AQUACULTURE ECONOMICS RESEARCH NEEDS

Report from a Workshop
to Identify Aquaculture Economics Research Needs
Atlanta, Georgia -- April 23, 1976

Frederick J. Smith, *Office of Sea Grant*
Kenneth J. Roberts, *Clemson University*

South Carolina Sea Grant
Technical Report Number 5

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South Carolina Marine Resources Center
Charleston, South Carolina 29412

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PREFACE

While the commercial aquaculture industry is growing and considerable aquaculture research is underway, there are many unanswered aquaculture economics questions. The way in which economists become involved in aquaculture research could have a major impact on research results and eventually upon the ultimate success of the aquaculture industry.

Concern over aquaculture economics and the economists' role in aquaculture research resulted in a one-day workshop in Atlanta, Georgia on April 23, 1976.

The ultimate purpose of this effort was to improve the economic relevance of aquaculture research.

Workshop participants attempted to answer the following questions: 1. When should economists get involved in aquaculture research? and 2. What can and should economists do to help? Several papers were presented and discussed. Extensive notes were taken during the group discussions and subsequent workshop session. These notes were summarized by a select committee who then reported back to the group as a whole for final modification.

This report represents substantive agreement among workshop participants. The major issues are presented in the body of the report. The workshop agenda and supporting documents are provided in the Appendix.

INTRODUCTION

The aquaculture economics research workshop had three overall objectives:

1. Contribute to economic relevance of aquaculture research,
2. Broaden economists contribution to aquaculture research, and
3. Contribute to improved performance of aquaculture economics research.

Focus was provided by the presentation of three papers:

1. Sea Grant Funded Research in Aquaculture Economics,
2. Economics Research Needs from the Industry View, and
3. Economic Research Needs from the Academic View.

The latter two papers were discussed by three panelists each and by participants in general. Following these discussions the 33 workshop participants discussed aquaculture economics research needs. These discussions are summarized here under seven headings. There is also a short statement on the opportunities for communication and cooperation in aquaculture economics research. This statement also resulted from discussions among workshop participants.

AQUACULTURE ECONOMICS RESEARCH NEEDS

In general, participants concluded that economists should play a larger role in aquaculture research, should become more involved in research planning, research management and should study institutions, regulations and policy as it influences the economics of aquaculture. Further, it was concluded that economic feasibility studies are essential.

Economic Feasibility Research

The traditional role of economists has been to project costs and returns for an assumed size and type of aquaculture venture. These projections are usually made after the biological and/or engineering research has been initiated, and usually at the discretion of the natural scientists in charge. This type of economic research will continue to be valuable since new systems, species and sizes of aquaculture ventures are constantly being tested. However, economic feasibility estimates provide only gross indications of ultimate feasibility, given the sometimes heroic assumptions that must be made.

More than one projection of economic feasibility can be justified for most aquaculture research projects. As the project progresses, old assumptions can be modified, new price and cost information can be acquired and costs and returns projected on a frequent if not continuous basis.

The economist (unless he administers the project) must not be placed in a position of causing the project to be shut down, simply because the project does not currently appear to be economically feasible. If the economist is in such a position, he will not be a welcome member of the research team and may not be able to assist the research in the most efficient and

honest manner. The economist can help steer the program on the course leading to economic improvement and ultimately commercial success.

Demand and Supply Research

Assumptions about the ultimate product price is one of many often made in determining economic feasibility. Usually, current market price for the closest aquaculture product substitute available is used. This ignores the price effect of product differences, price elasticity and income elasticity. The price depressing effect of product supply increases from aquaculture can be substantial.

Futhermore, the cost inflating effect of using up scarce aquaculture resources (clean water, lease areas, waste disposal permits, trained aquaculture technicians, etc.) can significantly impact economic feasibility. A significant commitment over many years to research on product and factor prices will be necessary if the quality of economic feasibility projections is to be improved. This type of research will require very little interaction between the aquaculture researcher and economist. However, it may require substantial interaction between the economist, industry and government.

Research Planning

The economist should be a member of the research team from the earliest planning for aquaculture research through the commercial implementation. The economist can provide guidance in terms of research methods, data needs, optimal timing, systems analysis, etc., all of which can move the project more efficiently toward real world economic feasibility.

Research Management

The economist should provide continuous assistance in the conduct and organization of aquaculture research. The economist can develop partial or full scale models of the aquaculture system, identify critical research paths, test the sensitivity of production variables, develop benefit/cost analyses, analyze project management procedures, etc.

These activities will contribute to more efficient aquaculture research better focused toward commercial viability. However, it is important to recognize that some aquaculture research which doesn't lead to commercial viability is also important.

Economic Impact of Institutions and Regulations

Aquaculture is a growing industry in the United States, using an increasing variety and quantity of common property resources. As aquaculture has developed, regulations and institutions not designed to cope with this industry have affected development. Studies are needed to address the economic impact of regulations and institutions on the development of aquaculture.

It is also necessary to analyze the kinds of institutions and regulations that are needed to enhance aquaculture development consistent with the other needs of society.

Policy Studies

The development of aquaculture (brought about in part by aquaculture research) is causing a reallocation of many scarce public resources and could have a major distributional impact (demographic and geographic) upon incomes. For example, use of coastal land and estuaries for private aquaculture, benefits the aquaculturists and aquacultured food consumers but reduces potential

benefits to recreationists.

Before aquaculture develops much further, it will be productive to examine the policy implications for the use of these public resources and determine whether public welfare is increased or decreased through aquaculture development.

Other Needs

As new aquaculture firms become established and grow, their research needs change. Basic research on production systems, viable species and reproduction should give way to development of new knowledge on management, marketing, disease diagnosis, etc. While government and academia can help develop this new knowledge, they can also provide some of the management training, diagnostic and other services that are usually slow to develop in small food production industries.

Opportunities for Communication and Cooperation in Aquaculture Economics Research

Communication and cooperation between social and natural science researchers is needed and should be enhanced. The need is often greatest within a project or an agency.

Institutions which have ongoing aquaculture research should fund an internal extension (advisory) activity for economists. Release time and financial support as well as the other institutional rewards (recognition, salary enhancement, prestige, etc.) may be required to encourage research planning, research management, marketing and other assistance from economists.

The same type of supported communication and cooperation should exist among agencies and academic institutions. Certain economists could become

recognized as expert "consultants" on aquacultural economics, locally and regionally.

Finally, the Office of Sea Grant needs to make its information system available and convenient to researchers so that each can be regularly apprised of who is doing what in aquaculture economics.

APPENDIX I

AQUACULTURE ECONOMICS RESEARCH WORKSHOP AGENDA

April 23, 1976

8:30 A.M. - Introduction - Ken Roberts, Clemson University

8:45 - Paper: Sea Grant Funded Research in Aquaculture Economics
Fred Smith, Office of Sea Grant

9:00 - Paper: Economics Research Needs from the Industry View
William McGrath, Ralston Purina, Inc.

9:15 - Panel: Economic Research Needs
Paul Sandifer, S. C. Marine Resources Research Inst.
Ronald J. Webber, Groton BioIndustries Development Co.
Dave Adams, Coastal Zone Resource Corporation

10:15 - Break

10:30 - Paper: Economic Research Needs from the Academic View
Dick Johnston, Oregon State University

10:45 - Panel: Economic Research Needs
Robert Shleser, Office of Sea Grant
John Gates, University of Rhode Island
Wade Griffin, Texas A&M University

11:45 - Lunch

1:00 P.M. - Workshop: Develop a Document Indicating When and How Economists Should Get into Aquaculture Research Planning, Proposal Development and Aquaculture Research -
Bill Shaw, Office of Sea Grant

2:30 - Break

2:45 - Workshop: Develop a Document Indicating Opportunities for Inter-institutional, Interdisciplinary and/or Regionally Coordinated Aquaculture Economics Research
Fred Smith, Office of Sea Grant

4:15 - Workshop Reports - Bill Shaw

5:00 - Concluding Remarks and Adjourn - Ken Roberts

APPENDIX II

INVITED PARTICIPANTS

AQUACULTURE ECONOMICS RESEARCH WORKSHOP

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APPENDIX III

AQUACULTURE ECONOMICS WORK

Frederick J. Smith
Associate Program Director
National Sea Grant Program

When the National Sea Grant Program was enacted by Congress, aquaculture was the only research area specifically designated in the legislation. It has been and continues to be a major segment of Sea Grant:

	FY 71	FY 72	FY 73	FY 74	FY 75
Aquaculture funding in $M	1.7	1.6	2.6	3.2	3.2
No. Institutions with Aqua. projects	24	22	24	19	24
No. projects	28	54	74	86	72
Aqua. funding as % of all grants	13.8	10.1	14.3	17.3	15

In addition to the current projects classified under aquaculture, there are 11 closely related and 21 terminated (completed) projects. There are 7 projects that are clearly economics oriented and several others that have economics elements. There are two legal projects, a food science project, a course development project and 4 extension projects in aquaculture.

We could spend considerable time discussing the aquaculture projects in general, but our purposes will be best served by focusing on the few current aquaculture economics projects.

The first is a project at OSU in which I am involved with Dick Johnston and Don Langmo. The title of the project is "Feasibility of Production and Marketing of Seafoods Reared by Aquaculture." Emphasis is on salmon and oysters and the research is highly integrated with the biological, nutritional and engineering work on these two products at OSU. A production cost analysis of oyster aquaculture based upon laboratory data has been completed. A similar analysis based on commercial operations is now underway.

Production cost analysis on pond cultured salmon based on commercial operations is also underway. A cost analysis of culturing Brine shrimp for salmon food has been initiated. Data are being collected for a demand analysis of yearling salmon.

Another closely related, and in fact, cooperative study is entitled, "Economic Feasibility of Alaska Non-Profit Salmon Aquaculture." Frank Orth and E.T. Robinson will do an economic feasibility study on a new salmon aquaculture operation on Prince William Sound. An interesting aspect of this work is measuring the benefits that accrue to the community at large through stock enhancement. They will also look at community economic impact due to increased local economic activity.

Warren Johnston and Geoff Allen have worked closely with Bob Shleser and others at Bodega Bay, California in analyzing the lobster aquaculture research there. They have developed a simulation (model) of a lobster production plant and are using it to project economic feasibility and more importantly are continually identifying the most cost sensitive variables that deserve further research. We are hoping that the model will be applied to other aquaculture projects and are attempting to get Allen involved in a unique project in St. Croix. Ron Webber of Groton Bio-Industries is attempting a similar model for their operation.

Richard Vilstrup has worked closely with aquaculture researchers at the University of Wisconsin on the economics of Yellow Perch aquaculture. Vilstrup is collecting cost of production information from the demonstration perch farm and has looked at the processing and marketing facilities for perch as well as the potential demand. To date, most of his work has been descriptive.

Reggie Bouchard is promoting blue mussel sales in New England. We are hoping that some people in the University of New Hampshire Business School will look at the short and long term impact of the intensive promotional efforts of aquacultured blue mussels.

John Gates at the University of Rhode Island has analyzed the eventual commercial feasibility of aquaculturing different species in New England. He is currently working closely with the silo culture people looking at various cost factors.

The University of Delaware has a continuing intensive oyster culture research program in which economics is a small by fully integrated element. They are now expanding a pilot scale oyster aquaculture operation and have completed an engineering cost analysis.

I must also mention the contributions of Ken Roberts in South Carolina, Lee Anderson in Miami and now Delaware and Wade Griffin at Texas A&M University. They have all contributed to the economics of aquaculture in a variety of ways.

In general, past work has emphasized partial cost and efficiency analysis of aquaculture systems-attempting to answer the eventual economic feasibility question. More recently, economists have begun to take a more comprehensive look at economics of aquaculture and are playing an increasing role in directing research. We are also finally beginning to look at pricing, market impacts, and marketing of aquaculture products.

APPENDIX IV

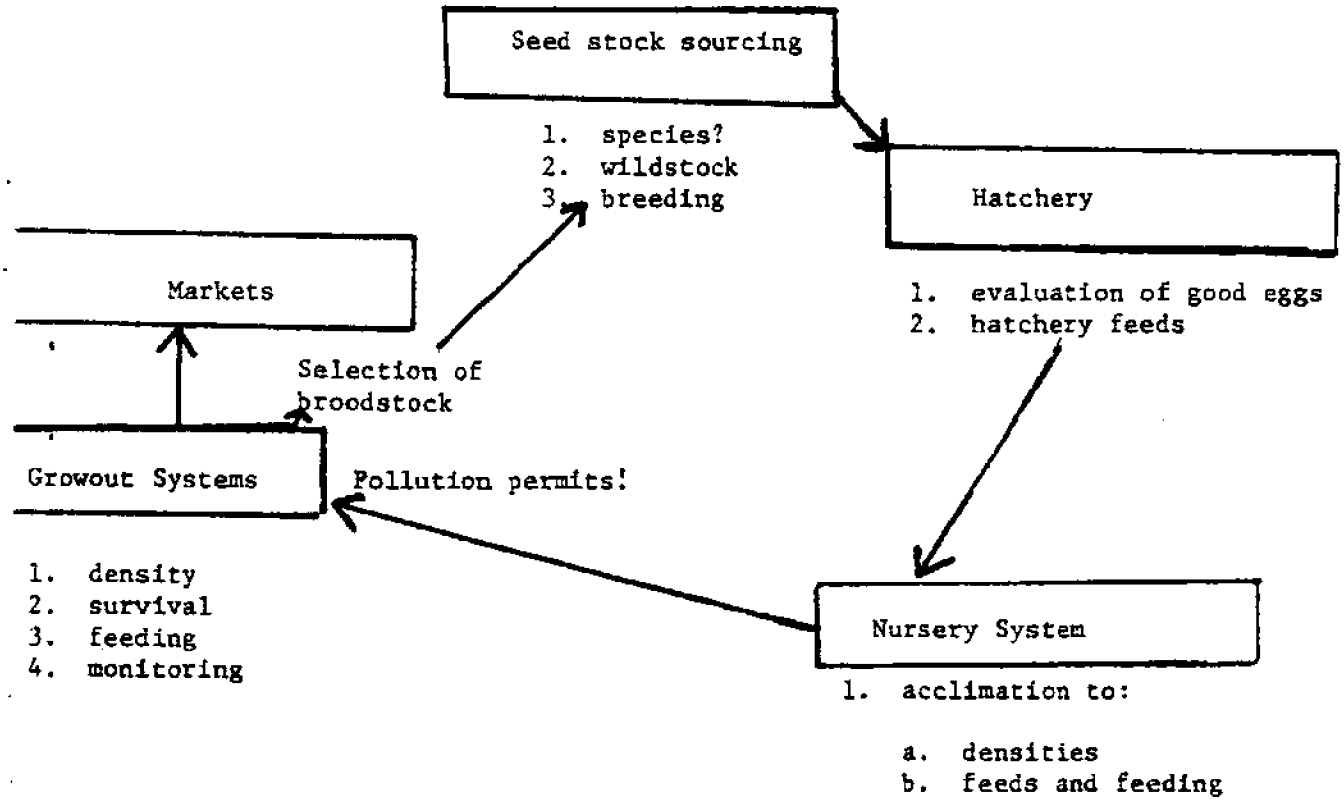
ECONOMICS RESEARCH NEEDS FROM THE INDUSTRY VIEW

William McGrath
Ralston Purina, Inc.

Elements of Decisions

1. Projected return on asset (ROA)
2. List profile on new business - what kind?
3. Market considerations
4. Time (how long to acquire objectives)
5. How much money?
6. Does it have a corporate fit?

Organization and Operation of a Pilot Plant



Priorities in Aquaculture Production

1. Seed Stock

   ideal species?
   how to select broodstock
   maintaining a consistent supply

2. Pollution Permits

3. Growout - survival - no feed rate
   optimization - affect
   food conversions

4. Miscellaneous

   Artemia - limited supply - costly in a pilot plant ($19.00 p/b)
   Disease - will happen

APPENDIX V

ECONOMIC RESEARCH NEEDS FROM THE ACADEMIC VIEW

Richard S. Johnston
Oregon State University

Probably the major reason for the recent increase in interest in aquaculture by researchers, especially economists, originates with the commercial interests expressed by private groups and individuals, and the parallel interests by governments. While aquaculture has been practiced for centuries, this recent surge in interest can, perhaps, be explained by the discovery by potential and existing entrepreneurs that aquaculture may be a new source of income or may serve as a replacement for their present source of income, which could be commercial fishing from a declining stock. The public policy interests stem, in part, from a recognition by public agencies of the potential of aquaculture to increase the world supply of protein and/or to supplement or rehabilitate declining natural stocks. I would conjecture that some of the commercial opportunities were made possible by the research discoveries made by physical scientists - especially fishery biologists, geneticists, nutritionists, etc. - operating largely out of curiosity in what could be called "basic research." Economists, on the other hand, have tended to follow the requests of industry and government groups who have identified problem areas and who seek answers to specific questions. This may be because much of the economic analysis in aquaculture is being done by agricultural economists with a strong problem-solving orientation. I have no quarrel with this except to the extent that it leads us to overlook some broader, longer-term issues.

In this paper I would like to suggest that:

1. university economists should not be afraid of basic research in the area of aquaculture and, indeed,
2. while the goals of university researchers exploring basic research questions and those of government and commercial interests may be different, such research may have "payoffs" to all three groups.

In discussing these proposals I shall draw upon rather limited personal experience in the area of "aquacultural economics" and shall, of course, present only my own views - views which should not be considered as representative of those of the "university community" as a whole. I should also point out that I do not wish to confine my remarks to Sea Grant supported research, although I do feel that Sea Grant's problem-solving orientation may have provided researchers with a disincentive to explore fundamental issues. This seems to be changing, however.

The word "aquaculture" has been variously defined but let me use it here to refer to "the application of a wide variety of methods devised to control the selection and to increase the production of aquatic organisms, whether fin fishes such as salmon, or mollusks, crustaceans, sea urchins or seaweeds" (2, p. 2). This definition, which appears in the prospectus of an aquaculture corporation, identifies the important characteristic of aquaculture, that of control. In this context control refers to the ability to make decisions regarding growth rates, harvesting, and marketing and to make them with some degree of certainty regarding the outcome of those decisions. The commercial raising of oyster seed in a hatchery, for example, provides the decision-maker with a different degree of control than is the case when that decision-maker must rely on

harvesting in a "natural" environment.

With some exceptions, economists have focused on how this control is excercised (in some cases they may even be concerned with how this control should be exercised), generally under the heading of "economic feasibility." Emphasis is on estimating the costs associated with producing various volumes under aquacultural conditions and on the demand for products so produced. Indeed, this approach characterizes my own work. In the course of looking at "economic feasibility" questions we may often find ourselves being of service to a variety of "clientele groups." The commercial entrepreneur may find estimates of demand elasticities and cost-volume relationships valuable to him in making decisions. (To the researcher this perceived benefit may facilitate the acquisition of data necessary to perform the analysis.) Government units may be assisted in answering questions such as how many commercial licenses to issue, what fee structure to impose, etc. Ultimately, consumers may benefit from the research, especially if it leads to increased production, lower prices, and increased choice. I don't wish to argue that these are not valid justifications for economic research (although a case can be made for having such research done somewhere other than at a publically-supported university). Rather, I want to suggest that such justifications may lead us to accept current institutional arrangements (price-determining processes, property rights, legal arrangements) as either given or outside of the purview of analysis and, hence, to overlook some long-run consequences of aquaculture. What phenomena will lead to different forms of control and what will be the consequences on resource allocation of these different forms of control? What will be the effects of aquaculture on income distribution in the marine environment?

Perhaps I can make my point with an example. One of my own research projects involves examining the economic feasibility of an industry based on Pacific salmon ranching and/or farming.* Consistent with the objectives of the project, we are looking at both production costs and demand factors. So far, so good. However, perhaps one of the most important aspects of salmon aquaculture is not being researched because of the difficulty of quantifying anticipated benefits from such research. I am referring to the consequences of what may amount to a major re-alignment of property rights in the salmon fishery. As "applied" economists we are so accustomed to working with quantifiable data that we find it easier to estimate demand equations for which price, quantity, income, etc. figures are available than to develop models which require that we treat government, property rights, etc. as endogenous variables. Yet such models may generate hypotheses which, while difficult to test, could improve our understanding of what consequences aquaculture is having and is likely to have on commercial fishing and seafood marketing and, hence, on resource allocation and income distribution in the seafood sector. Can the open access or common property nature of the salmon resource be treated independently of the enormous increase in salmon aquaculture both here and abroad? Will salmon aquaculture reduce the perceived need for limited entry programs in the fishery? What are the economic forces at work to change the present structure of property rights and what will this structure look like in twenty years? Despite its efficiency as a harvester of salmon, the salmon trap was outlawed in Alaska years ago because of fear of control of the industry by a few firms: those who held strong property rights through ownership of the traps. Will aquaculture be characterized by many small competing fish farmers

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* Under the former, young salmon are released to the ocean and harvested upon their return. With the latter, salmon are raised to "maturity" under environmentally controlled conditions.

or will seafood production be the responsibility of a few large firms? Will aquaculture relieve pressure on the ocean as a source of food or will it increase pressure? Internationally, what factors are associated with comparative advantage in aquacultural production of seafoods?

Are these "political" questions to which the economist can make no contribution? I think not. Demsetz has pointed out that the structure of property rights changes in response to changes in demand and the costs associated with defining and protecting property rights (1). This has been the case in agriculture, where we moved from a hunting to a farming mode in response to increased demand for food and opportunities to develop relatively low cost ways of defining and protecting rights in land. With present analytical techniques available for examining "long-run" demand factors and costs of alternative institutional arrangement, surely the economist can, through forecasting the nature and distribution of property rights, say something about what the seafood production system will look like and what factors will influence this system.

This, it seems to me, is a legitimate and entirely appropriate area of inquiry for university-based marine economists. In some respects it calls on us to behave in a way comparable to our counterparts in the physical sciences. I, frankly, am tired of hearing politicians trot out for public ridicule the titles of projects which seem to have no immediate payoff, such as one which researches the mating habits of some tropical insect. I suggest that, given full information on the nature of the research, the public would not be as critical of having public money devoted to such studies as some vote-seekers would like us to believe. These projects may have no immediate monetary payoff and may lead to no immediate public policy proposals but they help us better understand the world in which we live and, perhaps, may say something

about the way the world will look in the future. Similarly, the marine economist, drawing upon an analytical framework designed to help understand how societies make choices, may, through cooperating with the geneticist, the fisheries biologist, the oceanographer, etc. and by broadening his/her analysis to embrace changes in variables which he/she hold "fixed" (institutional arrangements, in particular), may help us better understand changes which are going on and what we can expect our world to look like in the future. Why is there currently so much interest in aquaculture? Are there important shifts taking place in property rights? If so, why? Will they continue? Will an important source of the world's protein be brine shrimp ponds located in downtown Detroit? The questions are endless and challenging to researchers.

But this is only part of the story. Just as these questions may be appropriate for university researchers, they are also of interest to those groups interested in short term payoff questions. Firms currently involved in aquaculture are discovering that what attracted them will attract others. They have an interest in what is likely to happen over time. Governments are interested in the long-term implications of their policies. I am not suggesting that these commercial and government interests are necessary to legitimize basic economic research at the universities. I am merely suggesting that, just as firms and governments may have an incentive to cooperate in "economic feasibility" projects, they may have an incentive to cooperate in research with a broader and longer term perspective.

Change is taking place in the marine environment. We can do several things: continue to look at it on a species-by-species, firm-by-firm basis and be a part of the change; wait until we have enough data on aquacultural production and then describe what has happened; look at the broad implication

of aquaculture as an important institution-changing phenomenon and forecast its consequences on resource allocation and income distribution questions. I submit that there is a role for all three but feel we may be short-changing the third. In my view, the opportunity costs of continuing to do so are high.

REFERENCES

1. Demsetz, Harold. "Toward a Theory of Property Rights," American Economic Review, May 1967.

2. Prince William Sound Aquaculture Corporation. Salmon Culture Program, 1975.

APPENDIX VI

DATA CONSTRAINTS ON AQUACULTURAL ECONOMICS RESEARCH

John M. Gates
University of Rhode Island

Quantitative economic research presupposes the existence of data to be analyzed. I would like to direct attention to the data base for aquacultural economics research. Data quantity and quality are not very fascinating topics but there are some issues to be raised and so I beg your indulgence for a few minutes.

A. A Review of the Data Situation

Agricultural economics research, data requirements and availability provide useful bench marks for comparisons and contrasts with aquacultural economics research. Traditionally micro data for agricultural economics research came from either (1) farm surveys, (2) farm account books or (3) experimental data. Each of these types of data has its advantages and disadvantages, but it is unquestionably true that a wealth of each has been accumulated over time. Aggregate agricultural economics data such as production, major stock and flow resource inputs, prices, etc. are compiled by numerous public agencies but mostly by the Department of Agriculture (USDA) and by research supported by Agricultural Experiment Stations. Such data is available yearly, by region, state, county, major commodities, etc.

Let us contrast this with the current and foreseeable situation in aquacultural economics. With the exception of the catfish industry one can count on one's fingers the number of published studies based on farm surveys and I know of none based on fish farm account books. Most of the literature on costs and revenues, including my own, has therefore been

synthesized in large part from experimental data from public operations. Synthetic projections certainly have their place particularly in projecting changes such as new technology for which there exists no observable commercial counterpart. Ultimately, however, they suffer from the defect that one must have empirical, real world verification of benchmark parameters and assumptions. Traditionally these benchmarks in agricultural economics were readily available from surveys and farm accounts.

As far as aggregative analyses of aquaculture are concerned, the terrain is even more barren. Where can one look, for example, for even a rudimentary supply-demand analysis of cultured products (as opposed to similar products derived from the capture fisheries). This of course is no accident - no data exists on which to base such analyses. As far as I know, no public agency is planning to rectify this situation.

B. Some Reasons for the Status Quo

Several interacting factors have contributed to the status quo. Among these are: (1) heterogeneity of the aquacultural "industry", (2) industry structure, (3) nascence of the industry and (4) diffused public sector responsibilities and competing priorities.

1. Heterogeneity

The only common biological denominator to be found in the aquacultural industry is that it involves man's deliberate intervention in one or more stages in the life cycles of aquatic organisms. Perhaps the common economic denominator is product prices which are relatively high compared to prices for other aquatic organisms which are not cultured. A minimal list of

species (actually groups of species) would include trout, salmon, clams, oysters, scallops, lobster, shrimp, shiners, bluegills, catfish. This list is not long but the resource requirement represented in it are extremely diverse. This implies that there is very little substitutibility for stocks of cultural and economic knowledge.

2. Industry Structure

The atomistic structure of agriculture and a long history of public agricultural research and extension made it relatively easy to accumulate information, including economic, via surveys and farm account books. Within aquaculture, the various species are cultured by small numbers of firms many of whom are zealously protective of what they consider to be proprietary information. The fact that we have had few services to offer by way of reciprocity has certainly not helped. The public sector is also very active in aquaculture via state and federal hatchery programs. It is in principle, at least, easier to obtain micro data from such public operations than from the private sector. Aggregate data could also be compiled on outputs and expenditures. There are obvious problems in converting physical outputs into value, but these are not insurmountable. The point is that these types of data are not readily available except for internal use of the public agency and little effort is made to summarize and analyze the data which does exist.

3. Nascence

The current intense interest in aquaculture is perhaps not a birth but a rebirth. Commercial trout culture in New England dates back at least a century. Oyster culture on private lease grounds in Long Island Sound are of comparable vintage. This rebirth has been associated with an almost euphoric view of the future role of aquatic (especially marine) biota in feeding the undernourished of the world. I think anyone who investigates aquaculture is soon disabused of this romantic conception. It is fair to say, however, that the current stock of knowledge and data base concerning aquaculture is at a par with nineteenth century agriculture in large part because interest in improving the status quo is quite recent.

4. Public Sector

Substantial public sector responsibilities for aquacultural programs exist in at least three federal departments: Commerce, Interior, and Agriculture. In addition, of course, there are numerous state counterparts. There is, therefore, considerable diffusion of responsibilities based on specific programs, species, resource characteristics etc. Sea Grant, for example, is interested only in mariculture. The National Marine Fisheries Service (NMFS) nominally has a memorandum of agreement with Agriculture (USDA) which delegates aquacultural responsibilities to NMFS. Yet, the best examples of solid aquacultural economics research are associated with the Soil Conservation Service in USDA and various Agricultural

Experiment Stations. In addition, the priority within NMFS for the foreseeable future will be extended fisheries jurisdiction. None of these agencies has a data collection program which even remotely approaches the detail of our general data series in Commerce or USDA. Furthermore, this Balkanization of responsibilities implies that we are unlikely to see research funds emanating from these agencies to support comprehensive analyses and farm management service programs by Universities. Sea Grant may support a farm survey of salmon mariculture but not of fresh water trout farmers despite the fact that the two groups overlap in various ways such as fingerling supplies, feed sources, and markets.

C. Some Implications

In view of what has been said, it seems clear that we need more data derived from actual operating experience of aquaculturists. This will not be easy but it would be facilitated if we can begin offering services to aquaculturists such as recordkeeping and analysis, farm management assistance, etc.

It also seems clear that there is a need for a data collection system within the federal bureaucracy. Data to be collected should include physical inputs; production products, prices, etc. It should also compile some of the institutional information to which Professor Johnston has referred so that one could begin to assess the impacts on supplies and prices of altering property rights.

It is also clear that there is not a coherent national aquacultural policy. There is rather a collection of programs and policies diffused among several agencies. It would seem that there is therefore, a need for some policy oriented research as well as the farm management types of studies which have predominated in the past.

APPENDIX VII

AQUACULTURE ECONOMICS
NATIONAL SEA GRANT PROGRAM
List of Current Projects by Classification
January 23, 1976

Institution	Title	Investigator	SG $	Matching
Texas A & M Univ.	"Shrimp Mariculture System"	J. Parker, W. Kluseman	$103,000	$ 69,399
Univ. of California	"Development of Aquaculture Systems"	R. Shleser	133,876	192,051
Univ. of Washington	"Improving Salmonid Aquaculture"	R.E. Nakatani, E. Brannon G. Pauley	156,200	75,900
Univ. of New Hampshire	"Feasibility of Salmonid Culture in Power Plant Heated Effluent"	Evelyn Adams, F. Towle	11,100	6,300
Univ. of Rhode Island	"Management of Salmonids in a Closed Circulating Controlled Environment System"	Thomas L. Meade	45,481	9,739
Oregon State Univ.	"Feasibility of the Production and Marketing of Seafoods Reared by Aquaculture"	R.S. Johnston, R. Langmo	27,300	32,900
Univ. of Wisconsin	"Raising Yellow Perch and Walleye Pike for Human Food Use"	H.E. Calbert, D.A. Stuiber	13,948	9,562
Univ. of Alaska	"Cost Factors Associated with Non-Profit Salmon Aquaculture"	E.T. Robinson	-	11,100
" " "	"Cooperative Aquaculture Economic Project"	F.L. Orth	3,000	-
Univ. of Maine	"Shellfish Hatchery Seed Stock Production and Development of Hatchery Techniques for Maine"	H. Hidu, D. Dean	62,217	26,248
Univ. of New Hampshire	"Edible Blue Mussel Product Development in Maine and New Hampshire"	R.J. Bouchard, Miller, Alonzo, Peters	34,800	38,500
Marine Resources Center (South Carolina)	"Investigation of the Potential of Intensive Oyster Culture in Coastal Impoundments in South Carolina"	V.G. Burrell, Jr., A. Jordan	23,400	20,900
Univ. of Delaware	"Commercial, Controlled Environment Mariculture: Development of Formulated Feeds"	C.E. Epifanio, K. Biddle	15,300	12,800

Institution	Title	Investigator	SG $	Matching $
Univ. of Delaware	"Commercial, Controlled Environment Mariculture"	C.E. Epifanio, C. Mootz	$ 23,100	$ 24,200
Univ. of Washington	"An Aquaculture Development and Feasibility Evaluation Program"	L.J. Bledsoe, J. Glude	22,800	-
Univ. of Wisconsin	"Economic Analysis of Income and Market Potential of Aquaculture Systems for Cold Water Fish"	R.H. Vilstrup	13,452	3,070
Univ. of California	"Economics of Aquaculture"	W. Johnston, P.G. Allen	10,849	9,101
" " "	"Effects of Public Regulation on California's Aquaculture Industry"	G. Bowden	8,196	12,096
Univ. of Alaska	"Development of Aquaculture in Alaska"	D.W. Hood	24,300	12,200
Univ. of Maine	"Development of a Graduate Course in Aquaculture"	Herbert Hidu	800	2,478
Univ. of Wisconsin	"Aquaculture"	J. Quigley	7,637	1,926
Univ. of Maine	"Commercial Implementation of Aquaculture in Maine"	Herbert Hidu	37,156	6,565
Univ. of Alaska	"Economic Feasibility of Alaska Non-Profit Salmon Aquaculture"	F.L. Orth	-	23,600

The Commercial Production of Topminnows -- A Preliminary Economic Analysis

Hawaii Inst. of Marine Biology, Honolulu. Herrick, Samuel F. Jr., Baldwin, Wayne J. January 1975. Report Number UNIHI-SG-AR-75-02.

In an effort to provide alternative supplies of live baitfish suitable for use in the skipjack tuna fishery, researchers have been investigating the feasibility of rearing the topminnow (Poecilia vittata) using high-density cultural techniques. Topminnows thrive and reproduce under a variety of environmental conditions. Broods produced by females kept in the prototype breeding pond contained significantly larger numbers than those produced by their counterparts in the wild. Newly released young were removed from the breeding pond on a regular schedule and grew to baitfish size within three months. Mortalities were exceptionally low. The cost of producing topminnows are substantially lower than the costs of capturing live bait. The topminnows may be sold to the skipjack tuna fishermen at a price low enough to assure the fishermen of a profit after expenses.

Cultivation of Freshwater Prawn "Macrobrachium"

Louisiana State Univ., Baton Rouge. Department of Food Science. Meyers, S. P. December 2, 1974. Pub. in Feedstuffs, v46 n49, 2 Dec 74.

Prawns (or freshwater shrimp) are being studied as major candidates for economically-oriented aquacultural enterprises. Interest in commercial exploitation of prawns is largely due to the desirable characteristics of the species including fast growth rate. Cultivation practices are being considered along two general lines - intensive pond culture in an optimal temperature area and confined tank or intensive culture structures with controllable environment. Both approaches pose separate maintenance or managerial problems. The cannibalistic nature of prawn is a critical factor in intensive cultivation under closed conditioning. Studies into feed costs, feeding rates, diet development, and management of grow-out facilities are in their early stages. Little reliable data are available concerning price and demand for prawn.

On the Mariculture of the Florida Seaweed, "Eucheuma isiforme"

University of South Florida, Tampa. Dept. of Biology. Dawes, Clinton J. August 74. Florida Sea Grant - 5.

A proposal is made for the mariculture of Eucheuma isiforme, a red alga belonging to the order Gigartinales, and containing the commercially important phycocolloid iota-carrageenan. Support for the proposal is drawn from presently known biological information of Florida Eucheuma and present mariculture practices for other red algae including species of Eucheuma of the central Pacific.

Economic exploitation of Florida Eucheuma is also supported by the increasing demand for iota carrageenan and the depletion of depletion of natural populations of phycocolloid bearing seaweeds. A comparison of yields from tank and field culture of Eucheuma fragments indicates that a value of $9.72/sq m/yr would be obtained from clean, washed, and dried plant grown in tanks while only $0.16 /sq m/yr would be obtained from field grown material.

Mariculture Potentials in Estuarine Oil-Pipeline Canals.

Nicholls State Univ., Thibodaux, LA. Dept. of Biological Sciences. Kilgen, Ronald H., Harris, Alva H. 1973. Included in Proceedings of Annual Session of the Gulf and Caribbean Fisheries Inst. (26th), New Orleans, LA, 29 Oct-1 Nov 73.

Rotenone samples of estuarine oil-pipeline canals in Louisiana showed that natural standing crops of harvestable fin-fishes ranged from 133 to 369 kilograms per hectare, with an average minimum wholesale value of $38.80 per hectare. Trawl samples indicated an abundance of blue crabs, and that white, pink and brown shrimp overwintered in these canals. Salinities ranged from 2.0 to 25 parts per thousand. Potential mariculture uses of these canals are discussed, involving polyculture of naturally occurring species of fishes, mollusks and crustaceans, along with cage culture of catfish, pompano, and other species. Problems associated with pipeline mariculture are discussed.

The Commercial Crawfish Industry of South Louisiana.

Louisiana State Univ., Baton Rouge, LA. Center for Wetland Resources. (408 059). Gary, Don L. January 1974. LSU -SG - 74-01

The crawfish enterprise of south Louisiana has expanded as much as eighteen-fold since the 1950's. It was estimated in 1973 that there were about 44,000 acres of managed crawfish ponds. Of the 334 ponds identified and mapped in this report, 231 are classed as open ponds, 45 as rice field ponds, and 58 as swamp ponds. The total Louisiana harvest of crawfish is estimated to about 11 million pounds annually valued at about $2.2 million. Increases in crawfish production and harvest, however, will probably depend upon further research leading to improvement of the crustacean, especially for greater percentage of edible meat; development of markets for crawfish waste; research leading to more efficient processing and longer storage time in retail markets; and a more stable, adequate price to provide the economic incentive. (Modified author abstract)

Aquaculture in New England.

Rhode Island Univ., Kingston, R.I. Marine Advisory Service. Gates, J.M., Matthiessen, G.C., Griscom, C.A. 1974. Marine-TR-18

The report is concerned with the present potential for, and limitations on, aquaculture in the New England region. It was found that, at the present time, those species appearing to have the greatest potential for commercial culture in New England are the American oyster, hard clam, bay scallop, American lobster and silver (Coho) salmon. The first four are indigenous to the New England area, while experimental introductions have demonstrated the ability of the silver salmon to thrive in this region. Furthermore, a technology exists for culturing these five species through all stages of their life cycles to marketable size.

The Mariculture Potential of Clam Farming.

Florida State Univ., Tallahassee. Dept. of Oceanography. Menzel, Winston. 1971. Pub. in the American Fish Farmer, p8-14 - Jul 71.

On the basis of experience gained in quahog clam mariculture, the author recommends the need for a well equipped hatchery, the use of F1 hybrid between northern and southern species for seed clams, adequate predator control, planting densities of not over 50/sq ft, and preliminary trial plantings for evaluation. Proper site selection is a critical factor. The site should have no extremes in salinity and temperature with salinity above 25 ppt. The site sould be devoid of pollution, have a substrate of mud-sand and the area should be protected from continual wave action. Currents not only bring in new supplies of food but also disperse the waste products so it is recommended there be some current. Estimates of costs and profits are included.

The Feasibility of Brine Shrimp Production on Christmas Island.

Hawaii Univ., Honolulu. Sea Grant Program. Helfrich, Philip,-Ball, John Berger,-Andrew, Bienfang, Paul,-Cattell, S. Allen. July 1973. UNIHI-SG-TR-73-02.

Christmas Island, in the equatorial Pacific, was chosen as a potential site for Artemia salina culture primarily because it possesses a number of desirable attributes including some 500 hypersaline lakes and sublagoons covering more than 60 square miles. It is located in a relatively low-rainfall zone with a favorable potential for support facilities, and an inexpensive labor force. The study indicated that the imposition of proper management could result in a continuous high yield of brine shrimp and their eggs in that environment.

An Annotated Bibliography for Economic Evaluations of the Aquaculture of Selected Crustaceans and Mollusks.

California Univ., San Diego, La Jolla. Inst. of Marine Resources. Johnston, Warren E., Collingsworth, Don W. Aug 1973. IMR-74-3 Sea Grant Pub-2.

The report represents a selective, working bibliography of sources of economic data and of previous economic analyses relating to the aquaculture of selected crustaceans and mollusks. It is primarily focused on the northern lobster, but it also contains selected references for the spiny lobster, and certain species of crabs, oyster, shrimp and prawns. One hundred and eleven items are included. (Author)

The Commercial Feasibility of Rearing Pompano, "Trachinotus carolinus" (Linnaeus), in Cages.

Miami Univ., Florida. Sea Grant Institutional Program. Smith, Theodore Isaac Joques. January 1973. Sea Grant Technical Bull-26

The University of Miami has been actively involved in developing pompano farming as a viable industry, both through its research programs and its consultations with companies involved with pompano-rearing. Objectives of this project were to assess the suitability of cages for raising pompano and to measure growth and mortality at stocking densities that would be likely in a commercial operation. This paper presents the results of the above investigation and, on the basis of data collected and observations made, discusses the problems and future of pompano farming as a potential industry.

The Cage Culture of Some Marine Fishes in the Intake and Discharge Canals of a Steam-Electric Generating Station, Galveston Bay, Texas.

Texas A&M Univ., College Station. Dept. of Wildlife and Fisheries Sciences. Marcello, Rocco Anthony Jr. September 1972. TAMU-SG-72-206.

Croaker (Micropogon undulatus), pinfisversodon rhomboides), pompano (Trachinotus carolinus), white mullet (Mugil curema), pigfish (Orthropristis chrysoptera), Gulf kingfish (Menticirrhus littoralis), silver perch (Bairdiella chrysura), spot (Leiostomus xanthurus), and black drum (Pogonias cromis) were stocked in cages in the intake canal, and croaker, pinfish, and pompano were stocked in cages in the discharge canal of the P. H. Robinson Generating Station on Galveston Bay, Texas, to determine survival, food conservation, length-weight relationship, condition, and growth. (Author)

Hawaii Univ., Honolulu. (164 500). Davidson, Jack R. 1971 9p. Included in Proceedings: National Sea Grant Conference (4th), Oct 71, p75-82, COM-73-10115. NOAA-72102701-3.

Special problems bearing on the selection of aquatic animals for culture are briefly discussed. Development problems hindering the growth of aquaculture into an economically viable industry are discussed. The need for inter-disciplinary cooperation in finding an early solution is emphasized. (Author)

Proceedings: National Sea Grant Conference (4th) Held in Madison, Wisconsin, 12-13 October 1971.

Wisconsin Univ., Madison. Sea Grant Program. Weimer, Linda,-Burroughs, Thomas,- Katzel, Jeanie. CO394J4 FLD: 6F, 6C, 8A, 78, 86M USGRDR7306, 13 Oct 71 262p. Rept No: WIS-SG-72-112 - Monitor: NOAA-72102701.

The general sessions deal with economic versus environmental considerations. Aquaculture is treated in terms of economic factors and ongoing research. The Advisory Services sessions focus on the definition of the concept, services offered, and mass communication techniques. Norwegian Advisory Services are described. Coastal zone management concepts are presented; the role of Sea Grant and university cooperation are discussed. Some of the legal-economic aspects of fisheries are viewed in light of recent draft legislation. The final session deals with training and education in ocean engineering. (Author)

Descriptors: (*Oceanography, Natural resources), (*Natural resources, Management), Management-planning- fisheries,-aquaculture,-Law (Jurisprudence), engineering, marine engineering, environments, ecology, consulting services.

Identifiers: Sea Grant Program, Coastal Zone Management

COM-73-10115 - NTIS Prices: PC$3.00/MF$0.95.

The Development of Closed System Oyster Culture.

Delaware Univ., Newark. Coll. of Marine Studies. Maurer, Don. Aug. 73. DEL-SG-4-73, Contrib-74. Published in Bull. of American Malacological Union, Inc. Feb 72 5p.

The article describes an aquaculture demonstration project under preparation by the University's aquaculture group. The project involves the production of commercial size oysters using an optimal combination of closed and semi-closed systems. The system will be designed to provide for production testing of other organisms as new target species evlove from the research. A brief outline of the scheme is set forth. It is expected to provide a sound minimum level to determine the technical and economic feasibility of scaling a controlled hatchery process to commercial production. A pilot shellfish hatchery has been designed and property acquisition has been arranged in a former oyster depuration plant and renovation is in progress.

Bardach, John E., et al., Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms, New York: Wiley-Interscience, a division of John Wiley and Sons Inc., 1972

An 868 page volume which provides a world-wide, species by species illustrated description of all aquatic plants and animals that are cultivated for food. Methods of cultivation are described. The authors include biological and ecological considerations of the organisms, the current and projected state-of-the-art of their cultivation and yields, diseases, and other problems. General principles and economics are dealt with in the first chapter.

Brett, J. R., et al., A Brief on Mariculture, Ottawa: Fisheries Research Board of Canada, Technical Report No. 301, 1972.

This is a collection of research papers dealing with the marine aquaculture of fish and invertebrates, its present status and potential.

One paper deals specifically with the culturing of lobsters (Homarus americanus), summarizing findings in this way: "Some preliminary answers to questions bearing on decisions to engage in a study of lobster culture are available. Lobsters can be mated, hatched, and reared in captivity. However, their rate of growth is slow, and mortality on a mass culture basis is high. There is evidence indicating that both can be improved by manipulation of the animal and the environment but there are some important economic factors to be considered: 1. Cost of production (cost estimates are given in the body of the paper) using present methods is much too high. Better engineering, biological and environmental optimizing are realistic objectives, 2. Selling price is about $.50/lb. to the East Coast fisherman and around $1.00 to $1.50/lb. to West Coast wholesale distributor, 3. Demand will probably exceed supply by 20 million pounds per year or more over the next decade." Included in the report (p. 43) is a partial listing of major companies and consultants actively engaged in mariculture programs (exclusive of oyster growers).

Davidson, Jack R., "Economics of Aquaculture Development," Proceedings: Fourth National Sea Grant Conference, Madison, Wisconsin, University of Wisconsin, Sea Grant Publication WIS-SG-112, October 12-13, 1971, pp. 75-82.

Discusses economic studies needed as aquaculture develops especially emphasizing the importance of the development of good economic data from the beginning of an aquaculture project.

Gaucher, Thomas A. (Editor), Aquaculture: A New England Perspective, Narragansett, Rhode Island: New England Marine Resources Information Program, 1971, 119 pp.

A report based on recommendations and key documents from a 1970 conference conducted by the Research Institute of the Gulf of Maine to plan for aquaculture in Northern New England. State-of-the-art of cultivation, favorable and unfavorable characteristics for commercial culture, and

consumption estimates to the year 2,000 are given for molluscs, crustacea and selected finfish. Legal aspects are also discussed. Excellent appendix of references.

Jones, Walter, "Commercial Fish Farming: How to Get Started," The American Fish Farmer, Little Rock, Arkansas: Vol. II No. 2, January 1970, (Also in December 1972).

Convenient checklist of economic, management, marketing, production and physical factors which are important to the commercial success of an aquacultural enterprise.

McNeil, William J., Marine Aquaculture, Selected Papers, Conference on Marine Aquiculture OSU Marine Science Center, 1968, Corvallis, Oregon State University Press, 1970.

The primary emphasis of this series of papers is biological. The one economic paper deals with common property problems. (See Scott, Anthony citation)

Ryther, John H. and John Bardach. The Status and Potential of Aquaculture Particularly Invertebrate and Algae Culture, Vol. I, part I, "The Status and Potential of Aquaculture"; Part II, "Invertebrate and Algae Culture," PB 1777 767, U. S. Department of Commerce, National Technical Information Service, May 1968.

The report deals with the status of aquaculture in today's world with remarks on its potential contribution to the war on hunger. Aquaculture may not only be greatly expanded, but its yields will be increased appreciably by use of modern science and technology.

Scott, Anthony, "Economic Obstacles to Marine Development." Marine Aquiculture, William J. McNeil (Editor), Corvallis, Oregon: Oregon University Press, 1970, pp. 153-167.

Discusses three chief impediments to the economic development of marine aquaculture: 1. Absence of strong demand for high cost aquaculture products except for luxuries, 2. Absence of property or sovereignty institutions in national waters, 3. Absence of property or sovereignty or sovereignty institutions in international waters.

United Nations, FAO Aquaculture Bulletin, Rome: Food and Agriculture Organization Department of Fisheries, Fisher Resource Division, Published quarterly.

A quarterly news digest of aquaculture research and development. It is largely prepared on the basis of contributions from correspondents and research and development agencies. Each issue carries a section on recent publications; each entry is annotated. (Previously FAO Fisheries Bulletin), (Quarterly since January 1, 1954).

Webber, Harold H., "Mariculture," Bioscience, 18 (10), (1968), pp. 940-5.

A non-technical essay which describes the potential of mariculture of molluscs, crustaceans, and finfish. The author reviews current major culture projects throughout the world.

Webber, Harold H., "The Design of an Aquacultural Enterprise," Proceedings of the Gulf and Caribbean Fisheries Institute Twenty-fourth Annual Session, Miami, Florida: University of Miami, School of Marine and Atmospheric Science, November 1971, pp. 117-125.

> Convenient checklist of ecological, economic, political, legal and social factors which are important in selecting a site for an aquaculture project.

Yee, W. C., "Thermal Aquaculture: Engineering and Economics," Environmental Science and Technology, 6 (3), (1972), pp. 232-7.

> The essay discusses the potential of warm water aquaculture, using thermal effluents from electric power stations. Some estimates of cost of production of such facilities are included, however, derivation of the estimates is not explicitly defined. The author deals principally with shrimp culture.

McLeese, D. W., Initial Experiments on Growth of the American Lobster in Captivity, Ottawa: Fisheries Research Board of Canada, Technical Report No. 320, 1972.

> A report on the Canadian experiments which were started in 1963 to study the growth of lobsters (Homarus americanus) weighing from 0.6 to 1.0 lbs. through at least one moult in captivity. Main factors investigated were temperature, feeding rate, diet, sex and protection for individual lobsters. Their conclusion was that it is not economically feasible to grow spring-caught lobster of 0.6 to 1.0 lb. through a moult in captivity. For culture to be economically feasible, better methods are required to virtually eliminate mortality and mutilations, to produce maximum weight increments following a moult, to promote early moulting and to maintain maximum moulting frequency.

Shang, Yung Cheng, Economic Feasibility of Fresh Water Prawn Farming in Hawaii, Honolulu, Hawaii: University of Hawaii, Economic Research Center, June 1972, 49 pp.

> Evaluation of economic feasibility of Macrobrachium Rosenbergii production in Hawaii. Cost studies for the hatchery were done for two sources of water supply, three production levels and five discount rates. Capital and operating costs are calculated for 10, 50, 100 and 150 acre rearing facilities. Estimates of potential market demand and price are also made.

Anderson, Lee G. and Durbin C. Tabb, "Some Economic Aspects of Pink Shrimp Farming in Florida", Gulf and Caribbean Fisheries Institute, Proceedings of the 23rd Annual Session, University of Miami, Coral Gables, Florida, June 1971, pp. 113-24.

> Study estimates the internal rate of return for each of six types of operations of various land characteristics. Estimates were made for both food and bait markets for shrimp. Study concludes that currently food shrimp farming is not profitable at any level of operation at any

land prices. Included is a section on the effects of shrimp farming on the price of shrimp, using demand elasticities for shrimp computed by Bureau of Commercial Fisheries in 1970.

Sielken R. L., et al., Extended Results on Optimal Investment Strategies in Shrimp Farming, TAMU-SG-72-211, Sea Grant Program, Texas A&M University, December 1972.

A method of obtaining optimal investment strategies for the shrimp fisherman is developed and illustrated. Basis for the method is a deterministic optimal control model of shrimp fishing firm. The method may be used to obtain guidelines for the shrimp industry in general or an individual firm. Computer costs to an individual seeking guidelines for his specific fishing environment and initial asset position should generally be less than $25 per year. Three numerical examples are discussed.

Subrahmanyam, C. . and C. H. Oppenheimer, "The influence of Feed Levels on the Growth of Grooved Penaeid Shrimp in Mariculture, "Proceeding of the First Annual Workshop, World Mariculture Society, James W. Avault Jr., Edmond Boudreaux, Edmonde Jaspers (Editors), Baton Rouge, Louisiana: Division of Continuing Education, Louisiana State University, 1971, pp. 91-95.

Various sizes of grooved penaeid shrimp were fed 5 and 10 percent of their body weight. Discusses weight and length increases, mortality and conversion ratios. An economical, "best growth" feed level is discussed.