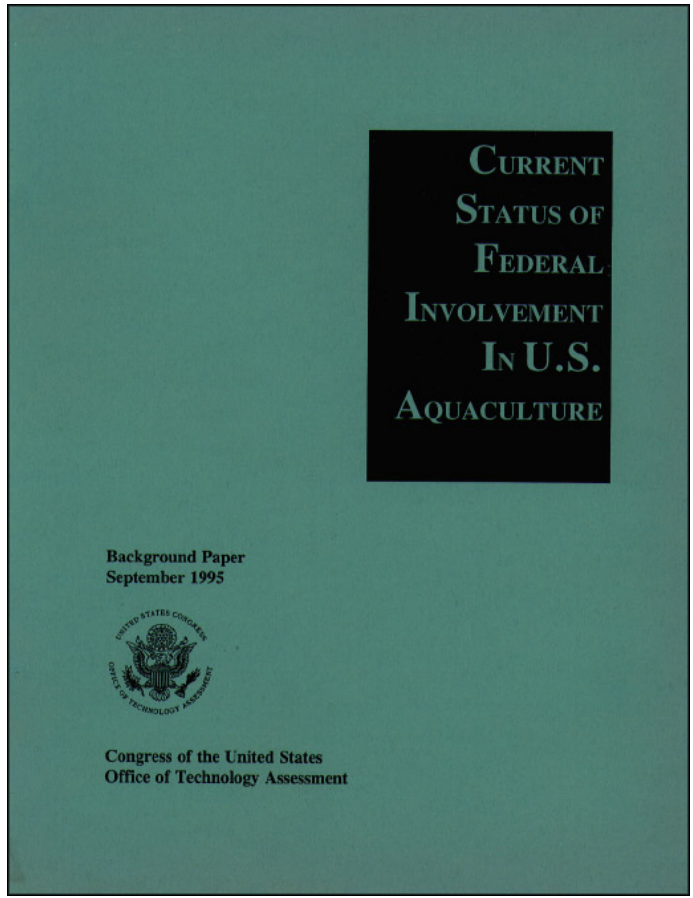
Current Status of Federal Involvement in U.S. Aquaculture

September 1995





Recommended Citation: U.S. Congress, Office of Technology Assessment, *Current Status of Federal Involvement in U.S. Aquaculture*, OTA-BP-ENV-170 (Washington, DC: Office of Technology Assessment, September 1995).

Foreword

As U.S. capture fisheries are declining, interest in aquaculture is again growing. Private, commercial aquaculture--the production of aquatic organisms (finfish, shellfish, and plants) by one or more individuals or corporate bodies that have owned them through all or part of their rearing period--is being considered for its potential to provide employment and income to declining coastal and rural communities, to help improve the U.S. balance of trade, and to provide consumers with a plentiful, safe, and nutritious protein source.

The United States lacks a strong national aquaculture policy and supporting federal presence. Over the years, levels and focii of agency involvement in aquaculture development have shifted in response to legislation and its differing interpretations. The National Aquaculture Act (NAA), the primary piece of aquaculture-related legislation, is slated for reauthorization in 1995 as part of the Farm Bill. One issue that underlies reconsideration of the NAA and related legislation is the federal role in research and regulation of this emerging industry.

Congress requested this Background Paper to provide information on technology issues of immediate importance to the U.S. aquaculture industry. This is a companion piece to the Background Paper on *Selected Technology Issues in U.S. Aquaculture.* Committees requesting the assessment were the House Committee on Merchant Marine and Fisheries (since disbanded), the House Committee on Agriculture and its Subcommittee on Livestock, and the Senate Committee on Governmental Affairs.

OTA greatly appreciates the contributions of the Advisory Panel, authors of contracted papers, workshop participants, federal liaisons, and the many additional people who reviewed material for the report or gave valuable guidance. Their timely and in-depth assistance allowed us to explore some of the complex issues related to the federal role in aquaculture. As with all OTA studies, the content of this report is solely the responsibility of OTA.

ROGER C. HERDMAN
Director

Advisory Panel

Jan Auyong, Chair
Mar Res Associates
Hatfield Marine Science Center
Newport, OR

Don Abt
Laboratory for Marine Animal Health
University of Pennsylvania
State College, PA

John Bardach
Office of Research and Education
East-West Center
Honolulu, HI

Merry Camhi
National Audubon Society
Islip, NY

John S. Corbin
Aquaculture Development Program
Honolulu, HI

Mike Freeze
Keo Fish Farm, Inc.
Keo, AR

Michael Hastings
Maine Aquaculture Innovation Center
Brewer, ME

Timothy K. Hennessy
Ekk Will Waterlife Resources
Gibsonton, FL

Bille Hougart
Oceanic Institute
Washington, DC

Robert Hulbrock
Department of Fish and Game
Sacramento, CA

Ann Kapuscinski
Sea Grant College Program
University of Minnesota
St. Paul, MN

Roy Martin
National Fisheries Institute
Arlington, VA

Joseph McCraren
National Aquaculture Association
Shepherdstown, WV

Ted McNulty
Arkansas Development Finance Authority
Little Rock, AR

David Ortman
Friends of the Earth
Seattle, WA

John Pitts
Bellwether Consulting
Quilcene, WA

Bradley H. Powers
National Association of State Aquaculture Coordinators
Annapolis, MD

Robert R. Stickney
School of Fisheries
University of Washington
Seattle, WA

Hugh Warren III
Catfish Farmers of America
Indianola, MS

NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

Project Staff

Clyde Behney
Assistant Director

Robert N. Niblock
Program Director
Environment Program

Cameron Proffitt Taylor
Principal Author

Alison L. Hess
Senior Associate

Robin A. White
Senior Analyst

Richard M. Carr
Analyst

Susan J. Wunder
Contract Editor/Writer

ADMINISTATIVE STAFF

Kathleen Beil
Office Administrator

Nellie Hammond
Administrative Secretary

Kimberly Holmlund
Administrative Secretary

Babette Polzer
Contractor

Working Group Participants

INNOVATIVE FUTURES FOR U.S. AQUACULTURE
September, 1993

Editor/Writer: Susan Wunder

Gary Arnold
Maine Aquaculture Innovation Center
Brewer, ME

Doug Burdette
Maryland Pride Farms
Aberdeen, MD

Peter Cook
Science and Technology Group
EPCOT Center, FL

John P. Craven
Common Heritage Corporation
Honolulu, HI

Michael Dicks
Department of Agricultural Economics
Oklahoma State University, OK

Ron Gulau
Florida Aquaculture
Punta Gorda, FL

Tom Hopkins
Maryland Aquaculture Association
Boyds, MD

Bo Kjaer-Olsen
International Aquafarms, Inc.
Hauula, HI

Cal Sims
Edisto Aquatic Farms
Orangeburg, SC

OFFSHORE AQUACULTURE
November, 1993

Writer/Editor: Susan Wunder

Robert Stickney
School of Fisheries
University of Washington
Seattle, WA

Bob Blumberg
Texas General Land Office
Austin, Texas

John Forster
Stolt Sea Farm, Inc.
Port Angeles, WA

Harlyn Halvorson
Policy Center For Marine Bioscience and Technology
University of Massachusetts at Dartmouth
North Dartmouth, MA

James P. McVey
National Sea Grant College Program
National Oceanic and Atmospheric
Administration
Silver Spring, MD

Russell Miget
Texas A&M Sea Grant College Program
Corpus Christi, TX

Granvil Treece
Texas A&M Sea Grant College Program
Bryan, TX

Robert Wilder
Center For Policy Analysis
University of Massachusetts at Dartmouth
North Dartmouth, MA

HIGHLIGHTS

- Private commercial aquaculture is practiced in every U.S. State and territory, from Atlantic salmon off the coast of Maine to alligators in Louisiana to giant clams on the Pacific islands of Micronesia. Although as many as 30 are commonly cited aquacultural species, fewer than 10 species make up most of U.S. aquacultured food production: catfish, trout, crawfish, salmon, hybrid striped bass, tilapia, and various molluscs.

- Aquaculture products as a proportion of total seafood consumption is gradually rising, likely reflecting increasing availability and favorable prices compared to wild caught seafood. This may portend growing consumer recognition of the nutritional value of seafood in general and confidence in the quality of aquacultured products in particular. Hopes for aquaculture as a growth industry, especially for economically troubled rural and coastal communities, remains high.

- Federal involvement in aquaculture is based primarily in three organizations: the Department of Agriculture, National Oceanic and Atmospheric Administration (Department of Commerce), and Fish and Wildlife Service (Department of Interior). Despite a long history of debate over Federal agency roles in aquaculture, and establishment of a coordinating body, specific agency roles and responsibilities remain unclear.

- Aquaculture received roughly $60 million in financial assistance from the Federal government in 1994. The U.S. Department of Agriculture was responsible for almost half, the Department of Commerce for nearly one-quarter, and the Department of Interior for just over one-tenth (the remaining funds were allocated among 24 other agencies). Each Department has research centers devoted in whole or in part to aquaculture development.

- Most Federal funding for aquaculture is directed to research, with substantially smaller amounts devoted to regulatory efforts and assistance programs. The U.S. Department of Agriculture, whose aquaculture funding rose 135 percent between 1988 and 1994, is the agency most active in commercial aquaculture research. Funding for the other Department rose substantially in the same period: nearly 100 percent for the Department of Commerce and 235 percent for the Department of Interior. The current research base is very diverse in terms of funding mechanisms, areas of science, and cultured species.

- Twenty Federal agency programs also may have potential for providing support to the aquaculture industry, mostly in the form of financial assistance; however these programs have not been used by or directed to the aquaculture industry.

1
Introduction

BACKGROUND

Aquaculture has a long history of supplying protein and other products around the world, but a short history of commercial production in the United States (box 1-1). Until the 1950s, aquatic species were produced mainly to supply fish restocking programs, to provide baitfish and sportfish for fee fishing operations, and for direct family consumption; little reached commercial markets. Although trout had been produced for food since the turn of the century, only with the advent of the catfish culture industry did commercial aquaculture gain visibility as a market force.[1]

Hundreds of different aquatic species are produced in the United States, including various animal and plant ornamentals, species for environmental remediation, industrial and pharmaceutical feedstocks, and products for biomedical research. Although as many as 30 are commonly cited aquacultural species, fewer than 10 species make up most of U.S. aquacultured food production: catfish, trout, crawfish, salmon, hybrid striped bass, tilapia, and various molluscs (appendix A).

Aquaculture is practiced in every U.S. state and territory, from Atlantic salmon off the coast of Maine to alligators in Louisiana to giant clams on the Pacific islands of Micronesia. Production systems are similarly diverse, ranging from nearshore bottom "seeding" of molluscs to expansive open ponds to high-tech water recirculating systems in warehouses to integrated systems cycling nutrients among land- and water-based production systems. However, certain aqua-culture systems and certain species are con-centrated in geographic regions (appendix B).

Catfish and trout, for example, are grown in nearly all regions of the country. However, by far the largest volume of catfish produced in the United States is cultured in open ponds in the Mississippi River Delta region. Seventy-five percent of cultured trout is produced in raceways beside the Snake River in Idaho (12). Such concentrations occur, in part, because of the growth rates of certain species in certain water temperatures. For example, the warmwater channel catfish prefers water within 26 and 30° C (78 to 86° F), while coldwater rainbow trout thrive in water temperatures between 10 and 16° C (50 to 60° F) (26).

Regional concentrations also reflect avail-ability of land and water. Prior to develop-ment of catfish culture, the Mississippi River Delta region was used for marginally productive rice and cotton farming (22) and had ample groundwater resources; transfer to an open pond system required relatively little capital expenditure. The Hagerman Valley of the Snake River was largely undeveloped prior to trout farming, and the plentiful springs provide a reliable source of water to route through trout raceways.

While shellfish are grown on all coastlines, net pen salmon production is concentrated in the northeast and the northwest. Culture of other marine species can be expected to concentrate in areas with water temperature most suitable to the species (e.g., red drum in the Gulf of Mexico).

Today, aquaculture is touted as the fastest growing segment of U.S. agriculture, based on

[1] For additional information on the historical development of aquaculture in the United States, see R.R. Stickney, *A History of Aquaculture in the United States* (New York, NY: John Wiley & Sons, in press).

Box 1-1: Definitions of Terms Used in This Background Paper

Definitions of certain terms used in the Background Paper are based on current common usage, or based on the specific request of the congressional requesting committees (see discussion below).

Aquaculture: For the purposes of this analysis, aquaculture will include only production of aquatic organisms (finfish, shellfish, and plants) that have been owned by one or more individuals or corporate bodies throughout their rearing period. Practices that include controlled rearing of aquatic organisms during only one part of their life cycle but that are exploitable at any time by the public as a common property resource (e.g., private ocean ranching, commercial and recreational enhancement stocking, and "fattening" of captured stock), were excluded by request of the congressional requesting committees, and are not considered here.

Fish: Unless specifically specified, the term fish is used to include finfish and shellfish. It does not include aquatic plants, reptiles, or amphibians.

Mariculture: Aquaculture operations that take place in nearshore or offshore waters. (Under this definition, mariculture does not include on-land aquaculture using pumped or artificial seawater.)

Offshore Aquaculture: Aquaculture operations that are undertaken in Federal waters of the Exclusive Economic Zone, generally the zone from 3 to 200 miles off the coast of U.S. states and territories.

Seafood: Unless otherwise specified, the term seafood includes edible products derived from fresh- and salt-water species.

Stock Enhancement: Programs designed to increase the stock of fish for exploitation by the public as common property resources are considered stock enhancement programs. These may include efforts to increase stocks for recreational or commercial purposes. Enhancement goals and programs are not included in this analysis.

Discussion: Definitions

Differing definitions of aquaculture cause considerable problems with use of data and with determination of the Federal role in aquaculture. A common definition of aquaculture would include propagation or cultivation of any aquatic organism during any part of its lifecycle to increase population regardless of purpose. The Joint Subcommittee on Aquaculture uses such a definition: "the farming of aquatic animals and plants" (14). Under this definition, aquaculture presumably would include private for-profit production of organisms in controlled environments, hatchery and release programs for profit or for common stock enhancement, and even deliberate protection of wild populations from predators or other adverse influences. The JSA definition also implies that aquaculture is a form of agriculture, while the National Marine Fisheries Service considers at least marine aquaculture (mariculture) a specialized form of the U.S. fishing industry (36).

The National Aquaculture Act defines aquaculture as: the propagation and rearing of aquatic species (finfish, molluscs, crustaceans, or other aquatic invertebrates, amphibians, reptiles, or aquatic plants) in controlled or selected environments, including, but not limited to, ocean ranching (except private ocean ranching of Pacific salmon for profit in those states where such ranching is prohibited by law).

Thus, the primary national aquaculture legislative language can be construed to include hatchery and release programs conducted by individuals or corporations for profit, but not efforts designed to enhance commercial fisheries, whether public or private.

On the other hand, the National Oceanic and Atmospheric Administration is mandated to use aquaculture "to enhance stocks of fish and shellfish whose populations are below long-term potential yield due to overfishing or habitat degradation" (37), expanding the definition beyond that of the National Aquaculture Act. Conversely, the U.S. Department of Agriculture's Noninsured Crop Disaster Assistance Program defines aquaculture species as "any species of aquatic organism grown as food for human consumption or fish raised as feed for fish that are consumed by humans, and which is propagated and reared in an aquatic medium by a commercial operator on private property in water in a controlled environment" (60 CFR 26669). Under this definition, aquaculture includes neither private ocean ranching, stock enhancement, nor non-edible product aquaculture such as ornamental fish production.

OTA's chosen definition of aquaculture is adapted from the definition developed by the United Nations Food and Agriculture Organisation and accepted by much of the international community (32). Legislative recognition of a single definition of aquaculture that could apply to all federal policies and programs would significantly improve data collection and interpretation, and likely reduce unnecessary confusion.

a fourfold increase in domestic output of fish, shellfish, and aquatic plants between 1980 and 1990 (12). By 1993, USDA estimated that the value of U.S. aquaculture products had reached $760 million (8).

Despite that auspicious cast, domestic aquaculture production accounts for only about 10 to 15 percent of the U.S. seafood supply. Most still is provided by capture fisheries and imports from other nations. (See appendix C for a brief description of aquaculture policy and development in other nations.)

Originally, a goal of the domestic seafood industry was to increase seafood consumption to 20 pounds per capita by the year 2000. With per capita consumption hovering between 14.5 and 15.5 pounds in the last several years, this goal is now seen as unrealistic (10). Seafood consumption is strongly affected by consumer perceptions of safety and quality, familiarity and ease of preparation, and price.

Despite the recent expansion in aquaculture production, pound-for-pound, seafood is more expensive than beef, pork, or poultry products. Further, consumers are more familiar with the latter; and brand-labels, generic advertising campaigns, convenience of preparation, and fast-food marketing accentuate the differences (11). (For comparison, U.S. annual per capita consumption of meat (boneless equivalent) is approximately 187 lbs. Major components are: turkey--14 lbs/capita; chicken--47 lbs/ capita; pork--49 lbs/capita; and beef--62 lbs/ capita (1).)

Aquaculture products as a proportion of total seafood consumption is gradually rising, likely reflecting increased availability (e.g., year-round supply) and favorable prices com-pared to wild-caught seafood. This may also portend growing consumer recognition of the nutritional value of seafood in general and con-fidence in the quality of aquacultured products in particular. Hopes for aquaculture as a growth industry, especially for economically troubled rural and coastal communities, remain high.

A BRIEF HISTORY OF FEDERAL INVOLVEMENT IN U.S. AQUACULTURE

Aquaculture-related hatcheries and fisheries research were spurred in the United States in the late 19th century by sport fishermen lobbying for artificial propagation of sport fish. This mission was shuttled among various federal organizations until it moved in 1939 to the newly created Fish and Wildlife Service (FWS) in the Department of the Interior (29). In 1956 the mission was divided into the Bureau of Sport Fisheries and the Bureau of Commercial Fisheries. The former remained a charge of the FWS,[2] and the latter was moved in 1970 to the National Oceanic and Atmospheric Administration (NOAA) and renamed the National Marine Fisheries Service (NMFS). Thus, the FWS and NMFS share a common history of aquaculture research and development.

The first attempts at commercial aquaculture were in salmon ranching and trout farming at the turn of the century, but it was not until the 1960s that the federal government directed attention specifically at private, commercial culture. FWS laboratories for investigation of fish drug clearance, fish genetics, and aquaculture of warmwater species were created, and research results were shared with U.S. Department of Agriculture experiment stations and extension services to transmit to the farmers.

Although Department of Agriculture (USDA) and Land-Grant University scientists had been

[2] At the peak of its operations in the mid-1970s, the FWS operated nearly a hundred hatcheries nationwide. As of 1994, the FWS operated 73 hatcheries and nine fish health laboratories. Most FWS fisheries research centers/laboratories were transferred to the National Biological Service in 1994. Legislative proposals are under consideration to transfer some or all of these aquaculture-related laboratories to the U.S. Department of Agriculture.

conducting experiments and assisting farmers with fish pond management for years, USDA's formal involvement in aquaculture began with the Saltonstall-Kennedy Act for Commercial Fisheries (15 U.S.C. 713 et seq.) that in 1954 required the Department of the Interior (DOI) to conduct research and educational services to be paid by USDA. The Fish-Rice Crop Rotation Farming Program Act of 1958 (16 U.S.C. 778 et seq.) also required cooperative work by USDA and DOI, and created the FWS Fish Farming Experimental Station at Stuttgart, Arkansas--the first center devoted expressly to development of commercial aquaculture.

Also in the 1960s, concern grew over lack of a cohesive national ocean policy. The Stratton Commission, created by the Marine Resources and Engineering Development Act of 1966 (33 U.S.C. 1101 et seq.), recognized aquaculture as a coastal use that should be included in a national ocean policy. The Commission also recommended that an independent ocean agency be created, and be given the mission (among others) to advance marine aquaculture. The National Oceanic and Atmospheric Administration (NOAA) subsequently was formed in 1970 as a semi-autonomous agency within the Department of Commerce (DOC), and assigned to develop aquaculture through the National Marine Fisheries Service, its coastal zone programs, and the newly established National Sea Grant College Program.

Aquaculture was mentioned in detail in the National Sea Grant College and Program Act of 1966 (33 U.S.C. 1121 et seq.), which recognized that "aquaculture, as with agriculture on land, ... can substantially benefit the United States" (29). In fact, the Sea Grant College Program was specifically designed to mirror the Land-Grant College program established for land-based agriculture, with teaching, research, and extension services.

Following the formal designation of FWS and NOAA as agencies with responsibilities for aquaculture, and during the gradual development of aquaculture expertise in USDA, the Congress passed numerous pieces of environmental protection and resource management legislation affecting the development of aquaculture, involving still more agencies in the development of aquaculture. The plethora of agencies, programs, and laws resulted in confusion and conflict.

By 1980 one report identified 120 federal statutory programs having a significant impact on development of aquaculture; however, less than one-half required a direct compliance response on the part of the culturist (2). The 1978 National Research Council report, *Aquaculture in the United States: Constraints and Opportunities* observed that "constraints on orderly development of aquaculture tend to be political and administrative, rather than scientific and technological" (19).

NATIONAL AQUACULTURE POLICY

The first major national aquaculture policy bill was the National Aquaculture Development Act of 1975 and 1976, which immediately engendered opposition from several of the agencies involved in aquaculture. Most of the tasks proposed already were being conducted by these same agencies; thus, there was concern that traditional programs were being challenged (17). The National Aquaculture Development Act of 1975 and 1976 was never passed.

The 1976 United Nations Food and Agriculture Organization Conference on Aquaculture prompted preparation of the National Aquaculture Organic Act. The bill proposed the establishment of a national aquaculture plan,[3] authorized appropriations of approximately $40 million for aquaculture research and development over a three-year period, and established a $100 million loan guarantee program for the industry. At the time, this bill was considered the most

[3] A national plan "to develop programs and encourage activities which will coordinate domestic aquaculture efforts, conserve and increase the availability of fishery resources, and create new industries and job opportunities."

significant in the political development of U.S. aquaculture. Although the bill attempted to unify the interests of government agencies, industry, and researchers, opposition continued. The most widespread disagreement regarded identification of a single agency to coordinate and oversee U.S. aquaculture activities. At the time, the Departments of Commerce and Interior were formally responsible for aquaculture support and wanted to continue in this role; the U.S. Department of Agriculture did not advance itself as a lead agency (17). The National Aquaculture Organic Act of 1976 was not passed.

Several other bills were unsuccessfully advanced between 1976 and 1980, including the National Aquaculture Organic Act of 1977 and the Aquaculture Policy Act of 1977. The issue of a lead agency continued to be controversial, with some bills proposing DOC as lead agency and others promoting USDA (17). Two prominent analyses conducted by the Congressional Research Service (33) and the National Academy of Sciences (1978) called for designation of a lead agency:

> "Although aquaculture has an active constituency, it has little political power within the framework of interest groups competing for government attention. To insure a reasonable rate of development for aquaculture, a uniform set of aquaculture policies must be established. A lead agency must direct, guide, support, coordinate, and be responsible and accountable for activities among the relevant federal agencies." (19).

Meanwhile, the Food and Agriculture Act of 1977 (7 U.S.C. 3101 et seq.) identified aquaculture as an area requiring a new federal initiative, and included aquaculture among the basic functions of USDA. This gave USDA authority to expand into aquaculture activities, but did not provide specific instructions or funding. The Act also designated USDA as the lead federal agency for research in the food and agricultural sciences, and included aquaculture in the definition of food and agricultural sciences. This seemed to indirectly indicate conferral of aquaculture lead agency status on USDA, but the legislative language did not specifically state this (17).

Concern remained that, under USDA's guidance, freshwater aquaculture would monopolize federal support for aquaculture. Marine aquaculture supporters pushed for passage of the National Aquaculture Act of 1978 that designated DOC as the lead agency; however President Jimmy Carter vetoed the legislation because of its high fiscal demands. The following year brought another attempt to pass legislation designating Commerce as the lead agency. Although the 1979 bill reduced the amount of the financial support requested, it was not passed by the Congress (17).

In September 1980, Congress reached an agreement with regard to the future of U.S. aquaculture, and the National Aquaculture Act (NAA) became law (U.S.C. 16 U.S.C. 2801, et seq.). The Act states that it is "in the national interest, and it is the national policy, to encourage the development of aquaculture in the United States." The NAA gives principal responsibility for the development of U.S. aquaculture to the private sector, but jointly assigned three federal agencies aquacultural-related responsibilities--the Departments of Agriculture, Commerce, and Interior.

The 1980 NAA only vaguely defined the responsibilities of each Department, stating that they were to be determined based on prior law, and "the experience, expertise, and other appropriate resources that the Department of each such Secretary may have with respect to the action required under the activity concerned." Some six months earlier an Interagency Agreement was reached among the Departments of Agriculture, Commerce, and Interior regarding "Designation of Areas of Responsibility in Aquaculture" (appendix D). In general, USDA was acceded responsibility for research and support activities for private freshwater aquaculture, DOC was determined responsible for marine and estuarine species,

and the DOI was responsible for technical research on freshwater finfish for recreational and commercial purposes. All three agencies were to coordinate their work on anadromous species (those migrating between fresh- and saltwater). Provision for a waiver from this division of responsibilities was made in case that "some crossing of these lines of division" would become "necessary to advance national objectives in aquaculture."

In addition to defining agency responsibilities, the Interagency Agreement contained provisions for coordination of federal activities in aquaculture.[4] The 1980 NAA formally designated the Joint Subcommittee on Aquaculture (JSA) the coordinating body for all federal activities related to aquaculture (box 1-2), with a goal of increasing the overall effectiveness and productivity of federal aquaculture research, transfer, and assistance programs. Chairmanship of the JSA was originally planned to rotate among Secretaries of the three primary Departments.

The Secretaries of the three relevant Departments also were instructed to develop a National Aquaculture Development Plan to identify aquatic species with significant potential for culturing on a commercial or other basis (e.g., stock enhancement), and to recommend actions to be taken by public and private sectors to achieve that potential.[5] The first National Aquaculture Development Plan was completed by the JSA in September 1983, providing the first comprehensive federal identification of priorities in U.S. aquaculture development.

The National Aquaculture Act of 1980 has been reauthorized twice: as amended by the National Aquaculture Improvement Act of 1985 (Public Law 99-198) and as further amended by the Food, Agriculture, Conservation, and Trade Act of 1990 (Public Law 101-624). Amendments to the NAA have been relatively minor, with one exception. The National Aquaculture Improvement Act of 1985 specifically established the Department of Agriculture as "the lead federal agency with respect to the coordination and dissemination of national aquaculture information" and designated the Secretary of Agriculture as permanent chair of the Joint Subcommittee on Aquaculture.

The current Secretary of Agriculture has stated a strong commitment to U.S. aquaculture and supports cooperation among federal agencies:

> I am committed to strong leadership by the Department of Agriculture of Federal programs to support the private U.S. aquaculture industry. . . The Department also

[4] During the political hearings through 1977 and 1978, federal agency staffs took the initiative to form an inter-agency group to maintain communication with regard to aquaculture. They were officially authorized as a subcommittee on aquaculture within the Inter-Agency Committee on Marine Science and Engineering. Early in 1979, under the Committee on Atmosphere and Oceans and the Committee on Food and Renewable Resources, a new Joint Subcommittee on Aquaculture was appointed by the Federal Coordinating Council for Science, Engineering and Technology. It replaced the Inter-Agency Committee, but its goals, of increasing the effectiveness of aquaculture research and development, were essentially the same (17). The Interagency Agreement formally recognized the Joint Subcommittee on Aquaculture as the group most suited to coordinate Federal activities in aquaculture. The National Oceanic and Atmospheric Administration has suggested that the 1980 Interagency Agreement be updated to "reflect the current coordination protocols...(and) to reduce confusion and conflict over agencies' responsibilities and functions" (36).

[5] The JSA currently is revising the National Aquaculture Development Plan, to focus on the Federal government role in U.S. aquaculture, and addressing opportunities in: research and development; regulatory framework; extension, education, training, outreach, technology transfer, and communications and information services; product quality assurance; aquatic animal health; new animal drug approvals; animal damage control; marketing, statistics, and economic services; export promotion; financial services and incentives; and partnerships and improved coordination in support of aquaculture development. The JSA anticipates release of the revised plan in summer 1996 (21). The National Oceanic and Atmospheric Administration has suggested that the JSA should "put forward an interagency national plan which recognizes the capabilities of each of the federal agencies, which has not been adequately done to date" (36).

Box 1-2: Joint Subcommittee on Aquaculture

The Joint Subcommittee on Aquaculture (JSA) was formally established in the National Aquaculture Act of 1980 to serve as a federal government-wide coordinating group to increase the overall effectiveness of federal research, transfer, and assistance programs in aquaculture, and to provide recommendations for federal aquaculture policy. The JSA operates under the National Science and Technology Council in the Office of the Science Advisor to the President. While receiving no direct funding, the JSA generally is thought a model coordinating mechanism for federal activities carried out by many agencies. The JSA is composed of the following people or their representatives:

- Secretary of Agriculture (Permanent Chair)
- Secretary of Commerce
- Secretary of Interior
- Secretary of Energy
- Secretary of Health and Human Services
- Administrator of the Environmental Protection Agency
- Chief of Engineers, U.S. Army Corps of Engineers
- Administrator of the Small Business Administration
- Administrator of the Agency for International Development
- Chairman of the Tennessee Valley Authority
- Director of the National Science Foundation
- Governor of the Farm Credit Administration, and

Heads of other federal agencies as deemed appropriate by the Director of the Office of Science and Technology Policy.

The JSA also has developed a number of Task Forces, Working Groups, and Steering Committees to help it set priorities and coordinate federal activities in certain substantive areas deemed particularly important to the future of U.S. aquaculture. These groups are composed of representatives of government agencies, private sector organizations, and members of the scientific/academic community. Subject areas include:

- Aquaculture Information and Technology Transfer
- Aquaculture Statistics and Economics
- Aquaculture Waste Management
- Federal Legislation and Regulatory Activities
- Quality Assurance in Aquaculture Production
- National Aquatic Animal Health Management Strategy

SOURCE: Joint Subcommittee on Aquaculture, 1992

recognizes that other Federal agencies, especially the National Oceanic and Atmospheric Administration, have strong programs and interests that support both private and public aquaculture. The Department strongly supports cooperation and collaboration with other agencies in the development of programs and policies that can support private U.S. aquaculture (6).

Specification of each Department's responsibilities, however, still requires concurrence among the three Secretaries and continues to be based on prior designation of respon-sibilities in

law or by executive action, or the experience and expertise of each Department.[6]

State Roles in National Aquaculture Development

Congress' decision to give the private sector responsibility for development of aquaculture in the 1980 NAA was made, in part, in response to prior independent establishment of university research and extension programs and individual state promotional programs (29). The 1983 National Aquaculture Development Plan reiterated this, noting that "much of the increased production occurred prior to the passage of the National Aquaculture Act because sufficient incentive and motivation in the private sector existed for the aquaculture industry to expand," although it did acknowledge the contributions made by various sectors of the federal government (15).

Also, Congress recognized that the states, rather than the federal government, have direct responsibility for fish and wildlife policy and programs, and land and water use planning, including determination of priority uses for the coastal zone. Federal pre-emption of these states rights and laws have been limited and controversial (34). States also interpret and implement many federal programs, including many environmental and food sanitation laws (2,29). Finally, many states have created statutes that mirror federal laws such as the National Environmental Protection Act and the Federal Food, Drug, and Cosmetic Act, requiring aquaculturists and others to comply with potentially more stringent requirements to permit development (25). In fact, most laws that specifically authorize, permit, or control aquaculture operations are found at the state level (18).

States' policies, programs, and attitudes towards aquaculture, however, vary greatly. Some, like Hawaii, Florida, Maine, and Mississippi actively promote aquaculture development. Others have developed state policies or even plans, but established few programs to assist the industry. A few may retain fish and wildlife laws that directly conflict with aquaculture development (box 1-3).

Just as the aquaculture industry has sought recognition and support at the federal level, they have actively sought governmental assistance at the state level. Part of the current concerns of the aquaculture industry reflect the uncertain and uneven treatment of aquaculture at the state level. Federal-level definitions and policy, some proponents hope, would promote uniformity in state and local regulations perceived as unnecessary or unfair hindrances to aquaculture development.

CURRENT CONGRESSIONAL INTEREST

Congressional interest regarding the federal role in U.S. aquaculture focuses on reauthorization of present legislation, deliberation over proposed new legislation, and reconsideration of the amount and allocation of federal funds spent on aquaculture development. In addition, significant reorganization and mission realignment among federal agencies is occurring and even more sweeping changes have been proposed for the future. Such changes are affecting agency roles, responsibilities, and commitments in aquaculture and likely will have even more effect in the next few years. A great deal of uncertainty exists among some key agencies about their future aquaculture responsibilities (20).

---

[6] The National Oceanic and Atmospheric Admin-istration has recommended that the JSA develop a formal voting structure to resolve contentious issues. "The voting structure should give equal weight to all three lead agencies (Department of Agriculture, Department of Commerce, and Department of Interior). Further, a dispute resolution escalation process for issues not resolved in the JSA should be developed. This process will help to resolve the confusion and conflict over agencies' responsibilities and functions. Consideration should also be given to permanent funding of the JSA for better coordination and consistency in policy implementation over time (36).

BOX 1-3: Distinguishing Between Wild and Cultured Product

As declining wild fish stocks come under increasing protection (37), aquaculture producers may be adversely affected by state regulations designed to protect wild populations of the same species. Fisherman are regulated by laws that specify the size and number of organisms they may possess, the season in which they may be caught, and the waters from which they may be harvested. States commonly also have regulations governing the interstate transport of aquatic organisms to protect against the introduction of disease or injurious organisms. Such laws may hinder aquaculture production or reduce the sale of aquacultured products, making it difficult for aquaculture to supply markets no longer satisfied by wild caught fish.

Organisms produced in aquaculture facilities are not always exempt from restrictions designed to protect wild resources. For example, possession of striped bass was illegal in the mid-eighties in Maryland due to a harvest moratorium (3). This regulation did not differentiate between farm-raised and wild caught fish. Similarly, cultured rainbow trout, coho salmon, and white sturgeon raised in Georgia were considered wild fish and confiscated by state authorities in one case (30). Even processed products may be prohibited from sale to protect wild species: Ohio passed a law that banned the sale of catfish nuggets because there was no way to determine whether the product was derived from farm-raised or wild caught catfish (28).

When conflicts arise between aquaculture producers and state resource protection regulations, definitive methods for distin-guishing wild caught organisms from cultured products are needed. Several methods are available. Morphological characteristics such as body shape may be used to differentiate some cultured organisms from wild-caught ones. For example, cultured trout may have rounded 'bullet' shapes and eroded fins caused by abrasion from concrete tanks (27). Gene probes have been used to differentiate striped bass from hybrid striped bass (9) and organisms can be physically or chemically marked (e.g., shell-fish and salmon) facilitating identification. In cases where differentiation is difficult, maintaining records and extensive documentation may also provide a method for identifying and tracking cultured products.

However, states may choose to disallow transshipment or sale of aquaculture products even when they comply with federal inspection and nationally-recognized certification programs. For example, Massachusetts has prohibited introduction of clams beneath the states' size limit due to concerns about creating a "black market" in under-sized clams (23;24). This prohibits sale of both seedstock and small clams in Massachusetts by out-of-state aquaculture ventures. In addition to reducing the potential market for any out-of-state producing firm, this also could prohibit Massachusetts aquaculturists from purchasing improved seedstock for grow-out, potentially hindering their competitive position. A number of states grant aquaculture exemptions to certain seafood product rules designed to protect wild resources given certain assurances of their source. A federally promulgated, nationally recognized aquaculture product identification system might assist states to reduce these constraints to interstate trade.The National Aquaculture Act was slated for reauthorization in 1993,[7] but agreement on certain provisions was not reached prior to debate on the 1995 Farm Bill. The Administration's 1995 Farm Bill Proposal includes reauthorization of the National Aquaculture Act with several amendments (35). Also currently up for reauthorization are the Regional Aquaculture Centers, the National Research Initiative, and other USDA programs that do or could support aquaculture development.

---

[7] During the 103d Congress, five bills that specifically focus on aquaculture were introduced for legislative consideration, but none became law. These bills focused on providing a national aquaculture policy and on topics specific to aquaculture research and development. Other legislation considered during the 103d Congress that mentions aquaculture include the Marine Mammal Protection Act (aquaculture proposed as an activity that does not justify harming or harassing marine mammals), the Clean Water Act (proposed exclusion of aquaculture from new wetlands regulations), the Magnuson Act (proposed that aquaculture be excluded from regulations on fisheries), and Disaster Assistance (proposed emergency loans to aquaculture farms substantially affected by disaster).

Determination of the future functions and funding of the National Sea Grant College Program, the National Marine Fisheries Service, and the Fish and Wildlife Service also are on the legislative agenda.

In addition, several Congressional members have introduced or have expressed interest in introducing new legislation to address unmet needs of aquaculture development in the United States. Several proposed bills include provisions to enhance marine aquaculture in largely through NOAA's Sea Grant College Program and Coastal Resources Management Program. Other bills establish a national policy and program for managing aquaculture development in federal waters.

The debate over a federal role in and home for aquaculture continues today. Despite varied attempts to promote cohesion and cooperation, federal agencies continue to vie for aquaculture funding, program lifetimes are uncertain, and aquaculturists still seek a strong national aquaculture policy and supporting federal presence.

REFERENCES

1. *Agricultural Outlook*, table: "Per Capita Consumption of Major Food Commodities," U.S. Department of Agriculture, Economic Research Service, Commodity Economics Division, May 1994.
2. Aspen Research and Information Center, "Aquaculture in the United States: Regulatory Constraints," Report to the U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., Mar. 16, 1981.
3. Baker, B., "Striped Bass Success Spawns New Legislation," *BioScience* Vol. 44 No. 8, September 1994.
4. Department of Fisheries and Oceans, Communications Directorate, "A Guide to Federal Government Programs," Ottawa, Ontario, Canada, 1993.
5. Erbacher, J. E., International Trade Specialist, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, Memorandum on "Defensible Statistical Data on Aquaculture" prepared for the Office of Technology Assessment, June 16, 1995.
6. Glickman, D., Secretary of Agri-culture, Statement made April 11, 1995 provided to the Office of Technology Assessment by Hank Parker, Aqua-culture Coordinator, U.S. Department of Agriculture, Washington, DC, May 1, 1995.
7. Grieve, I., "Dismantling Government Science and Technology Policy: Getting Hit by A Mack Truck," *Journal of Irreproducible Government Agencies* R(1P):1972-1995, July 20, 1995.
8. Hanfman, D.T., "The Status and Potential of Aquaculture in the United States," (Beltsville, MD: U.S. Department of Agriculture, National Agriculture Library, Aquaculture Information Center, July 1993).
9. Harrell, R.M., Xu, X.L. and Ely, B. 1993. Evidence of introgressive hybridization in Chesapeake Bay *Morone*. *Molecular Marine Biology and Biotechnology* 2: 291-299.
10. Harvey, D., "Aquaculture Situation and Outlook," Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, DC, Oct. 1994, AQS-13.
11. Harvey, D., "Outlook for U.S. Aquaculture," *Agriculture Outlook '94--Prospects for Livestock and Aquaculture* (Washington, DC: U.S.

Department of Agriculture, Dec. 1, 1993), pp. 39-45.

12. Harvey, D., "Aquaculture: A Diverse Industry Poised for Growth," *FoodReview*, vol. 14, Oct.-Dec. 1991, pp. 18-23.

13. Hess, A., "Policy Issues for Aquaculture in Federal Waters," paper prepared for the Office of Technology Assessment, September 1994 (Springfield, VA: National Technical Information Service, 1995).

14. Joint Subcommittee on Aquaculture, "Aquaculture in the United States: Status, Opportunities, and Recommendations," Report to the Federal Coordinating Council on Science, Engineering, and Technology, Office of Science and Technology Policy, Executive Office of the President, Washington, DC, May 1992.

15. Joint Subcommittee on Aquaculture of the Federal Coordinating Council on Science, Engineering and Technology, *National Aquaculture Development Plan* vol. 1 and 2, Washington, DC: U.S. Department of the Interior, September 1984).

16. Malone, R. F., "The Future of Recirculating Systems in the U.S. Aquaculture Industry," contract paper prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, 1994 (Springfield, VA: National Technical Information Service, 1995).

17. Nash, C. E., "Structure of US Aquaculture" *Food Policy*, August 1979, pp. 204-215.

18. National Research Council, *Marine Aquaculture--Opportunities for Growth* (Washington, DC: National Academy Press, 1992).

19. National Research Council, *Aquaculture in the United States: Constraints and Opportunities* (Washington, DC: National Academy Press, 1978).

20. Parker, H.S., Broussard, M. and Jensen, G., U.S. Department of Agriculture, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, August 16, 1995.

21. Parker, H., Aquaculture Program Coordinator, U.S. Department of Agriculture, and Chair, Joint Subcommittee on Aquaculture, letter announcing proposal to revise the National Aquaculture Development Plan, May 2, 1995.

22. Perez, K., Bailey, C., and Waren, A., "Catfish in the Farming System of West Alabama," IN: Bailey, C., Jentoft, S., and Sinclair, P. (eds.) *Aquacultural Development: Social Dimensions of an Emerging Industry* (Boulder CO: Westview Press, 1995).

23. Royal, T., Vice President for Sales and Marketing, SeaPerfect, Charleston, SC, letter to Jill Fallon of Kaye, Failcow, Richmond & Rothstein, Boston MA, Aug. 28, 1995.

24. Royal, T., "Potential Sources of Federal Assistance and Financial Aid for Aquaculture," contract paper prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, July 1994 (Springfield, VA: National Technical Information Service, 1995).

25. Rychlak, R.J., and Peel, E.M., "Swimming Past the Hook: Navigating Legal Obstacles in the Aquaculture Industry," *Environmental Law*, vol. 23, no. 3, 1993, pp. 837-868.

26. Stickney, R.R., *Principles of Aquaculture* (New York NY: John Wiley & Sons, Inc., 1994).

27. *The Seattle Times*, "More Atlantic Salmon, Likely Farmed in B.C., Ending

up in Alaska Nets," Dec. 18, 1994, p. B14.

28. Thomas, S.K., Vertrees, R.L., and Floyd, D.W., "Aquacultural Marketing Law: Assessing State-Level Regulatory Approaches in the North Central Region" *Journal of Applied Aquaculture* vol. 2(1) 1993, pp. 65-84.

29. Tiddens, A., *Aquaculture in America: the Role of Science, Government, and the Entrepreneur* (Boulder, CO: Westview Press, 1990).

30. Trosclair, C., "David Cochran May Finally Get His Day in Court," *Water Farming Journal*, Vol. 10 No. 5, April 10, 1995, p. 3.

31. United Nations, Food and Agriculture Organization, Fisheries Department, "Review of the State of World Fishery Resources: Aquaculture," FAO Fisheries Circular No. 886 (Rome, Italy: UNFAO, 1995).

32. United Nations, Food and Agriculture Organization, Fisheries Department "Aquaculture Production 1986-1992," Fisheries Circular No. 815 Revision 6, (Rome, Italy: UNFAO, 1993).

33. U.S. Congress, House Of Representatives, Committee on Merchant Marine and Fisheries, "Aquaculture," Statement of Dr. Robert Schleser before the Subcommittee on Fisheries and Wildlife Conservation and the Environment, and the Subcommittee on Oceanography, 94th Congress, 1st and 2nd sessions, 1975-1976, p. 590.

34. U.S. Congress, Office of Technology Assessment, *Harmful Non-Indigenous Species in the United States* OTA-F-565 (Washington, DC: U.S. Government Printing Office, September 1993).

35. U.S. Department of Agriculture, "1995 Farm Bill--Guidance of the Administration" (Washington, DC, 1995).

36. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, material provided to the Office of Technology Assessment to clarify NOAA policy, September 7, 1995.

37. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, "1995-2005 Strategic Plan Environmental Stewardship Portfolio--Build Sustainable Fisheries," (Washington, DC: USDOC, Revised December 1994).

38. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, "United States Trade in Edible Fishery Products 1992-1993" (Washington, DC: USDOC, June 1994).

39. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fisheries Statistics Division, "Fisheries of the United States--1993" (Washington, DC: U.S. Department of Commerce, 1993).

2

Federal Aquaculture Funds and Primary Functions

OVERVIEW

The National Aquaculture Act authorized funds to each of the three federal agencies for the fiscal years 1981 through 1993 for the purpose of carrying out its provisions. Despite two subsequent reauthorizations (the National Aquaculture Improvement Act of 1985, and the Food, Agriculture, Conservation and Trade Act of 1990), no federal funding has been appropriated under the National Aquaculture Act.

At least $60 million in aquaculture funding was distributed among 25 federal agencies in 1994.[1] An additional 20 programs may have the potential of providing support to the aquaculture industry; in some cases, these programs are beginning to actively solicit aquaculture projects (46).

Federal aquaculture funding arises as an issue in discussions regarding many aspects of aquaculture. Some sectors of the industry assert that there is insufficient federal funding for research aimed at solving the industry's immediate problems, such as aquatic animal health (funding for drug approval), biotechnology (funding for development of improved stocks), and predation (funding for development of new technologies to diminish predation).[2] Other sectors argue for increased federal emphasis on research areas unlikely to be taken up by the private sector, such as recirculating and offshore production technologies.

FEDERAL FUNDING LEVELS

In 1994, aquaculture received at least $60 million in financial assistance from the federal government, excluding monies spent on fish hatcheries (table 2-1).[3] The U.S. Department of Agriculture (USDA) was responsible for almost half of this $60 million ($28.7 million, or 47 percent of the total), while the Department of Commerce (DOC) spent 23 percent of the total ($13.9 million) and the Department of Interior (DOI) spent 12 percent of the total ($7 million).[4] Departments and agencies responsible for the remaining 18 percent ($10.7 million) include: Department of Energy, Agency for International Development, Environmental Protection Agency, Food and Drug Administration, National Science Foundation, and Tennessee Valley Authority.

From 1988 to 1994, federal funding for aquaculture increased by 75 percent ($26 million). This increase in spending occurred

---

[1] Table 2-1 lists aquaculture funding for 19 agencies; seven agencies were unable to separate out their aquaculture funding.

[2] For an analysis of aquatic health, biotechnology, and predation issues, see U.S. Congress, Office of Technology Assessment, *Selected Technology Issues in U.S. Aquaculture* (Washington, DC: Office of Technology Assessment, September 1995).

[3] In 1994, approximately $61 million was spent on U.S. fish hatcheries. The Fish and Wildlife Service spent $39.9 million, or 65 percent; the National Marine Fisheries Service spent $18.6 million, or 30 percent; and the Bureau of Indian Affairs spent $2.9 million, or 5 percent (table 2-2).

[4] All annual expenditures for aquaculture presented here must be viewed as approximations. OTA could not identify exact amounts of federal funding devoted to aquaculture for several reasons. First, aquaculture may be included within several budget categories for an agency making it difficult to single out aquaculture expenditures. Second, aquaculture expenditures may be summarized by different individuals in different ways from year to year. The variability in definitions, diversity in species and techniques, and lack of uniformity in reporting, makes obtaining exact amounts impossible.

TABLE 2-1: Federal Funding for U.S. Aquaculture, 1988-1994

Dept.	Agency	1988	1989	1990	1991	1992	1993	1994
USDA	AMS[1]	$15,000	$60,000	$58,254	$0	$91,500	$113,173	$81,140
	APHIS[2]	254,126	323,920	803,285	613,326	644,248	683,889	814,093
	ARS/ERS[3]	2.4 million	3.3 million	4.3 million	5.9 million	7.2 million	7.1 million	7.1 million
	CSREES[4]	9 million	10.3 million	10.3 million	16.6 million	16.4 million	18.8 million	19.5 million
	FAS/ICD[5]	141,322	29,020	235,020	165,000	244,609	694,498	757,470
	NRCS[6]	500,000	500,000	500,000	500,000	500,000	500,000	500,000
	Total	12.3 million	14.5 million	16.2 million	23.8 million	25.1 million	27.9 million	28.7 million
DOC	NMFS[7]	2.5 million	4 million	6.5 million	7.7 million	7.8 million	8.8 million	10 million
	SG[8]	4.5 million	3.9 million	4.3 million	4.2 million	4.3 million	4 million	3.9 million
	Total	7 million	7.9 million	10.8 million	11.9 million	12.1 million	12.8 million	13.9 million
DOD	ACOE[9]	1.7 million	1.1 million	180,000	0	0	0	0
DOE	BPA[10]	638,000	500,000	503,000	238,000	412,000	485,000	593,000
	BSD[11]	1.2 million	1 million	400,000	200,000	400,000	500,000	600,000
	Total	1.8 million	1.5 million	903,000	438,000	812,000	985,000	1.2 million
DOI	FWS[12]	2.1 million	2.3 million	3.4 million	4.5 million	6.6 million	7.8 million	2 million
	NBS[13]							5 million
AID	AID[14]	2.5 million	2.5 million	3.4 million	3.6 million	3.5 million	2.5 million	1.5 million
EPA	EPA[15]	500,000	500,000	500,000	500,000	500,000	500,000	500,000
HHS	FDA[16]	6 million	6 million	6 million	6 million	6 million	6 million	6 million
NSF	NSF[17]	394,000	824,000	203,000	186,000	319,000	321,000	1,089,000
TVA	TVA[18]	0	0	0	2-3 million	200,000	400,000	500,000
TOTAL	=====	$34.3 million	$37.1 million	$41.6 million	$53-54 million	$55.1 million	$59.3 million	$60.3 million

NOTES: Funding for the Agricultural Research Service (ARS) and the Economic Research Service (ERS) have been combined at the request of ERS. Sea Grant figures include funding for the National Coastal Resources Research and Development Institute.

SOURCES: [1]Hatamiya, L., Administrator, Agricultural Marketing Service, U.S. Department of Agriculture, personal communication, November 1994. [2]Langston, A., Animal & Plant Health Inspection Service, U.S. Department of Agriculture, personal communication, August 1994. [3]Michels, K., Budget and Program Management Staff, Agricultural Research Service, U.S. Department of Agriculture, personal communication, July 1994; Harvey, D., Economic Research Service, U.S. Department of Agriculture, personal communication, November 1994. [4]U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service, Current Research Information System, "Aquaculture Related Research: National Summary for CSRS\SAES\OCI," February 1994; Jensen, G., Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, personal communication, October 1994; Broussard, M., Principal Aquaculture Scientist, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, personal communication, November 1994; Jensen, G., National Program Leader, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, personal communication, October 1994. [5]Wicks, R.J., Acting Director, Dairy, Livestock and Poultry, Foreign Agricultural Service, U.S. Department of Agriculture, letter to M. Burkett-Yancey, Director, Legislative Affairs, July 1994; Beck, D., Foreign Agricultural Service/International Cooperation and Development, U.S. Department of Agriculture, February 1995. [6]Teels, B.M., Wetland Staff Co-Leader, Natural Resources Conservation Service, U.S. Department of Agriculture, personal communication, October 1994. [7]Parsons, D., National Aquaculture Coordinator, National Marine Fisheries Service, U.S. Department of Commerce, personal communication, May 1994; Parsons, D., National Aquaculture Coordinator, National Marine Fisheries Service, U.S. Department of Commerce, personal communication, September 1994 ($8.8 + $1.2 million--Fishing Industry Grant Program, i.e., the financial assistance program for the New England Fisheries). [8]U.S. Department of Commerce, National Oceanic and Atmospheric Administration, "The National Sea Grant College Program Annual Report FY 89;" U.S. Department of Commerce, National Oceanic and Atmospheric Administration,

almost entirely among the Departments of Agriculture, Commerce, and Interior. Over this seven year period, the Department of Agriculture experienced an increase of 135 percent (from $12.3 million to $28.7 million) in aquaculture funding; Department of Commerce funding rose almost 100 percent (from $7 million to $13.9 million); and Department of Interior had the largest percentage increase--235 percent (from $2.1 million to $7 million).[5]

Among the 25 federal agencies dedicating funds to aquacultural activities,[6] 13 fund aquaculture research, 12 distribute funding for aquaculture support activities, and seven allocate resources to regulate the industry (table 2-3). The majority of aquaculture fund-ing is directed to research. For example, USDA's 1993 total "system-wide" funding for aquaculture research was at least $42 million (13,61).[7]

Congress has provided support programs to address specific economic and infrastructure barriers to growth in the fishing industry, to traditional agriculture, and to small community and rural development. Many support programs include aquaculture in their mandates; other programs, while currently not providing support to aquaculture, do not exclude aquaculture from possible support (46).

At least seven agencies regulate the aquaculture industry. Certain agencies, such as the Animal and Plant Health Inspection Service, the Natural Resources Conservation Service, the Army Corps of Engineers, and the Food and Drug Administration, have clear regula-tory roles concerning the aquaculture industry. Other responsibilities may be held jointly; for example, the National Marine Fisheries Ser-vice and the Fish and Wildlife Service monitor bird and mammal predation activity on aqua-culture operations. The Environmental Protec-tion Agency has more diffuse responsibilities relating generally to pollution control and waste management.[8]

POTENTIAL AQUACULTURE FUNDING PROGRAMS

OTA identified 20 additional federal agency programs that might have potential for

National Sea Grant College Program, "Projects '90," March 1991; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Sea Grant College Program, "Projects '91," February 1992; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Sea Grant College Program, "Projects '92," February 1993; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Sea Grant College Program, "Projects '93," July 1994; McVey, J., Program Director, Aquaculture, Sea Grant, U.S. Department of Commerce, personal communication, February 1995; Olson, S.G., Deputy Director, National Coastal Resources Research and Development Institute, U.S. Department of Commerce, personal communication, December 1994. [9]Roper, W.E., U.S. Army Corps of Engineers, U.S. Department of Defense, personal communication, February 1994. [10]Parsons, D., National Aquaculture Coordinator, National Marine Fisheries Service, U.S. Department of Commerce, personal communication, May 1994; Gislason, J., Fishery Biologist, Bonneville Power Administration, U.S. Department of Energy, personal communication, July 1995. [11]Sprague, S., Manager, Aquatic Species, Biofuels Systems Division, U.S. Department of Energy, personal communication, March 1994. [12]Nickum, J., National Aquaculture Coordinator, Fish and Wildlife Service, U.S. Department of Interior, personal communication, May 1994; Nickum, J., National Aquaculture Coordinator, Fish and Wildlife Service, U.S. Department of Interior, personal communication, March 1995. [13]Nickum, J., National Aquaculture Coordinator, Fish and Wildlife Service, U.S. Department of Interior, personal communication, March 1995. [14]Rea, H., Office of Agriculture, U.S. Agency for International Development, personal communication, September 1994; U.S. Agency for International Development, "The Status of Fisheries and Aquaculture Development Assistance Programs," August 1993.[15]Bastian, R., Environmental Scientist, Environmental Protection Agency, personal communication, August 1994. [16]Billy, T., Director, Office of Seafood, Food and Drug Administration, personal communication, June 1994. [17]Mitchell, J., Senior Associate, Division of Ocean Sciences, National Science Foundation, personal communication, August 1994. [18]Behrends, L., Tennessee Valley Authority, personal communication, May 1994.

[5] In 1994, DOI funding for aqua-culture was divided between the Fish and Wildlife Service and the National Biological Service. 1994 funding decreased slightly from 1993 when DOI aquaculture funding peaked at $7.8 million.

[6] There are 19 agencies with known aquaculture funding amounts. There are six other agencies, as well as six programs, with unknown funding allocations to aquaculture (the seventh program is the US-Israel Science and Technology Grants Program, initiated in 1995, for which funding is known) (box 2-1).

[7] "System-wide" funding includes matching funds from federal and state agencies and a small contribution percentage from the aquaculture industry.

[8] For further information, see Rubino, M.C. and Wilson, C.A., *Issues in Aquaculture Regulation* (Bethesda, MD: Bluewaters, Inc, October 1993.

TABLE 2-2: Federal Funding for Hatcheries, 1988-1994
(in millions of dollars)

AGENCY	1988	1989	1990	1991	1992	1993	1994
National Marine Fisheries Service[a]	$8.3	$9.3	$9.3	$10.3	$13	$9.6	$18.6
Fish & Wildlife Service[b]	$12.5	$12.9	$14.1	$17.5	$40.6	$47.2	$39.9
Bureau of Indian Affairs[c]	$3.7	$3.7	$4	$4.4	$3.6	$3	$2.9
TOTAL	**$24.5**	**$25.9**	**$27.4**	**$32.2**	**$57.2**	**$59.3**	**$61.4**

a Funding for the Columbia River hatcheries.

b Funding for primarily salmonid production (90 percent salmonid; 10 percent nonsalmonid production).

c Funding for more than 100 fish hatchery operations on Indian reservations throughout the country.

SOURCES: (a) D. Parsons, National Aquaculture Coordinator, National Marine Fisheries Service, U.S. Department of Commerce, personal communications, November 1993 and May 1994; "Committee Approves Plan which includes $18.6 Million for Columbia River Hatcheries," Aquaculture News 2(10):12, August 1994: (b) National Research Council, Marine Aquaculture (Washington, DC: National Academy Press, 1992); J. Nickum, National Aquaculture Coordinator, Fish and Wildlife Service, U.S. Department of Interior, personal communications, May 1994 and March 1995; and T.D. Royal, "Potential Sources of Federal Assistance and Financial Aid For Aquaculture," unpublished contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, July 22, 1994; (c) G. Rankel, Program Manager, Fish, Wildlife and Recreation Program, Bureau of Indian Affairs, U.S. Department of Interior, personal communication, August 1994.

providing support to the aquaculture industry (table 2-4). Programs have been selected based on their potential to assist new aquaculture companies. For example, support programs aimed at farmers or fishermen may have the potential of providing assistance to aquaculturists.

The four USDA programs identified focus on loans and price supports,[9] and the eight DOC programs identified generally address the decline of fisheries or employment and capital needs in rural communities. Departments that do not currently fund aquaculture--the Departments of Labor, Treasury, and Housing and Urban Development, and the Internal Revenue Service--may have the potential of aiding aquaculture through grants, financing, and tax credits. It is not known how much money these programs could contribute to aquaculture (47).

The programs identified as potential aquaculture funding sources may not have been used by aquaculturists in the past for several reasons. First, the industry may be unaware that these programs could be beneficial to them. Thus, aquaculturists have made few, if any, attempts to obtain assistance from these government programs. Second, the government agencies themselves may be unaware that they could provide assistance to the aquaculture industry. Thus, government programs may not be marketed to the aquaculture industry.

FEDERAL AQUACULTURAL ACTIVITIES AND FUNDING

Federal agencies involved in aquaculture research, support, and regulation are described below. Under each department, the agencies are listed in order of funding amount devoted to aquaculture. If funding amount for aquaculture is unknown, or spending for aquaculture is less than $100,000 per year, the agency is listed under the heading "Other."

TABLE 2-3: Federal Agency Aquaculture Activity Breakdown

9 The USDA aquaculture coordinator notes that there are other USDA agencies, including under the mission areas of Natural Resources and the Environment; Food, Nutrition, and Consumer Services; Food Safety; and Marketing and Regulatory Programs that have programs that could be, but are not currently applied to aquaculture (41).

Category	Research	Support	Regulation
Agencies	CSREES	CSREES	APHIS
	ARS	FAS/ICD	NRCS
	FAS/ICD	APHIS	ACOE
	NMFS	AMS	FDA
	SG	CCC	NMFS
	FWS	CFSA	FWS
	NBS	ERS	EPA
	AID	NMFS	
	BSD	FCA	
	BPA	OJT	
	NSF	RHCDS	
	TVA	SBA	
	ACOE		

NOTES: See list of acronyms.

SOURCE: Office of Technology Assessment, 1995.

U.S. DEPARTMENT OF AGRICULTURE (USDA)

Total 1994 USDA Aquaculture Funding: $28.7 million

U.S. Department of Agriculture funding for aquaculture activities steadily increased by 135 percent, from $12.3 million to $28.7 million between 1988 and 1994. Whether this trend will continue in 1995 is unknown.[10]

USDA Research

The U.S. Department of Agriculture (USDA) is the agency currently most active in aquaculture research. Two areas in particular--aquatic animal health and production systems--receive the most aquaculture funding (61).[11] The current research base is very diverse in terms of funding mechanisms, areas of science, and cultured species.

In fiscal year 1994, USDA expended $16.5 million on aquaculture research. Approximately $12.5 million in aquaculture research was supported under Partnership Formula Programs (e.g., Hatch Act, McIntire-Stennis Cooperative Forestry Program, Evans-Allen Program),[12] Grants Programs (e.g., the National Research Initiative, Special Research Grants),[13] and direct federal administration. For the most part these funds are administered by the Cooperative States Research, Education, and Extension Service (CSREES). The Regional Aquaculture Centers shared the remaining $4 million, which was divided evenly among the five centers (box 2-2) (76). The USDA research funding sources typically employ joint funding between CSREES and other federal agencies,[14] state agencies, and a few industry groups (12).

In 1993, total joint funding for USDA aquaculture research was at least $42 million (13,61). The highest proportion ($23.8 million, or 57 percent) of aquaculture research funding was allocated to aquatic animal health and aquaculture production systems (61).[15] The species receiving the most joint funding were catfish and marine shrimp ($9.6 million

[10] USDA Secretary, Mike Espy, testified before the Senate Appropriations Committee and outlined the USDA FY 1995 budget. In FY 1995, USDA is hoping to devote $17.9 million to aquaculture activities. This would be a decline of 38 percent in funding for aquaculture. Of this amount, $15.1 million is proposed for research, $2.3 million for extension and statistics, and $500,000 for disease control (76).

[11] The Current Research Information Service identifies eight research areas: Genetic Resources; Integrated Aquatic Animal Health Management; Reproduction, Growth, and Nutrition; Aquacultural Production Systems; Product Quality; Marketing and Economics; Other; and Unclassified.

[12] The Animal Health and Disease Program is another Partnership Formula Program listed by USDA's Cooperative State Research, Education, and Extension Service (CSREES) as funding aquaculture research.

[13] The 1890 Capacity Building Grants Program and the Small Business Innovation Research Program are two Grants Programs listed as other sources of funding for aquaculture research by CSREES.

[14] Contributing federal agencies include USDA's ARS, NSF, DOE, DOD, AID, NIH, HHS, NASA and TVA (12). See list of acronyms.

[15] Other research areas: Genetic Resources; Reproduction, Growth and Nutrition; Production Quality; Marketing and Economics; Other; and Unclassified.

NOTES: See Appendix A for list of Acronyms.TABLE 2-4: Federal Agencies/Programs with Potential for Providing Support to Aquaculture

Agency/Program[a]	Focus	How Program Is Adaptable
Export Enhancement Program (USDA)	Helps U.S. farmers compete with products from countries that subsidize production, especially the European Union. Intended to challenge unfair trade practices. Benefit is cash bonus to qualifying exporter.	Aquaculture is not designated, but there are policy guidelines for selecting new commodities.
Federal Crop Insurance Corporation (USDA)	Provides a source of cost effective crop insurance for avoidable production losses.	FCIC has underwritten the inventory of aquaculture operations.
Food and Nutrition Service (USDA)	Service provides artificial price supports by purchasing surplus production for federal food and nutrition programs.	Service may purchase aquaculture products.
Rural Business and Cooperative Development Service[2] (USDA)	The financial assistance provided by this program is designed to make rural areas more economically competitive and improve the standard of living of its residents.	Making loans and grants available for infrastructure and working capital for aquaculture projects located in rural areas may improve the standard of living and make areas more economically competitive.
Business Development Assistance (DOC/EDA)	Available to individuals and private corporations for financial assistance of activities that create substantial new long term employment.	By providing loans and guarantees similar to the Small Business Administration, aquaculture projects may be developed in economically depressed areas, providing long term employment.
Fishing Vessel Capital Construction Fund (DOC/NMFS & IRS)	Assists fishermen in the construction, repair, or purchase of fishing vessels.	May assist in building equity and capital formation with before tax dollars.
National Fish and Seafood Promotion Council (DOC)	Established to strengthen the competitive position of the U.S. in domestic and international marketplaces through marketing and promotion.	The Council's mandate includes promotion of aquaculture products. However, funds have never been appropriated for the Council.

TABLE 2-4: Federal Agencies/Programs with Potential For Providing Support To Aquaculture (cont'd).

Agency/Program[a]	Focus	How Program Is Adaptable
Office of Sustainable Development and Intergovernmental Affairs (DOC)	Created by the Secretary of Commerce in 1994, the agency's purpose is to protect fish stocks in the New England area while minimizing adverse economic impacts on local fishermen. At least $60 million has been allocated to the agency.	Aquaculture is being examined as a potential area to finance for oyster and clam culture mitigation purposes.
Public Works and Development Facilities Grants and Loans (DOC & EPA)	Available for the improvement of public infrastructure for the express purpose of encouraging long term economic growth in distressed economies.	Possibility for aquaculture oriented industrial parks or other public infrastructure projects that may provide long term employment to low income families.
Special Economic Development and Adjustment Assistance Program (DOC & EPA)	Designed to assist localities that have experienced sudden and severe economic dislocation resulting in actual or threatened unemployment.	Funds available in conjunction with local government for infrastructure and work force training. May be applicable in coastal areas where wild catch fishermen could participate in aquaculture programs.
Trade Adjustment Assistance (DOC/EDA)	Provides training and income assistance to workers who have lost their jobs due to federal trade policy.	May be an opportunity to retrain commercial fishermen to work on aquaculture operations. To qualify, participants must have been displaced by imports.
Non-competitive, Discretionary Grants (DOL)	These grants are made to organizations to fund research and development, and demonstration projects, as well as provide technical assistance and training.	May be a vehicle for providing technology transfer and a trained work force to areas unaccustomed to aquaculture.
Overseas Private Investment Corporation Programs (DOS)	Provides project financing and other investor services overseas. While providing economic assistance, the program increases U.S. global competitiveness and creates U.S. based jobs by increasing domestic exports.	Aquaculture may be eligible, as an agricultural activity. May be used to finance U.S. companies in overseas production of species not suitable to grow in the U.S.
Export-Import Bank of the U.S. (DOT)	Responsible for 1) assisting domestic exporters compete in foreign markets, and 2) facilitating commercial export financing.	May be useful for aquaculture producers of species with export potential.

TABLE 2-4: Federal Agencies/Programs with Potential For Providing Support To Aquaculture (cont'd).

Agency/Program[a]	Focus	How Program Is Adaptable
Investment Tax Credit (DOT & IRS)	This tax credit is available as a percentage of the cost of rehabilitation expenditures on a certified historic building.	There are numerous aquaculture processing facilities and warehouses located in coastal communities in the U.S. that, if rehabilitated, may qualify for this credit and be suited for hatchery and nursery phases, recirculating systems, or processing.
Targeted Jobs Tax Credit (DOT & IRS)	A tax credit for wages paid to targeted groups, which are composed primarily of the handicapped and those from economically disadvantaged families.	May be a source of payroll subsidy for operations located in economically depressed areas with qualifying employees (less than 70% of the Bureau of Labor Statistics lower living standard).
Community Development Block Grants (CDBG) (HUD)	The program was established to provide grants through state and local governments to aid in the development of viable communities.	The *State and HUD Administered Small City Program* is the CDBG grant program that may be most suitable to aquaculture. It is designed to encompass communities that are small and/or rural communities. Loans are made directly to for-profit businesses to retain jobs and maintain economic viability.
Fishing Industry Loan Restructuring Initiative (SBA)	Intended to mitigate effects of governmental actions (e.g., catch limits).	May assist coastal processors to convert from wild-catch to aquaculture products.
504 Loan Program (SBA)	Provides funding for Certified Development Companies, which make loans to companies that promote economic development by creating or retaining jobs, being located in a distressed area, or promoting minority business development.	Aquaculture operations located in economically distressed areas or that could promote minority business development may be eligible for loans used for the purchase, construction, or improvement of fixed assets.

SOURCE: Office of Technology Assessment, 1995.

Box 2-1: Agency Listing and Corresponding Aquaculture-Related Activity

U.S. Department of Agriculture

USDA Research

- Cooperative State Research, Education, and Extension Service
- Agricultural Research Service
- Foreign Agricultural Service/International Cooperation and Development
- USDA Support
- Cooperative State Research, Education, and Extension Service
- Animal and Plant Health Inspection Service
- Foreign Agricultural Service/International Cooperation and Development
- Agricultural Marketing Service
- Commodity Credit Corporation*
- Consolidated Farm Service Agency*
- Economic Research Service

USDA Regulation

- Animal and Plant Health Inspection Service
- Natural Resources Conservation Service

Department of Commerce

DOC Research

- National Marine Fisheries Service (NMFS)
- Sea Grant (SG)
- SG's National Coastal Resources Research and Development Institute

DOC Support

- (US-Israel Science and Technology Grants Program)
- (Fisheries Obligation Guarantee Program)
- (NMFS' National Training Branch Seafood Inspection Workshops (e.g., HACCP))
- (Northeast Fishing Industry Grants Program)
- (US-Japan Cooperative Program in Natural Resources)

Department of Interior

DOI Research

- Fish and Wildlife Service
- National Biological Service

DOI Regulation

- Fish and Wildlife Service

Food and Drug Administration--Regulation

Agency for International Development--Research

Department of Energy

DOE Research

- Biofuels Systems Division
- Bonneville Power Administration

National Science Foundation--Research

Environmental Protection Agency--Regulation

Tennessee Valley Authority--Research

Other Agencies

Research

- Army Corps of Engineers
- (Small Business Innovative Research Program)

Support

- (Community Development Block Grants Program)
- Farm Credit Administration*
- Office of Job Training*
- Rural Housing and Community Development Services*
- Small Business Administration*

NOTE: Agencies are listed in order of their funding allocation to aquaculture-related activities. Programs are listed in parentheses.

* Funding unknown.

Box 2-2: USDA Regional Aquaculture Centers

In 1987 and 1988, five Regional Aquaculture Centers (RACs) were established in the United States: the Southern RAC administered through Mississippi State University; the Western RAC administered through the University of Washington; the Northeastern RAC administered through the University of Massachusetts Dartmouth; the North Central RAC administered through a joint effort between Michigan State University and Iowa State University; and the Tropical and Subtropical RAC administered through a joint effort between the University of Hawaii and the Oceanic Institute (75).

Under the direction of the Department of Agriculture's Cooperative State Reseach, Education, and Extension Service (CSREES), these regional centers were created for aquaculture research, development, and demonstration purposes. Since their establishment, the Centers have conducted nearly 100 regional projects; approximately 50 of these projects have been completed. Projects are selected based on priorities identified by the aquaculture industry in each region and the Centers' Industry Advisory Councils. Areas of priority research include aquatic animal health and disease control, genetics, finfish nutrition, domestication of finfish and shellfish broodstocks, aquaculture waste management, economics and marketing, production technology, and aquaculture product quality and safety. Recent annual appropriations have averaged $4 million, which is apportioned evenly among the five centers (64,75).

SOURCE: Office of Technology Assessment, 1995.

or 23 percent, and $5.1 million or 12 percent, respectively) (62).[16]

Cooperative State Research, Education, and Extension Service (CSREES)[17]

1994 CSREES Aquaculture Research Funding: $17.7 million

The Cooperative State Research, Education, and Extension Service (CSREES) is responsible for USDA functions related to agricultural research, extension, and education programs. The Service seeks "to enhance the knowledge and technology base necessary for the continued growth of the domestic aquaculture industry as a form of production agriculture" (12). Aquaculture funding is allocated through Formula Funds, Special Grants, and the Regional Aquaculture Centers (RACs). Funding also is channeled through CSREES to the USDA Office of Aquaculture, the director of which chairs the Joint Subcommittee on Aquaculture.

CSREES formula fund allocations are provided to state governments, and competitive grants are administered through the Aquaculture Special Grant Program and National Research Initiative (NRI). CSREES Special Grants are provided to aquaculture research projects considered of national importance by Congress, and research in the private sector is supported through the USDA Small Business Innovation Research Program (SBIR). In addition, aquaculture funding is provided through the Regional Aquaculture Centers (RACs) for university research and extension activities (13).

CSREES administers eight programs in animal systems research.[18] In 1981, aquaculture research was funded at the lowest level of the eight animal commodity programs. From 1981 to 1991, funding for aquaculture research increased by about 250 percent, the

[16] This excluded the category of "nonspecific," which receives the most funding. The nonspecific category classifies research programs that are broad and not specific to a particular species. Examples might include projects on aquaculture marketing, water quality in aquaculture systems, closed system design, and waste management in aquaculture systems. Also projects that covered four or more species are classified in this category because they have broad application and are not species specific (14). Other categories of species: Trout, Other Salmonids, Crawfish, Oysters, Clams/Mussels, Striped Bass, Tilapia, Other Shellfish, Other Finfish, Baitfish, Plants, Other (e.g., alligator and snapping turtles), and Unclassified.

[17] Legislation (P.L. 103-354) in October 1994 authorized reorganization of USDA. The Cooperative State Research, Education, and Extension Service (CSREES) was created by merging the Cooperative State Research Service (CSRS) and the Extension Service (ES).

[18] Beef cattle, dairy cattle, poultry, swine, aquaculture, sheep and wool, other animals, and non-commodity specific.

largest percent increase of the eight groups. In 1991, aquaculture research was apportioned the second largest amount of funding; the largest amount going to beef cattle research (13).

Agricultural Research Service (ARS)[19]

1994 ARS Aquaculture Research Funding: $7 million

As USDA's largest in-house research agency, the Agricultural Research Service (ARS) "has major responsibilities for conducting and leading the national agricultural effort" (51). Its research mission is to develop new knowledge and technology that will ensure an abundance of high-quality agricultural commodities and reasonably-priced products. ARS focuses on the development of technical information and products. The research applies to a wide range of goals, commodities, natural resources, fields of science, and geographic, climatic, and environmental conditions (51).

ARS conducts aquaculture research on marine and freshwater species "of national and regional importance" (51). Research is carried out on quantitative and molecular genetics, breeding, nutrition, disease diagnostics and control, water quality and use, and production systems, as well as processing, off-flavors, food texture and taste, packaging, food safety, and value-added products (51).

Foreign Agricultural Service/International Cooperation and Development (FAS/ICD)[20]

1994 FAS/ICD Aquaculture Research Funding: $500,000

The Foreign Agricultural Service/ International Cooperation and Development (FAS/ICD) conducts collaborative research in forestry and agriculture, including aquaculture, with other countries. The objective of research funded by FAS/ICD is to obtain "new knowledge and technology beneficial to the United States and cooperating countries" (63). FAS/ICD has five programs with aquaculture research components, including collaboration with India, China, Israel, and Egypt.[21]

USDA Support

Cooperative State Research, Education, and Extension Service (CSREES)

1994 CSREES Aquaculture Support Funding: $1.8 million

In addition to funding research, the Cooperative State Research, Education, and Extension Service (CSREES) supports development and delivery of educational programs and provides technical assistance to aquaculturists through the Cooperative Extension System. Programs are implemented in partnership with federal, state, and county levels of government,[22] and provide for the transfer of new science-based knowledge and technologies to the aquaculture industry (28).

---

[19] ARS was established on November 2, 1953, pursuant to authority vested in the Secretary of Agriculture by 5 U.S.C. 301, Reorganization Plan No. 2 of 1953, and other authorities (51).

The research performed by ARS is authorized by the Department of Agriculture Organic Act of 1862 (7 U.S.C. 2201, 2204), the Research and Marketing Act of 1946, amended (7 U.S.C. 427, 1621), the Food and Agriculture Act of 1977, as amended (7 U.S.C. 1281 note), the Food Security Act of 1985 (7 U.S.C. 3101 note), and the Food, Agriculture, Conservation, and Trade Act of 1990 (7 U.S.C. 1421 note) (51).

USDA reorganization dictated that ARS absorb the National Agriculture Library (NAL) and, thus, the Aquaculture Information Center (14).

[20] The Foreign Agricultural Service (FAS) and the Office of International Cooperation and Development (OICD) merged in October 1994 to create the Foreign Agricultural Service/International Cooperation and Development (FAS/ICD).

[21] 1) The Foreign Currency Research Program (P.L. 480) includes research, such as genetic studies of marine shrimp between the University of Houston and India; 2) the lnternational Collaborative Research Program includes research, such as the paddlefish project between Kentucky State University and China; 3) the U.S.-Israel Binational Agricultural Research and Development Fund (BARD); 4) the Scientific and Technical Exchange Program; and 5) the AID-Funded Egyptian Program (1; 6; 63).

[22] Some of this funding may be directed to extension activities funded jointly by CSREES and the Department of Commerce's Marine Advisory Services (MAS).

CSREES funds various projects related to producer-based quality assurance programs, such as producing Hazard Analysis Critical Control Point (HACCP) processing implementation manuals. CSREES also has initiated a worldwide computer database at Purdue University called AquaNIC (Aquaculture Network Information Center), which serves as an online aquaculture network information center. In past years, CSREES has participated in some special grants projects for aquaculture extension, for example, a hybrid striped bass project through University of Maryland, and development of an aquaculture technical series through a cooperative agreement with the University of Georgia (29).

Animal and Plant Health Inspection Service (APHIS)

1994 APHIS Aquaculture Support Funding: unknown percentage of $800,000

The Animal and Plant Health Inspection Service (APHIS) provides several animal and plant health protection services specifically to aquaculturists. The agency's Animal Damage Control provides on-site assistance with bird and mammal predation on aquacultural farms. APHIS' National Veterinary Services Laboratories (NVSL) in Ames, Iowa, provides diagnostic assistance such as veterinary consultations for diagnosing infections and toxicological problems of aquatic organisms (63). APHIS funding specifically targeted at aquaculture support activities is an unknown percentage of its 1994 aquaculture budget of $800,000.

Foreign Agricultural Service/International Cooperation and Development (FAS/ICD)

1994 FAS/ICD Aquaculture Support Funding: $240,000

The Foreign Agricultural Service/ International Cooperation and Development (FAS/ICD) represents U.S. agricultural interests overseas, including aquacultural interests. The agency assists U.S. exporters develop and obtain information on foreign markets. Responsibilities include counseling new entrants on the agricultural export business, helping companies identify and assess foreign markets, demonstrating how potential exporters can establish contacts with foreign buyers, and providing advice on the best marketing and distribution approach for foreign markets (46,63).

Two FAS/ICD programs directly benefit aquaculture species. The Foreign Market Development Program (FMD) provided The Catfish Institute (TCI) with 1992 funding for catfish market research in Japan and the United Kingdom (77). The second program is the Market Promotion Program (MPP)[23] provides financial resources for the promotion of aquaculture product exports. Aquaculture products promoted have included farm-raised crawfish and catfish. For example, since the mid-1980s, the Southern United States Trade Association has received funds to coordinate and conduct export promotions for catfish and crawfish in countries such as Japan, Sweden, Norway, Finland, and the United Kingdom (77). In FY 1993, MPP funding for seafood promotion totaled $8 million (17). The share devoted to aquaculture totaled $210,000 (46,77).

Other USDA Support Agencies

Other 1994 USDA Aquaculture Support Funding: each agency less than $100,000 or amount spent unknown

The **Agricultural Marketing Service (AMS)** provides marketing assistance to aquaculture through the Federal-State Marketing Improvement Program (FSMIP). FSMIP provides competitive matching grants through the state Departments of Agriculture. Objectives of FSMIP include analyzing markets, improving product marketing, overcoming marketing barriers, and reducing

---

23 The Market Promotion Program (MPP) succeeded the Targeted Export Assistance (TEA) Program in FY 1991 as authorized by the 1990 Food, Agriculture, Conservation and Trade Act.

producer and consumer marketing costs. An example of an aquaculture marketing research study is "U.S. Trout Markets: A Survey of Wholesale and Retail Distributors of Fresh Water Farm-Raised Rainbow Trout" conducted by the Idaho Department of Agriculture (30,31,63). In 1994, the amount of AMS funding devoted to aquaculture was about $80,000 (26).

The **Commodity Credit Corporation (CCC)** is responsible for protecting farm income and prices, maintaining sufficient supplies of agricultural commodities, and facilitating distribution of commodities. The Corporation uses the personnel and facilities of the Consolidated Farm Service Agency (discussed below) and the Foreign Agricultural Service/International Cooperation and Development to carry out its activities (39). There are two CCC programs that support aquaculture.The purpose of the GSM-102 Export Credit Guarantee Program is to facilitate U.S. agricultural exports by providing U.S. lenders, mostly commercial banks, with U.S. government guarantees. These guarantees encourage U.S. banks to extend credit to foreign banks. In January 1995, USDA authorized $60 million in credit guarantees for sales of U.S. agri-cultural commodities to countries in the Central America Region[24] under the CCC's Export Credit Guarantee Program. Presently, $40 million has been allocated to this program. In March 1995, USDA amended provisions of the program to include meat and aquaculture feed as eligible commodities. One of the requirements of aquaculture feed is that it must be certified as containing only U.S. ingredients (30).

The **Consolidated Farm Service Agency (CFSA)**[25] disburses payments to aquaculture producers under the Crop Loss Disaster Assistance program designated in the 1990 Farm Bill. CFSA funding of disaster benefits began in 1992; however, specific funding amounts for aquaculture are unknown (44).

The **Economic Research Service (ERS)** provides economic and social science information and analysis to improve "the performance of agriculture and rural America" (63). ERS publishes reports analyzing the production and demand for agricultural commodities. Specifically, the biannual "Aquaculture Situation and Outlook Report" provides information on the supply, demand, pricing, and trade for aquacultural products (63).

USDA Regulation

Animal and Plant Health Inspection Service (APHIS)

1994 APHIS Aquaculture Regulation Funding: unknown percentage of $800,000

The Animal and Plant Health Inspection Service is responsible for licensing all veterinary biologics (e.g. vaccines, diagnostic kits), regulating biologic imports, and certifying biologics for export and interstate transportation. APHIS also provides some export certification for aquacultured animals.[26] APHIS funding specifically targeted at aquaculture regulatory activities is an unknown percentage of its 1994 aquaculture budget of $800,000.

Natural Resources Conservation Service (NRCS)

1994 NRCS Aquaculture Regulation Funding: $500,000

The Natural Resources Conservation Service's (NRCS)[27] role has evolved from a

---

[24] Including Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

[25] In October 1994, a new Consolidated Farm Service Agency (CFSA), also called the Farm Service Agency, took responsibility for administering the farm functions of the Agriculture Stabilization and Conservation Service (ASCS), the Farmer's Home Administration (FmHA) and the Federal Crop Insurance Corporation (FCIC) (58).

[26] For further information, see Office of Technology Assessment, *Selected Technology Issues in U.S. Aquaculture* (Washington, DC: Office of Technology Assessment, September 1995).

[27] In October 1994, the new Natural Resources Conservation Service (NRCS) absorbed all programs of the Soil Conservation Service (SCS) and all conservation programs of the Agriculture Stabilization and Conservation Service (ASCS), except the

more traditional role of advising and assisting farmers to a newer role of regulatory enforcement (57). With regard to aquaculture, the primary objective of NRCS is to ensure protection of the soil and water resource base. This objective is accomplished through careful resource assessment during facility planning and construction. NRCS assists an initial resource assessment by furnishing data on water quality and quantity, and soils. The agency also provides planning assistance, training sessions, and field demonstrations (63).

DEPARTMENT OF COMMERCE (DOC)

Total 1994 DOC Aquaculture Funding: $13.9 million

DOC Research

National Marine Fisheries Service (NMFS)

1994 NMFS Aquaculture Research Funding: $10 million

The National Marine Fisheries Service (NMFS) is administered through the Department of Commerce's (DOC) National Oceanic and Atmospheric Administration (NOAA). NMFS conducts aquaculture research with its own funding, with other agency funds (e.g., CSREES, National Science Foundation and Bonneville Power Administration), and by funding aquaculture research carried out by other agencies and universities (e.g., through Saltonstall-Kennedy grants). (See box 2-3 for a discussion on the NMFS Laboratories involved in aquaculture research).

The Saltonstall-Kennedy (S-K) Program provides research and development grants to organizations that carry out projects (e.g., related to harvesting, processing, and marketing of fishery products) generally benefiting the fishing industry. The S-K fund is capitalized through collection, under customs laws, of import duties on fish and fish products. Funds equaling 30 percent of the gross duty receipts are allocated to the S-K Program.

In 1993, total duties collected on fishery imports were $204.7 million, and $61.4 million was transferred to the S-K Fund (67). At least $6 million was devoted to fifty-five S-K projects (50).[28] Eleven percent, or $711,000, of available funds were devoted to aquaculture (32,42). Funding was distributed to seven aquaculture research projects; the project receiving the most funding was a study on new medications to support U.S. fish farming (42).

Sea Grant

1994 Sea Grant Aquaculture Research Funding: $3.9 million[29]

The Sea Grant College Program, administered through DOC/NOAA, provides funding for aquaculture research through approved Sea Grant institutions that provide matching funds. Projects are selected based on the strength of the individual participating institution, the issues of regional and, often, national importance, and the priorities set for research, education, and service by the National Sea Grant Office (69).

In 1993, 80 aquaculture-related projects were funded. These projects are divided into six categories: 1) aquaculture systems and engineering; 2) genetics and selective breeding; 3) physiology and endocrinology; 4) nutrition; 5) disease/parasites; and 6) policy and economics. From 1988 through 1993, the

---

Conservation Reserve Program (CRP) and the Agricultural Conservation Program (ACP) (58).

[28] In 1993, $55 million of the S-K transferred funds was appropriated by Congress to offset the appropriation requirements of the Operations, Research, and Facilities (ORF) account. ORF is NOAA's major appropriation (67).

[29] This includes funding for the National Coastal Resources Research and Development Institute (NCRI), and may include extension funding through the Marine Advisory Services (MAS).

Box 2-3: NMFS Laboratories Involved in Aquaculture Research

The National Marine Fisheries Service (NMFS) has been involved in research and development programs relevant to aquaculture for almost one hundred and 25 years. Today, each of four regional Fisheries Science Centers supports several laboratories that specialize in research on species, production systems, and other topics of particular import to that region. The Centers contribute to stock enhancement activities as well as to the U.S. commercial aquaculture industry.

Southeast Fisheries Science Center: SFSC conducts research on identification of regional species for development; spawning, reproduction, and hatchery techniques; and research designed to seek regulatory approval of therapeutants for key marine species. Commercial aquaculture has particularly benefited from the Galveston Laboratory's research on development of marine shrimp hatchery techniques, including the "Galveston Method" of producing viable fertilized eggs. The Galveston Laboratory currently is conducting shrimp aquaculture research on the effects of environmental factors, such as temperature and salinity, on growth and survival of native shrimp species, and on natural and artificial diets for various shrimp species.

Northwest Fisheries Science Center: NWFSC conducts a variety of aquaculture research for freshwater and marine finfish. The extensive public salmon hatchery system in the Pacific Northwest has required research and development support from NWFSC for decades, particularly in the areas of fry and juvenile fish evaluation, management of captive broodstock of endangered species, feed development, and disease diagnosis and prevention.

The NWFSC established the Manchester Laboratory and companion facilities at Montlake and the University of Washington's Big Beef Research Station to develop commercially viable culture systems for Pacific salmon. Together these facilities have developed into a "center of excellence" for development of salmonid culture systems. Although emphasis has been on salmon species, cooperative studies with University of Washington scientists has allowed Center scientists to maintain expertise in marine fish and shellfish culture, including rearing a number of native species through a part of their life history.

Northeast Fisheries Science Center: Techniques for bivalve and algal culture developed at the Milford Laboratory in Connecticut are used worldwide by the shellfish aquaculture industry. In addition to extensive work on basic shellfish biology and reproduction, the Milford Laboratory has begun research on marine finfish species with culture potential. The Narragansett RI laboratory has a twenty-five year history of rearing marine finfish species to at least larval stages. At present, research studies are concentrating on cod and haddock as potential aquaculture species.

Alaska Fisheries Science Center: Three year-round research stations have freshwater and marine aquaculture research facilities (Little Port Walter, Osprey Bay, and Auke Creek). Current work is focusing on salmonid genetics, broodstock development, hybridization, and research on life histories.

SOURCE: Unless otherwise noted, information is derived from J. Erbacher, International Trade Specialist, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, fax memorandum, "Information on NMFS Fisheries Science Center Labs," to the Office of Technology Assessment, U.S. Congress, Washington, DC, August 31, 1995.

two categories, "physiology and endocrinology" and "genetics and selective breeding," received more funding than other project areas (40 to 60 percent of total funding) (69,70,71, 72,73).

Traditionally, salmon, marine shrimp, hard clams, and oysters have received the greatest species' research emphasis. Algae research also has been funded at high levels (69). The largest aquaculture programs, in terms of dollars allocated and project numbers, have been carried out in Hawaii, Texas, Washington, and California. In 1993, 40 percent of Sea Grant projects (33 out of 80), accounting for 45 percent of total funding, took place in these states (69,73).

The **National Coastal Resources Research and Development Institute (NCRI)** is federally funded, and university-based. It has its own legislative mandate, but is neither an agency nor a private, non-profit entity. NCRI reports and is administered by the National Sea Grant Office on a year-to-year basis. As in years past, NCRI was zeroed out of NOAA's

proposed budget for the upcoming fiscal year (1996), and its future is uncertain.

NCRI promotes public and private sector partnerships to implement advances in sustainable development and to increase the competitiveness of American coastal businesses. Since 1986, NCRI has funded 33 aquaculture development projects in 15 states. These projects are designed to facilitate commercial ventures of economically important species of finfish, shellfish, and seaweeds. Most of NCRI's research has been directed at new production technologies, although several projects have addressed legal and industry financing issues. In 1994, funding devoted to aquaculture was $205,000 (40).

DOC Support

US-Israel Science and Technology Grants Program

1995 US-Israel Grants Program Aquaculture Support Funding: $1.5 million*[30]*

In 1993, President Bill Clinton and Prime Minister Yitzhak Rabin established the US-Israel Commission to strengthen both countries' private- sector economies by promoting collaborative high-technology research. For the first US-Israel Science and Technology Grants Program, more than 100 proposals were considered.[31] Three grants were awarded; one grant involves two U.S. and two Israeli companies in a joint aquaculture technology venture. The four-year project, "Year-Round Production of High Performance Offspring for Rearing in Aquaculture," will focus on developing new fish and shrimp breeding and rearing technologies to promote efficient year-round production of farmed seafood. In February 1995, it was announced that the aquaculture technology joint venture will receive approximately $3 million in government grants, split evenly among the four companies. The partners must match the grant money, raising the amount of project money to roughly $6 million (3,4,53).

Other DOC Support Programs

Other 1994 DOC Aquaculture Support Funding: each agency less than $100,000 or amount spent unknown

The **Fishing Obligation Guarantee (FOG) Program**[32], administered by NMFS, enables fisheries interests access to the bond and institutional investment market. By bearing all credit risk, the Program guarantees private lenders that loans for the construction, repair, or purchase of commercial fishing vessels will be repaid. Aquaculture was specifically included in this program by the National Oceanic and Atmospheric Administration Act of 1991.[33] All structures as well as equipment and land for aquaculture are included. A significant amount of the Program's fiscal year 1995 credit authority ($25 million) may involve aquaculture (23,68).

The **National Training Branch** is the training and education arm for NMFS' Seafood Inspection Program. This branch of NMFS provides training services for NMFS inspection personnel, a variety of seafood education workshops for the industry (e.g., Hazard Analysis Critical Control Point workshops),[34] and specialized programs for retail and food service professionals (2).

---

[30] The first year of funding for this program will be 1995.

[31] Proposals were from a variety of fields, such as aerospace, pharmaceuticals, electronics and health care.

[32] The program is authorized by title XI of the Merchant Marine Act of 1936, as amended (46 U.S.C 1271-1279, *et. seq.*).

[33] Section 304 of Public Law 102-567 amended section 1101(k) of the Merchant Marine Act, 1936 (46 App. U.S.C. 1271(k)), broadening the definition of the term "fishery facility" to include any building, land, equipment, or vessel used for aquaculture purposes.

[34] The Hazard Analysis Critical Control Point (HACCP) system identifies possible seafood spoilage hazards, puts systems in place to prevent the hazard, and finally, establishes methods for documenting the hazard prevention process. In July 1992, NMFS launched a voluntary, seafood inspection program based on HACCP principles. In January 1994, the Food and Drug Administration proposed to make HACCP systems mandatory for all seafood (66). In 1995, the European Union announced its intent to require all seafood products produced for export to the European Union on or after January 1, 1996, to be processed using HACCP controls (22).

The **Northeast Fishing Industry Grants (FIG) Program**, administered by NMFS, addresses the most pressing needs of fishermen affected by the decline of traditional fisheries in the Northeastern United States and by federal regulatory actions. Fishermen, who require assistance in developing alternative employment or new business opportunities, may obtain grants to address employment impacts associated with reduced fishing opportunities. NMFS indicates that aquaculture may be considered an alternative employment option for these displaced fishermen (19).

Under DOC's **US-Japan Cooperative Program in Natural Resources**, U.S. and Japanese counterpart panels on aquaculture were formed in 1969. The panels include spe-cialists from the federal departments most con-cerned with aquaculture. Efforts have focused on exchanging aquaculture-related information that could benefit both countries (65).

DEPARTMENT OF INTERIOR (DOI)

Total 1994 DOI Aquaculture Funding: $7 million

The Fish and Wildlife Service (FWS) participates in several aquaculture-related activities. The agency conducts aquaculture research, provides private sector services (including fish health inspections at fish farms), and contributes to the salaries of the national and regional aquaculture coordinators. Since its inception in 1994, the National Biological Service (NBS) has conducted research applicable to aquaculture (37).

The Department of Interior (DOI) also has an extensive hatchery system; in 1994, almost $43 million was devoted to hatchery production (see table 2-2). The Fish and Wild-life Service spent almost $40 million operating hundreds of federal fish hatcheries; and the Bureau of Indian Affairs dedicated almost $3 million to oversee at least 100 fish hatcheries on Indian reservations. The fish hatchery sys-tem is beyond the scope of this analysis; how-ever, hatchery research with applications for commercial aquaculture has been included in this analysis.

DOI Research

Fish and Wildlife Service (FWS)

1994 FWS Aquaculture Research Funding: $2 million

In FY 1994, most of the fisheries research centers/laboratories under Fish and Wildlife Service (FWS) jurisdiction were transferred to the National Biological Service (NBS). Those laboratories that remained under FWS authority became known as technology centers. The purpose of these centers is to conduct applied research to support the FWS fish hatchery system. For example, the Bozeman laboratory is conducting research on fish feeds for threatened and endangered species brought into captivity. Findings may be useful to both the public and private aquaculture sectors (38).

FWS also administers Dingell-Johnson funding to state fish and game departments for projects relating to management and restoration of any species that has material value to sport or recreational fisheries.[35] Funding has been made available specifically for research into problems of fish management or culture affecting fish resources (46).

National Biological Service (NBS)

1994 NBS Aquaculture Research Funding: $5 million

The National Biological Service (NBS) conducts research relevant to aquaculture at many of its laboratories. However, the NBS budget does not list aquaculture as a research area; the federal hatcheries are the focus of most NBS laboratory research related to aquaculture (38).

---

[35] Dingell-Johnson funding was authorized by the Federal Aid in Fish Restoration Act of 1950 (16 U.S.C. 777-777k).

Several NBS laboratories target aquaculture species and topic areas. The Fish Farming Experimental Laboratory in Stuttgart, Arkansas conducts research targeting cultured species, such as catfish, baitfish, and minnows. The Southeastern Fish Cultural Laboratory in Marion, Alabama also conducts research on aquaculture topics, such as factors limiting commercial fish farming (37).[36]

The National Fisheries Leetown Center conducts multi-disciplinary research germane to aquaculture at laboratories in West Virginia, Idaho, Pennsylvania, and New York. Recent research projects have focused primarily on striped bass and salmonids (33). The National Fisheries Research Centers in Seattle, Washington, and LaCrosse, Wisconsin, conduct hatchery research pertaining to fish culture and health, focusing on issues such as drug and chemical approval (38).

DOI Regulation

Fish and Wildlife Service

1994 FWS Aquaculture Regulation Funding: $30,000

Fish and Wildlife Service (FWS) regulatory funding is spent on aquaculture-related predation-kill permitting (issuance of permits for killing birds and mammals that depredate aquaculture facilities). There is no central database or uniform reporting procedures to track FWS kill permit data; data is reported separately from each region. The majority of funding has been spent in two areas: field work and investigations, and permit issuance and administration. A third category was hearings and appeals. The majority (65 percent, or $20,777) of FWS regulatory funding was spent in Region 5 (the northeastern United States). In contrast, Region 7 (Alaska) spent no monies on regulatory activities (9,10,11).[37]

The FWS also is responsible for enforcing the Lacey Act of 1981, which protects indigenous species and prevents trade of threatened and endangered species.[38] The Act has been used by some state governments to prevent the culture of aquaculture species that the state considers a game fish, or a threatened or endangered species. State governments also have used the Act to prevent importation of potentially "injurious" certain species (e.g., grass carp) (48). Funding for enforcement of the Lacey Act with regard to aquaculture is unknown.

FOOD AND DRUG ADMINISTRATION (FDA)

Total 1994 FDA Aquaculture Funding: $6 million

FDA Regulation

The Food and Drug Administration (FDA), administered by the Department of Health and Human Services, is the primary authority in setting and enforcing regulatory guidelines concerning food safety. Agency resources are dedicated to research, and surveillance (inspections) and compliance (training). FDA is responsible for monitoring and regulating the use of drugs in aquaculture (8,63).

FDA published proposed regulations in 1994 requiring much of the seafood industry to adopt Hazard Analysis and Critical Control Point (HACCP) procedures. In addition, FDA is responsible for evaluating state shellfish sanitation programs under the National Shellfish Sanitation Program (NSSP), which is a cooperative federal-state-industry effort (59).

FDA estimated its 1994 aquaculture budget to be 15 percent of its total seafood-related annual budget.[39] In 1993, $1.95 million was

---

[36] Both of these laboratories are currently under legislative consideration for transferal to USDA.

[37] For a discussion of kill permitting, see U.S. Congress, Office of Technology Assessment, *Selected Technology Issues in U.S. Aquaculture* (Washington, DC: Office of Technology Assessment, September 1995).

[38] Title 16, U.S.C. 3371

[39] The FY 1994 FDA budget for all seafood activities is $40.5 million. A conservative estimate of the seafood consumed in the United States that is aquaculturally grown is 15 percent. FDA uses these figures as an index to roughly say that $6 million per year of the $40.5 million is spent on aquaculture produced seafood (8).

spent *specifically* on aquaculture in the following three areas: research on drugs, color additives, and pesticides;[40] pesticide and drug surveillance and compliance; and petition review. Sixty-six percent of these funds targeted drugs (8).

AGENCY FOR INTERNATIONAL DEVELOPMENT (AID)

Total 1994 AID Aquaculture Funding: $1.5 million

AID Research

The AID Bureau for Research and Development (BRD), within the Agency for International Development (AID), funds aquaculture research at U.S. institutions. BRD supports U.S. institutions linked to particular subject areas and/or geographical regions through cooperative agreements. U.S. institution expertise is applied to foreign technical services in specialized areas, such as aquaculture (60).

AID's Collaborative Research Support Program (CRSP) provides a forum for researchers from U.S. institutions to work with other experts on global issues affecting development. From 1982-1990, one CRSP project had a total funding of $11.3 million devoted to research of pond dynamics/aquaculture.[41] The project's purpose was to define aquaculture's potential as a dependable source of employment and inexpensive animal protein. Seven U.S. institutions[42] and three developing countries--Honduras, Rwanda, and Thailand--were involved (60).

DEPARTMENT OF ENERGY (DOE)

Total 1994 DOE Aquaculture Funding: $1.2 million

DOE Research

The **Biofuels Systems Division (BSD)** of the Department of Energy (DOE) has spent $4.3 million over the last seven years (1988-1994) on a focused energy-aquaculture project. In 1994, funding was $600,000. Since 1982, this Division has worked on developing technologies to transform aquatic biomass (plant material and waste products) into alternative liquid fuels for transportation. For example, one study investigated the production of diesel fuel from the mass culture of microscopic algae (52,74).

The primary goal of the BSD program is to reduce the cost of alternative fuels to competitive levels by the year 2000. The technical plan for 1992 through 1996 concentrates on two major areas: land and water-based biomass production systems, and the biological and thermochemical conversion of biomass feedstocks (74).

Bonneville Power Administration (BPA) is a federal entity, administered by DOE, set up to distribute power generated at federal dams on the Columbia River. From 1988 to 1994, BPA provided funds for salmonid research and restoration conducted by the National Marine Fisheries Service (43). In 1994, BPA funding for aquaculture was approximately $600,000; $460,000 was spent on the NMFS Redfish Lake Sockeye Salmon Captive Broodstock Rearing and Research Project, and $133,000 was spent on the NMFS Cle Elum Sockeye Restoration Project (25).

---

[40] Research was conducted into the metabolism of aquaculture therapeutants and pesticides, into methods for detection of parent compound residues, and into the metabolites from therapeutant, pesticide, and feed additive use. In addition, there are specific field compliance assignments issued from the Center for Food Safety and Applied Nutrition (CFSAN) for aquaculture drug residue testing in domestic and imported aquaculture produced foods.

[41] Breakdown: AID contribution, $7.449; university match, $1.668; host country contribution, $2.218.

[42] Oregon State University (management entity), Auburn University, University of Hawaii, University of Michigan, Michigan State University, University of Arkansas at Pine Bluff, and the Consortium for International Fisheries and Aquaculture Development.

NATIONAL SCIENCE FOUNDATION (NSF)

***Total* 1994 NSF Aquaculture Funding: $1.1 million**

NSF Research

The National Science Foundation (NSF) has a Small Business Innovation Research (SBIR) Program that annually solicits research proposals from small business firms on scientific or engineering issues that could lead to public benefit. NSF receives about 2000 SBIR proposals annually and funds more than 200 of them (35).

Aquaculture proposals are a very small portion of NSF's SBIR Program; however, it is the major means of NSF aquaculture funding. NSF usually receives about 16 proposals a year; one to four of these aquaculture projects are funded. Marine/Estuarine Aquaculture is the topic area that receives most of the aquaculture-related proposals.[43] However, certain other topic areas (e.g., engineering) could be appropriate, depending upon the nature of the proposed research (35).

In addition, NSF funds a range of basic research proposals that affect aquaculture. These awards, however, are rarely identified as "aquaculture" proposals. Research areas such as environmental engineering and marine biotechnology could potentially receive aquaculture-related proposals (35).

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Total 1994 EPA Aquaculture Funding: $500,000

EPA Regulation

The Environmental Protection Agency (EPA) has primary responsibility for promulgating and enforcing regulations aimed at reducing water pollution, a source of many seafood-borne contaminants (59). EPA regulates discharges of pollutants into U.S. waters under the Clean Water Act, requiring a National Pollutant Discharge Elimination System (NPDES) permit for point source discharges. Since 1979, when regulations for "concentrated aquatic animal production facilities" were published (48), most aquaculture facilities discharges are under the regulatory oversight of EPA.

EPA has six programs related to aquaculture regulation: 1) pollutant discharge permits, 2) pesticide registration, 3) water quality/effluent guidelines, 4) waste water treatment, 5) wetlands management, and 6) residual wastes. These programs focus on permitting, registering, and setting specific guidelines for resource use and discharge elimination. There are few, if any, specific aquaculture research projects; those that do exist usually are found in the discharge permits and pesticide registration programs (5).

TENNESSEE VALLEY AUTHORITY (TVA)

Total 1994 TVA Aquaculture Funding: $500,000

TVA Research

In the 1970s and 1980s, the Tennessee Valley Authority (TVA) conducted research on catfish, freshwater shrimp, and tilapia. In 1989, a refocused budget eliminated these programs. In 1991, TVA constructed a research and development facility in Alabama and initiated a research program on the use of constructed wetlands for wastewater treatment. Appropriated funds since 1991 have been used to cover salaries and operations. TVA envisions that constructed wetlands may be used in treating waters discharged from aquaculture operations (7).

OTHER FEDERAL AGENCIES/PROGRAMS

Funding for aquaculture-related activities can be found in several additional agencies and program areas. Below are seven programs that

---

[43] Initially, NSF had two SBIR aquaculture categories--freshwater and marine/estuarine. Now, the latter is the only NSF-SBIR aquaculture category (35).

support aquaculture, two through research and five through technical and financial assistance.

Research

The **Army Corps of Engineers' (ACOE)** interest in aquaculture stems from its mandate to protect the navigability of public waterways. The Corps is the only agency that has the statutory authority to issue permits for offshore aquaculture operations. Under Section 10 of the Rivers and Harbor Act, ACOE is responsible for permitting all aquaculture operations carried out in navigable waterways. Funding levels for ACOE permitting of aquaculture operations is unknown.

Much of the sediment dredged annually by the Corps is placed in dredged material containment areas (DMCAs), located on private land. Acquisition of land to establish DMCAs is difficult because of high real estate values, long-term nature of this use, and the public perception that dredged material is not aesthetic. To overcome these barriers to acquiring new DMCAs, the Corps has worked to develop integration of dredging material with other uses. Aquaculture is estimated to have high potential in this area (54).

Aquaculture is promising as a compatible activity because aquaculture ponds and DMCAs share many design characteristics. Common features include levees to retain water, relatively impervious soils, and water discharge control structures. Both types of operations have similar regulatory and permitting requirements, and include locations adjacent to coastal waterways (54). From 1986 to 1990, the Corps invested a total of $4.4 million in containment area aquaculture research. For example, the Corps conducted a demonstration project, studying marine shrimp culture in two active DMCAs near Brownsville, Texas (45,54).

The **Small Business Innovative Research (SBIR) Program** is administered by the Small Business Administration (SBA) in conjunction with a parent agency. Eleven agencies have SBIR programs.[44] Established in 1982, the SBIR program is responsible for strengthening the research and development role of small, innovative companies (55). It is intended to be a source of technical innovation, to provide opportunities for small businesses to contract with the federal government, and to increase commercialization of technology resulting from federal research and development (46).

Projects are funded in three stages: testing of scientific merit (phase I), development of projects that showed greatest merit in phase I (phase II) and commercialization of promising technology, which generally involves the use of nonfederal funds (phase III) (46,55). Specifically related to aquaculture, the NSF-SBIR provides funding to small business firms for research into scientific and engineering issues that could lead to public benefit, including research on marine/estuarine aquaculture (36). USDA and DOC also could single out aquaculture for SBIR funds.

Support

The **Community Development Block Grants (CDBG) Program** was authorized by the Housing and Community Development Act of 1974. Administered by Housing and Urban Development, the program was established to provide grants through state and local governments to aid in the development of viable communities. Since 1975, Congress has appropriated over $62 billion for CDBG (46).

The state and HUD Administered Small City Program, receiving 30 percent of CDBG appropriations, is the CDBG grant program

---

[44] Five agencies account for over 90 percent of SBIR awards: Department of Defense (DOD), the Department of Energy (DOE), the Department of Health and Human Services (HHS), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). The other six agencies, accounting for the remainder of SBIR awards, are: U.S. Department of Agriculture (USDA), the Department of Commerce (DOC), the Department of Education (DOEd), the Department of Transportation (DOT), the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission (NRC) (55).

most applicable to aquaculture. The Small City Program is designed to encompass small and/or rural communities well suited to and served by aquaculture projects. Small City Program funds were used as seed money for a Freshwater Prawn (*Macrobrachium rosen-bergii*) farm in Puerto Rico in 1984 (46).

The **Farm Credit Administration (FCA)** was established as an independent agency in the executive branch of the federal government (12 U.S.C. 2241 *et seq*. 1971). The FCA sets rules and governs lending institutions of the Farm Credit System, to ensure adequate credit for producers and harvesters of "food"[45] products. Credit is available for long-term mortgage loans associated with production, basic processing, and marketing, as well as several types of insurance associated with production (46).

In 1993, FCA loans were made to aquaculture facilities raising species such as catfish, shrimp, tilapia, trout, crawfish, clams, and tropical fish. Farm Credit Banks also made loans to hatchery operations and commercial fishing units, which are not easily separated out from the loans made to aquaculture facilities. Five Farm Credit Banks made 592 loans, equaling $111 million, to aquaculture, hatchery and fishing operations. The Farm Credit Bank of Texas, in particular, has made substantial loans to aquaculture operations. In 1993, the bank made 114 loans to catfish producers for a total of $38.7 million (15,21,27,34,49).

The **Office of Job Training Program**, under the Department of Labor's Employment and Training Administration, administers the Job Training Partnership Act (JTPA) (29 U.S.C. 1501). Block grants are made to each state or territory to train or retrain economically disadvantaged workers, dislocated workers, and others who face significant barriers to employment.

The Program is a source of aquaculture technology transfer, work force training, and technical assistance for aquaculture operations in economically distressed areas (46). Two specific programs have been used to support aquaculture development: 1) The Economic Dislocation and Worker Adjustment Assistance Act was an amendment to Title III of the JTPA. Funding is allocated at the discretion of the Secretary of Labor to alleviate, for example, national economic problems such as massive layoffs in one industry or region. In FY 1994, $1.118 billion went to this program. In relation to aquaculture, two shellfish culture projects in the state of Florida benefited from this program. 2) The Defense Conversion Assistance and Diversification Program was authorized in 1990 (PL 101-510 and 101-511) and will expire in 1997. Funds are channeled through the Department of Defense to assist displaced defense workers. In FY 1994, $150 million was allocated to this program. Allied Signal[46] is currently providing free technical assistance to aquaculturists under this program (46).

Rural Housing and Community Development Services (RHCDS),[47] administered through USDA, serves as a temporary source of credit and technical support for rural farmers in need of assistance for improving, establishing or maintaining a family-sized farm.[48] The agency makes direct

---

[45] Tropical fish operations have also received FCA funding (21).

[46] Allied Signal is a defense contractor. During the past few years, they have downsized and, in order to mitigate the impacts, they have looked for other industries in need of their technical expertise. The Office of Job Training allows Allied Signal employees to apply their engineering and environmental monitoring knowledge to the aquaculture industry. Employing environmental monitoring skills (previously used at nuclear facilities) to aquaculture industry water and contamination problems is one example. Other projects have included designing oxygenation systems, sensors to track fish numbers, and instruments to gauge water quality (16; 47).

[47] USDA reorganization of the Farmer's Home Administration (FmHA), into the Rural Housing and Community Development Services, began in October 1994 and is mandatory by October 1995. The former FmHA operated under the Consolidated Farm and Rural Development Act (7 U.S.C. 1921). The new agency falls under the jurisdiction of the Rural Economic and Community Development Office, under USDA (46; 47).

[48] The definition of a farm as it applies to loan making programs is "a tract or tracts of land, improvements, and other appurtenances considered to be farm property, which is used or

loans and guarantees loans made by other lenders for farm operations and farm ownership. Farmers may qualify for agency assistance until they are able to meet the financial requirements to qualify for loans through private lenders (18).

Between October 1, 1991 and July 31, 1993, approximately 289 RHCDS aquaculture loans were made,[49] totaling almost $38 million (56).[50] Mississippi alone received 35 percent, or 101, of all loans made during this period. Loans ranged in amounts from $2,500 to $400,000.[51] The majority of these loans (approximately 71 percent) were made for catfish production. Loans also were made for bass, minnows, baitfish, trout, oysters, salmon, lobsters, clams, crawfish and alligators (18).

"Animal aquaculture" small businesses are eligible for **Small Business Administration (SBA)** support. Assistance can be in the form of loan guarantees, business development counseling (including education and training opportunities), and support from SBA's Office of Advocacy. From 1983 through 1993, 20 loans[52] were made to animal aquaculture small businesses, equaling a total of $3.8 million(24).[53]

REFERENCES

1. *Aquaculture News*, "United States, China involved in joint research study on paddlefish," vol. 3, no. 2, December 1994, p. 7.
2. *Aquaculture News*, "USDC/NMFS National Training Branch sets '95 HACCP workshops," vol. 3, no. 3, January 1995, p. 8.
3. AquaPharm Technologies Corporation, "AquaPharm Receives U.S.-Israel Science and Technology Award," Press Release, February 1995.
4. AquaPharm Technologies Corporation, "U.S.-Israel Aquaculture Technology Joint-Venture: Year-Round Production of High Performance Offspring for Rearing in Aquaculture," Project Summary, February 1995.
5. Bastian, R., Environmental Scientist, Environmental Protection Agency, Washington, DC, personal communication to the Office of Technology Assessment, August 17, 1994.
6. Beck, D., Foreign Agriculture Service, U.S. Department of Agriculture, Washington, DC, letter to the Office of Technology

will be used in the production of livestock, including the production of fish under controlled conditions" (18).

[49] The information collected by survey is not guaranteed to be all-inclusive. Aquaculture is eligible for four of the eight types of loans: Operating Loans, Emergency Loans, Farm Ownership Loans, and Soil and Water Conservation Loans.

[50] Loan limits were set at $200,000 for direct loans and $300,000 or $400,000 for guaranteed loans (56).

[51] This includes both direct and guaranteed loans.

[52] There are three types of loans:

1) The *Business Loan Program* is authorized by the Small Business Act to make loans available to small businesses (15 U.S.C. 631 *et seq*. 1953). To qualify as a small business, a company must be independently owned and not be dominant in its field of operations. Candidates are required to have been rejected by conventional sources of debt financing. Financing is primarily provided by private lenders with SBA loan guarantees. Direct loans also are available to eligible borrowers: businesses located in areas of high unemployment or businesses owned by low income individuals, handicapped individuals, Vietnam veterans, or disabled veterans. This program also provides disaster assistance for small businesses and agricultural cooperatives that sustained substantial economic injury from a natural disaster (13 CFR Part 123).

2) *Small Business Investment Companies* are authorized by the Small Business Investment Act of 1958 to provide venture capital financing to small businesses (15 U.S.C. 661-696). These companies provide unsecured equity financing for small businesses and specialize in investment associated with higher risks.

3) *Local Development Company Loans* (LDCL) are available to any public or nonprofit group to improve the local economy (13 CFR Part 108). These funds can be used for infrastructure improvements that benefit small businesses. The LDCL must provide 10 percent of the projected costs in the form of a stock, bond, or other cash equivalent (46).

[53] As of April 15, 1994, six of the 20 loans had failed, resulting in a high failure rate of 30 percent.

Assessment, U.S. Congress, Washington, DC, February 21, 1995.

7. Behrends, L.L., Tennessee Valley Authority Environmental Research Center, Muscle Shoals, Alabama, personal communication to the Office of Technology Assessment, May 2, 1994.
8. Billy, T., Director, Office of Seafood, Center for Food Safety and Applied Nutrition, Food and Drug Administration, Washington, DC, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, June 8, 1994.
9. Brooks, J.L., Senior Special Agent, International Affairs, Fish and Wildlife Service, Department of Interior, Arlington, VA, e-mail to C. Proffitt, Office of Technology Assessment, U.S. Congress, Washington, DC, April 12, 1995.
10. Brooks, J.L., Senior Special Agent, International Affairs, Fish and Wildlife Service, Department of Interior, Arlington, VA, e-mail to C. Proffitt, Office of Technology Assessment, U.S. Congress, Washington, DC, April 14, 1995.
11. Brooks, J.L., Senior Special Agent, International Affairs, Fish and Wildlife Service, Department of Interior, Arlington, VA, e-mail to C. Proffitt, Office of Technology Assessment, U.S. Congress, Washington, DC, May 4, 1995.
12. Broussard, M., Principal Aquaculture Scientist, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Washington, DC, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, June 24, 1994.
13. Broussard, M., Principal Aquaculture Scientist, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Washington, DC, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, November 18, 1994.
14. Broussard, M., Principal Aquaculture Scientist, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Washington, DC, e-mail to C. Proffitt, Office of Technology Assessment, U.S. Congress, Washington, DC, April 20, 1995.
15. Carlisle, L.E., for William W. Hinkle, Farm Credit Bank of Texas, Austin, TX, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, March 30, 1994.
16. Carr, J., Allied Signal, Kansas City, MO, personal communication to the Office of Technology Assessment, July 1, 1994.
17. Chetrick, J. and S. Beasley, Foreign Agricultural Service, "The Evolving Role of the Foreign Agricultural Service in Seafood Promotion," Agriculture Outlook Conference '94, U.S. Department of Agriculture, Washington, DC, December 1, 1993.
18. Dunn, M.V., Administrator, Farmers Home Administration, U.S. Department of Agriculture, Washington, DC, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, July 19, 1994.
19. Erbacher, J., International Trade Specialist, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, August 30, 1995.
20. Erbacher, J., International Trade Specialist, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, fax memorandum, "Information on NMFS Fisheries Science Center Labs," to the Office of Technology

Assessment, U.S. Congress, Washington, DC, August 31, 1995.

21. Evans, A., Economist, Farm Credit Bank of Columbia, Columbia, South Carolina, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, March 19, 1994.

Appendix A:
Basic Production Data for Representative Species Cultured in the United States and Discussion of Data Quality

		1992 Production	
Common Name	**Scientific Name**	**Volume[1]**	**Value[2]**
American Oyster	Crassostrea virginica	83,544 mt	$82,432,000
Pacific Oyster	Crassostrea gigas	31,202 mt	
Blue Mussel	Mytilus edulis	639 mt	$1,162,000
Quahog clam	Mercenaria mercenaria	6,371 mt	$11,539,000
Japanese littleneck clam	Venerupis japonica (also Tapes japonica)	1,920 mt	
Shrimp (marine)	Penaeus spp.*	2,000 mt	$17,637,000
Red Swamp crawfish	Procambarus clarkii	28,591 mt	$34,860,000
Channel catfish	Ictalurus punctatus	207,460 mt	$273,506,000
Atlantic salmon	Salmo salar	10,028 mt	$75,193,000
Rainbow trout	Oncorhynchus mykiss**	26,057 mt	$53,942,000
Carps	Cyprinidae	1,659 mt	n/a
Tilapia	Tilapia spp.	4,082 mt	n/a
Hybrid striped bass	Morone chrysops x M. saxatilis	n/a	n/a
Other/Miscellaneous***			$173,916,000
TOTAL			$724,187,000

SOURCES:

[1] United Nations, Food and Agriculture Organization, Fisheries Department, "Aquaculture Production 1986-1992" FAO Fisheries Circular No. 815 Revision 6, (Rome, Italy: UNFAO, 1993). A metric ton is equal to 1.102 tons.

[2] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fisheries Statistics Division,"Fisheries of the United States--1993" (Washington, DC: U.S. Department of Commerce, 1993). Products are aggregated by general type (e.g., oyster, clam) and may include species other than those presented here.

***** The most commonly cultured marine shrimp in the United States is *Penaeus vannamei*, also known as the Vanna White shrimp.

****** Formerly Salmo gairdneri; data include freshwater and saltwater trout production.

******* Miscellaneous species include hybrid striped bass, tilapia, and nonfood products such as ornamental fish, aquatic plants, and baitfish.

DISCUSSION: DATA QUALITY

Aquaculture production (and thus value of production) is likely overcounted in the statistics: hatcheries commonly are separate from grow-out facilities, and there may be multiple grow-out facilities for different life stages. For example, fingerlings are grown to a certain size by grower A in state A; grower A then sells this intermediate product to grower B in state B. When statistics are reported the same product will be counted on the books in both states. In addition, the numbers of stock transferred between

growing stages are rough estimates expected to be off by as much as 1,000 in either direction (5); similarly, final harvest estimates may be off by as much.

In addition, inconsistencies are found in the units of measurements chosen. Some states report "live weight" (whole animal), some report headed and gutted (most nonedible parts removed). Some estimates of shellfish production include the shell and others do not (i.e., meat weight). Some estimates exclude cultured aquatic plants. Some states combine species by type (e.g., shellfish), others break them into subgroups (e.g., oysters, clams, mussels), and few if any report by species cultured (e.g., Manila clam *Tapes japonica*, quahog clam *Mercenaria mercenaria*). Finally, as data are aggregated by different organizations, assumptions and generalizations are made. For example, the Food and Agriculture Organization reported that the United States produced 9,352 metric tons of baitfish valued at $61,183,000 in 1992 (31), when in fact this is the production level for a single species of baitfish as reported by the National Marine Fisheries Service (38).

Finally, aquaculture-related data collection is erratic and incomplete. For example, the Census of Agriculture covers only a few aquaculture species and then only every 5 years, and the Bureau of Labor Statistics collects industry employment data via state unemployment insurance records, thus missing self- and family-employment, and temporary or seasonal labor, which may be extremely important in aquaculture. Thus, data presented in this report should be considered rough estimates. Without a centralized national statistical reporting network, data collected from state and local sources will continue to require manipulation, and cannot present a complete and accurate picture of the industry.

Appendix B: Aquaculture Production Systems and Associated Species and Regions

System	Description	Species Associated with System[1]	Region of Concentration
Pond	Located outdoors; may come in various depths, shapes, and sizes; floating cages in ponds, quarries, or reservoirs	*Catfish*, baitfish, crawfish; a little U.S. pond production of pike, freshwater prawn, shrimp	Found in almost every state; major concentration in the Mississippi River Delta region
Flow-through (raceways/tanks)	A raceway or series of tanks through which water flows continuously	*Ttrout*, salmon, alligator proposed: sea bass, Arctic charr	Idaho, although grown in most states
Recirculating	Culture system with water reconditioning capabilities, such that 50-90% of water can be re-used; idea is similar to a home aquarium	*Tilapia*, sturgeon, hybrid bass, red drum, trout, largemouth bass, softshell crabs, tropical fish; pioneer efforts: striped bass, redfish, catfish, and summer flounder	Commercial recirculating systems are found in almost all parts of the country (16)
Nearshore (net pens/ rafts/bottom)	Anchored or floating net pens and rafts; seeding the bottom of the water column and allowing natural growth	*Salmonids* (surface), *oysters* (bottom), clams, mussels and other shellfish	All coasts
Offshore	Advanced technology, commonly designed to have automatic feeding systems, areas for input storage, operator quarters, and sometimes on-site processing; for example, one design consists of a central dome and work platform above the surface with six 160-feet long barrel-like cages extending out like spokes 50 feet underwater for raising fish (13)	Proposed: Atlantic salmon, several species of Pacific salmon, red drum, dolphin fish (mahi-mahi), red snapper, cobia, mackerel, halibut, gilthead seabream, and sea bass	No commercial facilities; first approved facility under construction in the Gulf of Mexico
Integrated	Ponds located close to agriculture fields, greenhouses, or hydroponic systems; sequential tanks or raceways of species that can use waste products as inputs (e.g., catfish to algae to carp)	Several types of submerged, floating and emergent aquatic plants; zooplankton, crawfish, prawns, shrimp, blackfish, carp, tilapia, catfish, white amur, and mosquito fish	Inland areas

Source: Office of Technology Assessment, 1995

[1] Species found most frequently in the associated system are represented in italics.

Appendix C:
Selected Foreign Experience with Aquaculture

In several Asian countries, as well as Chile, Scotland, and Norway, a number of factors have coalesced to foster the development of highly productive aquaculture industries. Industry achievements in these countries have come in the context of different natural resource endowments, resource traditions and political systems. Many of the same factors, including strong national leadership and support, have operated to create an interest in aquaculture development and to facilitate this development in each case, yet industry experience of every country has been unique.

JAPAN AND OTHER ASIAN NATIONS

The policies and structure of Japan's aquaculture industry reflect one of the most, if not the most, effectively organized systems of aquaculture anywhere. Japan has borrowed extensively from technologies developed in the United States to build a highly sophisticated, diverse and complex industry, based on a variety of species and culture systems. Japan is notable for its national commitment to aquaculture; its system of industry-driven research and education; and its well-coordinated financing of private/public activities in support of aquaculture.

Japan has a long history of marine aquaculture, reflecting the relative scarcity of arable land for traditional agriculture, and religious and cultural preference for fish over other meat. Aquaculture production increased markedly after World War II, with the intensified production of high-priced species. High market demand coupled with rising prices, decreases in Japan's distant water fisheries, and strong policy leadership by the Japanese government at various levels are among the reasons for the success of aquaculture.

Policy leadership has been expressed via government programs designed to enhance marine aquaculture, and a highly organized professional research and education system, which includes the most extensive network of fisheries high schools and universities in the world. Japan's research program in aquaculture is large, decentralized and emphasizes regional priorities. Coordination of public and private research programs, and information dissemination via extension workers has accelerated the rate of commercial innovation.

Increasingly in Japan, fish farmers are gaining control of marine resources through ownership rights, a trend which seems to be a necessary foundation for systematic future development of the industry.

Other Asian nations, including China, Indonesia, Taiwan, Thailand and the Philippines also have highly complex and successful industries, which produce a large quantity of a broad range of species using a variety of culture systems and technical practices. Like Japan, these countries have a well-established critical mass of human resources, a range of technical training available, well established research and extension systems, available capital for investment, and government departments that focus on aquaculture.

CHILE

In South America, Chile illustrates the recent and rapid development of a simpler subsector (based largely on salmon) in a country with a national commitment to aquaculture, cheap labor, low production costs, abundant marine resources, and a diversified free market economy. In addition, Chile provides a model for public/private sector collaboration in commercializing applied research in aquaculture ventures. Such collaboration was institutionalized with the establishment of Fundacion Chile (FCh), a successful joint government/private sector research venture whose mission is to incorporate new technologies into the country's economy. FCh's aquaculture related activities haven been a key force in industry success.

Chile's success also rests on the fact that conditions for salmon rearing are ideal in its waters. This, along with inexpensive labor, helps to make production costs for salmon rearing the lowest in the world. Feed costs are substantially lower in Chile than in many other countries because of the ready availability of fish meal. Under Chile's ideal water temperatures, the feed conversion ratio is very high. The costs of smolts in Chile is approximately half what it would be in the United States.

The industry has been relatively free of problems in Chile, and the government offers strong support. Chile has a very predictable site-approval process, with an orderly and well-defined set of criteria for judging a site application; response is very quick. Under these conditions, marine salmon culture has increased tenfold since the 1980s.

NORWAY

Norway provides one of the best examples of major aquacultural success in the 20th century, a success secured through large national investments, incentives, and long-term development planning. Norway also provides an example of an aquaculture industry that is diversifying from a single species emphasis to new species and techniques.

A number of physical, biological, and social conditions were in place in Norway to favor the development of their salmon farming industry: the natural conditions of ideal sea temperatures and sheltered sites; the social conditions of a declining fishery and rural unemployment; a large capital base and favorable regulatory attitude; and support and positive cooperation by all levels of government were critical factors.

Norway had a 100-year tradition of fish farming before the first experiments in net pen culture began in the late 1950s. Up until the early 1970s, local citizens and communities had carried out independent, trial and error salmon culture techniques. The early farms were small, and family-built, -owned, and -operated with little or no supportive infrastructure.

The government began actively supporting aquaculture expansion to encourage coastal development in remote areas in 1973. By 1977, salmon production was doubling every two years. By the 1980s, private investment in aquaculture had expanded and support industries had grown. Government support at all levels was also increasing.

The Ministry of Fisheries increased efforts to provide scientific information to help farmers expand intensive production and improve processing and marketing. The National Veterinary Institute and the Norwegian Fish Farmers Association recognized the need for improved health care and cooperated toward this end. Trial and error treatment methods were soon replaced with veterinary diagnostics and scientific research.

By the mid 1980s, it was very clear that Norway was the leader and dominant producer of farmed salmon in the world. Setbacks occurred, but biological and technical solutions were evolving so rapidly that production was outstripping all projections for industry expansion. Norway dealt effectively with environmental problems and the recent marketing crises for farmed salmon. Funds were provided for basic and applied research aimed at solving environmental problems and achieving production savings; marketing efforts were increased.

Thus, despite serious economic losses, the industry has survived. Norway will likely diversify in the future using other marine species, new farming technologies and alternative strategies. For example, after extensive research in the past few years, halibut production now is occurring on a limited basis in land-based facilities. Cod culture already provides opportunity for fish stocking and enhancement and cod farming appears to be part of the Norwegian fish farming future.

SCOTLAND

Aquaculture in Scotland provides an excellent case study of public/private collaboration to develop an industry that has successfully helped revive a depressed rural economy. Eighty-five percent of the areas with sufficient potential for fish farming in the United Kingdom are located in Scotland's Highlands and Islands. The major asset of this economically underdeveloped area was abundant, clean, and productive marine water.

Salmon farming was identified as a potential economic development tool for this area by the Highlands and Islands Development Board (HIDB), which early on provided financial assistance for research and development, and for pilot projects. The success of small farms set up in the Western Isles with the aid of HIDB provided a major breakthrough in aquaculture and economic development. A five-year program introduced by the government in the early 1980s with financial assistance from the European Community, solidified the role of salmon farming in the Scottish economy. Private growers were also investing in aquaculture with new management technology for higher production potential. As smolt and salmon production increased, indirect employment in ancillary services developed, providing added growth for the coastal regions. Without a favorable government policy, provision of public research funding, and development of needed support services, the industry would not have grown as rapidly or been as diverse.

When Scotland's salmon industry suffered from the collapse of global salmon markets in the late 1980s, substantial public investments were made in marketing research and development. Similarly, when environmental problems arose, the government worked with salmon associations to find solutions. Scottish facilities and programs for education and training in aquaculture played a critical role and have attracted worldwide attention.

Government regulatory programs have offered important assistance to the industry, particularly in the area of disease control. While regulators are not always viewed as being supportive, the industry has been allowed to expand within an established regulatory structure.

CANADA

Canadian aquaculture is in much the same position as U.S. aquaculture--successful culture sectors are emerging, but the country ranks 27th in world production. Also like the U.S., the federal strategy is to recognize that aquaculture is a private sector initiative: "The principal responsibility for commercial development will rest with the industry." To support private aquaculture development, the Canadian Federal government has established roles in research, technology transfer, and training; maintenance of

environmental quality; product safety and inspection; market services; and advocacy services (e.g., to improve access to financing) (4).

Unlike the United States, the Canadian Department of Fisheries and Oceans (DFO) is designated the lead agency and aquaculture is considered a sector of the fishing industry. The DFO has established joint industry-government Aquaculture Implementation Committees (4). Canada's federal and provincial governments have worked together to support and plan aquaculture development through the use of memoranda of understanding (MOUs). However, these are not funding mechanisms and do not contain provisions for funding allocation.

In general, the level of government assistance is low compared with the total capital requirements of Canadian aquaculture. No federal assistance programs are targeted directly at the aquaculture industry. General programs do exist that might benefit salmon farmers, but for the most part these are small and operate either as guaranteed loan or low-interest packages. Foreign investment provides over 40 percent of capital for British Colombia's salmon industry.

OTHER COUNTRIES

In addition to these countries, established and successful aquaculture industries exist in Denmark (primarily trout), Ecuador (shrimp), and in Brazil, Egypt, Israel and Jamaica (all focusing on tilapia). Several countries in Central Europe and the Near East, as well as Bangladesh and Nepal have successful industries based mainly on carps. In all of these countries, technical, financial, and other support services are available, accessible, and well organized.

In a number of countries, aquaculture is an emergent subsector of the economy. Such countries are typically still in the research and development stage. Ventures may be backed by government or initiated by a few small-scale farmers operating with government support. Over 70 countries fall into this category, mainly in Africa, the Caribbean, Oceania, Central America and the poorest and most arid parts of the Middle East. In these countries, aquaculture may be a new interest, and there may not be traditional local markets for aquaculture products. Natural resources for aquaculture may be lacking or markets may be adequately supplied from wild sources of seafood. There are typically few support services such as educational programs, extension agents, credit systems and financial resources, or government departments designated with responsibilities to oversee aquaculture. Emergent subsectors all lack a critical mass of entrepreneurs, or primary producers, who have technical information and training.

SOURCE: Unless otherwise noted, information is derived from Andrea Katz, "International Examples of Success and Failure and Lessons for the United States," contract paper prepared for the Office of Technology Assessment, June 1994 (Springfield, VA: National Technical Information Service, 1995) as summarized by Susan J. Wunder, OTA contract writer/editor.

APPENDIX D:
1980 Designation of Responsibilities in Aquaculture Among Federal Agencies

INTERAGENCY AGREEMENT AMONG DEPARTMENT OF AGRICULTURE, DEPARTMENT OF COMMERCE, DEPARTMENT OF THE INTERIOR

Subject: Designation of Areas of Responsibility in Aquaculture

I. Background

Aquaculture--the propagation and rearing of aquatic species in controlled or selected environments--has important international and domestic ramifications. Internationally, aquaculture represents an important source of food and an industry particularly suited to developing countries. Domestically, aquaculture represents: an economically sound approach to meeting the increasing demand of the American people for seafood; a source of industrial materials, pharmaceuticals, and energy; a biological approach to control of pollution and degradation of human and industrial wastes; and a means of rehabilitation and enhancement of U.S. fish and shellfish resources.

Although aquaculture currently contributes approximately 10 percent of seafood production worldwide, less than 3 percent of current U.S. seafood production results from aquaculture. Thus, domestic aquaculture production has the potential for significant growth. The primary responsibility for attaining this potential rests with the private sector. However, it is the policy of the federal government to undertake those research, development, transfer, and assistance programs and activities necessary and appropriate to stimulate the development of an active and viable U.S. aquaculture industry.

A number of federal agencies have responsibilities and programs related to aquaculture. These range from regulatory responsibilities for chemical agents and environmental protection, to programs of financial assistance, research and development, technical assistance, advisory and information services, and education and training. Coordination of these activities is the province of the Joint Subcommittee on Aquaculture, established by the Committee on Food and Renewable Resources and the Committee on Atmosphere and Oceans of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

The primary responsibilities, resources, and programs in aquaculture reside in three Departments: Agriculture, Commerce, and Interior. If the federal government's efforts to stimulate and facilitate the development of aquaculture in this country are to succeed, it is essential that the activities of these three agencies be mutually reinforcing. It is for this reason that these Departments have entered into this agreement.

II. Purpose

The purpose of this Interagency Agreement is to increase the effectiveness and productivity of Federal aquaculture efforts by defining the primary areas of responsibility for the three principal Federal

Departments supporting and conducting aquaculture research , development, transfer, and assistance -- the Departments of Agriculture, Commerce, and Interior. The Agreement describes the central focus of the aquaculture activities of each Department, establishes a mechanism for reaching consensus on potential areas of overlapping interest, and defines the means through which the agencies will coordinate their efforts.

III. Areas of Responsibility

The Departments of Agriculture, Commerce, and Interior agree that the following paragraphs describe the primary focus of responsibility for aquaculture in each Department.

Department of Agriculture

The Department of Agriculture is responsible for support of and direct conduct of research, development, extension, and other support activities in aquaculture oriented toward the conservation and utilization of privately-owned or -leased land and water for commercial, recreation, and home-use aquaculture. This work will be predominantly oriented toward freshwater aquaculture. The Department coordinates its work on anadromous species with the Department of Commerce and the Department of the Interior.

Department of Commerce

The Department of Commerce, through the National Marine Fisheries Service and Office of Sea Grant, is responsible for aquaculture research and development on marine, estuarine, and anadromous species. Work on anadromous species is coordinated with the Department of the Interior and the Department of Agriculture (Forest Service). The Office of Sea Grant conducts education, training, and advisory services in aquaculture; its advisory services programs are carried our in collaboration with the Department of Agriculture's Extension Service.

Department of the Interior

The Department of the Interior, through the Fish and Wildlife Service, is responsible for technical research and development of freshwater finfish for recreational and commercial purposes. The Department coordinates its research and development on anadromous species with the Department of Commerce and the Department of Agriculture's Forest Service. Its activities are conducted in Fish and Wildlife Service laboratories engaged in research on nutrition, disease, genetics, drug registration, and environmental effects.

IV. Resolution of Problem Areas

The general division of responsibility outlined above will be maintained by the three Departments. However, it is understood that some crossing of these lines of division may occur when necessary to advance national objectives in aquaculture. In such instances, this Agreement will be amended by a simple Memorandum of Understanding initiated by the Department requesting the "waiver," and signed by all three Departments.

V. Inter-Agency Coordination

It is agreed that the FCCSET Joint Subcommittee on Aquaculture is the principal mechanism for achieving coordinated planning, implementation, and evaluation of Federal aquaculture programs among the three Departments as well as among all the Federal agencies active in aquaculture.

To maximize coordination of aquaculture activities both within and among the Departments of Agriculture, Commerce, and Interior, each Department has established the position of Aquaculture Coordinator. In addition to performing those duties required to further the programmatic objectives of the Department he or she serves, the Aquaculture Coordinator is the principal representative to the Joint Subcommittee on Aquaculture and the focal point of communication among the three Departments.

Anson R. Bertrand
Director, Science and Education Administration
Department of Agriculture
3/28/80

Richard A. Frank
Administrator
National Oceanic And Atmospheric Administration
Department of Commerce
4/23/80

Robert Herbst
Assistant Secretary for Fish and Wildlife and Parks
Department of the Interior
4/2/80

Acronyms

ACOE	U.S. Army Corps of Engineers (DOD)
ADC	Animal Damage Control (USDA)
AID	Agency for International Development (DOS)
AMS	Agricultural Marketing Service (USDA)
ANS	Aquatic Nuisance Species Task Force
APHIS	Animal and Plant Health Inspection Service (USDA)
ARS	Agricultural Research Service (USDA)
ASCS	Agriculture Stabilization and Conservation Service (USDA)
AVMA	American Veterinary Medicine Association
BPA	Bonneville Power Administration (DOE)
BRD	Bureau for Research and Development (AID)
BSD	Biofuels Systems Division (DOE)
BMPs	Best Management Practices
CCC	Commodity Credit Corporation (USDA)
CDBG	Community Development Block Grants
CFSA	Consolidated Farm Service Agency
COE	U.S. Army Corps of Engineers (DOD)
CRMP	Coastal Resource Management Program
CRS	Congressional Research Service
CRSP	Collaborative Research Support Program
CSRS	Cooperative State Research Service (USDA)
CSREES	Cooperative State Research, Education, and Extension Service (USDA)
CVM	Center for Veterinary Medicine (FDA)
CWA	Clean Water Act of 1977 (40 CFR)
DOC	Department of Commerce
DOI	Department of the Interior
DOD	Department of Defense
DOT	Department of Treasury
DOE	Department of Energy
DOS	Department of State
USDOTr	Department of Treasury
EDA	Economic Development Administration
EPA	Environmental Protection Agency
ERS	Economic Research Service (USDA)
ES	Extension Service (USDA)

ESA	Endangered Species Act
FACTA	Food and Agricultural Conservation and Trade Act of 1990
FARAD	Food Animal Residue Avoidance Databank (USDA program)
FAS	Foreign Agriculture Service (USDA)
FAS/ICD	Foreign Agricultural Service/International Cooperation and Development
FCA	Farm Credit Administration
FCCSET	Federal Coordinating Council on Science, Engineering, and Technology (OSTP)
FDA	Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FmHA	Farmers Home Administration (USDA) (RDA's predecessor)
FOG	Financial Obligations Guarantee
FPPA	Federal Plant Protection Act
FSA	Farm Service Agency
FSIS	Food Safety and Inspection Service (USDA)
FWPCA	Federal Water Pollution Control Act
FWS	U.S. Fish and Wildlife Service (DOI)
GAO	Government Accounting Office
GRAS	Generally Recognized As Safe (FDA)
HACCP	Hazard Analysis Critical Control Point principles for seafood inspection
IIPR	Intentional Introductions Policy Review Committee of the ANS Task Force
INAD	Investigational New Animal Drug (FDA)
ISSC	Interstate Shellfish Sanitation Commission
IRS	Internal Revenue Service
IR-4	(assistance for chemical development for minor economic crops; now named NRSP-7)
JSA	Joint Subcommittee on Aquaculture (OSTP)
MMPA	Marine Mammal Protection Act
MPP	Market Promotion Program
MESP	Marine and Estuarine Sanctuary Program
NAA	National Aquaculture Act
NAA	National Aquaculture Association
NADA	New Animal Drug Application (FDA)
NADP	National Aquaculture Development Plan
NAL	National Agriculture Library (USDA)
NAIC	National Aquaculture Information Center (NAL/USDA)
NASAC	National Association of State Aquaculture Coordinators
NASS	National Agricultural Statistics Service (USDA)
NBIAP	National Biological Impact Assessment Program (USDA)

NBS	National Biological Survey (USDOI)
NCRI	National Coastal Resources Research and Development Institute
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service (USDC)
NOAA	National Oceanic and Atmospheric Administration (USDC)
NPDES	National Pollution Discharge Elimination Systems permits (authorized in CWA)
NRAC	Northeast Regional Aquaculture Center
NRC	National Research Council (NAS)
NRCS	Natural Resources Conservation Service
NRI	National Research Initiative
NRSP-7	National Research Support Project-7
NSF	National Science Foundation
OCRM	Ocean and Coastal Resources Management (NOAA)
OICD	Office for International Cooperation in Development (USDA)
OSHA	Occupational Safety and Health Administration
OSS	Office of Seafood Safety (FDA)
OSTP	Office of Science and Technology Policy (Executive)
RDA	Rural Development Administration (USDA)
RHCDS	Rural Housing and Community Development Services (USDA)
SBA	Small Business Administration
SBIR	Small Business Innovation Research Program (NSF)
SCS	Soil Conservation Service (USDA)
SDWA	Safe Drinking Water Act
SG	Sea Grant (USDC)
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UJR	United States-Japan (cooperative aquaculture program)
USDA	U.S. Department of Agriculture
USAID	U.S. Agency for International Development
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior
USDOD	U.S. Department of Defense
USDOT	U.S. Department of Treasury
USDOE	U.S. Department of Energy
USDOS	U.S. Department of State
USFS	U.S. Forest Service (USDA)
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey (USDOI)

USHHS	U.S. Department of Health and Human Services
WAS	World Aquaculture Society

Contract Papers

CONTEXT OF U.S. AQUACULTURE

International Seafood Trade and the U.S. Aquaculture Industry
Raymond Rhodes (South Carolina Wildlife and Marine Resources, SC)

Aquaculture--International Examples of Success and Failure and Lessons for the United States
Andrea Katz (Associates in Rural Development, Inc., VT)

Market Constraints to Growth in the U.S. Aquaculture Industry
Upton Hatch (Auburn University, AL)

Aquacultural Contributions to Community Development in the United States
Michael Skladany and Conner Bailey (Auburn University, AL)

TECHNOLOGIES, PRODUCTS, AND APPLICATIONS

The Aquaculture of Endangered and Threatened Species and Restoration of Aquatic Systems
Jack Rudloe, Jeret Madei, and Anne Rudloe (Gulf Specimen Marine Lab, Panacea, FL)

Offshore Aquaculture--Technology and Policy Issues
Robert Stickney (University of Washington, WA)

Policy Issues for Aquaculture in Federal Waters
Alison L. Hess (Office of Technology Assessment, DC)

The Future of Recirculating Systems in the U.S. Aquaculture Industry
Ronald Malone (Louisiana State University, LA)

Benefits, Environmental Risks, Social Concerns, and Policy Implications of Biotechnology in Aquaculture
Anne Kapuscinksi (University of Minnesota, MN)
Eric Hallerman (Virgina Polytechnic Institute and State University, VA)

Sustainable Aquaculture Systems
David Brune (Clemson University of South Carolina, SC)

INDUSTRY DEVELOPMENT AND REGULATION

Improving the Competitiveness of U.S. Aquaculture
Per O. Heggelund (AquaSeed, WA)

Successes and Failures in Aquaculture
Rollin Johnson (Harvard University, MA)

Health and Disease Management in Aquaculture: Science, Technology, and the Federal Role
Fred Meyer (La Crescent, MN)

Bird and Mammal Predation in Aquaculture
James Parkhurst (Virginia Polytechnic Institute and State University, VA)

Environmental Aspects of Commerical Aquaculture
Thomas Hopkins (Biometrics, Inc., MD)

GOVERNMENT POLICY AND PROGRAMS

Potential Sources of Federal Assistance for Aquaculture
Thomas Royal (St. George Island, FL)

U.S. Aquaculture Marketing
Howard Johnson (Johnson and Assoc., Bellevue, WA)

WORKSHOPS

The Future of Aquaculture in the United States--September, 1993

Offshore Aquacultural Development in the United States--November, 1993