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FISHERIES STOCK ASSESSMENT

Title XII Collaborative Research Support Program

ANNUAL REPORT

1985 - 1986

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**FSA CRSP
Management Office
1109 Symons Hall
The University of Maryland
College Park, MD 20742**

**The Fisheries Stock Assessment CRSP
-- A Search for New Methods**

ANNUAL REPORT, 1985 - 1986

INTRODUCTION

This document presents the Annual Report for the period July 1, 1985 - June 30, 1986, for the Fisheries Stock Assessment Title XII Collaborative Research Support Program (CRSP). Funded by USAID under Grant No. DAN-4146-G-SS-5071-00, the Fisheries Stock Assessment CRSP is a 5-year collaborative research program extending from July 1, 1985 to June 30, 1990. Signed on August 26, 1985, the contract with the University of Maryland-College Park as the Management Entity authorized the beginning date retroactively as July 1, 1985. The Fisheries Stock Assessment CRSP is engaged in a global research program designed to develop new methodologies for stock assessment and management for small scale multiple species tropical fisheries.

Participating Institutions:

The Office of International Programs, College of Agriculture, University of Maryland-College Park serves as the Management Entity for the Fisheries Stock Assessment CRSP. The technical research efforts in eight separate projects, led by the University of Maryland-Center for Environmental and Estuarine Studies, the University of Rhode Island, and the University of Washington, are being conducted collaboratively with the University of Costa Rica and the University of the Philippines. Additional collaboration is being provided by the University of Maryland-College Park-College of Business and Management, the University of Delaware, the University of Miami, and the International Center for Living Aquatic Resources Management.

Goals and Objectives:

The Fisheries Stock Assessment CRSP is developing stock assessment methodologies for use by fisheries managers in developing countries. Specific objectives for the program include the following:

1. Production of a Stock Assessment Handbook for fishery managers in tropical countries -- a manual that will provide a "key" for optimal fishery stock assessment and management given the problem and available resources.
2. Testing of existing methodology for stock assessment as it applies to tropical fisheries.
3. Development of new methodologies for stock assessment in tropical developing countries.
4. Development and testing of multispecies fishery assessment methods.

Program Description:

The Fisheries Stock Assessment CRSP is composed of eight interrelated research projects, listed below in association with the names of the lead U.S. institutions and host countries where field research is being conducted.

The University of Maryland-Center for Environmental and Estuarine

Studies/Costa Rica:

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

The University of Washington/Costa Rica:

1. Sampling Catch and Abundance
2. Age and Size Dependent/Independent Modeling
3. Age and Size Relationships and Consequences of Errors
4. Shallow Water Hydroacoustics

The University of Rhode Island/Philippines:

1. Empirical Analyses and Modeling
2. Multispecies Field Studies

Research on the eight projects at participating institutions is being coordinated toward the achievement of overall project objectives. This coordination at each participating institution is being done by their respective principal investigators, who are providing an integrative role on their projects. Coordination among the projects at the various institutions is being facilitated by regular communication and cooperation. Overall technical guidance and coordination among the projects is being provided by the efforts of the Technical Committee which is composed of the Principal Investigators at the three lead U.S. institutions and the two lead host country institutions.

Structure of this Report:

The annual reports on the objectives and technical accomplishments for each lead U.S. institution and each of the eight projects are presented below. This is followed by a report on the activities of the Management Entity.

ANNUAL REPORT, 1985 - 1986**University of Maryland-CEES/University of Costa Rica Program****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,
2. Economic and Probabilistic Extensions of Standard Fisheries Models.

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

Additional collaboration on the Multiple Species Fisheries Research Project is being provided by the University of Maryland-College Park-College of Business and Management and by the University of Miami; and additional collaboration on the Economic and Probabilistic Extensions of Standard Fisheries Models Project is being provided by the University of Delaware. The two projects will, together, (1) design a decision support system utilizing some expert system features, to study population dynamics and management of tropical and subtropical multispecies fisheries, and (2) modify standard fisheries models to increase their utility to managers of small-scale fisheries.

The inadequacies of traditional stock assessment methods for managing artisanal and large-scale multispecies fisheries are well known. The conceptual scope, the range of available techniques, and the scale of existing stock assessment methods are too narrow. With few exceptions, the

scope of techniques in stock assessment, e.g., surplus-production, dynamic-pool (yield-per-recruit) and stock-and-recruitment models, is limited to applying or simulating standard models to optimize yield, yield-pre-recruit or recruitment, or to forecast the behavior of the fishery, in a single-species, large-scale, single-management-decision-per-year context.

The UMCEES/UCR program is designing a unique fisheries management decision support system, CANOFISH. The system is unique because it is canonical, that is, it is applicable to both small and large scale fisheries in a single and multiple species context. It is further unique because it explicitly links together sampling, optimization, and simulation techniques which are often implemented independently. The linkages are developed from recent advances in artificial intelligence, primarily expert or consultation systems techniques.

CANOFISH is a decision support system/expert system (DSS/ES) comprising five modules: ADVISOR, MONITOR, ESTIMATOR, OPTIMIZER, and SIMULATOR. CANOFISH is intended to identify and organize the basic requirements for a decision-theoretic fishery management system, namely: 1) states of nature, 2) alternative actions, 3) various metrics of performance such as catch or economic values, 4) discount rates, 5) utility functions, 6) hypotheses on population dynamics including those on recruitment, 7) and the identification of appropriate planning horizons.

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Project Name: MULTIPLE SPECIES FISHERIES RESEARCH

Host Country: Costa Rica

Host Country Lead Institution: University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigators: Dr. Jose Gracia (UCR),
Dr. Jaime Lobo (UCR),
Jorge Campos (UCR),
Eduardo Madrigal (Ministry of
Agriculture), and
J. C. Briceno (UCR)

United States Lead Institution: University of Maryland-Center for
Environmental and Estuarine Studies
(UMCEES)

United States Principal Investigator: Dr. Brian J. Rothschild (UMCEES)

Other Participating U.S. Institutions: University of Maryland-College Park-
College of Business and Management
(UMCP-CBM), and
University of Miami (UMiami)

United States Associate Investigators: Dr. Bruce Golden (UMCP-CBM), and
Dr. William Fox (UMiami)

United States Research Assistants: Cluney Stagg (UMCEES),
Haren Trivedi (UMCEES),
Jerald S. Ault (UMiami),
David Die (UMiami), and
Victor Restrepo (UMiami)

Research Locations: UMCEES, UMCP-CBM, UMiami, and UCR

Project Objective: Develop a better understanding of how multiple species
fisheries influence the ecology and population dynamics
of fish communities. Emphasis is placed on designing the
components of a decision support system (DSS)
incorporating some expert system features (ES) to study

the population dynamics and management of tropical and subtropical multiple species fisheries.

Specific Objectives for 1985 - 1986:

The specific objectives for 1985 - 1986 were to establish initial collaboration protocols, review the literature, and design the framework of the decision support system/expert system, CANOFISH.

Description of Work Undertaken:

The description of work undertaken by the Multiple Species Fisheries Research Project and by the Economic and Probabilistic Extensions of Standard Fisheries Models Project are presented together in the appropriate section of the latter project.

Technical Accomplishments:

The technical accomplishments of the Multiple Species Fisheries Research Project and of the Economic and Probabilistic Extensions of Standard Fisheries Models Project are presented together in the appropriate section of the latter project.

International Travel:

Dr. Rothschild traveled to Costa Rica, December 16-20, 1985. Drs. Rothschild, Golden, and Fox traveled to Costa Rica, January 20-25, 1986.

Training:

Initial orientation to the UCR-CIMAR collaborative team during a workshop conducted at UCR during January, 1986. Numerous interactions between UMCEES and UCR counterparts established mutual understanding of the research program thrust and of the approach to developing the DSS/ES prototype.

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Project Name: ECONOMIC AND PROBABILISTIC EXTENSIONS OF STANDARD FISHERIES MODELS

Host Country: Costa Rica

Host Country Lead Institution: University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigators: Arturo Villalobos (UCR),
Dr. Edison de Faria (UCR),
Jorge Campos (UCR),
Dr. Edwin Castro (UCR),
Dr. Ricardo Estrada (UCR), and
Eduardo Madrigal (Ministry of
Agriculture)

United States Lead Institution: University of Maryland-Center for
Environmental and Estuarine Studies
(UMCEES)

United States Principal Investigator: Dr. Brian J. Rothschild (UMCEES)

Other Participating U.S. Institutions: University of Maryland-College Park-
College of Business and Management
(UMCP-CBM), and
University of Delaware (UDelaware)

United States Associate Investigators: Dr. Edward D. Houde (UMCEES),
Dr. Lee Anderson (UDelaware),
Dr. Arjang Assad (UMCP-CBM), and

United States Research Assistants: Cluney Stagg (UMCEES)

Research Locations: UMCEES, UMCP-CBM, UDelaware, and UCR

Project Objective: Modify standard fisheries models to increase their utility
to managers of small-scale fisheries.

Specific Objectives for 1985 - 1986:

The specific objectives for 1985 - 1986 were to establish initial
collaboration protocols, review the literature, and design the framework of

the decision support system/expert system, CANOFISH, to incorporate economic and probabilistic extensions of standard fisheries models.

Description of Work Undertaken:

The description of work undertaken presented below is for both the Economic and Probabilistic Extensions of Standard Fisheries Models Project and the Multiple Species Fisheries Research Project. Contractual arrangements were made and initial collaboration protocols were established. The research efforts were directed to reviewing the available literature, assessing the applicability of various models, and designing the framework of CANOFISH. Regular seminar series and work sessions were conducted, numerous working papers are in preparation, and several team meetings were held in the U.S. and in Costa Rica.

Technical Accomplishments:

The technical accomplishments presented below is for both the Economic and Probabilistic Extensions of Standard Fisheries Models Project and the Multiple Species Fisheries Research Project.

General accomplishments of the UMCEES/UCR program include the following:

- (1) Compiled a fisheries management library at the University of Maryland-College Park, which has been shared with counterparts in Costa Rica.
- (3) Prepared several manuscripts described below.
- (4) Organized a biweekly UMCEES Seminar Series, concentrating on Bioeconomic Modeling by Colin Clark.
- (5) Organized periodic meetings at UCR to discuss project strategy and outline progress on the corvina fishery.
- (6) Interacted with Bill Fox (UMiami), Lee Anderson (UDelaware), Manuel Muril (UCR), Jose Gracia (UCR) in various locations.

- (7) Designed the first stages of CANOFISH system.
- (8) Discussed the CANOFISH system at national meetings.
- (9) Designed program work plan.

The first year's efforts have developed the foundations of and engaged in the initial implementation of CANOFISH, which incorporates advances from the field of artificial intelligence optimization and defines the direction that research will take in the UMCEES/UCR program. The conceptual basis for the system has been developed and systems implementation begun. The conceptual framework of the CANOFISH system is described below:

CANOFISH functions as follows:

- (1) Sampling is contained in the MONITOR module. Parameter estimates are derived from the sampled data in the ESTIMATOR module;
- (2) using output from ESTIMATOR, optimal values and sensitivities are determined using OPTIMIZER;
- (3) using the information from (1) and (2), extrapolations are made in a simulation model with SIMULATOR;
- (4) in a second phase of optimization, optimal values of the forecast estimates of objective functions are computed in the OPTIMIZER module;
- (5) the forecasted optimizations are compared to the actual optimizations from sampled data (as these data become available for each forecast period) by ADVISOR, and (4) is updated; and
- (6) problems such as extreme values, under- or over-sampling in either stage are diagnosed (ADVISOR).

This series of actions is iterative and continuous updating is a major feature of the model.

OPTIMIZER. The objective of OPTIMIZER is to indicate the management actions that will maximize the bioeconomic return from the fishery. OPTIMIZER

drives the determination of the information to be utilized and organized by CANOFISH. One of the primary research tasks has been to evaluate existing bioeconomic optimization models and to explore new approaches.

MONITOR. As noted earlier, MONITOR samples the fishery for the data used in the optimization and intermediate models. It samples the required data, catalogs appropriate data subsets, computes descriptive statistics and stores the results. MONITOR, through ADVISOR, determines sample size and assembles data files.

ESTIMATOR. Early in the study of a fishery, statistics are necessarily limited to mean, median, variance and related descriptive statistics. As time series of data begin to accumulate, it becomes possible to expand the statistical analysis to estimate and predict distributions and time-dependent parameters including time series analysis involving periodicities such as intraseasonal variation. The results of these analyses are then entered into the ADVISOR knowledge base and used for determining future sampling procedures and for designing SIMULATOR. Some of the information requirements for the optimization models require intermediate results from standard estimation procedures. ESTIMATOR estimates both standard sampling statistics and desired statistics such as growth rates and mortality rates.

SIMULATOR. The purpose of SIMULATOR is to make observations about the expected future behavior of the fishery, as it is modeled by the estimated parameters and the bioeconomic optimization models. These observations are extrapolated from the known data on the fishery, that is the results of MONITOR, ESTIMATOR, and OPIMIZER. In addition, SIMULATOR serves in the capacity of testing robustness of the model with respect to the parameter values, through sensitivity analysis.

ADVISOR. Control of the system and the consultation format are centered

in the module ADVISOR. The function and operation of this module distinguishes this DSS/ES as a new and innovative approach to fishery management. In a very general sense, the overall capabilities of ADVISOR include:

- (1) integration of the five main modules, the other components and the user;
- (2) an ability to recognize statistical patterns, make benefit-cost comparisons relative to those patterns, and offer advice on the alternative actions;
- (3) the foundation and flexibility to evolve as advanced optimization and intermediate models become available.

Specific details of what these three points imply for this first-cut version of the DSS/ES follow. The system-control functions of ADVISOR facilitate the use of MONITOR, ESTIMATOR, OPTIMIZER, SIMULATOR and the other components. The user is directed through menus and prompt screens on how to gain access to and use each of the modules. The user is routed through ADVISOR when shifting among modules, exiting the system and in error-recovery situations.

Additionally, an audit of the use of the DSS/ES up to the present is maintained, i.e. the stage/status of the current sampling program (study or real fishery) is continually updated. The "control" functions of ADVISOR are programmed to link the components functionally and logically.

The expert or consultation system component of ADVISOR is divided into two parts, the inference engine and the knowledge base. The inference engine through a set of rules relates the questions asked of the user and the answers given in reply to facts and relationships stored in the knowledge base. The knowledge base is being constantly appended by the results of the accumulating time series of sampling, estimation, optimization, simulation and previous consultations.

Based on the replies to questions asked by ADVISOR, combined with information in the knowledge base, ADVISOR provides the details of the initial (and subsequent) sampling programs. Specifically, it recommends the type (random, stratified random, etc.) and frequency (daily, weekly, monthly, etc.) of sampling and the sample size. Details of the results of regressions, statistical moments and time series analysis from previous sampling programs, the relevant results of sensitivity analysis and the cost of sampling are stored in the knowledge base. The "advise" functions are implemented within a commercial, programmable expert system shell.

System Development Accomplishments. Related to the development of the CANOFISH system, the following have been accomplished:

1. Microcomputer hardware and software for system development have been installed at UMCESS, and compatible hardware has been installed at the Universities of Miami and Delaware. Hardware has been specified by UCR and is on order at the University of Maryland.
2. A prototype system is partially completed at UMCEES. This includes the completion of the fishery data generator (FDG), creation of experimental databases and installation of software (Reflex-The Analyst) for MONITOR, ESTIMATOR, and SIMULATOR (Micro-Dynamo). Several commercial expert system shells, e.g., M1, Rulemaster, and GURU, have been tested for use as the ADVISOR package. Programming for linking the whole system together continues.

OPTIMIZER Development Accomplishments. Arjang Assad and Gerard DiNardo conducted an intensive effort to compile an annotated bibliography of extant papers on optimization methods as applied to fisheries modeling. As part of this effort, a library of papers and monographs on this subject has been assembled and is currently expanding as new additions are identified. The literature review will appear shortly as a working paper. Our goal is to

extend traditional bibliographies in at least two ways:

- a) The bibliography will provide a taxonomy for fisheries optimization models based on both the nature of the fishery and the problem being modeled (and hence a foundation for the OPTIMIZER/ADVISOR linkage). In our initial search, we found that good classification schemes are currently lacking. One use of a good classification scheme within the overall framework of the DSS/ES has to do with ADVISOR. In its future development, it is highly useful to have a variety of models, or an "optimization model library" for advisor to call upon or refer the user to.
- b) The bibliography is annotated to provide a quick review of each paper's contribution using uniform terminology. This should help us exchange the information on existing techniques with the research team in Costa Rica, Miami, and Delaware.

Over 100 papers have been reviewed and classified on optimization techniques, all within the context of fisheries and renewable resources. In the process of compiling the literature review, we are also evaluating the models with respect to data requirements and computational burden. The Costa Rican group, Estrada, Castro, and de Faria, are doing the same with special focus on the techniques of optimal control and dynamic optimization. Part of these initial evaluations will result in an initial set of models to include in OPTIMIZER. The other part involves a comparison of related models attacking the same problem. For example, the work by Lee Anderson on the "fishery-as-a-mine" concept involves a specific optimization model whose prescriptions can be compared with those of certain dynamic optimization techniques.

The following accomplishments are specific to the Anderson model:

- 1) The basic economic analysis of optimal harvesting without stock and recruitment information has been completed for the independent single fishery in both an aggregate and a cohort model.
- 2) The basic algorithm for implementing the economic model has been developed for use on a microcomputer.
- 3) A paper summarizing the theory of 1) and 2) is in preliminary form.

The Costa Rican optimization group has been meeting regularly once a week during the period from March to May. The first task has been to study carefully the dynamic optimal control models of fisheries management, as presented for example in the books by Colin Clark. Considerable time has been spent going over the details of the models and classifying them.

The whole UCR-CIMAR team has been meeting approximately every two or three weeks. In the first meetings, the actual situation of the Gulf of Nicoya fisheries was discussed. The availability of data for these fisheries has been characterized. These discussions have helped our working group classify the optimal control models according to their relevance in the Gulf of Nicoya context.

Parallel to this, Edwin Castro has started the construction of a library of computer optimization problems.

Collaboration has been enhanced by exchange visits. Gracia and Estrada have visited the University of Maryland and Gracia in addition has visited the University of Miami. As a result of Estrada's trip to the University of Maryland, he has been able to exchange ideas with various researchers of the University of Maryland team. The bibliographical search being done by Assad and DiNardo has been particularly useful. The summary of their work thus far, will help the UCR counterparts in their search for appropriate models for the Gulf of Nicoya setting.

MONITOR AND ESTIMATOR Development Accomplishments. Extant data on the Gulf of Nicoya fishery are being cataloged for entry into a computer database. These data will be used as the baseline data when the prototype is transferred to the real-world setting.

SIMULATOR Development Accomplishments. Professor Jose Gracia (UCR) spent the second week of June with Professor Fox in Miami as planned. They discussed ways to improve the computer science capability at UCR, reviewed progress on the institutional sector of the simulation model and discussed the candidate mathematics for use in the model.

Professor Fox spent the third week of June at UMCEES working with Professor Rothschild. Professor Fox gave a seminar about his work on sequential hermaphroditic reproduction common to tropical fish populations as it relates to the assessment of those populations, spent time on the final implementation of his generalized exploited population simulator on the project's microcomputer system, discussed project plans and ideas with Professor Rothschild, discussed the information network and project software with Mr. Stagg and provided input to the project's annual report. Numerous working papers are in preparation at UMiami.

Discussions with UMCEES counterparts resulted in agreement on the system configurations among UMCEES, UMiami and UCR. The microcomputer system for UMiami was purchased and about one week was devoted to learning the operating system and the necessary software. The bulletin board communication network is being designed at UMCEES and will be distributed later this summer.

UCR and UMiami investigators corresponded on the experiments and their protocols planned for the project. Professor Fox and Mr. Ault will be conducting experiments with reproductive strategies and spawning/recruitment patterns. Professors Fox and Rothschild have begun a manuscript on sequential

hermaphroditic reproduction in relation to tropical fish stock assessment.

Professor Chavarria and Professor Fox have completed a survey of stock assessment computer programs available at their respective institutions. An initial selection of ten of those programs was made to begin implementation on the project's microcomputer system. Professor Fox with Mr. Die and Mr. Restrepo have completed this initial implementation and have drafted a set of user's guides in both English and Spanish.

The biological sector is being developed in two lines: a continuous age-independent model being developed by Mr. Ault and a semi-continuous age-dependent model by Professor Fox. The continuous model is running currently on UMiami's Vax 785 computer and will be implemented in the project's microcomputer in the next year. The semi-continuous model, a generalized life history exploited population simulator, has been implemented on the project's microcomputer and debugged in its discrete recruitment version. A literature review on spawning/recruitment patterns in tropical and sub-tropical fishes has been completed and incorporated in a draft manuscript by Professor Fox with Mr. Ault which also defines a classification of patterns for experimentation.

Progress on the institutional sector consists of a comprehensive literature review on the Costa Rican fishery management institutional structure by Professor Gracia. Professor Fox and Professor Gracia reduced this structure to a model and developed a set of alternative institutional models to be implemented as part of the general simulation model. A manuscript by Professors Gracia and Fox on institutional structure was begun during Professor Gracia's visit.

Professor Anderson provided Professor Fox with some software that might serve as an economic driver for the general model. Several manuscripts are in

preparation.

In another segment of work on SIMULATOR, Dr. Rothschild has been studying in detail the multispecies problem. The first phase of the study has completed the development of a population-dynamics process model (Dynamics of Marine Fish Populations, Harvard University Press, October, 1986). In order to quantify various aspects of the population-dynamics process model, Golden, Rothschild, and Trivedi have done the research reported in a tentative working paper "A Simulation Study of Marine Population Dynamics." This represents an initial attempt at studying the population dynamics process for marine fish. Each life stage (adult, egg, larvae, and juvenile) is represented along with stabilizing mechanisms such as food and predation.

Two general approaches are applied--ordinary differential equations and Leslie matrix methods. Several different systems of differential equations are modeled. A key accomplishment here is that extensive sensitivity analysis has been performed, although on artificial data. To do this, we utilized Micro-Dynamo. Micro-Dynamo is a microcomputer-based simulation language which simulates the dynamic behavior of real-world systems over time and runs on an IBM-PC. The graphical features of Micro-Dynamo enhance the insight provided by the models. A working paper is in progress.

With this paper as a starting point, we have begun to move forward as follows: We are applying the above mentioned models to more realistic data. We are finalizing a working paper in which we critique the ordinary differential equation model. Jose Gracia's recent paper addresses the limitations of using ordinary differential equations and proposes a partial differential equation model. This is a rather innovative concept in that it allows the user to track each organism over time. We are still exploring the power of this new approach. We are in the process of writing a survey article

on the applicability of Leslie matrices to fisheries management. We are applying a preliminary birth and death process model to the study of marine population dynamics.

Working papers on each of the above tasks are being developed.

ADVISOR Development Accomplishments. The following summarizes the accomplishments in the development of the ADVISOR component of CANOFISH:

1. The functions of ADVISOR that relate to managing the system and the interactions among modules have been identified and are currently being implemented on the prototype system.
2. Four expert system shells have been experimented with for applicability to our need for expert system functions. These include EXPERT EST, M1, RULEMASTER, and GURU.
3. Several database management systems, integrated systems, and operating system environment software packages have been critically examined for use as the integrating "control of system" functions of ADVISOR. These include: DBASE III, REFLEX-The Analyst, INFORMIX, RBase 5000, GURU, and Windows.

UMCEES Seminar Series.

<u>Date</u>	<u>Speaker</u>	<u>Title</u>	<u>Place</u>
9/17/86	Planning Session -- Rothschild, Golden, Murillo, Anderson, Fox, Assad, Stagg, Trivedi, Rogers, and Wu		College Park, Maryland
9/26/85	-----Working Session-----		CBL, Solomons, Maryland
11/21/85	Brian Rothschild and Hiren Trivedi	The Multiple Species Problem in Fisheries Management	CBL, Solomons, Maryland
12/3/85	-----Working Session-----		College Park, Maryland
1/7/86	-----Working Session-----		College Park, Maryland
1/14/86	Arjang Assad	Fishing Effort and Search Theory	CBL, Solomons, Maryland

UMCEES/UCR

Extensions of Standard Fisheries Models

1/21/86 - 1/24/86	SACRSP Workshop	Collaboration and Research Directions	UCR, San Jose, Costa Rica
2/21/86	Gerard DiNardo and Peter Miller	Fishing Effort and Search Theory	College Park, Maryland
3/3/86	Hiren Trivedi, Gerard DiNardo and Cluney Stagg	Update of Ongoing Projects	CBL, Solomons, Maryland
3/31/86	Brian Rothschild	Single-Species Population Dynamics Model	College Park, Maryland
4/21/86	Brian Rothschild	Optimization and Fisheries Models	CBL, Solomons, Maryland
5/9/86	Lee Anderson	Fishery-as-a-Mine Approach	College Park, Maryland
6/16/86	William Fox	The Role of Hermaphroditism in Fish Population Dynamics	CBL, Solomons, Maryland

Tentative Working Papers. The list of tentative working papers by the

UMCEES/UCR program is summarized below:

Rothschild, B. J. "Feasibility of Relating Recruitment to Environmental Variation." 1985.

Assad, A. A. and B. L. Golden. "Expert systems, microcomputers, and operations research." 1985.

Rothschild, B. J., B. L. Golden, and A. Assad. "A microcomputer-based decision support system for multi-species fishery management." 1985.

Stagg, C. and J. Campos. "Report of Workshop, San Jose, Costa Rica, January 21 - 24, 1986."

Golden, B., B. Rothschild, and H. Trivedi. "A simulation study of marine population dynamics." 1986

Gracia, J. "Alternative population dynamics models." 1986.

Ault, Jerald and William W. Fox, Jr. "Spawning and recruitment patterns in tropical and sub-tropical fish stocks." In preparation.

Fox, William W., Jr., Juan Chavarria, Victor Restrepo, and David Die. "User guide to stock assessment programs for the Fisheries Stock Assessment CRSP." In preparation.

Fox, William W., Jr., and Brian J. Rothschild. "Stock assessment of tropical sequential hermaphroditic fish stocks." In preparation.

Gracia, Jose and William W. Fox, Jr. "The Costa Rican fishery management institutional structure: a comparison with alternative models." In preparation.

Estrada, Ricardo. "A difference equation simulation model of marine population dynamics." In preparation.

Rothschild, B. J. "Biodynamics of the sea--materials required for the development of multiple-species models." In preparation.

International Travel:

Dr. Houde traveled to Costa Rica, December 16-20, 1985. Drs. Houde, Anderson, and Assad and Mr. Stagg traveled to Costa Rica, January 20-25, 1986.

Training:

Initial orientation to the UCR-CIMAR collaborative team during a workshop conducted at UCR during January, 1986. Numerous interactions between UMCEES and UCR counterparts established mutual understanding of the research program thrust and of the approach to developing the DSS/ES prototype.

ANNUAL REPORT 1985 - 1986**PROGRAM COORDINATION**

The two UMCEES/UCR projects are being conducted in an integrated fashion. Details of collaborative interactions are summarized below: In September, 1985, Drs. Fox and Murillo participated in a CRSP planning session at the University of Maryland-College Park with Drs. Rothschild, Golden, Assad, and Anderson and Messrs. Stagg, Trevedi, Rodgers, and Wu. Drs. Rothschild and Houde met with Dr. Murillo and his colleagues in Costa Rica in December, 1985, to finalize budgetary matters and to set an agenda for the January, 1986, workshop. Drs. Rothschild, Golden, Assad, Houde, Fox, and Anderson and Mr. Stagg participated in the team planning workshop in Costa Rica, January 20-24, 1986, with the UCR-CIMAR collaborative team. Dr. Rothschild participated in a team planning meeting in Miami, February 23, 1986, with collaborators from UMiami, UCR, and UW. Professor Gracia collaborated on multiple species ecology research in College Park with Drs. Golden and Assad and Mr. Trevedi and in Solomons with Dr. Rothschild and Mr. Stagg. Dr. Gracia worked with Dr. Fox in Miami on the institutional sector of the general simulation model. Dr. Fox collaborated with Dr. Rothschild and Mr. Stagg on multiple species ecology research and development of CANOFISH. Professor Estrada met with Drs. Assad and Golden and Mr. Trevedi in College Park and Dr. Rothschild, Mr. Stagg and Mr. DiNardo in Solomons to collaborate on bioeconomic optimization research and the OPTIMIZER component of CANOFISH.

ANNUAL REPORT 1985 - 1986**University of Washington/University of Costa Rica Program****PROGRAM DESCRIPTION**

The University of Washington in collaboration with the University of Costa Rica is carrying out four CRSP research projects, noted as follows:

1. Sampling Catch and Abundance
2. Age-Size Dependent/Independent Modeling
3. Age and Size Relationships and Consequences of Errors
4. Shallow Water Hydroacoustics.

The principal host country institution collaborating on these four projects is the University of Costa Rica's Centro Investigacion en Ciencias del Mar y Limnologia (CIMAR). Additional collaboration on the Sampling Catch and Abundance Project is being provided by the University of Delaware.

The four 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, especially for tropical, artisanal fisheries. The work involves the integration of various field, laboratory, and theoretical studies.

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Project Name: SAMPLING CATCH AND ABUNDANCE

Host Country: Costa Rica

Host Country Lead Institution: University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigators: Juan Chavarria (UCR), and
Eduardo Madrigal (Ministry of
Agriculture)

United States Lead Institution: The University of Washington

Other Participating U.S. Institutions: The University of Delaware
(UDelaware)

United States Associate Investigators: Dr. Loveday Conquest (UW) and
Dr. Lee Anderson (UDelaware)

United States Research Assistant: Silvia Vega Gonzales (UW) and
Christopher Rogers (UDelaware)

Research Locations: Universities of Costa Rica, Washington, and Delaware

Project Objective: Develop statistical sampling methodology for the assessment of tropical stocks exploited via artisanal fisheries. Improvement over past efforts will be based upon the introduction of Bayesian and other decision theoretic techniques. Statistical sampling expert system software will be developed with and transferred to UCR. An economics component of the project will evaluate the utility of current stock and recruitment models for small-scale fisheries stock assessment and develop new methodologies and economic extensions of these models to provide useful bioeconomic information.

Specific Objectives for 1985 - 1986:

1. Develop phase 1 software and write documentation for use in the design of sampling/assessment problems.
2. Acquire relevant data and associated management information from UCR and the Ministry of Fisheries of Costa Rica.
3. Prepare a presentation for the XIII International Biometric Conference in Seattle.

Description of Work Undertaken:

We continue to acquire data from Costa Rica and to work towards improved formats for collecting the necessary data from new experiments.

Technical Accomplishments:

1. Phase 1 software is largely complete. Programs for stratified, cluster and proportional sampling are completed and field tested in the classroom.
2. Data have been acquired from UCR; further effort toward the coordination of sampling continues.
3. The paper for presentation is: "Survey Design for Estimation of Parameters of Exploited Stocks," by S. G. Vega and V. F. Gallucci.

Economics Component

The economics component of the Sampling Catch and Abundance Project is being carried out primarily by Dr. Lee Anderson (UDelaware) with assistance from Christopher Rogers (UDelaware) and in collaboration with C. Villalobos (UCR). This component is being conducted under a subcontract with the University of Delaware and is entitled "Economic and Probabilistic Extensions of Standard Fisheries Models." This work is also being done in cooperation with the UMCEES project with the same name. The annual report for this

component is presented separately below.

Economics Component Objective: Construct a mathematical representation of the economics of the harvesting operation in Costa Rica's Gulf of Nicoya.

Economics Component Specific Objectives for 1985 - 1986:

1. To gain an understanding of the operation of the fishing industry in Costa Rica.
2. To formalize an economic model to be used for estimating and updating an optimal TAC trajectory in the absence of stock recruitment information.
3. To develop a preliminary algorithm for implementing the above economic model.

Economics Component Description of Work Undertaken:

1. During visit to Costa Rica local studies of industry organization were obtained. Discussions about existing data bases were held, and several fishing operations were visited.
2. The basic economic analysis of optimal harvesting without stock and recruitment information has been completed for the independent single fishery in both aggregate and cohort models.
3. The basic algorithm for implementing the economic model has been developed for use on an IBC-PC. At this point, it is quite simple and can only handle aggregate natural and fishing mortalities, but it has been tested against known solutions and it does work.

Economics Component Technical Accomplishments:

1. A paper summarizing the theory developed above is in preliminary form.

International Travel:

Dr. Gallucci traveled to Costa Rica, February 23-March 1, 1986. Dr. Murrillo and Mr. Chavarria traveled to Miami, February 22-23, 1986.

Training:

1. Orientation and initial training of UCR counterparts.
2. J. Chavarria (UCR) and S. Vega (UW research assistant) went to the Miami meeting to present progress and gain from others' experience.

ANNUAL REPORT 1985 - 1986

Project Name: AGE AND SIZE DEPENDENT/INDEPENDENT MODELING

Host Country: Costa Rica

Host Country Lead Institution: The University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigators: Dr. Joseph Varilly (UCR)

United States Lead Institution: The University of Washington (UW)

United States Principal Investigator: Dr. Vincent F. Gallucci (UW)

Other Participating U.S. Institutions: None

United States Research Assistants: Patrick Sullivan (UW) and
Jose Orensanz (UW)

Project Objective: To develop the framework, methodology, and validation techniques necessary for understanding and predicting the abundance and growth of selected tropical fish and invertebrate stocks that are under artisanal fishing pressure. The project seeks to examine existing models, develop new ones as needed and ultimately to test models against field data. Data from field experiments seek to estimate parameters for models which are a basis for predicting productivity. Field experiments seek to estimate: 1) age/size distributions of stocks per species, 2) age/size specific rates of mortality, 3) fecundity, and 4) growth. The theoretical framework and software written for this project will integrate these estimates with data from other projects, to allow fishery

managers to follow the status of an exploited fish stock and to predict the consequences of changes in a stock's environment (such as gill net mesh size, changes in effort, etc.).

Specific Objectives for 1985 - 1986:

1. To develop a catch/size model to relate size distribution data to population parameters such as rates of growth and mortality, recruitment success, and exploitation pressure. Model and effort to be called CASA (Catch at Size Analysis).
2. Adapt the halibut age-specific model CAGEAN (Catch at Age Analysis) to relate age-dependent data to population parameters.
3. Begin discussion of a fecundity/time(s) of recruitment project to be coordinated with size and age analyses. Model and effort to be called FERET (Fecundity and Recruitment Timing).
4. Prepare abstracts and papers for presentation at the XIII International Biometric Conference and at the AAAS Pacific Division Meeting.

Description of Work Undertaken:

1. CASA: An estimation procedure based on a modification of the Baranov Catch Equation where $C(t, l)$ is the catch at time t in length (size) class l ,

$$C(t, l) = u(t, l) N(t, l)$$

$$u(t, l) = \frac{F(t, l)}{Z(t, l)} [1 - e^{-Z(t, l)}]$$

was developed to estimate the numbers of fish per length interval surviving and growing into the next length interval over a specified time period (e.g., week, month, year, etc.). Abundance is represented by $N(t+1, l)$, survival by $S(t, l)$, and fishing mortality by $F(t, l)$, where t is time (not age) and l is

the length interval.

2. The CAGEAN model, also based on the Baranov equation with the variable length replaced by age, is used to estimate population parameters such as abundance, survival and mortality; modification of this model was started.

Technical Accomplishments:

1. The CASA model was conceptualized and the optimization and statistical procedures were developed to estimate parameters. Elementary estimators were successfully used to confirm that the application to data would operate as expected.

2. The CAGEAN model was adapted for use with artisanal data, and documentation was written to facilitate application. Adjustment of code was started for use on an IBM-PC microcomputer. Simulation data was run with earlier versions and the characteristics of the program were noted.

3. Aspects of FERET to be coordinated with sampling designs were integrated into a proposed sampling plan to be discussed with UCR counterparts.

4. Papers prepared for presentation or as CRSP Technical Reports are:

a. Lai, H. L., and V. F. Gallucci. "Effect of Variability on Estimates of Cohort Parameters Using Length-Frequency Data."

b. Sullivan, P. J. "Deterministic and Stochastic Descriptions of Spatial Heterogeneity in a Predator/Prey-Reaction/Diffusion System."

c. Gallucci, V. F., J. M. Orensanz and H. L. Lai. "Dynamics of Benthic Production and Recruitment in a Boreal Ecosystem."

International Travel: None.

Training:

1. Orientation and initial training of UCR counterpart.

2. P. Sullivan (UW research assistant) traveled to Miami meeting to present progress and gain from others' experience.

ANNUAL REPORT 1985 - 1986

Project Name: AGE AND SIZE RELATIONSHIPS AND CONSEQUENCES OF ERRORS
(Age Determination)

Host Country: Costa Rica

Host Country Lead Institution: The University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigator: Jorge Campos (UCR)

United States Lead Institution: The University of Washington (UW)

United States Principal Investigator: Dr. Vincent F. Gallucci (UW)

Other Participating U.S. Institutions: None

United States Associate Investigators: Dr. Han Lin Lai (UW)

United States Research Assistants: None

Research Locations: Universities of Costa Rica and Washington

Project Objective: Establish new methods and validation criteria to be applied to tropical fish of the corvina type and begin the construction of an age to size relationship for these fish and selected invertebrates to draw inferences about recruitment, growth and mortality. A center for age determination that may later serve regional fisheries agencies in Latin America is also planned.

Specific Objectives for 1985 - 1986:

1. To develop an age determination methodology for tropical fish and invertebrates.
2. To develop an age-size relationship for the corvina-like species in the Gulf of Nicoya, to construct age-size keys and thus to draw inferences about

recruitment, growth, and mortality.

3. Complete analysis for three manuscripts to be presented at the XIII International Biometric Conference and to be produced as CRSP Technical Reports.

Description of Work Undertaken:

Establish an age determination laboratory at UCR and mutually define standards and procedures; begin the manual for ageing tropical fish and establish training procedures.

Technical Accomplishments:

1. Meetings were held and methodology established with UCR counterparts. Plans were made for exchange of material as samples are aged and for continued collaboration on standardization of reading techniques.
2. Sampling plans were defined taking into account variability, costs, etc. Progress toward development of an integrated length-frequency analyses model was made.
3. Papers prepared as Technical Reports or for presentation are:
 - a. "Implications of Aging Variability on Estimates of Growth, Mortality and Yield per Recruit for Pollock," by Lai, H. L. and D. R. Gunderson, for Fish Research.
 - b. "Validation and Variation of Age Determination for Sablefish," by Lai, H. L., for the Canadian Journal of Fisheries and Aquatic Sciences. This manuscript has the primary techniques and analyses to be employed on the tropical species.
 - c. "A Time Series Analysis Approach to Studying Microstructure in Fish and Invertebrates," by Lai, H. L., S. Adlerstein and V. Gallucci, as a CRSP Technical Report and later as a refereed paper. This methodology

will greatly aid in the search for and interpretation of patterns in microlines.

d. "A Generalized Optimum Sampling Design for Age-Length Keys," by Lai, H. L. and V. F. Gallucci. This manuscript will describe the sampling plan for age composition studies considering both the cost and variability in aging in the context of highly variable data.

International Travel:

Dr. Han Lin Lai traveled to Costa Rica, February 23-March 1, 1986.

Training:

1. Orientation and initial training of UCR counterpart.
2. H. L. Lai (post-doctoral) went to Miami Meeting to present progress and gain from others' experience.

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Project Name: SHALLOW WATER HYDROACOUSTICS

Host Country: Costa Rica

Host Country Lead Institution: The University of Costa Rica (UCR-CIMAR)

Host Country Principal Investigator: Dr. Manuel M. Murillo (UCR-CIMAR)

Other Participating Host Country Institutions: None

Host Country Associate Investigators: Jorge Campos (UCR)

United States Lead Institution: The University of Washington (UW)

United States Principal Investigator: Dr. Richard E. Thorne (UW)

Other Participating U.S. Institutions: None

United States Associate Investigators: Dr. Gary L. Thomas (UW)

United States Research Assistants: None

Research Locations: Universities of Costa Rica and Washington

Project Objective: Develop hydroacoustic fish assessment techniques for shallow water, multi-species, environments such as the Gulf of Nicoya, Costa Rica. There are four aspects:

1. Determine the distribution, abundance and behavior of the corvina-like fishes, evaluating variables such as tidal, diel, location, seasonal, and annual. Measurements will be taken on abundance, vertical distribution, and velocity of fish, as well as salinity and water currents. Dual stationary transducers will be used, one mounted at a slant angle on the bottom, the other deployed at the surface and mounted at 90 degrees.
2. Determine the effectiveness of artificial reefs in

attracting fish. The same deployment techniques as above are used at three locations (on an artificial reef, adjacent to the reef, and a control).

3. Determine the efficiency of locally fished gill nets and other direct capture techniques.
4. Introduce the results of hydroacoustics estimation as auxiliary input for artisanal fisheries catch and stock assessment analysis.

Specific Objectives for 1985 - 1986:

1. Prepare a field sampling plan for the Gulf of Nicoya by visiting the site and delivering the hydroacoustic sampling equipment.
2. Examine the local techniques of fishing with the object of estimating catch efficiency relative to what is present.
3. Make plans for 1986 - 1987 sampling and for presentation of results.

Description of Work Undertaken:

The several environments of the Bay of Nicoya were visited and measurements taken to test the applicability of the equipment that was carried to Costa Rica. Specific plans for collaboration were made.

Technical Accomplishments:

The site was visited and the equipment determined to be effective. Initial training of the UCR counterpart was started. Equipment remains at UCR.

International Travel:

Dr. Richard E. Thorne traveled to Costa Rica, February 23-March 1, 1986.

Training: Orientation and initial training of UCR counterparts.

ANNUAL REPORT 1985 - 1986**PROGRAM COORDINATION**

The four UW/UCR research projects are sufficiently complex that some are composed of several components, each of which is defined in the general description of that project. Objectives and methods employed in each project are complementary, so data developed in one has multiple uses.

The UW/UCR program is coordinated with the UMCEES/UCR program, which also has a subcontract to the University of Costa Rica and to the University of Delaware.

The annual report for the UW/UCR program has been presented project-by-project, but some aspects of the work have been program-wide and have benefited all projects. The report on project coordination elements is outlined below.

Program Coordination Objective: Implement the plan for the CRSP by negotiation of contracts, hiring, purchasing, etc. Define strategies to coordinate the four University of Washington projects within UW and with colleagues at UCR, UMCEES, and UDelaware.

Program Coordination Specific Objectives for 1985 - 1986:

1. To negotiate and sign contracts with the University of Costa Rica and the University of Delaware as subcontractors to the University of Washington. To negotiate and sign a contract with the University of Maryland-College Park, with the University of Washington as subcontractor.
2. To define requirements and purchase a microscope for ageing of fish.

3. To define requirements and purchase a microcomputer.
4. Assist in acquisition of a microscope and computer to be purchased for, and carried to, the UCR.
5. Visit Costa Rica to coordinate UW/UCR effort and meet with other CRSP investigators to exchange ideas.

Description of Work Undertaken:

Coordination of the four UW projects internally and establish the administration of the UW Program and its interaction with subcontractors and collaborators.

Technical Accomplishments:

1. The three contracts are signed.
2. A Zeiss microscope was chosen for UW and a Wild microscope was chosen for UCR; both were ordered and funds allocated. Delivery is pending USAID waiver of foreign manufactured product.
3. An IBM-AT and an IBM-RT were chosen and funds were allocated.
4. Coordination meetings were held and satisfactory communication established. The UW/UCR program is well underway.
5. Organized Miami meeting of USAID, ME, UMCEES, UMiami, UCR and UW participants to discuss progress and projections of work. All UW personnel were present. Three went to Costa Rica afterwards for field work (February, 1986).

Other Activities:

1. FISH 507D, "Artisanal Fisheries of the World," a graduate course taught at the UW in the Spring, 1986 Quarter.
2. Collaboration with Dr. Lavenberg, curator of Fishes, L.A. County Museum, on their project in Costa Rica.

ANNUAL REPORT 1985 -1986**University of Rhode Island/University of the Philippines Program****PROGRAM DESCRIPTION**

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

1. Empirical Analyses and Modeling
2. Multispecies Field Studies

The principal host country institution collaborating on the Empirical Analysis and Modeling Project is the University of the Philippines (Visayas), College of Fisheries, and the principal host country institution collaborating on the Multispecies Field Studies Project is the University of the Philippines (Diliman), Marine Science Institute. 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 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 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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- Project Name:** EMPIRICAL ANALYSES AND MODELING
- Host Country:** Philippines
- Host Country Lead Institution:** College of Fisheries, University of the Philippines in Visayas (UPVCF)
- Other Participating Host Country Institutions:** International Center for Living and Aquatic Resources Management (ICLARM) and Bureau of Fisheries and Aquatic Resources (BFAR)
- Host Country Principal Investigator:** Prof. T.V.C. Jamir (UPVCF)
- Host Country Associate Investigators:** Dr. J. Carreon (UPVCF), Dr. S. Formacion (UPVCF), T. Sylvester (UPVCF), and Dr. Daniel Pauly (ICLARM)
- United States Lead Institution:** The University of Rhode Island (URI)
- United States Principal Investigator:** Dr. Saul B. Saila (URI)
- Other Participating U.S. Institutions:** None
- United States Associate Investigators:** Dr. C. Recksiek (URI) and Dr. John McManus (URI)
- United States Research Assistants:** Xiu Chen (URI) and Karim Erzini (URI)
- Research Locations:** Universities of the Philippines and Rhode Island
- Project Objective:** To use existing fisheries data to contribute to the development of mathematical models and computer programs which address the relationship among harvests, fishing effort, species composition, and stability of tropical fish stocks. Major effort is being addressed to catch composition analysis.

Specific Objectives of 1985 - 1986:

1. Development of programs for the "Fisheries Application System" on various aspects of fish population dynamics applicable to tropical fisheries especially in the developing world.
2. Development of a multispecies fisheries forecasting and analysis program based on aggregated time series data. This phase involves background review, choice of approach, preliminary programming, and testing of model.
3. Preparation of a scientific paper for the national meeting of the American Fisheries Society on empirical models.

Description of Work Undertaken:

1. Development of Fisheries related computer programs, with emphasis on tropical and multispecies Fisheries.
 - a. A significant effort has been made toward making all programs as portable and "user friendly" as possible, within reasonable constraints.
 - b. Within the item a. above, the specific work undertaken has involved the development of a common input-output shell for all fisheries applications programs. This will involve a minimum knowledge and minimum training on the part of any user to effectively operate the programs.
 - c. A careful review of relevant fishery applications programs has been made. In general, it has been found that suitable statistical software is currently available for most applications. However, specific fisheries applications programs have been written in a variety of languages and dialects, primarily oriented toward main-frame computers. We are attempting to select and/or develop suitable fisheries applications programs and to put them into a common input-output shell and utilize a common, highly portable language BASICA.

2. Development of a multispecies fishery model.
 - a. A background literature review, peer review, and critical program development has been undertaken.
 - b. A specific empirical model has been selected, and programming and testing are under development.
 - c. Data sets from the Gulf of Thailand, the Philippines, and from the Northwest Atlantic have been examined for suitability in preliminary analysis with the multispecies model.

Technical Accomplishments:

1. Preparation and presentation of an invited paper to a Fisheries Stock Assessment Workshop sponsored by NMFS, Panama City, Florida, entitled "A Brief Review and Guide to Some Multivariate Methods for Stock Identification."
2. A common input-output shell for fisheries applications programs has been completed and tested in a preliminary manner.
3. Approximately 40 fisheries related programs have been written or translated into a common language (BASICA) and entered into a common input-output format. These programs, which currently reside on five double-sided, double-density disks have been brought to colleagues at the College of Fisheries, University of the Philippines; the Marine Science Center, University of the Philippines; and ICLARM for preliminary testing and applications.
4. A technical paper entitled "Multispecies Empirical Modeling - A Pragmatic Approach" is under preparation for presentation at the September, 1986, meeting of the American Fisheries Society in Providence, RI.
5. Preliminary development of programs which test the effects of life history parameter changes on population growth rate and population fecundity have been

URI/UP

Empirical Analyses and Modeling

completed. Extensive testing for suitability in tropical fishery applications is still required.

International Travel: None

Training:

Initiated through computer disk transfer to the University of the Philippines by J. McManus and C. Recksiek.

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- Project Name:** MULTISPECIES FIELD STUDIES
- Host Country:** Philippines
- Host Country Lead Institution:** Marine Science Institute, University
of the Philippines (UPMSI)
- Host Country Principal Investigator:** Dr. Edgardo D. Gomez (UPMSI)
- Other Participating Host Country Institutions:** International Center for
Living Aquatic Resources
Management (ICLARM), and
Bureau of Fisheries and
Aquatic Resources (BFAR)
- Host Country Associate Investigators:** UPMSI Staff, and
Dr. Dan Pauly (ICLARM)
- United States Lead Institution:** The University of Rhode Island (URI)
- United States Principal Investigator:** Dr. Saul B. Saila (URI)
- Other Participating U.S. Institutions:** None
- United States Associate Investigators:** Dr. John McManus (URI) and
Dr. Conrad W. Recksiek (URI)
- United States Research Assistants:** Mr. Alejandro Acosta (URI) and
Mr. Ralph Turingan (URI)
- Research Locations:** Universities of the Philippines and Rhode Island
- Project Objective:**
1. To produce at the end of the five-year CRSP one or more chapters in a book of methods for multispecies stock assessment, a summary of existing methods for assessing and managing shallow water (principally coral reef) multispecies fisheries, in conjunction with methods tested and developed by our own research team.
 2. To assess the impact of fishing pressure relative to other factors influencing the abundances and distributions of fish species across a heterogeneous coral reef system

and the variations in community structure over a three-year period.

3. To obtain general information as to the relationship between the catch composition yielded by each of several important small-scale fishing gears and the composition of the fish community being exploited.
4. To assess the relationship between catch composition, standing stock, and fishery production in a variety of shallow water fish habitats.
5. To determine to what extent the 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.
6. To disseminate this information to countries involved in multispecies fisheries management, including the United States and developing countries.
7. To develop within the host country collaborating institution the capability to continue independently to investigate and to refine the assessment and management approaches which are developed within the CRSP.

Specific Objectives for 1985 - 1986:

1. To initiate collaborative research projects with the University of the Philippines Marine Science Institute (UPMSI).
2. To assemble the equipment and supplies necessary to initiate a variety of

fishery research projects at the Bolinao Marine Laboratory of the UPMSI.

3. To establish collaborative ties to supportive institutions such as the Smithsonian Institution Sorting Center and ICLARM.
4. To initiate ground truth surveys in the Bolinao study area.
5. To begin a program of systematic identification of important fish and related organisms prior to repetitive visual sampling.
6. To initiate studies on the comparative fishery yields of major fishing gears on a coral reef complex and on comparing sizes and species distributions obtained by visual assessments with those obtained with fish pots on a heterogeneous portion of a reef flat.

Description of Work Undertaken:

1. While preliminary collaboration with UPMSI began earlier, formal joint research collaboration commenced on June 1, 1986. The host country counterparts initially include Ms. Annabelle Del Norte and Mr. Naniel Aragonés. Other researchers may be incorporated as they become available from projects near completion. Ms. Del Norte is currently doing a literature search on recruitment of fishes in coral reef areas. Mr. Aragonés has considerable experience working with the multispecies siganid (rabbitfish) community of the reef grass flats and is planning further investigations into aspects of this important fishery.
2. Dr. McManus met with Dr. Les Knapp and Dr. Menez of the Smithsonian Sorting Center, who agreed to supply sampling and preservation gear for unidentified specimens and to arrange for diplomatic pouch shipping to the museum from the Philippines. In the absence of field guides to the hundreds of nutritionally important fish species and related organisms in the Philippines, this tie to the Smithsonian is considered to be a major

enhancement to our ability to conduct the proposed research.

3. Discussions concerning the role of ICLARM in the field studies are underway and should be finalized by July 1, 1986.
4. Dr. Conrad Recksiek arrived in the Philippines on May 22, 1986 with research assistants Alejandro Acosta and Ralph Turingan to conduct field studies of fishing gears on the Bolinao reef complex. Mr. Acosta is a URI M.S. student from Venezuela whose thesis project will involve comparing the yields of gill nets, pots, and handlines on the reef flat. Mr. Turingan is a URI M.S. student and faculty member of UPVCF whose project will involve contrasting the sizes and species distributions in the catches of fish pots with those obtained from underwater visual estimates.
5. Dr. McManus arrived in the Philippines on April 28, 1986; held start-up meetings with UPMSI, UPVCF, USAID, PCARRD, and BFAR; and conducted preliminary surveys of the Bolinao reefs. He attended the Asian Fisheries Forum with Dr. Recksiek, Mr. Acosta, Mr. Turingan and Dr. McCreight. He is currently engaged in helping to set up the gear studies, as well as conducting initial broad area site surveys and working out local taxonomic identifications in preparation for the field monitoring exercises.

Technical Accomplishments:

1. Initial surveys of the study areas in Bolinao have yielded a considerable amount of information on the complex interrelationships between competing gear usage in this overfished area. The results of these informal surveys will be incorporated into the publications resulting from the subsequent quantitative studies.
2. The results of our preliminary surveys were used in site selections for an educational film segment about dynamite fishing sponsored by the German Agency

for Technical Cooperation (GTZ) in collaboration with ICLARM and the Philippines Bureau of Fisheries and Aquatic Resources (BFAR). This film will be used in a large-scale extension program in the Philippines to educate people about the uses and importance of coral reef resources and the need to protect them.

3. The preliminary surveys have also been used as a basis for selecting training sites for a United Nations Environmental Program ASEAN training workshop on coral reef fish sampling methods, and a regional "echo" training course for Philippine scientists in coral and coral reef fish monitoring methods. All three programs were based in Bolinao during May and June of 1986.

4. Our ongoing surveys are being used in the design of a USAID ASEAN Coastal Resources Management Project which will be based in Bolinao later this year. This project, which involves several Philippine agencies and ICLARM, is intentionally designed to complement the research of the CRSP and to incorporate locally useful results of the CRSP into a generalized management plan for the region.

International Travel:

J. McManus and L. McManus traveled to the Philippines, April 23, 1986, to be stationed there for the duration of the project. C. Recksiek traveled to the Philippines, May 19-July 5, 1986. R. Turingan and A. Acosta traveled to the Philippines, May 19-October 3, 1986.

Training:

Initial orientation and training of UPMSI counterparts conducted during research initiation phase at Bolinao.

ANNUAL REPORT 1985 - 1986**PROGRAM COORDINATION**

A program Coordinating Committee composed of J. McManus (URI), E. Gomez (UPMSI), and J. Carreon (UPVCF) has been established. This Coordinating Committee will meet regularly with representatives of BFAR, PCARRD, ICLARM, and the USAID Rainfed Resources Project to coordinate CRSP activities with those of others in the Philippines engaged in fisheries stock assessment activities. J. McManus is primarily working on the Multispecies Field Studies Project with UPMSI, but he will devote some effort to coordinating that work with and training personnel of the UPVCF who are working on the Empirical Analyses and Modeling Project.

ANNUAL REPORT 1985 - 1986**MANAGEMENT ENTITY ACTIVITIES**

The Fisheries Stock Assessment CRSP was established under USAID Grant No. DAN-4146-G-SS-5071-00, which was signed on August 23, 1985, by the University of Maryland-College Park, the assigned Management Entity. This grant established the CRSP for a 5-year period, July 1, 1985 - June 30, 1990, at a funding level of \$5 million. The Program Director, Dr. John Rowntree, proceeded to finalize subcontracts with the principal U.S. institutions, the University of Maryland-Center for Environmental and Estuarine Studies, the University of Rhode Island, and the University of Washington. The Program Director also facilitated the signing of Memoranda of Understanding and finalizing of sub-subcontracting with the host country institutions, the University of Costa Rica and the University of the Philippines. By the end of the first year of the CRSP, all subcontracts and sub-subcontracts have been finalized and research activities are underway at all participating institutions. Budgeting and invoicing procedures have been established.

Technical Committee: A five person Technical Committee has been established and is composed of the following representatives: Dr. Vincent Gallucci, UW; Dr. Edgardo Gomez, UPMSI; Dr. Manuel Murillo, UCR-CIMAR; Dr. Brian Rothschild, UMCEES; and Dr. Saul Saila, URI. Dr. Jose Carmona, UPVCF, has been designated as an alternate Technical Committee member representing the University of the Philippines.

A Technical Committee organizing meeting was held in College Park, Maryland on September 17, 1985.

Board of Institutional Representatives: A four person Board of Institutional Representatives (hereinafter referred to as the Board) has been established and is composed of the following representatives: Dr. Gerald Donovan, URI (Chair); Dr. Peter Larkin, University of British Columbia (an outside member representing the Management Entity); Dr. Ian Morris, UMCEES; and Dr. Robert Stickney, UW.

A Board meeting was held in College Park, Maryland on December 9, 1985.

Selected Activities:

1. The Program Director prepared draft "Bylaws and Operating Guidelines" for the Fisheries Stock Assessment CRSP. These were given tentative approval by the Board at the December 9, 1985, meeting.
2. The Program Director prepared draft Publications Guidelines for the CRSP, establishing procedures for the publication of Technical Reports and Working Papers.
3. The Program Director prepared Travel Guidelines for CRSP participant travel, establishing travel request and trip report procedures.
4. The Program Director began preparation of a Directory of Participants for the CRSP and of a Fisheries Stock Assessment CRSP brochure.
5. The Program Director has participated in three meetings (two in Washington, D.C. and one in Rhode Island) of the Committee for International Fisheries Research and Assistance Institutions (CIFRAI), an informal network of the seven AID/S&T fisheries projects, and has served as the Executive Secretary of CIFRAI, producing its newsletter.
6. The Program Director and the Board Chair have participated in meetings of the CRSP Council, an organization of CRSP Program Directors and Board Chairs. Dr. Donovan is chairing a CRSP Council committee to prepare a Congressional briefing to be held on July 25, 1986, and Dr. Rowntree and his assistant, Ms.

Management Entity

Activities

Sue Schram, are preparing a slide presentation on the scope accomplishments of the CRSP's for the briefing.

7. The Program Director prepared a Program Overview of the Fisheries Stock Assessment CRSP to circulate widely and increase the understanding and visibility of the CRSP.

8. The Program Director has initiated discussions within the CRSP regarding the establishment of the External Evaluation Panel.

Travel: Travel funded by the Management Entity during its first year of operation includes the following:

1. Dr. Rowntree traveled to California (to visit the Small Ruminants CRSP), Oregon (to visit the Pond Dynamics/Aquaculture CRSP), and Washington (to visit the UW team), July 2 - 12, 1985.
2. Dr. Manuel Murillo, UCR, traveled to the U.S. to attend the Technical Committee organizing meeting, September 16 - 22, 1985.
3. Dr. Rowntree traveled to the Philippines to establish communication with the USAID Mission, to finalize the Memorandum of Understanding between URI and UP, and to establish coordination between the CRSP and other institutions in the Philippines engaged in Stock Assessment activities, such as PCARRD, BFAR, ICLARM and the USAID Rainfed Resources Project, September 23 - October 4, 1985.
4. Dr. Rowntree traveled to Rhode Island to participate in a CIFRAI meeting, October 15 - 17, 1985.
5. Drs. Donovan, Morris, and Stickney traveled to College Park, Maryland to attend the Board meeting, December 9, 1985.
6. Dr. Rowntree traveled to Miami to participate in a team planning meeting, February 22 - 23, 1986.
7. Dr. Rowntree traveled to Costa Rica to establish communications within the

Management Entity.

Activities

USAID Mission and to facilitate the finalization of the subcontract with and work plan for UCR, February 23 - March 1, 1986.

8. Dr. Rowntree traveled to Chicago to attend a CRSP Council meeting, March 27, 1986.

9. Dr. Donovan traveled to Washington, D.C., to attend a CRSP Council meeting, April 29, 1986.

10. Dr. Donovan traveled to Washington, D.C., to attend a CRSP Council Committee meeting on May 14, 1986.

Budget, Expenditures, and Matching Contributions:

Under the terms of USAID Grant No. DAN-4146-G-SS-5071-00, the sum of \$500,000 was budgeted for the period July 1, 1985 - December 31, 1986. An amendment in December, 1985, added \$600,000 to the CRSP, extending the period of performance to July 31, 1986. A further amendment in June, 1986, added \$200,000 to the CRSP, extending the period of performance to January 23, 1987. The total obligated funds of \$1,300,000 were allocated to the participating institutions, in accordance with guidelines of the Board, as indicated in the following table.

Budget Allocations
July 1, 1985 - January 31, 1987

	<u>USAID</u>	<u>Host Country Allocations</u>	<u>University Matching Contributions</u>
UMCEES/UCR (UCR Share)	\$ 301,036	(\$ 59,421 or 16.8%)	\$ 74,192
URI/UP (UP Share)	\$ 405,208	(\$ 97,714 or 24.1%)	\$ 91,480
UW/UCR (UCR Share)	\$ 405,208	(\$ 50,134 or 12.4%)	\$ 81,042
Management Entity	\$ 188,548		---
Total	\$ 1,300,000		\$ 246,714

Management Entity

Activities

In January, 1986, the Management Entity was notified that the Fisheries Stock Assessment CRSP would be funded at an \$800,000 per year level rather than the initially planned \$1,000,000 per year level. One consequence of this abrupt reduction in funding was that the universities involved incurred greater cost-sharing than that initially planned; this, of course, is temporary, and the universities will eventually reduce their contributions to accommodate the smaller research program. Actual expenditures plus encumbrances, U.S. university matching contributions, and host country contributions are summarized in the following table.

Expenditures, Encumbrances, and Matching Contributions
July 1, 1985 - June 30, 1986

	Actual Expenditures and Encumbrances (<u>USAID Funds</u>)	U.S. University Matching <u>Contributions</u>	Host Country <u>Contributions</u>
UMCEES/UCR	\$ 169,133	\$ 90,216	\$ 25,646
URI/UP	\$ 230,252	\$ 51,548	\$ 22,400
UW/UCR	\$ 259,943	\$ 60,385	\$ 21,767
Management Entity	\$ 102,605	\$ 29,550	---
	<hr/>	<hr/>	<hr/>
Total	\$ 761,933	\$ 231,699	\$ 69,813

The Management Entity employs a half-time Program Director, a half-time assistant, and a full-time secretary. In addition to ordinary supplies and office expenses, the Management Entity budget also covers the expenses of the Board meetings and associated travel, the expenses of the Technical Committee meetings and associated travel of host country representatives, and the expenses of the External Evaluation Panel, soon to be appointed. A detailed

Management Entity

Activities

accounting of the Management Entity expenses for the period July 1, 1985 -
June 30, 1986, is in the table below.

Management Entity Expenditures
July 1, 1985 - June 30, 1986

DIRECT COSTS

Salaries, Wages, and Benefits	\$ 55,701
Supplies, Materials, and Expenses	7,554
Travel - International	3,464
Travel - Domestic	1,693
Technical Committee	1,000
Board of Directors	<u>1,941</u>
 SUBTOTAL, Direct Costs	 71,477
 Equipment	 <u>3,424</u>
 TOTAL DIRECT COSTS	 74,777
 TOTAL INDIRECT COSTS	 <u>24,828</u>
 TOTAL COSTS	 \$ 102,605