

Mariculture: A Developing Industry



The terms mariculture and aquaculture are often used interchangeably, but they actually have different meanings. Aquaculture is a general term that refers to production of plants or animals in water in which the producer controls a minimum of one life stage. Mariculture, more specifically, refers to production of plants and animals in water where the producer controls a minimum of one life stage in saltwater and uses organisms commonly found in the oceans and estuaries. Both terms imply ownership of the product. The term aquaculture sometimes refers to both freshwater and saltwater production while the term mariculture is only used in relation to saltwater production.

Organisms can be cultured in large, earthen ponds measuring many acres or in small holding units of less than a few gallons. Salinity in mariculture operations can range from as little as 3 parts per thousand to full-strength seawater at 35 parts per thousand or higher. In many cases, mariculture species have more complicated life histories including salinity requirements that vary with different life stages.

Culture operations in mariculture can be extensive, semi-intensive, or intensive, representing a respective increase in control over the culture by the producer.

Methods of Culture

Extensive aquaculture involves little or no input from the producer and relies on natural production in a water body. Producers trap, hold, and harvest a final crop. Some examples include capturing juvenile fish and holding them at low densities in net enclosures until they are harvested at a marketable size. The water quality and nutrient input depend on the nature of the area of the enclosure. With this practice, yields can range from 500 to 1,000 kilograms per hectare per year.

Semi-intensive aquaculture may involve a pond that is fertilized before stocking to boost the natural nutrients essential for food production. Juvenile fish are added at moderate stocking densities and remain until harvest time with no additional input from the producer. This form of aquaculture can generate better yields than extensive aquaculture, ranging from 1,000 to 2,000 kilograms per hectare per year.

Intensive aquaculture relies on constant input by the producer, including feed, fertilizer, and water quality manipulation. Densely stocked recirculating systems are good examples of intensive culture. This type of aquaculture generates as much as 5,000 kilograms per hectare per year.

Economics

The 1998 agriculture census conducted by the U.S. Department of Agriculture reported 815 mariculture farms (64,179 acres) and 478 leased sites (28,471 acres) in the United States. Problems facing both mariculture and aquaculture operations include water quality factors, such as temperature, oxygen, ammonia, and nitrite levels, as well as bacterial, viral, and parasitic diseases. Mariculture operations must be able to maintain salinity levels and adapt to the changing needs of the culture animals. Disease-free seawater can be made with sea salt, but it is often expensive. Raw seawater can be expensive given the typically high value of waterfront property. Raw seawater can introduce diseases and competitors that can devastate culture organisms.

Offshore mariculture is growing in popularity in the United States. Cage operations are found in the Atlantic, Caribbean, and Pacific oceans. Investigations into the feasibility of mariculture in the Gulf of Mexico are ongoing. Private firms interested in leasing sections of the Gulf of Mexico for the purpose of offshore mariculture have applied for permits. Laws pertaining to offshore mariculture permits are not clear-cut. Permitting institutions including the Corps of Engineers, the National Marine Fisheries Service, the National Oceanic and Atmospheric Administration, the U.S. Coast Guard, state Marine Resources Divisions (state waters), and the Gulf of Mexico Fishery Management Council have all been involved in permit request reviews. Efforts are currently under way to streamline the procedure for acquiring leases of seafloor in federal waters for the purpose of mariculture operations.

Given the high start-up costs, most successful mariculture operations target high-value fish, such as ornamental fish, as well as food fish, such as cobia (ling), red snapper, eels, and various drum species. Shellfish mariculture has a broader product range including clams, oysters, shrimp, scallops, and crabs. Algae are often produced with finfish or shellfish to provide a food source for the primary product.

A major cause of failure in any aquaculture or mariculture operation is poor marketing. In mariculture, farmers are competing with wild-caught commercial species. This can be beneficial, given wild stocks are declining and seasonal availability can produce supply shortages that a producer can fill if he or she can

Table 1. Common Mariculture Species

Common name	Scientific name	Advantages	Disadvantages	Optimal salinity range (ppt)
Cobia	<i>Rachycentron canadum</i>	Rapid growth	Unknown cold tolerance	Wide range
Red drum	<i>Sciaenops ocellatus</i>	Popular food fish	Poor cold tolerance	20 to 30
Red snapper	<i>Lutjanus campechanus</i>	Popular food fish	Poor larval survival	Wide range
Southern flounder	<i>Paralichthys lethostigma</i>	Popular food fish	Poor larval survival	12 to 20
Oyster	<i>Crassostrea virginica</i>	Popular food	High culture maintenance	16 to 26
Clown fish	<i>Pomacentridae</i>	Popular ornamental	High culture maintenance	25 to 29
Fire shrimp	<i>Lysmata debelius</i>	Popular ornamental	High culture maintenance	30.5 to 33.2
Blue crab	<i>Callinectes sapidus</i>	Popular food	Cannibalistic	Wide range

arrange harvests for the times of shortages. However, if wild catches are plentiful, the producer may not be able to sell the product at a price that covers costs.

Common Species

Global commercial landings in 2001 fell 3 million metric tons while aquaculture and mariculture increased by a combined 2.4 million metric tons. U.S. landings were 95 million pounds lower in 2002 (9.4 billion pounds) than they were in 2001. Per capita consumption of seafood in 2002 was 15.6 pounds, up 0.9 pounds from 2001.

These data indicate that wild catches are falling and demand is increasing for seafood. This shortfall provides mariculturists an opportunity to produce seafood at a profit. Domestic producers will be competing with both wild catch and foreign producers. U.S. producers have limited access to therapeutic remedies that may be used in other countries. However, animals that are documented to be free from exposure to chemicals, such as chloramphenicol, may be more marketable in the United States compared to their foreign counterparts. To overcome the minimal number of therapeutic remedies, U.S. mariculturists must produce a superior product through better farm management that minimizes the chance for disease outbreaks.

**Table 2.** Top 10 Products Consumed Per Capita in 2002

Rank	Product	Per capita consumption (pounds)
1	Shrimp	3.7
2	Canned Tuna	3.1
3	Salmon	2.021
4	Pollock	1.13
5	Catfish	1.103
6	Cod	0.658
7	Crabs	0.568
8	Clams	0.545
9	Tilapia	0.401
10	Flatfish	0.317

Oysters

Oysters are extremely popular on the Gulf Coast as raw and cooked seafood. Seasonal rains and other water quality parameters govern the open or closed condition of commercial reefs. Farm-raised oysters may be able to avoid the problems of pollution that close wild beds. Single oysters can be farmed, providing a more desirable product to the half-shell market. Several culture methods for oysters are implemented around the world. These include the adjustable long-line system, mesh bags or cages, and plastic trays. Each focuses on maintaining high densities of oysters in a small, easily accessible unit. The containers provide some protection from predators, such as crabs and drills, and provide significant washing by wave action. This washing is necessary to provide oysters with food and to remove waste. Each requires some maintenance to reduce fouling and to maintain maximum flushing. The systems differ in the degree of labor required for cleaning and harvesting as well as the cost. Locations

will sometimes dictate which of the many options are appropriate. For example, the adjustable long-line system works well in shallow water while a rack system employing mesh bags is better suited for deeper water.

Shrimp

Shrimp is the most commonly consumed seafood item because of its many cooking options. The 1998 USDA agriculture census reported 42 U.S. farms produced \$12 million (4.217 million pounds) of farmed shrimp. Shrimp are also farmed in Central America and Asia. Domestic producers compete with these and commercial catches. Producing a superior product and developing brand recognition may be the only competitive options for domestic producers. Some development of low salinity shrimp culture has occurred inland. Producers in West Alabama have shown some success in growing shrimp in ponds. Water for these shrimp has very low salinity but contains trace elements vital to the growth and survival of the shrimp. The source of this water is ancient saltwater aquifers in the area.

Bait and ornamental shrimp are included in shrimp mariculture. Live bait shrimp production has the potential to deliver higher quality animals to bait shops. These animals may live longer since they have been handled more carefully than their wild counterparts. Harvests are more predictable and can be arranged to fit the demand schedules of bait shop owners.

Finfish

Finfish mariculture is also an important segment of this growing industry. Wild catches of popular food fishes are leveling or declining worldwide. Demand for these foodstuffs is increasing, leaving mariculture to fill the gaps. Among the finfish produced are cobia (ling), salmon, red drum, red snapper, and southern flounder. These animals represent high-dollar species, which are necessary to offset the costs of production. U.S. producers have to face rising feed and fuel costs as well as an increasingly complicated series of environmental regulations. To compete with substitute goods, such as beef, pork, and chicken, as well as foreign products not subject to the same quality controls, domestic producers must bring a superior product to the market. Many of the operations involve large cages located just offshore. These culture units use natural currents to provide high-quality water and remove wastes, allowing high densities to be stocked.

Catch limits, laws against possessing undersized animals, and confusion among permitting authorities have slowed progress in this segment of mariculture. This method of culture is occurring worldwide, particularly in the Mediterranean region. Alternatives to offshore culture include low-salinity, inshore operations. Some animals including cobia and red drum can be acclimated to low salinity. Research is under way to determine the potential of culturing these and other marine species inland.

Soft-Shelled Crabs

Soft-shelled crabs are a delicacy, drawing a higher market value than their hard-shelled counterparts. Most operations derive their peeler crabs from commercial crabbing efforts and hold them for a short time for molting. Though not a true mariculture in terms of feeding and growth, these operations are good examples of value adding.

Cannibalism is an obstacle that must be overcome in soft-shelled crab operations. Soft crabs are defenseless against hard crabs and are often eaten before the farmer can harvest them. Shedding tables are commonly used with dividers to separate crabs for molting. Timing is crucial in this production setup. To generate the most valuable product, crabs must be allowed to molt and reabsorb water but not begin hardening. Typically, crabs shed seasonally and at night, making long hours for the farmer. Low calcium and water draw down systems may provide additional control over the molting process.

Ornamental Fish

Not all mariculture is the production of food fish or shellfish. The aquarium trade is a lucrative segment of the mariculture industry with 2003 imports of ornamentals projected to exceed \$40 million. Marine ornamental fishes found in aquaria include clown fish and tangs. Ornamental shrimp are also cultured for the aquaria trade. Beautiful specimens, such as the fire shrimp, have been produced for hobbyists. The demand for ornamentals depends on the health of the economy. Consumers buy them for entertainment, not food. When global economies are soft during recessions, ornamental production declines since people do not have as much disposable income to spend on non-necessities. As economies recover, consumers are more willing to spend money on luxury items such as aquaria fish.

Bait

Bait production is potentially a viable mariculture industry. Shrimp, crabs, and small finfish, such as bull minnows, are among the products grown for the bait industry. Bait producers can deliver predictably to the market, and their products are usually hardier. Problems that can occur in baitfish mariculture, including disease and predation, are similar to those in food fish production.

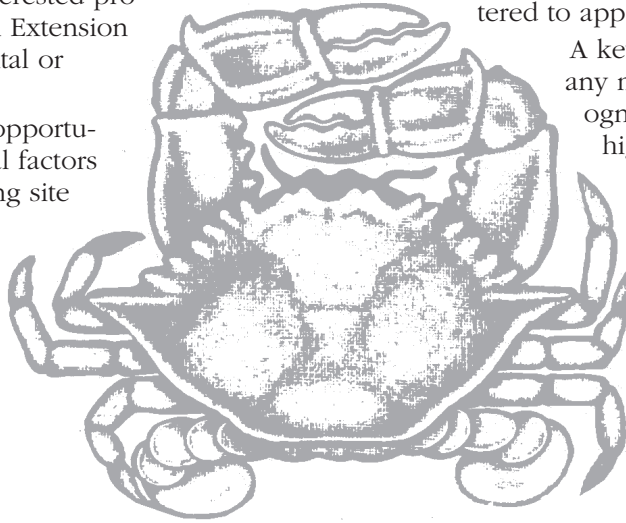
The Future

Opportunities exist for expanded mariculture operations in the United States. The permitting process is complex and should be addressed early in the development phase of a mariculture operation. It can be a daunting procedure and an interested producer should seek advice from Extension personnel or from environmental or regulatory agencies.

While offshore mariculture opportunities are expanding, additional factors need to be considered including site selection, storm loss, harvesting regulations, and the environmental impact of water quality and escapement.

Interested producers will be competing with other mariculture operations, both domestic and abroad, as well as with wild catch. As a result, niche markets, if available, could provide a producer an entry to the market. Other avenues of entry include value adding where an existing product is improved or altered to appeal to a consumer base.

A key to the successful marketing of any mariculture product is brand recognition. A brand associated with a high-quality, consistently available product will be at a competitive advantage to those products of lesser quality. Potential producers should complete their marketing homework early.



ANR-1251

MASGP-04-003

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This publication was supported by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA Grant #16RG2258, the Mississippi-Alabama Sea Grant. The views expressed herein do not necessarily reflect the views of any of those agencies.

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2.5M, **New May 2004**, ANR-1251