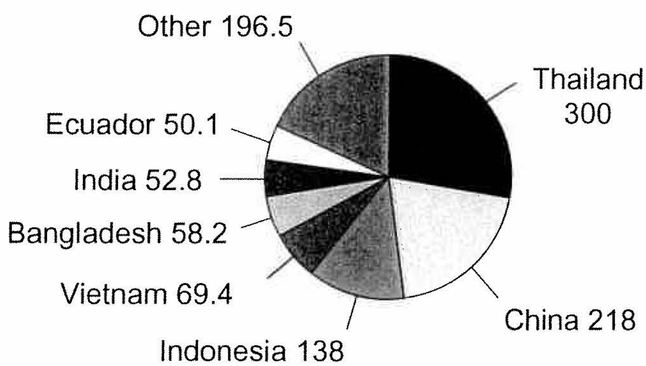
Shrimp *Penaeus monodon* and *P. vannamei*

Production	
Area Under Cultivation	1.8 million ha
Global Production	1.1 million MT
Average Productivity	611 kg/ha
International Trade	
Share of World Production	91%
Share of Exports (with wild caught)	45%
Exports	1 million MT
Average Price	$6,334 per MT
Value	$6,334 million
Principal Producing Countries (by weight)	Thailand, China, Indonesia, Vietnam, Bangladesh, India, Ecuador
Principal Exporting Countries	Thailand, China, Indonesia, Vietnam, Bangladesh, India, Ecuador
Principal Importing Countries/Blocs	United States, European Union, Japan
Major Environmental Impacts	Destruction of coastal wetlands and mangroves Introduction of species into new areas Water pollution in coastal areas Depletion of fish stocks used for feed
Potential to Improve	Good Prices are high enough to cover BMP costs Better practices are being identified Declining prices encourage greater efficiency

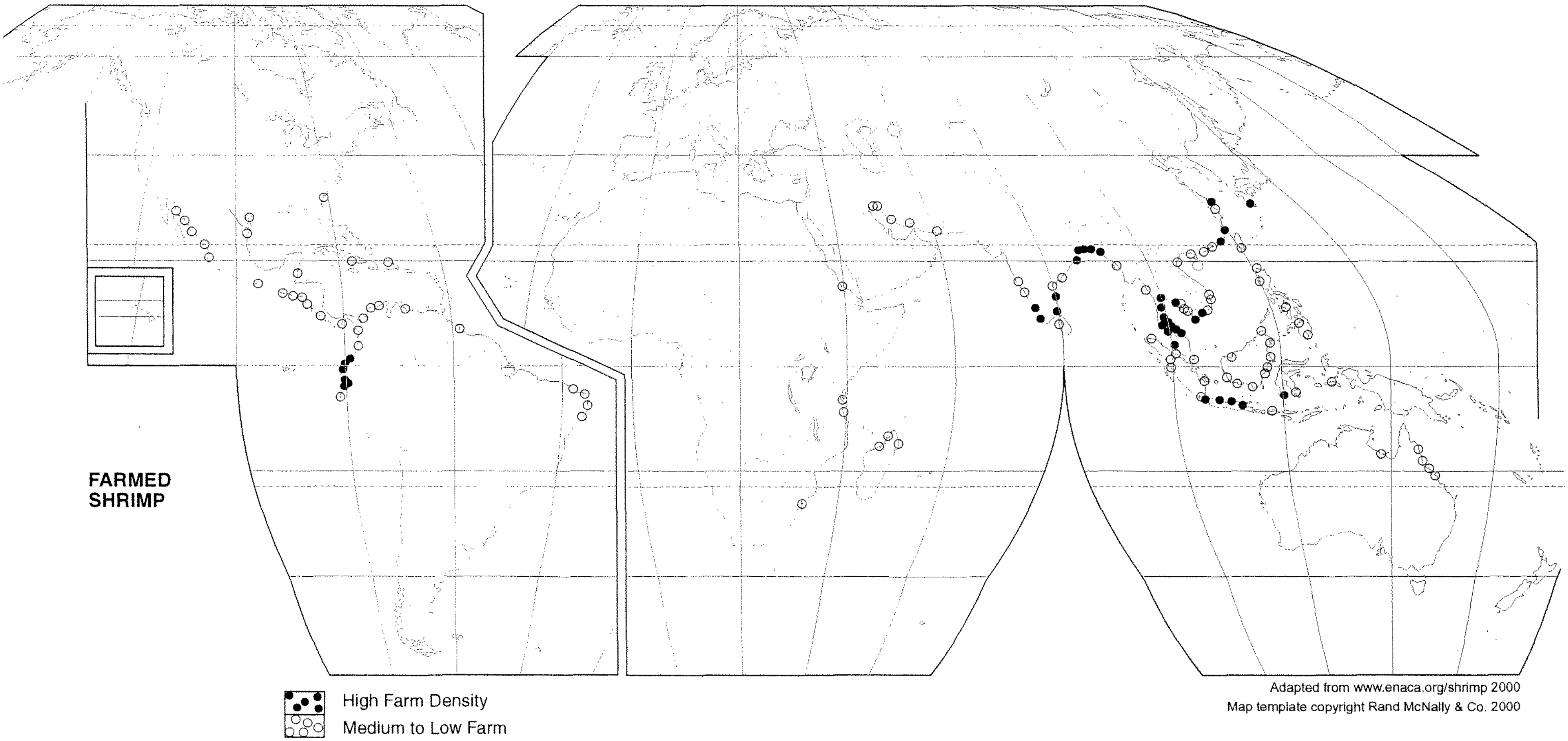
Source: FAO 2002. All data for 2000.

Shrimp

Total Production (MMT)



FARMED SHRIMP



Adapted from www.enaca.org/shrimp 2000

Chapter 22

Shrimp

Overview

Aquaculture is the fastest-growing form of food production in the world. Carp and mollusks, produced mostly in China and to a lesser extent in India, dominate aquaculture production by volume and area of land used. But shrimp dominate aquaculture production by value. Consequently, shrimp aquaculture is one of the fastest-growing forms of aquaculture. From 1982 to 1992 shrimp production increased nine fold (FAO 2002). In spite of dramatic increases in production, the price of shrimp did not decline over the same period. Demand has more than kept pace with increased supply. In fact, one of the major factors contributing to unsustainable production practices, at least until recently, is that farmers have simply made too much money doing shrimp aquaculture the wrong way for anyone to be able to convince them to change. There is evidence, however, that this situation is changing.

The shrimp aquaculture industry can cause considerable damage to fragile coastal wetlands. The types of habitat that have been affected include mangroves, salt flats, mudflats, estuaries, tidal basins, and coastal marshes. While few of these areas appear to be hot spots of biodiversity, they are nonetheless essential hunting, nesting, breeding, and migratory homes to many fish, invertebrates, migratory birds, and other species. Furthermore, these coastal areas are extremely important for regulating the ecological interactions between land and water. They buffer the impact of storms and high tides on land, and they trap sediments and other organic matter on land, preventing it from choking aquatic life near the shore or deeper in the oceans. Shrimp aquaculture has often changed fundamentally the hydrology that is the basis of these ecosystem functions.

Producing Countries

The most reliable estimates of the amount of land used for shrimp aquaculture indicate that the overall area in production at any given time is about 1.8 million hectares, and that at any one time another 300,000 to 400,000 hectares of ponds are either idle or temporarily abandoned (World Bank et al. 2002). The countries with the most land devoted to shrimp aquaculture, in descending order, are Vietnam, Indonesia, China, Bangladesh, Ecuador, Thailand, the Philippines, Mexico, Honduras, Brazil, and Colombia (Rosenberry 2000; 2003).

The top producers by weight are Thailand, China, Indonesia, Vietnam, Bangladesh, India, and Ecuador. Other countries that produce large amounts of shrimp from aquaculture include the Philippines, Mexico, Brazil, Malaysia, Colombia, Honduras, Venezuela, Taiwan, Sri Lanka, and Nicaragua. There are several tropical countries where shrimp aquaculture is being practiced on a small scale but has the potential to expand. The most rapid expansion of shrimp aquaculture, however, is occurring in countries that are already significant producers, e.g. China, Indonesia, Mexico, and Brazil.

Consuming Countries

At this time, 75 percent of the shrimp produced in the world comes from trawling; the remainder comes from aquaculture. However, because so much of the trawled product is consumed locally, shrimp aquaculture accounts for almost half of all internationally traded shrimp. Shrimp is the most valuable traded fish product in the world today. By value, it accounts for nearly half of all seafood imports to the United States (Johnson and Associates 2002).

The main consuming countries of shrimp produced from aquaculture are the United States, the countries of the European Union, and Japan. These constitute the final markets for more than 90 percent of shrimp produced from aquaculture. Only in Japan has per-capita shrimp consumption been declining for the past decade.

Shrimp is a highly differentiated product. There are more than seventy classifications of shrimp in the United States alone based on size and degree of processing. The European Union and Japan have similar classifications. Even so, most shrimp is classified only by size or processing. There is rarely any reference to species, country of origin, or whether the shrimp was produced in a pond or caught in the ocean.

Production Systems

Globally, the number of shrimp producers has been estimated at some 400,000 (World Bank et al. 2002). These range from individual small-scale producers, to cooperatively held operations, to operations owned by corporations.

There are three main shrimp aquaculture production systems, characterized by the intensity of their resource use—extensive, semi-intensive, and intensive. In general these different intensities of production are classified according to the density of shrimp stocked in the ponds as well as the nature and type of feed used, the rate of water exchange, and whether aeration is used to increase the oxygen levels of the water.

Extensive Production

So-called extensive systems of aquaculture raise fewer than five shrimp for each cubic meter of pond water. Extensive producers tend to be characterized by their reliance on cheap land and labor, naturally occurring seed stock and feeds, and the tidal exchange of water. Individuals or families set up their operations with few inputs and little technical know-how. They construct impoundments or large ponds, of up to 100 hectares, in coastal areas where land is inexpensive. The most primitive forms of containment for extensive aquaculture consist of constructed "plugs" or dams in natural watercourses or channels that create pools or ponds.

Extensive ponds are stocked with post larvae (PL, or juvenile shrimp) either caught in nearby estuaries or brought into ponds on the incoming tides and trapped. In these systems, shrimp eat the feed that grows in the pond. Shrimp are harvested by draining the pond and catching the shrimp as they pass through the break in the dam. Diseases are rare due to the low density at which animals are stocked in the ponds.

Because these production systems are built in tidal areas and because they are extensive relative to their yields, they contribute to considerable habitat conversion relative to the income they generate in coastal areas. Yet, because no feed is added to the system and there is little water exchange, very few effluents are put into the environment. Extensive farmers do not use chemicals or medicines of any kind. Production is less than 1,000 kilograms per hectare per year in extensive operations. Often production reaches only a few hundred kilograms per hectare.

Semi-Intensive Production

Semi-intensive shrimp aquaculture involves stocking densities beyond those that the natural environment can sustain without additional inputs. Most of these operations stock at densities of 2.5 to 20 animals per cubic meter. Semi-intensive systems depend on a regular supply of larvae, and more control over the water. Ponds with regular shapes and depth are constructed with levees or dikes and are much easier to harvest.

Semi-intensive production systems require more capital for construction, labor, maintenance, larvae, feed, and energy for pumping water. As the shrimp grow, supplemental feeding is required. Because the shrimp are stocked at higher densities, the risks from disease are higher than in extensive systems.

There are different environmental risks associated with this production system. Habitat conversion, for example, is less than with extensive systems. Other potential environmental impacts include production of nutrient-rich effluents, the use of chemicals and medicines, and increased water use. Production in semi-extensive systems can average from 1,000 to 2,000 kilograms per hectare per year (Clay 1996; World Bank et al. 2002).

Intensive Production

Intensive operations are stocked with densities that exceed 20 animals per cubic meter and sometimes reach as much as 150 animals per cubic meter. Intensive ponds are usually much smaller (.01 to 5 hectares) and require far more inputs to maintain a healthy environment for the shrimp.

In intensive operations shrimp must be fed the entire time they are in the ponds. Because so many nutrients are being brought into the system, the water has to be aerated in order to keep the oxygen levels high enough for the shrimp to survive. In the most intensive operations production can exceed 22,000 kilograms per hectare per crop, with 2.4 crops per year (World Bank et al. 2002).

In intensive production systems there is little room for management error; the systems can crash in a matter of hours. Diseases have been a major problem with intensive shrimp aquaculture. Production averages from 3,000 kilograms per hectare per year to more than 50,000 kilograms per hectare per year depending on stocking densities, the length of time to harvest, survival rates, and the number of crops per year.

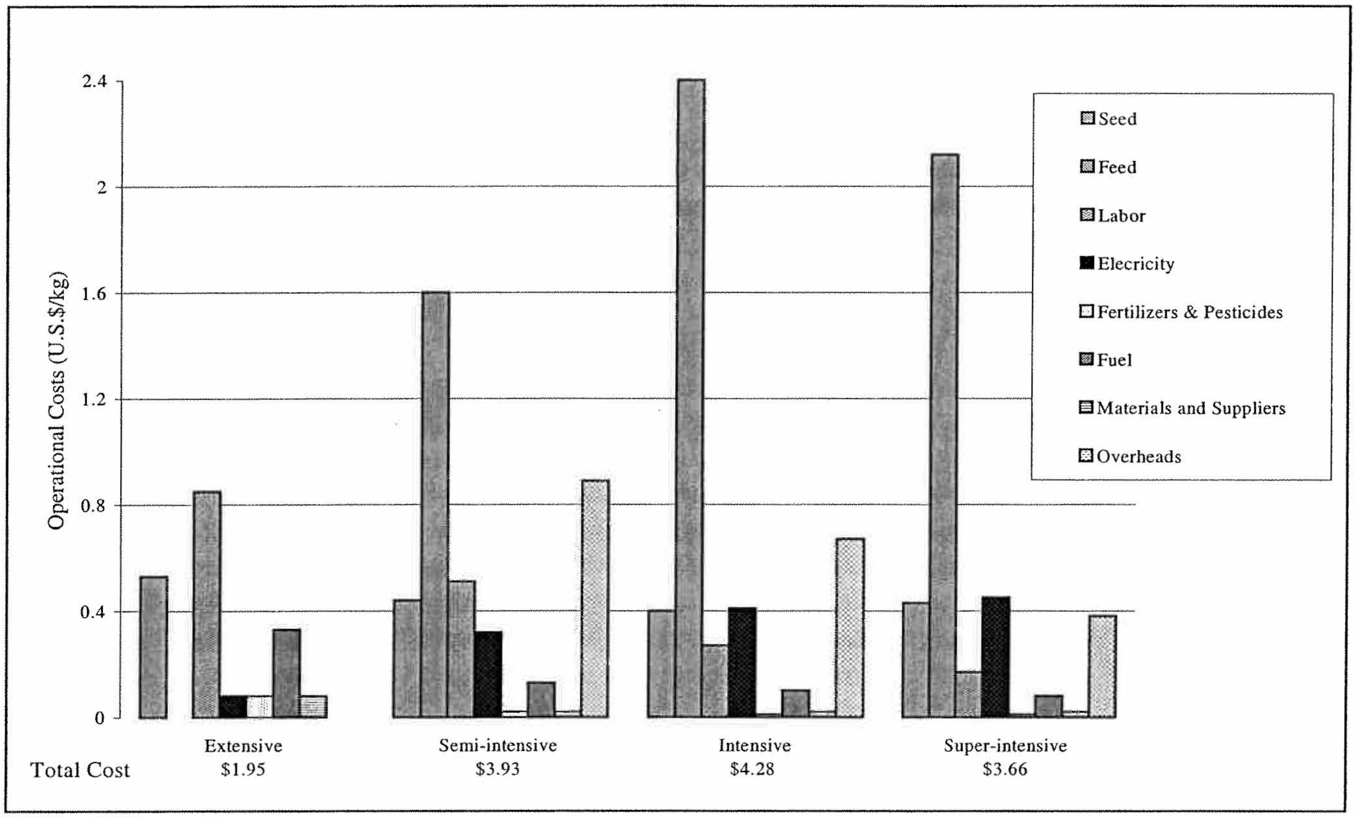
For the semi-intensive and intensive systems of production, pond construction costs range from $10,000 to $50,000 or more per hectare. Even in extensive production where family labor is often used to build ponds, the investment is considerable. For this reason there is a financial incentive for the operations to last as long as possible. This is perhaps the most important incentive for shrimp farmers to adopt better practices regardless of the scale or intensity of their production.

The single most intensive shrimp operation today is run by a company in Belize, but on average, Thailand has the most intensive shrimp aquaculture countrywide. Other Asian countries often have a mix of extensive aquaculture practiced by undercapitalized producers and intensive aquaculture practiced by larger, better-financed operations. Semi-intensive production dominates Latin America. There are, of course, exceptions to these generalizations.

Virtually no domestication has taken place for any of the species produced in aquaculture systems. About two percent or less (the proportion is declining) of all producers depend on wild caught post-larvae (PL) to stock their ponds (World Bank et al. 2002). This is most common in Bangladesh, India, and Ecuador where hatcheries are not required by law. Globally, some 98 percent or more of all post-larvae used by the industry are produced in hatcheries. The vast majority of hatcheries still depend on the capture of wild brood stock. Breeding programs are just beginning. For the first time, brood stock are being hatched and raised in captivity. This provides an opportunity for selective breeding for specific characteristics that will improve the overall performance of the different shrimp species when produced by aquacultural methods (World Bank et al. 2002).

Figure 22.1 compares the operational costs of four different intensity shrimp aquaculture production systems—extensive, semi-intensive, intensive, and super-intensive. While the extensive system has the lowest costs (labor and seed being the two largest costs), it is also the least productive. For the other three systems, the most expensive single input is feed which represents from 40 to 60 percent of all costs. For these systems, profits will depend on the ability of producers to reduce or use more efficiently the various inputs.

Figure 22.1 Comparison of Operational Costs of Four Types of Shrimp Aquaculture Production Systems



Processing

Most of the larger shrimp producers (e.g. those with 300 hectares or more of semi-intensive operations, or their equivalent in intensive production) have their own on-farm processing facilities. Smaller producers sell their production to nearby processing plants. Globally there are probably thousands of processing companies, but the market is dominated by no more than one hundred. The value of the production from processing is about $7–8 billion depending on the amount of value added to the product (World Bank et al. 2002).

The most important issue that arises from shrimp processing is the creation of waste. More than 40 percent of the weight of shrimp, including the heads, is waste. Removing the heads creates a disposal problem. This material can be ground up and used for fish meal or animal feed. The shells can also be used for other processed items. Unfortunately, in many processing plants most of the heads and other waste material are dumped into nearby water bodies. This can spread disease and cause nutrient loading and biological oxygen demand (BOD) problems.

Increasingly, shrimp are shipped frozen with heads on and are then processed in other countries under Hazard Analysis and Critical Control Point (HACCP)-approved conditions. It has been proven, however, that frozen shrimp can also carry diseases. This is of particular concern when frozen shrimp act as vectors to bring diseases into new regions (e.g. from Asia into the Americas or vice versa). While no one has documented the impacts of such disease transmission, there is some concern that white spot (a common disease in Asia) was brought to the Americas, where it has caused billions of dollars of damage in the past two years (World Bank et al. 2002).

When shrimp are first harvested, they are soaked in metabisulfite, an antioxidant, to increase their shelf life and reduce the activity of oxygen on the shrimp's body or shells. This chemical is used because it helps to prevent spots from developing, and any spots reduce the value of shrimp. After soaking, the chemical is dumped and readily finds its way into natural water systems. Its impact has not been studied. However, since the chemical is used to retard bacterial growth, it is presumed to have some impact in natural ecosystems.

Substitutes

The main substitute for shrimp produced from aquaculture are shrimp that are caught in the wild. At this time, the largest shrimp cannot be produced in aquaculture systems; they can only be captured from the wild. Smaller sizes do tend to be substituted for each other, but aquaculture shrimp are generally cheaper to produce and therefore cause tighter profit margins for the wild-caught shrimp rather than the other way around.

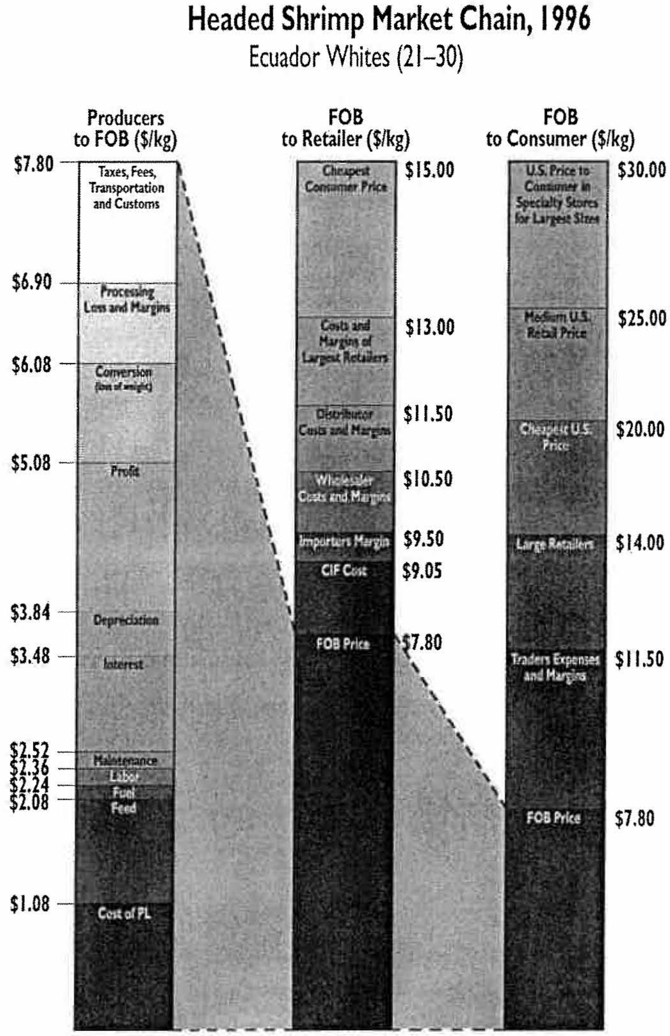
Other seafood items are perhaps also functional substitutes for shrimp. Few wild-caught fish, however, are available year-round, as consistently cheap, as sought out by consumers, or as available in many different sizes. All of these factors make shrimp ideal for direct purchase by consumers or for purchase by larger institutions and restaurants. In effect, shrimp has become the most commonly consumed fresh or frozen seafood in the United States, Europe, and Japan because it can be favorably substituted for so many other sea foods.

Market Chain

Figure 22.2 shows the market chain for Ecuadorian shrimp of one size as they move from the producer to the consumer. The size and species have some impact on the value in the market chain for shrimp, but this chart gives a good indication of how and where value is added as shrimp move through the system.

What the chart does not indicate is the number of players involved at each stage of the operation. There are some 400,000 shrimp aquaculture producers. While there have been a few attempts by corporations to build central facilities and work with many small producers, this is not the norm. Most producers are independent. In countries where financial crises have occurred (e.g. Indonesia, Thailand), input suppliers have extended their goods as a form of credit and producers are then required to sell to certain buyers and/or processors. In general, however, direct involvement in production is seen as too risky by most of the feed, seed, or processing companies. They want access to the product, but they do not want to produce it themselves.

Figure 22.2



There are probably 1 to 1.5 million people employed directly by the industry. Most research shows that they tend to be paid double, or more than double, the going rate for labor in their areas. Consequently, the turnover rate for labor is relatively low. Another million people depend on the industry for a major portion of their livelihood through the capture of broodstock and wild shrimp post-larvae, the latter of which are used to stock 2 percent of all the shrimp aquaculture operations in the world. Employment for these people is seasonal and earnings are much lower. This work tends to be dominated by women and children and is most common in Bangladesh, India, and Ecuador, where there is no law requiring shrimp hatcheries in order to protect local fisheries during post larvae collection (World Bank et al. 2002).

In general, the overall employment multiplier effect (i.e. how many jobs are created in the economy as a whole for each job in the shrimp industry itself) of the industry is probably five or six, particularly if employment in input and processing industries is included. This would mean a rough estimate of some 5 to 9 million jobs. Since the industry is only twenty-five years old, and much less in some countries, good data do not yet exist on this topic.

The number of people involved declines through the processing and export/import activities and then begins to increase again through distributors, retail outlets, and restaurants before reaching the end consumer. For example, there are probably a few thousand shrimp processors in the world. Many of these also process wild-caught shrimp. There are hundreds of exporters and probably hundreds of importers. Some are much larger than others, however. Ocean Garden Products, for example, is estimated to import 25 percent of all shrimp into the United States (Johnson and Associates 2002). Often one or two companies will dominate imports and distribution, even though there may be a number of other smaller companies as well. There are more distributors than there are importers, and more retailers than wholesalers. Globally there are probably thousands of distributors, tens of thousands of wholesalers, and millions of retailers who sell shrimp produced by aquaculture. There are far more retailers and restaurants, for example, than there are shrimp producers.

Relatively little shrimp is purchased and prepared directly by the consumer in the main consuming countries. In general, the main buyers of shrimp in the United States, Europe, and Japan are institutions (e.g. restaurants, educational institutions, government facilities, the military, etc.). They purchase some 70 percent or more of all shrimp sold in these markets. In the United States, Darden (owner of the Red Lobster and Olive Garden restaurant chains) purchases half of all shrimp used by the top ten restaurant chains. SYSCO, a large food distribution company, reportedly buys half of all the shrimp distributed in the United States. These institutional buyers and distributors are important because only one or two individual purchasers for each make the decisions about which shrimp will be purchased for millions of consumers who subsequently eat in restaurants. Diners are not given the choice of which kind of shrimp produced in which way they would like in their meal. Strategically, then, this is the most efficient place to address consumer issues (Clay 1996; Johnson and Associates 2002; David and Lucile Packard Foundation 2001).

Market Trends

The main market trends in shrimp production are increased production, increased demand, and increased interest in product quality. To date, even though there has been a constantly increasing supply of shrimp from aquaculture and wild-caught sources, there has been no overall decline in price. While prices have varied somewhat over time, there is no identifiable trend. Until recently, shrimp prices have remained relatively stable (Rosenberry 2003).

However, as shrimp producers adopt better practices, production will both expand and become more stable, and this is likely to cause shrimp prices to decline eventually. This will be an important counter trend to the likely increase in the price of wild-caught shrimp as supplies become over-exploited or as costs increase. If anything, this will tend to push demand for aquaculture shrimp even further.

Since September 11, 2001, shrimp prices have declined. Although it is unclear if this is a short-term fluctuation or the beginning of a trend, it has led to speculation (e.g. purchasing and holding the product, waiting for the price to rise), which has caused prices to decline even further and stockpiles to increase. This will affect markets at least through 2004, but most analysts do not believe that the markets will ever recover fully.

Another trend of note is the increasing concerns regarding chemical residues found in shrimp. Shrimp from China and Vietnam have been confiscated and destroyed in the European Union due to the discovery of chloramphenical, an antibiotic. As a consequence, shrimp shipments are under increasing scrutiny in the European Union as well as Japan and the United States and for a wider range of contaminants (including PCBs, dioxins, and the antimicrobial drug furazolidone).

Environmental Impacts of Production

As with any production system, there are hundreds if not thousands of environmental impacts from shrimp aquaculture. However, there are six to ten key environmental impacts from shrimp aquaculture worldwide, with only three to five being significant on any given farm. The extent of the impacts depends on the intensity and scale of production, the laws of the specific country, and when and where the ponds were built. The most important impacts are discussed below.

Siting and Coastal Habitats

There is good evidence that as much as 90 percent of all of the environmental problems from shrimp aquaculture arise from where the ponds are built (Boyd and Clay 1998). The impacts include the loss of habitat, interference with ecosystem hydrology, and loss of coastal barriers that prevent storm damage. Siting can also accentuate the eventual impacts of on-farm management practices. If an operation is not built in the right place it will be hard to get to, and roads and other necessary infrastructure may cause problems unnecessarily. Poor siting can also lead to poor water quality or the inability to evacuate effluents. Siting is also the single largest source of conflicts with local communities and other resource users.

For those who can afford to buy the best-suited pieces of land for shrimp aquaculture, the overall siting of operations is not generally an issue at least from an environmental point of view. In addition, more is known today about the best sites for shrimp aquaculture. New ponds established after a search for better sites are not generally a problem. However, for those small-scale producers who are trying to grow shrimp on the piece of land they already own, this can be a very important issue.

Without simply closing poorly sited ponds or even entire operations in some instances, it is very difficult to address their problems. Some problem sites can be remedied if the ponds are relatively small and if the water can be pumped to another containment area or discharged into a canal where it can be treated.

New ponds that are built after the best sites have already been developed can also pose environmental threats. By themselves, many such operations would probably be able to operate within acceptable environmental parameters. However, the cumulative impacts of having many operations built in the same area often exceed the local carrying capacity. This is most often a problem when producers take chances on developing more marginal areas because they are the only unoccupied sites available in an area where everyone is apparently getting rich from producing shrimp.

Shrimp farming alone appears to be responsible for some 5 to 10 percent of the global loss of mangrove habitat (Boyd and Clay 1998). Yet in some countries it has caused as much as 20 percent of the damage to mangrove areas, and in some watersheds shrimp farming accounts for virtually all mangrove destruction. In part this situation resulted from the advice of experts who initially thought that because shrimp spend part of their lives there, mangrove habitats were the best sites for shrimp farms. Over time, it became clear that the acid soils of mangrove habitats were not suitable for shrimp ponds. But the damage to these ecosystems had already been done.

Another factor complicating this issue was that many development agencies wanted to help the poor. Building shrimp ponds in tidal areas saved farmers the expense of water pumps and long-term pumping costs. Today, while it is generally known that mangrove areas are not the best sites for shrimp ponds, farmers will still build there because land is cheap or free, there are no conflicts with other agriculturalists, and profits from even a couple of years make the efforts attractive financially.

Shrimp aquaculture has also been responsible for the conversion of other fragile coastal habitats in the tropics. Little attention has been given to the loss of mud and salt flats, coastal estuaries, and wetlands to shrimp aquaculture. It is now known that while such areas are not the permanent homes for much biodiversity, many are seasonally quite important in the life cycles of some species. Furthermore, they are important from an ecosystem point of view.

A few hundred thousand hectares of coastal areas may have been converted to shrimp farms that failed and were then abandoned. These areas include a wide range of former habitats. Unfortunately, most failed shrimp operations are not required to recreate the hydrology of the coastal areas that they degraded. In many cases, simply opening the dikes so that the water could flow would reestablish the areas again.

Capture of Larvae and Brood Stock from the Wild

Most shrimp farms depend on the capture of brood stock (adult females and males that are captured and spawn in captivity) from the wild, while only about two percent of all post-larvae used to stock shrimp ponds are captured in the wild. Little is known about the impact of these activities. However, there is some evidence that for every captured post-larva, twenty to forty other living organisms are killed (Boyd and Clay 1998; World Bank et al. 2002). Post larvae are captured near shore and are taken to land to sort. Bycatch is discarded on the land, where it dies. For an industry that depends on more than a trillion post-larvae annually, this could be a significant issue. However, little is known about recruitment of the different species in the surf areas where post-larvae are harvested. Because brood stock must be taken live from the ocean (and are caught at night), much more care is taken and by-catch is not seen as a serious issue.

Introduction of Nonnative Species

Little is known about the overall impact of the introduction of shrimp species from aquaculture. For some time, the species *Penaeus vannamei* from the west coast of Latin America has been farmed along the Caribbean and Atlantic Coasts from South Carolina to Brazil and more recently in Asia. Likewise, shrimp of the species *P. monodon* from Asia have been transported throughout Asia and brought to Latin America. *P. monodon* shrimp from Africa have been taken to Asia and the Pacific, and there has been a flow of this same species from Southeast Asia to South Asia and vice versa. Escapes, however, have not yet shown up in wild shrimp catch.

The introduction of shrimp from different regions, even of the same species, introduces new DNA and characteristics that have not evolved in situ. These interactions are probably insignificant within ponds, but when shrimp escape during water exchange or harvest they could cause genetic pollution that could alter the inbred characteristics, and perhaps the viability, of wild populations.

The introduction of disease pathogens from other areas is equally important. Diseases previously found only in Taiwan and China have now spread throughout Asia and even into Latin America, where they have caused billions of dollars in damage each year. The impact of disease pathogens on wild stocks is not documented, but anecdotal information suggests that it may be serious. For example, in 1992–1993 when diseases reduced shrimp aquaculture production in China by 60 to 70 percent, the production of wild-caught shrimp in that country also declined by 90 percent. It is not clear whether the disease was transmitted from the wild to the ponds or vice versa, but there does seem to be some direct relationship.

Pathogens can be introduced through the transportation of infected larvae or brood stock that are released without proper quarantine and handling. In addition, diseases have been found to be viable in processed frozen product that is shipped to another region for further processing.

Pollution from Effluents

Pollution from effluents comes from many sources in shrimp production. Perhaps the most important is the feed. Semi-intensive and intensive production systems require about 2 kilograms of feed to produce 1 kilogram of shrimp. This feed averages from 15 to 35 percent fish meal by weight, and from 20 to 40 percent protein by weight. Consequently, feed is a major cause of water quality deterioration in shrimp ponds. This problem is accentuated because as much as 33 percent of the food is not even consumed by the shrimp. Shrimp farmers cannot know precisely how many shrimp are alive in their ponds, so feeding is guesswork.

The main problem with nutrient loading in local water systems occurs during the shrimp harvest. Shrimp are harvested by draining the ponds, and it is estimated that 90 percent of all the nutrients that are produced in a shrimp pond are released during the last 25 percent of pond draining. No one has yet found a way to harvest shrimp efficiently without draining the ponds.

The effluents from individual ponds or single operations may fall within reasonable standards. However, too many farms in one area may well exceed the carrying capacity of the ecosystem to assimilate nutrients.

Use of Chemicals and Medicines

The main chemicals used in shrimp aquaculture are fertilizers, which stimulate growth of plankton on which the shrimp feed, and various forms of lime (calcium) that are used to adjust the acidity of the water and underlying soil. Zeolites are also added to remove ammonia. In some instances, calcium hypochlorite, formalin, chlorine, and other compounds are used to kill pathogens and pests.

Medicines are another story. Many shrimp farmers still use medications such as antibiotics routinely. A recent survey by the Global Aquaculture Alliance of what are considered some of the more progressive producers in the industry found that 35 percent were using such antibiotics as chloramphenical (George Chamberlain, personal communication). In all likelihood, poorer and less-educated producers are probably more likely to misuse medications. They are also probably more susceptible to the salespeople who push medications.

Antibiotics and other medications can be added directly to the water or included in the feed. One survey in Colombia indicated that 15 percent of producers still have antibiotics included in the manufacture of part of their feed. The most problematic aspect of prophylactic use of medications is that those used are not even effective for the diseases that are common (e.g. antibiotics are used for viral diseases).

Over reliance on Fish Meal and Fish Oil in Feeds

Currently, four of the top five and eight of the top twenty capture fish species are used primarily to make fish meal and fish oil for aquaculture and livestock feed. Globally, 35 percent of all capture fisheries are used for fish meal. Aquaculture is the fastest growing user of fish meal and fish oil in the world. Shrimp and salmon account for most of the use. Shrimp farming uses, on average, two to three times as much wild fish in feed as the weight of the shrimp it produces. This contributes to a net loss to global fisheries. Globally, no one knows what the environmental impacts are of removing so many fish that are currently used for fish meal. It is not even known if the populations of fish-meal fish are greater at this time because so many of the predator carnivore species have been fished to the point of capacity or overfished. It is clear that some fish-meal species are not palatable to humans and have only limited, if any, markets. Nonetheless, to continue to use high concentrations of fish meal in feed formulations when there are ways to reduce them is at the very least inefficient.

Better Management Practices

In 1999 the World Wildlife Fund (WWF), the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and Network of Aquaculture Centres in Asia-Pacific (NACA) began a three-year project to undertake a series of case studies from around the world on better management practices (BMPs) for shrimp aquaculture. This consortium funded some forty case studies on BMPs to reduce environmental and social impacts of shrimp aquaculture (some of these are included in the reference list at the end of this chapter).

The most effective conservation strategies will be those that address directly the environmental impacts described in previous sections of this chapter. The recent three-year consortium project suggests that only six to ten activities account for the vast majority of environmental and social impacts. Furthermore, in most cases, the ways to reduce these impacts pay for themselves within two to three years or less. Some of the key findings are discussed below.

Implement Coastal Zoning

One of the best ways to limit the environmental impact of shrimp aquaculture is to identify those areas where the industry can be undertaken with the least impact and those areas where it should not be undertaken at all. For example, shrimp farms should not be built in areas where water quality is affected by human settlement, extractive industries such as mining, or industries that use pesticides such as agriculture. Operations should be built where intake water is distinct from water bodies that will receive effluents. Within areas that are identified as appropriate for shrimp aquaculture, carrying capacities need to be determined to indicate how many producers can exist simultaneously.

Operations should not be sited below the high tide mark, as those operations will always interfere with coastal wetlands. It is environmentally, economically, and socially better to build shrimp ponds inland from mangrove habitats and other fragile coastal ecosystems and pump water into and out of them. This reduces some of the most significant impacts of the industry. Even so, care must be taken not to change the hydrology of coastal areas with the construction of intake canals, pipes, or effluent canals. In several countries shrimp farms are already being located well inland where water salinity is as low as 1 part per trillion.

Even building behind fragile coastal wetlands can cause impacts. Zoning should stipulate the principle of no net loss of such areas as a result of shrimp farming. Building operations inland from mangrove habitats requires the construction of canals or pipelines to bring water to the site and to take effluent away. If mangrove wetlands or other fragile areas are altered, producers should be required to offset that impact through the creation of an equal amount of mangrove wetland or other type of ecosystem somewhere else.

This solution is not ideal, but it does at least force the developer to acknowledge the problem and to attempt to balance any losses. To date this concept has been accepted for mangrove wetlands and is now generally agreed to by many in the industry. Colombia has even put this into law.

Use Land Efficiently

Many producers stock large ponds with very small animals. While the shrimp eventually grow and use the entire space, this is an inefficient use of resources. Initial grow-out ponds or raceways allow farmers to produce the same total production on less land and with lower capital investment costs. Raceways can replace 25 to 45 percent of the need for grow-out ponds. Put another way, this approach allows for at least one additional crop per year on the same amount of land. Furthermore, survival rates in the smaller ponds appear to be higher. All in all this is a simple strategy that could help to minimize the expansion and impact of ponds while maximizing the return on investment.

Another way to reduce the impact on the surface area is to use deeper ponds. In Latin America, pond water depth is 0.85 to 1.2 meters. In Thailand, ponds are 1.5 to 2 meters deep. The use of Aqua mats (material suspended vertically from wire or ropes in the pond) and other devices to create surface areas for shrimp to colonize within the water column allows for higher carrying capacity. In addition, if well managed the water column will produce an increasing proportion of the shrimp feed.

Reduce Water Exchange

Less water exchange is better for the environment. In parts of Asia the exchange rates are down to 3 percent per day, and in Latin America the average rates in many countries are as low as 5 percent. In both areas, the rates are still declining. One operation in Belize with lined ponds has no exchange and only replaces water lost to evaporation at a rate of 0.5 percent per day.

The use of effective microorganisms has been shown to reduce the need for aeration and water exchange. In Thailand, some small farmers have drastically reduced water exchange through the incorporation of microorganisms that function as providers of dissolved oxygen in the water because of the presence of the photoautotrophic bacteria. In some farms, water exchange and aeration have been reduced or even eliminated (Panfilo Tabora, personal communication).

Reduce Nutrient Loads in Effluent

At harvest, if not long before, water must be released from shrimp ponds. In the past this has been done when the water quality deteriorates, when there is disease, or to remove the shrimp from the bottom during harvest. This effluent will increase the nutrient load in the local receiving water bodies, and should not be released into natural waterways without treatment. If the area has a low evacuation or flushing rate or if there are too many farmers in one area, this can lead to eutrophication which can in turn deplete oxygen to the point that aquatic species are stressed or even killed.

All shrimp producers should be required to have settlement ponds, canals, or biological filters (biofilters) that treat the effluent. In Colombia, shrimp farmers are required to treat the effluent so that the water they release back into the environment is of as good or better quality as that which they brought into their ponds. To date most of these systems are passive and treat the water through settlement or holding ponds, canals, or biofilters. Each of these captures the nutrient-rich sediments so that they do not foul local waters. Suspended solids can take a week to settle out. Many farms have found that an area equal to 10 to 25 percent of the surface area of the ponds is required for settlement. This is a considerable investment as well as an opportunity cost—land used for settlement ponds cannot be used to grow shrimp. However, land used correctly to produce shrimp can be used indefinitely.

Eliminating nitrogen and other nutrients requires more active management than removing sediments. Biofilters are only beginning to be used for these purposes. These include both natural and artificially created wetlands and mangrove areas. Another form of treatment in settlement ponds or canals to ensure decomposition of organic matter is to add populations of microbes that aid decomposition. While this range of practices is more common perhaps than before, there are no global estimates of the prevalence of different practices.

A number of farmers have found that by settling their water, they can then recirculate it back into other ponds for stocking. This allows them to avoid the downtime required to condition the new water until it begins to produce the feed that small shrimp need to survive. Most of the water released during water exchange and the first three-quarters of the harvest can easily be used for recirculation—provided there is no evidence of disease in the pond in question.

Recirculating the water has a number of other advantages in addition to reducing the downtime before restocking. It reduces the total amount of settlement ponds required and the amount of time the water stays in them. It reduces the cost of pumping water from more distant areas. It reduces the chances of bringing disease into the ponds through contaminated intake water. Finally, it reduces the total amount of water used in the operation, as well as the amount that is released back into the environment. Most of these approaches increase resource use efficiency, reduce environmental impacts, and increase net returns.

Finally, the use of polyculture systems, in which multiple species are grown in the same space, is another possibility for reducing overall effluent load in the water. This can either be done in the shrimp ponds themselves (which is difficult in commercial operations attempting to maximize shrimp production) or undertaken sequentially with the effluent so that different species are part of the treatment process. At this time simultaneous shrimp polyculture systems produce shrimp and fish such as tilapia (an omnivore) or milkfish (an herbivore). Sequential polyculture systems tend to focus on bivalves, seaweed, etc. In some areas, sequential polyculture is similar to crop rotation, as different species (e.g. milkfish, tilapia, red claw, or bloodworms) are produced as alternate crops in the same ponds. This also functions as a form of fallowing. The same water could be recycled into these ponds. Polyculture is practiced in several countries, but it has become most common in countries that have disease problems. In general, polyculture is still not financially viable for most large-scale, commercial shrimp producers. However, as farmers begin to understand better the costs of disease and pollution, or as they are required by government to improve their performance or pay fines, this situation may change.

Encourage Domestication of Shrimp

The collection of wild post-larvae should be prohibited. This will eliminate by-catch issues and is an important step toward closing the production system. Brood stock will still be captured in the wild, but most scientists agree that their capture has little impact on the marine environment. There is no by-catch from this activity, and the numbers of individuals involved are so small as to have an insignificant impact on populations and reproduction even in a local area.

Domestication is the best way forward. This will entail raising the brood stock in hatcheries. Selective breeding programs can help develop animals that convert feed better, require less protein in general and fish meal in particular, perform better under stress, mature and gain weight more quickly, and have disease resistance. It is even possible that domestication programs could be used to make shrimp dependent on specific trace elements so that they could not survive if they escaped from the ponds. This would have a positive impact on local biodiversity.

Regulate Introduction of Species

There are several protocols on the shipment, handling, and quarantine of nonnative species. Many shrimp are now not native in the areas where they are being produced, so producers, their associations, and governments should insure that escapes are eliminated. In this regard, shrimp producers should be required to use fine-meshed screens when bringing water into their ponds or releasing it back into natural water bodies. This would prevent all but the tiniest organisms from entering the aquaculture system from the outside, and it would prevent similar organisms from the pond escaping into the wild.

Reduce Use of Chemicals and Medicines

Shrimp producers should not use chemicals or medications prophylactically. Furthermore, they should not use any chemicals or medications that are banned in the countries that buy their product. The use of such items should be in response to specific problems that have been identified. When chemicals or medications are used, the water should be held for the amount of time required for that substance to break down before it is released into the environment.

Most informed producers realize that the routine use of medicines can create resistance so that the same medicine will not be effective when it is needed. It is not clear that smaller, less-educated producers understand this concept. Any problem is accentuated when illiterate producers cannot read the labels. The real problems arise during periods of new disease outbreak when most producers will do anything to protect the animals and their investment. During such periods, a wide range of medicines and home remedies are tried to see if any will help reduce the risk of total crop loss.

The best way to maintain healthy ponds is to avoid overstocking or overfeeding. Good health is directly related to reduced stress or the conditions that lead to it. Consequently, the most profitable operations are those that have found ways to promote better management by creating worker incentives that are tied directly to monitoring and maintaining the health and density of the animals stocked, and to reducing the feeding levels to what is actually eaten so that water quality can be maintained. Feeding trays help producers monitor overall feed intake as well as feeding habits. Some farmers put all their feed in feeding trays (which requires much more labor); others only use feeding trays as an indicator of what is happening in the pond.

More intensive shrimp producers tend to fertilize their ponds to stimulate growth of aquatic organisms that young shrimp eat. Over time in such operations, the natural feed in the water column is supplemented with manufactured feed. Historically, traditional agricultural fertilizers were used. There are some attempts to use "bokashi" (fermented organic matter that includes effective microorganisms) as a substitute for inorganic fertilizer. The beneficial microbes in the bokashi digest the organic matter, which in turn promotes the development of plankton and diatoms as natural feed for the shrimp (Panfilo Tabora, personal communication).

Reduce Use of Fish Meal

Most shrimp farmers are becoming more efficient in managing the feed conversion ratios (FCRs) on their farms. As a consequence, they are using less fish meal. A smaller number of producers are actually trying to reduce not only overall feed use, but the actual proportion of fish meal in the feed as well. Ideally, farmers should produce their shrimp with an amount of fish meal that represents a weight of wild fish that is equal to or less than the shrimp being produced. It may take some time to achieve this ideal throughout the industry, however.

There are several ways that fish meal use can be reduced. For example, omnivorous shrimp require less fish meal than carnivorous species. (As an aside, fish in general are the only carnivores that are still consumed in any quantity by people.) Farmers should focus on omnivorous species. In addition, domestication programs should focus on omnivorous species. Moving aquaculture production down the food chain will reduce considerably its overall environmental impact.

Some shrimp producers have reduced fish meal use to such an extent that they can produce a kilogram of shrimp using only 0.7 kilograms of wild fish as feed. In part, the success has been due to increasing the production of food within the water column. Part of such success also has been achieved by converting production from more carnivorous to more omnivorous shrimp species. Given that feed is the largest single operational cost of most shrimp farmers (some 40 to 60 percent of total costs) and the industry spends some $1.5 billion on shrimp feed, using feed more efficiently is an area that will assume far more importance in the future as the markets become more competitive (World Bank et al. 2002).

Another way that shrimp farmers have found to reduce fish meal use and the overall cost of producing shrimp is to shorten production cycles and harvest earlier. By harvesting aquaculture shrimp at an earlier stage, farmers are able to use less feed of any kind, and this has considerable implications for the amount of fish meal that is used. The downside is that the shrimp are smaller and tend to be sold with their heads on. Neither of these characteristics is valued in the U.S. market. However, in many parts of the world intact shrimp are more highly valued because it is clear that they are not diseased.

Finally, another strategy to improve feeding efficiency and conversion ratios is to use feeds that are inoculated with beneficial microbes that help improve feed digestion and assimilation. Experiments with this have occurred in both Thailand and Costa Rica (Panfilo Tabora, personal communication).

Use Regulations to Encourage BMPs

Governments can use better practices as a basis for the development of laws and regulations to reduce the social and environmental impacts of the shrimp aquaculture industry. In addition, they can make permits and operating licenses dependent on proven adoption of such BMPs. In this way a government could work with an entire industry to set the performance bar sufficiently high so that anyone who wants to become a producer will have to agree to those standards from the outset. A reputation for reduced social and environmental impacts could easily have a market impact. At this time, Thai shrimp receive a 5 percent market premium just because they are Thai shrimp, as the perception in the market is that the shrimp produced in Thailand are better. (Of course, this means that Thai exporters can buy shrimp from other areas and re-export them, knowing that they will get a 5 percent margin.)

Governments can also require, as a condition of permitting and licensing, the posting of an environmental performance bond. Such a bond would provide the money necessary to correct environmental damage from a shrimp operation or to rehabilitate a shrimp aquaculture operation back to a natural ecosystem state if it fails. This is common in other industries (e.g. mining, oil, and gas), but it is not yet common in aquaculture.

Link BMPs to Third-Party-Certified Eco-labels

One way to improve the overall performance of the industry and reduce harmful environmental impacts is to develop a BMP-based third-party certification program for shrimp aquaculture. If such a program is based on BMPs, then consumers of shrimp in developed countries can help to finance the cost of conversion to better practices. Since most ecological certification (eco-labels) for products currently requires that producers obey all relevant local laws, government enforcement of local laws could be strengthened by international consumers of the product through third-party programs that require compliance (and perhaps pay a higher price) as a condition of shrimp certification.

Product quality issues have led to increased interest in certification and eco-label systems in general and for shrimp in particular. As of 2002, there were six such systems either in place or in development (Clay 2002 makes a side by side comparison of these programs). While these programs are based on the same principles—broadly speaking to make shrimp aquaculture more sustainable—few actually back up their claims with measurable results (Clay 2002). Furthermore, nearly all certify production processes and not the final product. Most consumers are more concerned about the final product, as that is what they actually eat, so they are far more interested in chemical residues than water exchange rates or food conversion ratios. In the future, such eco-labels could lead to consumer confusion and even backlash. There is a need to develop a BMP-based shrimp aquaculture certification program that delivers on its claims. In addition, the program should be created through wide multi-stakeholder participation, should be transparent, and needs to be overseen by a third party. Finally, it should test and stand by the final product.

Outlook

Aquaculture is the fastest-growing food production system in the world. Because of its overall value, shrimp aquaculture is one of the fastest growing forms of aquaculture. This situation is not likely to change in the near future. While early producers caused tremendous negative environmental and social impacts, many producers have found ways to address most of these issues. There is, however, a large gap between what is known and practiced by some producers and what is done by others. There is tremendous room for improvement. Many of the better practices pay for themselves. With the expected future downward trend in shrimp prices, farmers will adopt these as a way to stay competitive.

The adoption of better practices should be encouraged by buyers, investors, insurers, and governments—out of self-interest and reduced risk if for no other reason. As these sectors see increased profits and revenues or reduced risk from the adoption of producer-level BMPs, they will certainly encourage them. Finally, as certification becomes more common, it will push the industry to be more transparent and accountable. Shrimp, unlike many of the commodities discussed in this book, is sufficiently profitable that there are both revenues within the supply chain to cover the costs of better practices and interests in maintaining or improving the image of the product and the industry. In short, both the means and the motivation exist to push the industry to become more sustainable.

Resources

Web Resources

Aquaculture:
www.seaweb.org/resources/sac/
www.fao.org/sof/sofia/index_en.htm
www.fao.org/fi/default_all.asp
www.aquamedia.org/
www.was.org
www.gaalliance.org/
aquanic.org/

Shrimp:
www.davidsuzuki.org/Oceans/Fish_Farming/Shellfish/
enaca.org/shrimp/
www.shrimpnews.com/
www.usmsfp.org/

Additional resources can be obtained by searching on "shrimp" or "aquaculture" on the WWF International Intranet:
http://intranet.panda.org/documents/index.cfm

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