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SHRIMP AQUACULTURE IN MEXICO†

The shrimping industry is one of Mexico's most important and established economic sectors. The industry has provided the basis for development of many port cities, including Mazatlan and Guaymas on the Pacific Coast and Ciudad del Carmen on the Gulf shore. Shrimp are also a significant source of foreign exchange and traditionally have placed among the nation's top ten non-oil export products.

During the 1980s, however, at a time when the country faced a prolonged balance of payments crisis and government incentives were being given to exporters, the sale of Mexican shrimp on international markets stagnated. As a result, the industry's relative importance to the economy declined significantly. In 1977, for example, shrimp represented 6.9 percent of Mexico's total exports; in 1987 the figure was less than 2.3 percent (Mexico, 1987). Its share in the rapidly expanding U.S. market fared no better. In 1977, Mexico accounted for nearly 40 percent of total imports; by 1987, its participation had fallen to 18 percent and by 1989 to 12 percent (USDC, 1977–89).

At one level, the source of Mexico's relative decline is not hard to find.

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High-seas trawling continues to be responsible for most of Mexico's shrimp production, and the limits of this type of exploitation are close to being reached, if they have not been already passed. Scientists and fisherman both agree that more resources have been devoted to shrimp trawling than would be desirable from a social point of view. Indeed, in an effort to preserve the high-seas fisheries, the government in recent years has restricted credit to fishing cooperatives for the purchase of more equipment.

At another level, however, the decline in market share is more complex and more interesting. China and Ecuador, whose exports of shrimp to the United States were insignificant ten years ago when Mexico was the undisputed leader, now respectively hold first and second place. It is no coincidence that these two nations are also projected to finish 1990 in first and second place in international production of cultured shrimp. Production of cultured shrimp in China has increased more than ten-fold since 1982, while Ecuador has quadrupled its production (*Aquaculture Magazine*, 1990). Mexico, blessed with a lengthy shoreline, an agreeable climate, and immediate proximity to the largest imported shrimp market in the world, has been unable, however, even in the presence of export incentives, to make the transition to shrimp farming. Aquaculture was estimated to be responsible for less than 5 percent of total Mexican shrimp production in 1988 (Hicks, 1989a), and this figure has not increased significantly in the last two years.

The present study investigates the interplay of economic, legal, and institutional considerations that have stood in the way of greater Mexican participation in the aquaculture revolution and the dilemmas posed by policy reforms that will need to be resolved if a more dynamic industry is to emerge. It is clear from the simple benefit-cost analysis reported below that aquaculture is highly profitable from both a private and social point of view. However, private entrepreneurs have been prevented from acting on these opportunities for a host of institutional and legal reasons. Many of these are the legacy of Mexico's social revolution and were designed to prevent the exploitation of *campesinos*[1] by forbidding the purchase and sale of land. Numerous legislative acts extended these laws by also reserving fishing rights to cooperatives in the social sector. A virtual government monopoly on marketing exports, through the state-run firm Ocean Garden, limited the possibility of private sector participation even further.

The shrimp industry has provided the Mexican government with a lucrative source of foreign exchange earnings, but continued reliance on the social sector for future development would cause serious difficulties. The

[1] Campesino is often translated as "peasant" but, more specifically, it denotes here those members of the rural population who work the land but not as salaried laborers; campesinos receive a substantial share of their income from sales of crops they produce.

paper suggests that, in part, the problems that have been encountered have arisen because of the institutional fragmentation created by successive legislative acts designed to deal with the difficulties of the traditional high-seas and estuary fisheries. The failure to move more rapidly is also a function of the lack of managerial and technical expertise in the *ejidos*[2] and cooperatives that control the land and fishing rights. Finally, at the level of the bureaucracy, the nationalization of the trawler fleet in 1980 and continued emphasis on Ocean Garden as exporter created a budgetary and oversight burden and greatly limited the Ministry of Fisheries' (SEPESCA) ability to innovate. The lack of private sector participation and government inertia resulted in Mexico relinquishing a major share of its international market to foreign competitors.

Currently, barriers to individual entrepreneurship and private investment are rapidly being dismantled in a wide-ranging reform of the Mexican economy. The first steps taken to open the shrimp industry to greater innovation and competition were codified under the Federal Fisheries Law of 1986. Amendments to this law passed by the Mexican Senate in December, 1989, furthered these objectives by clearing the way for private investment in shrimp farming. Despite the importance of these changes in the legal framework, the shrimp aquaculture industry has yet to take off.

The lesson being learned in Mexico is similar to that being learned by other economies in which state intervention has been ubiquitous. Previous policies that have become embedded in the structure of the economy cannot be reversed overnight. The shrimp larvae resource upon which cultivation facilities depend, for example, is still regulated by SEPESCA, and foreign participation is limited to 49 percent in accordance with the existing law for foreign investment. Moveover, in the case of shrimp aquaculture, the argument for extensive involvement of the private sector presents the government with a painful dilemma. Seventy to 90 percent of the coastal land judged suitable for the cultivation of shrimp is in the hands of ejidos or held as a government concession by cooperatives.[3] These groups contain many of Mexico's poorest citizens; there is strong political resistance to making their lands available for private development. Unfortunately, as noted above, even if the government were to provide the capital, these cooperatives are not in a position in terms of organization and management to build a dynamic shrimp industry without outside help. The result has been a kind of paralysis in policy and program initiatives that is extremely difficult to overcome.

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[2] An ejido is a legally recognized form of campesino organization in which members share irrevocable communal ownership of land. While group production is possible, members often farm their own designated plot alone.

[3] Estimates were obtained through interviews with officials of the National Trust Fund for Fisheries Development (FONDEPESCA) and SEPESCA.

The paper proceeds by first describing historical developments in the shrimp industry that led to its stagnation. Subsequently, a simple benefit-cost analysis is employed to establish the kinds of returns that might be expected from investments in the industry. In light of these findings, new legislation is examined that attempts to create incentives for various groups to invest in the industry while trying to leave as much as possible of the existing legal and institutional framework intact. It is a balancing act that, if successful, would make the Mexican experience relevant to the transformation of state-run economies in other parts of the world that are attempting similar strategies.

THE SHRIMP INDUSTRY: BACKGROUND

Currently, about 60 percent of Mexico's shrimp production is caught off the Pacific Coast and 40 percent in the Gulf of Mexico. Over the last 20 years, Gulf production has increased by more than 30 percent, whereas Pacific production has not changed significantly.[4] The shrimping seasons for the Pacific and Gulf Coasts are independent, and the type of shrimp caught in each ocean is different. The production technology, however, is the same on both coasts. Each trawler trip lasts approximately three weeks, and shrimp are captured in large, specially designed nets. The shrimp are preserved in freezer units on board the trawlers and processed when the ship returns to port.

High-seas trawlers capture nearly half of their full season production on their first outing. The public or "commons" nature of fisheries resources encourages individual producers to fish the maximum amount that they can when the season begins; they cannot expect part of the total resource to be protected for their subsequent trips. The concentration of production in October and November on the Pacific Coast and in March, April, and May in the Gulf, the months when the shrimping season opens on the respective coasts, attests to the importance of the boat's first season catch.

Trawlers represent the vast majority of the direct investment in high-seas shrimp production. Macroeconomic policies followed by the Mexican government in the 1960s and 1970s were a major factor favoring the high-seas shrimping industry and even, to a lesser extent, the river fishermen. An overvalued peso subsidized purchases of imported boats and motors, the main investment expenses for capture of shrimp. The excessive growth of the trawler fleet was further spurred by private investors who were eager to invest in the high-seas shrimp industry but unable to do so directly. The only means open to them for extending their involvement was to increase the number of boats that they could rent to registered cooperatives. In

[4] Information obtained from the Office of Information, Statistics, and Documentation, SEPESCA.

addition, the price of oil and diesel fuel, the main operating expenses, were also subsidized and kept below prices prevailing in international markets. As a result of cheap inputs, investments in the industry boomed. With little or no increase in total shrimp production and a growing trawler fleet, the average catch per boat fell from 25 metric tons (mt) in the 1960s to between 10 and 15 mt in the 1980s.[5]

Legal Issues

The traditional shrimp industry has been the target of a series of significant government policy interventions. The story begins in 1938 when President Lazaro Cardenas established the judicial framework for cooperative organizations. The General Law for Cooperative Societies had a definite socialist character and spoke of social transformation as well as class struggle. Members of cooperatives had to come from the working class, with a minimum requirement of ten participants. The law was not designed to facilitate collaboration between the social and private sectors but, rather, was an attempt to protect the former from the latter. The Fisheries Law of 1950 significantly increased the economic and political importance of the cooperatives through what is commonly referred to as the "reserved species legislation." Cooperative organizations were granted the sole right to fish for several of Mexico's most valuable fishery products including, in addition to shrimp, lobster, oyster, clam, and abalone.

The Fisheries Law of 1950, however, reserved species only in the capture and cultivation phases of production; processing, marketing, and other complementary industries were left open to private investment. Moreover, private ownership of the trawler fleet was left intact. Cooperatives, who had the legal permits to capture the shrimp, rented boats and equipment from private third parties. Private entrepreneurs provided capital and maintained the equipment and cooperatives handled the catch. Some private businesses also established processing plants. Thus a significant portion of shrimp value-added was still captured by private entrepreneurs.

The Fisheries Law of 1950 left a number of loopholes and ambiguities regarding fishing and cooperatives and, in response, the Fisheries Law of 1972 was promulgated. It went further in defining and dividing the fields of competition for the capture and production of shrimp. In particular, it clearly distinguished between high-seas cooperatives and those involved in the exploitation of interior waters, the so-called "river cooperatives." The legislation was conceived to increase the number of people who would benefit from the shrimp resource, by restricting cooperatives to either high-seas

[5] Interviews indicate that competition for shrimp in interior waters has also increased significantly over the past 20 years. However, hard statistical data are not available for this segment of the industry. Data on trawler fleet obtained from SEPESCA annual reports.

or river capture. It specified that if cooperative members had access to both oceanic and river sources of captured shrimp, those having access to interior water would not be permitted to fish in the ocean as well. They were, however, granted the rights to extend their interior water fishing to include the cultivation of marine speciies, including shrimp farming. The effect of the legislation was to further increase the fragmentation of institutions and make it impossible for the high-seas cooperatives, which had far greater revenues than their "river" counterparts, to establish aquaculture enterprises.

Institutional Fragmentation

Because of the ease of entry and subsidized inputs, by 1980 the private sector had increased the number of trawlers significantly, and the cooperatives, who had the fishing permits, were equally interested in exploiting the resource. The government feared that these pressures would ultimately bring about a serious decline in the shrimp catch. In an effort to control the industry more closely, in 1980 the government nationalized the trawler fleet and forced private owners to sell boats and equipment to the high-seas shrimping coooperatives. At the same time, as a concession to the private owners of the fleet, cooperatives were required to purchase virtually everything offered for sale including trawlers and equipment that were obsolete or in need of expensive maintenance and repair. In some cases, competent and well managed cooperatives were able to take advantage of the opportunity and became viable business organizations. The overriding result at the industry level, however, was to create a large group of debt-burdened cooperatives with old and ill-maintained equipment. The process did produce a leveling-off of the pressure on the fishery, but at a considerable social adjustment cost. In fact, a 1986 FONDEPESCA report stated that financing represented over 30 percent of production costs on an average shrimp trawler.

In order to secure repayment, indebted cooperatives were required to sell their catch to Ocean Garden, a subsidiary of the state-owned firm, Fisheries Products of Mexico (PPM). Debt payments were automatically deducted from sales and remitted to the National Bank for the Fisheries Industry (BANPESCA). This provoked resentment from cooperatives who were told future credit could depend on their compliance in selling to Ocean Garden. Private processing and exporting firms also complained that this produced undue pressure on cooperatives to sell to the public sector and constituted an unfair advantage that stifled development of the private sector. Ocean Garden in fact was formed to exploit Mexico's once dominant position in the U.S. shrimp market as well as to take advantage of economies of scale in marketing operations. It is still responsible for shipping 60 to 70 percent of Mexico's shrimp to international markets, and these policies

strengthened its market share. As a result, however, many cooperatives faced liquidity constraints.

The situation was further exacerbated by the financial difficulties of the government agencies involved in the trawler buy-out. The absorption of government funds for the shrimp industry by the traditional ocean-catch cooperatives preempted other activities. Additional funding for development of shrimp aquaculture was viewed by some government planners as unjustifiable given the already high level of public support for the shrimp industry. The large revenues and foreign exchange generated by the sector also made public support unpopular even though high costs and debt meant that many cooperatives did not have large profits. The fact that support of high-seas cooperatives would not lead to development of aquaculture was overlooked by those who insisted on viewing the shrimp industry as a single entity benefiting one small group.

Government planners reluctant to invest additional funds in the shrimp industry for budgetary reasons also had allies in the high-seas shrimp cooperatives who did not want new entrants to the industry. So long as they were excluded, they protested against changes in the fisheries laws intended to facilitate development of aquaculture. For example, the 1986 Fisheries Law providing for the entry of new cooperatives in the shrimp cultivation industry, as well as for contracts with private parties, was vehemently opposed by high-seas cooperatives. They resisted the 1986 law because they felt private sector investors, with greater access to credit, would come to dominate the shrimping industry. They also feared that the development of cultivation facilities could reduce the larvae resource on which high-seas fishing also depends.[6]

As the present analysis shows, the legal framework for exploitation of Mexico's shrimp resource was developed in such a way that participation was increasingly divided and restricted. This made the transition to aquaculture extremely difficult. Although many high-seas cooperatives were indebted, some were still financially healthy and benefited from substantial revenues from their ocean shrimp catches. They could have provided the needed capital, however, they were legally prevented from extending their activities into shrimp farming. The river cooperatives, on the other hand, while having the right to harvest the inland larvae resource, did not have the land or the capital to convert their shrimp-fishing operations into

[6] The issue of larvae competition is controversial. It is true that all shrimp larvae live for a period in the shallow waters of the coastal areas. However, due to the low level of aquaculture development in Mexico and consequent low demand on the larvae resource, no negative effects have yet been documented. Ecuador did experience a generalized problem in 1985 with its shrimp resource due to extensive larvae catches by aquaculture facilities; this problem has since been corrected.

shrimp farming. The ejidos and communal land-holding groups controlled much of the suitable land but lacked the technical expertise and capital to exploit their coastal land holdings. The ejidos were also initially denied access to the shrimp larvae resource. The result was an impasse.

The picture that emerges from this description of the traditional industry is one of extreme institutional fragmentation. Purchase of equipment, trawling, processing, marketing, and financing were managed by different parties, often as mandated by government laws. Even within the production area, access to resources was split across groups in ways that did not lend itself to an integrated commodity development approach. There was no focal point around which the ingredients of innovation could come together. Ocean Garden, the state-run firm, might have played the role of innovator. But its mandate, to process and market, was derived from policies determined by the Ministry of Fisheries. Without a change in its mandate—and substantial additional budgetary support—there was little incentive to enter into the difficult area of negotiating with the cooperatives about investment in production facilities.[7]

THE POTENTIAL FOR SHRIMP AQUACULTURE

According to official estimates, less than 1 percent of the coastal lands suitable for shrimp aquaculture in Mexico have been developed into projects. The Ministry of Fisheries has stated that a conservative estimate of Mexico's land resource for shrimp aquaculture development is over 300,000 hectares (Barrena Vasquez, 1987, p. 4). Many estimates place it at twice this size. Roughly 80 percent of the suitable land is ejidal or communal property; the remaining 20 percent is designated as Federal or National and can only be acquired by Mexican citizens through concessions from the government.[8]

As of December, 1985, there were only 20 cultivation projects in construction or operation in Mexico, covering an approximate area of about 1,300 hectares. The success of Ecuador and Panama's shrimp aquaculture programs, as well as the loss of the Mexican market share in the international shrimp industry, prompted the Mexican government to take steps to promote additional investments. A report by the U.S. Embassy in Mexico estimated that Mexico had 2,100 hectares of shrimp ponds as of 1988

[7] In 1987, the Ministry of Fisheries changed its policies toward aquaculture, and Ocean Garden announced its intention to support aquaculture development through loans to eligible cooperatives. Unfortunately, the question of how the cooperatives are to gain access to managerial and technical expertise was not adequately addressed.

[8] Estimates were obtained through interviews with officials in FONDEPESCA and SEPESCA.

(Hicks, 1989a). Although Mexican government statistics indicate an area under cultivation of two to three times that size, it is still a fraction of the country's potential. Independent sources concur that the contribution of aquaculture to shrimp production is very small, representing at most between 5 and 10 percent of Mexico's total (*Aquaculture Magazine*, 1990, p. 10).

Shrimp Aquaculture Technology

In addition to the limited area under cultivation, Mexico's early ventures in aquaculture have, for the most part, employed a low level of technology. Classification of shrimp aquaculture is usually done according to the density of the shrimp population per hectare and most of Mexico's projects fall into the "extensive" category. In the last two years, however, semi-intensive cultivations have increased far more than extensive ones.

Extensive aquaculture refers to those technologies that have a low density of biomass within a given area and, accordingly, the lowest production volumes per unit of pond area. The following technical criteria apply to extensive projects in Mexico:[9]

1. Density of shrimp between 5,000 and 30,000 organisms per hectare.
2. Limited water exchange, less than 10 percent each 24-hour period.
3. Supplemental food not necessary for weekly weight gain of between 0.75 and 1.00 gram per organism.
4. Unlimited pond size.

Extensive aquaculture increases the size of the natural shrimp larvae population by reducing predators and assuring more favorable levels of water and salinity.

Semi-intensive cultivation of shrimp involves stocking densities beyond those that the natural environment can sustain without additional inputs. Therefore, supplemental feed is necessary, as is a pumping system to increase water exchange and maintain water, salinity, and oxygen levels. The specific technical characteristics that differentiate extensive and semi-intensive technologies are the following:

1. Between 30,000 and 100,000 shrimp per hectare.
2. Increased control over water characteristics due to higher rates of water exchange: minimum daily exchange = 10 percent.
3. Use of supplemental food and fertilizer.
4. Smaller pond sizes: two to ten hectares.

In both extensive and semi-intensive aquaculture projects, shrimp larvae are placed in ponds with earthen borders for between three and six

[9] Artisanal fishing methods, such as the use of nets at the mouths of rivers, are not counted as extensive aquaculture in this paper since they do not increase shrimp production beyond the size it would attain naturally.

months. At the end of the cultivation period, the mature shrimp are harvested through floodgates. Semi-intensive facilities may also include a laboratory for reproduction of shrimp, since larvae demands are greater and therefore strain natural sources.

Semi-intensive facilities have higher initial construction costs than extensive cultivations. Increases are due to longer borders needed to create a number of smaller ponds; a greater number of flood gates to allow for water flow between ponds; a more extensive pumping system to maintain acceptable oxygen levels; and laboratory and testing equipment necessary to monitor water characteristics and the shrimp population more closely. The costs of operation of a semi-intensive facility are also greater. Of particular importance are the increased costs of food, fuel to run the pumps, and the salaries of qualified technicians, including biologists, chemists, engineers, and business managers. The entire operation is more complicated from a technical, engineering, and administrative standpoint.

Semi-intensive facilities also need more unskilled and semi-skilled labor. Additional demand for labor comes from an increased number of tasks that must be performed; feed must be introduced into the ponds at regular intervals, water characteristics—such as salinity, oxygen and pH—must be monitored, and the pumping system must be operated.

The additional costs of investment in semi-intensive aquaculture are offset in the long term by higher production volumes. Since semi-intensive technologies use the land more intensively, they are further justified when land is relatively limited or costly. Their higher variable costs, however, for food, diesel, and larvae, make the investment more risky; price changes in these inputs have a direct effect upon project profitability.

Most projects now in operation in Mexico use extensive technologies. However, due to their superior per hectare yields, semi-intensive projects are responsible for more than 50 percent of Mexico's production. As the profitability estimates given below make clear, most future aquaculture investment is likely to follow current trends and be in semi-intensive production facilities.

Aquaculture Investments: Sinaloa

Because of its natural resource endowment, aquaculture facilities are widely assumed to be potentially profitable enterprises in Mexico. However, few publicly available studies have actually computed the internal rate of return at both private and social prices. Moreover, some of Mexico's competitors such as Ecuador and China have increased their market share in part because of substantial public investment in infrastructure required by the aquaculture sector. Hence it is of interest to examine the returns to investment at both private and social prices for clues about Mexico's long-run competitive position.

Data are limited on costs of investment, construction and operation, employment affects, and production yields for shrimp farming enterprises. However, activities in Sinaloa provide a basis for developing enterprise budgets since approximately 70 percent of all shrimp aquaculture projects in construction and operation in Mexico are located in this state (Hicks, 1989a). The districts along Sinaloa's coast contain over 200,000 hectares of undeveloped land unsuitable for either agriculture or grazing. (Mexico, 1977). A sizable portion of this land is suitable for shrimp cultivation, although the exact amount is unknown. Most of Sinaloa land is under ejidal control, which means that the legal and institutional difficulties described earlier are important determinants of the rapidity with which investments can be realized.

A total of eight cooperatives were surveyed in depth, and the budgets shown in the Appendix were developed on the basis of this information. In addition, interviews were conducted with officials of construction companies involved in aquaculture development and with appropriate government officials. For the extensive technology, it was assumed that one-half harvest would be obtained the first year, one the second year, and 1.66 for the remaining 13 years of the project. For the semi-intensive technology, it was assumed that, at full development, the projects would yield two full harvests each year. The base case assumed that the wholesale price of shrimp for export was $3.50 per pound for a harvest equally divided between 36/40 and 41/50 count shrimp.

Table 1 presents internal rates of return (IRR's) to aquaculture projects under several different assumptions about the opportunity cost of resources. The values shown for commercial enterprises are the most conservative because they include a charge for both larvae and land at market prices. The ejido IRR's, on the other hand, assume that low-lying coastal lands have no alternative agricultural use. Similarly, it is assumed that cooperatives capture the larvae using unemployed labor that also has no opportunity cost.[10]

Three things stand out in the comparison of the IRR estimates. First, there are clearly significant economies of scale. These occur in part because of the decline in unit investment costs. Increases in the cost of buildings, canal construction, and pond construction, for example, are not proportional to the increase in capacity. The same is also true of some types of variable or operating costs. Food and fuel, for example, increase roughly in proportion to the density of the shrimp population. But such indivisibilities as fixed annual labor employed for guard duty, business management, and other types of technical work, do not.

Semi-intensive technology is clearly superior to extensive technology in

[10] In her 1988 article in *El Financiero*, Julieta Medina Santos states that open unemployment in the countryside is 30 percent.

Table 1.—Internal Rates of Return on Aquaculture Investment
(*Annual percent return on investment*)

	50 hectares	100 hectares	200 hectares
Extensive			
Commercial	.21	.31	.37
Ejido	.41	.61	.74
Semi-intensive			
Commercial	.45	.59	.67
Ejido	.73	.94	1.06

Source: Author's survey and calculations.

terms of the return on capital invested. This result is due to the four-fold increase in yields that are experienced under controlled conditions when the shrimp are fed. The infrastructure investment is, of course, greater. Buildings, pumps, ponds, and canals all cost more to build. But the significant difference between extensive and semi-intensive projects resides in the level of management that is needed. In the extensive technology case, the job of management, once the larvae have been seeded, is to exercise a minimum control on water circulation. This is in contrast to the semi-intensive technology where the shrimp must be fed, disease outbreaks generated by the higher densities must be controlled, and water characteristics such as salinity levels must be regulated with greater care.

A third point that is clear from the figures is that the cost of land is an important component of commercial enterprises. While the ejido lands may have little opportunity costs, they cannot be sold to commercial interests. Hence the more favorable areas that are in private hands and can be purchased have become quite expensive. The option of the ejidos to earn substantial sums by leasing or selling their lands is foreclosed, as noted previously, by the legal status of these communal lands.[11]

The IRR estimates are impressive and indicate that, even when firms are required to pay full value for land and larvae, there are positive private financial incentives to undertake investments in aquaculture. However, for a commercial firm they are modest if the firm must compete for the limited amount of suitable land that is available from private sources. Much more impressive are the returns to aquaculture when the IRR's are computed at social prices that represent costs and returns to the economy as a whole.

[11] The situation confronting the cooperatives is similar to that of American Indians. They are also prevented from using their lands as collateral to obtain investment capital. However, they differ from the ejidos in that they have been able to lease their land to outside developers.

This case approximates the ejido estimates in that the land being used for shrimp farming has no opportunity cost as a result of foregone agricultural output.

Two further adjustments must be made to obtain an estimate of social IRR's. The first improves the social IRR over the private IRR by using the marginal product of labor as the cost of labor rather than the wage rate. It is estimated that underemployment may run as high as 30 percent in the Mexican countryside. However, a reduction in the labor costs of, say, 50 percent applies only to unskilled labor and not to business managers, accountants and technicians.

The second adjustment decreases the social IRR. Certain types of specialized equipment, such as imported pumps and motors, are purchased at an exchange rate that has tended to be overvalued. Social accounting requires that this subsidy be removed in computing the social IRR.

Despite the increase in purchased input costs, the significant decrease in the unskilled labor cost offsets the input subsidies and the IRR's computed at social prices are approximately 10 percent higher than the estimated IRR's for the ejido projects.

When compared to an estimated social opportunity cost of capital of 15 percent, aquaculture projects developed under the assumptions described are socially profitable. However, the intense competition that Mexico will face in international markets is cause for some concern about the financial viability of different types of projects. For example, if the price of shrimp were to decline to $3.00 per pound (average cost for a pound of shrimp made of 50 percent 36/40 count, 50 percent 41/50 count), small commercial ventures would find it unprofitable to invest in extensive technology. However, if the project were based on semi-intensive technology, even small ventures would continue to be profitable. If shrimp prices were to decline still further, say, to $2.50 per pound, the picture would change for the small investor. However, larger units employing semi-intensive technology could expect a financial IRR on the order of 25 percent. At current private interest rates in Mexico, this type of investment might not interest private entrepreneurs, but it indicates that Mexico could be competitive at prices that are substantially lower than those presently in effect.

As noted previously, the private returns significantly underestimate the social returns because of the high prices charged for land. If the low-lying coastal lands were valued at something closer to their opportunity costs, the IRR would be roughly same as the private computations for the ejidos. To be sure, if prices fell to $2.50 per pound, small units based on extensive technology would be socially unprofitable. However, the 200 hectare units would yield an IRR of 26 percent. If cooperatives could invest in this size unit using semi-intensive technology, the IRR would be over 50 percent. Returns of this magnitude underscore the high social returns to

the economy of financial and technical assistance to the ejido communities.

Employment Effects

In thinking about its policies in the aquaculture area, the government has been concerned that the ejido communities capture potential returns to the coastal lands that they control. However, what has sometimes been overlooked in the effort to insure that cooperatives participate in developing land is the trade-off between distant returns to land and more immediate returns to labor. That is, many cooperative communities might be better off if they could lease lands to developers with capital and managerial expertise because of the employment that these activities provide. If sufficient productive employment for relatively unskilled labor were created by aquaculture investments, welfare within the cooperative might be improved substantially without necessarily having to insist on control over the entire operation. Such arrangements in fact are being attempted on an experimental basis in Sinaloa.

Table 2 provides comparative data on employment drawn from the extensive and semi-intensive shrimp operations. As might be expected from the intensification of effort, employment generated per hectare by semi-intensive facilities is a little less than twice that generated by extensive facilities. However, semi-intensive projects require three times the capital to generate a little less than twice the direct employment. If aquaculture projects were to be developed by ejidos, it is likely that maximizing employment generation would be an important objective and that both liquid capital and technical and business expertise would be in short supply. Given these constraints, extensive projects would appear to be most appropriate and would allow ejidos to become familiar with the production technology before large sums had been invested. However, if land is being leased to developers who are providing the capital, the ejidos would be better off with semi-intensive technology. Not only does it provide more absolute employment, but these types of investment are more likely to survive wholesale price fluctuations than would enterprises based on extensive technology.

RECENT DEVELOPMENTS

The foregoing estimates of returns to capital make clear that investments in aquaculture are profitable from both a private and social point of view. However, the general legal and institutional obstacles that must be overcome to take full advantage of these opportunities are formidable. The Mexican government recognized these difficulties and promulgated a new fisheries law in 1986.

The Federal Fisheries Law of 1986 provide a new legal framework for the development of aquaculture and other commercial fishing activities.

Table 2.—Direct Employment Generation
(Labor units: one laborer working 8-hour days, 300 days per year)

Number of hectares	Unskilled	Skilled	Total	Total wages[c] (*dollars*)
Extensive facilities				
50	7.3	1.5	8.8	16,345
100	10.6	3.0	13.6	29,355
200	21.0	6.0	26.0	58,643
Semi-intensive facilities				
50	11.0	4.0	15.0	36,568
100	17.0	6.5	23.5	55,632
200	33.0	10.0	43.0	97,118

Source: Author's survey and calculations. Unskilled salary based on minimum wage. Skilled laborers and technicians, excluding foreign specialists, assumed to receive between $550 and $1,000 per month.

It ended the trend in legislation in which the exploitation of the shrimp resource was increasingly partitioned and opened new avenues for the development of shrimp aquaculture. In particular, it provided a way for the private sector to participate by expanding the definition of the cooperative sector.[12]

The 1986 law and related changes in procedure weakened the restrictions on cooperative membership. Cooperatives were now recognized that had only ten members instead of the previous minimum requirement of 30. Further, cooperatives could be formed of members of the same nuclear family and be of an entrepreneurial character, where cooperative members would not actually work in the project but rather act in the capacity of shareholders or investors. This was a significant departure from the original cooperative legislation, which suggested that membership should be limited to the working class and that all members should contribute directly to production.

The position of the ejido in the development of aquaculture projects was also clarified in the 1986 law, which stipulated that the cultivation of reserved species on ejidal or communal lands required the involvement of recognized ejidal or communal fishing cooperatives with the approval of the

[12] A number of Eastern block countries, most notably the Soviet Union, are currently experimenting with similar methods to encourage private initiatives while minimizing the redefinition of property rights.

community assembly. The inalienable nature of the ejido and communal land tenure was not challenged, i.e., land cannot be sold or leased to the private sector. The 1986 law did provide, however, a mechanism for private investors to enter into business agreements with established cooperatives, including those with ejidal membership, to develop shrimp farms.

The Federal Fisheries Law of 1986 was designed to bridge the gap between the private and social sectors through a compromise solution. Instead, it was criticized from all sides. Advocates for the social sector, including members of existing fishing cooperatives, protested the the potential entry of new producers to the industry. Private investors on the other hand, criticized the law for not giving the private sector direct access to the capture or aquaculture production of reserved marine species, including shrimp. The difficulties of obtaining cooperative status as well as uncertainty about further modifications in the legal structure due to the change in presidential administrations in late 1988 were the two main factors retarding investment through 1989.

In December 1989 the Salinas government issued a series of amendments to the 1986 Fisheries Law. Article 24 of the Amendments opened the door to full participation of the private sector in shrimp aquaculture. It states that Mexican citizens or wholly Mexican capital firms may obtain permits from the Ministry of Fisheries allowing 100 percent direct investment in shrimp farming operations on private land or for projects developed in federal water and coastal property. Foreign individuals and firms are restricted to 49 percent ownership in keeping with the 1973 foreign investment law that applies to virtually all economic activities. Private investors may not directly invest, however, in the cultivation of reserved species on ejidal or communal lands. Projects in these areas must still adhere to the 1986 legislation and to the Law for Agrarian Reform, requiring community consent and involvement, most likely through cooperative organizations. The Amendments also provide for a regulatory role for the Ministry of Fisheries, particularly concerning protection of the shrimp larvae resource and of endangered marine species.

Sufficient time has not yet elapsed to evaluate the effectiveness of the Amendments to the legal code. Private investors are now guaranteed a role in the Mexican shrimp aquaculture industry, however, it is not yet clear to what extent they will participate. For political as well as economic reasons, it would be best if the private sector develop in tandem with the social sector and not to its exclusion. In the long run, development of aquaculture on ejidal and communal lands will be critical to realizing Mexico's potential production of cultured shrimp, since such groups control well over half of suitable coastal lands. Further, ejidal and communal fishing cooperatives could disrupt aquaculture facilities' use of the wild shrimp larvae resource, particularly if they themselves are not involved in the industry. In fact,

absence of a secure supply of shrimp larvae could directly jeopardize the development of Mexico's aquaculture industry.

Efforts are now underway to encourage private sector investment while supporting development of projects by cooperatives, especially on ejidal lands. In an approach reminiscent of earlier solutions, one suggestion has been to reserve specific technologies for specific groups. For example, extensive technologies are less technically sophisticated, requiring a substantial land base and relatively low initial investment; they are well suited to development in ejidos or by cooperatives. Further, community members have an opportunity to become familiar with the industry before large investments are made, increasing the probability of project success in the long term.

By the same token, the private sector could be encouraged to undertake investments in semi-intensive facilities, particularly for projects proposed for use on federal lands. In some areas, investors have been able to purchase coastal property suitable for aquaculture, however, in many places coastal lands remain the property of the state. In these locations, private investors are competing with cooperatives for permission to develop the property. In order to control the strain on natural resources and promote investment in more technically sophisticated projects, private sector investors have been encouraged to develop semi-intensive facilities. Such projects require greater investment capital but also have a higher rate of return. Semi-intensive projects are also expected to supplement wild larvae, increase Mexico's technology base in this industry, and help to insure project success by reducing dependency on one source for a critical factor of production. It is also intended to reduce conflicts between cooperatives and private investors. By producing larvae on site, private developers will not have to take a disproportionate share of the shrimp larvae resource for their higher cultivation density ponds. As social sector facilities gain technical sophistication, their demands on the environment may also increase to the point where they would become purchasers of laboratory-produced larvae.

Whether the new law and suggestions for application will create the necessary framework for significant expansion of private sector participation remains to be seen. The government, however, does have another option for developing shrimp aquaculture, namely, it can try to assist ejido communities to take advantage of lands over which they exercise control.

Organization and Management

Organization and management of ejido and cooperative efforts to develop shrimp farming operations present the government with special problems. First, the responsibilities for aquaculture development are scattered between different government ministries, a legacy of the institutional fragmentation that accompanied earlier interventions in the shrimp industry. For example, SEPESCA, the Ministry of Agrarian Reform (SRA), and the

Ministry of Agriculture and Hydraulic Resources (SARH), all have areas of responsibility crucial to the successful development of shrimp aquaculture, however, each has a different primary objective. SEPESCA, for example, is responsible for development of fishing industries, and thus has been most directly involved in shrimp cultivation projects. SRA, however, is concerned with land tenure and is more interested in traditional agricultural activities than in shrimp farming. The two ministries must be involved, however, in those cases where lands for cultivation are concessioned to ejidos or communal groups. SARH is critical because it distributes water resources; authorization to use existing canals for aquaculture projects can have a large effect on project costs and, in some cases, viability. Like the Ministry of Land Reform, SARH has also concentrated on traditional agriculture and thus is not accustomed to perform the evaluation of aquaculture projects. Different objectives and organizational structures between these groups have created additional administrative obstacles to the development of the industry.

Coordination of government funds for aquaculture between these different ministries may help to reduce these institutional barriers. Several joint programs have been established between the involved government ministries and public development banks. The elaboration of financial project evaluations in common may improve communication and understanding between government sectors. Like all government decision-making, however, the process is likely to be slow and cumbersome. A more flexible approach may be the changes in policy made in 1987 that encourage Ocean Garden to provide loans to eligible cooperatives. To date, however, Ocean Garden has invested relatively little in the aquaculture industry.

The lack of capital is not the only impediment to development in the social sector. Ejido shrimp cultivation projects require substantial outside technical assistance in order to be successful. Although community members can be trained informally to perform the majority of tasks required in an extensive facility, technical supervision is still necessary. Technical assistance is especially important in larvae gathering, monitoring the stock during the growth period, and in selection of the appropriate time for harvest. Thus expanding the corps of trained "extension agents" who bring some competence in business techniques to the ejido is vital to the development of the industry in the social sector.

Another organizational problem that must be dealt with in social sector aquaculture projects is a tendency toward excessive labor use. Ejidos and fishing cooperatives with a defined membership base have a tendency to increase the number of people involved in projects beyond optimal levels. If there are more associates working in the aquaculture project than are needed to run the facility, the payroll alone can create a drain on funds. The development of aquaculture cooperatives on communal lands or within

fishing cooperatives must be carefully negotiated so that membership is defined and profits protected for project development.

Financing Aquaculture Development

Before 1987, Ocean Garden and BANPESCA had invested very limited amounts in the industry; probably less than $5 million total over the previous five years.[13] In 1987, interest within the Mexican government increased substantially and financial resources available for aquaculture development were augmented. Approximately $25 million was set aside for the development of shrimp aquaculture; this represented approximately 80 percent of all funds marked for aquaculture projects. Subsequent interest in the industry among commercial bankers resulted in a rapid expansion of investment in shrimp aquaculture, albeit still at low absolute levels. Under the current austerity program, the government is hard pressed to provide the capital required to take advantage of Mexico's coastal waters and its proximity to the greatest shrimp market in the world. The Mexican government has been trying to secure funding from international organizations and institutions to strengthen its ability to foster the industry's development. Priority for current public funds for aquaculture, however, has been given to low value species destined for domestic consumption such as carp and tilapia, while funds for shrimp aquaculture are mainly expected to come from the private sector (Hicks, 1989b). In Ecuador, an estimated $350 to $500 million has been invested in the shrimp cultivation industry by private firms and individual entrepreneurs. Private sector involvement is the only way that Mexico will generate a similar level of investment in the near future.

THE POLICY DILEMMA

The dilemma facing the Mexican government as it moves in the direction of privatizing the economy is not confined to the aquaculture sector. The oil boom of the 1970s fueled subsidies to food and a wide variety of social services that are now painfully being phased out. What makes the aquaculture problem so difficult, however, is that the incentives needed for widespread private sector investment affect what have been important elements of the country's rural development policies, namely, a commitment to communal land ownership and support of cooperative enterprises.

Communal productive organizations, including ejidos and fishing cooperatives, have had difficulties developing within the framework of the pre-

[13] BANPESCA invested about $1 million in a cultivation facility in Sonora in 1982 that experienced severe political and organizational problems. The example of this facility, as well as the barriers earlier mentioned, created very negative attitudes in the government about further aquaculture financing.

dominantly capitalist Mexican economic system. Their existence nonetheless represents an important constraint to the development of the private sector in this industry. The success and ultimately the viability of a Mexican shrimp farming industry will rest not only on project profits but on the contribution facilities make to local employment and development.

From the viewpoint of the economy as a whole, the government needs the participation of private capital and, in particular, private managerial and entrepreneurial talent if Mexico is to exploit its natural resources. With some exceptions, the ejido community is distrustful of joint ventures involving activities they do not completely control and may only partially understand. The Federal Fisheries Law of 1986 encouraged private sector cooperation with communal organizations but was largely unable to spark investment in the industry. The 1989 Amendments to the legislation allow the private sector to invest and develop shrimp aquaculture projects without the participation of social sector organizations. Elements of policy that have remained intact include limited government regulation, particularly regarding protection of the shrimp larvae resource; the continued dominant position of Ocean Garden, the state-run firm dedicated to the export of Mexican shrimp; and the restriction on foreign investment in the industry beyond 49 percent.

The Mexican government is betting on the ability of the private sector to develop a shrimp-farming industry. This will not be easy given the increasing technological sophistication of the industry and growing international competition. Development of the industry would provide important returns to investment, however, as calculations of the internal rate of return on projects from both a commercial and social accounting standpoint have shown. As centrally planned economies the world over are discovering, there is no quick fix to the tensions between a well articulated social policy and the need for a more dynamic, albeit self-centered, private sector.

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APPENDIX.-BUDGETS FOR SHRIMP CULTIVATION FACILITIES

Appendix Table 1.—Investment Expenses:
Extensive Shrimp Cultivation Facilities
(*U.S. dollars*)

Investment costs	50 hectares	100 hectares	200 hectares
Tasks			
Constructing border	27,806	39,333	55,627
Clearping land	5,556	11,111	22,222
Building canal	4,167	8,333	16,667
Flood gates	2,014	4,028	8,056
Pump and motor	13,333	26,666	53,333
Transport	3,333	3,333	6,666
Fiberglass tank	889	889	1,778
Boats	1,667	1,667	3,333
Structures	5,556	11,111	22,222
Miscellaneous	5,110	7,992	13,838
Subtotal	69,431	114,463	203,742
Land	27,778	55,556	111,111
Investment			
Without land	69,431	114,463	203,742
With land	97,209	170,019	314,853

Source: Author's survey and calculations.

Appendix Table 2.—Operating Costs:
Extensive Shrimp Cultivation Facilities
(*U.S. dollars*)

Operating costs	50 hectares	100 hectares	100 hectares
Inputs			
Fertilizer	212	317	633
Diesel	4,000	8,000	16,000
Gas	867	1,734	1,733
Pump maintenance	556	1,111	2,222
Truck maintenance	556	556	1,111
Nets	222	444	889
Ice	212	424	848
Border maintenance	4,171	5,900	8,344
Subtotal	10,796	18,486	31,780
Labor			
Guard duty	2,500	3,333	6,667
Larvae collection	278	556	1,042
General maintenance	2,500	3,333	6,667
Technicians	6,667	13,333	26,667
Shift manager	1,067	2,133	4,267
Business director	3,333	6,667	13,333
Subtotal	16,345	29,355	58,643
Larvae cost	3,750	7,500	15,000
Processing			
Packing ($.33/kg)	2,228	4,455	8,910
Distributor (7.5%)	3,898	7,796	15,593
Export duty (1%)	520	1,040	2,079
Taxes (2.3%)	1,195	2,391	4,782
Subtotal	7,841	15,682	31,363
Total costs			
Without larvae	34,982	63,523	121,786
With larvae	38,732	71,023	136,786
Shrimp yield (kg/ha)	135	135	135
Shrimp price ($/kg)	7.7	7.7	7.7
Total net revenue			
Excluding larvae	16,993	40,427	86,114
Including larvae	13,243	32,927	71,114

Source: Author's survey and calculations.

Appendix Table 3.—Investment Expenses:
Semi-intensive Shrimp Cultivation Facilities
(*U.S. dollars*)

Investment costs	50 hectares	100 hectares	200 hectares
Tasks			
Constructing border	47,475	88,550	152,958
Clearing land	16,667	33,333	66,667
Building canal	40,000	53,333	113,333
Flood gates	10,000	16,667	44,444
Pump and motor	41,111	82,222	164,444
Transport	3,333	6,667	16,667
Fiberglass tank	1,778	3,556	7,112
Boats	2,667	3,333	6,667
Structures	50,000	83,333	122,222
Pond	14,518	27,708	53,167
Miscellaneous	3,333	5,556	11,111
Subtotal	230,882	404,208	758,792
Land	27,778	55,556	111,111
Investment			
Without land	230,882	404,208	758,792
With land	258,660	459,764	869,903

Source: Author's survey and calculations.

Appendix Table 4.—Operating Costs:
Semi-intensive Shrimp Cultivation Facilities
(*U.S. dollars*)

Operating costs	50 hectares	100 hectares	200 hectares
Inputs			
Fertilizer	212	317	633
Diesel	4,044	8,089	16,178
Gas	867	1,734	2,778
Pump maintenance	2,222	4,444	8,889
Truck maintenance	556	1,111	2,778
Nets	222	444	889
Ice	667	1,333	2,667
Food	8,367	16,734	33,469
Border maintenance	7,121	13,275	22,944
Subtotal	24,278	47,481	91,225
Labor			
Guard duty	2,500	3,333	6,667
Larvae collection	500	1,000	2,000
General maintenance	2,500	3,333	6,667
Technicians	6,667	13,333	26,667
Shift manager	1,067	2,133	4,267
Water control	9,167	14,167	21,667
Nursery	7,500	8,333	15,850
Business director	6,667	10,000	13,333
Subtotal	36,568	55,632	97,118
Larvae cost	25,000	50,000	100,000
Processing			
Packing ($.33/kg)	6,600	13,200	26,400
Distributor (7.5%)	11,500	23,100	46,200
Export duty (1%)	1,540	3,080	6,160
Taxes (2.3 %)	3,542	7,084	14,168
Subtotal	23,232	46,464	92,928
Total costs			
Without larvae	84,078	149,577	281,271
With larvae	109,078	199,577	381,271
Shrimp yield (kg/ha)	400	400	400
Shrimp price ($/kg)	7.7	7.7	7.7
Total net revenue			
Excluding larvae	69,922	158,423	334,729
Including larvae	44,922	108,423	234,729

Source: Author's survey and calculations.