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 mollusks (table 1-1).

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 mollusks to expansive open ponds to high-tech water recirculating systems in warehouses to integrated systems cycling nutrients among land- and water-based production systems.

Today, aquaculture is touted as the fastest growing segment of U.S. agriculture, based on a fourfold increase in domestic output of fish, shellfish, and aquatic plants between 1980 and 1990 (61). By 1993, USDA estimated that the value of U.S. aquaculture products had reached $760 million (57). Domestic aquaculture production currently accounts for about 10 to 15 percent of the U.S. seafood supply.

Aquaculture products as a proportion of total seafood consumption is gradually rising, likely reflecting increasing availability (e.g., year-round supply) and favorable prices compared to wild caught seafood. This also 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, remain high.

The National Aquaculture Act was slated for reauthorization in 1993, 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 (144). Also currently pending reauthorization are the Regional Aquaculture Centers, the National Research Initiative, and other USDA programs that do or could support aquaculture development. 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 are also on the legislative agenda.

[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 on the specific request of the congressional requesting committees as discussed 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 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 three to 200 miles off the coast of U.S. states and territories.

Seafood: Unless 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.

The federal government has made a commitment through the National Aquaculture Act to support development of a private aquaculture industry.[2] Of immediate concern to established sectors of this industry are technologies affecting aquatic animal health, products of biotechnology, and controlling predation in aquaculture facilities. Loss of aquaculture production to disease and predation are major problems for the industry.

Technologies that help to address these issues may help to increase the profitability of the industry. Similarly, application of biotechnology may yield faster growing or more disease resistant organisms and other benefits. However, the implementation of technological interventions in these areas require careful evaluation to prevent possible adverse consequences to human health or the environment.

AQUATIC ANIMAL HEALTH MANAGEMENT

Aquatic animals in the United States. are affected by numerous diseases which lead to substantial economic losses by the U.S. aquaculture industry (70). Total losses attributed to disease varies from year to year and among species; reported losses have ranged from $2.5 million (trout 1988) to $23 million (catfish 1989) (88,89). including good husbandry and management to minimize stress and exposure to pathogens; vaccines, if available; and culture of disease-aresistant or certified disease-free stocks.

A single disease can wipe out an entire aquaculture crop, implying that it is economically prudent to maintain production system health. Profligate use of chemical treatments, on the other hand, may affect consumer safety or the environment. For

[2] For an analysis of federal involvement in aquaculture, see 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).

example, chemicals and antibiotics used in health management can leave residues in cultured and wild organisms, leading to potential health problems for consumers, as well as harming the environment and potentially creating antibiotic resistant strains of pathogens. Chemical use may be minimized by technologies that prevent disease including good husbandry and management to minimize stress and exposure to pathogens; vaccines, if available; and culture of disease-resistant or certified disease-free stocks.

TABLE 1-1: Production Data for Representative Species Cultured in the U.S.

Common name	Scientific name	1992 Production	
		Volume[a]	Value[b]
Mollusks			
• 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	
• Japanese littleneck clam	*Venerupis japonica (*also *Tapes japonica)*	1,920 mt	$11,539,000
Crustaceans			
• Shrimp (marine)	*Penaeus spp.*[c]	2,000 mt	$17,637,000
• Red Swamp crawfish	*Procambarus clarkii*	28,591 mt	$34,860,000
Finfish			
• Channel catfish	*Ictalurus punctatus*	207,460 mt	$273,506,000
• Atlantic salmon	*Salmo salar*	10,028 mt	$75,193,000
• Rainbow trout	*Oncorhynchus mykiss*[d]	26,057 mt	$53,942,000
• Carps	*Cyprinus spp.*	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[e]			$173,916,000
TOTAL			**$724,187,000**

[a] A metric ton is equal to 1.102 tons.

[b] Products are aggregated by general type (e.g., oyster, clam) and may include species other than those presented here.

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

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

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

SOURCES: Office of Technology Assessment, 1995; (volume data) United Nations, Food and Agriculture Organization, Fisheries Department, "Aquaculture Production 1986-1992" FAO Fisheries Circular No. 815 Revision 6, (Rome, Italy: UNFAO, 1993); (value data) 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).

BIOTECHNOLOGY

Many biotechnologies used in aquaculture are developed to increase production, reduce costs of production, manage disease outbreaks, raise the value of currently cultured organisms, or result in the culture of new species. However, use of these technologies may pose risks to human health or the environment or conflict with moral and ethical values. Therefore, increasing use of biotechnologies in aquaculture is of concern to Congress. Currently, federal oversight of some aquatic genetically modified organisms (GMOs)[3] is fragmented among several federal agencies, while other aquatic GMOs receive no federal oversight. Although several federal agencies have developed guidelines or promulgated regulations governing use of GMOs, new legislation specifically addressing the use and release of aquatic GMOs may be needed to minimize potential adverse impacts on the environment and human health and safety (74).

BIRD PREDATION

Potential predators of aquacultural crops include piscivorous birds, marine mammals, fish, turtles, sea snakes, and squid (9). Predation problems can arise in virtually any type of aquacultural endeavor except those where cultured stocks are contained indoors or in sealed holding structures (i.e., "enclosed system" operations). Often predatory animals may be protected by law making lethal methods to reduce predation unacceptable unless a permit is obtained and lethal control is combined with non-lethal methods. Technologies are needed that efficiently and economically reduce crop loss without significantly affecting predator populations or their roles in ecosystem health.

Facility design may make certain operations especially vulnerable to predation problems (107). Large ponds are difficult and expensive to cover with overhead netting. Gently sloping embankments of ponds may closely resemble natural feeding sites and are attractive to foraging by wading predators. Unprotected containment units or flow-through raceways provide predators good feeding platforms or access to stocks, and thus these areas can be subject to predation problems. Nearshore off-bottom culture is subject to both bird and marine mammal predation problems. Special precautions must be taken to prevent predation from below the water's surface (e.g., by seals).

The federal government already has established roles in development and regulation of technologies affecting aquatic animal health, biotechnology, and predation. The following chapters examine these three topic areas and related congressional interest, issues, and technological developments. Enhancing aquatic animal health management, expanding use of biotechnology, and developing more effective predation control methods could support accelerated expansion of the aquaculture industry by increasing production and profits for producers, ensuring safety to consumers, and maintaining or improving environmental quality.

[3] Defined in chapter 3.