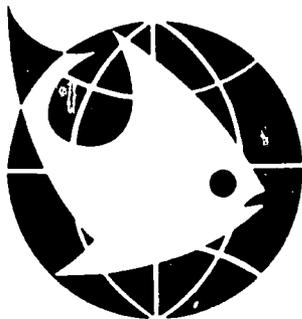# FISHERIES STOCK ASSESSMENT

TITLE XII COLLABORATIVE RESEARCH SUPPORT PROGRAM

Continuation Proposal Amendment

September 1989

FSA/CRSP
Management Office
International Programs
College of Agriculture
The University of Maryland
College Park, Maryland 20742

The Fisheries Stock Assessment

Title XII Collaborative Research Support Program

CONTINUATION PROPOSAL AMENDMENT

September, 1989

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Executive Summary

This document is an amendment to the Fisheries Stock Assessment Title XII Collaborative Research Support Program (CRSP) Continuation Proposal, May, 1989. The JCARD/BIFAD review committee suggested that the CRSP revise its work plans and budgets to a request for $704,000 per year rather than the initial request of 845,000 for a three year extension of the program (July 1, 1990 - June 30, 1993). The CRSP then underwent a restructuring of its research agenda during July and August, 1989.

The restructuring plan maintains the integrity of the research program with its central focus on developing improved methodologies for stock assessment and management of small-scale multispecies tropical marine capture fisheries. The limited budget required eliminating numerous special studies which could improve the overall product, but which are not essential to the principal thrust of developing the CRSP's final deliverable product, the CRSP Stock Assessment Manual.

Selected research elements restricted or eliminated from the new work plans include the following. The expert system for fisheries stock assessment and management will be completed and be fully operational, but will have less than immediately applicability in its off-the shelf state to fishery systems quite different from those in the principal host countries because of its restricted data base. It will, however, serve as a demonstration system, capable of being expanded, for other fishery systems in the world. Selected evaluations of multispecies assessement techniques will be foregone. Some work on the development of time series models of catch and effort will be deleted from the program, and a multi-year fish mark-and-recapture experiment, to validate some of the fish ageing work, will not be undertaken. Hydroacoustics and ageing work will be limited. The extensive field monitoring program on the coral reef flat fishery system in the Philippines will be ended a year early. Several specialized studies on food web structure, fishing gear and effort, and reproduction and recruitment have been dropped from the work plans. The elements have been carefully pruned from the program in order to maintain the effort on the central thrust of the program.

The CRSP Stock Assessment Manual will serve as a guide for optimal stock assessement and management for small-scale

multispecies tropical fisheries in developing countries. Funds have been set aside for the preparation and dissemination of the Manual, and for conducting two regional training workshops (one in Costa Rica and one in the Philippines) at the end of the eighth year of the program to ensure the orderly transfer of CRSP-developed methcdologies and techniques to developing country professionals. The initial version of CRSP Stock Assessment Manual to be completed in year five of the program will also serve as a key marketing device in seeking non-AID funds for further testing, validation, and extension of the CRSP results.

In the restructuring plan, host country budgets have been maintained and travel budgets have been increased in order to facilitate scientist interactions. Plans for continued program coordination have been made.

Contents

I. Introduction

This document is submitted to USAID as an amendment to the Fisheries Stock Assessment Title XII Collaborative Research Program (CRSP) Continuation Proposal, May, 1989. This amendment was requested following the JCARD/BIFAD review of the Continuation Proposal on June 15, 1989. (For reference, see the memorandum dated July 14, 1989, from J.B. Henson to the CRSP Program Director in the Appendix to this amendment.)

The following is only an amendment to the Continuation Proposal, May, 1989, and, while every effort has been made to provide sufficient narrative to make this amendment clear to the reader, the full scope of the research agenda and highlights of the accomplishments to date and those expected by the end of a three year extension of the CRSP (July 1, 1990-June 30, 1993; years six through eight) are found in the initial Continuation Proposal.

1. The Budget Issue and this Amendment

A principal issue calling forth this amendment was the budget request and associated workplans. The Continuation Proposal submitted a budget for $845,000 per year for the three year continuation period. The CRSP has been informed, however, that the budget level will remain at $704,000 per year for the continuation period, if the extension of the program is approved. Accordingly, the objectives and workplans for the three year continuation have been revised and amended to accomodate funding at $704,000 per year, the level of funding at which the CRSP has operated during the past two years. Initially planned and contracted to be funded at approximately $1 million per year, the CRSP has been operating at the $704,000 per year level since the end of the second year of the grant. With level funding for the continuation period, assuming a modest 5 percent inflation rate, the real inflation-adjusted AID funding for CRSP programmatic activities for the continuation period will be less than 80 percent of the CRSP funding during year four (1988-89). Hence, the necessity for reprogramming the CRSP research agenda.

The revised workplans reflecting the expected budgetary levels ($704,000 per year for three years) are included in Section II of this report, Amended Objectives and Work Plans. Section II presents a brief description of each research component, an overview of the work plan modifications, revised project objectives, and detailed work plans for years six through eight for each of six projects. These work plans are revised

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versions of those submitted in Chapters III, IV, and V of the Continuation Proposal. Section II also presents an overview modified directions of the Management Entity and program coordination activity.

Section III of this report presents a detailed revised budget. The budget itself (Table 1, of this report) is a revised version of Table 13 in Chapter VIII of the Continuation Proposal.

2. The Restructuring Process

During the two months following the review on June 15, 1989, consultations among the Program Director, the Board, and the Technical Committee led to a serious restructuring of the work plans for the continuation period. The principal objective of this restructuring was to accomodate activities undertaken to the limitations of the budget while maintaining the integrity of the research program and preparing the final CRSP product, a CRSP Stock Assessment Manual, and disseminating the CRSP-developed methodologies and techniques to developing country professionals in regional workshops at the end of the program in year eight. The CRSP proposes to set aside $80,000 for end-of-project activities, including two regional workshops, one in the Philippines and one in Costa Rica, and the publication and dissemination of the CRSP Stock Assessment Manual.

The initial version of the CRSP Stock Assessment Manual will be completed at the end of year five of the CRSP, June 30, 1990. This manual is intended as a guide or a "key" for optimal stock assessment and management for small-scale multispecies tropical fisheries in the developing countries. Dissemination of the initial version of the CRSP Stock Assessment Manual is planned as a cornerstone of the CRSP marketing endeavors designed to solicit private and public "buy-ins" to facilitate further testing, validation, and extension of the CRSP-developed methodologies and techniques. A full description of the manual is found in Chapter VI of the Continuation Proposal.

3. An Overview of the Work Plan Modifications

Detailed descriptions of the modifications in the objectives and work plans required by the budget limitations are found in Section II of this report. A brief summary of some of those modifications follows.

The Maryland/Costa Rica component of the CRSP will continue the development of a expert support system for fisheries stock assessment and management, but, while funding limitations will not preclude completion of the system in the allotted time, the expert system will be more specific for Costa Rica and similar fisheries and not as immediately applicable to other fishery systems in its "off-the-shelf" state. In addition, planned work

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by the University of Miami on determining the appropriateness of multispecies assessment techniques will be foregone; however, other aspects of multispecies theory development will proceed as planned.

The Washington/Costa Rica component will limit work on hydroacoustics and ageing, both areas in which substantial progress has been made to date. A planned multi-year mark-and-recapture experiment to validate some of the ageing work will be dropped. Several special studies such as pre-recruit (young fish) studies, benthic studies, and multispecies assemblage studies will be curtailed. One of the most significant deletions from the program is the work on time series models on catch and effort. However, every effort is being devoted to assuring a high quality integrated product in spite of eliminating or reducing certain more specialized aspects of the research.

The Rhode Island/Philippines component is significantly scaling down the field monitoring program during the continuation period, and will terminate the field monitoring program at the end of year seven, focusing in year eight on data analysis, report preparation, and training and dissemination of findings. Several specialized studies, such as analyses of food web structure, comparative gear studies to standardize effort, and reproduction and recruitment studies, have been omitted from the revised workplans; however, the primary goal of quantitatively analysing the dynamics of the heavily exploited fish community is expected to be achieved.

In summary, each of the principal CRSP components has eliminated or reduced effort devoted to particular aspects of the research agenda which would have strengthened the final overall product of the CRSP research. However, the research strategy has focused on the key issues and problems to be solved which will ensure the high quality, usefulness, and transferability of the CRSP Stock Assessment Manual, leaving many less central issues for future research efforts.

4. Host Country Strengths and Strengthening

One of the major concerns facing the Board, the Technical Committee, and the Program Director in restructuring the program within the context of the level-funded budget over the continuation period was the impact on the host country institutions, their researchers and their ability to contribute to the program. In the restructuring the overall share of expenditures in the host countries during the three year continuation period has remained at the same 20.4 percent of the CRSP programmatic expenditures which were spent in the final two years of the initial grant. However, there were significant reductions in the Philippine field studies operational account, while host country subcontract funds have been increased.

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The host country collaborating institutions were selected because of their scientific excellence and their substantial contribution to the CRSP research has confirmed that earlier assessment. Though not required to make financial contributions to the CRSP activities, the commitment of the host country institutions is indicated by the fact that their contributions in facilities, supplies, equipment, and personnel have amounted to about six percent of programmatic spending and about 30 percent of the AID funds spent in the host countries. Were the host country contributions to be valued at U.S. prices, the host country contributions would probably exceed the amount of AID funds they have received.

In both host countries CRSP researchers are collaborating with fisheries managers and researchers from the official host government fisheries agencies. Collaboration in the ongoing research and continuing on-site workshops and training programs are ensuring regular and continuous transfer of CRSP developments to host country professionals. This continuous transfer process provides assurance that the CRSP products are useable and transferrable to developing countries. In fact host country collaborators in both host countries are expected to be key participants in providing the end-of-project regional workshops to transfer and disseminate CRSP findings to developing country professionals. The CRSP is continuing to strengthen the host country institutions so that at the end of the eight years it is expected that field monitoring and assessment activities will continue under local auspices and host country collaborating institutions will continue independently to provide stock assessment training for professionals in their respective regions.

5. **Rationale and Benefits of the CRSP**

The CRSP research agenda is directed to developing new methodologies for stock assessment and management of the small-scale multispecies tropical fisheries which are responsible for about 25 percent of the world fish catch and supply 30-50 percent of the animal protein consumed in developing countries. With the world fish catch approaching its sustainable maximum size while population, income, and, hence, demand for fish continue to grow, fish prices are expected to continue rising and intensified fishing pressure on the fish populations are expected to undermine efforts to sustain fishing yields, particularly in the heavily populated tropical coastal fisheries. Improved stock assessment and management methodologies are essential to sustaining global fishery resources. The methodologies and techniques developed by the CRSP are directed to stock assessment in small-scale or artisanal and multispecies fisheries, and, thus, will be applicable to at least half of the U.S. fisheries which are small-scale, non-industrial, fisheries. Furthermore, solutions to the inherent problems of multispecies situations

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will contribute to the development of fisheries science and management in general. In summary, the CRSP researchers and their respective institutions which are making substantial financial contributions to CRSP activities are excited in the hope of continuing the CRSP research for an additional three years to develop methods essential to successful sustainable fisheries resource management in the tropics and around the world.

The following Section II provides the detailed amended objectives and workplans for the CRSP during a three year continuation period, and Section III provides the detailed amended budget for the continuation period.

II. Amended Objectives and Work Plans

The following presents the revised and amended objectives and work plans for the proposed three year continuation of the Fisheries Stock Assessment CRSP, July 1, 1990-June 30, 1993. The amended objectives and work plans for the three programmatic components of the CRSP, Maryland/Costa Rica (Section A), Washington/Costa Rica (Section B), and Rhode Island/Philippines (Section C), are revisions in the objectives and work plans submitted in Chapters III, IV, and V of the Continution Proposal of May, 1989. Detailed descriptions of the program components and the research accomplishments expected during the first five years are found in the Continuation Proposal, May, 1989, and no effort here has been made to review the overall program. However, in order to facilitate a review of the work plan modifications, Sections A, B, and C below present a brief program description and an overview of the work plan modifications prior to the revised work plans. The amended programmatic objectives and work plans are followed in Section D by an overview of the program-wide modifications in program coordination, Management Entity activities, and end of project activities.

A. The University of Maryland-Center for Environmental and Estuarine Studies and The University of Costa Rica Program

The following presents a description of The University of Maryland-Center for Environmental and Estuarine Studies (UMCEES) and The University of Costa Rica (UCR) research program, an overview of the modifications in the work plans required by the reduced budget, and the amended work plans for the continuation during years six through eight. These work plans represent a revision of those included in Chapter III of The Continuation Proposal submitted in May, 1989.

1. Program Description

The University of Maryland-Center for Environmental and Estuarine Studies (UMCEES) in collaboration with The University of Costa Rica (UCR) is carrying out two CRSP research projects, noted as follows:

1. Multiple Species Fisheries Research, and
2. Economic and Probabilistic Extensions of Standard Fisheries Models.

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The principal host country institution collaborating on these two projects is UCR's Centro de Investigacion en Ciencias del Mar y Limnologia (CIMAR).

During the initial five year of the grant period additional collaboration on the Multiple Species Fisheries Research Project was provided by The University of Maryland-College Park-College of Business and Management (UMCP-CBM) and by The University of Miami(UMiami); and additional collaboration on the Economic and Probabilistic Extensions of Standard Fisheries Models Project was provided by The University of Delaware (UDelaware). Collaboration with UMiami and UDelaware will not be continued in the three year continuation period due to limited funding.

The two projects together focus on 1) the design of a decision support system, utilizing some Expert Systems (ES) features, to study population dynamics and management of small-scale multispecies fisheries and 2) the modification of standard fisheries models to increase their utility to managers of small-scale fisheries.

2. Overview of Work Plans Modifications

The modifications in the work plans to accomodate level funding of the research program in the face of continued inflation and the necessity of setting aside funds for extension and dissemination of the research accomplishments at the end of year eight in the program have been two fold. First, the contribution to the UMCEES/UCR program by The University of Miami has been terminated. This work was focused on developing techniques for assessing tropical multispecies fisheries. The extension of this work to multiple species multicohort populations and the assessment of techniques under various hypotheses of interspecies relationships will not be continued. Other work on what drives both recruitment variability and the interactions among species will, however, continue. Second, the expert support system (CANOFISH) designed to aid fisheries scientists and managers in stock assessment which was originally intended to be fully transferrable to a variety of fisheries around the world will not be as extensively applicable as planned. The reduced funding will not preclude completion of the system in the allotted time, but CANOFISH will now be more specific for the Costa Rica fisheries and will not be as immediately applicable to other fishery systems in its "off-the-shelf" state. However, CANOFISH will be directly transferrable and useable in many fisheries and will serve as a demonstration system for others.

3. Amended Objectives and Work Plans

a. The Multiple Species Fisheries Research Project

1) Objectives

The research objectives in years six through eight will continue along the lines pursued during the first five years, namely (1) the investigation of multispecies fishery system complexity in order to understand multispecies fisheries and how they relate to community and population dynamics, and (2) to continue contributing to the advancement of fishery management in small-scale fisheries. A concrete objective is to complete, at the end of eight years, a fully integrateu expert support system (ESS) incorporating advances in stock assessment, multispecies research, and artificial intelligence.

The specific areas of research we plan to focus on are further enhancement of the CANOFISH expert support system; continuing development and application of tropical fisheries stock assessment techniques; articulation, development, and practical applications of multispecies fisheries theory; and researching the interactions of industrial and artisanal fisheries in Costa Rica. The following discussion elaborates upon each of these research areas:

a) CANOFISH

The canonical fishery management expert support system, CANOFISH, will be further enhanced in a number of areas during years six through eight. The specific tasks will involve (1) application of the fishery analytic/decision models components of CANOFISH II to the Gulf of Nicoya corvina fishery, (2) development of the artificial intelligence module, and (3) implementation of the system in Costa Rica.

In year six, much emphasis will be placed on using the various parametric and nonparametric fishery models contained in CANOFISH II to analyze the Gulf of Nicoya corvina fishery. The methods used in this analysis will be an extension of those developed in years four and five which are comprised of merging systems identification, time-series, and multivariate statistical techniques with standard parametric fishery models. The specific bioeconomic optimization/decision analysis model and accompanying software developed in years three through five for the corvina fishery will be used to create a fishery management plan for selected species assemblages. The CANOFISH system itself will be further enhanced by the addition of fishery econometrics data handling and analysis procedures.

One of the major tasks of the UMCEES-UCR research program will be to develop a state-of-the-art artificial intelligence

module, called ADVISOR, which will provide "expert advice" on all aspects of the CANOFISH system, including sampling, data handling and management, simulation, model identification and estimation, optimization, decision analysis, and METASYSTEM models. The development of ADVISOR will entail advances in expert system technology, since an expert system which is expressly integrated with a complex decision support system does not exist at the present time in any field, let alone the ecological sciences. Based on our previous work on the ADVISOR module in CANOFISH I, we will not use an expert system shell as the basis of the module but rather develop an original shell with the artificial intelligence language Turbo PROLOG. The integration of ADVISOR with the CANOFISH II system will yield a fully integrated fishery management expert support system linking all of the fundamental activities of fishery stock assessment and management. This version will be called CANOFISH III, and will be completed by end of the year eight.

Coincident with the application of CANOFISH II to the corvina fishery and the development of the ADVISOR module will be the implementation of the CANOFISH system at both CIMAR and the Ministry of Fisheries in Costa Rica. The first task will be to develop a Spanish-language version of CANOFISH II, including both the user interface and supporting documentation. The second will be to implement the system on microcomputers at CIMAR and the Ministry of Fisheries, along with extensive training of personnel. A researcher from UMCEES will assist in these tasks being in residence in Costa Rica for a one year period, projected for portions of years six and seven. At the end of this period a Latin America-wide symposium/short course will be held on the theory and practical applications of the CANOFISH system to the assessment and management of tropical fisheries. The final task will be to complete both English and Spanish language versions of the CANOFISH III User's Guide.

b)   Multispecies Fisheries Theory

In order to manage multispecies fisheries, it is imperative to understand what drives both recruitment variability and the interactions among species. Research in years four and five is exploring the relationship among physical oceanographic factors-- wind, temperature, turbulence, etc.--and both multispecies interactions and recruitment variability. In year six, a monograph will be completed on this subject. The work in years seven and eight will entail developing simulation models incorporating these relationships and applying them to Costa Rican fisheries. These multispecies assessment and simulation techniques will be incorporated into CANOFISH III in year eight.

c)   Industrial and Artisanal Fisheries Gear and Fleet
     Interactions

     To gain a better understanding of the Gulf of Nicoya corvina
fishery, it will be necessary to assess the impact of the Costa
Rican industrial shrimp fishery on the artisanal corvina fishery.
The first task in achieving this understanding will be to gather
the extant historical data on the shrimp fishery in Costa Rica,
including landings, biological information, and economic
information. This information will be used to develop models
which assess both gear and fleet interactions between the shrimp
and corvina fisheries. These models will subsequently be bench-
tested and then applied to an overall fishery management plan in
the Gulf of Nicoya. The models will be incorporated into
CANOFISH III, and implemented within the system at the Ministry
of Fisheries in Costa Rica.

2)   **Work Plans for Year Six**

a)   CANOFISH

     i)   Apply systems identification, time-series, and
           multivariate statistical techniques to the Gulf of
           Nicoya corvina fishery.

     ii)   Develop and expand econometrics data handling and
           analysis procedures.

     iii) Implement bioeconomic optimization/decision analysis
           software for the Gulf of Nicoya corvina fishery.

     iv)   Integrate decision analysis techniques with other
           components of the system.

     v)   Begin development of ADVISOR, or the artificial
           intelligence component of the system.

     vi)   Develop a Spanish language version of CANOFISH II,
           including both the user interface and supporting
           documentation.

     vii) Begin implementation of the CANOFISH system at CIMAR
           and the Ministry of Fisheries.

b)   Multispecies Fisheries Theory

    i)   Complete monograph on the relationship between physical oceanographic factors and both multispecies interactions and recruitment variability.

c)   Industrial and Artisanal Fisheries Gear and Fleet Interactions

    i)   Assemble extant data for Costa Rican shrimp fishery.

    ii)   Develop models to assess gear and fleet interactions between the artisanal corvina fishery and the industrial shrimp fishery in Costa Rica.

3)   Work Plans for Year Seven

a)   CANOFISH

    i)   Update and refine the CANOFISH system for application to all aspects of the Gulf of Nicoya corvina fishery.

    ii)   Complete the development of econometrics analytic procedures.

    iii) Incorporate the AHP decision analytic models for the corvina fishery into the system.

    iv)   Continue development of ADVISOR, with emphasis on an integrated analysis of the results of a wide variety of fishery/economic/decision models.

    v)   Complete the development of a Spanish language version of CANOFISH II.

    vi)   Complete implementation of the CANOFISH system at CIMAR and the Ministry of Fisheries, including extensive training of personnel.

b)   Multispecies Fisheries Theory

    i)   Develop simulation models to incorporate physical oceanographic factors with multispecies interactions and recruitment.

c)   Industrial and Artisanal Fisheries Gear and Fleet Interactions

    i)   Complete development and testing of models to assess gear and fleet interactions between the artisanal corvina fishery and the industrial shrimp fishery in Costa Rica.

4)   Work Plans for Year Eight

a)   CANOFISH

   i)   Complete development of ADVISOR.

   ii)   Integrate ADVISOR with the CANOFISH system to create
         a fully operational fishery management expert
         support system, CANOFISH III.

   iii) Complete English and Spanish language versions of
         the CANOFISH III User's Guide.

   iv)   Hold a Latin America-wide symposium/short course
         on the theory and practical applications of the
         CANOFISH system to the assessment and management
         of tropical fisheries.

b)   Multispecies Fisheries Theory

   i)   Apply the theory and assessment models incorporating
        physical oceanographic factors with multispecies
        interactions and recruitment to Costa Rican fisheries.

   ii)   Integrate the assessment models into CANOFISH III.

c)   Industrial and Artisanal Fisheries Gear and Fleet
     Interactions

   i)   Integrate the models assessing gear and fleet
        interactions between the Costa Rican artisanal corvina
        fishery and the industrial shrimp fishery into CANOFISH
        III.

**b.   The Economic and Probabilistic Extensions of Standard
       Fisheries Models Project**

1)   Objectives

    The research objectives in years six through eight will be
to develop stock assessment techniques for simple data
situations, to extend standard fishery/economic models with
particular regard to optimization, and apply operations research
techniques to sampling problems.

    To achieve the desired objectives, three lines of research
will be pursued: (1) the continued development of a fishery
management METASYSTEM; (2) the development and application of a
variety of bioeconomic optimization/decision analysis techniques
to Costa Rican coastal fisheries in particular and tropical
fisheries in general; and (3) the application of operations

research techniques to sampling both biological and econometric fisheries data. Each of these research areas is discussed below:

a)   METASYSTEM Development

The basic premise of a fishery management METASYSTEM is to provide information for assessing and managing a fishery when little or no data exists. A metasystem model contains information on previously studied similar fisheries located around the world which may yield insight into the behavior of the fishery in question. It is projected that metasystem models for global crab and shrimp fisheries will be completed at the end of year five. The first task in year six will be to integrate these completed models with the simulation, sampling, and model identification components of CANOFISH II. The second task, to be completed in year seven, is to develop metasystem models for global sciaenid and clupeid fisheries. The third task is to apply these models in the sampling, assessment, and management of Costa Rican coastal fisheries. By the end of year eight, the METASYSTEM environment containing the completed models will be fully integrated into the CANOFISH III expert support system.

b)   Bioeconomic Optimization and Decision Analysis

During the first five years, models involving bioeconomic optimization, the analytic hierarchy process (AHP), and decision analysis were/are being developed, tested, and incorporated into CANOFISH II. The emphasis in year six will be using those models within the CANOFISH system to explore various strategies of assessing and managing the Gulf of Nicoya corvina fishery. The specific optimization/decision analysis model for the corvina fishery will be used to compare various strategies of bioeconomic optimization of that fishery. An AHP model that chooses optimal sampling programs developed in years four and five will be also be applied to the corvina fishery.

New avenues of research in these areas will also be pursued. Along more theoretical lines, the application of asymptotic analysis to fisheries optimization problems will be explored. Also, in conjunction with the fishery models developed in the Multiple Species Research Project, an optimal resource allocation strategy for the interacting corvina and shrimp fisheries in Costa Rica will be constructed.

As new models are developed, the CANOFISH system will be used to compare the performance of the various optimization/decision theoretic models applied to tropical fisheries assessment and resource allocation problems. After testing, the appropriate models will be incorporated into CANOFISH III.

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c)   Operations Research Applications to Sampling Problems

A novel approach to determining an optimal fisheries sampling strategy is currently being developed for the fish species of the Chesapeake Bay. Although this work is not funded by the CRSP program, the resulting techniques can be applied to monitoring Costa Rican coastal fisheries. The techniques involve a merging of network theory, the AHP model discussed above, and expert systems technology. A similar sampling program will be also be developed to monitor Costa Rican fisheries econometric information. During years six and seven, emphasis will be placed on development of the respective sampling strategies. In year eight, the implementation of the sampling regimes in Costa Rica and the construction of features merging the sampling strategies with the CANOFISH system will be the main priorities. At the end of year eight, continuous updating and analysis of Costa Rican fisheries stock assessment and econometrics data will be an integral part of CANOFISH III.

2)   Work Plans for Years Six

a)   METASYSTEM Development

i)   Integrate the completed crab and shrimp METASYSTEM models with the simulation, sampling, and Model ID components of CANOFISH.

ii)   Begin development of METASYSTEM models for sciaenids and clupeids.

b)   Bioeconomic Optimization and Decision Analysis

i)   Use the optimization/decision analysis model for the Gulf of Nicoya corvina fishery within the CANOFISH system to assess various strategies of bioeconomic optimization.

ii)   Develop an analytic hierarchy process (AHP) decision analytic model to assess sampling strategies in the Gulf of Nicoya corvina fishery.

iii) Explore the application of asymptotic analysis to fisheries optimization problems.

iv)   Begin development of an optimal resource allocation strategy for the interacting corvina and shrimp fisheries in Costa Rica.

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c)   Operations Research Applications to Sampling Problems

   i)   Begin development of an optimal sampling strategy to
        monitor Costa Rican coastal fisheries, using expert
        systems technology, network theory, and AHP techniques.

   ii) Begin development of an optimal sampling strategy
        to monitor Costa Rican fisheries econometric
        information.

3)   Work Plans for Year Seven

a)   METASYSTEM Development

   i)   Complete development of METASYSTEM models for
        sciaenids and clupeids.

   ii) Begin implementation of sciaenid and clupeid METASYSTEM
        models into CANOFISH II.

b)   Bioeconomic Optimization and Decision Analysis

   i)   Begin constructing fisheries optimization models based
        on asymptotic analysis theory.

   ii) Apply the sampling strategies AHP decision analytic
        model to the Gulf of Nicoya corvina fishery.

   iii) Continue development of an optimal resource
        allocation strategy for the interacting corvina
        and shrimp fisheries in Costa Rica.

   iv) Using the CANOFISH system, compare the performance
        of various decision theoretic models applied to
        tropical fisheries assessment/resource allocation
        problems.

c)   Operations Research Applications to Sampling Problems

   i)   Complete development and begin implementation of an
        optimal sampling strategy to monitor Costa Rican
        coastal fisheries.

   ii) Complete development and begin implementation of an
        optimal sampling strategy to monitor Costa Rican
        fisheries econometric information.

4)   **Work Plans for Year Eight**

a)   METASYSTEM Development

   i)   Complete implementation of sciaenid and clupeid
        METASYSTEM models into the CANOFISH system.

   ii) Fully integrate the METASYSTEM environment into the
        CANOFISH III expert support system.

b)   Bioeconomic Optimization and Decision Analysis

   i)   Apply newly developed fisheries optimization models
        based on asymptotic analysis theory to Costa Rican
        fisheries, and incorporate into CANOFISH III.

   ii) Incorporate the tested decision analytic models for
        tropical fishery stock assessment and resource
        allocation into the CANOFISH system.

c)   Operations Research Applications to Sampling Problems

   i)   Construct features merging optimal sampling
        strategies with the CANOFISH system, allowing for
        continuous updating and analysis of Costa Rican
        fisheries stock and econometrics data.

B.   **The University of Washington and
     The University of Costa Rica Program**

        The following presents a description of The University of
Washington (UW) and The University of Costa Rica (UCR) research
program, an overview of the modifications in the work plans
required by the reduced budget, and the amended work plans for
the continuation during years six through eight. These work
plans represent a revision of those included in Capter IV of The
Continuation Proposal submitted in May, 1989.

1.   **Program Description**

        The University of Washington (UW) in collaboration with The
University of Costa Rica (UCR) is carrying out two CRSP research
projects, noted as follows:

        1.   Management and Stock Assessment Sampling, and
        2.   Recruitment and Productivity.

        The principal host country institution collaborating on
these two projects is UCR's Centro de Investigacion en Ciencias
del Mar y Limnologia (CIMAR). During the initial four years of
the CRSP, additional collaboration was provided by The University
of Delaware (UDelaware).

These two projects compose an integrated investigation of stock assessment and prediction that has as its objective the adaptation of concepts and methods of temperate fisheries management and the development of new methodologies to tropical, artisanal fisheries. The work involves the integration of various field, laboratory and theoretical studies.

During the initial five years the UW/UCR program was composed of four projects. However, work on age determination and hydroacoustics experienced substantial progress, and future work on these aspects will be carried out at a reduced level and will be subsumed under the two on-going projects.

2.   Overview of Work Plans Modifications

Several work plan modifications were made to accomodate the research program to the level-funded budget. In the Management and Stock Assessment Sampling Project the single biggest deletion is the work on time series models on catch and effort. The applicability of time series analysis is undoubted, but the inability of the budget to support this somewhat new thrust in the project forces its deletion or postponement at this time.

Another area that may receive less attention is the estimation of fleet fishery effort. Some time has been spent on this subject both at The University of Washington and at The University of Costa Rica but it has not yet been possible to cope with the limitations of the data. A new source has become available but it is not clear that there are funds to pursue the analyses. There is little doubt, however, of the importance of this analysis. Thus it would be a natural extension following year eight.

Concerning the Recruitment and Productivity Project modifications, hydroacoustics research is continuing, but only in a small way. The planned work on fish ageing validation via a multi-year mark-recapture experiment will not be pursued. Post-larval pre-recruit to the fishery studies will be greatly curtailed or funding sought from other sources. This is a critical aspect that should become a major thrust for future work. Thus FERET (Fecundity and Recruitment Timing) will be deemphasized. Nevertheless, it continues to be important to collect and analyze gonadal data to estimate basic reproductive data that is central to other aspects of the research project.

Studies of species interactions and productivity in the benthos will be deemphasized but it is important to develop our idea that the benthos can be a quick-and-dirty indicator of the factors that control reproduction and spawning in a tropical bay. Therefore, we will pursue this idea, the full development of which should lie beyond year eight of the CRSP. It is precisely in the same sense that we will curtail much of the effort on the

benthos-water column linkage but will develop it enough to establish a basis for future research.

Work on the assemblage information from multispecies association will be curtailed as well. It is, however, an innovative approach based on information-theoretic concepts which should be a part of future work. In years six through eight effort spent on this subject will focus on how the presence of multiple species affects sampling and effort types of analyses.

Year eight of the project is being reserved primarily for data analysis, manual preparation and the conducting of workshops. Funds continue to be available for a UCR graduate student in The University of Washington School of Fisheries.

3. Amended Objectives and Work Plans

a. Management and Stock Assessment Sampling Project

1) Objectives

This project is divided into five subunits numbered a) to e) and described below.

a)   Application of CASA for Stock Assessment.

By year six it is anticipated that appropriate stock assessment models such as CASA (Catch at Size Analysis) will be operational. Further, it is reasonable to assume that an efficient and not overly expensive sampling scheme will provide data on catch. It is these data that will enter into another length based assessment model to be used with CASA to provide estimates of stock abundance. Further, it is anticipated that enough experience will have been gained to allow periodic biological sampling programs to evaluate recruitment strength and an index of stock abundance. These data would be supplemented with biomass estimates from hydroacoustic surveys that are conducted at least annually. The focus of the hydroacoustic effort would therefore be upon the utilization of the resultant data and the training of CIMAR staff.

b)   A Length-structured Population Matrix Model.

Traditional age or length-structured models used for stock assessment concentrate on the fully recruited maternal stock. The CASA model uses an ad hoc stochastic recruitment to the fishery pattern because the model uses catch-at-length data and ignores the pre-recruit stages. These stages, however, are considered to be the determinant factor in recruitment success. Another concern is that most models focus on parameter estimation and are ill-adapted for prediction of consequences. Ideally, the best management strategy would satisfy criteria from evolutionary

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biology, such as: is there, and if so where, a stable age or length distribution, and how is it approached? Further, what are its stability properties and are these compatible with an optimal harvesting strategy? To approach answers to these concerns, a length-structured population matrix model is developed, built upon the work in years four and five. The model is a generalized case of a Leslie model, which would deal with an age-structured population, and is parallel to the CASA model while allowing the explicit expression of pre-recruit abundance, possible fecundity, and survival to recruitment. The length-structured population matrix model will be used in many ways:

i) As a model for population parameter estimation.

This is best described by Kalman filter or state-space modeling:

$$\underline{n}_t = A_t \underline{n}_{t-1} + e_t \text{ and}$$

$$\underline{c}_t = U_t \underline{n}_t + e_t$$

where the first equation describes the progress of the stock length distribution, n_t, in a discrete time domain subject to the reproduction and survival processes in A_t; the second equation describes the harvesting process of the exploited population. Applying the Kalman filter or the estimation procedures in CASA, the initial population abundance at time 0, the elements in A_t and U_t can be estimated.

ii) Estimation of pre-recruitment mortality.

If the parameters in (A_t) are all known except the survival rate (S_0) for the pre-recruitment stage, the method of Vaughan and Saila (1979) can be extended to estimate S_0 for the length-structured population matrix model in an equilibrium state. This will be an attractive estimator which could have wide application in fisheries, in general.

ii) Computation of an intrinsic rate of population growth from a stable length distribution and reproductive value using eigenvalue analysis.

If the elements in At can be obtained from biological studies and stock assessment, then the intrinsic rate of population growth, the stable length distribution and reproductive value can be estimated. These estimators have been used to address the process of fitness and adaption via natural selection, which in turn, addresses the possibility of a population being driven to extinction. Knowledge of an

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intrinsic rate of population growth and of reproductive
value may also give preliminary guidelines for deciding
which length section of a population can be caught and then
possibly suggest optimal gear.

iv)   Sensitivity analysis of changes in population
parameters.

An explicit sensitivity index for the intrinsic rate of
population growth can be derived when population
parameters change due to either environmental factors
or fishery pressures. This model will provide an
alternative interpretation of the impact of fishing.
This is an especially important consideration when
certain gears catch smaller sized fish, substantially
reducing the reproductive value of the population.
Once age and fecundity data are available, prospective
problems of recruitment and growth over fishing can be
quantitatively addressed.

v)   In the event, that this length structured state
space model does not yield rather rapidly to analysis,
efforts will be redirected to other aspects of the
applications of CASA. In this event or the event that
only a limited model results, the development of a
general length based state-space model would be a
natural extension for future research.

c)   Risk Analysis in Stock Assessment.

An evaluation of the risks associated with the specification
of particular stock assessment approaches with particular
management tactics is an important part of responsible
management. The collection of data for management purposes is
clearly costly in terms of direct expenditures, but the over
conservative harboring of biomass is also costly, though less
obviously. The level of expenditure for assessment must be
balanced with present as well as future catch expectations for
effective management. Attempts to limit assessment effort or
inefficient uses of assessment data that lead to non-conservative
management tactics clearly endanger the resource and have high
cost risks.

The situation is confounded by the urgent need for baseline
data to deal with trends in the fishery that may be dictated not
only by management tactics over the years, but also by the
multiple ways in which a society uses a resource such as the Gulf
of Nicoya. An example is the manifest concerns over several
different sources of pollution in the Gulf of Nicoya.

The basic theories behind our analyses will involve
adaptions to artisanal fisheries of the concepts of operations

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research and statistical reliability theory developed to deal with complex man-made systems such as manufacturing plants.

d) Sampling Studies of Catch Data.

The rich data set from Costa Rica will continue to grow and to be cleaned so as to be useful for understanding the relationships between fishermen metier, gear characteristics, and the environment of the Gulf of Nicoya. Understanding this scenario will provide a pattern for interpreting similar complex interactions in other artisanal fisheries. The particular activities to be carried out are:

i) Specification of guidelines for data management.

ii) Continuation of the central objective of any stock assessment: estimating the impact of harvesting by the study of the rate of fishing mortality in terms of gear selectivity and effort.

iii) Continuation of the development of optimal sampling designs for stock assessment, including those that make use of the existing data, perhaps as a Bayesian-prior, as a guide for subsequent sampling without significant loss of efficiency.

Items ii) and iii) follow directly from the work conducted in years four and five. However, item i) is new and reflects the expectation of a greatly enlarged data set and our view of both the concomitant data management problems (item i) and opportunities (item iii).

Point i) is elaborated below.

Data Management in an Artisanal Fishery

Data management is an atheoretic but essential practical function in natural resource management units, including those supporting artisanal fisheries. It is critical path, sometimes even a bottleneck, in the orderly flow of information from the field, to the analysts, and thence to the decision-makers. In years six through eight we would like to undertake a formal systems analysis of data management roles and activities for an artisanal fishery. Our experiences during the first five years of the project with the Gulf of Nicoya data sets will add a realistic flavor to this analysis.

The systems analysis would entail identification and specification of various data management system attributes, including purposes and goals, constraints imposed by the environment, resources available, and employed, input and output characteristics, and the system's components and their

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interrelationships. Identification of the roles of the various kinds of system users will all be undertaken.

The multiple scientific, bureaucratic, and political cultures that may comprise management in an artisanal fishery create diverse data requirements. There is frequently a distinction between data that is convenient to collect and data that is required for bioeconomic models used for management decision making. Particular sensitivity must be developed to the financial realities of management units supporting artisanal fisheries in developing nations. The resources for the collection and processing of fisheries data may be quite limited. For example in the Gulf of Nicoya fishery, the management group is technically sophisticated but has finite limits on the human and computational resources available to address the diverse issues presented to it. Although a commercial fish ticket program is in place for monitoring the artisanal catch, there is not sufficient data entry capacity to keep up with data flow. In an earlier component of this project we demonstrated the utility of subsampling these catch slips to minimize the data flow while maximizing the precision of the resulting statistical estimates. In years six through eight we plan to undertake a feasibility analysis of using machine readable source media, for example the development of punch card catch slips distributed by the management agency to the fish buyers for support of their primary commercial transaction. Another possibility would be the development of software to optically scan the hand-written catch slips and decode the information automatically. Such systems, while complex, have proven functional in environments with a restricted transaction language, as in inter-bank technical communication among financial institutions.

The output characteristics of the data management function are also important. An emerging requirement of data management systems is that they must have input and output channels to articulate with other information technologies such as expert systems and decision support platforms, and interface with statistics packages without the need to transform the representation of the data structures.

The resource limitations and geographical isolation of the managers of many artisanal fisheries in developing countries sustains interest in microcomputer implementation of data management tools. Microcomputer environments induce both constraints and opportunities for data managers, as hardware and software functionality rapidly increases. A number of excellent microcomputer database systems are currently available, however none are completely appropriate for the mixture of data types and retrieval requests that naturally develop in a fisheries research and management unit.

The future of data management support for administrators of artisanal fisheries will undoubtedly see increasing functionality in computer hardware and software and the development of an extendable world-wide specialist network for communication of data, programs, electronic mail, and expertise relevant to artisanal settings. The proposed systems analysis of the data management functions supporting artisanal fisheries would be a pragmatic step toward the realization of such a future not only for Costa Rica but world-wide.

e)   Management Strategies for Artisanal Fisheries.

During years six through eight, the above sketch for stock assessment would begin to feed into a preliminary strategic framework for managing an artisanal fishery. It is not clear at this time what tactical combination of regulations would be most efficient in dealing with possible exploitation. Possibilities for effort regulation range from mesh size control to limited entry and include quota and closed season constraints. The framework would be used to provide fishery management advice for the Gulf of Nicoya but, in fact, the objective is to keep the concepts general and widely applicable to other artisanal fisheries of similar circumstances.

After progress has been made in the definition of management strategies, a workshop is proposed to be held at a suitable time and location (e.g, an AFS symposium or at one of the participating locations) to review and debate fisheries management frameworks ir developing countries. The best guess is that year eight would be an appropriate year. This workshop would supplement the year four workshop in Toronto at the 1988 AFS symposium.

The management advice sketched above is a realistic objective but the degree to which it is accomplished will depend upon the degree to which biological problems concerning recruitment and biomass productivity can be resolved and the degree to which progress is made in the specification of biological reference or critical points that allow the setting of levels of exploitation. Further, some of the research plan outlined for this component requires integration of effort with the Recruitment and Productivity component, as well as with UMCEES/UCR efforts.

Finally, UW has incorporated effort in the Philippines to field test methodology developed in Costa Rica. If possible, testing would include hydroacoustic techniques, the CASA model and sampling designs. The prospects of needing to redesign or to adjust methodology is expected and part of the planning.

2) Work Plans for Years Six Through Eight

a) Application of CASA, and length-structured matrix models in the Gulf of Nicoya.

b) Continue the development of biological reference points incorporating the results from stock assessment modeling to monitor fishing pressure on the exploited species in the Gulf of Nicoya.

c) Continue the compilation of catch slip data and sampling for biological data. Publish the data and results in CRSP technical reports.

d) Begin analysis of cost-benefit risk analysis.

e) Hold CRSP workshop to review and debate fisheries management frameworks in developing countries. The workshop could be at an AFS Conference in year eight (1992) or at one of the participating universities.

f) Test and extend results in the Philippines.

g) Revise the handbook/manual.

b. The Recruitment and Productivity Project

1) Objectives

This project is divided into five subunits numbers a) to e) and described below.

a) Growth and Ageing

It is anticipated that the new age determination center in the UCR will carry out the length and age sampling, age determination for the species of interest, and update of the data base for common uses in the CRSP. The existing data base would include an age-length key and enable the estimation of age composition and growth rate for corvina over their lifetimes. This component will extend the investigation of otolith microgrowth increment width. The present investigation of growth rates has already demonstrated that two of the corvinas experience extremely rapid growth which appears to show correlation with the environment. Density or environment-dependent growth and survival of larval-juvenile stages of fish are frequently considered the primary determinants of year class strength.

b)   FERET (Fecundity and Recruitment Timing)

The data of the first five years will be the basis for research on the mechanisms and representations of recruitment in the management of tropical fish. The data base we plan to develop would include sex ratio, maturity proportion, gonad index, fecundity, and recruitment timing. Of great practical concern is the prospect of recruitment overfishing from uninformed changes in the legal gear and effort; for example, in response to competing pressures such as those stemming from a shrimp fishery. Until more is known about reproductive effort vs. age or size, there is a real danger to the corvina fishery in the Gulf of Nicoya, and by analogy, to other artisanal fisheries with similar circumstances. The intent here is to link the research started in years four and five on biological reference points and concerns over both recruitment and growth overfishing, to the computation of a conservative harvesting strategy and to an understanding of the processes behind recruitment.

c)   Species Interactions and Productivity in the Benthos

This work is directed at the determination of whether various properties of related macrobenthos species are useful indicators of events in the corvina species. For example, there is a hint that certain species reproductive patterns are highly correlated with corvina reproduction. This is a limited scope component.

d)   Assemblage Information from Multispecies Associations

Information-theoretic measures have successfully revealed structure in apparently unstructured data by the specification of a definition of organization against a stochastic background. The methods are a diverse combination of probabilistic guidelines that are not limited to one area of application but currently find use in areas ranging from communications to the statistical mechanics of gases. The results are often the derivation of particular rules such as Nyquist frequency or the development phenomenological laws such as that of Boltzman or useful devices such as the Demon of Maxwell.

Initial work during the first five year period indicates that the areas of application can be expanded to include ecological multispecies studies. As in the known applications, it is necessary to bring to the problem a working sense of the structure of a complex system, something that seems to be coming from on-going exploratory studies of the multiple species co-occurring in the Gulf of Nicoya and the subset co-occurring in mixed species catches.

Co-occurrence of different species in the catch of artisanal vessels means something in terms of ecosystem relations, fish behavior, fisherman strategies and in the bio-oceanographic context. The information derivable from multispecies catch reports in an operating fishery, while not as pristine as that obtained in formally defined research sampling experiments, has the advantages of availability and topicality for the local fishery participants.

The objective of this research is to focus on how the presence of multiple species affects sampling and other types of analyses.

e)   Hydroacoustics

Hydroacoustics has been de-emphasized; however, there are several reasons why it is premature to delete its presence altogether. These include:

i)   Significant new work in a dissertation being completed in the project that will allow extension of the methods to estimate fish abundance in shallow water environments.

ii)   The possible availability of improved equipment for The University of Costa Rica from sources outside USAID.

iii) The identification of expertise of The University of Washington and an appropriate investigator-trainee at CIMAR to continue applications.

iv)   The fact that hydroacoustic data is a natural source of supplemental or auxiliary data to CASA making the model even faster and more accurate.

v)   The prospect that The University of Costa Rica and CIMAR could become a Central American regional center for the estimation of abundance and for ecological studies using hydroacoustic methods.

2)   Work Plans for Years Six Through Eight

1) Continue the development of the age determination center at CIMAR, continue age-reader training via workshops, staff exchange, and updating the data base for age and growth.

2) Continue otolith microgrowth increment analysis.

3) Update the data base for FERET, ageing, and growth.

4) Begin development of the methodology and software to compute productivity and turn-over rates.

5) Test and extend results in the Philippines.

6) Update the handbook/manual.

C.   The University of Rhode Island and The University of the Philippines Program

The following presents a description of The University of Rhode Island (URI) and The University of the Philippines (UP) research program, an overview of the modifications in the work plans required by the reduced budget, and the amended work plans for the continuation during years six through eight. These work plans represent a revision of those included in Chapter V of the Continuation Proposal submitted in May, 1989.

1.   Program Description

The University of Rhode Island (URI) in collaboration with The University of the Philippines (UP) is carrying out two CRSP research projects, noted as follows:

1. Empirical Analyses and Modeling, and
2. Multispecies Field Studies.

The principal host country institution collaborating on the Empirical Analyses and Modeling Project is The University of the Philippines in the Visayas, College of Fisheries (UPVCF), and the principal host country institution collaborating on the Multispecies Field Studies Project is The University of the Philippines (Diliman), Marine Science Institute (UPMSI). Additional collaboration is being provided by the International Center for Living Aquatic Resources Management (ICLARM) which is based in the Philippines. The work is being coordinated with fisheries stock assessment activities undertaken by the Bureau of Fisheries and Aquatic Resources (BFAR) and the USAID/ASEAN Coastal Resources Management Program (CRMP), and institutions in Thailand and Indonesia are sharing in the exchange of fisheries data bases and research developments.

The two projects will integrate modeling and field studies to address tropical fisheries stock assessment issues. The two projects, respectively, will 1) use existing fisheries data to develop mathematical models addressing the relationship among harvests, fishing effort, and species composition, and 2) develop and validate techniques for estimating fishery productivity and potential in reef and shore-line fisheries based on field studies.

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2. Overview of Work Plan Modifications

Many analytical approaches being developed for application to the field data require a time series of several years to properly account for interannual variability, the generation times of the fish, and the feedback response times of the fishermen. It is, therefore, important that the field monitoring continue as long as possible, albeit at a reduced level. In spite of reduced activity the large size and complexity of the database will require that intensive effort be devoted to analyses in the final year. Additionally, results of analyses should be available in time for proper dissemination through such activities as training programs and published papers. Therefore, the field monitoring activity will continue at a minimal level until the end of year seven, at which point it will be terminated with a view to continuation by the host country. Year eight will be reserved exclusively for final analyses, publication, training, and conferences.

The field work in the Philippines led to a number of important hypotheses about the ecology of the fishery resources which warrant testing. A number of supportive experiments and studies were planned for this purpose, and were included in a preliminary version of the Continuation Proposal. Several of these proposed studies were omitted from the Continuation Proposal as submitted in May 1989 in order to accomodate to an inflation adjusted budget. Further limitations in specific field objectives have been made for years six, seven, and eight which reflect the anticipated level-funding and the need to terminate fieldwork in year seven. The omitted studies would have added greatly to our ability to interpret results of the monitoring program, but the primary goal of quantitatively analyzing the dynamics of the heavily exploited fish community is expected to be achieved.

Studies which have been omitted from the current proposal include:

- Analyses of food web structure
- Comparative gear studies to standardize effort
- Reproduction and recruitment studies
- Analysis of fish migrations
- Studies of soft-bottom and estuarine fisheries adjacent coral reefs

The training activities in the Philippines will continue to focus heavily on the hands-on, day-to-day training of staff of The University of the Philippines involved with the project and associated projects for which the CRSP serves in an advisory role. Training in prior years has been particularly extensive, in that we have supplemented this long-term training with two international workshops and three graduate level courses on

relevant material. To date, more than sixty researchers from the Philippines and other developing countries have been trained by the URI/UP component. We will round off this training effort with a major workshop/conference in Manila tentatively planned for the Spring of 1993, at which time the final results of the program will be disseminated to representatives from target agencies in developing countries.

3. Amended Objectives and Work Plans

a. The Empirical Analyses and Modeling Project

1) Objectives

The ultimate goal of the empirical modeling study is the development of rational management tactics and strategies for tropical multispecies fisheries. In this context, rational management refers to exploitation at an optimal or specific level with a minimum negative impact to the ecosystem.

Our work to date has clearly indicated that the tropical multispecies fisheries we have examined are very complex and only limited historical data are available. Analysis of such fisheries must contend with high species diversity, considerable environmental variability, many interacting components, and very poorly known structures or functions. In addition, management should include complex socioeconomic factors. However, we have already developed an empirical management model which has some tactical as well as strategic components. That is, the model has utility for both short-term and long-range projections. It is based on aggregated time series of research vessel survey data, which are reduced to a transition probability matrix and analyzed. This work remains to be expanded and further tested with other data.

Our work to date is also providing guidance on approaches we should not pursue. For example, we are now convinced that extensions of deterministic models, such as those developed by Anderson and Ursin (1977), are unrealistic for our application. On the other hand, there is some reason to believe that extensions of the so-called stock production model may have utility for some applications. We believe that the approach we have developed (based on probabilistic models) is appropriate for continuation.

In order for our understanding of tropical multispecies fisheries to advance from a natural history and descriptive approach to a point where some control is feasible, we must include certain vital elements or concepts in our model formulations. The following concepts are considered to be important for incorporation into future research related to controlling multispecies systems: 1) Uncertainty, 2) Complexity

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and interaction, 3) Dynamic system optimization, and 4) Limited data and management information. Each of the above will be given some attention in our future work.

The project has the following two basic objectives: 1) to develop tactical (short-term) models and methodologies, 2) to develop strategic (long-term) models and methods, and 3) to increase host country institutional capabilities.

The proposed extension of work related to tactical models will address specific problems concerning how to test for significant differences between multispecies fish assemblages over space and time. Our approaches will include fitting certain known distributions to data, and testing for the goodness-of-fit. They will also involve Monte Carlo simulation of assemblages to establish empirically derived probability distributions which will be compared to the expected overlap of paired multispecies samples.

The proposed extension of strategic models will become oriented toward finite state, finite action, infinite discrete time horizon Markov decision processes. It is believed that these form a class of optimal control processes sufficiently broad to be generally applicable to multispecies fisheries. The focus will be on infinite time processes because it is believed they fit into the framework of marine fisheries management, wherein protection against long-term degradation of the system is a necessary component. It should be pointed out that the above-mentioned Markov decision processes do take into account the major elements mentoned previously, namely uncertainity, complexity, and dynamic solutions, and they can be utilized with limited information.

2)   Work Plans for Year Six

a)   Statistical Modeling

   i)   Start work on analysis of the distribution
        over time and space of the various fish
        species of the Philippines. Consider non-linear
        mapping and/or clustering of the various fish
        species of the Philippines using techniques which are
        independent of sample size.

   ii) Use results of a) in the discrete-time MARKOV
        chain model and compare results with previously
        derived results.

   iii) Start work on developing continuous-time MARKOV
        models relevant for tropical fisheries management.

iv) Collaboration/consultation with URI scientists on the development of the models.

v) Start work on a revised manual which includes the use of MARKOV models and other new models for fisheries stock assessment.

b) Empirical Studies - Philippines

i) Continue to compile and anlyze existing fishery data from various agencies in the Philippines. Continue fishery data from various agencies in the Philippines. Continue the training of personnel from these agencies.

ii) Continue length-frequency, catch-effort, and community structure studies of existing Philippine data sets.

iii) Continue study on multispecies population analysis using existing Philippine data sets.

iv) Comparative analysis of hard and soft-bottom fish communities.

v) Continue quantification of natural mortality (M) estimation for exploited and less exploited fish species using available techniques and collected data.

vi) Review exploitation and management of Philippine marine fisheries.

c) Comparative Studies, Methods, Training

i) Begin catch composition and community structure analyses of other Southeast Asian fisheries data sets.

ii) Update microcomputer package for ecological statistics to include probabilistic approaches to data structure analysis.

3) **Work Plans for Year Seven**

a) Statistical Modeling

i) Continue work on space and time distribution of Philippine fish species.

ii) Continue work cn continuous-time Markov decision models.

iii) Continue work on the manual and the use of Markov models on fisheries stock assessment incorporating new results and findings.

b) Empirical Studies - Philippines

i) Continue to compile and analyze fishery data from various agencies in the Philippines.

ii) Continue length-frequency, catch-effort, and community structure studies of existing Philippine data sets.

iii) Continue quantification of natural mortality (M).

c) Comparative Studies, Methods, Training

i) Continue comparative analyses of multispecies fishery data sets from Southeast Asia and Tropical Australia.

ii) Revise and update microcomputer package for ecological statistics as necessary.

iii) Continue regional training programs on specialty fishery management approaches.

4) **Work Plans for Year Eight**

a) Statistical Modeling

i) Start investigating relationships between space and/or time distribution of the various Philippine fish species and environmental factors.

ii) Apply developed continuous-time Markov decision models and other methods to Philippine data sets.

iii) Finish with the manual on the use of Markov models in fisheries stock assessment.

b) Empirical Studies - Philippines

i) Complete compilation and analysis of existing fishery data from various agencies in the Philippines.

ii) Summarize length/frequency, catch effort, and community structure studies of existing Philippine data sets.

iii) Production of manuscripts on the following: 1) Philippine capture fisheries, 2) Compilation of stock assessment methods developed within the Empirical and Multispecies Field Projects, and 3) Compilation of computer programs.

iv) Finalize studies on recruitment patterns.

c) Comparative Studies, Methods, Training

i) Publish final version of TACO (Table Analysis by Classification and Ordination) for microcomputers.

ii) Prepare chapters for CRSP major handbook on fisheries methodologies.

iii) Conduct training programs in Southeast Asia and elsewhere.

b. The Multispecies Field Studies Project

1) Objectives

The overall goals and objectives of this project are the following: 1) To determine the effects of applying various levels and types of fishing effort on the catch composition and harvestable production of Southeast Asian coral reefs and associated shallow-water ecosystems. 2) To determine to what extent the potential catch composition and fishery production of a coastline can be predicted from habitat information obtained from satellite imagery, aerial photographs from low-cost aircraft, chart information, bathymetry, and environmental parameters obtained from site sampling. Morphocedaphic indices will be developed from the above, if appropriate. 3) To use the field data and conclusions drawn from it as the basis for microcomputer programs to facilitate analyses of coral reef fisheries from the aspects of classification, ordination, and stochastic modeling. 4) To disseminate this information to countries involved in multispecies fisheries management, including the United States and developing countries; and 4) To develop within the host country collaborating institutions the capability to continue independently to investigate and to refine the assessment and management approaches which are developed within the CRSP. This includes augmenting the faculty of the Marine Science Institute and supporting selected CRSP researchers each year for advanced degree training in this institute. The field data will be used as a basis for classification, ordination, and stochastic approaches to fisheries modeling and

analysis. The development of microcomputer programs are also a primary component of the field project.

2. Work Plans for Year Six

a) Evauluate long-term monitoring tasks to determine which facets should be reduced or otherwise modified to provide the data most critically needed for various management schemes, including the expert systems and bioeconomic models under development by other project components in the U.S. and Costa Rica. Recognizing that work on both expert systems and bioeconomic models are to be terminated at the end of year five, those to be incorporated will be those current at the time.

3) Work Plans for Year Seven

a) Present results of all coral reefs studies in the Seventh International Coral Reef Symposium. This periodic series of congresses is the largest international gathering of coral reef scientist, providing a focal point for the release of research results in many of the major integrated reef studies of the world. It is, therefore, the most appropriate forum for the culmination of our long-term studies. The Seventh ICRS is tentatively scheduled for sometime in mid-1992, and will probably be held in the Caribbean, the Red Sea, or Okinawa.

b) Complete monitoring tasks initiated during year six.

4) Work Plans for Year Eight

a) Summarize and finalize all results. Assimilate data into data reports and user-friendly data-base systems. Collaborate with other CRSP entities to permit the incorporation of the final results and data into management models. Prepare final publications.

b) Present results in regional workshops to be held at the Philippines and in Costa Rica.

c) Integrate all results into the end-product manual format, and assist in manual preparation.

d) Planning and organization of regional workshop/conference tentatively scheduled for Manila during the Spring of 1993.

D. The Management Entity and Program Coordination Activity

Under the revised budget projections of $704,000 per year for years six through eight for the CRSP, the Management Entity continues to retain 17 percent of the AID funding, as in the initial grant period and in the original $845,000 per year budget submitted in the Continuation Proposal, May 1989. Until now, the

Technical Committee has been meeting about two times a year and the Board has been meeting about once a year. The constrained budget during the continuation period will limit the ability to hold formal meetings of the Technical Committee and Board, but innovative use of conference calls and electronic communications should enable the technical and administrative interactions to be maintained at an appropriate level.

In response to the recommendations of the review committee on June 15, 1989, the CRSP has set aside $80,000 for the preparation and dissemination of the final CRSP product, the CRSP Stock Assessment Manual, and for conducting two regional training workshops, one to be held in the Philippines and one in Costa Rica, during the final year of the program (1993). These workshops will be explicitly oriented to transferring the CRSP-developed methodologies and techniques to developing country users.

The initial version of the CRSP Stock Assessment Manual, described in detail in Chapter VI of the Continuation Proposal, will be completed by the end of the initial five years of the grant. This manual will be a single, unified, integrated manual which will consist of several volumes, often with associated microcomputer software and documentation, which will describe and explain specific models, methods, approaches, and limitations to Tropical Fisheries Stock Assessment and Management, with emphasis on multispecies capture fisheries. This initial version of the CRSP Stock Assessment Manual will be an impressive set of documents and software which will serve as the CRSP's key marketing showpiece for seeking additional (non-AID) financial support for testing, validating, extending, and transferring CRSP-development methodologies and techniques during the continuation period. Complementing the ongoing training workshops and extension activities of the CRSP, the immediate useability and transferability of initial version of the CRSP Stock Assessment Manual should stimulate potential support from non-AID sources. The Management Entity plans to produce an updated CRSP brochure to be widely disseminated, along with the introductory overview volume of the CRSP Stock Assessment Manual to AID Missions, developing country fisheries agencies, and potential private and public sector donors. A concerted effort by all of the participating CRSP institutions will be made to seek additional funding suport via buy-ins.

In order to facilitate increased program coordination activities the CRSP has already planned a CRSP-wide workshop to be held in January, 1990, in Costa Rica. Every effort will be made to continue training workshops in Costa Rica and in the Philippines, and, despite the reduction in funding, the CRSP expects to hold annual CRSP-wide technical coordination meetings. Further, in order to facilitate continued program coordination and scientist interaction, the proportion of the programmatic

budgets devoted to researcher travel has been increased by approximately 50 percent over that during the initial five year period of the grant.

While $25,000 has been set aside for conducting each of two regional workshops during year eight to promote the transfer of the CRSP-developed methodologies and techniques for multispecies tropical stock assessment, the Management Entity and the participating CRSP institutions fully expect to seek and to obtain additional private and public sector support for enlarging and extending these regional workshops to train as many developing fisheries managers and scientists as possible in using the CRSP products.

III. Amended Budget

Initially planned as a $5 million, 5 year program, the CRSP experienced several budget cuts during the first two years of operation (July 1, 1985-June 30, 1987), and is operating on AID funds of $704,000 per year during the final three years of the grant (July 1, 1987-June 30, 1990). The original Continuation Proposal submitted work plans commensurate with a budget of $845,000 per year, a 20 percent increase over the $704,000 per year budget, to continue the research effort at roughly a constant level in the face of continued inflation. However, the CRSP was advised during the review in June, 1989, that AID funding would be limited to the $704,000 per year level. Accordingly, the CRSP has amended its work plans and budget allocations to $704,000 per year.

The guidelines used in developing the budget allocations for the reduced funding level were as follows. The Management Entity, which supports a half-time Program Director and a half-time secretary and which covers the expenses of the Board, the Technical Committee, and the External Evaluation Panel, is maintained at 17 percent of AID funds, the same percentage as in the initial five year grant. In addition, $80,000 was set aside in year eight to prepare the final CRSP Stock Assessment Manual and to conduct end-of-project regional training workshops in the Philippines and in Costa Rica. The balance of AID funds was then divided among the principal collaborative groupings (UMCEES/UCR, UW/UCR, and URI/UP) in proportion to earlier allocations and consistent with the work being carried out at each research site. Host country institutions were targeted for at least 19 percent of programmatic funds, and travel budgets were targeted at approximately six percent of programmatic funds, roughly an increase by 50 percent over the proportion devoted to travel during the initial five years in order to facilitate greater scientific interaction.

As finally determined, AID funds devoted to programmatic ends (i.e., excluding the Management Entity and end-of-project expenses) comes to 79.2 percent of the total. Total host country expenses amount to $341,000 over the three years, or 20.4 percent of programmatic expenses, not including the costs of maintaining a University of Rhode Island scientist in the Philippines full time during years six and seven and half time during year eight. The travel budget as a proportion of programmatic expenses comes to 6.9 percent.

The total budget request from AID for the three year
extension, based on $704,000 per year, comes to $2,112,000.
Contractually matchable funds over the three years, excluding the
Management Entity and host country subcontracts, comes to
$1,406,300. The required U.S. university match of 25 percent of
matchable funds comes to $351,575, but the actually budgeted U.S.
university matching funds amount to $380,100, or approximately 27
percent of the contractually matchable funds.

The commitment of the participating institutions to the CRSP
research agenda is evidenced by the fact that U.S. university
matching amounted to about 40 percent of matchable AID funds
during the first three years of the CRSP, and are continuing to
exceed the required match. Furthermore, the host country
institutions have been contributing facilities, supplies and
equipment, and personnel valued at more then six percent of total
programmatic funds. Together, U.S. and host country institutions
have been contributing approximately 50 percent of the
contractually matchable funds supplied by AID, about double the
contractually required match. This measure of the institutional
commitment to the CRSP dramatically understates the actual
matching contributions, both because the host country matching
contributions would be substantially larger if they were valued
at U.S. prices and because many scientists and researchers,
including the External Evaluation Panel members who serve without
compensation, are contributing to the research effort because of
the exciting and important work being done rather than because
they are compensated for their efforts.

Several efforts are underway to seek additional buy-ins to
the CRSP research programs. The CRSP Stock Assessment Manual,
the first version of which will be available at the end of the
fifth year of the program, will serve as a major marketing tool
for seeking additional funding during the continuation period for
testing, validating, and extending the CRSP findings in other
fisheries around the world. Furthermore, while $25,000 has been
set aside for each of two end-of-project regional training
workshops in Costa Rica and in the Philippines to extend CRSP-
developed techniques and methodologies to developing country
professionals, efforts will be made to seek additional funding
support to extend the final CRSP products in expanded workshops.

As described in the earlier sections of this Continuation
Proposal Amendment, the level-funded budget of $704,000 is a
serious constraint on the CRSP research program. In the
development of the continuation period work plans, however, a
concerted effort was made to concentrate the work on the most
essential core of the CRSP research agenda, leaving many fruitful
areas of research for the future. It is strongly believed that,
despite the budget limitations, the Fisheries Stock Assessment
CRSP, in spending approximately $5.8 million in AID funds over
the eight year period, will make a substantial contribution to

developing the much needed methodologies and techniques for assessing the stocks and managing the world's small-scale multispecies tropical fisheries in addition to making significant developments in the global understanding of fisheries management in general.

Table 1 presents the detailed budgets, based on an AID funding of $704,000 per year, for the three year continuation period. Table 1 shows the detailed budgets in the context of earlier years' spending patterns and the overall AID and U.S. university matching funding for the eight years of the CRSP. Table 1 is a revised and amended version of the budget submitted as Table 13 in the original Continuation Proposal, May, 1989.

Table 1. Institutional and Project Budgets By Line Item, Years 1 - 8 (7/1/85 - 6/30/93)
($ 000)

	Estimated Expenditures Yrs. 1-3	Yr. 4	Yr. 5	Total Exp. Yrs. 1-5	Yr. 6	Yr. 7	Yrs. 8	Total Exp. Yrs. 6-8	Total Exp. Yrs. 1-8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Programmatic Expenses

UMCEES/UCR
Multiple Species Fisheries Research

Personnel	132.6	37.8	42.8	213.2	35.5	35.5	31.5	102.5	315.7
S&E	4.2	1.8	1.7	7.7	2.3	2.3	1.1	5.7	13.4
Travel	11.8	3.1	3.1	18.0	5.7	5.7	5.0	16.4	34.4
Equipment	.8	0.0	0.0	.8	0.0	0.0	0.0	0.0	.8
U.S. Subcontracts, MI.	91.3	15.2	0.0	106.5	0.0	0.0	0.0	0.0	106.5
HC Subcontracts, UCR	52.3	15.6	13.9	81.8	18.0	18.0	15.7	51.7	133.5
Indirect Costs	58.2	16.4	18.6	93.2	29.0	29.0	24.9	82.9	176.1
Total Costs	351.2	89.9	80.1	521.2	90.5	90.5	78.2	259.2	780.4
*Budgeted Match	99.1	17.5	19.1	135.7	20.1	20.1	17.3	57.5	193.2

UMCEES/UCR
Economic & Probabilistic Extensions
of Standard Fisheries Models

Personnel	78.2	26.2	28.9	133.3	25.7	25.7	23.0	74.4	207.7
S&E	3.1	.6	.4	4.1	1.6	1.6	.5	3.7	7.8
Travel	12.0	3.1	3.1	18.2	5.7	5.7	4.9	16.3	34.5
Equipment	7.3	0.0	0.0	7.3	0.0	0.0	0.0	0.0	7.3
U.S. Subcontracts, DE.	27.9	8.3	0.0	36.2	0.0	0.0	0.0	0.0	36.2
HC Subcontracts, UCR	52.3	15.6	13.9	81.8	18.1	18.1	15.6	51.8	133.6
Indirect Costs	37.7	11.6	13.7	62.0	22.0	22.0	19.0	63.0	125.0
Total Costs	218.5	65.4	59.0	342.9	73.1	73.1	63.0	209.2	552.1
*Budgeted Match	51.2	13.3	12.8	77.3	15.2	15.2	13.1	43.5	120.8

UMCEES/UCR TOTAL

U.S. University	465.1	124.1	111.3	700.5	127.5	127.5	109.9	364.9	1065.4
Host Country	104.6	31.2	27.8	163.6	36.1	36.1	31.3	103.5	267.1
Total UMCEES/UCR	569.7	155.3	139.1	864.1	163.6	163.6	141.2	468.4	1332.5
*Total Budgeted Match	150.3	30.8	31.9	213.0	35.3	35.3	30.4	101.0	314.0

Table 1. Institutional and Project Budgets By Line Item, Years 1 - 8 (7/1/85 - 6/30/93)
($ 000)

	Estimated Expenditures Yrs. 1-3	Yr. 4	Yr. 5	Total Exp. Yrs. 1-5	Yr. 6	Yr. 7	Yrs. 8	Total Exp. Yrs. 6-8	Total Exp. Yrs. 1-8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Programmatic Expenses

UW/UCR
Sampling Catch

Personnel	103.1	42.5	45.3	190.9					190.9
S&E	19.8	5.8	10.4	36.0					36.0
Travel	4.7	2.1	1.0	7.8					7.8
Equipment	6.9	0.0	0.0	6.9					6.9
U.S. Subcontracts, DE.	52.2	8.8	0.0	61.0					61.0
HC Subcontracts, UCR	37.3	14.2	16.9	68.4					68.4
Indirect Costs	42.0	15.7	15.7	73.4					73.4
Total Costs	266.0	89.1	89.3	444.4					444.4
*Budgeted Match	71.7	24.5	27.8	124.0					124.0

UW/UCR
Age/Size Modeling

Personnel	97.0	31.0	31.2	159.2					159.2
S&E	11.8	4.2	3.1	19.1					19.1
Travel	8.8	1.0	1.0	10.8					10.8
Equipment	4.9	0.0	0.0	4.9					4.9
U.S. Subcontracts	0.0	0.0	0.0	0.0					0.0
HC Subcontracts, UCR	22.6	6.6	8.5	37.7					37.7
Indirect Costs	48.0	11.9	12.0	71.9					71.9
Total Costs	193.1	54.7	55.8	303.6					303.6
*Budgeted Match	50.5	12.0	11.8	74.3					74.3

UW/UCR
Age Determination

Personnel	55.2	11.6	11.6	78.4					78.4
S&E	5.1	2.4	2.7	10.2					10.2
Travel	5.8	1.0	1.0	7.8					7.8
Equipment	4.3	0.0	0.0	4.3					4.3
U.S. Subcontracts	0.0	0.0	0.0	0.0					0.0
HC Subcontracts, UCR	14.0	3.5	4.6	22.1					22.1
Indirect Costs	27.6	6.3	6.5	40.4					40.4
Total Costs	112.0	24.8	26.4	163.2					163.2
*Budgeted Match	12.9	5.3	5.5	23.7					23.7

Table 1. Institutional and Project Budgets By Line Item, Years 1 - 8 (7/1/85 - 6/30/93)
($ 000)

	Estimated Expenditures Yrs. 1-3	Yr. 4	Yr. 5	Total Exp. Yrs. 1-5	Yr. 6	Yr. 7	Yrs. 8	Total Exp. Yrs. 6-8	Total Exp. Yrs. 1-8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Programmatic Expenses									
UW/UCR									
Hydroacoustics									
Personnel	59.3	20.0	19.6	98.9					98.9
S&E	11.4	3.4	3.6	18.4					18.4
Travel	7.7	1.0	1.0	9.7					9.7
Equipment	0.0	0.0	0.0	0.0					0.0
U.S. Subcontracts	0.0	0.0	0.0	0.0					0.0
HC Subcontracts, UCR	17.8	5.2	6.9	29.9					29.9
Indirect Costs	27.8	8.2	8.5	44.5					44.5
Total Costs	124.0	37.8	39.6	201.4					201.4
*Budgeted Match	19.4	8.2	8.2	35.8					35.8
UW/UCR									
Assessment Sampling & Modeling									
Personnel					49.0	49.0	43.6	141.6	141.6
S&E					2.0	2.0	3.8	7.8	7.8
Travel					4.0	4.0	2.0	10.0	10.0
Equipment					0.0	0.0	0.0	0.0	0.0
U.S. Subcontracts					0.0	0.0	0.0	0.0	0.0
HC Subcontracts, UCR					12.0	12.0	9.4	33.4	33.4
Other HC Expenses					14.0	14.0	13.9	41.9	41.9
Indirect Costs					30.8	30.8	28.2	89.8	89.8
Total Costs					111.8	111.8	100.9	324.5	324.5
*Budgeted Match					23.2	24.6	24.7	72.5	72.5
UW/UCR									
Recruitment & Productivity									
Personnel					50.0	50.0	40.5	140.5	140.5
S&E					2.1	2.2	3.3	7.6	7.6
Travel					4.4	4.4	2.1	10.9	10.9
Equipment					0.0	0.0	0.0	0.0	0.0
U.S. Subcontracts					0.0	0.0	0.0	0.0	0.0
HC Subcontracts, UCR					16.0	16.0	13.7	45.7	45.7
Indirect Costs					26.0	26.0	21.1	73.1	73.1
Total Costs					98.5	98.6	80.7	277.8	277.8
*Budgeted Match					19.5	20.7	20.7	60.9	60.9
UW/UCR TOTAL									
U.S. University	603.4	176.9	174.2	954.5	168.3	168.4	144.6	481.3	1435.8
Host Country	91.7	29.5	36.9	158.1	42.0	42.0	37.0	121.0	279.1
Total UW/UCR	695.1	206.4	211.1	1112.6	210.3	210.4	181.6	602.3	1714.9
*Total Budgeted Match	154.5	50.0	53.3	257.8	42.7	45.3	45.4	133.4	391.2

Table 1. Institutional and Project Budgets By Line Item, Years 1 - 8 (7/1/85 - 6/30/93)

($ 000)

	Estimated Expenditures Yrs. 1-3	Yr. 4	Yr. 5	Total Exp. Yrs. 1-5	Yr. 6	Yr. 7	Yrs. 8	Total Exp. Yrs. 6-8	Total Exp. Yrs. 1-8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Programmatic Expenses

URI/UPVCF
Empirical Analyses and Modeling

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Personnel	83.7	41.9	36.5	162.1	45.8	44.7	62.6	153.1	315.2
S&E (U.S.)	18.9	5.0	5.0	28.9	4.8	4.8	8.3	17.9	46.8
S&E (Host Country)	0.0	0.0	0.0	0.0	9.2	9.2	20.7	39.1	39.1
Travel	26.2	6.5	6.5	39.2	7.6	7.6	21.6	36.8	76.0
Equipment	8.5	0.0	0.0	8.5	0.0	0.0	0.0	0.0	8.5
U.S. Subcontracts	0.0	2.5	2.5	5.0	3.5	3.5	3.5	10.5	15.5
HC Subcontracts	36.9	8.5	8.5	53.9	11.5	11.5	11.5	34.5	88.4
Indirect Costs	48.6	18.2	17.8	84.6	17.1	16.9	32.9	66.9	151.5
Total Costs	222.8	82.6	76.8	382.2	99.5	98.2	161.1	358.8	741.0
*Budgeted Match	41.5	24.1	25.1	90.7	20.1	20.1	40.8	81.0	171.7

URI/UPMSI
Multispecies Field Studies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Personnel	131.4	42.9	46.8	221.1	47.1	48.4	5.1	100.6	321.7
S&E (U.S.)	48.5	5.8	5.8	60.1	7.1	7.1	.9	15.1	75.2
S&E (Host Country)	60.6	34.2	39.3	134.1	13.8	13.8	2.3	29.9	164.0
Travel	44.9	6.5	6.5	57.9	11.4	11.4	2.4	25.2	83.1
Equipment	4.6	0.0	0.0	4.6	0.0	0.0	0.0	0.0	4.6
U.S. Subcontracts	0.0	2.5	2.5	5.0	1.5	1.5	1.5	4.5	9.5
HC Subcontracts	91.1	7.5	7.5	106.1	4.5	4.5	4.5	13.5	119.6
Indirect Costs	91.2	24.5	25.9	141.6	25.5	25.4	3.7	54.6	196.2
Total Costs	472.3	123.9	134.3	730.5	110.9	112.1	20.4	243.4	973.9
*Budgeted Match	103.5	21.5	24.1	149.1	30.1	30.1	4.5	64.7	213.8

URI/UP TOTAL

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
U.S. University	506.5	156.3	155.8	818.6	171.4	171.3	142.5	485.2	1303.8
Host Country	188.6	50.2	55.3	294.1	39.0	39.0	39.0	117.0	411.1
Total URI/UP	695.1	206.5	211.1	1112.7	210.4	210.3	181.5	602.2	1714.9
*Total Budgeted Match	145.0	45.6	49.2	239.8	50.2	50.2	45.3	145.7	385.5

Table 1. Institutional and Project Budgets By Line Item, Years 1 - 8 (7/1/85 - 6/30/93)
($ 000)

	Estimated Expenditures Yrs. 1-3	Yr. 4	Yr. 5	Total Exp. Yrs. 1-5	Yr. 6	Yr. 7	Yrs. 8	Total Exp. Yrs. 6-8	Total Exp. Yrs. 1-8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Programmatic Expenses									
Personnel	740.5	253.9	262.7	1257.1	253.1	253.1	206.3	712.5	1969.6
S&E	103.0	29.0	32.7	184.5	19.9	20.0	17.9	57.8	242.3
Travel	117.2	24.3	23.2	169.4	38.8	38.8	38.0	115.6	285.0
Equipment	30.4	0.0	0.0	37.3	0.0	0.0	0.0	0.0	37.3
U.S. Subcontracts	171.4	37.3	5.0	213.7	5.0	5.0	5.0	15.0	228.7
Host Country Expenses	384.9	110.9	120.0	615.8	117.1	117.1	107.3	341.5	957.3
Indirect Costs	381.1	112.8	117.7	611.6	150.4	150.1	129.8	430.3	1041.9
Total Costs	1959.9	568.2	561.3	3089.4	584.3	584.3	504.3	1672.9	4762.3
*Budgeted Match	449.8	126.4	134.4	710.6	128.2	130.8	121.1	380.1	1090.7
Management Entity Expenses									
Personnel	164.9	49.8	52.1	266.8	59.3	61.7	64.2	185.2	452.0
S&E	44.6	12.0	22.6	79.2	12.0	12.0	12.0	36.0	115.2
Travel	45.5	34.8	26.9	107.2	13.0	10.6	8.1	31.7	138.9
Equipment	3.4	0.0	0.0	3.4	0.0	0.0	0.0	0.0	3.4
End of Project Activities	0.0	0.0	0.0	0.0	0.0	0.0	56.3	56.3	56.3
Indirect Costs	94.4	39.1	41.1	174.6	35.4	35.4	59.1	129.9	304.5
Total Costs	352.8	135.7	142.7	631.2	119.7	119.7	199.7	439.1	1070.3
*Budgeted Match	48.0	16.5	16.5	81.0	16.5	16.5	16.5	49.5	130.5
TOTAL U.S. UNIVERSITY	1575.0	457.3	441.3	2473.6	467.2	467.2	397.0	1331.4	3805.0
TOTAL HOST COUNTRY EXPENSES	384.9	110.9	120.0	615.8	117.1	117.1	107.3	341.5	957.3
TOTAL PROGRAMMATIC EXPENSES	1959.9	568.2	561.3	3089.4	584.3	584.3	504.3	1672.9	4762.3
TOTAL MANAGEMENT ENTITY	352.8	135.7	142.7	631.2	119.7	119.7	199.7	439.1	1070.3
TOTAL AID FUNDING	2312.7	704.0	704.0	3720.6	704.0	704.0	704.0	2112.0	5832.6
TOTAL BUDGETED MATCH	449.8	126.4	134.4	710.6	128.2	130.8	121.1	380.1	1090.7
TOTAL AID + BUDGETED MATCH	2762.5	830.4	838.4	4431.2	832.2	834.8	825.1	2492.1	6923.3

IV. Appendix

Memorandum concerning the Fisheries Stock Assessment CRSP review
on June 15, 1989, to John Rowntree, Program Director, from J. B.
Henson for the Joint CRSP Review Committee of JCARD and of the
Agricultural Sector Subcommittee, dated July 14, 1989.

MEMORANDUM

TO: John Rowntree
           Program Director
           Management Entity
           Fisheries Stock Assessment CRSP

FROM: J.B. Henson for Joint CRSP Review Committee of JCARD and of
           Agricultural Sector Subcommittee

DATE: July 14, 1989

SUBJECT: Fisheries Stock Assessment Tri-Annual Review

The following represent conclusions and suggestions from the Joint Committee concerning the Tri-Annual Review and proposed 3-year extension of the Fisheries Stock Assessment CRSP. We appreciate the participation of you and your colleagues in the discussions and the work that has been carried out to prepare the various documentation and to participate in the review.

Overall Program

The Review Committee was impressed with the overall program. The research appears to be making good progress and is very relevant to fisheries in the developing countries. The U.S. institutions and the researchers are good. As a result, the Committee is very supportive of the CRSP and its activities. We would also like to commend EEP for a thorough and useful assessment of the CRSP.

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In our presentation to BIFAD, we emphasized our support and our assessment of the high quality of the research program. We recommended to the Board, however, that approval not be given for the 3-year extension at the present time. This decision is based upon budgetary constraints and the need for additional information related to the budget and other topics which are given below. Therefore, we wish to indicate a need for additional information and/or action directed to the following specific topics.

Budget

During the discussion, we were informed that the budget level would remain at $704,000 per year. This obviously has impacts on the proposed program of work and the resultant products from CRSP activities.

The Committee recognizes the severe budgetary limitations and the impact upon participation of your universities in the CRSP. We hope that in the future it will be possible to increase the amount of funds based upon overall AID budgets and fund availability. The limitations of the budget indicate the need to attempt to obtain additional funds from other sources, both within and outside of AID. An example are funds available for biodiversity, which might be examined for potential use for CRSP activities. The potential for soliciting funds from the private sector, mission buy-ins, and others were discussed during our meeting. We encourage you to pursue appropriate alternatives to augment the present level of funding. We would encourage you to include in your overall strategic plan marketing endeavors that would serve to make potential funding sources aware of the

CRSP and its potential contributions, and to stimulate potential support from Non-AID/S&T sources.

Strategic Plan and Proposed Workplans

We propose that the CRSP develop a strategic plan. The plan should specifically address coordination of the diverse activities and institutions within the concept of the global nature of the CRSP. We further request that you restructure your plan of work to be consistent with the indicated funding level. We would also wish to know the impact of this funding level on the CRSP products which you propose to have available at the end of the 3-year funding period, at which time it is our understanding that the CRSP will terminate. We wish to receive revised plans of work reflecting the budgetary levels. In this regard, we would like you to relate the budget to proposed activities and anticipated outputs including the projected final products of the CRSP, including the Stock Assessment Handbook, methodologies for stock assessment and their application to tropical fisheries, etc. as defined in the goals, objectives and rationale section of the continuation proposal.

CRSP Life of Project Products and Transfer of Information to Developing Countries

The further definition of the final CRSP products and their potential impact on stock assessment of tropical fisheries of the developing countries is requested. In addition, we propose that the CRSP examine the possibility of orienting CRSP activities in the later years to specifically and explicitly transfer technology and information to developing country users. This could take a number of formats including regional conferences, workshops and training activities, "how-to" sessions related to the use of the manual and

methodologies developed, etc. We feel it important that the CRSP address these issues since the transfer of developed technical information is critical for impact. This should be included in the overall strategic plan for the 3-year extension of the CRSP. In addressing transferability, we continue to recognize the central purpose of the CRSP - i.e. collaborative research.

Coordination

It is difficult to coordinate the activities of independent universities working in different countries on different topics. This was addressed by the EEP and noted as an important need, i.e. improving communication and coordination of activities. In the oral EEP report there was an indication also evidenced in the budget that additional funds are being made available to strengthen communications and coordination activities. In this regard, the Committee would encourage you to continue to emphasize improved coordination and communications.

Allocation of Funds

It appears obvious that the fund availability will require difficult decisions on the allocation and use of the available funds to optimize the potential impact of the CRSP. We briefly discussed this with you and were assured that these decisions will be made. This is a difficult circumstance for all of the CRSPS, but we encourage you to address this important and difficult requirement and so indicate in the workplan.

Host Country Institutional and Personnel Development

This topic has been addressed briefly above and has relevance to the transferability and the appropriateness of CRSP products in terms of utility and potential utilization impact on the developing countries.

We appreciate the budgetary limitations, but feel it appropriate for the CRSP to address the issue of training and institution development more explicitly in the additional information to be provided. How are and will capabilities of potential utilization users be strengthened so that the products of CRSP activities can be applied in the field in the developing countries?

Benefits to U.S.

We suggest you indicate more explicitly benefits to the U.S. from CRSP activities.

Summary of CRSP Accomplishments

The Committee requests that you prepare a 1-2 page summary of CRSP accomplishments and actual and potential utilization impact on developing countries and the U.S. This summary should be able to be used independently for information and PR purposes for the general public and potential utilization supporters of the CRSP.

Next Steps

Following are the proposed next steps.

- The CRSP prepare an amendment to the proposed continuation based upon the above suggestions and our discussions.

- The above be submitted to Dr. Fred Johnson of the BIFAD staff, who will in turn submit it to Committee members. We would propose that this be done at the latest by August 1, if you wish to attempt to have the process completed in time for a recommendation to the BIFAD Board at its August meeting. There is also a Board meeting in September, which would allow some additional time.

- After receiving the information, Committee members will examine it. A conference call be initiated to discuss the submission by the Committee.

- After discussions by the Committee, a conference call will be initiated with participation by appropriate individuals in the CRSP. We propose ME, TC, EEP, and Board member participation.

- If conclusions cannot be reached by the above process, a meeting of the CRSP and the Committee will be convened.

Committee conclusions and potential recommendations be discussed with the CRSP and recommendations made to the Board concerning the 3-year extension.

We will supply any additional information or clarify any aspects of this memorandum with the CRSP. However, I will be out of the country until July 24. If there are questions, it is recommended that you contact Dr. L. Apple, who will assist in clarifying any questions or provide additional information. Dr, Apple's telephone number is (919) 737-3201. My telephone number is (509) 335-2541.

Again, we appreciate your activities and your efforts to provide information to the Committee.

Thank you.

cc: L. Pesson, Executive Director, BIFAD

Committee Members

J. Nichalaides, JCARD Chair

B. Furtick, S&T/Agriculture

Joint JCARD Subcommittee and Agriculture Sector Subcommittee

for Review of the Stock Assessment CRSP

June 15, 1989

List of Attendees

William Fred Johnson — BIFAD staff

B.J. Rothschild — University of Maryland

Tejpal S. Gill — AID/S&T/AGR/NR, 874-4307

Richard Neal — AID/S&T/AGR

Lamarr Trott — AID/S&T/AGR

Saul Saila — University of Rhode Island

Michael Sissenwine — NMFS, NOAA, Woodshole, MA

508-548-5123/EEP Chair

Robert R. Stickney — University of Washington/Board Chair;

206-543-4270

John T. Rowntree — University of Maryland, College Park

301-454-6407/Management Entity

Jim Walker — AA/IRAD/OICD/USDA; 202-653-7965/JCARD

Calvin Martin — AFR/TR; 703-235-0801

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Jim Henson — Washington State University/JCARD

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Chris Jones — ST/AGR/RNR; 703-875-4016