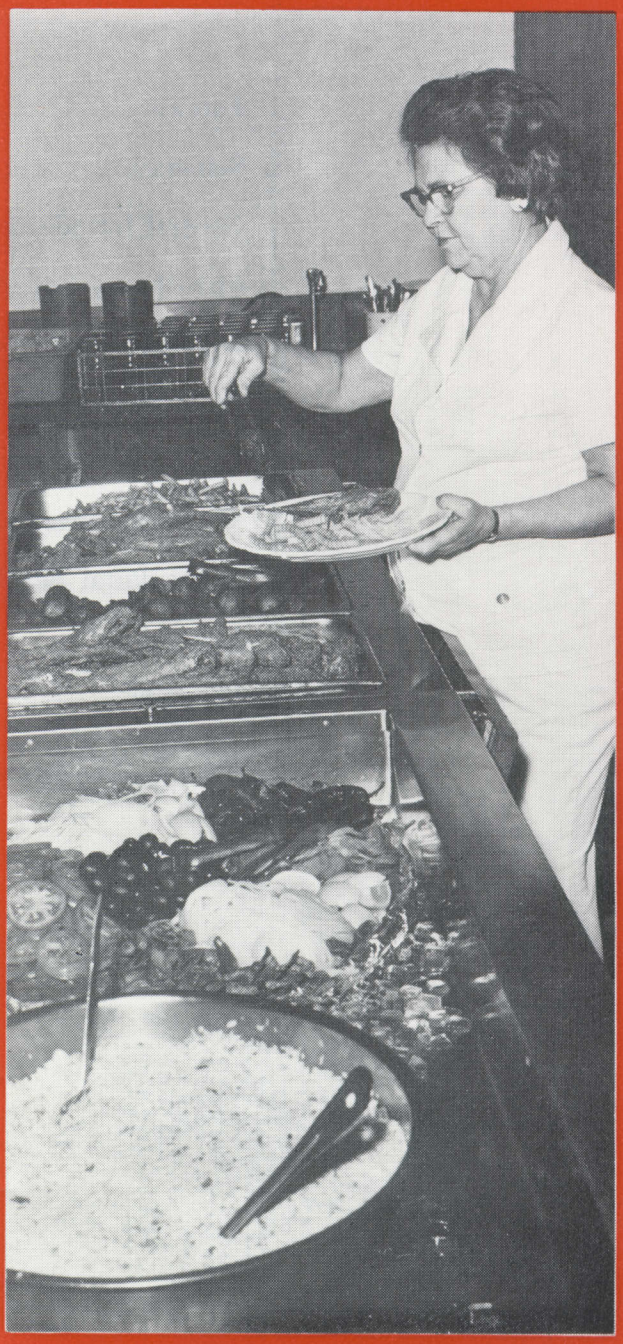
Research Needs of the Southern Region



Freshwater Foodfish (and crawfish)

April 1975

Aquatic Food Animal
Task Force RP 4.07

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FOREWORD

This Task Force (TF) report was prepared by a joint Task Force of Southern Region fisheries scientists from State Agricultural Experiment Stations, the Cooperative State Research Service (USDA), the Fish and Wildlife Service (USDI), the National Marine Fisheries Service (USDC), the Tennessee Valley Authority (TVA), the Kerr Foundation, and representatives of the producers and users of aquatic food animals or their products, especially representatives of Catfish Farmers of America and U.S. Trout Farmers Association. It is part of a larger and continuous effort of State Agricultural Experiment Stations (SAES) and the United States Department of Agriculture (USDA) to assure coordination of research studies, minimize duplication, and develop research priorities designed to achieve specific and defined goals. The goal of the Aquatic Food Animal Task Force has been defined as follows: "To assure an increasing supply of fishery products produced through aquaculture to meet growing world food demands in the face of leveling or declining supplies of fish from natural sources. This goal will be achieved through cooperative government, industry, and university efforts to provide critical research and services information and to assist and encourage public and private groups engaged in aquaculture."

In 1966, a National Program of Research for Agriculture, commonly called the Long-range Study, was conducted by representatives of USDA and SAES. As a followup to this, 32 national task forces were appointed to study problem areas and research needs related to their respective topics. Aquatic food animals were not considered in these national task forces. In the Long-Range Study, fish and wildlife species were considered as a natural resource and the culture of aquatic species for the purpose of producing food as a commodity was not considered. At the time, the National System of Classification of Agricultural Research was being developed, the Southern Association of Agricultural Experiment Station Directors officially petitioned that cultured aquatic food animals be classified equally with other animal commodities so that research efforts could be classified according to problem areas in the same manner as beef, dairy, swine, and poultry. This was not accepted, therefore, the "Manual of Classification of Agriculture and Forestry," which serves as a guide for CRIS (Current Research Information System), has research on aquatic food animals classified under Research Problem Area (RPA) 904. This RPA covers all wildlife including fish from the viewpoint of natural resources. In fact, the system excludes consideration of aquatic food animals under most Research Problem Areas that are concerned with problems of culture or husbandry of animals.

In order to identify research needs of aquatic food animals by problem areas, commodity exclusions called for in regard to fish in the Manual of Classification of Agricultural and Forestry Research was disregarded in this task force effort for research problem 4.07. This task force strongly recommends an official reclassification so that aquatic food animals can be treated as a commodity in CRIS. The culture of aquatic food animals faces the same range of problems as is faced by other animal commodities.

When the Southern Regional Agricultural Research Planning Committee designated Administrative Representatives for Southern Regional Task Forces, a USDA co-chairman for Aquatic Food Animals was not named. The SAES Administrative representative visited with the Administrator of ARS and the Administrator of ERS, and urged them to designate a USDA co-administrative representative. They both indicated that at present they did not have sufficient research input in aquatic food animal problems to justify taking a leadership role in a task force effort. In consultation with the Administrator of CSRS, the SAES Administrative Representative contacted USDI and USDC research administrators and extended an invitation to both of them to name co-administrative representatives. They accepted the invitation and each designated an appropriate administrative representative. These three administrative representatives defined the above goal and after considering the various species and systems of aquaculture production, elected to restrict the scope of this task force to research and service problems associated with freshwater culture of trout, catfish, carp/buffalo, others, and freshwater crawfish in the Southern Region. The "other" category would generally consist of, but not be limited to, species such as tilapia, white amur, and silver carp. Although the culture of freshwater crawfish is somewhat different from those of finfish, it is included in this task force report.

Solutions to some of the problems facing aquaculturists cannot be found through research alone. In these areas, the task force concluded that services must be provided through government efforts in order to achieve the overall goal in behalf of the public. Such services programs required in aquaculture include: statistical services, extension and advisory services, and consumer educational and marketing services. The service needed in these areas, and projected programs to meet these needs, are described in the body of this report.

Six writing committees were identified and provided with guidelines for completing their assignment. They were instructed to solicit help from other scientists and to identify individuals with experience in production, processing, or marketing of these species of aquatic food animals, so they could serve as "user" reviewers in the final review and assignment of priorities.

These six committees of the Aquatic Food Animal Task Force were as follows:

Fish and Parasites and Diseases (RPA 210, 211, and 212); Chairman, John Plumb, AES, Auburn, Alabama and Glenn Hoffman, USDI, Fish Farming Experiment Station, Stuttgart, Arkansas.

Pollutants and Toxins (RPA 213, 701, and 901); Chairman, Blake Grant, USDI, Southeastern Fish Cultural Laboratory, Marion, Alabama, and Claude Boyd, AES, Auburn, Alabama.

Production and Management (RPA 310, 311, 312, 313, and 317); Chairman, Harry Dupree, USDI, Stuttgart, Arkansas; James W. Andrews, AES, Skidaway, Georgia; Roland Reagan, AES, USDI, State College, Mississippi; R. Oneal Smitherman, AES, Auburn, Alabama; and Don Greenland, USDI, Stuttgart, Arkansas.

Product Development and Quality (RPA 409, 410, 411, 412, 702, and 703; Chairman, G. R. Ammerman, AES, State College, Mississippi; Tom Lovell, AES, Auburn, Alabama; and Melvin Waters, USDC, Pascagoula, Mississippi.

Marketing Research and Economics (RPA 506, 507, 508, and 511); Chairman, Charles A. Oravetz, USDC, Little Rock, Arkansas; Harold B. Allen, USDC, St. Petersburg, Florida; John E. Greenfield, USDC, St. Petersburg, Florida; Edward W. McCoy, AES, Auburn, Alabama; J. R. Russell, ERS, USDA, Griffin, Georgia; E. Evans Brown, AES, Athens, Georgia; and John E. Waldrop, AES, State College, Mississippi.

Aquacultural Services; Chairman, Harold Allen, National Marine Fisheries Service, USDC, St. Petersburg, Florida.

Crawfish (RPA All): Chairman, James W. Avault, AES, Baton Rouge, Louisiana.

Administrative Representatives: R. Dennis Rouse, State Agricultural Experiment Stations, Southern Region; Harold B. Allen, National Marine Fisheries Service, USDC; Harry K. Dupree, Fish and Wildlife Service, USDI.

Cooperative State Research Service, USDA: Earl J. Splitter.

User-Reviewer Committee

Henry Anthony, Chairman, Alice-Sidney Farms, Star Route 2, Lake Village, Arkansas, 71653; Porter Briggs, Executive Secretary, Catfish Farmers of America, Tower Building, Little Rock, Arkansas; James Coleman, Route 4, Yazoo City, Mississippi, 39194; Joe Glover, Farm Fresh Catfish, P.O. Box 188, Greensboro, Ala., 36744; Sam Hinote, ConAgra Fish Products, P.O. Box 9367, Jackson, Mississippi, 39206; Stan Hudson, Ozark Fisheries, Stoutland, Missouri, 65567; Tom Reed, Delta Corporation, P.O. Box 419, Belzoni, Mississippi, 39038; Dr. Paul Smith, Farm Fish Company, Route 1, Box 108A, Louise, Mississippi, 39707.

This is an initial effort of the Southern Regional Task Force on Aquatic Food Animals. Subsequent evaluations will be a basis for updating this report. Reviewers are encouraged to direct comments and suggestions to the most appropriate member of the Task Force or to the appropriate Administrative Representative.

Since this is an initial working document and it is expected to be updated, only a limited number of copies were printed. However, while they last, copies may be obtained from the Department of Research Information, Agricultural Experiment Station, Auburn University, Auburn, Alabama.

SUMMARY

SOUTHERN RESEARCH PLANNING PROGRAM—RESEARCH PROBLEM AREA 4.07 FRESHWATER FOODFISH AND CRAWFISH

RPA	Problem Title	Priorities[1] Short/ Long	SMY 1974 Base	SMY Recommended 1975	SMY Recommended 1980
	FRESHWATER FOODFISH RESEARCH				
	Fish diseases and parasites				
210	Control of external parasites of fishes	1/2	1.60	2.00	3.00
211	Control of microbial diseases of fishes	2/1	5.25	3.00	3.00
212	Control of internal parasites of fishes	2/2	0.50	.50	1.50
	Subtotal		7.35	5.50	7.50
	Pollutants and toxins				
213	Protection of cultured aquatic animals	1/2	1.30	1.80	1.30
701	Clearance of chemicals for aquaculture	1/1	0.20	2.55	3.50
901	Water quality management	2/1	3.60	3.60	7.50
	Subtotal		5.10	7.95	12.30
	Production and management				
310	Reproductive performance	4/4	1.60	1.60	3.00
311	Improvement of biological efficiency	1/1	11.10	14.90	20.00
312	Environmental stress in production	1/3	2.17	3.00	3.00
313	Production management systems	3/2	5.25	0.00	4.00
317	Mechanization and structures	2/3	2.00	0.00	2.00
	Subtotal		22.12	19.50	32.00
	Product development and quality maintenance				
409	Production of fishery products with improved acceptability	1/1	0.95	0.95	2.50
410	New and improved fishery food products	2/1	1.55	1.00	3.50
411	New and improved non-food fishery products	2/3	0.70	0.70	1.50
412	Quality maintenance in marketing fishery products	2/4	1.00	1.00	2.20
702	Protect food and feed supplies from harmful organisms and toxins	1/1	0.80	0.80	1.50
703	Food choices, habits and consumption	1/1	0.00	1.00	2.00
	Subtotal		5.00	5.45	13.20
	Market research and economics				
506	Supply, demand, and price analysis of animal products				
	Demand elasticity for aquatic food animals in selective markets	1/1	0.00	0.00	1.50
	Economic analysis of aquacultural production and processing	2/2	1.28	1.28	1.50
507	Competitive interrelationships in agriculture	3/3	0.03	0.50	.50
508	Development of domestic markets for aquaculture products	1/1	1.30	2.00	4.00
511	Improvement in aquacultural statistics	1/1	0.30	0.30	2.00
	Subtotal		2.91	4.08	9.50
	Freshwater Food Fish Totals		42.48	42.48	74.50
	Increase		------	------	32.02
	AQUACULTURAL SERVICES				
	Marketing services for aquatic food animals	1/1	0.85	0.85	2.00
	Statistical reporting services for aquatic food animals	2/2	2.00	2.00	2.00
	Information and technical assistance to food fish producers	1/1	4.00	4.00	6.00
	Service Totals		6.85	6.85	10.00
	Increase		------	------	3.15
	CRAWFISH				
	Production and management				
311	Improvement of biological efficiency	1/1	0.25	0.25	3.00
313	Production management systems	2/2	0.00	0.00	0.50
317	Mechanization and structures	1/1	0.00	0.00	0.50
	Product development and quality maintenance				
409	Production of products with improved acceptability	2/2	0.00	0.00	0.25
	Marketing research and economics				
506	Supply, demand and price analysis	1/1	0.00	0.00	1.00
	Total		0.25	0.25	5.25
	Increase		------	------	5.00

[1] Priorities are shown as short form/long form and are expressed on a scale of 1 to 4, with 1 as the highest priority: short term—problems needing immediate effort; longterm—problem needing long term effort or problems whose solution is less urgent to the industry, but will require effort in the next 5-10 years.

FRESHWATER FOODFISH (and crawfish)

Research Needs in the Southern Region Aquatic Food Animal Task Force Report 4.07

GENERAL INTRODUCTION

Present world production of aquatic food organisms, plants, and animals are estimated to be in excess of 5,000,000 metric tons, about twice the United States landings of fisheries products, (NOAA). Present world production of fish through aquaculture is double that of five years ago and the FAO has estimated that a 500 percent increase over present levels can be achieved by 1985. There are indications that the United States will have to become more and more dependent on aquaculture as a source of fish. The climate and topography of the Southern Region suggests that many acres would be suited to aquaculture production. All indications are that with a greater research base to reduce uncertainty and increase efficiency, freshwater aquaculture production in the Southern Region will become a major supplier of fish. A production exceeding one billion pounds of fish food products of the species covered by this report can be easily supported. If this were achieved, the present production of less than 100 million pounds would have been increased more than ten-fold. This could be achieved by better utilization of available water in land and water areas that are presently productive only as a habitat for wildlife.

This tremendous potential for animal protein production, for employment of people, and for better land and resource utilization justifies the effort of this task force in identifying and assigning priority to needed research. With such an opportunity, every effort must be made to bring a maximum research effort to bear on aquaculture. This task force is dedicated to this purpose!

FISH DISEASES AND PARASITES

Introduction

Diseases of fish reared for human consumption are not greatly unlike those of conventional livestock. Cultured fish are affected by viral, bacterial, ecto- and endoparasitic organisms, many of which may be devastating to fish crops.

Viral diseases affect young fish and under certain conditions may kill up to 100 percent of the infected stock. There is no chemotherapy for viral diseases; the only control is through avoidance of exposure of non-infected susceptible fish to virus infected populations, prevention by using virus-free adult fish as egg sources, and proper management to reduce stress conditions.

Bacterial diseases may be specific to certain fish families or they may be nonspecific. Some pathogenic bacteria are obligate pathogens while others are normally free-living in the water. Poor environmental conditions are often precursors of microbial disease outbreaks; low oxygen, adverse temperatures, crowded conditions, accumulation of metabolites and organic matter in the water, pH, and hardness are thought to be some predisposing factors which affect disease susceptibility. Studies which correlate these environmental anomalies with certain diseases may lead to means of predicting outbreaks which would allow preventive measures prior to epizootic conditions.

Ectoparasites flourish in some waters, and if unchecked may kill a large percentage of the fish stock. Some of these parasites are host specific and others are not. Such parasites get into fish culture systems via contaminated water supplies, transfer of asymptomatic infected fish, or non-fish vectors.

Some internal parasites are devastating to fish stocks while others cause moderate debilitation. Some are unsightly, resulting in the fish being rejected by the consumer.

Chemotherapeutics and drugs are available for many bacterial and parasitic diseases, but some of these materials have marginal efficacy or are not approved by regulatory agencies for use on food fish. Improved methods of disease therapy would increase production on many fish farms.

Title: Control of external parasites of fishes.

Priorities: Short term 1; Long term 2.

Objectives: To develop more economical and effective therapeutics for external parasites and work towards approval of these compounds by government regulatory agencies; to elucidate the epizootiology and environmental requirements of ectoparasites; to improve diagnostic procedures for subclinical infestations, particularly *Ichthyophthirius.*

Situation Evaluation: There are many external protozoan and helminth parasites that cause diseases of fish. Most of these organisms are ubiquitous and only under certain conditions cause fish losses. The protozoan, *Ichthyophthirius* is probably responsible for the greatest loss and is the most difficult to control.

Intensive culture of food fishes often provides an environment where external fish parasites may flourish, resulting in high production losses. In some cases disease organisms are introduced through the water supply or by intermediate vectors, but in other cases parasites are introduced on the stocked fish. When fish are transferred from farm to farm, parasites may be transferred undetected on asymptomatic fish. Many diseases of fish cannot be completely eradicated and detection of subclinical infestations or a carrier state is difficult. Although broad spectrum therapeutics are currently used, none gives 100 percent control. More economical and efficacious control measures and reliable diagnostic procedures are necessary. The lack of knowledge of the epizootiology and environmental requirements of some ectoparasites complicates their control. Development of therapeutic resistance by some ectoparasites has not been investigated.

Research Approaches: Better diagnostic procedures are needed in some cases where partially immune carrier fish occur; it is likely that zenodiagnostic (test fish) and immunologic procedures can be developed. Although there are effective chemotherapeutics available for some external parasitic diseases, their use on food fish is negated by governmental restrictions. Much work is needed to clear the use of these chemicals through EPA, FDA, and USDA. More efficacious and economical therapeutics are needed and a screening program for efficacy and practicality should be developed for chemicals and systemic drugs. New and old chemotherapeutic methods should be tested in water re-use culture systems. Some attention should be given to research on the development of resistant fish stocks through hybridization and selective breeding.

Priority: Development of more efficacious and economical therapeutics is needed for control of external parasite infestations. The presently used therapeutics and new compounds must be approved by the Food and Drug Administration for use on aquatic food animals. The relationship of environmental conditions on external parasitically induced epizootics is of primary concern. Improved diagnostic procedures for subclinical infestations are also important.

SMY Distribution

RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
210	1.60	2.00	2.50	3.00

Title: Control of microbial diseases of fishes.

Priorities: Short term 2; Long term 1.

Objectives: To evaluate the effects of "stress" and physiological conditions on viral and bacterial disease susceptibility; to develop techniques for identifying pathogen carrier fish in asymptomatic populations; to identify the major viral and bacterial agents that cause diseases of cultured fishes, and to develop more efficacious and economical therapeutics for their control; to determine variation of disease susceptibility in different strains of fish.

Situation Evaluation: Increased operational costs have resulted in demand for higher fish production per culture unit. The means for obtaining higher production per unit often lead to environmental deterioration, results in greater physiological stress on the fish and is thought to render them more susceptible to diseases. It is not known exactly how these conditions stress fish and what physiological changes actually take place that result in greater disease susceptibility. In order to prevent diseases of fish, scientists must know what environmental factors are actually involved.

A number of bacterial diseases of fish are known, but periodically there are instances where new or previously unknown organisms are associated with fish mortalities. These organisms must be identified and their pathogenicity studied. There are only a few chemotherapeutics, some with questionable efficacy, that can be used to treat diseased food fish. More efficacious and economical therapeutics should be developed and progress made toward their approval from regulatory agencies for use on food fish.

Many microbial diseases of fish only occur in epizootic proportion at certain times, usually when fish are stressed, or when the environment favors pathogen over host; at other times their presence is difficult to detect. This is true of furunculosis, columnaris, and channel catfish virus disease (CCVD). Columnaris is of particular concern in fish culture ponds in the southern U.S. and the effects of acute or chronic low oxygen and other stresses of this disease, along with effective controls, must be defined.

Only two virus diseases are known to seriously affect fish in the southern U.S.; infectious pancreatic necrosis (IPN) of trout and CCVD of channel catfish. Others may be introduced into the area and monitoring for such viruses must be routinely done. Identification of IPN carrier populations is done by appropriate sampling techniques, however, at present, CCV is impossible to detect in a carrier state, which may serve as a reservoir for infections. A concerted effort towards elucidating the carrier state in post CCV epizootic catfish populations is of primary importance.

There is evidence that a difference in susceptibility to diseases may occur between homo-and heterogenetic strains of channel catfish; this aspect should be further explored to determine if the differences are significant in improving production.

Research Approaches: The effects of environmental stresses on susceptibility of fish to diseases would be done in culture units where various conditions such as temperature, oxygen level and metabolites could be monitored. Parameters measured for evaluating the conditions of fish would include hematocrits, hemoglobin, presence or absence of specific antibodies, and growth rate. Under various environmental stresses the fish would be challenged by different pathogenic microorganisms.

Pathogenesis and histopathology of newly described diseases would be experimentally determined in susceptible hosts. Accepted and new therapeutics would be tested against described and new pathogens and experimental design would be directed toward governmental approval.

Detection of carrier states for bacterial and viral disease agents would start with extensive sampling of cultured fish populations known to have been exposed to various diseases. Application of currently acceptable assay methods would be followed by experimental infection of populations and

determining the pathogenesis of the disease. Fluorescent antibody, selective media, antibody assay, specialized tissue culture techniques, and electronmicroscopy are some techniques that may be used in detecting carrier animals.

Homogenetic and heterogenetic strain susceptibility to diseases would be closely correlated with cultural characteristic studies. Comparison of susceptibility would necessitate experimental challenge by known amounts of pathogens by several routes of infection and under controlled environmental conditions.

Priority: The effects of stress, physiological and environmental conditions on disease susceptibility are of primary importance. Development of diagnostic techniques for identifying pathogen carrier fish in asymptomatic populations is desperately needed. A vigorous effort to develop more efficacious and economical therapeutics, and methods of treating bacterial diseases should be carried out. The variation of disease susceptibility between strains of fish is of lesser importance.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
211	5.25	3.00	3.00	3.00

Title: Control of internal parasites of fishes.

Priorities: Short term 2; Long term 2.

Objectives: To develop methods of control for sporozoan protozoa, unsightly helminths, and certain systemic fungi of cultured fishes; and to study the epizootiology of internal parasitemias.

Situation Evaluation: Intensive pond culture of fishes may cause the accumulation of internal parasites in the fish culture system; this is particularly true of myxosporidians and microsporidians. Certain nematodes, trematodes and cestodes may also accumulate in the system if the proper intermediate hosts are present. Factors favoring development of intermediate hosts are not well known; if these factors were known, control of intermediate hosts could probably be accomplished through subtle changes of the environment, rather than drastic chemotherapy of the host.

Research Approaches: More research on therapy of endoparasites is needed. It would be appropriate to isolate and culture the sporozoa, and to attempt to infect fish under a variety of circumstances. The transmission of most myxosporidians should be determined experimentally; production of infective spores may be more involved than simple aging of the spores. The intermediate hosts of dangerous helminths should be determined and factors involving the development of those hosts investigated. A greatly expanded histopathology program is needed to help understand the pathogenesis of these diseases and to help assess the damage they cause.

Priority: Control methods of sporozoan protozoa and unsightly helminths of catfish and trout are needed. The study and understanding of the epizootiology of internal parasitemias is essential for control.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
212	0.50	0.50	0.50	1.50

POLLUTANTS AND TOXINS

Introduction

Regard for pollution in aquaculture includes (1) problems resulting from unintentional contamination of water and artificial diets with economic poison and agricultural and industrial chemicals; (2) the need for "fishery" chemicals that are purposefully applied to water in aquacultural practices; (3) acceptable controls over water discharges from fish farming operations; and (4) maintenance of acceptable water quality in aquaculture systems.

Unintentional contamination varies from low concentrations of persistent organochlorines such as the polychlorinated biphenyls and DDT analogues and isomers to relatively high concentrations of organochlorine insecticides such as toxaphene and, to a lesser extent, endrin around cotton farming. Fish kills result from accidental spills, careless applications, and irresponsible discharges of these and other economic poisons and industrial chemicals.

Pesticides and other chemicals also pose less obvious problems to aquaculture when magnitude, application method, location, time, or lack of containment present high probability for water contamination. Contamination at levels less than that causing immediate kills is also recognized as potentially damaging. Fish exposed to contaminated water may accumulate residues to harmful levels that can decrease productivity, produce off-flavor, or be a health hazard as food for man or other animals. Several trace organics are concentrated as high as 100 thousand-fold over levels in water. These trace contaminants also accumulate in fish via natural forage and artificial food.

A contrasting concern for pollution in aquaculture results from intentional application of "fishery" chemicals to water when residues and adverse biologic effects may occur in non-target species. Various acceptable chemicals are needed in fish culture, but few are registered for aquatic use or comply with the Food, Drug, and Cosmetic Act or the Federal Environmental Pesticide Control Act. In most cases, no monetary incentive exists for their development by industry, which includes generating data on safety, efficacy, toxicity, residue dynamics, and carcinogenicity, teratogenicity, or mutagenicity. These needed chemicals include biocides (parasiticides, herbicides/algacides, insecticides, piscicides, etc.); therapeutants (bacteriostats, fungistats, antihelmintics, etc.); stimulants (growth, reproduction, etc.); and other chemicals including attractants, repellents, fertilizers, anesthetics and tranquilizers. Clearance and registration of these "tools" have broad economic scope and public interest.

Better techniques for maintaining acceptable water quality in culture systems will allow high production and minimize risks of fish kills from water quality deterioration. Finally, methods for treating effluents must be developed to satisfy new restrictions on effluent discharge.

Title: Protection of fish and other cultured aquatic animals from toxic chemicals in food and water.

Priorities: Short term 1; Long term 2.

Objectives: To evaluate residue dynamics and biologic impact of toxic chemicals in fish.

Situation Evaluation: Several groups including the EPA, Fish and Wildlife Service, NMFS, and others have ongoing research of pollution ecology. But the main emphasis of their research is not directed toward assessing biologic impacts and residue dynamics of cultured aquatic species. Their research does not necessarily exclude "domestic" spe-

cies, but a more concentrated effort with emphasis on intensely cultured species is needed. For example, information is available on accumulation rates, toxicity, and sublethal effects of several pesticides and industrial chemicals in a few key species. This allows general predictions of how a organic will behave in an aquatic ecosystem. General predictions, however, are not satisfactory when production of marketable products for human consumption demands finite estimates of toxic residues in consideration of human health. Economic assessment also requires finite estimates of tonnage loss through growth inhibition or mortality.

Collateral information from research described herein will help in developing practical methods of reducing levels of toxic chemicals from water and natural or artificial food to prevent or reduce actionable residue levels in fish to be marketed. Related criteria are needed to eliminate toxic substances in construction materials used in or near fish holding systems.

Research Approaches: Controlled applications of toxicants, such as pesticides, industrial chemicals, and when appropriate, their metabolites may be given to fish or fish forage to evaluate tolerance limits and residue accumulation/disappearance rates. Standard procedures that are available for a few species can be used or modified as necessary to accommodate catfish, trout, other fish and fish forage invertebrates. Effects on reproduction or complete life cycle studies in controlled environments can be undertaken. Sublethal effects on other physiologic functions, i.e., dysfunction of adaptive mechanisms in disease challenges, thermal shock, and other environmental stresses can be assessed. Lowered tolerance of standardized stress challenges, body residues, impaired reproduction, reduced growth, etc. can be correlated with contact exposures and dosing via diet to determine maximal levels of environmental pollutants that can be tolerated in fish production.

Priority: Increasingly greater use of water for food production in highly agricultural areas requires safe and efficient use of biocides and other synthetic compounds having biologic activity. Criteria for safe use are yet to be established for the few main chemicals used in the south.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
213	1.30	1.80	2.60	1.30

Title: Clearance and registration of chemicals for aquaculture.

Priorities: Short term 1; Long term 1.

Objectives: To provide background information on efficacy, safety, residues, toxicity, carcinogenicity, etc. necessary for registering fishery chemicals.

Situation evaluation: Current efforts to register aquatic chemicals are progressing slowly. The Fish and Wildlife Service, Bureau of Reclamation, Agricultural Research Service, and U.S. Corps of Engineers have mutual interest in several herbicides/algaecides. They cooperate and support registration studies on a limited basis.

Since the implementation of the Federal Environmental Pesticides Control Act, the use of many chemicals in fish culture has been rendered illegal. Some are indispensable for achieving high success in fish cultural operations, while other chemical agents, such as growth and reproduction stimulants, attractants, fish sterilants, etc., could increase productivity and reduce costs.

The IR-4 Committee helps to register minor-use pesticides and may provide support in processing information as a collective body.

Research Approaches: The FDA and Pesticides Regulation Division of the EPA provide general guidelines for generating efficacy, safety, residue, carcinogenicity, and other data to support registration. Many immediate research needs could be conducted in existing programs as a collective endeavor, if they were organized, coordinated, and funded with sufficient "seed" money.

Ancillary information to be derived from research described herein can lead to development of biologic or integrated controls in lieu of strictly chemical methods. Practical means of detoxifying treated water and aquaculture systems can be related developments. Research and development of "new" fishery chemicals should proceed along lines of anticipating residue and toxicity problems. That is, it initially should exclude those kinds of compounds having propensity for bioaccumulation and narrow margins of safety between target and non-target organisms.

Priority: Several chemical agents need to be registered immediately to preserve the present state of fish production. These include several herbicides, prophylactics, bacteriostats, a broad spectrum antibiotic or combination of antibiotics, an anesthetic, and several parasiticides. Other chemical agents have lower priority but their research and development is almost completely lacking. Their priority may be judged by their potential for increasing production at greater economy.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
701	0.20	2.55	3.00	3.50

Title: Water quality management.[1]

Priorities: Short term 2; Long term 1.

Objectives: Develop techniques for preventing fish mortality after water quality deterioration, predicting water quality problems, maintaining high quality water, and reducing enrichment or other pollution in aquaculture effluents.

Situation Evaluation: In static ponds, particularly those receiving daily feeding, nutrients from uneaten feed and excreta frequently cause excessive phytoplankton production. A number of problems, including odors, off-flavor in fish, presence of toxic substances, and shallow chemical and thermal stratification have been attributed to excessive production of blue-green algae. Furthermore, under certain conditions blooms of blue-green algae suddenly die and their decomposition leads to oxygen depletion and fish mortality. The production of fish is limited by the amount of feed which can be added to ponds without development of potentially dangerous algae problems. Chemical, biological, or mechanical means of reducing phytoplankton production would permit increased production and reduce risks. Accurate prediction of phytoplankton die-offs would allow prophylactic treatment and prevent fish mortality. The risks of oxygen related fish kills in ponds could be further reduced with better techniques for supplying supplemental oxygen during periods of oxygen stress.

Flowing water cultures, either in ponds or raceways, are dependent upon large volumes of high quality water. As this water passes through the system, its quality progressively deteriorates. In many situations effluents from the

[1] Research covered under RPA 901, Alleviation of soil, water, and air pollution and disposal of wastes.

lower end of flowing water systems are simply discharged to the environment. However, to reduce pollutional aspects of flowing water cultures and effect more efficient use and re-use of water, better techniques for reclaiming and recirculating spent water are needed.

Recent action by the Environmental Protection Agency requires effluents from cultures to meet certain water quality standards. Careful studies are needed to supply data upon which to formulate realistic water quality criteria for effluents. Techniques must be quickly developed for improving water quality in cultures and minimize treatment of wastes. Furthermore, economical means of treating effluents will be necessary in some situations. This aspect is probably of the highest short-term priority to the fish farming industry.

Research Approaches: Short-term emphasis should be given to monitoring the quality of water discharged from various types of cultures. These data should be evaluated to establish realistic water quality criteria. Economical waste treatment techniques should be adopted from other applications or developed specifically for fish culture operations.

Problems of excessive phytoplankton production, oxygen depletion, and reclamation and reuse of water should be assigned high long-term priority. Research should be conducted in ponds and raceways which are comparable to those used by fish farmers. Investigations should include: (1) causes of blue-green algae blooms, (2) causes of phytoplankton die-offs, (3) methods for predicting phytoplankton die-offs, (4) supplemental methods for supplying oxygen to ponds, (5) chemical control of excessive phytoplankton, (6) biological and mechanical means of reducing excess phytoplankton, (7) methods for reclaiming effluent discharge for re-use, and (8) waste treatment of effluents prior to discharge to natural waters.

Priority: The quality of water in culture systems decreases as standing crops of fish increase and upper limits of fish production are imposed by failure to maintain adequate water quality. Sudden deterioration of water quality may result in fish mortality and serious economic loss. Improved techniques for maintaining water quality would allow greater production in cultures and minimize economic risks. Furthermore, effluents from cultures with high quality water would be less concentrated with pollutants and thus waste treatment cost would be minimal.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
901	3.60	3.60	3.60	7.50

PRODUCTION AND MANAGEMENT

Introduction

More efficient production and management of freshwater fish for food is essential if fish farming is to achieve a status equal to that of other types of animal husbandry. Research programs patterned after those in animal husbandry should achieve similar advances, but the unique situation of fish living in water presents special problems of feeding, environmental quality, and harvesting.

Improved breeds with fast growth, efficient feed conversion, and ability to tolerate environmental conditions of intensive culture are urgently needed. Additional knowledge of feed formulation, nutrient utilization, and metabolism would be useful for developing more effective production. Research on control of environmental quality and waste removal from water are especially important before other advances can be placed into management practices. There is need for increased production and knowledge on regulating, handling, harvesting, and transporting large numbers of live fish.

Physiological functions are similar for all animals including fish. However, fish are "cold blooded" animals and acquire a body temperature almost identical to the environment. These differences in body temperature affect "metabolic rate," which becomes slower in winter than in summer. The fishery researcher recognizing these inherent species and physiological differences can utilize scientific literature on nutrition, breeding, pollution, pesticides, and stress, and apply these findings to interpret particular fishery studies. In contrast, there is no similarity between fishery production techniques and harvest and those used in farm animal husbandry. The fishery researcher must develop equipment, facilities, and techniques with little or no assistance from the agricultural literature.

The objective of this task force is to identify high priority problems; then to elicit investigation to provide a base of knowledge for reliable management practice. Fish husbandry is still in its infancy and properly applied management should raise production, increase efficiency, improve product quality, and thus assure the further expansion and prospering of the fisheries industry.

Title: Reproductive performance.

Priorities: Short term 4; Long term 4.

Objectives: Determination of the genetic bases and environmental limitations for optimum reproduction of commercially cultured fishes, and the development and improvement of methods for artificial reproduction.

Situation Evaluation: Controlled reproduction is a necessary feature of any type of efficient animal husbandry. It is particularly important in fish culture since we wish to increase reproductive potential in some cases but in others to limit it. In cold water culture (trout and salmon) increase of reproductive potential is an appropriate goal, whereas in some warmwater species (e.g., tilapia) that reach sexual maturity in a few months, reproduction must be limited so that the production of harvestable-sized fish is not impaired by excessive spawning.

Some species that have a short culture history and long generation interval (e.g., paddlefish) can only be reproduced by using wild fish collected during natural spawning. This is obviously a serious impediment to the efficient culture of these species.

Many environmental factors effect the number of eggs produced by a female fish, and the survival and hatching success of the embryos. These factors range from thermal shock to bacterial and fungal diseases of developing eggs. Mitigation of known deleterious factors relies on improved management of broodstock and hatching facilities; others are more problematic and require in-depth study.

Hormonal controls and influences on reproduction are not fully understood for any species of fish. Pituitary extracts and human chorionic gonadotropin effectively induce maturation and ovulation in some species but their usefulness in artificial spawning of other species is not known.

Optimization of reproduction through genetic techniques is virtually untapped, aside from trout and salmon. Many cases of decreased fecundity of broodstock and increased deformities of fry have been attributed to excessive inbreeding in the broodstock. Solution to these problems is one of improved management of the broodstocks. Problems relating to an overall genetic selection program may be somewhat more resistant to solution. Some species (e.g., catfishes, paddlefish) have a relatively long generation interval. This long generation interval retards progress in selection programs. There is no satisfactory technique for long-term storage of fish sperm, therefore a breakthrough in this area would provide researchers with a powerful tool in genetics selection research.

Research Approaches: The development of techniques for spawning in captivity of those species where this is presently impossible would be the first step in culturing these species. In species whose culture is well developed, study of environmental and physiological limitations of spawning would provide information necessary for the reproduction of optimum numbers of offspring for each culture situation. Genetic studies, such as; reduction in age at maturity, increased and decreased fecundity, inbreeding depressions, gynogenesis, and long-term sperm preservation are needed. Control of sex using sex reversal or gynogenesis would provide a tool for complete elimination of reproduction.

Priority: The development of broodstock management techniques to reduce effects of inbreeding depression are needed immediately. Other management procedures for broodstock and hatching facilities are also needed. The genetic research is of a long-term nature and should be initiated as soon as possible.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
310	1.60	1.60	1.60	3.00

Title: Improvement of biological efficiency.

Priorities: Short term 1, Long term 1.

Objectives: To establish nutritional requirements and their interactions with feeding additives for growth of fishes; to determine nutrient availability and improve utilization, especially for protein; to develop more effective feeds for specific environmental conditions, and more economical feed delivery systems; to evaluate hereditary influences on fish production and apply this knowledge toward achieving improved strains, and management of breeding stocks.

Situation Evaluation: Compared to the wealth of information on nutritional requirements and genetic parameters in livestock and poultry, little is known on these biological factors in fish. Knowledge of the utilization of individual nutrients and the effects of hormones or other additives to feed is fragmentary and of little predictive value in formulating more effective fish feed. Protein and fat, which make up the most expensive portion of the ration, is of particular concern. Rapidly changing feed sources and prices result in substitution of ingredients with little knowledge of effects on feed quality. Environmental conditions, especially temperature, effect fish to a greater degree than livestock, but how this relates to nutritional needs is poorly understood and not generally considered in management. Fish feed is modified animal feed; needed are major innovations to improve delivery, water stability, and availability to fish. Current feeding systems are only partially mechanized.

Undeveloped wild stocks and nominally domesticated fish are now used in culture. Programs of artificial genetic selection and strain development are planned. Most fish are highly variable in growth and viability, which suggests the possibility for rapid progress in selective breeding. However, almost no information correlates genetics or heritability with variable factors. Fish culture practices leads to inbreeding, the effects of which are unknown. Better mating systems and improved management of breeding stocks are needed. Information on the relationships of nutrition and genetics is essential for the development of fish farming into a major food production industry.

Research Approach: Improved biological efficiency would be achieved with more information on nutritional requirements, digestion, and metabolism. Not to be overlooked is effect of nutrient composition and biological availability as affected by feed preparation and storage. Identification of amino acid requirements, evaluation of the utilization of synthetic amino acids, and isolation of growth factors in fish meal not present in plant protein would lead to improved feed formulations. Further definition of dietary requirements for vitamins, minerals, lipids, and effects of hormones and therapeutics in feed would be made. Optimizing dietary protein and energy levels under specific environmental (i.e. temperature) conditions and determination of nutrient availability in various feedstuffs would lead to development of least-cost formulae for fish feeds. Modifications in feed processing and feed systems with a goal of improving delivery, increasing consumption, reducing wastes, and lowering labor costs would improve the economics of fish farming.

To develop a genetic basis for improving strains of fish through selective breeding, heritability and genetic correlation of the different economically important traits in catfish, trout, and other commercial species would be studied. Investigation of inbreeding, methods of selection, methods of mating, and other aspects of reproduction would relate to operational breeding. Information derived from these studies will serve to maximize efficiency in fish production, and in addition, improved strains of fish would be available to fish husbandrymen.

Priority: Improvement of efficiency in production has immediate pay-off by increasing the economic return to fish farmers with little increase in costs. Basic knowledge of fish nutrition will allow use of cheaper feed ingredients and better yields. Development of improved strains of fish has potential to revolutionize fish husbandry just as improvement of chickens changed poultry husbandry. This research has priority because of the favorable ratio between program costs and potential economic return.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
311	11.10	14.90	14.90	20.00

Title: Environmental stress in production.

Priorities: Short term 1; Long term 3.

Objectives: Definition of factors within the freshwater environment which compound stress upon farm-raised fishes and crustaceans; development of systems which minimize stress in intensive culture.

Situation Evaluation: The metabolism and growth of "cold blooded" aquatic animals varies according to the temperature of the water. An optimum temperature range exists for each species and temperatures outside this range result in stress and inefficient conversion of feedstuff to fish flesh. In addition rapid temperature changes within the optimum range may result in stress whereas more gradual changes

would allow adjustment. Optimum temperatures have not been established for many culturable species and relationships between temperature and other stresses are not completely understood.

Inadequate dissolved oxygen, or high concentrations of carbon dioxide and nitrogenous compounds often produce respiratory impairment, causing poor feeding efficiency and resulting in further organic fouling of the culture medium. Stressed fish may refuse feed for several days, and the accumulated uneaten material stimulates excessive algae production. Overabundant algae intensify stress because it causes extreme diurnal fluctuations of oxygen concentration, and certain blue green algae are directly toxic to fishes. Control of algae is possible with biological or chemical methods but these are not generally utilized by the fish husbandry industry.

Resistance to disease is lowered by stresses. Aquatic animals are also predisposed to disease by handling, and are particularly susceptible to bacterial infections once the mucous-covered epithelium is broken. Certain species of fish undergo "shock," apparently fright-related, when handled. Many never recover, or develop other disease symptoms. The physiological basis of handling stress and shock are inadequately known.

Intensively cultured fishes, stocked at densities much greater than in the wild, must adapt to crowded conditions. Certain species do not adapt well, and disease organisms and parasites are transmitted more readily in the confined medium where other stresses may have predisposed them. Crowded fish secrete organic chemicals into the water which depress cardiac function and inhibit growth. Culture systems with apparent physical advantages actually increase stress. Raceway culture, especially that with units in series, accumulates metabolic products. The fishes in down-stream units grow more slowly and convert food less efficiently, for reasons that are poorly understood. In cages and raceway culture the artificial diet must be a nutritionally complete one, since natural foods are largely excluded from the fishes intake.

Research Approaches: Upper and lower tolerance limits, and optimum range of temperature for growth should be established for exotic species under consideration for culture. Comparisons of oxygen requirements should be conducted for carps, buffalo, tilapias, paddlefish, and others planned for polyculture in intensively managed systems. Evaluation of these fishes' ability to consume detritus, waste feed, algae and other undesirable byproducts of intensive culture should be made. Artificial aeration systems should be developed. Genetic selection, and cross breeding of species, should be made to discover lines of fishes more tolerant of the stresses produced by intensive cultures. The physiological causes and effects of shock and crowding should be studied.

Priority: The development of efficient and economical artificial aeration and destratification systems is of great importance for intensive production. It has often been noted that disease is rare and food conversion and growth are good in well-oxygenated systems. At present, fish culture is highly dependent for oxygen upon the photosynthesis of natural algal populations. Given the relative unpredictability of algal die-offs, safeguards against stresses of oxygen depletion are needed.

	SMY Distribution			
RPA	1974 Base	1975 No Increase	1975 10% Increase	1980 Recommended
312	2.17	3.00	3.00	3.00

Title: Production management systems.

Priorities: Short term 3; Long term 2.

Objective: Development of productive methods based on sound principles, including computer simulations, requires identification of key parameters and establishment of their interrelationships in order to provide effective management choices relative to fish production.

Situation Evaluation: Culture of freshwater fish for food promises to become a major agricultural industry. In its beginning fish farming was a sideline and management was interrelated with other husbandry to make better use of irrigation water, farm labor, stock ponds, marginal land, etc. Management alternatives were simple, and evaluated and selected according to monetary return under existing circumstances. These alternatives are no longer valid with today's competitive conditions, high feed costs, larger production units, EPA regulations, and labor costs. Fish producers in the past considered protein levels in feed, stocking levels, size of stocked fish, length of growing season, size of fish at harvest, and methods of processing in his management decisions. However, with today's knowledge, species utilized, use of aeration equipment, mechanized equipment, year-around harvest, and other alternatives must also be considered. Agriculturists incorporating fish production into a complete farming operation are faced with still more alternatives. Integrated information is generally not available to fish producers in a form whereby management decisions can be determined rationally. Future expansion of the fish husbandry industry, combined with more sophisticated knowledge of biological systems, is likely to compound this problem.

Research Approach: Solution of current and future problems requires an inventory of information on all parameters related to freshwater fish production. Evaluation of information and demonstration of relationships between components is essential for arriving at integrated management systems. Alternate integrated systems will be compared under field conditions.

Priority: Management of fisheries production can be improved with detailed knowledge of component parts and overviews of their interactions. There is urgent need to identify significant deficiencies in knowledge and to integrate present information on fish production systems. It is essential that technology be made available to fish farmers in a readily understood and usable form.

	SMY Distribution			
RPA	1974 Base	1975 No Increase	1795 10% Increase	1980 Recommended
313	5.25	0.00	0.00	4.00

Title: Mechanization and structures.

Priorities: Short term 2; Long term 3.

Objectives: Improve structures and mechanical devices used in spawning, rearing, feeding, holding, and harvesting bait fish, trout, catfish, and other commercially important species of freshwater food fish, and develop new, more efficient mechanized cultural equipment and structures.

Situation Evaluation: Expansion of the freshwater fish industry has been curtailed by rising production costs. Growers of major freshwater food fish crops are facing problems of greater feed, labor, energy and construction costs. Buyer resistance to resulting high fish prices has developed. Higher production and increased efficiency obtained from improved facilities and equipment would con-

tribute to lower food fish prices and benefit both the producer and consumer.

Research Approaches:

A. Intensive culture of food fish in tanks, raceways, or vats would allow producers to utilize limited space and water supplies more efficiently. At the present time however, production costs for fish reared in such facilities are high. Research is needed to develop specialized structures to facilitate waste removal, to equalize growth rates and to reduce maintenance labor. Mechanization of cultural activities such as feeding, grading, harvesting, and loading of fish reared in intensive production facilities would be useful to fish producers.

Priority: Initial efforts should be concentrated on developing waste removal equipment and methodology. That would make water re-use more feasible. Short term studies to develop practical grading methods should have high priority.

B. Improvements are needed in traditional pond fish production facilities and equipment. Methods of removing waste from fish ponds by mechanical methods would be of value as this is becoming a limiting factor as ponds age. New grading and harvesting methods are needed to increase production efficiency and to reduce labor requirements. Mechanical devices or specialized structures to selectively harvest different fish species would be helpful to fish producers in developing polyculture methods as would specialized feeding systems that could be used to selectively feed individual species raised in a mixed community.

Priority: Selective harvesting gear and partial harvesting devices should receive major effort. Long term studies are needed to develop waste removal and selective feeding devices.

C. Research is necessary to devise mechanical equipment and specialized structures for rearing fish in conjunction with other crops. Combined production of fish and rice may prove to be practical with the right combination of facilities. Also, fields fitted with specialized structures may be useable with little alteration for rotation of fish crops with soybeans or other grains. A double crop system or more flexibility in land use would be of major benefit to farmers.

Priority: Major emphasis should be on fish-grain crop rotation research. Information obtained in these studies would be useful in developing programs to study double-cropping techniques.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
317	2.00	0.00	0.00	2.00

PRODUCT DEVELOPMENT AND QUALITY MAINTENANCE

Introduction

Americans consume 12.5 pounds per capita of fish and fish products annually. It is difficult to obtain data indicating the exact amount of freshwater fish consumed in contrast to total per capita consumption. However, there is data to show that consumption of freshwater species is increasing. In 1954, 1.2 to 1.4 million pounds of trout were produced by aquaculture, and by 1974 production had increased to 40 million pounds annually. In 1954, there were less than 100,000 pounds of catfish produced on farms, but by 1974 this had increased to some 50 million pounds.

Fresh water fish presently provide a good source of high quality protein. It has been estimated that some 10 percent of the world's water-derived protein comes from aquaculture. Worldwide production of fish by aquaculture has doubled in the last 5 years, and some countries rely on this source for 40 percent of their total fisheries products. This increase in fish production by aquaculture has been caused in part by a growing world demand for high quality protein. It has been furthered by the limited catch and increased cost of commercially captured marine fish and the attractiveness of fish farming operations as farm enterprises.

In the United States over half the catfish consumed comes from fish farms. Presently, there are over 4,000 commercial ventures involving freshwater aquatic animals. Interest has rapidly increased and research expanded on the production of warm water aquaculture of fast-growing herbivorous fishes.

In the Gulf States alone there are over 2 million acres of low-value land, which is suitable for fish farming. Utilization of this land could provide 8 billion pounds of fish per year on a fresh weight basis, or roughly 4 billion pounds of usable fish and fish products annually. Work is needed in the area of product and process development to keep pace with production research in these areas. Obviously, production of this quantity of food fish by pond culture can develop only when suitable products have been developed and markets found. Research under this project has as its major goal the development of products and maintenance of quality so as to permit maximum development of the potential for freshwater fish and fish products.

Title: Production of fishery products with improved acceptability.

Priorities: Short term 1; Long term 1.

Objectives: To determine effects of production environment and processing procedures on nutritional and sensory properties of freshwater fishery products.

Situation Evaluation: One problem associated with fish-culture is off-flavors. An "earthy-musty" type of flavor has been found in commercially cultured channel catfish and has effected serious losses. This same flavor is a problem in the trout industry and has been found in other species. Information is needed on identity of the organisms responsible for production of the off-flavor, environmental conditions favorable for their growth, chemical identification of the compounds responsible for the flavor, and methods of management to prevent its development or to remove this flavor from the fish once it has been acquired.

Relatively little is known about the effects of feeding or other management practices on chemical composition of cultured food fish. With livestock, these conditions have marked influence on carcass quality which, in turn, affects consumer acceptance of the product. Such factors as composition of the diet, amount and frequency of feeding, water temperature, and size of fish are likely to affect the amount of fat or muscle, dressing percentage, appearance of flesh, or flavor. Thus, the effects of production practices on carcass quality and the subsequent effects on marketability of freshwater food fish should be identified.

There are also possible genetic or species-related factors that may influence consumer acceptance. For example, both white catfish (*Ictalurus catus*) and albino channel catfish have lighter, more appealing flesh than regular channel catfish. Differences in body conformation among strains of

channel catfish from different populations affect dressing percentage or consumer appeal.

Nutritional and chemical evaluations of various species of fish will provide useful information for the consumer to use in determining the contribution to his diet, for the technologist to use in evaluating the processing properties, and for the processor to make decisions concerning nutritional labeling.

The effects of handling and preservation procedures on quality of freshwater fish should be understood if improvements in acceptance of the marketed product are to be made through processing alternatives. Examples of areas where more information is needed are: (1) effect of packaging methods or use of preservatives on keeping quality in fish stored at low temperature; (2) effects of refrigeration, ice-packing, and various temperatures below freezing on keeping quality; (3) effects of plant sanitation on quality and storage life; (4) and effects of pre-processing, handling, and slaughter methods on quality.

Data on consumer attitudes towards freshwater fish products are necessary. Areas in which consumer preference information is needed are: fresh versus frozen fish; portion size or package size; whole fish, steaks, or filets; attitudes about unconventional species such as buffalo fish or silver carp; attitudes about new products such as minced fish products, canned, pre-cooked, frozen, smoked, or pickled fish.

Research Approach: Organisms and pond conditions responsible for synthesis of off-flavor compounds should be identified, management practices to prevent or remove off-flavor conditions in ponds should be investigated, chemical identification of off-flavor compounds should be determined, and objective and subjective tests for practical evaluation of fish flavor should be developed.

To evaluate the effect of the production system on body composition of cultured fish, experiments will be designed to evaluate the effects of feeding regime, size of fish, condition of fish, harvest season, and water temperature on the dressing percentage and body chemical composition of fish. Subsequent consumer acceptance studies will be conducted to identify the preference of consumers for fish with various carcass quality traits.

Comparisons of consumer preference attributes of various species or genetic strains of fish will be made. If superior sensory qualities are identified for a species or strain, economic benefits as well as other practical considerations associated with producing the fish for marketing will be investigated.

Unconventional fish species that may be useful in polyculture systems will be evaluated for consumer acceptability. These fish will be evaluated in various marketable forms, such as dressed un-cooked fish, in minced fish products, canned fish, or pre-cooked breaded and frozen.

A comprehensive chemical evaluation will be conducted. This will include analyses for proximate composition, amino acids, fatty acids, cholesterol, essential minerals, vitamins and gross energy. Variations in chemical composition within species which may be related to size, season, feeding regime, genetic trait, processing methods, or other factors will be determined.

Processing variables that may affect quality, such as slaughter methods, time and temperature conditions in the processing plant, packaging and storage methods, bacterial quality of the initial and final product, plant sanitation, and others will be investigated. Objective tests for quality will be made in bacteriological, chemical and physical factors which are related to consumer acceptance.

Product modifications that appear to improve acceptability will ultimately be evaluated by consumers.

Priority: Species such as channel catfish have excellent yield potential but are unfamiliar to many consumers in the United States. To gain new consumers, these fishery products must have a high level of acceptability. The pond-related off-flavor problem deserves immediate attention. Information on consumer opinions about freshwater fishery products will be obtained as quickly as feasible; and methods to provide products to meet the consumers' wishes and to stabilize the quality of these products will be developed.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
409	0.95	0.95	0.95	2.50

Title: New and improved fishery food products.

Priorities: Short term 2; Long term 1.

Objectives: To develop new fishery food products, such as minced fish blocks; breaded ready-to-eat fillets; pickled fish; canned fish; pre-cooked frozen fish; development of convenience items such as sausage, stuffings, and croquettes; ingredients for deviled or stuffed crabs; fish stew, gumbo, and jambalaya. Considerable work has been done on canning catfish and pre-cooked frozen fish, however, little attention has been paid to other freshwater species that might be frozen or canned successfully.

Situation Evaluation: Information is needed on the development of new products such as pickled fish, fish pastes, and fish sauces. Work is necessary to determine suitable enzyme systems for production of such pastes and sauces, and development work would be initiated on a process for producing pickled freshwater fishery products. Work with other fish species has indicated the possibility of preparing food binders from fish flesh.

Labor saving methods for processing are vitally necessary. Mechanical (or chemical) procedures for sorting, sizing, conveying, deheading, gutting, skinning or scaling, filleting, deboning, washing, and packaging should be developed or adapted from existing equipment or methods.

Procedures for use or disposal of solid and liquid plant wastes, which comply with Environmental Protection Agency (EPA) regulations, must be made available for the industry. Until recently most freshwater fish processing plants were not affected by government regulations on waste disposal, but subsequent to June, 1974, mandatory guidelines established by the EPA apply to all fish processing plants.

Developments in areas which affect quality of the raw product are needed. This includes improvements in techniques of harvesting, hauling and handling fish prior to processing.

Research Approach: The research approach for development of a single new fishery food product will be used as an illustration of how this phase of research will be approached. The first step in any new product development program involves procurement of a large number of researchable ideas. Some few ideas as to possible new fishery food products have been enumerated in the objective section, but they are only to illustrate the types of items concerned in this research. Other new product ideas will be gathered from traditional sources, such as magazines and journals, conversations with people in the trade, discussions with other technologists involved in various areas of related research, and discussions with housewives concerning fishery products they would like to purchase.

Researchable ideas will be discussed and the most promising will be selected for further development. Laboratory prototypes of the new products will be developed and subjected to chemical, microbiological, physical, and organoleptical evaluations. Based on these tests, the products will be improved and second generation prototypes will be developed and consumer acceptance tested. The consumer acceptance tests will involve development of about 200 to 250 samples, and this test will be conducted by placing food products in normal household situations for consumption and evaluation.

Based on the results of consumer acceptance tests, further product improvements will be made in the laboratory and efforts will be made at this point to interest commercial firms in production and market testing of the products. Throughout the development of new products, economic and technological feasibility studies will be carried out to evaluate the possibility of commercialization of the products with resultant benefits to consumer and industry.

Development of procedures for waste disposal that comply with EPA guidelines will depend to a large extent upon finding economical uses for solid processing waste. This not only will reduce the expense of waste disposal, but will eliminate a large portion of the waste. Measurement of amounts of various materials in effluent from various processing operations will be made as an initial step. Subsequently, procedures will be developed that will reduce the concentration of critical materials in the effluent to acceptable levels.

Development of processing methods for new products will require extensively equipped laboratory facilities and pilot plant facilities. For example, to develop a procedure for smoking fish, a smoker with equipment for measuring internal flesh temperature is essential; to develop time and temperature requirements for thermal processing of fish products, various types of steam retorts with thermocouples for measuring internal can temperature are necessary; to work with minced fish products, a fish deboning machine is required; processing freshwater fish waste into fish meal will require a laboratory model steam dryer. In addition to these major items or equipment, facilities for packaging, storing and chemical, microbiological, and sensory analyses of fish products are necessary. Because of the extensive requirements for facilities, as well as research personnel, this research area must be shared by several laboratories.

Priority: The development of new and improved freshwater fishery food products has been assigned a short and long term priority of 1, indicating a degree of urgency in the development of new products, such as ready to-eat breaded fillets, minced fish blocks from fish frames, pickled fish, canned fish, stews, gumbos, and convenience items such as fish sausage, stuffings, croquettes, and ingredients for deviled crabs and similar products. Development of the industry to date has been based almost exclusively on fresh fish, frozen fish, and other similar products. New products such as precooked, breaded frozen fish, ready-to-heat-and-eat fish croquettes, and similar convenience type foods are essential for the industry to grow and prosper in proportion to its potential.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
410	1.55	1.00	1.00	3.50

Title: New and improved non-food fishery products.

Priorities: Short term 2; Long term 3.

Objectives: To determine economical uses for freshwater fish processing by-products.

Situation Evaluation: Processing waste constitutes approximately 40 percent of the weight of channel catfish, and presently the industry is realizing relatively little economic return from this by-product. Fish processing waste should make a valuable ingredient for fish or livestock feeds, considering the present high value on marine fish meal. Information is needed on the biological value of freshwater fish processing wastes in various fish and animal rations, the effect of this material on sensory quality of the flesh of the animal consuming it, and the technology of processing the waste into meal or other forms of use in animal feeds.

Processing wastes may also be used as ingredients in foods for non-food animals, such as pets or fur animals. Additional uses may include bait for crayfish or lobster traps, sources of pharmaceutical products such as insulin, protein hydrolysates for bacterial media and other purposes, oils for cosmetic or food industries, and possibly a number of others.

Technology for processing these wastes into commercial forms will have to be developed. Also, the logistical aspects of supply, transportation, and plant site for processing waste materials must be investigated. The economics of processing waste into a potentially valuable product will have to be evaluated.

Economical uses of freshwater fish processing waste would substantially reduce processing costs and, consequently, the retail price of the fish.

Research Approaches: Chemical evaluation of processing waste from the various freshwater fish that are being cultured commercially should be the primary step. This should include detailed analysis for nutrients, fatty acids, and compounds of potential value such as hormones. Variations in waste composition with harvest date, size of fish, feeding regimes, and species, should be determined.

Subsequently, biological evaluation of waste materials in various fish and animal diets should be made. This should include feeding trials with semi-purified diets to evaluate specific nutrients or other components. Also, practical diets should be tested for food fish species, swine, poultry, and pets. The wastes should be evaluated in commercial crayfish and lobster traps under practical conditions and the catches compared with those from conventional baits.

If freshwater fish wastes have potential commercial value, such as in the form of fish meal, technology converting the material to marketable form must be established. This may involve one or more of the operations of dehydrating, extracting, clarifying, concentrating, pasteurizing, particle separation, packaging, and conveying.

The economics of processing waste should be studied concomitantly with developing technology. Identification of location and size of supplies of wastes should be made. These factors would be important in determining the most feasible location, size, and type of waste processing plants.

Priority: Essentially no economic benefit is presently derived from processing wastes from freshwater fish processing plants, and this by-product represents approximately 40 percent of the weight of the fish. Valuable uses for this material must be provided immediately to reduce processing costs of freshwater fish.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
411	0.70	0.70	0.70	1.50

Title: Quality maintenance in marketing fishery products.

Priorities: Short term 2; Long term 4.

Objectives: To determine the oil composition of fish during various seasons of the year and how oil composition is influenced by various feed formulations; to develop dependable chemical, physical, organoleptic, and microbiological tests to assess the quality of fishery products; to evaluate the need for anti-microbial agents in fishery products; to investigate quality changes in the product during storage, and determine the role that proteins play in these changes; to investigate rancidity development during production, processing, storage, and marketing of fishery products; to investigate packaging material most suitable for preserving the quality of fish products; to develop quality control procedures to insure high quality fishery products.

Situation Evaluation: It is hypothesized that various ingredients used in fish feed formulas influence to a large degree the ultimate oil composition of fish. A better knowledge of this relationship would dictate animal or plant protein supplements to be included in the formula to produce more desirable characteristics in fish. For example, marine fish meal as a part of the diet may produce oil in the fish with a large number of double bonds, which is desirable from a medical standpoint.

There have been numerous tests developed to assess the quality of fishery products; chemical, physical and microbiological, and the results correlated with organoleptical evaluations. Some apply to certain species, but not to others. For example, the tri-methylamine nitrogen test works well with cod but for other species not containing tri-methylamine oxide the test is not applicable. The test for indole works well with species containing large amounts of tryptophan, but in species with little tryptophan, the method is useless. Dependable methods must be developed to assist plant quality control personnel to improve product quality.

Fish during processing, storage, and marketing are subject to contamination by microorganisms. This microbial contamination may consist of pathogens and toxigens, as well as spoilage organisms. In order to prevent food poison outbreaks and hold product degradation to a minimum, effective anti-microbial agents must be found. Effective bactericidal and bacteriostatic compounds are not available since the FDA removed antibiotics from the list of approved additives in 1966. A study should be made to determine if anti-microbial agents are necessary, and if so, which chemicals are effective.

During storage of fish, certain quality changes take place. For example, during frozen storage, denaturation of protein takes place, thereby altering texture. Denaturation of protein also causes excessive drip loss in freshly iced fish and thawing fish, resulting in loss of valuable nutrients. The use of polyphosphates has prevented the loss of moisture during storage in some cases. A better understanding of the behavior of fish proteins during storage is basic to prevent, or at least minimize, quality changes during storage.

Development of rancidity in some species starts immediately upon death of the animal and proceeds rapidly. Development to a level detectable by organoleptic means may be accomplished in 2-5 days, especially if fish are improperly handled.

Some packaging materials are designed to prevent the transfer of moisture and gases from the product, while others are designed simply as a cover to prevent contamination. Some packaging materials are designed to package products having sharp points or edges and are considerably more expensive. Requirements for packaging fishery products must be assessed and if these requirements are not satisfied in available materials, suitable materials must be developed.

Firms successful in marketing a consistently high quality product employ some type of quality control system. Such systems include evaluating the product and process from raw materials through the channels of production, packaging, storage, and distribution. A central system must be devised, including the evaluation of critical control points and especially an examination of raw materials. A statistical quality control system has been used successfully and can be applied to the processing of freshwater fishes. Product specifications for each product should be developed and proven quality control procedures incorporated into the system to make it meaningful. Statistical quality control limits should be developed to permit production of the most economically feasible product.

Research Approaches: A thorough study of culture waters, harvesting techniques, and pre-handling methods is prerequisite for establishing quality control procedures. Product characteristics, chemical constituents and microbiological profile should be determined for all processed species. Processing techniques applicable to freshwater species should be evaluated. A review of scientific literature and state, federal, and local laws should be made to prevent any malpractice in processing and/or costly recalls of the product. A quality control system should be developed to ensure that only wholesome and safe fishery products reach the consumer. Finally, maintenance of records of the product's history, from harvesting to consumption, should be recommended as a safeguard against public health hazards and costly law suits.

Priority: This research has been given a low priority because it is believed that most processors are doing an adequate job. If this were found to be untrue, the priority would advance to number one.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
412	1.00	1.00	1.00	2.20

Title: Protect food and feed supplies from harmful organisms and toxins.

Priorities: Short term 1; Long term 1.

Objectives: To determine the extent of parasite infestation of freshwater fishery products; to determine the incidence of heavy metals in fishery products; to determine pesticides associated with fishery products and develop methods to eliminate them; to establish time and temperature parameters for processing fish which will meet the Food and Drug Administration's Good Manufacturing Guidelines; to investigate the microbiology of freshwater fishery products; to investigate the possible presence of non-microbial toxins in freshwater products; and to examine feed supplies to determine if they contain microorganisms or toxins which may be transmitted to fishery products.

Situation Evaluation: In recent years, evidence has incriminated various parasites in fishery products as the causal agent in outbreaks of human illness. The evidence points to consumption of raw or improperly processed products. Regulatory agencies are focusing on this problem and are becoming increasingly aware of the potential health hazards associated with the presence of these organisms.

The lethal effects of high concentrations of heavy metals in food products are well documented. Heavy metals such

as mercury, arsenic, lead, and cadmium in fishery products have caused considerable concern in recent years among regulatory agents, the medical profession and fish processors. For example, high concentrations of mercury in swordfish resulted in the FDA removing this product from the market, thereby eliminating a new and budding industry. Little is known about the level of these metals in freshwater fishes and how they may become a problem in processed products.

Growing freshwater fishes in farm ponds in close proximity to crops treated with pesticides is a real problem. Water run-off and drifts into farm ponds cause fish to become contaminated with the pesticide. Correlation between the pesticide found in the fish and that used to treat crops can be a useful tool in pinpointing the pesticide source.

As new heat-processed fish products are developed, time and temperature relationships must be established which render the product safe for human consumption. Smoked catfish involves a new process which heretofore has been a "hit-or-miss" process which may or may not render the product safe for human consumption. Recent studies at various universities have established guidelines to follow in smoking catfish. Other species need to be researched and similar procedures developed.

The canning of freshwater species is another new endeavor in which time and temperature parameters need to be established. This process has been determined for catfish; however, a canning procedure must be developed for all species before consumer acceptance can be evaluated.

Little is known about the total microbiological profile of processed freshwater fishes.

Occasionally, the addition of food additives, to improve product characteristics, results in formation of toxins in that product. A good example of this is the addition of nitrites to smoked fish. In some cases, this compound combines with some metabolic product of the fish to form nitrosoamines.

Ingredients of fish feeds have long been suspected as a source of contamination which may be transmitted to processed freshwater fishes. Fish meal, meat, and poultry scraps have been identified as contributors of *Salmonella* in feeds. Fish meals have on occasion contained polychlorinated biphenyls (PCB's) through an accident in processing. Also fish meal and other animal and plant protein supplements have occasionally contained pesticides. Procedures for routine analysis of these contaminates will be worked out for the producer so that he can evaluate his feed supplies.

Research Approaches: Critical points of chemical and microbial contamination must be determined and those contaminated identified. Corrective measures must be found to effectively reduce these contaminates to a safe level. Food additives and/or processing techniques, which may result in formation of toxic substances in processed fishery products, must be researched to determine if these could become a problem. Processing procedures for new products must be accurately determined to prevent outbreaks of food-borne illnesses.

Priority: In recent years there has been a significant increase in the number of reported food-borne illnesses. Eighty percent of these cases were caused by microorganisms in food which was probably mishandled. Heavy metals, toxins, and parasites in fishery products have received much attention in the last several years and the fishing industry has suffered severe losses due to the bad publicity. This problem area was assigned a high short and long term priority, because solutions to the problem are basic to the proper development of this industry.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
702	0.80	0.80	0.80	1.50

Title: Food choices, habits, and consumption.

Priorities: Short term 1; Long term 1.

Objectives: The objectives of this research are to determine consumer attitudes towards freshwater fish and fishery products; to determine ways of describing differences in both external and internal quality factors of the product; and to develop product quality guidelines to aid the industry in increasing consumption of freshwater fish and fishery products.

Situation Evaluation: Consumer attitudes toward freshwater fishery products as compared to marine fishery products and other animal protein sources need refinement. The roles of product appeal and relative convenience of preparation of freshwater fishery products need definition.

Research Approaches: Consumer attitudes toward freshwater fish and fishery products will be determined from personal interviews, household surveys, and other appropriate techniques for this type of research. The information to be obtained will include the extent and frequency of use, ways the products are prepared, degrees of satisfaction or dissatisfaction with the products, reasons why some consumers never purchase and use the product, and what can be done to correct any dissatisfaction on the part of consumers.

Literature should be reviewed and the state of knowledge determined. Experiments will be designed to yield information which can be applied by industry.

In order to evaluate differences in external and internal quality of fish and fishery products, it will be necessary to develop objective physical, chemical, and organoleptical methods for evaluating these parameters.

For example, it will be necessary to have a satisfactory method for evaluating moistness, color, texture, flavor, etc. Once important quality criteria have been identified and methods for measuring them have been developed, various levels of these quality attributes can be studied in terms of consumer reaction to them.

When consumer attitudes toward the product have been documented, guidelines can be developed to aid industry in producing those fish and fishery products which will be consumed in the largest quantities.

Priority: This work has been assigned both short term and long term priority numbers of 1.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
703	0.00	1.00	1.00	2.00

MARKETING RESEARCH AND ECONOMICS

Introduction

Marketing and economic research for aquatic food animals has been very limited and incomplete when compared to that for other food animals. Increased research in these fields is necessary for cultured fishes to attain a position in the market place that is now enjoyed by other fishery and livestock products.

Both marketing and economic research should be aligned with other research areas for aquatic food animals including production techniques, management, diseases, and product development so that each can be evaluated in terms of the other.

Research into different culture methods is of little value if the methods indicate slight chances for economic success. In turn, the development of new markets cannot be undertaken if sufficient production and processing capacity do not exist or fail to show the long term potential for profit.

Increases in production through methods such as polyculture, diversification of systems, and interactions with other farm enterprises all must be considered as areas of research when demand characteristics are established and market and economic research indicate that the increases are warranted. Further consideration must be given on how factors such as extended fisheries jurisdiction, statistics, and market identification will assist in the growth and development of the culture of aquatic food animals.

Title: Supply, demand, and price analysis of crop and animal products – demand elasticity for aquatic food animals in selected markets.

Priorities: Short term 1; Long term 1.

Objectives: To gather information on consumer buying patterns at various price levels in potential market areas for aquatic food animals.

Situation Evaluation: Production of aquatic food animals has historically been more expensive than other fish products, and products such as beef, pork, and poultry.

Because of the relative newness of the fish farming industry, these products have not enjoyed long term acceptance in the market place. Retail prices and demand of farmed fish products are directly related to fluctuating production costs and to changes in price levels of competitive food products. Since farm-raised fish are usually processed and retailed through supermarkets, fish markets, and restaurants, demand characterization might be established in all these markets; however, the majority of foods consumed are purchased at supermarkets which indicates that research should start with these outlets.

Little is known about those markets which have the highest demand for farmed fish and at which price and quantity levels optimum profits can be achieved. Information on the effect of consumer education to stimulate demand at different price levels is also lacking for aquatic food animals.

Research Approach: A determination of those markets having the greatest potential for farmed fish should be made. In these selected market areas price and quantity relationships should be established both without advertising and with different types of advertising or educational efforts. Price levels and advertising methods used should be evaluated on the basis of industry production, costs, and advertising capabilities.

Priority: Demand patterns are increasingly important in the overall development efforts of the fish farming industry. Long term value will be achieved as production costs and management practices improve to reflect differences in retail price levels.

		SMY Distribution		
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
506	0.00	0.00	0.05	1.50

Title: Economic analysis of aquacultural production and processing.

Priorities: Short term 2; Long term 2.

Objectives: To integrate economic data on various production systems with data on economically efficient processing units in order to establish optimum systems for meeting consumer demands.

Situation Evaluation: Consumer preference ultimately determines the size of any industry. The consumer is not aware or interested in the type of production or processing unit used. Quality, price, and availability are factors influencing consumer purchase decisions. The fish processor changes the form of the product and makes it available when the consumer desires to purchase. Within these utility functions processors face innumerable economic decisions. Under existing health regulations fish processing must begin with a live fish, thus, plant location is determined by production areas. The saleable product from processing represents only 60 percent by weight of the product purchased by processors. With small scale processing operations the quantity of waste is insufficient to warrant further processing into feed ingredients or other products. Research into economics of scale could indicate the optimum location and size of plant to minimize processor margins with full returns to all input factors.

Aquacultural production involves a myriad of organisms each with relatively unique biological habitat requirements. Catfish require a water temperature above 60°F, while trout require cooler water. Some fish species require complete rations while others feed on micro-organisms in the pond. Coupled with the multiplicity of species and species combinations are the diverse production systems including ponds, tanks, raceways, cages, and others. There is no one optimum production and culture system for all aquatic organisms. Given production constrains of physical terrain, availability and quality of water, soil type, climatic factors, investment capital, quantity and quality of available labor, and preference of managers, unique optimum individual fish production systems can be determined. Producers have market opportunities in addition to sales to processors. Production systems to satisfy fishout, livehaul, restaurants, or other markets would not necessarily be identical to units developed for sales to processors. For long term growth in the industry further penetration into institutional and supermarket sales must be made. Growth of the industry and growth in processing are synonomous. Production for processor sales ideally requires year round production of fish with a stable supply processed.

Research Approach: No state has all the various aquatic organisms under production, nor does any state have sufficient numbers of production units of each type for detailed analysis. Coordinating research efforts to avoid duplication should be undertaken.

Three levels of economic research are uniquely involved in aquatic production and processing. Production systems

must be designed with recognition of consumer preferences as expressed by processor demands for the product. The relationship between production and processing is crucial in economic analysis. Consumer preference for fresh over frozen fish as expressed by price differentials must be great enough to warrant development of systems that will ensure a supply of fresh fish. As with all products; production, marketing, and consumption must be considered simultaneously. Beyond production and processing, however, the broader questions of equity must be analyzed. In effect, who in society benefits from the development of an aquacultural system. The impact and incidence of changes in employment and income resulting from expansion of aquaculture should be evaluated. Consideration of impacts at the farm, industry, regional, and national levels can be utilized to determine the overall economic feasibility of the system.

Priority: With fixed land resources and increasing input costs, maximum food and fiber production must be obtained from resource use. The urgent need for food supplies, especially protein, in lesser developed countries indicate a high priority need for basic economic systems research in aquaculture. The complexity of the multi-dimension nature of aquacultural economic research indicates substantial SMY's should be devoted to various aspects of the problem.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
506	1.28	1.28	1.80	1.50

Title: Competitive interrelationships in agriculture competition of pond-raised commercial catfish with other farm enterprises.

Priorities: Short term 3; Long term 3.

Objectives: To estimate the extent to which commercial catfish compete with or are complimentary with other farm enterprises in the use of critical resources.

Situation Evaluation: Modern agriculture is capital intensive. Commercial catfish production is an even more capital intensive enterprise. The current high cost of capital and other resources (labor, feed, and management) requires that the greatest economic efficiency possible be achieved in the allocation and use of these resources.

While there have been many studies of conventional farm organization and resource use, and limited studies on the catfish enterprise, there have been no studies that concentrated on commercial catfish as one of several alternative crops on suitable farms.

If commercial catfish were found to be complimentary or supplementary with respect to one or more major resource (land, labor, or management) and highly competitive with none, substantial cost savings might be possible. On the other hand, if commercial catfish are highly competitive with other enterprises with regard to one or more major resources, costs might be expected to rise even higher as producers continue to bid for these resources.

Research Approach: Commercial catfish enterprise "budgets" can be developed similar to budgets for other farm enterprises. These budgets, one for each appropriate situation, along with budgets for other enterprise will provide the needed information for mathematical programming analysis that will satisfy the objective for alternative resource situations.

Conventional linear programming techniques currently available are adequate for obtaining such solutions. The major research efforts should concentrate on developing the appropriate detailed information concerning alternate methods of producing commercial catfish. Such efforts (and expenditures of funds) seem justified since such a model would allow resource owners (farmers) to maximize their net returns to all uses including catfish.

Priority: This effort should be assigned a high priority since estimates of the cost of production under various resource situations are critical in establishing the competitive position of farm-raised catfish in the market place.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
507	0.03	0.50	0.50	0.50

Title: Identification of markets for catfish producers — development of domestic markets for aquacultural products.

Priorities: Short term 1; Long term 1.

Objectives: To combine information from federal, state, and local levels on a timely basis to provide current and projected supply and demand information for catfish producers.

Situation Evaluation: The National Marine Fisheries Service provides information on domestic production and imports of catfish on a monthly basis. The Catfish Farmers of America publishes a list of catfish producers, processors, and live haulers who are members of the organization. The Cooperative Extension Services of several states have specialists in catfish production and marketing, who serve as a clearinghouse for market information. None of these organizations or individuals wholly meet the needs of catfish producers or buyers.

The marketing system for catfish is characterized by the dual nature of catfish as a sport fish and as a food fish. During certain periods of the year recreational sales are strongly competitive with food fish sales. Principal buyers of catfish can be identified as processors, local retailers, live haulers, and individuals. Direct sales are also made to restaurants and local fish markets. Live haulers may re-sell fish to any of the other market sectors. Processor sales are directed to all sectors except the recreational markets. Lack of producer information regarding supply and demand situations have restricted growth of the industry. Approximately half of the production acreage in Alabama was planned for commercial production, then converted to other uses when markets for the fish could not be found.

Research Approach: A complete inventory of all existing production facilities, including existing stocks, should be conducted. An inventory of all catfish buyers, including brokers with pass-through functions with a detailed description of the seasonal, location, quality, quantity, and portion control needs of each, should be computed. A functional analysis of the marketing system including costs of product utility changes would identify inefficiencies in the market system and clarify the role of each marketing sector.

Basic supply and demand interactions should be investigated to determine the response capability of catfish production and marketing. The degree of consumer response to changes in product prices has not been determined. The presence of only eight major processors indicate a trend toward concentration in catfish marketing, however, processors purchase less than 35 percent of total production. The marketing margin between pond banks and grocery store shelves is more than 100 percent with a substantial portion due to 40 percent weight loss in processing.

Priority: Marketing problems were ranked number one among catfish producers and processors in 1970 and 1974.

Production and processing problems are interrelated, however, growth in the industry is hampered by lack of data regarding market source. A mechanism for establishment of an information clearing house should have high priority. Additional economic evaluation of the catfish marketing system to establish efficiencies and to reduce marketing margins should also have high ranking in the catfish research priorities.

RPA	SMY Distribution 1974 Base	1975 No Increase	1975 10% Increase	1980 Recommended
508	1.30	2.00	2.00	4.00

Title: Improvement in aquaculture statistics – investigation of a system for proper collection of aquacultural statistics.

Priorities: Short term 1; Long term 1.

Objectives: To establish a method of collection of aquacultural statistics necessary for research and use by producers, associated industries, and government.

Situation Evaluation: The aquacultural industry in the United States is relatively new when compared to other farm enterprises, and because of its short history many areas of information about the industry have not been established.

There are numerous federal, state and local governments, as well as private groups, attempting to assist the industry in its development and growth. Since involvement by these groups is fragmental and diversified, none has yet assumed the total responsibility for the initiation and development of a statistical reporting system for the aquacultural industry. Some attempts have been and are being made by several agencies to gather statistics, but these efforts have been directed primarily toward the farm-raised catfish segment.

The National Marine Fisheries Service of the U.S. Department of Commerce currently reports processed catfish statistics and collects yearly production data in cooperation with the Fish and Wildlife Service of the Interior Department, USDA's Soil Conservation Service, State Game and Fish Commissions, and industry trade groups. The USDA Cooperative Extension Service, State Departments of Agriculture, and other groups, both public and private, have made additional attempts in statistical gathering for individual states, both for catfish and other species, to a limited extent. Because fish production from aquaculture is considered a private resource, further problems are created regarding jurisdiction and responsibility of various agencies for statistical collection and reporting.

Research Approaches: An evaluation of cost input data, production volume, value, and market movement should be accomplished to determine specific information needed about each. These four areas can be incorporated as the foundation for a statistical gathering program. Further requirements of such a program should be determined, incorporating the collection of cold storage holdings and other information to make forecasting possible.

An investigation into the possibility of an aquacultural statistical program being incorporated into the USDA's Crop Reporting Service should be accomplished. It appears at least initially that this would be a logical function of the Crop Reporting Service if fish farm production is to be considered an agricultural commodity.

Priority: It is extremely important for all new industries to be monitored and investigated so that problem areas can be identified. The size and value of an industry often determines the amount and level of research it receives; therefore, to quantitatively identify this industry an adequate statistical program must be started and updated on a continuing basis.

RPA	SMY Distribution 1974 Base	1975 No Increase	1975 10% Increase	1980 Recommended
511	0.30	0.30	1.00	2.00

AQUACULTURAL SERVICES

Introduction

The freshwater aquacultural industry is presently composed of established producers of various aquacultural commodities throughout the southern and midwestern states. In almost all cases aquaculture is engaged in as a supplement to cotton, soybeans, rice, or a similar stable agricultural crop production. The production of cultured fish has been carried on for a very short period of time in comparison with these other agricultural products.

Because of this newness of the industry and the great differences in production, marketability, distribution, and management between fishery products and agricultural products there exists a critical need for services to the aquacultural industry. Services to provide industry with the necessary knowledge to create and expand markets for their product will enable them to establish and develop an industry whose success or failure is based on saleability to consumer.

Statistical services can provide the necessary measuring tools that are needed to define establishment and growth of an industry. Information and technical assistance are important to a young industry because tradition in production methods has yet to be established. Innovations and techniques should be passed on to present as well as potential aquaculturists so that all may benefit from common problem solving.

Title: Marketing services for aquatic food animals.

Priorities: Short term 1; Long term 1.

Objectives: To promote the development of freshwater aquaculture by assisting industry to improve the efficient movement of aquatic food products through the national food marketing system and by educating the public on purchasing, handling, and preparation of fish.

Situation: Evaluation current production of farm-raised catfish in the United States is approximately 50 million pounds live weight. There are approximately 2,000 individual producers growing catfish in at least 20 states. Major markets for farm-raised catfish are in the southern and midwestern states. Primary sources of distribution for farm-raised catfish are processors (32% of production), who sell through distributors and brokers to both retail and institutional customers, live haulers (44% of production), who sell almost exclusively to recreational fee fishing facilities; and local retailing by producers (24% of production). The industry in recent years has been faced with very high production costs caused by record prices for catfish feed ingredients and inflation. These conditions have further precipitated consumer resistance at the retail level.

Competition from imported fresh and saltwater catfish has increased substantially over the past several years. These products, which comprise a variety of species, are freely

substituted for domestic species. Since these other species can be produced at a relatively low cost, they are obtaining an increasing share of the traditional markets for actual farmed-raised catfish products.

Service Approach: A concerted effort in market development, consumer education, and technical assistance must be implemented to enable the industry to maintain its identity and to grow. Market development activities will involve the investigation of new domestic and foreign markets. Marketing of species of fish cultured in conjunction with catfish, such as tilapia, carp, and baitfish, should be investigated. Consumer education should be directed at increasing the consumer's awareness as to the difference between species so they can make informed purchasing decisions. Further, efforts should be directed to informing potential consumers in new markets by the use of food editor materials, recipe publications, cookery demonstrations, and public service spots on radio and television. Technical assistance in the form of market information and statistics must be furnished to existing potential new entrants into fish farming. Market intelligence, including marketing alternatives, new product development, package design and distribution practices should be supplied to existing members of industry.

Priority: Market services are needed as an integral part of the movement of any commodity from producer to consumer. Marketing is of paramount importance in the growth cycle of any new product.

	SMY Distribution		
1974 Base	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
0.85	0.85	0.85	2.00

Title: Statistical reporting services for aquatic food animals.

Priorities: Short term 2; Long term 2.

Objectives: To gather, tabulate, and report statistics including monthly processed production of farm-raised catfish and an annual survey of the production of farm-raised catfish, trout, and baitfish; emphasizing production, prices, and market movement.

Situation Evaluation: Presently there are a number of species of freshwater fish being cultured in the U.S. Those having the greatest commercial value and being produced on a large scale are catfish, trout, and baitfish. Only the NMFS (USDC) is currently engaged in the collection of statistics on these three species. The NMFS has continually collected information on the monthly processed production of farm-raised catfish since 1969. These reports include the amount of fish processed, inventory levels, prices paid to producers, and imports of freshwater catfish. There have been annual surveys of the production of farm-raised catfish completed in 1970, by the University of Arkansas; in 1971 by the NMFS, and in 1973 by the NMFS in cooperation with the Catfish Farmers of America and the Soil Conservation Service (USDA). A survey of the production of catfish, trout, and baitfish in 1974, is in progress by the NMFS in cooperation with the CFA and SCS.

Service Approach: The collection and reporting of processed farm-raised catfish production will be continued on a monthly basis. This report will include the round weight processed, average prices paid to producers, inventories, net sales, and imports. The report will be updated and revised as required.

A survey of the annual production of catfish, trout, and baitfish will be continued by the Soil Conservation Service (USDA) at the request of Catfish Farmers of America, until an investigation of a specific statistical reporting system by the proper agency of USDA can be completed. Limited use of management capabilities will be provided by the FWS (USDI) and the NMFS in this production survey.

Information on this annual survey will include acreage in production, pounds of fish sold, average prices per pound, market movement, and alternative methods of production. This report will also be revised and updated as necessary.

Priority: Statistical information on aquatic food animals is needed by industry members, government, university, and private groups as well as the public for use as a justification for research projects, private and public expenditure, and as a tool for the measurement of industry growth.

	SMY Distribution		
1974 Base	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
2.00	2.00	2.00	2.00

Title: Information and technical assistance to food fish producers.

Priority: Short term 1. Long term 1.

Objectives: To provide information and services to persons, agencies, and corporations interested in fish, and aquaculture, to perform diagnostic disease and management services, and to compile technical information for use by fish producers and related industries.

Situation Evaluation: High product demand, increasing costs of feeds, chemicals, and other materials, decreasing labor supplies, and shrinking profit margins have combined to intensify management problems and practices. This has led to the need for up-to-date information on husbandry and marketing.

The husbandry and marketing practices of today have developed essentially during the last quarter century. Some of these practices are inefficient; others are not known by all aquaculturists. Some new practices and techniques are being developed.

Extension specialists are seeking to reduce management problems and increase profit margins by providing information and technical assistance to food fish producers. In the future aquaculturist will not be dependent on out-dated recommendations or inaccurate or misleading information. Answers to questions on feeds, disease, water management, pesticides, harvesting, and a multitude of other problems can be provided by trained persons possessing the best information.

Service Approaches: Adequate assistance to fish producers and related industries requires specialists in disease diagnosis, and fish husbandry. Dissemination of their knowledge and advice is made by personal contact, letter, radio and T.V., public appearances, referrals, news articles, and scientific publications.

Priority: Growth of the domestic food fish industry has been phenomenal during the last decade. Continued expansion of the industry is certain. It is essential that food fish producers and those persons in related industries be provided information and technical assistance that will insure high productivity with a reasonable profit margin.

	SMY Distribution		
1974 Base	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
4.00	4.00	4.00	6.00

CRAWFISH

Introduction

The potential of crawfish as human food is great, but this aspect of aquaculture has been greatly neglected. This fact was emphasized at the First International Crayfish Symposium in Austria, September, 1972.

A total of 44,000 acres were devoted to crawfish farming in Louisiana alone in 1973. By comparison, approximately 55,000 acres were devoted to pond culture of catfish in the United States in 1973.

Crawfish offer great potential as aquatic food crops. They can be grown on land unfit for traditional agriculture, or fish culture; there is direct development from young to adult, and there are no larval stages to contend with as in marine shrimp. Newly hatched young can be grown to market size in 3 months, making several crops a year possible; and production of 1,000 pounds per acre can be realized without artificial fertilization or feeding. A market value of up to 65 cents a pound live weight, with an average of 35 cents a pound, make crawfish farming profitable.

In spite of the above advantages, crawfish farming is still a trial and error process, and research is badly needed. The Louisiana Crawfish Farmers Association has outlined various research priorities. Some of these priorities, such as marketing, are being studied by other workers and will not be included in this proposal.

Title: Improvement of biological efficiency – agricultural by-products as supplemental feed for crawfish.

Priorities: Short term 1; Long term 1.

Objectives: To determine if agricultural by-products can be utilized as feed by crawfish.

Situation Evaluation: Highest production of crawfish consistency comes from ponds that first produced a crop of rice. Following rice harvesting ponds are reflooded. Crawfish feed on decaying rice stubble and on periphyton associated with the stubble. Thus, double-cropping of rice and crawfish is possible. Besides rice stubble, other agricultural by-products show promise. In laboratory studies, sweet potato vines and trimmings were fed separately to crawfish and they grew well on such a diet, when held in containers with soil and water.

Several questions should be answered if agricultural by-products can be used commercially. Is the by-product nutritious? What volume of the by-product is available? When is it available? Is it economical to get out of the field and what care is needed to handle it?

From preliminary work comes some answers to these queries. Generally, to be nutritious the by-product must have a C:N ratio of 17.1 or lower. The potential volume of the by-product would depend on the specific crop and on the state or area. By-products are available in the fall and winter months when most crops are harvested and at a time when young crawfish are beginning to grow.

If certain by-products prove successful as fodder for crawfish, crop farmers and crawfish farmers can benefit immediately. No sophisticated feed mill or drying process is needed.

Research Approaches: Various agricultural by-products screened in the laboratory, will be tested as feed for crawfish in ponds. Water quality, particularly oxygen, will be monitored.

Priority: This study should be given increasing priority.

SMY Distribution

RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
311	0.00	0.00	0.25	0.50

Title: Population dynamics of crawfish – improvement of biological efficiency.

Priorities: Short term 1; Long term 1.

Objectives: To study the population dynamics of crawfish in ponds for improved management.

Situation Evaluation: Currently crawfish farmers seed their ponds with brood crawfish in the summer, and production is harvested by trapping in the fall. There is no control over crawfish recruitment, and virtually nothing is known about population dynamics as related to management.

Research Approaches: Crawfish should be sampled weekly in production ponds to determine when gravid females are found; when young are recruited, and composition of size classes. From these data interpretations will be made as to time to begin and terminate harvesting, and quantity of crawfish to harvest.

Priority: This study should have high priority so that current management can be improved.

SMY Distribution

RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
311	0.25	0.25	0.25	1.50

Title: Intensive culture – improvement of biological efficiency.

Priorities: Short term 2; Long term 2.

Objectives: To develop culture techniques for growing crawfish in tanks.

Situation Evaluation: In past years there was wide spread interest in intensive culture of penaeid shrimp. This has not proven feasible because of the many larval stages involved and because each had specific feed requirements. *Macrobrachium* culture currently has wide spread interest and shows much promise. Crawfish culture in tanks also has real potential: development from egg to adult is direct with no larval stages; live food is not required; crawfish can be grown to market size in 3 months, allowing for three to four crops a year.

Research Approaches: Crawfish will be stocked in tanks to evaluate stocking rates, feed requirements, water quality requirements and other parameters. If successful, the study would ultimately be expanded to study feed requirements in more detail. Crawfish parasites and diseases and their control, and breeding would be studied.

Priority: This study is currently not of high priority because crawfish are generally grown in ponds. However, aquaculture with other species indicates that intensive culture has real potential.

SMY Distribution

RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
311	0.00	0.00	0.25	1.00

Title: Production management systems – polyculture of crawfish with other species.

Priorities: Short term 2; Long term 2.

Situation Evaluation: Crawfish show potential for cul-

ture with other species such as catfish, which could be cultured in cages and crawfish in open ponds. Crawfish would utilize uneaten catfish feed and their solid wastes. Hopefully total production would increase, and crawfish, acting as biological filters, would improve water quality. Polyculture of catfish and crawfish could be accomplished immediately with no major adjustments. Crawfish also may have potential in raceway systems. Raceways on the tail end usually have poor production because of the build up of wastes and crawfish may have potential as biological filters.

Research Approaches: Catfish could be stocked in cages, while crawfish could be stocked in the same open pond. Other treatments will include both catfish and crawfish in open ponds. Controls would include catfish and crawfish stocked separately in ponds.

Priority: This project is not urgent. However, production of crawfish on a wider scale could greatly increase if polyculture is successful.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
313	0.00	0.00	0.00	0.50

Title: Mechanization of structures – harvesting techniques.

Priorities: Short term 1; Long term 1.

Objectives: To evaluate current harvesting techniques and to determine better methods.

Situation Evaluation: Over half of the gross income from a crawfish pond goes to the trapper. Crawfish are harvested by trapping with wire mesh traps. The pond owner usually leaves trapping rights for one-half the market price. This "labor" is most unpredictable and unreliable.

Research Approaches: Current harvesting techniques should be improved if possible; and better baits and attractants should be evaluated in crawfish traps. New harvesting techniques, such as trawling, could be tried where ponds will be fertilized to shade out aquatic plants. Pond bottoms will be smoothed to facilitate trawling.

Priority: This study is very much needed. Crude harvesting techniques and unpredictable high-cost labor reduce profits.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
317	0.00	0.00	0.25	0.50

Title: Production of fishery products with improved acceptability – Iron sulfide discoloration in cooked crawfish and its prevention.

Priorities: Short term 2; Long term 2.

Objectives: To identify the mechanism of iron sulfide discoloration in cooked crawfish, and to determine the necessary additives and processing conditions essential for preventing such discoloration.

Situation Evaluation: The situation encountered with thermally processed crawfish is somewhat different than for other fishery products in that the meat itself turns black. Elevated temperatures may permit naturally occurring metals in crawfish to be liberated from their sites and combine with sulfur found in certain amino acids, producing iron sulfide. This does not involve health or safety, but results in loss of product appeal.

Research Approaches: Various temperatures would be used in cooking tail meat in combination with selected food additives in an attempt to prevent the discoloration.

Priority: This should have high priority. If markets are to be expanded, acceptance of new product depends on appearance as well as price.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
409	0.00	0.00	0.00	0.25

Title: Production economics, supply, demand, and price analysis.

Priorities: Short term 1; Long term 1.

Objectives: To determine costs for growing crawfish commercially.

Situation Evaluation: Economics of crawfish production is not well known. Only rough estimates are available.

Research Approaches: Crawfish farmers should be interviewed regarding production costs, which should be compared to crawfish cultured in research ponds, to simulate commercial procedures. Expenses, labor, etc. will be recorded. Production costs of crawfish will be determined, and both gross returns and returns to land and management will be calculated.

Priority: This should have high priority. Production costs should be a foundation on which to fuse other research priorities.

	SMY Distribution			
RPA	*1974 Base*	*1975 No Increase*	*1975 10% Increase*	*1980 Recommended*
506	0.00	0.00	0.25	1.00

APPENDIX

TABLE 1. RESEARCH PROBLEM 4.07—FRESHWATER FOODFISH AND CRAWFISH BY PRIORITIES WITH RECOMMENDED DISTRIBUTION OF SMY's

Problems by Short Term Priorities	RPA	SMY 1974 Base	SMY 1975 No Increase	SMY 1975 10% Increase	SMY 1980 Recommended
Freshwater Foodfish					
Priority 1					
Control of external parasites	210	1.60	2.00	2.50	3.00
Protection of cultured animals from toxins in food and water	213	1.30	1.00	2.60	1.30
Improvement in biological efficiency	311	11.10	14.90	14.90	20.00
Environmental stress in production	312	2.17	3.00	3.00	3.00
Production of fishery products with improved acceptability	409	0.95	0.95	0.95	2.50
Demand elasticity for aquatic food animals in selective markets	506	0.00	0.00	0.05	1.50
Development of domestic markets for aquaculture products	508	1.30	2.00	2.00	4.00
Improvement in aquacultural statistics	511	0.30	0.30	1.00	2.00
Clearance of chemicals for aquaculture	701	0.20	2.55	3.00	3.50
Protect food and feed supplies from harmful organisms and toxins	702	0.80	0.80	0.80	1.50
Food choices, habits, and consumptions	703	0.00	1.00	1.00	2.00
Subtotals		19.72	29.30	31.80	44.30
Freshwater Foodfish					
Priority 2					
Control of microbial diseases of fishes	211	5.25	3.00	3.00	3.00
Control of internal parasites of fishes	212	0.50	0.50	0.50	1.50
Mechanization and structures	317	2.00	0.00	0.00	2.00
New and improved fishery food products	410	1.55	1.00	1.00	3.50
New and improved non-food fishery products	411	0.70	0.70	0.70	1.50
Quality maintenance in marketing fishery products	412	1.00	1.00	1.00	2.20
Economic analysis of aquacultural production and processing	506	1.28	1.28	1.80	1.50
Alleviation of water pollution and disposal of wastes	901	3.60	3.60	3.60	7.50
Subtotal		15.88	11.08	11.60	22.70
Freshwater Foodfish					
Priority 3					
Production management systems	313	5.25	0.00	0.00	4.00
Comparative interrelationships in agriculture	507	0.03	0.50	0.50	0.50
Subtotal		5.28	0.50	0.50	4.50
Freshwater Foodfish					
Priority 4					
Reproduction Performance	310	1.60	1.60	1.60	3.00
Subtotal		1.60	1.60	1.60	3.00
Freshwater food fish totals		42.48	42.48	45.50	74.50
Increase					32.02

TABLE 2. RESEARCH PROBLEM 4.07—FRESHWATER FOODFISH AND CRAWFISH BY PRIORITIES WITH RECOMMENDED DISTRIBUTION OF SMY's

Problems by Short Term Priorities	RPA	SMY 1974 Base	SMY 1975 No Increase	SMY 1975 10% Increase	SMY 1980 Recommended
Aquacultural Services					
Priority 1					
Marketing services for aquatic food animals	-----	0.85	0.85	0.85	2.00
Information and technical assistance to food fish producers	-----	4.00	4.00	4.00	6.00
Subtotal		4.85	4.85	4.85	8.00
Aquacultural Services					
Priority 2					
Statistical reporting services for aquatic food animals	-----	2.00	2.00	2.00	2.00
Subtotal		2.00	2.00	2.00	2.00
Aquacultural services total		6.85	6.85	6.85	10.00
Increase					3.15

TABLE 3. RESEARCH PROBLEM 4.07—FRESHWATER FOODFISH AND CRAWFISH BY PRIORITIES WITH RECOMMENDED DISTRIBUTION OF SMY'S

Problems by Short Term Priorities	RPA	SMY 1974 Base	1975 No Increase	1975 10% Increase	1980 Recommended
Crawfish					
Priority 1					
Population dynamics	311	0.25	0.25	0.25	1.50
Harvesting techniques	317	0.00	0.00	0.25	0.50
By-products as feed	311	0.00	0.00	0.25	0.50
Production economics	506	0.00	0.00	0.25	1.00
Subtotal		0.25	0.25	1.00	3.50
Crawfish					
Priority 2					
Intensive Culture	311	0.00	0.00	0.25	1.00
Production management systems	313	0.00	0.00	0.00	0.50
Production of products with improved acceptability	409	0.00	0.00	0.00	0.25
Subtotal		0.00	0.00	0.25	1.75
Crawfish totals		0.25	0.25	1.25	5.25
Increase					5.00

TABLE 4. RESEARCH PROBLEM 4.07—FRESHWATER FOODFISH RESEARCH DISTRIBUTION OF RESEARCH BY AGENCY[1]

RPA	SAES	TVA	USDI	USDC	Kerr	Total
210	0.60	0.20	0.80	------	------	1.60
211	1.65	0.40	3.20	------	------	5.25
212	0.40	------	0.10	------	------	0.50
213	0.30	0.10	0.90	------	------	1.30
701	------	------	0.20	------	------	0.20
901	0.20	1.60	0.80	1.00	------	3.60
310	0.90	------	0.70	------	------	1.60
311	9.40	0.40	0.80	0.50	------	11.10
312	1.57	0.20	0.40	------	------	2.17
313	3.30	0.70	0.00	0.50	0.75	5.25
317	0.20	0.50	0.30	1.00	------	2.00
409	0.75	0.20	------	------	------	0.95
410	1.55	------	------	------	------	1.55
411	0.70	------	------	------	------	0.70
412	1.00	------	------	------	------	1.00
702	0.80	------	------	------	------	0.80
703	------	------	------	------	------	0.00
506	0.73	0.30	------	------	0.25	1.28
507	0.03	------	------	------	------	0.03
508	1.14	------	------	0.16	------	1.30
511	------	0.20	------	0.10	------	0.30
Totals	25.22	4.80	8.20	3.26	1.00	42.48

[1] The research considered by this task force deals with freshwater foodfish and crawfish and is limited to the Southern Region of the United States. A number of governmental agencies are conducting research on freshwater and marine fish, and sport fish outside the Southern Region. Results of this research is applied by those in the Southern Region. The direct contributions are difficult to quantitate, consequently they are not included in this summary.