ARROYO

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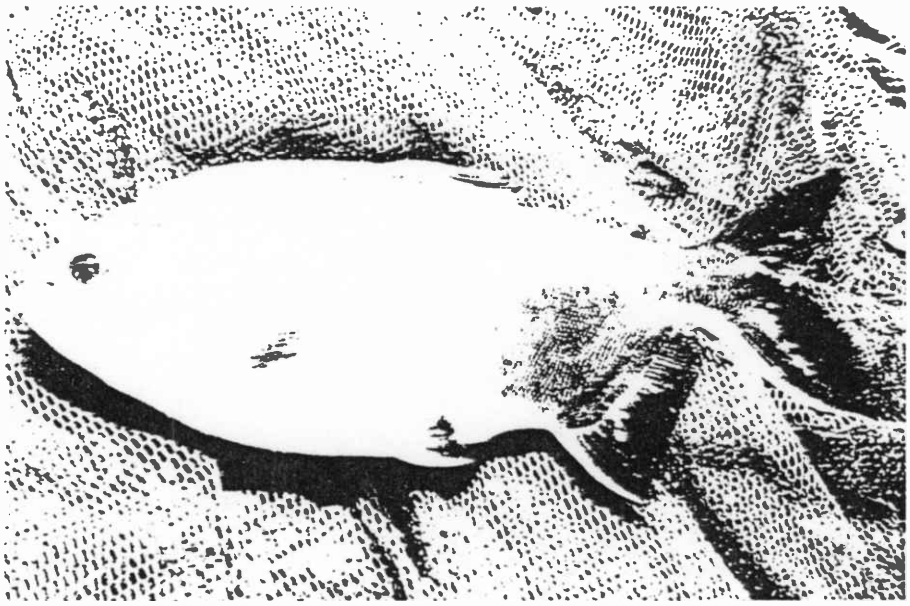
Fish May Be Cash Crop for Arizona Farmers

Harvesting the Desert Waters

by Joe Gelt



Work is underway at Maricopa Agricultural Center to determine if pacu (shown above), a fish native to the Amazon drainage basin, can be successfully farmed in Arizona. Preliminary results are promising.

A fish out of water" is a figure of speech expressing incongruity. At first sight, "Fish farming in the desert" might seem to express a similar sense of dislocation, even futility. But, in fact, fish farming or aquaculture is attracting interest in Arizona. Its supporters, few in number but committed, believe that aquaculture, a field relatively new to the state, has the potential to become a viable Arizona industry.

At second thought this should not seem so strange. Desert lands bloom with cotton, citrus, pecans and other cultivated crops. Should it then seem odd that catfish, tilapia, trout, as well as other cultivated fish are harvested from desert waters? Human effort and ingenuity have made some desert areas remarkably fertile.

Variants of aquaculture exist depending upon the prevailing conditions of an area. For example, fish farming operations in Arizona, a mostly hot, arid region, will differ from what occurs in the Southeast, a wet region and the center of aquaculture in the United States. Desert aquaculture is lesser known, its practice and potential still being explored.

Aquaculture, a Growth Industry

The growing interest in aquaculture and its expansion into various geographic areas, including the desert Southwest, is easily explained. Aquaculture generally is recognized as a growth industry, with a good potential for increased development and economic gain. In fact, some economists assert that aquaculture represents the fastest growing and the most lucrative sector within U.S. agriculture.

Aquaculture's favored status reflects what is happening in the ocean. Once the source of bountiful harvests of fish, oceans now are yielding fewer fish. As a result, the fish populations in the ocean are viewed with some concern, even alarm. Like the buffalo on the plains, whose numbers also once were considered limitless, some varieties of fish are becoming scarce.

The issue recently attracted na-

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tional attention. For example, the spring issue of the National Academy of Science's publication, *Issues in Science and Technology*, describes the ominous depopulation of the ocean. A virtual litany of fish species are listed whose numbers are diminishing.

During the 1980s yield for food fish such as grouper and snapper plummeted by 80 percent, while tuna and marlin fell more than 50 percent. Overfishing has so depleted populations of swordfish, yellowtail and summer flounder that their breeding rates are unable to maintain their current numbers. Halibut and haddock now are rare along the New England coast. The U.S. and Canadian cod industries have hit bottom. The numbers of lobsters and scallops have never been so low. The list continues.

Various factors are identified as contributing to the demise of fish populations. Prime among them is the success of the fishing industry, a success that included the seeds of its own destruction. Seafood demand was up, the numbers of fishermen increased, and technological improvements enabled greater numbers of fish to be caught. The result was over-fishing of the ocean. Environmental factors such as pollution and habitat destruction also did their part to decimate numbers of fish.

The interconnection of the world marketplace is such that conditions in the open seas affect developments inland, even within the irrigation canals and ditches of Arizona. As the ocean becomes hazardous to the health and well being of fish, the controlled conditions of aquaculture offer a potential breeding ground for fish supplies needed for the domestic market.

Fish farmers have taken note. For example, in response to the diminished numbers of salmon in the wild, salmon production in Washington and Maine has increased greatly during the last few years. As a result, even though much fewer salmon are being caught in the wild, salmon prices have not increased. In fact, salmon prices actually have decreased despite the environmental problems that have reduced their numbers. The same is true for shrimp.

Aquaculture may be thriving nationally, but can Arizona share in the success story? Does the state offer fertile ground – or, stated more accurately, ample waters – for an aquaculture industry to develop and grow? A review of current aquacultural activities in the state might begin to answer such questions.

Ooops

The last edition of *Arroyo*, Volume 7, Number 3, should be dated April 1994. It was erroneously dated April 1993

Aquaculture in Arizona

Arizona aquaculture facilities can be characterized as either warm or cold water operations. Water temperatures determine which fish species can be farmed at a location. There are 25 licensed commercial fish farms in the state, with six cold water and 19 warm water operations. The number of licensed fish farms has remained fairly stable during the last three or four years. A few new fish farms have offset the few that did not continue operations.

Most of the cold water fish farms in Arizona are located in the mountainous or higher reaches of the state, including Sedona, Show Low and other White Mountain locations. In the fish farming business cold water is water below 60 degrees. Cold water fish farmers mainly specialize in trout. Researchers have looked at the possibility also of raising Atlantic salmon in northern Arizona, and at least one fish farmer has expressed interest in attempting to raise the species.

Blue River Recreational Fish Hatchery, Inc. located in the White Mountains is a cold water facility. Managed by the Joy family, the facility raises rainbow trout, kamloop trout and brown trout. Fry and fingerlings are raised in raceways for about six months. When they average five inches, they are transferred to eight ponds. Water comes from the Blue River.

The hatchery ships out about 1,200 lbs. per week of live, adult trout, mostly to government agencies and to private lakes and ponds for stocking. The farm is looking into prospects for entering the retail trade; i.e., restaurants and supermarkets, and estimates that retail sales could increase its production by 1,000 lbs. per week. The hatchery also maintains three fish-out ponds. A family operation, the fishery employs five full-time people and has been in business since 1989.

Some of the warm water facilities in Arizona take advantage of geothermal wells, with water ranging between 85-105 degrees Fahrenheit. Facilities using geothermal springs benefit from being able to maintain constant warm-water temperatures year round.

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Sitting atop a large geothermal aquifer, Hyder Valley in southwest Arizona is a center for warm water fish farming in the state. Because of its close proximity to a possible Southern California market and its access to geothermal springs, Hyder Valley is considered to have tremendous potential as an aquaculture center in the state.

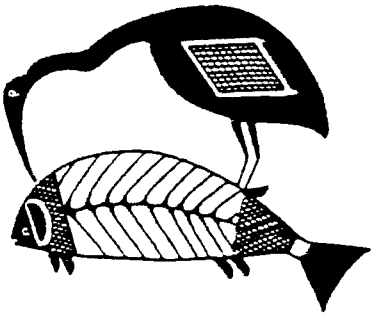
Other warm water operations rely on pumped groundwater or surface water and are located mainly in the southern, warmer part of the state. Irrigation water flowing in canals in desert regions of the state is especially suitable for warm water fish farming. The desert climate warms the water above 70 degrees. Warm water fish include tilapia, catfish, and large mouth bass.

Gila River Fishery located west of Gila Bend, near Hyder and Agua Caliente, is a warm water fish farm. The facility consists of a long, U-shaped raceway and nine ponds, each about an acre. Last year's output was about 300,000 lbs. of tilapia which was sold to retail outlets and restaurants, with some sold for stocking in the spring.

Water is pumped from geothermal springs. After its use on the fish farm, the water irrigates crops. The business is family owned and operated, with a full-time staff equivalency of between four to six.

Arizona fish farmers produce about 500,000 lbs of fish per year, primarily catfish, trout and tilapia. About 40 percent of the total is for stocking various facilities, with 60 percent sold as food or table fish. Tilapia and catfish mostly are sold for human consumption in the Tucson and Phoenix metropolitan areas. Fish farmers, however, also sell at the gate or from the back of a pickup. Much of the trout is sold for stocking.

Fish farming in Arizona mainly consists of family operations. As such, some people view fish farming as fitting within the celebrated agricultural tradition of the independently owned and operated family farm. No large corporative operations are established in the state yet, although future ventures are likely.



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Exact aquaculture employment figures for Arizona are not readily available. Obtaining such statistics is difficult because most fish farms are family operated, with some use of occasional labor. Estimates indicate there are about 45 full-time equivalency positions. Fish farming is not a labor intensive activity.

Arizona Conditions Favorable to Aquaculture

In some ways Arizona conditions are very favorable to aquaculture.

For example, its climate benefits fish farming, especially in the southern part of the state with its abundance of sunny days. Sunny days are growth days for fish. Further, in Arizona, fish do not have to be sheltered against severe weather conditions. In other states with a less favorable climate little or no growth occurs from two to four months out of the year. Fish also need to be sheltered in such states.

Fish farming advocates even interpret Arizona's aridity, the very condition that might seem to disfavor aquaculture, as a factor to justify its practice in the state. Water must be used wisely in the desert, and a wise water-use goal is using limited supplies more intensely and more productively. In other words, every drop must count.

And, if counting drops demonstrates careful water use, aquaculture, which encourages multiple uses of water, permits a double count. Aquaculture thus allows a limited water source to be used more productively. Recognizing this principle, several Mideastern nations, including Israel, Syria and Jordan, are involved in aquaculture.

Aquaculture encourages multiple use of water by sharing a water source with agriculture, to the benefit of both types of operations. In fact, its link with agriculture is a central characteristic of Arizona aquaculture. More than a convenient strategy, this arrangement also is necessary because Arizona is without large ponds, a feature of aquaculture prevalent in other, more temperate parts of the country.

Instead, much of Arizona's water flows through canals and ditches for use in irrigation. These canals and ditches also can serve as fish farms. In general, water used to irrigate plants will support fish production. Thus arises another feature of Arizona aquaculture that at first seems at odds with conditions in the state. Arizona has ample water that is suitably contained to support a fish farming industry.

Further, farmers already have various equipment for use in the field that also is needed for aquaculture; e.g., tractors, back hoes, welding equipment, pickup trucks, and cold storage. It then follows that the extensive agricultural industry in the state with its reliance on irrigation offers another advantage to aquacultural development.

The Agriculture-Aquaculture Connection

Aquaculture and agriculture therefore are closely linked in Arizona. They might be viewed as complementary activities, with fish farmers and crop farmers benefiting from each other's operations. What develops is a mutually advantageous, even symbiotic arrangement between aquaculture and agriculture. Each serves the other's needs.

As a result, aquaculture is not so much a relatively new and possibly up-and-coming activity in Arizona, but instead is a new component to agriculture. Instead of breaking new ground – or to use a more appropriate metaphor, creating a new ripple – aquaculture might be seen as a recent strand in the ongoing agricultural tradition.

For example, aquaculture needs water. Water is relatively scarce in Arizona and is too expensive to purchase and devote entirely to raising fish. Sharing water with a present user offers possibilities to manage costs. Agricultural operations are such that its water can also be used for fish farming.

Not only is agricultural water available but it is suitably contained for aquacultural use, its flow confined to ditches and canals. This admirably serves the purpose of the fish farmer who needs not just water, but water that is controlled and managed.

Adapting irrigation ditches to aquaculture might be as elementary as installing screens in the ditches. Or it may involve a more sophisticated system of diverting irrigation water through dedicated tanks or raceways before the water flows to crops.

Agriculture thus serves the needs of aquaculture, but the reverse also is true: fish farming benefits crop farming. For example, a farmer growing crops confronts steep water costs, a significant budget item. The farmer must pay for the water as well as the cost to pump the water to irrigate. With water costs greatly affecting agricultural profits, farmers would benefit from a strategy to share such costs.

Fish farming provides a likely strategy. Fish can be cultured in irrigation water to double up on water use. A crop farmer could learn the necessary aquacultural skills to grow fish as another cash crop or the farmer could lease facilities to someone who will do the actual fish farming. Either way the farmer will reap additional profits to help defer water costs. Fish farmers and crop farmers are natural water partners.

Agriculture stands to further benefit from fish farming. Farmers must fertilize their fields. Not only does this represent an expense, but the use of chemical fertilizers has been identified as a source of non-point source pollution. Chemical fertilizers contain nitrates that can leach into groundwater. Crop farmers are criticized for its excessive use.

Irrigation waters used for fish farming contain fish effluent rich in nutrients which can be used to fertilize, thus reducing the need for chemical fertilizers. Further, the crops in turn purify the water by removing and using the fish waste. Irrigation return flow is cleaner.

The organic matter within fish effluent especially benefits desert soils. Much of the nutrient in fish culture is bound in solids or other complex organic forms. Thus it is likely that nitrates within fish effluent do not migrate through the soil as rapidly as they do in chemical fertilizers. This lessens the chances of nitrates leaching into the groundwater.

Future of Arizona Fish Farming

Is fish farming an up-and-coming industry in Arizona? Aquacultural activities are presently at a modest level in the state, but is there potential for fish farming to expand? How far can it go as a viable Arizona industry? What form would a new and expanded Arizona fish farming industry take?

A major obstacle confronting all U.S. fish farmers is competition with imported aquaculture products. For example, imported South American tilapia undersells the U.S. grown species. This does not, however, exclude a domestic market for U.S. tilapia. A market exists for high-quality, fresh, chilled or live products grown close to a metropolitan center. The product's freshness and the reduced transportation cost are appealing.

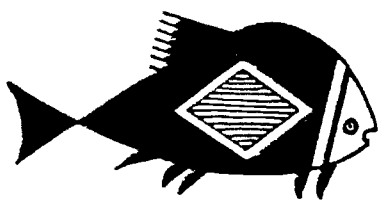
Such a market for farmed fish likely exists within Arizona. Hard data are difficult to come by, but estimates indicate that Arizonans consume about 15 or 16 million lbs. of whole and filleted, fresh and frozen fish per year. Arizona fish farmers produced about 500,000 pounds of fish last year. Even if this entire production were consumed by Arizonans, it only represents about three percent of total fish consumption within the state. About 99 percent of fish consumed in Arizona now is imported from out of state.

Arizona fish farming presently is directed at small, niche markets within the state. The niche or local market may be a group of restaurants in the Tucson or Phoenix areas. Some aquaculturists believe Arizona's fish farming future mainly will be confined to servicing such in-state niche markets.

Other people believe that in-state niche marketing is just a beginning strategy. They believe that Arizona aquaculture has the potential to eventually enter larger market areas, with the Southern California market the primary and most profitable objective. Not only do a great number of people reside in Southern California, but the area includes a large Asian

population. These factors ensure a large demand for live fish products.

The California Fish and Game Department, however, forbids the importation of live tilapia to protect state waterways from the species. Some people claim California's actions are politically motivated. They say California really is attempting to protect its own fish farmers by setting up a closed shop. They resent this action since the live tilapia market alone in California is estimated to be about two million lbs. per year.



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Some people foresee an eventual change in California's policy. A California market opened to Arizona fish farmers would greatly boost the industry here. For example, a California wholesaler might want as much as 4,000 lbs of finished fish product per week. At present this exceeds the total weekly production of all Arizona's warm water fish farms. A changed California policy would especially benefit Hyder Valley fish farmers because of their proximity to Southern California.

Plans are afoot to establish large-scale fish farms in Arizona. For example, the facilities of the Gila River Farms on the Gila River Indian Reservation include a dozen large ponds with a total surface area of 27 acres and containing 57 million gallons. Catfish, tilapia and hybrid striped bass are to be grown. Some people view the establishment of large-scale aquaculture operations as a sign that the industry in Arizona is maturing.

Constraints to Arizona Aquaculture

Certain constraints or obstacles exist to the development of aquaculture in the state. For example, Arizona fish farmers now have difficulty competing with fish farmers in other parts of the United States. For example, trout are raised in Idaho and Colorado at less cost than in Arizona. Some are sold in Arizona.

Raising fish is more costly in Arizona partly because aquaculture is a relatively new activity in the state. Not enough fish farmers are buying fish and feed to ensure low costs. Nor is centralized processing available to further reduce costs. Cooperative purchasing activities among present fish farmers is a strategy to save money. More fish farmers, however, are needed to ensure lower prices for aquaculture supplies and services.

The lack of managerial talent also is a factor limiting aquacultural development in Arizona. Many Arizona fish farmers enter the field from a background in cotton or cattle. This background does not automatically qualify them as aquaculturists. Farmers must learn fish farming using new methodologies and technologies. This can be a challenging endeavor.

Related to the above concern is the complaint that aquaculture at times attracts the wrong kind of interest, and that some individuals approach fish farming as an alternative profession. To such people fish farming is tending fish, a clean, idyllic, undemanding way of life promising quick profits. They tend to underestimate the amount of work required to raise fish, and their eventual failure discredits the industry and complicates business for the more committed.

Regulation of Aquaculture

The Arizona Department of Agriculture is chiefly responsible for regulating fish farming in the state. Initially the Arizona Game and Fish Department was in charge, but after lobbying efforts by state aquaculture interests, legislative action relocated aquaculture within Agriculture. Certain advantages accrued.

Aquaculture gained financially by moving to Agriculture. Fish farming then became an agri-business and eligible for certain financial benefits. For example, fish farmers now were entitled to lower agricultural water rates.

State officials also believed the change was warranted. It was believed that Agriculture was in a better position to enforce rules and regulations. Agriculture maintains border stations and assigns inspectors to cover dairy and chicken farms. These operations could readily be broadened to include fish farms.

Agriculture is involved in the day-to-day operations of aquaculture facilities including issuing licenses for various activities such as fish farming, transportation, processing and fee fishing. The rules and regulations the agency enforces range from those pertaining to recordkeeping to the health of the fish.

An important regulatory concern shared between Agriculture and Game and Fish has to do with the establishment of a new or exotic species in the state. State live wildlife rules include a listing of various restricted wildlife, including various species of fish. Fish on the restricted list cannot be possessed or imported into Arizona without a special license or an exemption from Game and Fish. Wildlife rules also include criteria for the issuance of a license or an exemption.

Restricted wildlife is "that wildlife

which has been determined by the commission to be an actual or potential or significant threat to indigenous wildlife by competition, disease or parasite, habitat degradation, predation, or impact on population management or an actual or potential significant threat to public safety by disease, physical threat, property damage, or nuisance."

The restrictive list doesn't necessarily ban outright a specie of fish, but requires a license or an exemption to better control its occurrence in the state. The white amur is a case in point. This species of fish eats aquatic vegetation and is useful for controlling vegetation growth in canals and waterways. The white amur, therefore, is a valuable fish to Arizona.

The white amur, however, is restricted in the state. Arizona Game and Fish is concerned that its escape could cause habitat destruction along the Colorado River. White amur are allowed in the state only if they are triploids or, in other words, sterile. This, in effect, prohibits Arizona fish farmers from breeding white amur because diploids, fertile fish, are needed to produce triploids. Only sterile white amur are allowed in the state.

The case of the red fish also demonstrates the regulatory workings. The profitable market for red fish prompted Arizona fish farmers to request permission to raise the species. Originally from the Gulf of Mexico, red fish favor estuaries or brackish waters and are raised in fish farms in Texas and Louisiana.

Game and Fish turned down the request. The agency's justification was that red fish raised in south-central Arizona could escape into the Gila River during a severe flood event. Such an event occurred last year. If released by a flood, the red fish could reach Yuma and then enter the Gulf of California. Game and Fish feared the environmental consequences if the red fish entered a new ocean setting.

Some people involved in Arizona aquaculture claim that the state's regulatory agencies are unduly conservative, and their list of approved fish overly restrictive. They say Arizona has approved fewer fish species for its aquaculture list than most other states. They see this situation as unfair since Arizona is mostly desert with little surface water to contaminate.

Game and Fish officials say they are looking at the broad environmental picture that is sometimes overlooked by individual fish farmers. They believe that, since 32 of the 36 native Arizona fishes are threatened or endangered, caution is justified to prevent further threats to native fish.

Arizona regulations pertaining to fish effluent are favorable to fish farmers. Aquaculture waste generally is classified either as an industrial or point source pollutant. In many states discharge of fish effluent, therefore, must meet various and often strict regulations.

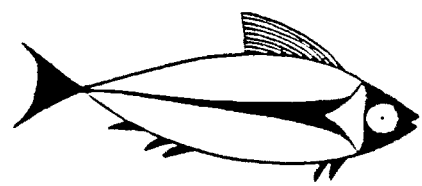
In Arizona, aquaculture interests worked with state regulatory agencies to simplify the permit process. The goal was to allow the use of aquaculture effluent for irrigation as an approved method of disposal. As a result, the Arizona Department of Environmental Quality included a new facility category for aquaculture requiring less information, with no monitoring requirements unless problems arise. Also, no application or permit fees were established.

Other Aquacultural Benefits

Aquaculture involves more than fish farms raising fish for eventual consumption, to be purchased in markets or restaurants or captured from stocked ponds. Aquaculture also involves other uses of cultured fish including maintenance of water quality in human-made lakes and channels.

For example, the Salt River Project and the Central Arizona Project use white amur in their canal systems to control moss and algae. This vegetative growth reduces flow rates and waste thousands of acre-feet of water every year. SRP is forced to expend considerable funds to combat the nuisance.

In 1989 SRP began a pilot program placing about 1,500 white amur in two of its canals. The project proved successful. As a result, SRP



Mimbres pottery design.

expanded its efforts and now has about 15,000 white amur in its system. With few exceptions, the fish seem to be performing well.

An advantage of using white amur to control vegetation is that the method is less expensive than other strategies. These voracious weed eaters consume three quarters of their body weight in algae each day. This reduces the need for expensive machinery as well as the use of chemical herbicides. The University of Arizona's Maricopa Agricultural Center (MAC) helped the Maricopa and Central Irrigation districts save a significant amount of money by using white amur to manage canal vegetation.

Since white amur is a restricted fish in Arizona and unable to be bred here, SRP obtains its supply from Arkansas. The fish shipped to Arizona are sterile, but SRP still is re-

quired to keep them in a controlled area, within grated canals to restrict their movement. Some golf courses also use white amur in their ponds.

Tilapia also have been used to control weed growth in canals. A warm water fish, tilapia do not survive the winter months when water temperatures get below 60 degrees Fahrenheit. With tilapia, sterilization and canal grating are not required. Studies are underway to identify other species of fish suitable to control vegetation in Arizona.

Although not strictly a fish farming issue, fish can be used as a bioassay to interpret water quality. They are sensitive to aspects of water quality not readily recorded by other testing methods. For example, when examining fish in Deer Valley MAC personnel found scar tissue on the gills. This indicated a presence of ammonia that was traced to a deficiency in a treatment facility. Also some toxins such as mercury accumulate in fish fat.

Fish species can be selected depending upon their sensitivity to various water quality factors. Some people suggest that bioassay be mandatory in areas of industrial development.

Promoting Arizona Aquaculture

Various University of Arizona programs are concerned with aquaculture. The UA's Environmental Research Lab is noted for its involvement in species selection and management for the aquaculture exhibit at the Disney World EPCOT facility. ERL also has surveyed species and systems for aquaculture potential in Arizona. A current research project is looking at tilapia nutrition.

The UA's College of Agriculture has several programs promoting aquaculture. The college's Maricopa Agriculture Center possibly is the most important source of fish farming information and services in the state. Combining aquaculture and irrigated agriculture, MAC likely is the largest integrated aquaculture farming operation in the world today. It attracts visitors world-wide.

The MAC aquaculture facility consists of four main reservoirs where various species of fish are studied for possible use in Arizona including pacu, tambaqui, koi, carp and amur. The center also provides fish farmers technological support and information. The center emphasizes the need to develop interest in aquaculture at the grassroots level.

The UA Agricultural Education Program conducts aquaculture in-service training for high school agriculture teachers in the state. Entitled "Intermediate Aquacultural Education," this year's in-service was conducted in Tucson the week of June 20. Ten teachers participated. Topics included water quality and testing, fish biology, aquaculture marketing, fish diseases and fish nutrition.

Arizona high schools increasingly are establishing aquaculture programs. About ten high school aquaculture programs currently are operating, at varied levels of complexity, with about another ten at the planning stage. A basic, entry-level program would be two 210-gallon tanks and a biofilter. More sophisticated programs have dedicated facilities and more tanks. The Safford High School program has 24 210-gallon tanks. High school aquaculture programs help ensure that trained personnel will be available to operate the state's future fish farms.

Chino Valley High School has the most advanced high school aquaculture program in the state. The school has a dedicated indoor facility with multiple tanks and an outdoor pond. This year the school raised 2,500 trout which were marketed during a "fish-off" on the pond. About 95 vocational agriculture students are involved in the program.

The Chino Valley aquaculture program, which began three years ago, attracts interdisciplinary interest. Chemistry students do water analysis to test for impurities in the water. Math students work on such problems as computing the volume of inflow needed to reduce water temperature in a tank. The wood technology program built needed redwood stands and steps.

The nonprofit Arizona Aquaculture Association is a professional society to promote fish farming in the state. Membership includes commercial fish growers, producers and university personnel. The association along with the UA College of Agriculture supports a free bimonthly newsletter, *Arid Lands Fish Production*. Present subscribers number 600 readers. To receive the newsletter contact: Wayne Collins, Editor, 1526 Supai, Chino Valley, AZ 86323; phone: 602-636-1324.

Conclusion

Many people envision a promising future for aquaculture in Arizona. This perception rests not so much on present activities, which admittedly are limited, but on the multiple water-use philosophy associated with fish farming in the state. A nonconsumptive sharer of irrigation water, aquaculture represents a strategy to help crop farmers pay their water bills.

At this point of time the possibilities of Arizona aquaculture are being explored. Much work needs to be done. For example, research is needed to identify new species suitable for culture within the state. Recognizing this need, some aquaculturists acknowledge at the same time that identifying new species will not ensure that the public will buy them. Consumers are wary of products they are not familiar with. This brings up another aquaculture need.

Market research is needed to interpret the potential fish market within the state. What kind of fish do people buy and how much of it? How much are people willing to pay for fish? What proportion is purchased fresh, frozen, and canned? What variables affect the purchase of fish products? Such information is needed to plan fish farming activities in the state. The availability of such information also will help plan a market strategy, another necessity.

Other needs include more lenient terms from lending institutions. Money is not readily available now to support aquaculture. More educational opportunities for persons now engaged in fish farming also are important.

Working out the above matters will help define aquaculture in Arizona, its characteristics and potential.

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