish and shrimp is the most common and the higher price commanded by shrimp assures a greater return from the pond.

Objective

To maximize the control of critical production factors in the semi-intensive monospecies and polyculture growout of milkfish and minimize the costs and risks involved.

Farmers have been growing milkfish for centuries using traditional methods but the development of a fry culture technology, which has been the

focus of this project to date, will allow the expansion of milkfish farming to new areas which are not dependent upon wild-catch supply. In some locations, only milkfish can be grown because of their tolerance of extreme conditions. The maximum production of the conventional milkfish culture system is estimated at 2,500 kg/ha. Deep water culture produces more milkfish but high capital costs are required. A system with the merits of both systems can be designed to improve yield, and hence profits, for the small farmer. Another way of increasing the income of small fish farms is the introduction of the polyculture system. The use of formulated feeds will be necessary in both systems and a low-cost protein source must be found. Soybeans may prove to be the best protein source avaialble. This will require the collection and analysis of production data not yet available. Some are now being collected under the Pond Dynamics CRSP but further data collection, analysis and modeling will be necessary to focus on alternative management practices and yield.

Output No. 1 - Estimated completion date - 1991.

Study completed on the exosystems for deep-water, shallow-water and polyculture utilizing natural productivity.

Summary Work Plan

This work will be conducted through a network of collaborative institutions which will collect information on current pond culture systems and present this information using quantitative figures rather than description. Data will be compiled in Hawaii and will serve as a baseline.

As a result of the interaction among participating institutions, an experimental design will be standardized and used to compare results from different geographical locations. Through this network, improvements can be made after each set of experiments.

Output No. 2 - Estimated completion date - 1991

Theoretical production model developed for milkfish (and adaptable to other finfish) to increase understanding of the effect of different management practices on yield.

Summary Work Plan

The construction of a theoretical model will guide the research required to (a) define critical system parameters, (b) use this knowledge to make predictions, and (c) use these predictions (and simulations) to control outcomes, i.e., increase yield.

Work under this output will begin with a literature search of the modeling work being carried out by the CRSP, which concentrates on collecting baseline data on ecosystem components, and that being developed by IBSNAT which focuses on specific crops. Representatives from both AID-funded projects will be invited to share their experiences and plans with OI and help us put together a preliminary model design which could, for example, begin by micro-modeling, i.e. the oxygen, nitrogen and carbon flows and balances; or design a macro-model for the general system.

For this purpose, a new Technical Advisory Group for the Principal Investigator will be established for guidance in modeling and similar decision-making processes. While the status of aquaculture in terms of modeling is greatly hampered by the lack of basic information, which will

be ameliorated to some extent by the CRSP experiments, work on modeling cannot await a stage of perfection. It should begin immediately to provide research guidelines and an interaction with the activities to be carried out in Output No. 1 above. As the model is perfected, in Phase III artificial intelligence (expert system) can be used to transfer technology (and knowledge) directly to the end-user. A fish model can also be used by governments in sub-sector (aquaculture) analysis and by development banks and entrepreneurs when considering aquaculture investments.

The first stage will involve considerations of the feasibility of constructing a theoretical finfish production model. Based on the results of such an exercise, and in close collaboration with AID/S&T and CIFRAI members, a more detailed work plan will be developed, including the role and expected contributions from each of the participants.

Output No. 3 - Estimated completion date - 1991

An economically and readily available fish feed formulated for use in semi-intensive milkfish growout.

Summary Work Plan

Soybeans have been used as the protein source in formulated catfish feed in the United States and have proven to be nutritionally adequate. They are usually available in the developing world in large quantities and at a reasonable price. Therefore, experiments will be conducted to formulate a diet for milkfish using soybeans as the major protein source. Cooperation will also be sought with the International Center for Aquaculture at Auburn University which has considerable experience in similar feed development programs.

MANAGEMENT PRACTICES

Background

The ultimate purpose of the research carried out above under technology development is, of course, to provide the various participants in the production process with alternative and improved management strategies and practices which maximize control, yield and profit under varying ecological, economic and social conditions. This will require packaging the technologies in forms usable to the hatchery and nursery manager and the small farmer. In some cases, this packaging will be the outcome of at least pilot-scale on-site applications of the technologies developed in the laboratories of Oceanic Institute and elsewhere. This will require work programs developed in cooperation with and primarily carried out by cooperating institutions.

1. Hatchery Management

Output No. 1 - Estimated completion date - 1991

A technology package developed and field-tested for the maturation, spawning and larval rearing of milkfish.

Summary Work Plan

A preliminary package of recommended hatchery management practices, based primarily on laboratory results but applying lessons learned from other AID fisheries projects, will be prepared by OI staff containing the following elements:

- o Formula for enhancing maturation with hormone therapy;
- o Equation for optimal dosage of hormone injection to induce final maturation and spawning;

- Strategy for control of environmental parameters and kinds of treatments which reliably produce highest egg quality;
- Procedure for producing consistent supply of nutritionally enriched live food organisms;
- Formula for practical and low-cost feed regime for larval growth;
- Hormone therapy for maximizing larval survival and growth rates;
- Guidelines on hatchery location, design and construction.

The practices included in the preliminary package will be field-tested in the Philippines, China and Indonesia and perhaps other locations selected to provide a full range of geographic, social and economic conditions. The exact locations, cooperating institutions and methodology will be determined in close cooperation and consultation with AID and CIFRAI institutions through a workshop called for this purpose. OI personnel will, in collaboration with the host country intitutions, design the field testing, monitor progress and translate the results into an operations manual.

2. Nursery Management

Output No. 2 - Estimated completion date - 1991

A technology package developed and field-tested for the production of fingerlings.

Summary Work Plan

A preliminary package of recommended nursery management practices, based primarily on laboratory results but applying lessons learned from other AID fisheries projects, will be prepared by OI staff containing the following elements:

- o Guidelines on optimum stocking densities based on available facilities;
- o Guidelines for controlling water quality;
- o Guidelines on optimum feed regime.

Field testing will take place in the same manner and locations as described above for hatchery management.

3. Farm (pond) Management

Output No. 3 - Estimated completion date - 1991

A first-approximation technology package developed for the production and harvesting of adult fish.

Summary Work Plan

As results are achieved, preliminary recommended pond management practices will be proposed based upon OI-conducted and/or coordinated studies, Pond Dynamics data, and the experience of other CIFRAI institutions. It is not expected, however, that during the five year time-span of this proposal, the results will be adequate for field testing as a comprehensive package.

B. OTHER DESIRABLE FINFISH SPECIES

Introduction

Aquaculture can supply low cholesterol animal protein to humans at various costs, i.e., while milkfish can be produced at an affordable price, other fish species can only be cultured as luxury food fish. It is proposed that both types of fish are appropriate for culture in developing countries, the former as a low-cost protein supply for widespread human consumption and the latter as an export earner and for the development of

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new industries, including supporting infrastructure.

The technologies developed for milkfish, with some relatively minor modifications, will be applicable to other selected species. The Oceanic Institute proposes that collaborative programs be initiated on sea bass and snappers as export items, and mullet and tilapia as low-cost food fish.

Mullet can be cultured under various environmental conditions ranging from freshwater to seawater, and can utilize the natural productivity of the pond for growth. Mullet is also an ideal species for polyculture. In the Philippines, mullet has been listed as a priority species for research. However, techniques for induced spawning have not yet been developed. Oceanic Institute has investigated this problem and is leading the field in mullet research. Our reproduction techniques are ready for transfer to other institutions and mullet farmers but further work is necessary on larval rearing and stock improvement.

Tilapia is the dominant species cultured in tropical freshwater systems and is desirable as a culture species for its hardiness and growth characteristics. Expansion of the culture of this species into coastal land areas has been impeded by its poor reproduction and growth under conditions of increased salinity. Some species of tilapia display varying degrees of salt tolerance, however, a trait which suggests the possibility of an expansion of their culture into brackishwater or marine systems. If research can lead to a solution of this problem, tilapia would then become an additional protein source for many countries.

Both sea bass and snapper are proposed because (a) they are most easily adaptable to culture, and (b) they are in high demand as luxury

fish, with a limited supply resulting in a high-priced export commodity.

1. Mullet

Objective

To develop a cost-effective method for production of juveniles and the improvement of economically desired characteristics - estimated completion date - 1991.

Summary Work Plan

The majority of the techniques and methods developed for milkfish juvenile production can be directly applied to mullet. Modifications will be desired, however, to adapt to the longer early-life history of mullet. Commercially available diets and live food organisms will be tested at the several developmental stages to improve production efficiency. Critical environmental parameters, e.g., dissolved oxygen, temperature, pH and salinity, will be defined.

The first step is to identify stock distribution and evaluate similarities of differences in morphological, meristic and physiological traits. The second step is to identify specific traits that have economic potential, e.g. growth rate, color, fecundity, etc. Both sets of activities will be initiated in the laboratory in 1987 and completed in 1991. During this period, potential collaborative institutions for field testing will be sought in other countries, e.g., Egypt, Israel, China and the Philippines.

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2. Tilapia

Objective

To identify a potential tilapia strain for saltwater culture - estimated completion date - 1991.

Summary Work Plan

The International Center for Aquaculture at Auburn University, a member of CIFRAI, is a recognized leader in the biology and culture of freshwater tilapia. The Oceanic Institute is located in a subtropical climate zone, has considerable experience in mariculture and is also a CIFRAI member, i.e., a principal AID fisheries contractor. Both institutions agree that by working together, an effective and minimum cost program to achieve the above objective can be developed.

The approach will begin in 1987 with a state of the art review by OI staff and a joint effort to identify the problem areas in tilapia culture in salt water. On the basis of this exercise, a work plan and division of labor will be developed in 1988. Using different strains of tilapia, one each year, a series of experiments will be conducted, beginning in 1989, to characterize particular traits in response to various salinities. Each strain and the progeny of selected crosses between strains is to be evaluated in terms of color, growth and survival.

During this period, potential collaborating institutions will be sought in other countries, e.g., Panama, Philippines, Indonesia.

3. Sea Bass and Snapper

Objective

To refine the technology and practices for the cost-effective control

of the reproductive cycle in selected high-value species, i.e., sea bass and snapper. - estimated completion date - 1991.

Summary Work Plan

Establish a collaborative program with selected hatcheries in countries interested in the culture of these species for the purpose of field-testing the application of hormonal therapies developed from milkfish and mullet research. Significant work on these species is not expected until 1988 or 1989.

C. POST-HARVEST COMPONENTS

Background

A systems approach involves the interaction of production with post-harvest activities ending with consumption. As such, it covers processing, packaging, storage, marketing, distribution and consumer acceptance and use. Post-harvest losses due to spoilage, insect infestation and poor methods and practices for handling, preservation, transportation and marketing are particularly prevalent in the tropics and can be exceedingly high. In both small and larger-scale commercial mariculture, the demands and constraints of the market and the supporting infrastructure must be considered in the species selection and design of the production process.

Objective

To increase the understanding of the socio-cultural conditions associated with mariculture and develop guidelines useful for planning the creation of new, or expanding existing, finfish mariculture industries - continuing.

Summary Work Plan

Spotty and insufficient research has been done on the problem areas of spoilage, contamination, inadequate distribution and marketing methods. A better understanding of the socio-cultural factors associated with small-scale fisheries is needed to assess the impact of technological changes on fish farmers, processors, wholesalers, retailers and consumers.

Some aspects of these problems as they concern conditions found in the tropics have been addressed by the International Center for Marine Resources Development (ICMRD) at the University of Rhode Island (URI) and the University of Hawaii. To date, however, they have primarily concentrated on post-harvest losses of marine capture fisheries. The Oceanic Institute and the ICMRD have agreed to work together in conducting further research in this area in connection with the technology field testing of management practices on milkfish life-cycle culture and, perhaps later on, with the field testing of technology and practices for other finfish species.

Sometime in 1987 or early 1988, URI and OI staff will meet to identify and select the priority problems for investigation, develop the products or outputs which will provide the material for preparing useful guidelines to planners, financiers and managers, prepare a joint work program and agree on the sharing of costs. Other members of CIFRAI will be invited to participate and provide field linkages, particularly ICA/AU, ICLARM, the University of Hawaii and the NMFS.

D. POLICY AND SOCIO-ECONOMIC BENEFITS

Background

A key problem in the expansion of aquaculture, including mariculture, in the developing countries, is that national planners and decision-makers, economists, bankers and other key players sometimes overlook or underestimate its potential in a country's total development picture. This is at least partially due to the inability of aquaculturists to develop credible analytical tools to compare trade-offs with other agricultural crops and animals and/or between species.

This deficiency has been due to a number of factors, the most important of which are (a) the lack of sufficient and viable data, (b) the absence of a systems approach and (c) the difficulty of developing models and cost-benefit analysis techniques for decision-making under such circumstances. However, the baseline data being developed under the Pond Dynamics CRSP and other sources, including this project, and the development of at least a theoretical production model in the near future make it a propitious time to begin attacking this problem.

Finally, in AID's strategy statements included in its publication, "Blueprint for Development", it is recognized that a policy dialogue leading to agricultural and similar reforms is necessary, aimed at what is often the most critical limiting factor in developing countries, public policy. This is particularly true when dealing with small and independent fish farmers and entrepreneurs who view public sector endeavors with great skepticism. In any event, technological improvements and their transfer will be inhibited if not prevented by counter-productive government

policies.

Objective

To develop a practical methodology, compatible to the extent feasible with agricultural and other sectorial tools, for the credible sub-sector analysis of fisheries, primarily aquaculture. - 1991.

Summary Work Plan

The statement of the objective above has been formulated to cover the culture of marine, brackish water, and freshwater fish on the assumption that the methodology will be the same, regardless of water medium and it will permit comparison of trade-offs and alternatives.

The work on this methodology, as well as the pre-feasibility methodology included below, will draw on the modeling achievements in this proposal as well as the Pond Dynamics modeling which is scheduled for field testing in 1989-90. As background, the ICMRD lists a number of decision points in implementing aquaculture which can be used as a starting point.* The ICA has also been planning to prepare a textbook on aquaculture strategy and a systems approach which will provide useful guidelines to the researchers.

It is proposed that a new Technical Advisory Group be established in the near future which will include "technical" representatives from all interested parties, i.e., IBSNAT, Pond Dynamics CRSP, Stock Assessment CRSP, ICA/AU, ICMRD/URI, NMFS and AID/S&T, to assist the Institute in developing an effective and minimum-cost and coordinated work program to produce usable tools for decision-making at policy, investment and

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* Pollnac et al. (1982)

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management levels.

Objective

To develop appropriate methodologies for pre-feasibility studies on life-cycle mariculture - 1991.

Summary Work Plan

The design, construction and operation of hatcheries will require a considerable capital investment by government in the case of a horizontally integrated system or by the entrepreneur/small farmer in a vertically integrated culture system. A similar investment of comparable burden will be required to construct ponds and begin intensive or semi-intensive production. Donor organizations, development and commercial banks and other financing sources will require, at the minimum, pre-feasibility studies which provide an economic analysis of production with the optimum configured enterprise under various assumptions and conditions. Marketing surveys are also required for any medium or large-scale facility for high-value fish including projected cash flow, returns on investment, etc. In the case of low-value fish, public welfare benefits also need to be considered, including employment and quality of life.

In some cases, seed and juvenile production may be a government operation. Even so, adequate financial analysis will be required. Insofar as we can determine, very little work has been done in this area. ICA/AU has developed a "checklist" but it is far short of what is required. The United Nations Industrial Development Organization (UNIDO) has developed a general methodology for pre-feasibility studies of industrial projects which may serve as a starting point. Components of such a methodology,

e.g., marketing surveys, already exist and only need adaptation. The predicted yield from the proposed production model will be a crucial input.

Again we propose that OI provide AID with a central focus and mechanism to develop and perfect a pre-feasibility methodology as part of a package approach, i.e., production model, sub-sector and pre-feasibility methodologies, with the guidance and support of a Technical Advisory Group and participation of CIFRAI members. The URI and AU have indicated strong support for such an endeavor and we assume ICLARM and Oregon State University, among others, will have similar sentiments.

Objective

Create the basis and opportunities for policy dialogue with developing country officials, development banks, entrepreneurs, etc., alerting them to the potential economic and social benefits from aquaculture and the need for supportive public policy. - continuing.

Summary Work Plan

The purpose of this program will be to bring together the information being gathered through technology development, basic research, economic analysis, etc., to overcome the problem manifested in the relative low use of aquaculture and the potential of aquaculture crops as a supplement to food consumption and farm income in stress areas. The place of aquaculture in a small-farm, multiple-cropping system is not fully appreciated. Similarly, the systems approach necessary for relatively large-scale production and successful marketing of high-value fish as an export earner can be overlooked with unanticipated and undesirable results. It is not technology transfer but rather a form of salesmanship that is necessary

until more demonstrable results have been achieved on a larger scale. Programs, materials and media will be developed and opportunities would be used when they appear, e.g., during individual consultations, as part of on-going AID-sponsored fisheries activities in the field. However, they would also be planned for particular targeted countries and audiences and involve appropriate experts from within the CIFRAI community and, in some cases, outside. Work under this objective is planned to begin in 1989.

E. TECHNOLOGY TRANSFER

Background

The transfer and adaptation of appropriate technology, as a generalization, is sometimes more difficult than the development of the technology itself and this is certainly true in mariculture. Agricultural Extension Services in many developing countries are historically weak. In the case of fish culture, the infrastructure is often almost non-existent. There usually is a scarcity of qualified nationals to develop demonstrations, manage experimental or pilot-scale hatcheries and growout ponds, and provide the necessary training to participate in the total system chain. During the research phase, the traditional methods of information exchange can be used, i.e. preparation and distribution of technical papers, presentations at professional conferences, workshops, etc. As this project moves into the testing and application of the technologies developed, a more selective and innovative approach must be taken which involves consultant or technical assistance for any or all components of the system, a wide variety and type of training, and special efforts to reach, inform and persuade critical parties in the fisheries

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process. As in other portions of the AID fishery program, it makes more sense, i.e., it is cost-effective, to plan and implement training and similar activities on a coordinated and cooperative basis with other institutions.

Objective

To transfer the technologies, management practices, and methodologies developed under this project in a cost-effective manner.

Output No. 1 - continuing.

Technical assistance provided on finfish mariculture.

Except when a part of research or similar work is carried out on-site to produce other outputs under this project, it is proposed that technical assistance be provided to host governments and entrepreneurs on all aspects of the system on the basis of mission buy-ins or a similar arrangement. The Oceanic Institute will make available its own staff for short-term assignments or assist field missions in locating suitable candidates from the U.S. and the international aquaculture community. This will be a continuing activity based on demand which is expected to increase gradually with project maturity.

Output No. 2 - continuing.

Training provided on all aspects of aquaculture concerning coastal finfish species.

In cooperation with CIFRAI institutions, the Institute will hold workshops and seminars and conduct short-term training courses on the various components of the aquaculture system tailored for specifically targeted audiences, e.g., scientists, economists, modelers, development

planners, hatchery and cooperative managers, technicians and farmers.

The focus and priority of this training will change as project results on the several system components permit. In-country and on-site training will be the preferred mode, designed in part to create or strengthen indigenous training and extension capabilities. For example, initial emphasis will be on maturation, spawning and larval rearing techniques for hatchery managers and technicians and will gradually shift to extensive efforts for farmers with, perhaps, the hatchery itself becoming a training center. This will be a continuing activity for the life-cycle of the project.

Output No. 3 - continuing.

Workshops, Demonstrations, Case Studies and Publications.

In addition to workshops, seminars, etc., held to disseminate research results and improved management practices, experience with the prototype industries will be closely monitored and documented. Appropriate publications will also be produced throughout the project life. The more successful ventures may also be used to give demonstrations at the pilot or full-scale commercialization level. These activities will take place near project completion and may also involve other bilateral contractors.

Summary Work Plan

Detailed work plans on these outputs will be developed as technology development moves to the field-testing stage. In the interim, the following near-term activities can be scheduled.

- To co-organize, with the Canadian IDRC, a workshop tentively titled, "Recent progress on the technique of inducing spawning of

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important finfish" to be held in 1987. Prerequisite to any form of aquaculture is the acquisition of seedlings, therefore, progress on technical developments in induced spawning of the cultured species is essential to the aquaculture industry. This workshop will promote discussion among currently active scientists on new techniques and solutions to problems. Results will be promulgated and shared among researchers and farmers.

- At the end of the milkfish season in 1987, techniques for inducing maturation and spawning of milkfish will be ready for dissemination to interested countries. It would be appropriate at this time to hold a second workshop on the newly developed but not yet field-tested techniques and to discuss current problems, potential solutions and the methodology and locations for field testing. A third workshop will be held when field testing is completed to present the management practices packages developed before preparation of operational manuals. Any further study will focus on fine-tuning the discoveries and techniques already developed.
- A revised State of the Art Review will be published at that time and will be available to all interested parties. This in conjunction with the operations manuals covering the different life stages will provide the best guidelines available for milkfish farmers. Guidelines on post-harvest components will be initiated in the latter portion of this or the beginning of the next phase.

VII. MANAGEMENT REQUIREMENTS

A. Cooperative Agreement

We have been collaborating with AID on the research to date under a cooperative agreement executed in 1984. This mechanism was chosen by AID, as we understand it, to provide the flexibility required and a continuing process of review and feedback to determine the direction of the research program and accommodate any changes in project priorities. While the research direction is much clearer at this point, we believe the collaborative relationship between AID and the Oceanic Institute, fostered by the cooperative agreement, is still necessary for the development of a systems approach involving considerable coordination and collaboration with other AID fishery contractors. Therefore, we believe that a cooperative agreement would also be the appropriate mechanism for the next phase but with increased day-to-day or operational authority provided to the Principal Investigator.

B. Advisory Groups

TAG

The Technical Advisory Group (TAG), with representation from AID, NMFS, the University of California and the scientific community of collaborative countries and the profession, has proven to be an effective mechanism for reviewing plans and progress and offering valuable advice on priorities, research methodology, linkages, etc. Therefore, we would expect such a mechanism to remain intact for the production research portion of the next phase. However, with the comprehensive and complicated program proposed for modeling, including methodologies for analysis and

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decision-making, it is proposed that a new TAG be created solely for this function and to perform a similar role.

CIFRAI

With the support of AID, the principal AID fishery contractors have recently formed an informal Committee for International Fisheries Research and Assistance Institutions (CIFRAI) which includes representatives from the Pond Dynamics CRSP, Stock Assessment CRSP, ICLARM, Auburn University, University of Rhode Island, NMFS and our Institute. The group seeks to increase the awareness of the potential role of fisheries in development, to improve the effectiveness of AID-supported fisheries research and development activities through better communication and coordination, and to generate new ideas, approaches and methodologies for promoting wise use of national resources in developing countries through fishing and aquaculture. As a first step, CIFRAI is assisting AID/S&T to draft a fisheries policy and strategy statement. We are cooperating in this important endeavor and welcome the opportunity to work closer with our colleagues.

C. Lead Organization

As explained in our proposal, a systems approach to aquaculture (for marine finfish or in general) with emphasis on the total process, will require major contributions from institutions represented in CIFRAI and perhaps others. An important subject for negotiation between the Oceanic Institute and AID will be how to bring this about using this project as a prototype. One example is the matter of financing and stimulating such collaboration. Where institutions have cooperative agreements, Title XII,

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strengthening grants, and/or flexible research targets such as in the CRSPs, it may simply amount to a minor reprogramming of available funds. In other cases, new funds may be required which can be made available to the institutions directly or, in the case of mariculture, funneled through the Oceanic Institute in the mode of a management entity (CRSP) or lead organization (FSSP). In any event, the Oceanic Institute is ready to assume whatever role seems appropriate and most likely to be most effective and acceptable.

D. Management and Review

As the project focus shifts from research on seed and juvenile production, greater flexibility in work planning and fund allocation will be required. To maximize flexibility while maintaining reasonable program control, we propose that a Management Review Committee (MRC) be established consisting of the AID/S&T Program Coordinator, the Principal Investigator and the current chairmen of the two TAGs. The function of the MRC will be to review annual work plans, major funding changes, and progress in producing scheduled events and outputs.

In conjunction with AID policy on the evaluation of major projects and as a decision-making device regarding the continuation or reorientation of the project in Phase II, it is also proposed that a comprehensive, issue-oriented external evaluation be held during the latter half of 1989.

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SCHEDULE OF ACTIVITIES AND BUDGET

	Year 1 1987	Year 2 1988	Year 3 1989	Year 4 1990	Year 5 1991	TOTAL
A. MILKFISH						
Technology Development						
1. Seed Production	525.6K	532.6K	574.3K	213.8K	222.8K	2069.1K
Output 1-Controlled maturation	X	X	X			
2-Controlled spawning	X	X				
3-Larval rearing technology	X	X	X	X	X	
2. Juvenile Production	276.9K	297.1K	496.7K	349.6K	357.7K	1778.0K
Output 1-Optimize stocking density	X	X	X			
2-Water quality parameters	X	X	X			
3-Feed regime	X	X	X	X	X	
3. Fish Production	494.0K	542.3K	566.4K	625.0K	644.0K	2871.7K
Output 1-Production system	X	X	X	X		
2-Production model	X	X	X	X	X	
3-Cost-effective feed	X	X	X	X	X	
Management Practices				150.0K	150.0K	300.0K
1. Hatchery				X	X	
2. Nursery				X	X	
3. Pond/Farm				X	X	
B. OTHER DESIRABLE FINFISH SPECIES	90.2K	10.0K	106.4K	393.4K	408.6K	1008.6K
1. Mullet cost-effective hatchery techniques	X	X	X	X	X	
2. Tilapia-Identify saltwater strain	X		X	X	X	
3. Sea Bass and Snapper			X	X	X	

POST-HARVEST COMPONENTS		15.0K	25.0K	50.0K	50.0K	140.0K
POLICY AND SOCIO-ECONOMIC BENEFITS						
1. Sub-sectorial analytical methodology				25.0K	50.0K	75.0K
2. Pre-feasibility methodology			50.0K	50.0K	10.0K	110.0K
3. Policy dialogues		15.0K	25.0K	25.0K	25.0K	90.0K
Sub-total		15.0K	75.0K	100.0K	85.0K	275.0K
TECHNOLOGY TRANSFER						
1. Technical assistance	10.0K	20.0K	50.0K	50.0K	70.0K	200.0K
2. Training	15.0K	25.0K	50.0K	75.0K	75.0K	240.0K
3. Workshops, demonstrations, case studies	40.0K	40.0K	50.0K	60.0K	60.0K	250.0K
4. Publications	5.0K	10.0K	15.0K	15.0K	15.0K	60.0K
Sub-total	70.0K	95.0K	165.0K	200.0K	220.0K	750.0K
MANAGEMENT						
1. TAG (R & D)	20.0K	20.0K	10.0K			50.0K
2. TAG (modeling)	10.0K	20.0K	20.0K	30.0K	30.0K	110.0K
3. Mid-term evaluation			15.0K			15.0K
Sub-total	30.0K	40.0K	45.0K	30.0K	30.0K	175.0K
TOTAL	1486.7K	1547.0K	2053.8K	2111.8K	2168.1K	9367.4K

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PAUL K. BIENFANG
The Oceanic Institute

Academic

Ripon College, Ripon, Wisconsin. 1966-67.
University of Hawaii, Honolulu, Hawaii. B.S. Biology. 1971.
University of Hawaii, Honolulu, Hawaii. M.S. Oceanography. 1974.
University of Hawaii, Honolulu, Hawaii. Ph.D. Oceanography. 1977.
University of Hawaii, Honolulu, Hawaii. Management Program. 1983.

Positions and Experience

University of Hawaii, Honolulu, Hawaii. Department of Oceanography, Affiliate Faculty Member. 1984 - present.

OI Consultants, Inc., Waimanalo, Hawaii. Vice President. 1984 - present.

The Oceanic Institute, Waimanalo, Hawaii. Vice President. Responsible for overseeing all research components at the Institute, providing technical input as necessary and monitoring progress of programs. Review of research design, results, and reports. Over a decade of experience in environmental consulting and surveys. 1982 - present.

The Oceanic Institute, Waimanalo, Hawaii. Biological Oceanographer. 1973 - present.

Hawaii Institute of Marine Biology, Pacific Biomedical Research Center, Kaneohe, Hawaii. Research Affiliate.

University of British Columbia. Visiting Faculty Member. 1980.

British Columbia, Research Investigator, CEPEX Program. Summer 1978.

Member of scientific party on over forty research cruises in the subtropical Pacific, Tierra del Fuego expedition, and off the California coast.

Consultant Phytoplankton Ecologist, Microbiologist, Nutrient Chemist 1971-74.

Microbiologist on expeditions to Pala Lagoon, American Samoa, 1972.

Hawaii Institute of Marine Biology, Kaneohe, Hawaii. Research Assistant to Drs. S. A. Cattell and J. Caperon, 1972-73; Dr. Philip Helfrich, 1971-72; Dr. Kaare Gundersen, U.H., Microbiology Department, University of Hawaii, 1969-70.

PAUL K. BIENFANG (contd)

Research Interests

Phytoplankton ecology. Physiological control of phytoplankton buoyancy. Technical and theoretical aspects of measuring phytoplankton sinking rates, primary particle sedimentation rates, and biogenic transport flux. Phytoplankton growth rates and community size structure in oligotrophic marine environments. Influence of environmental factors on the growth of marine phytoplankton. Dynamics of deep chlorophyll maxima. Phytoplankton nutrient uptake, growth and community response to deep ocean water. Ecology of Hawaiian anchialine ponds.

Academic Awards

Bachelor of Science degree conferred with Highest Honors (1971)
Arthur Lyman Dean's Prize for Outstanding Undergraduate Research (1971)
President's Stipend to United Nations FAO Convention in Rome, Italy, (1970)
Jessie Smith Noyes Foundation, Ph.D. Fellowship, 1977.

Membership in Scientific Societies

American Society of Limnology and Oceanography
Western Society of Naturalists
American Association for the Advancement of Science
Phycological Society of America

Publications and Reports

Bienfang, P. K. 1971. Taking the pollution out of waste heat. New Scientist and Science Journal 51: 456-457.

Gundersen, K. and P. Bienfang. 1972. Thermal Pollution: Use of deep, cold, nutrient-rich seawater for power plant cooling and subsequent aquaculture in Hawaii. In: Marine Pollution and Sea Life (M. Ruivo, ed.) Fishing News (Books) Ltd., London 624 pp.

Raymond, L. P., P. K. Bienfang and J. A. Hanson. 1974. Nutritional considerations of open sea mariculture. In: Open Sea Mariculture (J. A. Hanson, ed.) Dowden, Hutchinson & Ross, Inc. Stroudsburg, Pa. 410 pp.

Bienfang, P. K. 1975. Steady-state analysis of nitrate-ammonium assimilation by phytoplankton. Limnol. and Oceanogr., 20: 402-411.

Bienfang, P. K. and K. Gundersen. 1977. Light effects on nutrient-limited oceanic primary production. Mar. Biol., 43: 187-199.

Bienfang, P. K., E. Laws and J. Johnson. 1977. Phytoplankton sinking rate determination: Technical and theoretical aspects, an improved methodology. J. exp. Mar. Biol. Ecol., 30: 283-300.

PAUL K. BIENFANG (contd)

Rothwell, G. N. and P. K. Bienfang. 1978. MARS - A new instrument for measuring phytoplankton sinking rate. Mar. Tech. Soc. J. 12: 13-17.

Bienfang, P. K. 1979. A new phytoplankton sinking rate method suitable for field use. Deep-Sea Res., 26: 719-729.

Bienfang, P. K. 1980. Herbivore diet affects fecal pellet settling. Can. J. fish. Aqua. Sci., 37: 1352-1357.

Bienfang, P. K. 1980. Phytoplankton sinking rates in oligotrophic waters off Hawaii. Mar. Biol., 61: 69-77.

Bienfang, P. K. 1980. Water quality characteristics of Honokohau Harbor: A subtropical embayment affected by groundwater intrusion. Pac. Sci., 34(3): 279-292.

Bienfang, P. K. and W. Johnson. 1980. Response to subtropical phytoplankton to power plant entrainment. Environmental Pollution (Series A) 22: 165-178.

Bienfang, P. K. and W. Johnson. 1980. Planktonic properties of Honokohau Harbor: a nutrient enriched subtropical embayment. Pac. Sci., 34(3): 293-300.

Bienfang, P. K. 1981. SETCOL - A technologically simple and reliable method for measuring phytoplankton sinking rates. Can. J. fish. Aqua. Sci., 38(10): 1289-1294.

Bienfang, P. K. 1981. Sinking rate dynamics of Cricosphaera carterae Braarud I. Effects of growth rate, limiting substrate, and diurnal variation in steady-state populations. J. exp. Mar. Biol. Ecol. 49: 217-233.

Bienfang, P. K. 1981. Sinking rate dynamics of Cricosphaera carterae Braarud II. Senescence response to various limiting substrates in non-steady-state populations. J. exp. Mar. Biol. Ecol., 49: 235-244.

Bienfang, P. K. 1981. Sinking rates of heterogeneous temperate phytoplankton populations. J. Plankton Res., 3(2): 235-253.

Bienfang, P. K. and J. P. Szyper, 1981. Phytoplankton dynamics in the subtropical Pacific Ocean off Hawaii. Deep-Sea Res., 28(9): 981-1000.

Takahashi, M. and P. K. Bienfang. 1981. The structure and dynamics of phytoplankton population in the eastern subtropical Pacific. Kaiyo-Kagaku (Marine Sciences Monthly), 13: 551-554 (in Japanese).

PAUL K. BIENFANG (Contd)

Bienfang, P. K. 1982. Phytoplankton sinking rate dynamics in enclosed experimental ecosystems. In: Marine Mesocosms. Biological and Chemical Research in Experimental Ecosystems. (G. D. Grice and M. R. Reeve eds.) Springer-Verlag, New York.

Bienfang, P. K., P. J. Harrison and L. M. Quarmby. 1982. Sinking rate response to depletion of nitrate, phosphate and silicate in four marine diatoms. Mar. Biol., 67: 295-302.

Bienfang, P. K. and J. P. Szyper. 1982. Effects of temperature and salinity on sinking rates of the centric diatom Ditylum brightwelli. Biol. Oceanogr., 1:3: 211-223.

Noda, E. N., P. K. Bienfang, W. J. Kimmerer and T. W. Walsh. 1982. Plume survey OTEC-1 mixed-water discharge April 11-12, 1981. Ocean Sci. Eng., 7(1): 107-146.

Takahashi, M., I. Koike, K. Iseki, P. K. Bienfang and A. Hattori. 1982. Phytoplankton responses to nutrient changes in experimental ecosystems in the sea. In: Marine Mesocosms, Biological and Chemical Research in Experimental Ecosystems. (G. D. Grice and M. R. Reeve eds.) Springer-Verlag, New York.

Bienfang, P. J., J. P. Szyper and E. Laws. 1983. Sinking rate and pigment responses to light-limitation by a marine diatom. Implications to dynamics of chlorophyll maximum layers. Ocean. Acta., 6(1): 55-62.

Takahashi, M. and P. Bienfang. 1983. Size structure of phytoplankton biomass and photosynthesis in subtropical Hawaiian waters. Mar. Biol., 76(2): 203-211.

Smayda, T. J. and P. K. Bienfang. 1983. Suspension properties of various phyletic groups of phytoplankton and tintinids in an oligotrophic subtropical system. Mar. Ecol. Prog. Ser., 4 (4): 289-300.

Bienfang, P. K. and M. Takahashi. 1983. Ultraplankton growth rates in a subtropical ecosystem. Mar. Biol., 76(2): 213-218.

Bienfang, P. K. and P. J. Harrison. 1984. Co-variation of sinking rate and cell quota among nutrient replete marine phytoplankton. Mar. Ecol. Prog. Ser., 14(2): 297-300.

Bienfang, P. K., L. Morales, K. Klein and M. Takahashi. 1984. Picoplankton growth rates in subtropical Hawaiian embayments. Pac. Sci., 38(2).

Bienfang, P. K., J. P. Szyper, M. Okamoto, and E. Noda. 1984. Temporal and spatial variability of phytoplankton in a subtropical ecosystem. Limnol. Oceanogr., 29(3): 527-539.

PAUL K. BIENFANG (Contd)

Laws, E. A., D. G. Redalje, L. W. Haas, P. K. Bienfang, R. W. Eppley, W. G. Harrison, D. M. Karl and J. Marra. 1984. High phytoplankton growth and production rates in oligotrophic Hawaiian coastal waters. Limnol. Oceanogr. 29(6): 1161-1169.

Bienfang, P. K. 1984. Size structure and sedimentation of biogenic microparticulates in subarctic ecosystem. J. Plankton Res. 6: 985-995.

Bienfang, P. K. and P. J. Harrison. 1984. Sinking rate response of natural temperate and subtropical phytoplankton assemblages to nutrient depletion. Mar. Biol. 83: 293-300.

Bienfang, P. K. 1985. Size structure and sinking rates of various microparticulate constituents in oligotrophic Hawaiian waters. Mar. Ecol. Prog. Ser. 23: 143-151.

Parsley, P. E., C. O. Davis and P. K. Bienfang. In preparation. Phytoplankton dynamics in experimental ecosystems: A comparison of the initial diatom blooms during CEPEX Foodweb I Experiments.

Bienfang, P. K. Aspects of phosphorus limitation and sedimentation in oligotrophic waters. Paper presented at the 1984 International Association of Great Lakes Conference, St. Catherines, Ontario. April, 1984

Bienfang, P. K. Size structure and sedimentation of biogenic microparticulates in a subarctic ecosystem. Paper presented at the 1984 ASLO Conference, Vancouver, B.C., June, 1984.

In addition to these publications in scientific journals, Dr. Bienfang's published contributions include more than thirty technical reports on various aspects of subtropical phytoplankton ecology.

CHENG-SHENG LEE
The Oceanic Institute

Academic

National Taiwan University, Department of Zoology, B.S. Fishery Biology. 1970.
National Taiwan University, The Institution of Oceanography, M.S. Marine Biology. 1972.
University of Tokyo, Department of Fisheries, Ph.D. Aquaculture. 1979.

Positions and Experience

The Oceanic Institute, Waimanalo, Hawaii. Principal Investigator for Finfish Program. In charge of administration of program, experiment design, execution and reports. 1984 - present.

The Oceanic Institute, Waimanalo, Hawaii. Shrimp and Finfish Program Manager. 1981-84.

The Oceanic Institute, Waimanalo, Hawaii. Research Associate. 1980-81.

The Oceanic Institute, Waimanalo, Hawaii. Post-doctoral Research Associate. 1979-80.

Joint Research with Philippines on the Induced Spawning of Milkfish *Chanos chanos*. 1979.

Joint Research with Japanese on the Induced Spawning of *Anguilla japonica*. 1976-79.

Tungkang Marine Laboratory, Taiwan Fisheries Research Institute, Taiwan. Aquatic Biologist. 1973-76.

Publications

Lee C. S. 1972. Effect of periodic starvation on prawns. M.S. Thesis, National Taiwan University.

Lee C. S. and I. C. Liao. 1972. The effect of periodic starvation on prawns - I. Periodic starvation related to feeding amount and growth of *Penaeus penicillatus* Alcock. (In Chinese). J. Fish. Soc. Taiwan 1(1):99-120.

Lee C. S., S. R. Liang and I. C. Liao. 1974. The effect of periodic starvation on prawns - II. Periodic starvation related to feeding amount and growth on *Penaeus monodon* Fabricus. (In Chinese). J. Fish. Soc. Taiwan 3(2):93-110.

Lee C. S., S. R. Liang and I. C. Liao. 1976. The effect of periodic starvation on prawns - III. Periodic starvation related to feeding amount and growth of *Penaeus japonicus* Bate (In Chinese). J. Fish. Soc. Taiwan 4(2):11-20.

C.-S. LEE (contd)

Lee C. S. 1979. Fundamental studies on seedling production of Sillago sihama (Forsskal). Ph.D. Dissertation, University of Tokyo.

Lee C. S., F. Hu and R. Hirano. 1981. Salinity tolerance of fertilized eggs and larval survival in the fish Sillago sihama. Mar. Ecol. Prog. Ser. 4:169-174.

Lee C. S. 1981. Factors affecting egg characteristics in the fish Sillago sihama. Mar. Ecol. Prog. Ser. 4:361-363.

Lee C. S. and F. Hu. 1981. Salinity tolerance and salinity effects on brood size of Tigriopus japonicus Mori. Aquaculture 22:377-381.

Lee C. S., F. Hu and R. Hirano. 1981. Organisms suitable as food for larvae of black sea bream. Prog. Fish. Culture 43(3):121-124.

Lee C. S. and B. Menu. 1981. Effects of salinity on egg development and hatching in grey mullet Mugil cephalus L. J. Fish. Biol. 19:179-188.

Lee C. S. and R. Hirano. 1981. Suitable food organisms and feeding schedules for the larvae of Sillago sihama (Forsskal). Rapp. P. V. Reun. Cons. Int. Explor. Mer., 178:533-537.

Lee C. S. and F. Hu. 1983. Influence of Ca and Mg ions on egg survival in Mugil Cephalus. J. of Fish Biology. 22:13-20.

Lee C. S. and G. M. Weber. Preliminary studies on the maturation of milkfish Chanos chanos Forsskal, in an environmentally controlled system. Presented at the Second International Milkfish Conference, Philippines. 4-8 October, 1983.

Lee, C. S., G. M. Weber and J. Thomas. 1984. Effect of orally administered 17α-methyl-testosterone on gonad development in immature milkfish, Chanos chanos Forsskal. Asian Aquaculture Vol.II (2), p.6.

Lee, C. S. and R. A. Shleser. 1984. Production of Penaeus vannamei in cow-manure-enriched ecosystems in Hawaii. J. World Maric. Soc. 15: 52-60.

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

Lee, C. S. 1985. Environmental Factors in Milkfish Reproduction. Proceedings of the Workshop on the Reproduction and Culture of Milkfish, held in Taiwan on April 22-24, 1985. p.99-114.

C.-S. LEE (contd)

Lee, C. S., C. S. Tamaru and L. W. Crim. 1985. Preparation of a Luteinizing Hormone-releasing Hormone Cholesterol Pellet and its Implantation in the Milkfish (Chanos chanos Forsskal). Proceedings of the Workshop on the Reproduction and Culture of Milkfish, held in Taiwan on April 22-24, 1985. p.215-226.

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

Lee, C. S., J. N. Sweeney and B. Richards. 1985. The effects of stocking densities on growth and survival of Penaeus vannamei in cow manure-enriched ponds. Proceeding of the First International Conference on the Culture of Penaeid Prawns/Shrimp. p. 170.

Lee, C. S. and J. N. Sweeney. 1985. Morphometric studies on three penaeid shrimp, Penaeus japonicus, P. vannamei, and P. marginatus in Hawaii. Proceeding of the First International Conference on the Culture of Penaeid Prawns/Shrimp. p. 176.

Lee, C. S. and L. Krishnan. 1985. Influences of Calcium and Magnesium Ions Embryo Survival, Percentage Hatching and Larval Survival of Dolphin Fish Coryphaena hippurus L. (Accepted by World Mariculture Society Publications.

Lee, C. S., C. S. Tamaru, J. E. Banno and C. D. Kelley. Induced spawning of milkfish (Chanos chanos) by LHRH-a. Presented at World Mariculture Society, Reno, January 19-23, 1986.

Lee, C. S. and C. S. Tamaru. 1985. (Accepted by Aquaculture). Induced maturation and spawning of milkfish Chanos chanos Forsskal, by hormone implantation.

Lee, C. S., G. M. Weber and C. S. Tamaru. (Submitted to Journal of Fish Biology). Effect of Orally Administered 17 -methyl testosterone on Spermatogenesis in Immature Milkfish, Chanos chanos Forsskal.

Lee, C. S., G. M. Weber and C. S. Tamaru. (Submitted to Journal of World Mariculture Society). Studies on the maturation and spawning of milkfish Chanos chanos Forsskal in a photoperiod controlled room.

Wyban, J. A., C. S. Lee, J. N. Sweeney and W. K. Richards. (Submitted to Journal of World Mariculture Society). The effects of light intensity, photoperiod, water temperature and female eyestalk ablation on maturation, mated spawning frequencies and nauplii production in Penaeus vannamei.

EIRIK O. DUERR
The Oceanic Institute

Academic

Vanderbilt University, Nashville, Tennessee. B.A. Molecular Biology. 1968.

University of Miami, School of Marine and Atmospheric Science, Miami, Florida. M.S. Marine Biology. Title of Thesis: "Oxygen consumption studies on the pink shrimp *Penaeus duorarum*". 1976.

University of Miami, School of Marine and Atmospheric Science, Miami, Florida. Ph.D. 1981. Marine Science. Title of Dissertation: "Aerobic nitrogen fixation by two unicellular marine cyanobacteria (*Synechococcus* spp.)".

Positions and Experience

The Oceanic Institute, Waimanalo, Hawaii. Feeds Program Manager. Responsible for directing the Biomass Production component of a comprehensive feeds development program funded by USDA. This primarily involves the development of culture methods for the mass production of *Spirulina* that will reduce the cost of production enough to make the algae economically feasible as a protein feed ingredient. 1984-present.

University of Miami, Department of Biology, Coral Gables, Florida. Postdoctoral Research Associate. Lab director: Dr. Howard Teas. Coordinated conference on Marine Biomass Production and Utilization. Research on petroleum pollution effects on mangrove (*Rhizophora*) physiology. 1983.

University of Texas, Department of Botany and Marine Science Institute, Port Aransas, Texas. Postdoctoral Research Associate. Lab director: Dr. Chase Van Baalen. Research areas included coupling of photosynthesis with nitrogen fixation, and field experiments on natural samples of diazotrophs. 1981-82.

Work experience during graduate training included: one year study on shrimp karyotyping; fish larvae survey (identification and enumeration) of coastal and shelf spawning species; survey of fish of Biscayne Bay, Florida for pollution related diseases and malformations; shrimp hatchery and pond culture related work; participation in six cruises through the Gulf of Mexico and Bahamas; was chief scientist during a ten day cruise; collection and isolation of photosynthetic microorganisms from marine and estuarine areas; extensive biochemical and physiological assays for describing photosynthetic microorganisms.

Commissioned officer in the U.S. Army; responsible for directing over 20 civilian employees.

E. O. DUERR (contd)

Teaching Experience

Taught semester course in conversational German
Taught lab sections dealing with nitrogen fixation and with salinity stress
Numerous seminars and presentations given including national meetings of: American Society of Plant Physiologists; American Society for Microbiology.

Honors

Dean's List, Vanderbilt University (also 3 athletic letters)
Dow Chemical Company Graduate Research Assistantship
Sarah Mellon Scaife Foundation Graduate Research Assistantship
Weyerhaeuser Company Summer Intern

Language Abilities

German: excellent reading, speaking and understanding
Norwegian and Spanish: good to excellent in each category

Publications

Mosig, G., R. Ehring and E. O. Duerr. 1968. Replication and recombination of DNA fragments in bacteriophage T4. Cold Springs Harbor Symposia 33: 361-369.

Mitsui, A., E. Duerr, S. Kumazawa, E. Phillips and H. Skjoldal. 1979. Biological solar energy conversion: hydrogen production and nitrogen fixation by marine blue-green algae. p.31-35. In: Sun II, Proc. Intl. Solar Energy Soc. (ed. by Boer, K.W. and B. H. Glenn) Pergamon Press, New York.

Duerr, E. O., S. Kumazawa and A. Mitsui. 1982. Nitrogen fixation among free-living algae. p.251-264. In: C.R.C. handbook of biosolar resources, Vol.1, Part 1 (ed. by Mitsui, A. and C. C. Black) C.R.C. Press, Boca Raton.

Duerr, E. O. and A. Mitsui. 1982. Salinity preference and tolerance of aquatic photosynthetic organisms. p.223-244. In: C.R.C. handbook of biosolar resources, Vol. 1, Part 2 (ed. by Mitsui, A. and C. C. Black) C.R.C. Press, Boca Raton.

Hugh, W. I., W. Dominy and E. Duerr. 1985. Evaluation of Dehydrated Spirulina, (Spirulina platensis) as a Protein Replacement in Swine Starter Diets. Research Extension Series, Univ. of Hawaii. 630 US ISSN 0271-9916, 10pp.

E. O. DUERR (contd)

Manuscripts submitted:

Duerr, E. O., F. R. Tabita and C. Van Baalen. Wavelength effects on the *in situ* light stimulated nitrogen fixation by blue-green algae.

Duerr, E. O. and C. Van Baalen. Light quality effects upon the maintenance of nitrogenase activity in a heterocystous blue-green alga.

Manuscripts in preparation:

Duerr, E. O., S. Izawa and A. Mitsui. The synchrony of metabolic activity with peak nitrogenase activity in the cyanobacterium *Synechococcus* sp.

Duerr, E. O. and A. Mitsui. The distribution and growth physiology of aerobic, nitrogen fixing strains of *Synechococcus* spp.

OI Reports

Comprehensive Feeds Development Program. Phase II Report with Appended Progress Report through October 12, 1984. Submitted to U.S. Department of Agriculture, September, 1984.

Comprehensive Agriculture and Aquaculture Feeds Production System. USDA Grant No. 59-32U4-4-25. Annual Report 12/30/83 to 12/31/84. Submitted to U.S. Department of Agriculture. Research Scientists: S. Divakaran, W. Dominy, E. Duerr, B. Hunter, M. Landau. February, 1985.

Comprehensive Agriculture and Aquaculture Feeds Production System. USDA Grant No. 59-32U4-4-25. Phase IV Progress Report 1/1/85 to 4/30/85. Submitted to U.S. Department of Agriculture. Research Scientists: S. Divakaran, W. Dominy, E. Duerr, B. Hunter, M. Landau. June, 1985.

Comprehensive Agriculture and Aquaculture Feeds Production System. USDA Grant No. 59-32U4-4-25. Phase V Progress Report 5/1/85 to 8/31/85. Submitted to U.S. Department of Agriculture. Research Scientists: S. Divakaran, W. Dominy, E. Duerr, B. Hunter, September, 1985.

Comprehensive Agriculture and Aquaculture Feeds Production System. USDA Grant No. 59-32U4-4-25. Annual Report 12/31/84 to 12/31/85. Submitted to U.S. Department of Agriculture. Research Scientists: L. Campbell, S. Divakaran, W. Dominy, E. Duerr, B. Hunter, J. Ivy. January, 1986.

E. O. DUERR (contd)

Abstracts:

Duerr, E. O. and A. Mitsui. 1980. Aerobic growth and nitrogenase activity of a marine unicellular blue-green alga, Synechococcus sp. Plant Physiol Suppl. 65 (6): 160.

Duerr, E. O. and A. Mitsui. 1981. Aerobic growth characteristics of two marine unicellular nitrogen-fixing cyanobacteria. Abstr. Ann. Meeting Amer. Soc. Microbiol. K 85.

Duerr, E. O. 1982. Light quality effects upon nitrogenase activity in two heterocystous cyanobacteria. Abstr. Ann. Meeting Amer. Soc. Microbiol. CC II 20.

Kumar, A., E. O. Duerr, F. R. Tabita and C. Van Baalen. 1983. Heterocyst isolation from a cell-wall deficient mutant of Anabaena strain CA. Abstr. Ann. Meeting Amer. Soc. Microbiol.

Aerobic nitrogen fixation by two unicellular marine cyanobacteria (Synechococcus) spp.). (December, 1981).

Abstract of a doctoral dissertation at the University of Miami. Dissertation supervised by Professor A. Mitsui.

A widespread distribution of unicellular cyanobacteria was observed in the South Florida, Bahama Islands area. Unicells capable of growth in combined nitrogen free media were found in 44% of all stations. Two strains were selected for isolation and study of their nitrogenase activity. They were classified as Synechococcus sp. according to their oval shape, lack of laminate sheath and division in a single plane. Microscopically the two strains could be distinguished during their nitrogen-fixing growth cycle according to their degree of synchrony of the peripheral cytoplasmic organization development. A totally different cytoplasmic organization was noted for cells grown in medium containing combined nitrogen.

Differing environmental preferences distinguished the two strains most clearly. Both were classified as obligate halophytes with strain BG 043511 growing optimally in medium containing 8% NaCl and strain BG 041621 in 16% NaCl. Both strains grew well in seawater salinities. Other differences were noted in their pH, light, and temperature preferences. Growth rates were similar for both stains; peak doubling times of 17 hours existed in the combined-nitrogen free medium, while 13-15 hours were required in media containing combined nitrogen.

Nitrogenase activity (acetylene reduction) varied with respect to growth phase in both organisms, reaching peak activity during early log phase. Both strains had similar activity rates; aerobic rates peaked at 11-13 nmoles C_2H_4/mg dry weight/min and anaerobic rates peaked at 16 nmoles. The ratio of aerobic to anaerobic activity peaked at 0.7 during early log phase.

Possible oxygen protection mechanisms were investigated. It was noted that normal dark respiration, a second oxygen reducing component, unbound phosphate content, and carbohydrate content peaked during the same period as peak nitrogenase activity. A hypothesis was developed on the oxygen protection mechanisms based upon the results of these investigations.

JAMES A. WYBAN
The Oceanic Institute

Academic

Northwestern University, Evanston, Illinois, B.S. Biology. 1973.
Marine Biological Laboratory, Woods Hole, Massachusetts. Summer Physiology Program. 1978.
University of Hawaii, Honolulu, Hawaii, Ph.D. Zoology. 1981.

Positions and Experience

The Oceanic Institute, Waimanalo, Hawaii. Research Scientist. Program Manager of State of Hawaii Shrimp Program entitled "Examination of factors influencing reproduction and grow-out of *Penaeus vannamei*." 1985. Co-manager of U.S. AID cooperative research program with SEAFDEC-AQD, Philippines and Tungkang Marine Laboratory, Taiwan, entitled "Reproductive studies on milkfish". 1985. Principal Investigator of USDA-funded marine shrimp program, entitled "U.S. Marine Shrimp Farming Program". 1986 - present.

Northshore Fish and Produce, Haleiwa, Hawaii. President. Owned and operated a 7-acre commercial fishfarm. Emphasized intensification of production from extensive to semi-intensive through increased stocking densities and inputs. Improved systems management and continuous harvesting methods. Developed hybrid red tilapia hatchery and brackishwater polyculture system (shrimp/mullet/tilapia). 1981-84.

Hawaii Institute of Marine Biology, Kaneohe, Hawaii. Research Assistant. Conducted research in biochemical genetics of fish development. Projects involved laboratory spawning and maintenance of large fish populations. 1976-81.

Marine Biological Laboratory, Woods Hole, Massachusetts. Trainee. Received a NIH training fellowship to attend the summer course in Physiology at MBL with intensive training in molecular biology including recombinant DNA technology. Summer 1978.

Institute for Cancer Research, Philadelphia, Pennsylvania. Research Associate. Conducted biochemical analysis of chicken DNA studying endogenous virus using recombinant DNA technology and Southern Blot techniques. Fall 1978.

Professional Expertise

Aquaculture expertise includes penaeid shrimp culture; coastal zone aquaculture; polyculture; red tilapia hybridization and grow-out techniques; penaeid shrimp reproduction; marketing of aquaculture products; small business management. Considered the State's expert on Hawaiian Fishponds including anthropological significance, current methods of use, and future potential. Basic science research expertise includes biochemical genetics; electrophoresis; developmental genetics; fish development; molecular biology.

J. A. WYBAN (contd)

Professional Affiliations

American Society of Zoologists
Federation of American Scientists
National Wildlife Federation
World Mariculture Society
Governor's Aquaculture Industry Development Committee

Publications

Wyban, J. A. and G. A. Ahearn. 1977. Electrogenic alanine absorption by the perfused midgut of the freshwater prawn, Macrobrachium rosenbergii. Am. Zool. 17:942.

Wyban, J. A. 1978. Molecular mechanisms of nutrient absorption by Macrobrachium rosenbergii. Pac. Sci. 19:126.

Wyban, J. A. 1979. Peptidase isozyme expression during early development in the Japanese medaka. Am. Zool. 19:891.

Wyban, J. A. 1979. Variation in genome locations of chicken endogenous virus. Pac. Sci. 21:211.

Wyban, J. A. and S. M. Astrin. 1979. Multiplicity and diversity of chicken endogenous virus. Virology 52:1022.

Astrin, S. M., H. L. Robinson, L. B. Crittenden, E. G. Buss, J. Wyban and W. S. Hayward. 1979. Ten genetic loci in the chicken that contain structural genes for endogenous virus. Cold Spring Harbor Symp. Quant. Biol. 44:1026-1037.

Ahearn, G. A., J. A. Wyban and L. A. Maginniss. 1979. Metabolic effects of alanine and glucose on intestinal transmural PD and net Na transport in freshwater prawns. Physiologist 1979:144.

Wyban, J. A., G. A. Ahearn and L. Maginniss. 1980. Effects of organic solutes on transmural PD and Na transport in freshwater prawn intestine. Am. J. Physiol. 239:C11-C17.

Wyban, J. A. 1980. Yolk utilization in teleost development. Pac. Sci. 22:62.

Wyban, J. A. 1981. Biochemical and genetic aspects of peptidase isozyme expression during ontogeny in the Japanese medaka, Oryzias latipes. Ph.D. Dissertation, Department of Zoology, University of Hawaii, Honolulu. 180 pp.

Wyban, J. A. 1982. Soluble peptidase isozymes of the Japanese medaka: Tissue distribution and substrate specificities. Biochem. Genet. 20:849-858.

J. A. WYBAN (contd)

Wyban, J. 1982. Brackishwater polyculture in an ancient Hawaiian Fishpond. Proc. Third Hilo Aqua. Conf.

Wyban, J. 1982. Lokoea Fishpond: Learning from the past, looking to the future. Aquaculture in Hawaii. DLNR, State of Hawaii. Vol. 1 No. 4.

Wyban, J. 1982. Lokoea Fishpond offers lessons in polyculture. Aquaculture Magazine Vol.9, No. 1.

Wyban, C. A. and J. Wyban. 1984. Molokai Hawaiian Academy of Knowledge Aquaculture Curriculum. 29 pp.

Wyban, J. A., C. S. Lee, J. N. Sweeney and W. K. Richards. 1986. The effects of light, temperature and female eyestalk enucleation on reproduction in Penaeus vannamei. (Submitted to Journal of World Mariculture Society.)

Wyban, J. A., J. Ogle, G. D. Pruder, L. W. Rowland and P. S. Leung. 1986. Design, operation, and comparative financial analysis of shrimp farms in Hawaii and Texas. (Submitted to Journal of World Mariculture Society.)

Yano, I., J. N. Sweeney, C. S. Tamaru and J. A. Wyban. 1986. Internal tagging method for individual identification of penaeid shrimp. (Submitted to Aquaculture.)

Lee, C. S., C. S. Tamaru, C. Kelley, J. Banno and J. A. Wyban. 1986. Induced spawning in milkfish by hormone implantation. (Submitted to Aquaculture.)

W. K. Richards, J. N. Sweeney and J. A. Wyban. 1986. Oceanic Institute Shrimp Manual. (To be published.)

J. A. WYBAN (contd)

Selected Recent Project Experience

7/84-9/84 Under contract with Kamehameha Schools/Bishop Estate provided on-site technical supervision for mullet cage culture project at Keawanui Fishpond, Molokai. Developed aquaculture curriculum for Molokai Hawaiian Academy of Knowledge to be used at Keawanui.

7/84-8/84 Appointed to the Aquaculture Research Advisory Panel, Department of Land and Natural Resources. Assignment was to review all aquaculture grant proposals submitted to State's Aquaculture Development Program, DLNR (total research budget $425,000) to be submitted to Legislature for funding FY85-86.

1/83-7/84 Designed and built hatchery and developed tilapia hybridization technology for production of red hybrid tilapia to stock in Lokoea Fishpond.

9/83-2/84 Appointed member of Governor's Aquaculture Industry Development Committee. GAIDC was charged with reviewing recent history of State's aqua-industry and preparing report for Governor detailing future State activities needed to speed expansion of commercially viable aquaculture industry in Hawaii.

6/83-8/83 Under contract with Office of Hawaiian Affairs made site assessment of Keawanui Fishpond, Molokai. Presented long-term aquaculture development plan for Keawanui on behalf of OHA to Board of Trustees, Bishop Estate.

DAVID A. ZIEMANN
The Oceanic Institute

Academic

Pennsylvania State University, University Park, Pennsylvania, B.S. Zoology. 1966.
University of Hawaii, Honolulu, Hawaii, M.S. Oceanography. 1970.
University of Hawaii, Honolulu, Hawaii, Ph.D. Oceanography. 1975.

Positions and Experience

The Oceanic Institute, Waimanalo, Hawaii. Program Manager for Oceanography. Responsible for program development, project management, technical writing and editing, client relations, computer and analytical systems development. Projects managed have included impact analysis for development of an OTEC pilot plant in Hawaii; impact analysis for large resort complexes on Oahu and the island of Hawaii; large-scale algal production system and oyster growth studies; bioassay testing of chemical incinerator process brine. 1983 - present.

AECOS, Inc., Kaneohe, Hawaii. (Formerly ECI). Vice President and Project Manager for Fisheries and Environmental Studies. Responsible for coordination and management of company manpower; project management; technical writing and editing; computer systems development and management. Projects managed have included fisheries development and related business plans for central and western Pacific islands; coastal resource inventory for Kauai; OTEC-related baseline environmental and monitoring studies; and assessments of environmental impacts of proposed developments in Hawaii and the Pacific Basin. 1979-83.

Environmental Consultants, Inc., Kaneohe, Hawaii. Biological Oceanographer. Responsibilities included field collection, laboratory analysis, and technical writing. Projects included OTEC-related studies and environmental assessment of development projects in Hawaii and the Pacific Basin. 1977-79.

Hawaiian Electric Company, Honolulu, Hawaii, Private Consultant. Contracted to determine the effects of power plant entrainment on nearshore zooplankton communities. 1977.

University of Hawaii, Hawaii Institute of Marine Biology, Kaneohe, Hawaii. Postdoctoral Research Associate. Responsible for field collection and laboratory analysis of zooplankton samples, data analysis, and technical writing and editing. 1975-77.

Research Assistant. Responsible for collection and analysis of samples for automated nutrient analysis during investigations of phytoplankton uptake kinetics and water pollution. 1973-75.

D. A. ZIEMANN (contd)

Research Assistant. Responsible for collection and analysis of mesopelagic organisms during a study of oceanic ecosystems. Work led to Ph.D. degree in Oceanography. 1970-73.

Research Assistant. Responsible for collection and analysis of zooplankton samples during a study of plankton distribution in Kaneohe Bay. Work lead to M.S. degree in Oceanography. 1968-70.

Oceanographic Experience

Chief Scientist on several 30-day oceanographic cruises; extensive shipboard sampling and analytical experience; approximately one year of accumulated ship time.

Professional Memberships

American Society of Limnology and Oceanography

Committees

State of Hawaii Technical Committee on Water Quality Standards

Publications, Technical Reports and Presentations

Ziemann, D. A. 1970. The horizontal distribution of zooplankton in Kaneohe Bay, Oahu, Hawaii. M.S. Thesis. University of Hawaii. 56 p.

Ziemann, D. A. 1975. Patterns of vertical distribution, vertical migration and reproduction in the Hawaiian mesopelagic shrimp of the family Oplophoridae. Ph.D. Dissertation, University of Hawaii. 112 p.

Caperon, J. and D. A. Ziemann. 1976. Synergestic effects of nitrate and ammonium ion on the growth and uptake kinetics of Monochrysis lutheri in continuous culture. Mar. Biol., 36:73-84.

Szyper, J. P., J. Hirota, J. Caperon and D. A. Ziemann. 1976. Nutrient regeneration by the larger net zooplankton in the Southern Basin of Kaneohe Bay, Oahu, Hawaii. Pac. Sci., 30(4): 363-372.

Ziemann, D. A. and W. Kimmerer. 1976. The impact of seawater intake on the near-shore zooplankton off Kahuku, Hawaii. Prep. for Kahuku Farms. 13 p.

Ziemann, D. A. 1977. Zooplankton entrainment studies at Kahe Generating Station. Prep. for Hawaiian Electric Co., Honolulu, Hawaii. 37p.

D. A. ZIEMANN (contd)

Ziemann, D. A. and G. Krasnick. 1978. Zooplankton and larval fish study off Sand Island and Makapuu ocean outfall sewage disposal areas. Prep. for City and County of Honolulu, AECOS Tech. Rept. No. 141. 79 p.

Schell, D. and D. A. Ziemann. 1979. The nutrient regime of Kaneohe Bay. Unpublished ms.

Ziemann, D. A. and P. Bartram. 1979. Groundwater simulation studies relative to the deep well injection of liquid wastes from a manganese module processing facility. AECOS Tech. Rept. No. 201. 26 p.+ appendices.

Ziemann, D. A. 1979. OTEC Benchmark Environmental Studies. Interim Report: Zooplankton and Nutrients. AECOS Tech. Rept. No. 207A. 30 p.

Noda, E. K., P. K. Bienfang and D. A. Ziemann. 1980. OTEC Environmental Benchmark Survey off Keahole Point, Hawaii. Final Report. Prep. for Lawrence Berkeley Laboratory. 161 p.

Ziemann, D. A. 1981. Water quality monitoring services in support of EPA NPDES Permit No. H10110272 (OTEC-1); and Technical and analytical services in support of OTEC-1 systems operations. Final Report. Prep. for U.S. Department of Energy. AECOS Tech. Rept. No. 299. 105 p.

Ziemann, D. A., P. Bartram and R. Brock. 1981. A review of the nearshore and oceanographic literature pertinent to an OTEC facility in the area of Kahe Point, Oahu, Hawaii. Prep. for Parsons Hawaii. AECOS Tech. Rept., No. 312. 105 p. + appendices.

Ziemann, D. A., and D. Crear. 1981. Bench-scale water filtration tests on raw water samples from Hana, Kaupo, and Keanae, Maui. Prep. for S. Hirota, Assoc. AECOS Tech. Rept. No. 314. 18 p.

Ziemann, D. A. 1982. Nutrient and suspended solids budget for Kawainui Marsh, Oahu. Prep. for State of Hawaii, Department of Planning and Economic Development. AECOS Tech. Rept. No. 268. 54 p + appendices.

Ziemann, D. A. 1982. Bioassay and bioaccumulation testing of dredge materials, Magazine Loch, Pearl Harbor, Oahu. Prep. for U.S. Navy., PACNAVFACENGCOM. AECOS Tech. Rept. No. 277, 42 p.

Ziemann, D. A. 1982. Baseline water quality monitoring, Barbers Point, Oahu. Prep. for Pacific Resources, Inc. AECOS Tech. Rept. No. 353.

Ziemann, D. A. 1982. Hawaii Marine Water Quality Index. Prep. for State of Hawaii, Department of Health, Office of Environmental Quality Control. AECOS Tech. Rept. No. 360. 16 p + appendices.

D. A. ZIEMANN (contd)

Ziemann, D. A., P. Bartram and J. Clark. 1982. Kauai Island Coastal Resource Inventory (KICRI). Prep. for U.S. Army Corps of Engineers. AECOS Tech. Rept. No. 364. 18 separately-numbered sections + appendices.

Ziemann, D. A. and P. Bartram. 1983. Central and Western Pacific Regional Fisheries Development Plan. Volume 4. Regional Plan. Prep. for Pacific Basin Development Council. AECOS Tech. Rept. No. 303D. 317 p. + appendices.

Ziemann, D. A. and P. Bartram. 1983. Opportunities for American Samoan involvement in miscellaneous fish transactions. Prep. for Pacific Business Center, University of Hawaii. Honolulu. AECOS Tech. Rept. No. 319C. 15 p.

Ziemann, D. A. 1983. Zooplankton and larval fish at the Sand Island Deep Ocean Outfall. Final Report. Prep. for City and County of Honolulu. AECOS Tech. Rept. No. 277B. 34 p. + appendices.

Ziemann, D. A. 1983. Zooplankton and larval fish at the Honouliuli Deep Ocean Outfall. Interim Report. Prep. for City and County of Honolulu. AECOS Tech. Rept. No. 277C. 24 p. + appendices.

Ziemann, D. A. 1983. Testing of Dredged Materials for Dredging, Pearl Harbor, (Phase II) Naval Station, Pearl Harbor, Hawaii. Final Report. Prep. for M & E Pacific, Inc. 34 p. + appendices.

Szyper, J. P., P. K. Bienfang, L. D. Conquest, K. Klein and D. A. Ziemann. 1984. Distribution of Oceanographic Parameters and Phytoplankton Response to Deep-Water Nutrient Enrichment off Kahe Point, Oahu. Prep. for TRW Energy Development Group, Redondo Beach, CA. 90 p. + appendices.

Ziemann, D. A. 1984. Description of the Marine Environment off Kahe Point, Oahu, Hawaii; Assessment of Impacts of the Kahe Point OTEC Pilot Plant. Prep. for TRW Energy Development Group, Redondo Beach, CA. Sections of various length.

Ziemann, D. A. 1984. Analysis of Biological Impacts of the Lagoon/Marina Development at West Beach, Oahu, Hawaii. Prep. for West Beach Estates, Honolulu. 17 p. + appendix.

Ziemann, D. A. 1984. Pilot-Scale Culture of Algae in Outdoor Tanks and Preliminary Oyster Growth Studies. Prep. for Hawaiian Seafarms, Honolulu. 26 p. + appendices.

Ziemann, D. A. 1984. Impact Analysis of the Hyatt Regency Waikoloa Hotel Development on the Aquatic Resources of the Waikoloa Beach Resort Area, Hawaii. Prep. for Belt, Collins and Associates, Honolulu. 26 p.

D. A. ZIEMANN (contd)

Ziemann, D. A. 1984. Impacts of Terrestrial Storm Runoff on the Nearshore Marine Environment off Kuilima and Kahuku, Oahu, Hawaii. Prep. for Kuilima Development Co., Honolulu. 42 p. + appendices.

Ziemann, D. A. 1984. Process Waste Scrubber Brine Bioassay and Testing. Johnston Atoll Chemical Agent Disposal System (JACADS). Prep. for Department of the Army, U.S. Army Engineer District, Honolulu. 12 p. + appendices.

Ziemann, D. A. 1985. Anchialine Pond Survey of the Northwest Coast of Hawaii Island. Final Report prepared for Transcontinental Development Company. 39 p. + appendices.

CLYDE S. TAMARU
The Oceanic Institute

Academic

University of Hawaii, Honolulu, Hawaii. B.S. Biology, 1976.
University of Hawaii, Honolulu, Hawaii. M.S. Zoology, 1981.

Positions and Experience

The Oceanic Institute, Waimanalo, Hawaii. Primary duties to carry out the determination of the population structure of Chanos chanos throughout the Pacific Islands which involves using starch-gel and polyacrylamide electrophoresis procedures. Involved in producing a chapter in the State-of-the-Art review regarding milkfish population structure in the Pacific. Responsible for the determination of circulating steroid levels (testosterone and 17B Estradiol) in Chanos chanos blood which involves using radioimmunoassay procedures. Provide assistance in the implementation of the proposal maturation experiments on Chanos chanos males which involves the acquisition of broodstock, production of hormone deliverying system (i.e., silastic implants, cholesterol pellets) and the collection and analyses of data. 1984 - present.

Queen's Medical Center, Honolulu, Hawaii. Radiochemistry Technologist Duties included: conducting clinical analysis of patient serum or plasma utilizing radioimmunoassay methods. Quantitate drug levels, hormones, viral agents, and vitamins. Clinical Laboratory licence #2660, State of Hawaii, licence eligible Nuclear Medicine technologist. 1980-84.

Leeward Community College, Pearl City, Hawaii. Lecturer. Planned and carried out instruction of basic concepts of Biology and Zoology to community college level students. (Fall semester 1983 - Spring semester 1984).

Windward Community College, Kaneohe, Hawaii. Planned and carried out the instruction of Zoology, Identification of Hawaiian Reef fishes. Basic concepts of systematics and evolution of vertebrates. Lecturer (Fall semester 1981).

Hawaii Institute of Marine Biology, Kaneohe, Hawaii. Research Assistant. Carried out the electrophoretic analysis of proteins from several fish species for the determination of the evolutionary interrelationships of species and also to aid in determining the taxonomic status of several fish species. Analysis of proteins involved utilizing electrophoretic techniques (starch-gel, polyacrylamide,and cellulose acetate) coupled with the histochemical staining of several enzyme and isozyme systems. Approximately 50 gene loci were covered. 1979-81.

Department of Zoology, University of Hawaii, Honolulu, Hawaii. Graduate Teaching Assistant. 1979-80.

C. S. TAMARU (contd)

Oceanic Institute, Waimanalo, Hawaii. Research Assistant. Planned and conducted field collections of specific fish species. Collection of live fish specimens, and transportation of live fish specimens. Assist in methods of induced spawning utilizing hormone injections. Responsible for rearing of larval fish from fertilization to post metamorphosis. Responsible for the maintenance of viable broodstocks of selected fish species. Preparation and administration of food stuffs, treatment of parasite infestations, etc. Plan and establish a field laboratory in relatively-remote areas on the islands of Hawaii, Kauai, and Christmas Island. Conducted experiments on the induced spawning of milkfish, Chanos chanos. Worked with Mugil cephalus, Chanos chanos, Forcipiger flavissimus, Chaetodon miliaris, Dascyllus albisella, Abudefduf abdominalis, Cyprinus carpio, Polydactylus sexfilis, and Kuhlia sandvicensis. 1976-80.

University of Hawaii, Honolulu, Hawaii. Marine Options Program, Fish Transect Team Under the general supervision of biologists from the Division of Fish and Game, conducted visual fish transects to estimate the baseline standing crop of fishes present from Kapahulu Groin to the Diamond Head Lighthouse. (Summer 1975).

Special Skills

1. Knowledgeable and skilled in techniques of protein electrophoresis using three different media: starch-gel, polyacrylamide, and cellulose acetate. Includes sample preparation, histochemical staining, data collection and processing.
2. Knowledgeable and skilled in producing parafilm sections and staining of a variety of vertebrate tissues.
3. NAUI certified SCUBA diver.
4. Able to operate small boats.
5. Skilled and knowledgeable in conducing radioimmunoassays utilizing 1-125 and c057 isotopes.

Publications

Shaklee, James B. and C. S. Tamaru. 1977. Biochemical and morphological evidence of sibling species of bone fishes, Albula vulpes. Amer. Zool. 17:973 (abstract).

Tamaru, Clyde S. 1979. Genetic similarity and distance of Hawaiian goat fishes. Pacific Science. 33(1):117 (abstract).

Tamaru, Clyde S. 1980. Ontogeny of lactate dehydrogenase in developing carp embryos. Pacific Science. 34(3):338 (abstract)

Shaklee, James B. and C. S. Tamaru. 1981. Biochemical and morphological evolution of Hawaiian bone fishes (Albula). Systematic Zoology 30(2):125-146.

C. S. TAMARU (contd)

Tamaru, Clyde S. 1981. Lactate dehydrogenase ontogeny and liver differentiation during the development of the common carp (Cyprinus carpio L.). Masters Thesis, University of Hawaii. 104 pp.

Shaklee, James B., C. S. Tamaru and R. S. Walpes. 1982. Speciation and evolution of marine fishes studied by the electrophoretic analysis of proteins. Pacific Science. 36(2):141-157.

Shaklee, James B. and C. S. Tamaru. 1981. Evolutionary genetics of Indo-west Pacific bone fishes (Albula): Biochemical and morphological characteristics and zoogeographic patterns. In manuscript.

Lee, C. S., C. S. Tamaru and L. W. Crim. 1985. Preparation of a luteinizing hormone-releasing hormone cholesterol pellet and its implantation in the milkfish (Chanos chanos Forsskal). Proceedings of the Workshop on the Reproduction and Culture of Milkfish, held in Taiwan on April 22-24, 1985. p.215-226.

Lee, C. S., C. S. Tamaru, J. E. Banno and C. D. Kelley. Induced spawning of milkfish (Chanos chanos) by LHRH-a. Presented at World Mariculture Society, Reno. January 19-23, 1986.

Lee, C. S. and C. S. Tamaru. 1985. (Accepted by Aquaculture). Induced maturation and spawning of milkfish Chanos chanos Forsskal, by hormone implantation.

Lee, C. S., G. M. Weber and C. S. Tamaru. (Submitted to Journal of Fish Biology). Effect of Orally Administered 17 -methyl testosterone on Spermatogenesis in Immature Milkfish, Chanos chanos Forsskal.

Lee, C. S., G. M. Weber and C. S. Tamaru. (Submitted to Journal of World Mariculture Society). Studies on the maturation and spawning of milkfish Chanos chanos Forsskal in a photoperiod controlled room.

Yano, I., J. N. Sweeney, C. S. Tamaru and J. A. Wyban. 1986. Internal tagging method for individual identification of penaeid shrimp. (Submitted to Aquaculture)

Lee, C. S., C. S. Tamaru, C. Kelley, J. Banno and J. A. Wyban. 1986. Induced spawning in milkfish by hormone implantation. (Submitted to Aquaculture)

GARRET T. MIYAMOTO
The Oceanic Institute

Academic

Mid-Pacific Institute, Honolulu, Hawaii. Graduated May 1974 with honors.

University of Hawaii at Manoa, Honolulu, Hawaii. B.A. Zoology. 1979.

University of Hawaii at Manoa, Honolulu, Hawaii. M.S. Animal Science. 1983.

Positions and Experience

The Oceanic Institute. Waimanalo, Hawaii. Feeds Program. 1984-85. Research technician *Artemia* (brine shrimp) project. Protein extraction project. Assist in all aspects of milkfish maturation project (egg collection, microscopical and histological examination of eggs, hormone pellet making and implantation, etc. 1985 - present.

University of Hawaii, Honolulu, Hawaii. Graduate Research Assistant. Duties included research on diseases of *Macrobrachium rosenbergii* or freshwater prawn. Included clinical pathology, histopathology, collection and statistical analysis of data, organizing and reporting results, and performing other duties as assigned. 1983.

University of Hawaii, Sea Grant College, Honolulu, Hawaii. Worked under Stephen Ralston, a doctoral candidate from the University of Washington, College of Fisheries. His research involved the development of a biological basis for managing the handline fishery for snapper and grouper populations in the Hawaiian archipelago. As a lab technician, I determined the age and studied the reproductive biology of the *Opakapaka* a local snapper species. 1979-81.

University of Hawaii, Department of Zoology, Honolulu, Hawaii. While pursuing an undergraduate degree at the University of Hawaii, I completed a project under the direction of Craig McDonald, Assistant Researcher of the University of Hawaii, Department of Zoology and the Marine Options Program. The project was titled: "Population size structure and reproductive patterns of the damselfish, *Chromis caerulea*, at Enewetak Atoll." 1977-79.

Sears Roebuck and Company, Ala Moana, Honolulu, Hawaii. Part-time Sales Clerk. 8 years.

G. T. MIYAMOTO (contd)

Courses taken at the University of Hawaii

Aquaculture
Living Wealth of the Oceans
Conservation of Resources and Ecology
Oceanography
Behavior of Marine Animals
Ichthyology
Invertebrate Zoology
Economics of Fisheries and Aquaculture
Controlled Environment Aquaculture
Prawn Production

Other Related Courses

Zoology Literature
Natural History of the Hawaiian Islands
Animal Ecology
Microtechnique
Vertebrate Zoology
Ethology
Photographic Techniques
General Zoology
Biochemistry
Animal Diseases
Animal Physiology
Animal Breeding and Genetics
Applied Nutrition
Animal Nutrition
Introduction to Animal Science
Water Quality Chemistry
Vector Control
Comparative Pathology
Prokaryotic Microbiology
Introduction to Microbiology

Statistics Courses

Advanced Biometry
Biometry
Introduction to Statistics

Hobbies and Skills

Fishing; Scuba Diving -NAUI Certified; Skin Diving; Tennis/Outdoor Sports; Reading Books (fiction and non-fiction); CPR Certified; First Aid - Red Cross.

Community Activities

Boy Scouts of America - Rank of Eagle Scout

G. A. MIYAMOTO (contd)

Publications

Landau, M., G. Miyamoto, and C. Bolis. 1985. Growth and amino acid composition of *Artemia salina* (L., 1758) fed algae grown in different media. (Anostraca). *Crustaceana* 49(3) 318-321.

Memberships

The World Mariculture Society
Ultralight Hawaii Fishing Club

CHRISTOPHER D. KELLEY
The Oceanic Institute

Academic

Marietta College, Ohio. B.S. Biology, 1977
University of Hawaii, Honolulu, Hawaii. M.S. Zoology. 1984
University of Hawaii, Honolulu, Hawaii. Graduate Ph.D. Student, 1985-present.

Positions and Experience

Oceanic Institute, Waimanalo, Hawaii. Graduate Research Assistant. Primary Responsibilities: preparation of chronic release hormone pellets for implantation in milkfish; document spawning behavior of milkfish; perform histology on the gonads of milkfish and mullet; thesis research on enzyme activity during final maturation of mullet oocytes. 1985-present.

University of Hawaii, Honolulu, Hawaii, Zoology Department Curator. Reorganizing fish collection to use as a teaching aid for the general and advanced ichthyology courses. 1984.

University of Hawaii, Honolulu, Hawaii, Zoology Department Graduate Teaching Assistant, Aquanaut and Surface Support Scientist in St. Croix, U.S. Virgin Islands. 1981-83.

U.S. Peace Corps, Washington, D.C. Inland Fisheries Advisor for the Batouri fish station, Cameroon, West Africa. Worked with *Tilapia*, *Clarias* and *Heterotis* fingerling production. 1977-79.

Memberships

Associate member of Sigma Xi, the scientific research society of North America.
Student member of American Society of Zoologists.

Publications

Kelley, C. D. and T. F. Hourigan. 1983. The function of conspicuous coloration in chaetodontid fishes: a new hypothesis. Animal Behaviour. 31:615-618.

Kelley, C. D. 1983. A new hypothesis to explain aspects of coloration in chaetodontid fishes. Pacific Science. 36(4):513

Kelley, C. D. 1984. Histological evidence for sex change and data on spawning frequency from the gonads of a pomacanthid fish. Pacific Science. 38: 365-366.

Hourigan, T. F. and C. D. Kelley. 1985. Histology of the gonads and observations on the social behavior of the Caribbean angelfish *Holacanthus tricolor*. Marine Biology. 88: 311-322.

C. D. KELLEY (contd)

Lee, C. S., C. S. Tamaru, J. E. Banno and C. D. Kelley. Induced spawning of milkfish (Chanos chanos) by LHRH-a. Presented at World Mariculture Society, Reno. January 19-23, 1986.

Kelley, C. D. In press. Cytochemical evidence for the involvement of cortical alveoli during pre-ovulatory hydration of oocytes in a teleost fish. Pacific Science.

Lee, C. S., C. S. Tamaru, C. Kelley, J. Banno and J. A. Wyban. Induced spawning in milkfish by hormone implantation. (Submitted to Aquaculture).

Lee, C. S., C. S. Tamaru, J. E. Banno and C. D. Kelley. Influence of chronic administration of LHRH-analogue and/or 17 -methyltestosterone on maturation in milkfish, Chanos chanos. (Submitted to Aquaculture).

Hourigan, T. F., F. Stanton, C. D. Kelley, P. Motta and B. Carlson. Feeding behavior and social organization of three species of Caribbean angelfish. (Submitted to Bulletin of Marine Science).

Tab D

R E P R O D U C T I V E S T U D I E S

O N

M I L K F I S H

T H E O C E A N I C I N S T I T U T E

PROGRAM DESCRIPTION

(SCOPE OF WORK)

MFTC:7/24/86:Revised 7/28/86

Reproductive Studies on Milkfish
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MFTC:7/23/86:Revised 7/28/86

MFCASEC1

REPRODUCTIVE STUDIES ON MILKFISH

PROGRAM DESCRIPTION

I. Purpose of the Cooperative Agreement Extension

The purpose of the Cooperative Agreement is to assist the recipient, The Oceanic Institute to: 1) utilize and enhance its resource base to develop and evaluate technologies to shorten the time-span for gonadal maturation of milkfish in captivity; 2) maximize the production of fertilized eggs; 3) develop semi-intensive and cost-effective culture systems for larval rearing; 4) use hormone technology on other finfish species; 5) determine the feasibility of adapting new maturation technologies in LDCs; 6) study the feasibility of using milkfish as baitfish; and 7) expand existing and create new networking relationships to disseminate and obtain information on fish reproductive technologies.

II. Oceanic Institute Background, Programs and Staff, Facilities and Funding Source

A. Background

The Oceanic Institute (OI) is a non-profit, private marine science center independent of State or Federal Agencies. Its purpose is to secure scientific and technical knowledge through applied research and development, for economical, efficient use of the ocean and its resources, and to share that knowledge with the peoples of the world.

The Institute was founded in 1960 as a division of the Oceanic Foundation, a three-part complex which included Sea Life Park, a public oceanarium, and Makai Range, an engineering facility. In 1973, the Foundation was reorganized, and the Institute assumed control of the entire 118-acre center. The Institute is governed by a Board of Trustees.

B. Programs

The present program of the Institute includes three main themes which, though distinct from each other, are often interrelated in projects and research. These themes are:

1. To increase the production of food from the sea with its attendant responsibilities of protection and conservation. Current activities include:

   - Research and development in fish farming technology;
   - Induced breeding and larval rearing of brackish-water and marine fish;
   - Research in reproductive physiology of food fish;
   - Development of hatchery techniques for mass production;
   - Design of fish hatcheries; and
   - Application of aquaculture to enhance over-fished stocks of marine animals.

2. To improve mankind's compatibility with the aquatic environment through an interest in both basic research and the practical needs of today's demanding society, is assuming greater importance in the Institute's affairs. Current activities associated include:

   - Studies of energy flow in the marine environment;
   - Research on photosynthesis - light relationships in the open sea;
   - Phytoplankton ecology and fisheries recruitment;
   - The effects of pollutants and effluents in coastal waters; and
   - Design and environmental planning for coastal development.

3. To preserve the heritage of the sea for future generations through education and management of existing resources. Activities include:

   - Evaluation of existing resources;
   - Conservation and management of resources from the sea;
   - Development and management of new resources;
   - Providing consulting and advisory services;
   - Training and practical instructions;
   - Publications of books and reports; and
   - Workshops and training tours.

C. Staff, Facilities and Funding Sources

The Oceanic Institute has a staff of 64 with 13 postdoctoral researchers and over 20 technical personnel with either bachelor's or master's degrees. Its research programs are supported in part by algology and zooplanktonology laboratories. The Institute has adequate facilities to implement this project, including a 1,500 gallons per minute (gpm) seawater supply system, indoor and outdoor fiberglass and cement tanks, raceways of varying sizes and shapes and over three acres of lined and unlined ponds. These facilities are valued at approximately $5.0 million. The facilities to be used for the activities under the cooperative agreement are valued at $1,218,000 and equipment at $200,000.

Funding for the various programs is obtained from private firms and foundations, and State, Federal and international sponsors including the State of Hawaii, National Science Foundation, U.S. Army Corps of Engineers, U.S. Department of Agriculture, the Food and Agricultural Organization, UNESCO, and the Agency for International Development (AID). AID's funding is restricted to research and development which will benefit LDCs. In addition, the Institute obtains funding from various business firms, community leaders, trusts and foundations which finances staff development, laboratory improvements and construction, and certain innovative research.

III. Scope of Work for the Cooperative Agreement Extension

The following activities correspond with the output and implementation sections of the logframe (attached).

A. Seed Production

Objective: To control factors influencing seed production for cost-effective culture of milkfish seed.

Task 1: Development and evaluation of technologies for (a) shortening the time-span for gonadal maturation in captivity from approximately 10-11 years to about 6 years; and (b) developing methods for providing eggs for fertilization on a demand basis.

Summary Work Plan:

- Verify previous experimental results using combinations of LHRH-a cholesterol pellets plus liquid testosterone capsules through intramuscular implants. These experiments will be conducted in Hawaii and LDCs to insure the transferability of results.

- Measure the reproductive steroid levels in the blood serum of experimental fish through radioimmunoassay (RIA) methods after fish have received the hormone implants.

- Evaluate photoperiod as a factor in determining maturation, as measured by time of maturation, fish size and age. The experiments will be conducted in photoperiod controlled rooms. Photoperiod will be adjusted to identify the effects on the maturation of milkfish.

- Conduct field surveys of environmental parameters in the locations where spawnings have occurred in captivity.

- Determine through trials the relative importance of age and size on gonad development. The experiments will be designed to determine age and size of maturation through measurement of the percentage of fish maturing under each condition. If size is determined to be critical, a diet (feed) for maximum growth will be identified.

- Develop an optimum combination treatment of hormones and diet for accelerating maturation in milkfish. Experimentation will include the analysis of relative biochemical composition of gonads and muscle to identify the nutritional needs in their maturation diets.

- Replicate the hormone therapy experimentation to achieve suitable reliability of methodology in LDCs.

- Conduct trials of the hormone therapy for maturation and spawning using different age and size groups to determine the minimum responsive ages and sizes.

- Conduct biochemical studies to determine the releasing rate of pellets. This work will be conducted with in vivo and in vitro studies through cooperative agreements with other institutions.

Task 2: Technology will be developed and tested for controlling and maximizing the production of fertilized eggs.

Summary Work Plan

- Determine the environmental conditions required for obtaining viable spawnings. Environmental surveys will be conducted in locations where spawnings are recorded in captivity. This work will be partly conducted in collaboration with LDC institutions.

- Determine the optimal sex ratio in spawning tanks. Experiments will be conducted with different ratios of males to females in induced spawning trials. From the percentage of successful spawnings, other critical bio-environmental factors also will be determined.

- Repeat the male pretreatment experiments on a larger scale (30 or more trials) to provide statistically significant data on timing and quantity of dosage for optimum male response.

- Determine the optimal ovarian stage of maturation for spawning after treatment with one application of LHRH-a (female). Fish with different sizes of eggs will be induced to spawn using LHRH-a administered at a range of different dosages. The optimal dosage and egg size for the final maturation and spawning will be determined.

- Determine the optimal hormonal pretreatment of male milkfish. The male milkfish will be injected with different doses of LHRH-a before they are used for spawning attempts. Treatment will be evaluated and success determinated by the percentage of successful spawnings from each treatment.

- Determine the difference in egg quality under different treatments; e.g., nutritional condition of broodstock, and kinds and dosage of hormones. Eggs from treatments will be collected and stored at low temperatures until samples are analyzed biochemically.

Task 3: Technology will be developed and tested for semi-intensive and cost-effective culture systems for larval rearing.

Summary Work Plan:

- Determine optimal incubation systems for normal development of fertilized eggs, and design rearing systems to maximize larval survival. Eggs from the spawnings will be incubated under different conditions of salinity, density, dissolved oxygen, water exchange and water filtration.

- Refine live food production techniques for microscopic organisms such as rotifers. Procedures will be developed for producing a consistent supply of nutritionally enriched live food organisms. Experiments also will be designed to determine the best conditions for the mass production of resting eggs of rotifers. If rotifers are not a satisfactory food organism, research will be extended to other invertebrates, protozoans and algae, as necessary.

- Evaluate various formulated feed as a supplemental food. Commercially available formulated feeds or experimental feeds will be used to raise the fish larvae to the fry stage. The feed will be evaluated through the survival and growth of fish larvae, and in comparison with live foods.

- Improve larval survival and growth rates through the application of thyroid hormone, steroids or growth hormones. Use of hormones will be limited to research work. Any further application of these techniques to production systems will follow the policies, guidelines and regulations of appropriate US Governmental Agencies.

- Design methodology for a semi-intensive larval rearing system. Experimental raising of fish larvae in outdoor large-scale ponds will be conducted to decrease the high capital cost of hatchery culture. Fish larvae will be transferred to outdoor facilities at different stages of development to test their survival under controlled, outdoor conditions.

- Collect basic physiological information during embryonic and larval stages of milkfish development.

- Analyze biochemically the food organisms and early life stages of milkfish.

- Conduct experiments on mass production of rotifer resting eggs to improve food production systems.

B. Mullet

Objective: To develop a cost-effective method for production of juvenile mullet.

Task 4: Develop technology for controlling mullet reproduction.

Summary Work Plan:

- Refine the induced spawning techniques used for milkfish to identify the best method. During the mullet spawning season, mature mullet will be induced to spawn using cost effective synthetic hormones such as LHRH-a and pimozide.

- Develop applicable technologies for altering the spawning season. The spawning season for grey mullet will be extended or altered through the manipulation of environmental factors (such as photoperiod) and application of hormones (such as chorionic hormones).

- Develop methods for accelerating the reproductive cycle. Immature mullet of various sizes and ages will be dosed with steriods as a maturation stimultant. Maturation of mullet will be checked through the gonadal cannulation technique.

Task 5: Develop technology for reliable fry production.

Summary Work Plan:

- Apply technology developed for milkfish to further improve mullet hatchery operations.

C. Other Desirable Species

Objective: To improve marine finfish aquaculture development in LDCs.

Task 6: To apply newly developed technology to other important marine finfish species in LDCs.

Summary Work Plan:

- Cooperate with colleagues in identifying critical species for which assistance in reproductive technology is needed. Technology developed for milkfish will be adapted for those species identified as having the most promise.

- Develop induced spawning and larval culture techniques for representative species of at least two additional families of fish.

D. Economic Analysis

Objective: Determine if maturation technology can be economically adapted to LDC environments and what impact milkfish hatcheries will have on the incomes and employment of the poor.

Task 7: Economic analysis to determine the feasibility of adapting new maturation technology to LDCs.

Summary Work Plan

- Develop economic models to determine the likely impact of milkfish hatcheries on the incomes and employment of the poor in Indonesia and the Philippines. Analyses will include hatchery cost/benefit analyses, measurement of projected benefits to the milkfish industry in these countries and evaluations of impact on incomes of people employed in the existing milkfish fry and production industries.

E. Milkfish as Baitfish

Objective: To determine if milkfish can be used successfully in LDCs as baitfish.

Task 8: Feasibility study on use of newly developed technology to use milkfish as baitfish.

Summary Work Plan

- Rear milkfish fingerlings in sufficient quantity to permit large scale testing of milkfish as tuna bait aboard commercial vessels.
- Determine economic feasibility of large scale maturation and larval rearing technologies.
- Conduct studies to determine the technical and economic feasibility of using milkfish as baitfish for tuna.

F. Technology Transfer

Objective: To increase the production of finfish and availability of fish protein in the LDCs.

Task 9: Transferring technologies for maturation and spawning of milkfish and rearing of milkfish larvae to LDCs.

Summary Work Plan

After the new technology is developed, it will be transferred to the LDCs through various means such as publications, workshops and training, as mutually determined by interested USAID Missions, S&T/AGR, and the Oceanic Institute.

G. Networking

Objective: To establish an international network of institutions with programs in the reproduction of milkfish and other finfish.

Task 10: Expansion of network on reproductive technologies.

Summary Work Plan

- A network system will be established focussing on technology transfer, discussions, and problem identification and research. Through the network, critical problems in fish reproduction will be identified and addressed using the most efficient and appropriate methods. Oceanic Institute will continue working with the Committee for International Fisheries Research and Assistance Institutions (CIFRAI) and other institutions involved in fish production and research.

IV. Substantial Involvement Understanding

Substantial involvement of the Agency for International Development (A.I.D.) in the management of this Cooperative Agreement is anticipated. Participation and collaboration by A.I.D. is expected, in particular, as follows:

A. A.I.D. will be consulted during the development of the Implementation Plan and have the right of final approval of all areas of the Plan where A.I.D. resources are included.

B. A.I.D. will be consulted and will have right of approval to revisions of the Implementation plan which involves the use of A.I.D. resources.

C. A.I.D. will be involved in the selection of sites, methodologies and strategies to be used in field activities funded under this Agreement.

D. A.I.D. will clear all field fisits to LDCs to funded under this Agreement. the recipient will acquire clearances from missions/representatives in the developing countries and the A.I.D. regional bureaus.

E. A.I.D. will be involved in the selection of the key personnel.

F. A.I.D. will be involved in the selection of consultants hired to be funded under this agreement.

G. A.I.D. will be involved in the selection of trainees and participants to attend the annual courses, workshops and seminars and for on-the-job training to be held at the Institute and in LDCs,

H. A.I.D. will review all publications, handbooks, manuals, etc., prior to publication and dissemination.

I. A.I.D. will participate in all reviews and evaluations. In addition, review and evaluations teams charged to this CA will be selected by the S&T/AGR Project Manager.

J. A.I.D. will approve all Memoranda of Understanding signed between the Oceanic Institute and LDC governments and/or institutions.

The above specific involvement is in addition to the normal program monitoring by A.I.D. project personnel of the Recipient's program and the other administrative requirements established by the Standard Terms and Conditions of the Cooperative Agreement.

V. Implementation Plan, Reports and Evaluations

A. Implementation Plan

The Oceanic Institute will develop the Implementation Plan as a working document to guide the operations and achievements expected from the project. It will be forwarded to S&T/AGR for approval each year. The amended FY 1986 implementation plan will be submitted no later than 30 days after the cooperative agreement amendment is signed and will cover the period July 15, 1986 to January 14, 1988. The second implementation plan will be submitted December 1, 1987 and will cover the reporting period January 15, 1988 through January 14, 1989. The third implementation plan will be submitted December 1, 1988 and will cover the reporting period January 15, 1989 through July 15, 1989.

S&T/AGR will review the contents of the proposed implementation plan with the Technical Advisory Panel, ask for points of clarification, if required, and grant final approval of the contents as proposed or modified by agreement between Oceanic Institute and S&T/AGR. The process of review and approval will be completed not later than 30 days after receipt of the original implementation plan from the Institute.

The Implementation Plan shall cover the following:

- A list of activities to be undertaken during the reporting period, categorized by Tasks indicated in the Scope of Work.

- A statement of how the activities relate to the output and research priorities.
- A projected beginning and ending period for the activities. The implementation schedule is to be updated as appropriate.
- The projected expenditures of person-months of input for each activity.
- The projected stage of the activities at the end of the implementation plan.
- Facilities required to achieve research results.
- Schedule of the TAG Meetings
- Other pertinent data related to the scope of work.

B. Reports

1. Progress Reports - A progress report of project activities will be submitted in 25 copies to the A.I.D. Project Manager by December 31, 1986 and semi-annually thereafter. A final report in 50 copies will be submitted by December 31, 1989.

2. Fiscal Reports - A fiscal report will be prepared every six months from the date of project amendment showing actual expenditures and projected expenditures for the following six months. This report will be submitted in six copies to SER/OP with an additional copy to the project manager.

3. TDY Reports - After completion of each TDY international assignment, a trip report will be prepared and three copies sent to the S&T/AGR Project Manager. These reports will contain, but not be limited to, the following information: a) logistical information, i.e., type of activity, geographical area of activity, dates of TDY, and team composition; b) objective of TDY, including scope of work, as appropriate; c) activities performed while on TDY; d) summary of any technical reports resulting from TDY; e) summary of identifiable techniques or information which could be transferred to other LDCs; and f) summary of future potential needs of, or opportunities for, assistance to LDCs or missions, including possible networking potential.

4. Other Reports - 10 copies of all reports, manuals and documents developed under this cooperative agreement will be sent to the S&T/AGR Project Manager.

5. State-of the-Art Document - 100 copies of the final State-of-the-Art document will be submitted to S&T/AGR Project Manager by October 31, 1986.

6. Impact Analysis Report - Impact Analysis reports will be submitted as an annex to the progress reports and will summarize the impact of Oceanic Institute's activities in the public and private sector in terms of increased maturation and spawning of milkfish, shortened life cycle for spawning, and acceptability of hormonal implant technology. This report will provide a feed back system for measurement and evaluation of the impact of adaptive research undertaken in the LDCs, services provided and scientists and technicians trained.

   The impact analysis is defined as a measurement of results generated by activities undertaken by Oceanic Institute in accordance with the project description in the scope of work of this cooperative agreement. For the most part, the impact analysis will be qualitative in nature, and quantified only as appropriate and will cover activities funded under this project and/or the previous contract with Oceanic Institute.

7. Training Activities - The recipient shall provide to A.I.D. Project Officer a quarterly summary of training activities which will include the following information:

   a. Total number of trainees during the period; and

   b. The following information for each LDC trainee:

      - name
      - citizenship
      - sex
      - training site
      - beginning and ending dates of training
      - purpose of training
      - type of training activities
      - source of funding

8. Documentation Coordinator - The recipient shall submit four copies of all reports listed as being a product of the CA (administrative, trip, progress, final, technical reports, etc.) to the Documentation Coordinator, PPC/DIU, Agency for International Development, Washington, D. C. 20523, or his designee. Such reports shall include a title page showing the title of the report, project title as set forth in this CA and the CA number. One copy of each report shall be clearly typed or printed on white paper so that it may be photographed to produce a micro-film master. Technical reports shall be accompanied by an author-prepared abstract. Copies of this material shall also be submitted to the A.I.D. project Manager.

C. Evaluation

1. In Depth Evaluation - A formal in depth comprehensive evaluation will be performed during the project extension by qualified scientists and experts in finfish reproduction who will review the progress made to achieve the established outputs. This evaluation will be scheduled after the spawning season in 1988, or at such time as determined to be appropriate by the Technical Advisory Group. The evaluation factors will include the following: a) project achievements in successfully replicating the maturation techniques in other environments; b) LDC adoption of resultant technologies and products; c) net increases in the number of larvae produced and successfully reared; d) compliance to the implementation plan (Attached to the Logframe); and e) achievement of outputs specified in the logframe (attached).

The evaluation will determine if project inputs are being provided as planned, that conditions and covenants of the project workscope are being met, and that project outputs are being accomplished as planned. It will be used as the basis for recommending changes in the scope of work to achieve stated purpose and end of project status.

Terminal Evaluation - A terminal evaluation will be scheduled for December 1989.

These evaluations will be based on monitoring reports, inspection of physical facilities, the Institute's progress reports, technical publications, impact analysis and reports on participating countries involvement in the reproductive technologies.

2. Technical Advisory Group - The Technical Advisory Group will continue to function during the extension of this cooperative agreement. Membership will continue to consist of milkfish researchers from Philippines and Taiwan, and others as deemed appropriate by S&T/AGR. The group will be convened semiannually or periodically (or individual members may be called upon at any time) by S&T/AGR to provide advise and guidance to S&T/AGR and the Oceanic Institute regarding the work under the cooperative agreement.

VI. Cooperative Agreement - Terms and Budget

A. Terms - This amendment of the Cooperative Agreement extends the termination date by three years to July 14, 1989.

B. Five-Year Budget - The proposed budget for the three-year extension is $3,600,000 to be added to the $1,250,000 previous obligated. Thus the total of the Cooperative Agreement is increased to $4,850,000.

VII. Article # - Voucher Identification

In each instance of voucher (SF 1034) submission made by the recipient for payment hereunder, the following identification data will appear on the face of the voucher.

Cooperative Agreement:	To be determined
Project Number:	936-4161
Project Office:	S&T/AGR/RNR, Dr. Richard Neal

Drafted:7/23/86:MFCASEC1:Revised 7/28/86

Tab D

R E P R O D U C T I V E S T U D I E S

O N

M I L K F I S H

T H E O C E A N I C I N S T I T U T E

PROJECT DESIGN SUMMARY

LOGICAL FRAMEWORK

MFTC

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/15/86
Revised: 7/16/86

Project Title & Number: Reproductive Studies on Milkfish

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To provide technology to increase stability of employment and provide fish protein to LDC people.	Measures of Goal Achievement: - Overall increase in fish production and utilization - Increase in employment and income. - Appropriate technological package developed for maturation and larval rearing for milkfish and other important species	- National Surveys - Mission Reports - FAO Production statistics - Impact Evaluation - External Evaluations. - Technical Advisory Group (TAG)	Assumptions for achieving goal targets: - Fish production is a high priority in LDCs. - LDCs will use the new techniques developed at Oceanic Institute - Improved techniques can be adapted to other biophysical and geographical environments.
Project Purpose: The purpose of this project amendment is to: 1. Refine newly developed methodology for maturing and spawning milkfish in captivity. 2. Develop new methodology for rearing larvae of milkfish. 3. Demonstrate dependable methods for maturation and spawning milkfish 4. Expand developed methods to mullet and other marine species, such as snappers, groupers, etc.	Conditions that will indicate purpose has been achieved: End of project status. 1. Maturation of milkfish is controlled artifically. 2. Significantly reduced mortality of artificially propagated milkfish larvae 3. Developed methods demonstrated in LDCs. 4. Newly developed methods successfully used on other marine species.	1.2.3.4. - Scientific publications and presentations at scientific meetings. - Reports from Missions and Oceanic Institute. - Evidence of research being undertaken - Site visits.	Assumptions for achieving purpose: 1.2.3.4. - The purpose can be achieved within funding and time constraints. - Methods of maturation, spawning and rearing of milkfish can be successfully implemented in LDCs and used on other marine fish species.

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AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/15/86

Revised: 7/16/86: 7/22/86

Project Title & Number: Reproductive Studies on Milkfish

NARRATIVE SUMMARY Outputs:		OBJECTIVELY VERIFIABLE INDICATORS Magnitude of Outputs:	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS Assumptions for achieving outputs:
1. Hormonal implants inserted in Milkfish reducing spawning age by 50%	T1 T2	1. Minimum of 100 fish mature and spawn at Oceanic Institute and at least 20 in two LDCs	1.2.3.4.5.6.7.8.9. - Scientific publications and project reports - On site reviews and evaluations - Expanded LDC scientists knowledge of hormonal implants to stimulate maturation and spawning - Data from Oceanic Institute's ponds and tanks - Use of hormonal implants on other species - Evaluations, both indepth and management - Mission reports - Increased supply of milkfish and other species.	1.2.3.4.5.6.7.8.9. - Research directions pursued by scientists will lead to successful maturation of milkfish and other species - LDCs will continue to cooperate and support the research in their countries - Technologies developed at the Oceanic Institute can be successfully duplicated in other environments - LDCs will approve training of scientists in hormonal implants - Funding will be adequate to support the program.
2. Major environmental factors determined which influence maturation of milkfish	T1 T2	2. Six environmental factors identified, including water chemistry and nutrition and determined as important to maturation of milkfish		
3. Improved knowledge of milkfish encrinology thru tissue and serum bioassay	T1 T2	3. Refine existing techniques to determine hormonal level due to implants to an accuracy of + or - of 10 percent.		
4. Larvae raised to fry size	T3	4. Survival rate improved by 20% at the Oceanic Institute and in two LDCs.		
5. Hormone technology demonstrated in other Finfish	T4 T5 T6	5. Implant technology successfully demonstrated on a minimum of 3 additional species, other than milkfish		
6. Economic Analysis to determine the feasibility of adapting new technology to LDCs	T7	6. One Economic hatchery model developed and analysis completed in at least 2 LDCs		
7. Milkfish tested as baitfish using implant technology	T8	7. Analysis completed for potential use of milkfish as baitfish in South Pacific Region. Results published and distributed		
8. Technology Transfer a. Training b. Publications c. Workshops or Planning Sessions held for LDC & Mission professionals	T9	8. Technology Transfer a. 10 LDC researchers trained in maturation technology b. State-of-Art document published & distributed to 100 LDC national, regional and international institutions and to appropriate Missions -5 scientific articles published annually in refereed journals. c. One in each region held annually; i.e., AFR, ANE and LAC		
9. Expand existing research network of cooperators (reproduction)	T10	9. Network expanded to at least 10 institutions in the developed and developing world.		

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AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK
Inputs

Project Title & Number: Reproductive Studies on Milkfish

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/16/86

NARRATIVE SUMMARY | OBJECTIVELY VERIFIABLE INDICATORS (In thousands) | MEANS OF VERIFICATION | IMPORTANT ASSUMPTIONS

	Milkfish Technology Development	Larval Rearing	Mullet	Other Finfish	Economic Study	Baitfish	Network	Expenditures 7/84 - 7/86	Year 1 Pipeline 7/15/86	Year 1 New Money	Year 1 Total	Year 2	Year 3	Total
Principal Investigator	x	x	x	x	x	x	x		19	19	38	38	38	114
Administrative Assistant	x	x	x	x	x	x	x			22	22	22	22	66
Secretary	x	x	x	x	x	x	x		7	8	15	15	15	45
Senior Biologist	x		x	x			x		14	14	28	28	28	84
Reproductive Physiologist	x		x	x			x		10	10	20	21	21	62
Tissue Culturist	x		x	x						20	20	20	20	60
Technician (1)	x		x	x							-	18	18	36
Technician (2)	x		x	x						9	9	18	18	45
Technician (3)	x		x	x						18	18	18	18	54
Visiting Scientist	x	x	x	x						20	20	28	28	76
Larval Physiologist		x	x				x		10	14	24	28	28	80
Larval Feed Specialist		x	x				x			11	11	22	22	55
Technician		x	x							18	18	18	18	54
Technician		x	x							18	18	18	18	54
Technician		x	x							9	9	18	18	45
Biochemist	x	x	x							10	10	20	20	50
Economist					x	x	x			22	22	22	22	66
Temporary Help	x	x	x	x						15	15	15	15	45
Total Salaries								240	60	257	317	387	387	1,091
Benefits (26 percent)								61	15	67	82	100	100	282
Total-Salaries & Benefits								301	75	324	399	487	487	1,373

July 16, 1986

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AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK
Inputs

Project Title & Number: Reproductive Studies on Milkfish

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/16/86

Revised: 7/22/86

NARRATIVE SUMMARY | OBJECTIVELY VERIFIABLE INDICATORS | MEANS OF VERIFICATION | IMPORTANT ASSUMPTIONS

	Milkfish Technology Development	Larval Rearing	Mullet	Other Finfish	Economic Study	Baitfish	Network	Expenditures 7/84 - 7/86	Year 1 Pipeline 7/15/86	Year 1 New Money	Year 1 Total	Year 2	Year 3	Total
Indirect Costs								243	62	306	368	460	460	1,288
Consultants														
TAC										30	30	15	15	60
External Evaluation Panel									10	25	35	15	15	65
Publications								30				10	10	20
Workshop										20	20	6	10	36
Travel								38	10	35	45	10	10	65
Support Facilities								38	12	50	62	25	20	107
Equipment & Supplies								48	10	36	46	20	20	86
Collaborative Research								91	34	155	189	46	30	265
Equipment & Supplies for Collaborators								175	46	144	190	83	93	366
Networking Activities								7	5	50	55	10	10	75
Travel & Moving Expenses for Visiting Scientists										20	20	8	10	38
Grand Total								9	6	5	11	5	10	26
								980	270	1,200	1,470	1,200	1,200	3,870

July 16, 1986 :Revised 7/22/86

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AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: Reproductive Studies on Milkfish

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/22/86

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS

OUTPUT BUDGET
(in thousands)

	7/15/86 - 7/14/87	7/15/87 - 7/14/88	7/15/88 - 7/14/89	Total
Research	853	662	662	2,177
Technology Transfer	419	360	363	1,142
1. Training	399	344	347	1,090
Oceanic Institute	280	247	203	730
Workshops and Seminars	119	97	144	360
2. Publications	20	16	16	52
International Network	62	43	40	145
Technical Advisory Group	35	15	15	65
Evaluations	-	20	20	40
Support Staff	101	100	100	301
TOTAL	1,470 a/	1,200	1,200	3,870

a/ Includes $270 in the pipeline as of 7/14/86

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AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1984 to FY 1989
Total U.S. Funding $4,850,000
Date Prepared: 7/16/86

Project Title & Number: Reproductive Studies on Milkfish

IMPLEMENTATION PLAN FOR MILKFISH YEAR 1 TO YEAR 3

	Year 1						YEAR 2						YEAR 3					
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
MILKFISH SEED PRODUCTION																		
T1. Control Maturation																		
Maturation hormone--reproductive	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Endocrinology	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maturation environments; eg. Taiwan	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Growth enhancement			x	-	-	-	-	-	-	x					x	-	-	-
Nutritional requirements	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biological minimum size and age	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T2. Valid Spawning																		
Oocyte staging	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Hormonal requirement (doses)	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Egg quality & fertilization rates	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Natural spawning; eg. Taiwan	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Bio-environmental factors	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T3. Cost-Effective Larval Rearing																		
Embryonic development (environmental parameters)	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Live food production	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Formulated feed; eg. microencapsulation	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Larval physiology (environmental)	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Larval nutrition	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Hormonal application for growth	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
Semi-intensive rearing	x	-	-	-	-	x		x	-	-	-	-	-	-	-	-	-	x
MULLET																		
T4. Control Reproduction																		
Induced spawning technique						x	-	-	-	x								
Extension & control of spawning season	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Determine minimum reproductive size				x	-	-	-	-	-	x								
T5. Refining Hatchery Technique Larval Rearing System						x	-	-	-	-	x							
OTHER DESIRABLE SPECIES																		
T6. Application of Technology to Other Species																		
Induced maturation of male and female fish in two new families	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Induced spawning	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilization and larval culture	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T7. Economic Analysis	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T8. Milkfish as Baitfish							x	-	-	-	-	-	-	-	-	-	-	-
T9. Technology Transfer	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T10. Network on Reproduction	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	J	F	M	A	M	J
MILKFISH SEED PRODUCTION						
T1. Control Maturation						
Maturation hormone--reproductive	-	x	-	-	-	x
Endocrinology	-	-	-	-	-	-
Maturation environments; eg. Taiwan	-	-	-	-	-	x
Growth enhancement						x
Nutritional requirements	-	x	-	-	-	x
Biological minimum size and age	-	-	-	-	-	x
T2. Valid Spawning						
Oocyte staging	-	x	-	-	-	x
Hormonal requirement (doses)	-	x	-	-	-	x
Egg quality & fertilization rates	-	x	-	-	-	x
Natural spawning; eg. Taiwan	-	x	-	-	-	x
Bio-environmental factors	-	-	-	-	-	x
T3. Cost-Effective Larval Rearing						
Embryonic development (environmental parameters)	-	x	-	-	-	x
Live food production	-	-	-	-	-	x
Formulated feed; eg. microencapsulation	-	x	-	-	-	x
Larval physiology (environmental)	-	x	-	-	-	x
Larval nutrition	-	x	-	-	-	x
Hormonal application for growth	-	x	-	-	-	x
Semi-intensive rearing	-	x	-	-	-	x
MULLET						
T4. Control Reproduction						
Induced spawning technique		x	-	-	-	x
Extension & control of spawning season	-	-	-	-	-	x
Determine minimum reproductive size		x	-	-	-	x
T5. Refining Hatchery Technique Larval Rearing System		x	-	-	-	x
OTHER DESIRABLE SPECIES						
T6. Application of Technology to Other Species						
Induced maturation of male and female fish in two new families	-	-	-	-	-	x
Induced spawning	-	-	-	-	-	x
Fertilization and larval culture	-	-	-	-	-	x
T7. Economic Analysis	-	-	-	-	-	x
T8. Milkfish as Baitfish	-	-	-	-	-	x
T9. Technology Transfer	-	-	-	-	-	x
T10. Network on Reproduction	-	-	-	-	-	x

TO: M/SER/OP, Ms. Kathryn Cunningham

FROM: S&T/FA, Duane Acker

SUBJECT: Award of Cooperative Agreement to the Oceanic Institute Without Consideration of Other Sources for "Reproductive Studies of Milkfish"

I request that you consider only the Oceanic Institute for the cooperative agreement to: 1) utilize and enhance its resource base to develop and evaluate technologies to shorten the time-span for gonadal maturation of milkfish in captivity; 2) maximize the production of fertilized eggs; 3) develop semi-intensive and cost-effective culture systems for larval rearing; 4) use hormone technology on other finfish species; 5) determine the feasibility of adapting new maturation technologies in LDCs; 6) study the feasibility of using milkfish as baitfish; and 7) expand existing and create new networking relationships to disseminate and obtain information on fish reproductive technologies.

The Oceanic Institute of Hawaii submitted a four-year unsolicited proposal for research on milkfish in January 1984. The proposal was reviewed by the S&T/AGR and members of the Fisheries and Aquaculture Subcommittee of the Sector Council for Agriculture who recommended funding only the first phase or the first two years of the proposal. Research activities under the cooperative agreement began in July 1984. During that phase of the project, Oceanic Institute developed the technology and demonstrated the techniques for enhancing the maturation and spawning of milkfish in captivity. Additional experiments and trials are required for further verification, to be followed by field-testing and refinement of hatchery technology for rearing juvenile finfish. Management practice manuals are needed for hatchery managers. In March 1986 the Oceanic Institute submitted an unsolicited proposal for continuation and expansion of the research to fund the second phase of the research and development activities.

Milkfish has been cultured for centuries in Southeast Asia. However, it has not been successfully reared through its full life cycle in captivity. The young fish are collected in the wild, and suffer greater than 90 percent mortality before reaching a harvestable age and size. By funding the proposed extension, A.I.D. will be following its mandate to develop means of increasing food production in the developing world. The research proposed will

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address the primary problems of sexual maturation of milkfish in captivity and larval survival so that State-of-the-Art information on milkfish culture will be published and disseminated to LDCs and other interested institutions under this project. The research results will be of immediate benefit to LDCs, particularly in Southeast Asia. The extension will provide for training of LDC nationals at the Oceanic Institute. Further, the technology developed for milkfish will be applied to other marine fish species that are important species for aquaculture in developing countries.

The Oceanic Institute has recognized capability in culture of marine and brackish water fish and shellfish species. Its scientists are known for their expertise in reproductive physiology of fish. This Institute is the only U.S. entity which conducts research on milkfish. It also has worked on such species as mullet, marine shrimp, and dolphin fish. It has the capability to train LDC nationals at the Institute and in the LDCs.

Oceanic Institute has an in-house staff of scientists with backgrounds in marine fish culture and marine fish reproduction. It has strong professional linkages with scientists and technical specialists currently working on milkfish culture in LDCs. It has well-equipped marine aquacultural research facility in the tropics valued at over $5.0 million. The Bureau for Science and Technology therefore, has decided to extend the existing cooperative agreement through July 14, 1989 based on the Institute's capabilities and the contribution this research will make toward solving the Agency's problem areas of hunger and inadequate income growth.

There are no other U.S. institutions which could undertake such a program. The capabilities of other U.S. marine research laboratories and universities have been considered in this analysis. Those considered and the reasons for their elimination are listed below:

<u>Auburn University</u> - lacks a tropical marine facility and professional staff with experience in milkfish reproduction.

<u>University of Miami</u> - lacks facilities and staff with experience in fish reproduction, milkfish culture and marine aquaculture.

<u>University of Hawaii</u> - lacks professional staff with milkfish culture experience.

Texas A and M University - lacks tropical fish culture facilities and staff experience in milkfish culture and reproduction.

University of Puerto Rico - lacks staff with experience in milkfish reproduction and culture.

The most compelling reason for the selection of the Oceanic Institute over other institutions is its major and concerted efforts entirely devoted to research on maturation and spawning of milkfish and other finfish in captivity. Through this research, it is expected that the availability of fish protein in the LDCs will be greatly increased.

In consideration of the above, the Directorate for Food and Agriculture, Bureau for Science and Technology requests that the Office of Procurement proceed to award an extension and expansion of the Cooperative Agreement to the Oceanic Institute through July 14, 1989, based on the unsolicited proposal. (Attachment 2 to the PIO/T).

Clearance: S&T/AGR,	Richard Neal	RAN	date	7/29/86
	Betty Roche	[illegible]	date	7/29/86
	Tejpal Gill	[illegible]	date	7-28-86
S&T/PO,	Vivian Anderson	[illegible]	date	7-31-86
	Gerald Gower	[illegible]	date	8/1/86

MFCANCAW:S&T/AGR:7/22/86:Revised 7/29/86

REPRODUCTIVE STUDIES ON MILKFISH

THE OCEANIC INSTITUTE

Environmental Threshold Determination

and

Initial Environmental Examination

7/21/86

July 25, 1986

MEMORANDUM TO: S&T/FA, Dr. Duane Acker

FROM: S&T/AGR, Tejpal Gill

SUBJECT: Environmental Threshold Determination

REF: Reproductive Studies on Milkfish
936-4161

I have concluded that this project involves controlled experimentation exclusively for the purpose of research and field evaluation, in the form of testing on live fish in containment facilities both of which are carefully monitored. The categorical exclusion from environmental review set forth in Section 216.2(c)(2)(ii) of AID's Environmental Procedures is applicable, therefore to this project. Nevertheless, S&T/AGR has conducted an Initial Environmental Examination of this project.

On the basis of the Environmental Threshold Determination, I recommend that you make the following determination:

_X_ 1. The proposed agency action is not a major Federal action which will have a significant effect on the human environment.

____ 2. The proposed agency action is a major Federal action which will have a significant effect on the human environment, and:

____ a. An Environmental Assessment is required; or

____ b. An Environmental Impact Statement is required.

The cost of and schedule for this requirement is fully described in the referenced document.

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3. Our environmental examination is not complete. We will submit the analysis no later than _____ with our recommendation for an environmental threshold decision.

Approved: _____

Disapproved _____

Date: 8-1-86

Clearance:Environmental Officer _____ 7/21/86
Carroll Collier

7/21/86

Reproductive Studies on Milkfish

INITIAL ENVIRONMENTAL EXAMINATION

PROJECT LOCATION:	WORLDWIDE
PROJECT TITLE:	Reproductive Studies on Milkfish
PROJECT NUMBER:	936-4161
LIFE OF PROJECT:	Three Year Extension to a Total of Five-Years
IEE PREPARED BY:	Richard Neal
DATE:	July 21, 1986
ACTION RECOMMENDED:	NEGATIVE DETERMINATION

CONCURRENCE: _____

DATE: 8-1-86.

Reproductive Studies on Milkfish

ENVIRONMENTAL ANALYSIS

I. Project Description - This project is designed to develop methods for maturation and spawning of milkfish (Chamos Chamos) in captivity, to improve methods for rearing milkfish fry in hatcheries and to extend methods developed for milkfish to other commercially important marine culture fish species. Scientists will be developing methods to control these natural processes in captive fish under artificial conditions.

Wild fish will be held under laboratory and pond conditions for this experimentation and treatments including environmental manipulation and administration of minute quantities of hormones will be utilized. Laboratory studies will have no environmental consequences and outdoor experiments will include modification of water quality, temperature and salinity patterns in ponds to duplicate natural oceanic conditions under which milkfish normally mature and spawn. These procedures will improve rather than degrade the pond environments.

No genetic alteration of experimental fish will be undertaken during these studies. No foreign substances will be released into the environment and no undesirable effects on water, soil or air quality can be anticipated.

Successful completion of the project will lead to increased fish farming in developing countries in coastal impoundments, ponds and cages. These forms of aquaculture are environmentally compatible and complementary to management of coastal resources for maximization of long-term sustained yields. Because coastal aquaculture can be conducted only in relatively unpolluted areas, the net role of aquaculture on coastal environments tends to be positive rather than a negative one.

II. Recommendations

From the discussion above and the analysis contained in the following "Impact Identification and Evaluation Form," it is determined that the initial implementation of this project will not have a significant direct affect on the environment. A negative determination is recommended.

Reproductive Studies on Milkfish

ENVIRONMENTAL ANALYSIS

IMPACT IDENTIFICATION AND EVALUATION FORM

Impact Areas and Sub-Areas	Impact Identification *
A. LAND USE	
1. Changing the character of the land through:	
a. Increasing the population	N
b. Extracting natural resources	N
c. Land clearing	N
d. Changing soil character	N
2. Altering natural defenses	N
3. Foreclosing important use	N
4. Jeopardizing man or his work	N
5. Other factors:	
Reducing pesticide pollution and contamination	L+
B. WATER QUALITY	
1. Physical state of water	N
2. Chemical and biological states	N
3. Ecological balance	N
4. Other factors	N
C. ATMOSPHERIC	
1. Air additives	N
2. Air pollution	N
3. Noise pollution	N
4. Other factors	N
D. NATURAL RESOURCES	
1. Diversion, altered use of water	L-
2. Irreversible, inefficient commitments	N
3. Other factors	N

E. CULTURAL	
1. Altering physical symbols	N
2. Dilution of cultural traditions	N
3. Other factors	N
F. SOCIO-ECONOMIC	
1. Changes in economic/employment patterns	L-
2. Changes in population	N
3. Changes in cultural patterns	N
4. Other factors	N
G. HEALTH	
1. Changing a natural environment	N
2. Eliminating an ecosystem element	N
3. Other factors	
Reducing pesticide poisoning	N
Reducing nitrates in water	N
H. GENERAL	
1. International impacts	N
2. Controversial impact	N
3. Larger program impacts	N
4. Other factors	N
I. OTHER POSSIBLE IMPACTS (not listed above)	
1. Introduction of new plant species	N
2. Agricultural chemicals	N
3. Other factors	N

* The following symbols are used for Impact Identification

N = No environmental impact
L = Little environmental impact
M = Moderate environmental impact
H = High environmental impact
U = Unknown environmental impact

+ = Beneficial impact
- = Negative impact