An Analysis of the Feasibility of Providing Federal Multiple-Peril Crop Insurance To Aquaculture

A Report to the Risk Management Agency

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Table of Contents

EXECUTIVE SUMMARY

U.S. aquaculture is a highly diverse industry with a wide range of products. Aquaculture production utilizes a number of different aquatic environments and several different types of growing systems. Aquaculture operations are located in virtually every State, but in terms of quantity and dollar value, production is concentrated in the southern States of Mississippi, Alabama, Arkansas, and Louisiana.

Aquaculture production encompasses the output from both warm and cold, fresh and salt water operations. Aquaculture utilizing salt water is sometimes referred to as mariculture, but for the purposes of this report, aquaculture is used for both fresh and salt water operations. In terms of products, aquaculture encompasses the production of edible and nonedible fish, shellfish, mollusks, edible and nonedible aquatic plants, algae, and some reptiles. Species cultured include those indigenous to the United States as well as some non-native species.

Declining wild harvests for a number of species and the destruction of native habitat have been two of the main factors behind the development of many of today's commercial aquaculture operations and the continued experimentation with the commercial production of additional fresh water and marine species. Developmental work in aquaculture has been concentrated on high value species or on species whose populations have been reduced by over fishing or habitat destruction.

Although some elements are common to most aquaculture operations, the wide variety of species produced plus the different types of growing systems and aquatic environments utilized means that aquaculturists face a variety of production hazards many of which will be unique to the species they are producing or the growing system they are using.

Since only a few aquaculture species have been grown in the United States for any length of time, many aquaculture growers do not have a long track record of production. This combined with the unique problems of estimating inventories for most operations presents a difficult problems for establishing rates for production insurance.

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INTRODUCTION

Aquaculture was first established in the United States in the late 1800's with the development of methods used to spawn trout. These original efforts were aimed at restocking rivers and streams where native trout species had been over fished. Restocking efforts undertaken by public agencies or non-profit fish hatcheries were the chief form of aquaculture production for many years.

Modern commercial aquaculture in the U.S. really began in the 1950's with the expansion of trout production in the Snake river valley in Idaho. In the late 1950's and early 1960's the beginning efforts to develop a catfish industry in Arkansas and Mississippi were undertaken, but production would not begin to expand rapidly until the mid-1970's.

Declining wild harvests for a number of species and the destruction of native habitat have been two of the main factors behind the development of many of today's commercial aquaculture operations and the continued experimentation with the commercial production of additional fresh water and marine species. Developmental work in aquaculture has been concentrated on high value species or on species whose populations have been reduced by over fishing or habitat destruction.

Over the last decade aquaculture or fish farming has received a considerable amount of media coverage as a growth industry and as an alternative method of seafood production. During this time, there have been some notable successes in the aquaculture industry and a number of costly failures.

Definition. Aquaculture can be broadly defined as, "the production of aquatic organisms in a controlled environment for all or part of their life cycles." Under this definition, aquacultural production in the United States covers a wide range of products. Examples include ***finfish***--catfish, trout, salmon, carp, and tilapia; ***shellfish***--shrimp, crawfish, and freshwater prawns; ***mollusks***--clams, oysters, mussels, abalone, and scallops; ***nonfood species***--ornamental fish and baitfish; ***plants***--seaweeds, watercress, and aquatic grasses; and ***other***--alligators, turtles, and frogs. In addition the industry is constantly examining the aquacultural potential of other species.

A chief factors behind the recent growth in aquacultural production is the fact that wild-harvest of seafood remains one of the last commercial vestiges of hunting and gathering activities. Aquaculture, on the other hand, is the farming of aquatic organisms. Farming became the primary source of vegetables, fruits, grains, and meat products hundreds, if not thousands, of years ago. Now a similar change is expected for seafood. This switch has already started to occur in parts of the seafood industry and over the next decade or two the changeover from reliance on wild harvest to aquaculture should accelerate.

There are two principal reasons behind aquaculture's transformation as a commercial activity. First, fish catching technology has improved to a point where seafood stocks can be harvested faster then they can reproduce. These increases in technology have made it possible for fishing fleets to harvest seafood from all the oceans of the world. Initially, improvements in technology led to greater total harvests as new fishery stocks were discovered. However, traditional seafood harvests may have reached their limit and between 1990 and 1997 the world's wild seafood harvests as estimated by the Food and Agriculture Organization of the United Nations (FAO) were basically flat and declined in some regions (1).

A continuing increase in total world harvests has chiefly been the result of greater aquaculture production in Asia. Due to the increase in seafood harvesting efficiency, a growing number of wild species have reached their estimated limits for annual harvesting. In response to this, many governments have applied annual catch limits or various other restrictions to the harvesting of many fresh and marine species.

Second, water pollution stemming from chemical and nutrient runoff from industry, housing developments, and agriculture has reduced water quality in many freshwater and coastal areas. The degradation of a number of coastal habitats has had a tremendously deleterious impact on aquatic organisms ability to reproduce as these areas serve as breeding grounds for a large number of aquatic species.[1]

International seafood trade. The United States is the world's second largest exporter of seafood products, while at the same time it is a net seafood importer. In 1997, the United States was the world's third largest seafood exporter with exports valued at $2.7 billion, and the world's second largest seafood importer, after Japan, with imports valued at $7.8 billion (2).

U.S. exports of seafood products are dominated by shipments of salmon (fresh, frozen, and canned), crabs, and surimi.[2] U.S. seafood product imports are concentrated in shrimp and tuna. In 1997, shrimp and tuna accounted for almost half the value of U.S. imports of edible fishery products (2). U.S. seafood imports come from a number of countries, but our largest seafood suppliers are Canada, Thailand, and China. The chief products from Canada are lobster and flatfish. Thailand and China are major suppliers of shrimp and tuna.

THE U.S. AQUACULTURE INDUSTRY

Industry Structure

The three most important species in global aquaculture are shrimp, salmon, and catfish[3]. This same

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[1]As a result of the harmful effects of pollutants, a number of media reports have questioned the safety of some seafood products. However, aquaculture producers operate under very different circumstances because they regularly monitor the water quality in their operations and control the quality of the feed that their fish are receiving.

[2]Surimi is derived from inexpensive fish whose flesh is minced and then retextured for use as a replacement for more expensive products such as crab or lobster.

[3]This refers to commercial aquaculture production focused on sales to other consumers, not small scale production primarily focused at consumption by the producer. In Asia a tremendous amounts of carp, milkfish, and tilapia are grown and consumed at the local level.

breakout holds for the U.S. aquaculture industry.

The largest sector in U.S. aquaculture is the catfish industry, with annual production approaching 560 million pounds in 1998 (3). Catfish is grown commercially in several States, but Mississippi accounts for about 70 percent of production. Other major producing States are Alabama, Arkansas, and Louisiana. Virtually 100 percent of the catfish sold commercially in the United States now comes from farmed production.

Trout production is the second largest sector in the domestic industry. In 1998, total U.S. production of food-size trout was estimated at approximately 55 million pounds and valued at $60 million (4). There is also a market for smaller trout that are released into lakes and rivers to supplement wild fish for recreational fisherman. As with catfish, almost 100 percent of commercial trout sales to restaurants and grocery stores are farm-raised. Idaho is the dominant trout producer in the United States, accounting for approximately 75 percent of all food-size trout production in 1998 (4).

The third largest sector in U.S. aquaculture is the crawfish industry. Concentrated mostly in Louisiana, crawfish farming utilizes approximately 100,000 acres of ponds and annual farmed production between 1990 and 1997 has ranged from 44 to 61 million pounds (5). Unlike most catfish or trout, there is also a considerable harvest of wild crawfish, again mainly in Louisiana. The annual amount harvested from the wild varies widely depending on weather conditions, but can run as high as __ million pounds (5).

Globally, the farm-raised shrimp industry is probably aquaculture's most valuable sector. U.S. shrimp farmers only produced about 7 million pounds of product in 1997, but worldwide farm-raised shrimp production is now estimated to be about 660,200 metric tons representing over 25 percent of the world's total shrimp supply (3). Since most areas of the United States are not well suited climatically to be a major shrimp producer, the domestic industry has concentrated on providing advanced technology for intensive shrimp farms and the development of virus-free post-larvae for further growout.

U.S. shrimp imports now amount to over $3 billion a year and an estimated 50 percent of those imports are farm-raised. While shrimp farming operations grow a number of different species of shrimp with varying rates of growth, most production is concentrated in medium-sized shrimp. The very largest and very smallest shrimp seen in the market come mainly from wild harvest.

The U.S. farm-raised salmon industry is a large part of the domestic aquaculture industry, but the United States is only a minor producer when compared to the worldwide industry. The majority of U.S. salmon production comes from wild harvest in Alaska. Even with a large wild harvest, the domestic farmed salmon industry, centered in Maine and Washington, has continued to grow. Most of the farmed production is Atlantic salmon, but some coho and chinook salmon are also produced. In 1997, U.S. imports of farmed salmon were valued at almost $400 million, with about 90 percent coming from Chile and Canada, although Norway is the world's largest producer (3).

Aquaculture's Expanding Variety

Frequent harvesting of declining marine populations has helpe dto increase interest in expanding the number of marine species used in aquaculture. Some species already have well developed commercial markets, while others are new to the United States and will need some type of promotion program to build market awareness. Two species that have garnered a lot of publicity over the last couple of years are hybrid striped bass and tilapia.

Hybrid striped bass is most often a cross between a striped bass female and a white bass male although other crosses are sometimes used. Presently, hybrid striped bass are cultured mostly in the United States, but interest in producing these fish is growing, especially in Asia. The development of a farm-raised hybrid striped bass industry stems from the many restrictions placed on the commercial wild-harvest of striped bass. However, producers of hybrid striped bass still face large swings in prices at those times of the year that wild striped bass are being harvested commercially.

Tilapia is native to Africa and the Middle East, but its production is expanding quickly throughout the world. Tilapia is a warm water fish, whose rapid growth rate and disease resistance have made it a good candidate for aquaculture. U.S. production in 1997 was around __ million pounds, up __ percent from a year earlier (6). Imports of tilapia are also growing rapidly and reached 54 million pounds in 1997 (3). Due to the fact that tilapia is a warm water species, most tilapia production in the United States occurs in intensive indoor production systems.

A number of other species with only limited commercial production at this time are redfish, sturgeon, and arctic char. Redfish production facilities are located mostly along the Gulf Coast. Interest in red fish production has been stimulated by the restrictions placed on its wild-harvest. Sturgeon production currently is concentrated in California and other Northwest states, although recently there has been some interest in Florida. Most of the farms currently in production have had to focused on meat production due to cash flow considerations, but a long term goal for the sturgeon industry is the production of caviar. Arctic char, a freshwater fish similar to trout and salmon, are currently grown mostly in Iceland and Canada, but are being evaluated for possible culture in cold water areas of the United States.

There are also a number of other species that have attracted the interest of the aquaculture industry, but at this time are mostly at the experimental stage. Fresh water species with ongoing research into their commercial possibilities are black carp, yellow perch, and walleye. With stocks of Atlantic cod and halibut severely depleted, there is interest in farming these species and growers in Norway are already producing limited amounts of farm-raised halibut. Other species that may eventually end up as aquaculture industries are mahimahi and bluefin tuna. In the future the species most likely to be investigated for aquaculture potential are those whose wild stocks have been depleted or those with a high market value.

Aquaculture production in the United States

The U.S. aquaculture industry has a number of advantages relative to other producers that improve prospects for its long-term success.

Proximity to market--Along with Japan and the European Union (EU), the United States is one of the world's largest seafood markets. For some U.S. farm-raised species, the domestic live market is a major outlet and one that pays premium prices.

Transportation network--Many aquaculture operations are in rural areas, but most places in the United States have relatively easy access to good transportation and can get their products to market rapidly.

Scientific and technology infrastructure--Producers in the United States can take advantage of a growing network of researchers and companies working in the aquaculture field and developing new equipment for the industry.

Abundant grain supplies--Feed can account for up to 50 percent of total variable production costs for many aquaculture species. The U.S. is not only a major producer of grains, but also has large supplies of livestock byproducts and fish meal that can be incorporated into feed products.

Geographic and water resources--The U.S. has a wide variety of climates and a long coast line for marine aquaculture, as well as abundant fresh water resources.

Environmental safeguards--The U.S. aquaculture industry faces strong regulations on the quality of water leaving an operation. While strong environmental regulations may add to production costs in the short term, if they result in improved water quality they are likely to help the industry in the long-term. In a number of foreign countries, uncontrolled aquaculture development has resulted in wide-scale disease breakouts and crop failures. The U.S. aquaculture industry also benefits from regulations restricting the amount and type of pollutants entering water from other industries.

The principal disadvantages facing the U.S. aquaculture industry include the following.

Climate--A number of the biggest farm-raised species are tropical. The United States does not have any tropical areas, with the exception of Hawaii. This means less than ideal growing conditions for these species.

Land costs--Land costs are generally higher in the U.S. especially compared to less develop countries. This is especially true when looking at coastal properties for marine aquaculture operations.

Labor costs--In most cases labor costs are considerably higher in the United States than in competing countries. In some cases foreign labor costs may be only a fraction of the costs for those same activities in the U.S. This is pertains to both the cost of producing and processing aquaculture products.

Regulations--Many countries have fewer regulations controlling production and processing practices, thus potentially lowering their operating costs. Also many foreign governments have been actively supporting their aquaculture industries as a method of acquiring export earnings.

Aquaculture Compared to Other Meat Products: Strengths

Aquaculture products compete not only with other seafood products, but also with other protein products. However, aquaculture industry has several strengths relative to other meat-producing sectors that give it a competitive advantage.

Feed conversion--As cold blooded organisms, fish and shellfish do not have to expend energy to maintain a specific body temperature. Also being suspended in the water means they do not have to expend much energy to move around. As a result, feed conversion ratios for some fish species, under ideal conditions, can be as low as 1.2 pounds of feed to 1 pound of weight gain. This is substantially below feed conversion rates of other meat-producing animals.

Low cost rations--Many fish species thrive on relatively low cost rations or are able to utilize natural foods available in their environment. This is the case in most mollusk operations and also, to a large extent, in the crawfish industry.

Breeding productivity--Fish are more productive in terms of the number of offspring they can produce per year than other types of livestock operations. For example, a 5-pound female catfish will produce 15,000 to 25,000 eggs during the spawning season. In the wild most of these eggs would die, but in a hatchery situation a high percentage will survive to be placed in fingerling ponds (survival percentages will vary depending on specific industry knowledge concerning hatchery procedures for different species). This is a benefit to fish breeders, allowing them to produce large numbers of improved strains of fish for commercial production.

Adaptability to genetic restructuring--Because fish and shellfish are available at the egg stage, a number of genetic manipulations are available to aquaculture producers and breeders that can not be used on domestic livestock and poultry. The eggs of some fish species can be sex directed through exposure to hormones to achieve single sex populations or, in some cases, techniques can be used to force eggs to retain an additional set of chromosomes, thus making the resulting organism sterile. These types of manipulations help to promote faster growth, thus reducing the growout time and cost from egg to market size.

Speed of growth--Some aquaculture species have very fast growth rates. For example, Mahimahi (dolphin fish) have been grown out from fry (3mm long and 1 gram in weight) to 3 pounds in 150 days, that is a compound growth rate of approximately 5 percent per day. If the growout is continued to eleven months the result is a 25 pound fish. The disadvantage for aquaculture species is that they begin their growout aan extremely small size relative to other domestic meat-producing animals. For example, compare a newly hatched chick with a catfish fry.

Falling real prices--Most segments of the aquaculture industry are relatively new. As new technologies are developed and selective breeding is being done for faster grow rates and disease resistance, the efficiency of aquaculture operations are expected to climb, resulting in falling real prices. This has already been the case for a number of farm-raised species.

Aquaculture Compared to Other Meat Products: Weakenesses

The aquaculture industry also must confront and deal with several weakenesses relative to other meat-producing sectors that tend to diminish its competitive advantage. These weakenesses include the following.

Aquatic environment--In most situations the fish being raised are out of the sight of those individuals monitoring their growth, a number of common farming practices become more difficult such as observing feeding behavior--uneaten feed has a negative impact on the water quality and fish environment; observing the early stages of infections or diseases making timely treatment more difficult; and verifying the number of fish or mollusks on hand in order to adjust feed levels and other grow-out activities.

Chemicals--Only a very small number of therapeutic compounds have been approved for use in aquaculture.

Predators--Except for indoor facilities, predators are a major source of production loss in aquaculture. In many cases aquaculturalists are only allowed to discourage the predators, not to kill them as the predators may themselves be protected species, e.g., Seals and a number of birds.

Cannibalism--Many fish species on other fish in the wild feed. This behavior can frequently carry over to a domestic environment. In a farmed situation, the fish may have to be routinely graded to maintain a consistent size in the pond. If there is too large a size difference between individuals then cannibalism could result.

Long-term outlook for aquaculture

Over the next 30 years, the world's population is forecast to grow from 5 billion to 8.5 billion. If per capita consumption rates hold steady, the absolute quantity of seafood consumption would have to grow tremendously. As more restrictive regulations are placed on the harvesting of wild stocks, the total harvest available from them is expected to stabilize or even decline. Any additions to seafood consumption would thus have to come from increased aquaculture production.

Fortunately for seafood buyers, rising aquaculture production under rapidly improving technology should result in long-term declining real prices for many seafood products. A favorite saying of the aquaculture industry is that "aquaculture is agriculture." In fact, aquacultural production does have many of the features of a livestock or poultry enterprise. Those similarities are expected to allow fish farmers to increase the efficiency of their production and processing operations, which in turn should lead to the falling real prices that have been experienced in the other meat-producing sectors.

The long term reduction in prices will probably not be the result of any one single jump in technology, but rather from continued advances in many areas. Two areas that have received a large amount of research work are feed and genetics. For many aquacultural species, feed can account for 50 percent of variable costs. As a result, research on developing nutritionally complete and lower cost feeds is an industry priority. Genetic selection is expected to greatly increase production efficiency through faster growth rates and improved disease resistance. Other areas that should yield benefits to fish farmers are improved growing and feeding techniques, better facility design, and specialized processing and transportation equipment. Also, as the various sectors of the industry expand they will be able to achieve economies of scale in both the production and processing sides of the business, where per unit costs tend to fall as the size of the operation expands.

PRODUCTION PRACTICES

Elements of Production System

While the methods used to produce the wide variety of species currently grown by the U.S. aquaculture industry differ according to the species and environment used, there are a number of basic similarities between almost all production systems.

Broodstock management and selective breeding programs are the first focus of an aquaculture industry once the basics of growth throughout an entire life cycle in a farmed situation have been achieved. Since most aquaculture industries began by utilizing wild stocks, selective breeding for traits that result in greater productivity is an early priority. Productivity gains can come from a number of areas: faster growth, more efficient feed utilization, changes in body configuration for better edible-meat yields, higher disease resistance, etc.

In some of the established aquaculture industries (e.g., salmon, catfish, trout), breeding operations have already become specialized operations. These farms select improved broodstock for growers and also handle the spawning and development of larvae or fingerlings. In a number of farm-raised species, spawning calls for special growing conditions such as tightly controlled water temperature, light intensity, or photoperiod. A number of species will not spawn naturally in a farm operation so spawning has to be artificially induced. This is usually done through the use of various hormone products. In a number of species, eggs and milt are stripped from the fish and mixed by hand.

The early live stages of a number of aquaculture species requires special conditions or special feeds. Unlike other livestock operations where newly born animals are smaller but very similar to adults, many aquatic organisms go through a number of different life stages before they reach their adult forms. This is especially true of mollusk and shellfish species. Breeders must be able to supply these special environmental conditions and different foods for the different life stages.

Hatchery operations are often in enclosed buildings--spawning fish and eggs need special temperatures and light conditions for optimum development. For many fish species a critical period is when the fry change over from taking their nutrients from their egg sack and begin feeding. Special types of feed in a size appropriate to the size of the fry are need at this point. For a number of species this entails the production of live feed.

A second stage in most fish production and some shellfish and mollusks industries is the development of post-larvae or juveniles. This stage often means moving juveniles to an outdoor but protected environment, and in the case of fish, conditioning them to accept prepared feeds.

The third stage for most aquaculture industries is the final growout to market size. This usually involves a larger facility, a higher density of fish per acre, and the use of commercially-prepared feeds.

Processing and Preservation. The processing of aquaculture products is as varied as their production methods. The range of processing ranges from none to fully prepared, ready-to-eat products. Items such as baitfish and ornamental fish are not processed at all, but are sold live to the final buyer. Some fish, shellfish, and mollusks also fit into this category. A good portion of domestic tilapia production is sold live to restaurants and food stores. Mollusks--e.g., oysters and mussels--are often sold live to restaurants or grocery stores. Shellfish, such as crawfish, often go to restaurants live.

Some aquaculture products are only slightly processed. This category would include such products as fresh, gutted fish and fresh sucked mollusks. A good percentage of fish is marketed this way. The prime example is farmed Atlantic salmon which is often sold as a fresh, whole, gutted product.

Further down the processing line are products that have gone through a slightly higher level of processing. Examples of this are steaked or filleted fish or heads-off or peeled shrimp.

At the highest level of processing are the value added products or prepared products. To meet the demands of grocery chains and the food service industry, many aquacultural processors have developed value-added products. Examples of this are already marinated catfish and trout fillets, fully cooked shrimp, and crawfish meat.

Transportation and marketing.   *** What types of information are needed? ***

Grow-out systems

Aquaculture has a large variety of production systems to meet the needs of the various species being cultured and the variety of environments used (e.g., outdoor, indoor, freshwater, saltwater). The following are simplified descriptions of some of the most common types of aquaculture growing systems and examples of products that are produced using these systems. Within each type of growout system there can be a number of variations in the ownership of the operation, the purpose of the aquaculture production, and the use of resources.

Mono- & Polycultures. Most aquaculture operations are monocultures focusing all their work on one species. However, there are aquaculture farms where more than one species is produced. This can either be in the same pond or tank (a polyculture) or separate ponds or tanks. A good example of a polyculture is the production of carp and catfish in the same pond. The carp are used as a means of weed control or to lower the amount of algae present in the pond. Other polyculture trials have had oysters being raised in shrimp ponds. They were introduced to help improve the water quality by filtering microorganisms from the water.

Private vs common resources. Fresh water aquaculture is for the most part based on the use of private land and ground water resources. In this case ownership rights are fairly clearly defined. Ocean based aquaculture, on the other hand, is the private use of what traditionally has been a common property resource. In this case the aquaculture firm must lease ocean bottom or water column rights from the state or federal government.

Pond culture. This is probably the oldest and most common type of aquaculture growing system. Ponds have been used for carp and tilapia culture for centuries. In the past, when the ponds were constructed, the fish were placed in the pond, but in most cases, especially for carp, the fish were not fed directly. Instead, manure or plant material was added to the pond to encourage the growth of plankton blooms and aquatic weeds which the fish then fed on. This method is still used in some baitfish and ornamental fish production. Today, in most pond fish culture it is more common for specially prepared feeds to be the primary food source. In most cases, prepared feeds are necessary because the biomass of fish in the ponds is too high to be supported by the naturally occurring food in the pond. A high biomass is necessary to make pond production profitable.

Higher fish densities also call for supplemental aeration of some kind to ensure that dissolved oxygen is maintained at optimum levels. The aeration equipment removes a second constraint on the tonnage of fish that can be produced from a given pond.

Pond culture can occur in a wide variety of settings. In the United States the most common pond cultured species is catfish. A catfish pond can range as high as 20 acres with a depth of a few feet, however most ponds are probably in the 5 to 12 acre range. The ponds are equipped with overflow drains, aeration equipment, and water supply pipes from wells. The areation equipment maybe automatically controlled by monitoring devices that activate the areation equipment whenever necessary. Species such as hybrid striped bass and red fish are also pond cultured. The one major difference from catfish is that both red fish and hybrid striped bass can be grown in a range of water salinities. The most common example of saltwater pond culture in aquaculture is shrimp farming.

Flow-through systems. The chief feature of flow-through production systems is the constant addition of new water and the removal of waste products with the water leaving the system. The most common type of flow-through aquaculture system in the United States is raceway systems used for trout culture. A raceway refers to a long narrow trough where the fish are grown. In many cases the troughs are concrete, but they can also be made of other materials. Water for these operations is most often from springs or wells. The water flows through a series of raceways and then through a settling basin to remove any solid wastes before it is discharged. As with the pond culture, the carrying capacity of these systems can be increased with the reoxygenation of the water as it goes from one raceway to the next. This can be done by injecting oxygen into the water or by allowing the water to fall several feet before it enters the next raceway.

While most flow-thru production systems utilize raceways, these systems can also be configured to use tanks. The principal is the same with water moving through a series of tanks before it is discharged.

Closed-system recirculation. The opposite of the flow-thru systems is a closed system were the same water is reused continuously. There are two reasons why an aquaculture operation may be set up with a closed or recirculating production system. First, the operation may be located in an area where the quantity of water available is not great enough to support a flow-thru system. Second, some times the severity of restrictions placed on the discharge of water from the operation makes it necessary to reuse the available water. An example might be if the farmer is growing a non-native species. To prevent escape of the non-native species into nearby watersheds, the State may require zero discharge of water from the operation into adjacent streams or creeks. In this case the operators would be forced to recirculate the water to meet state or federal regulations.

Probably the most common reason to utilize a recirculating water system in an aquaculture operations is due to the need for warm water. A number of farmed species achieve optimum growth in relatively warm water. To reach these temperatures the water must be heated and the cost of heating the water demands that the water be recirculated and reused.

Recirculating the water allows growers to produce in areas without large water resources or grow warm water fish in colder locations. However, the process of setting up and maintaining a recirculation production system is considerably more complex than a pond or raceway system. After each pass through the production system but before the water can be reused, all the settleable solids must be removed. These are mostly uneaten feeds and feces. Also, the dissolved wastes must be removed or transformed. This calls for some type of filtration that involves contact with media having microorganisms on them that can prevent the buildup of waste materials in the water before they reach toxic levels. This is done with some type of filter (a number of different types are available).

In addition, the water must be reoxygenated before it can be returned to the growing system. Again, there are a number of ways that producers can do this. While any one who has had tropical fish knows how to set a simple closed system, the problem for growers is to design a system that keeps water quality high enough for optimum growth of the species being cultured, and yet can handle the waste products of a high enough biomass of fish to make the whole system profitable.

Heated or cooled water. Fish are cold blooded and adopt the temperature of the surrounding water. While many fish can survive in a wide range of water temperatures, most have a narrower temperature range where maximum growth rates can be achieved. This optimum temperature range varies from species to species. Some aquaculture operations achieve this optimum temperature by using recirculation systems and heating the water. Some growers, however, have access to heated geothermal water sources. These waters are mixed with water from other sources to arrive at the desired temperature range. In some cases a warmwater species may be cultured in the first warmer raceways, then as the water cools a different species with lower optimum growout temperature can be cultured in the latter series of cooler raceways or tanks.

Nearshore (State waters). A major difference between freshwater and saltwater aquaculture is that many saltwater operations are set up in the ocean. The major exception to this is shrimp culture, which most often uses salt water in an on-land pond culture system.

When utilizing the ocean for an aquaculture operation, the growers are using a common property resource. As such the grower must be granted a lease by the State whose water they want to use. This arrangement presents a grower with an additional set of considerations--the lease conditions (e.g., the cost per acre, the maximum amount of acreage a singe lessor can have, and the length of the lease)--when making decisions about taking out loans or trying to expand. The aquaculture producer must also compete with commercial wild harvest interests and other user groups such as recreational fisherman and boaters.

There are two major types of ocean culture operations. The first is bottom culture. As the name implies, the species is cultured on or just off the ocean bottom. This type of culture system is almost always some type of mollusk culture. A mollusk-type of culture system is usually easier to get approved as mollusks are not fed so there are no waste feed products and the systems do not interfere with boating or most fishing operations.

The second most common type of ocean aquaculture utilizes the total water column. The most common example is the floating net pens used for salmon production. In this case the state must give the lease to the site, but it must take into account that floating net pens will block free navigation in the area and will prevent commercial or recreational fishing in these sites. This requires that the Coast Guard and the Army Corps Of Engineers gives its approval. Another problem encountered in the leasing of sites for aquaculture operations that use the whole water column is that waste from uneaten salmon feeds and salmon feces could foul the ocean bottoms under the cages if the production sites are not located correctly. In addition sometimes the owners of expensive ocean front houses have objected to the placing of floating aquaculture operations within their view. This objection has been termed “visual pollution.” These potential problems can make the planning and site approval process for an ocean aquaculture project very expensive.

Offshore (Federal waters). Until recently all ocean aquaculture operations had been in State waters (i.e., from the coast to 3 miles out). However, given concerns about bottom fouling and visual pollution there has been interest in the possibility of using locations in federal waters (i.e., from 3 to 12 miles out from the coast). These involve some type of floating structures, similar to a current salmon net pen, only larger and built to survive the rougher conditions of the open ocean. A second type of operation would site the pens near or attached to non operating oil platforms. The advantage of siting the pens close to existing oil drilling platform is that they would not create any additional hazard to navigation. Open ocean aquaculture is still in the experimental stage and even if cages can be designed to withstand the rigors of the open ocean conditions they many not prove economical to use.

Promising new approaches and technologies

While the cultivation of fish and shellfish for food has been around for centuries, many of the species currently being grown are newcomers to aquaculture. Therefore, by applying the same types of scientific research used in the livestock industries, large gains in productivity are expected in the coming decade.

Domestication. With many species of aquaculture, growers are still essentially working with wild stock. As the industry matures one of the first objects that growers have is to use selective breeding to achieve an improved strain of fish or shellfish that promises to have higher disease resistance, better feed conversion, low oxygen tolerance, or more meat yield. Breeders will also be looking for strains of fish that are able to better tolerate the crowded conditions of an aquaculture operation. As the industry grows there is likely to be more specialization in terms of producers of market size fish and firms specializing in breeding improved lines of fingerlings for sale to growers. This is already the case where hybrid fish are used and the breeding must be done artificially therefore requiring a fairly high degree of scientific knowledge.

Biotechnology. Along with producers in the livestock industry, aquaculturalists are looking to biotechnology to help increase their productivity in the future. While traditional breeding activities are rapidly progressing in most species, the hope is that biotechnology advances will shorten the process.

Work has also been done on the development of transgenic fish--fish with one or more genes from other species. Most of this research has focused on carp, catfish, and salmon, but none of this work has advanced beyond the research stage. Aquaculture, unlike other livestock operations, faces the prospect of an accidental escape of a transgenic fish into the wild. Because of this, all transgenic research has been done under very tight controls. Even if future research proves the advantage of transgenic fish in terms of growth rate or disease resistance, it is very likely that growers will be reluctant to utilize these fish due to expected resistance in marketing these products.

Integration of agriculture and aquaculture. Due to increasingly strict environmental regulations relating to waste water discharge some aquaculturalists are looking at the possibility of combining aquaculture operations with some form of plant production. An example would be the combination of aquaculture and hydroponic vegetable production. In this type of set up the waste water from the aquaculture operation would be utilized as the nutrient source for the vegetables. At the end of the vegetable production the water would be recycled back into the aquaculture side of the operation. This type of approach makes the most sense for relatively small indoor operations that lack any crop land for fish manure disposal.

Industry characteristics

Farmer characteristics. For the most part, aquaculture production is done by small independent farms. In most cases, the industries producing individual species are not large enough to employ the type of contract grower, vertical integration seen in the poultry and hog industries. The background of the growers can also vary by the species they produce. Catfish and crawfish growers are also the most likely to be traditional row crop farmers, while mollusk and salmon farmers are the most likely to have some type of traditional fishing background.

Regional concentration of production. The production of most aquacultural species in the United States is relatively concentrated geographically. The concentration is most likely caused by growing conditions in a specific location, water availability, or that the species is native to that area of the country. Examples of this are the catfish and crawfish industries. Catfish production is centered in

Mississippi and includes the surrounding states of Alabama, Arkansas, and Louisiana. Together these four States account for over 90 percent of total U.S. production. The catfish industries' concentration in these states is mainly due to good soil conditions for pond construction, large amounts of available water, and the fact that catfish were already a species with a strong regional demand. Crawfish are primarily produced in Louisiana where again there is a strong traditional demand and the crawfish species most commonly grow are native to that State.

Segmented vs integrated production systems. As the aquaculture industry matures, the organizational make up of the industry is likely to change with firms expected to specialize in one area of production--either the hatchery end or the growout end of the business. However, the speed at which this type of specialization will occur is expected to vary widely. Presently, most production comes from independent farms. In a number of cases the processing is done by a separate company or a coop arrangement.

Subsidiary industries.

MARKETING

Harvesting

Transportation

Marketing channels

COST OF PRODUCTION

PRODUCTION PERILS

Disease

As with all livestock enterprises, one of the chief causes of production losses are deaths due to diseases. All aquaculture operations are vulnerable to this, especially as the production densities in the system are increased. Where aquaculture operations differ from the other livestock industries is that for many diseases the exact causes have not been isolated and no specific therapeutic compounds are available to treat the fish. The "catch 22" of the aquaculture industry is that, for many of the individual species, total sales are not great enough to warrant a pharmaceutical company investing millions of dollars in the development and testing of a drug to fight the disease, while lack of the proper therapeutic compounds may prevent the industry from expanding.

Presently, only the largest industries such as salmon, catfish, and shrimp are large enough to interest the efforts of pharmaceutical companies. Even so, much of the effort, in recent years, has been directed towards the development of vaccines. This situation may change somewhat in the future as available data on the use of specific drugs in fish species expands. Another factor that could improve the outlook for the development of disease fighting drugs for fish would be the modification of regulations to allow the approval process to be applied to whole classes of fish rather than go through the testing process for each individual species.

Climate--flood, drought, temperature

Pollution

Aquaculture crop losses due to pollution would likely be limited to operations based in the ocean or other public waters where exposure may be greatest with the least opportunity for individual control. Losses from chemical spills at fresh water aquaculture operations would likely be contained within a single pond or raceway and would not effect the total operation. However, if an aquaculture operation's water source aquifer became polluted, then the entire operation would be affected.

Saltwater operations such as salmon and mollusks production are likely the most vulnerable to spills or outbreaks of such things as red tides. Mollusks are especially susceptible to pollution problems because they are filter feeders and tend to bioaccumulate toxins.

Predation

The severity of predation problems for aquaculture operations depends on the type of production system utilized. Those operations using an indoor water recirculation system have little or no predation problems as long as water entering the facility comes from wells or has been filtered to keep out predators.

However, for most outside aquaculture production systems, predation is a major concern. Netting can help keep predation down in many systems that use small ponds or raceways, but predators will still often find their way into the production facility. And, netting can interfere with many of the daily operations at the facility. Birds are the chief predators at most aquaculture sites, but mammals such as otter, raccoons, snakes, turtles, and seals can also become problems. Seals are a problem to salmon growers at their ocean sites. Most salmon cages are double netted below the water and also have nets above the water. Seals present a special problem because of their intelligence and the fact that they are protected animals. While acquiring a special permit to reduce the number of nuisance birds attacking aquaculture facilities such as catfish ponds might be possible, the chance of issuing permits to kill seals that raid aquaculture facilities is zero for all practical purposes.

USDA's Animal Damage Control group with the Animal and Plant Health Inspection Service has been undertaking a number of studies of catfish growers loses due to predation. The studies have a dual focus. First, to document the amount of losses that birds could have on a pond. Second, to try and develop ways to keep the birds (mostly double crested cormorants) from roosting near catfish operations and seeing the farms as their easiest source of food. Another source of information on predation is from the annual trout production report done by the National Agricultural Statistics Service (4). In the report covering September 1, 1995 to August 31, 1996, trout growers reported they loss 27.4 million fish with a weight of 5.1 million pounds. Of this total, predation was estimated to account for 24 percent or 6.5 million fish. The average weight of the fish lost through predation was approximately 0.2 pounds, so most of the predation occurred while the fish were relatively small.

AQUACULTURE INSURANCE IMPLEMENTATION ISSUES

The implementation of "crop" insurance to the aquaculture industry will likely present a number of special issues due to the nature of the production systems used, the fact that many aquaculture producers may not be as familiar with the record keeping required for insurance purposes as their "traditional" agriculture counterparts, and scarcity of established markets and publicly available market prices for a number of aquaculture commodities.

Production histories

Inventory estimates

Accurate inventory estimates have been a problem for in the aquaculture industry both in terms of obtaining financing from banks, to plan feeding requirements for different ponds, and to accurately determine production yields. As with most items connected with aquaculture, the severity of the problem varies with the type of production system used. Pond culture and ocean bottom culture of some mollusks would likely have the most problems with maintaining an accurate inventory estimate

Establishing an accurate inventory estimate has been a continuing problem for the catfish industry for three reasons. Machines can accurately count the number of fingerlings being stocked in a pond, but over time that figure can be influenced by “die offs” from disease, predation, or other problems. With catfish ponds averaging anywhere from 5 to 10 acres and with limited visibility in the water, there is no good way to visibly check if their is 10,000 or 50,000 fish in a pond. Although the fish do come to the surface when fed, no accurate count can be taken. Second, most catfish farms operate under a batch production system, i.e., the ponds are stocked, the fish grown to market size, and then the whole pond is harvested. However, a certain percentage of fish always manage to evade the harvesting seine and remain in the pond. In a continuous harvesting system, a seine with a larger mesh is used to selectively harvest only the larger fish. In either case growers have to make estimates of the total biomass remaining in the pond because this is what the quantity of feed used in a specific pond is based on.

Some mollusks producers, chiefly oyster and mussel producers, utilize leased ocean bottom for their production location. The mollusks are broadcast over the area and are allowed to grow naturally. Again, the combination of tracking mortality after the stocking and incomplete harvesting would make it difficult to arrive at inventory estimates.

Another species that could present problems in estimating inventory is crawfish production. In these operations crawfish are stocked in the ponds after the ponds are constructed, but subsequent production depends on natural reproduction in the pond. So each year growers have only limited information about the total population of crawfish in each pond, and the percentage of the total population in each of the various size classes.

Inventory estimates are much less of a problem as production moves away from pond systems to raceway, tank, or other similar production methods. In most of these methods the fish can be more closely monitored and with a decrease in predation, mortalities can be more accurately tracked. In ponds, birds can eat sick or dead fish before they can be noted by workers.

Market prices

Another major factor impacting the development of accurate estimates of an insured loss is that for many aquacultural species there are no widely referred to market quotes to establish an accepted market price.

For catfish and trout there is generally enough production to establish a market price. However, trout growers in the eastern part of the country sell a good proportion of their production, not for processing, but for use in stocking lakes and streams for recreational fishing. Prices for these fish are much harder to establish.

References

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(2) Fisheries of the United States, 1997, National Marine Fisheries Service, U.S. Department of Commerce, Sept. 1998, Current Fishery Statistics No. 9500

(3) Aquaculture Outlook, various issues, Economic Research Service, U.S. Department of Agriculture.

(4) Annual Trout Report, October 1998, National Agricultural Statistics Service, U.S. Department of Agriculture.

(5) World Shrimp Farming 1998, Number 11, Editor Bob Rosenberry, published by Shrimp News International.

APPENDIX[4]

A. **Some firms presently offering insurance to aquaculture producers**

B. **Organizations Involved in Aquaculture**

C. **Regional Aquaculture Centers**

D. **Extension Specialists**

E. **State Aquaculture Coordinators**

F. **Aquaculture Producer Organizations**

[4]Note - These are not definitive lists, rather a sample.

A. Some firms presently offering insurance to aquaculture producers

Companies listed in Aquaculture Magazine's 1998 Buyer's Guide:

Outdoor Risk Management, Inc.
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Sedgwick Limited Insurance Brokers
2600-200 Granville Street
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Phone 604-682-0811 FAX 604-682-5867

Companies listed in Aquaculture Magazine's 1997 Buyer's Guide:

Alabama Catfish Producers
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Montgomery, AL 36191
Ph: (205) 613-4214   FAX: (205) 284-3957

American Live Stock Insurance Co.
P.O. Box 520
Geneva, IL 60134
Ph: (708) 232-2100   FAX: (708) 232-2292

McDonald Insurance Group
P.O. Box 3089

Kirkland, WA 98083

PH: (206) 827-7400   FAX: (206) 827-7402

Sedgwick Limited Insurance Brokers

1600 401 West Georgia Street

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Ph: (604) 682-0828   FAX: (604) 682-5867

B. Organizations Involved in Aquaculture

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