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MANAGING SHRIMP MARICULTURE DEVELOPMENT

Since the late 1970s, shrimp mariculture has been one of the most powerful agents of social and ecosystem change along Ecuador's coast. Despite repeated efforts, Ecuador's Coastal Resources Management Program (PMRC) has found it difficult to establish a productive relationship with this industry. This has been frustrating, since an integrated resource management program has much to offer the industry. If shrimp mariculture is to be sustainable, issues of competing coastal activities must be resolved, and ecosystem qualities essential to the profitability of the industry need to be maintained. This paper describes three distinct periods in the program's attempt to understand the environmental and social issues affecting shrimp mariculture and to propose constructive management strategies. These three periods are:

- Formulation of a national strategy to promote a sustainable shrimp industry in Ecuador (1986–1987);
- Formulation of a national strategy to diversify mariculture operations (1988–1990); and
- A research and extension program directed at mariculture management issues in the special area management zones (1991–1994).

The PMRC's experience demonstrates the difficulties in promoting a long-term perspective within Ecuador's shrimp mariculture industry and in creating interest in more structured and participatory governance. The reluctance of mariculture industry leaders to engage in a dialogue with the PMRC contrasts sharply with the demand for improved governance and integrated approaches to problem solving among the poorer segments of Ecuador's society.

SHRIMP MARICULTURE: THE COSTS AND THE BENEFITS

Growth of the shrimp industry

The great monetary profits that can be made in shrimp mariculture prompted anarchic, gold-rush–like expansion of the industry in the 1960s, '70s, and '80s. This occurred without any meaningful planning, controls, or consideration of long-term impacts. It was common in the early years of development for shrimp farmers to recover the entire investment in a new farm within a single year. Worldwide, it is still not unusual for shrimp farms to operate at annual profit margins that are 50 to 100 percent above operating costs (Weidner et al., 1992).

Shrimp farms expanded rapidly in the 1980s (Table 1), with construction frequently outstripping the regulatory system. By the mid-1980s, shrimp farmers were building in upland sites, rather than in the beach and bay zone (Figure 1).

Year	Shrimp ponds detected by remote sensing (ha)	Authorized shrimp ponds (ha)	Illegal ponds (ha)
1984	89,368	81,075	8,293 (9 percent)
1987	117,729	114,385	3,344 (3 percent)
1991	145,998	131,961	14,037 (10 percent)

Sources: CLIRSEN (1992), Cámara de Productores de Camarón (1993).

Table 1. Estimated area, in hectares (ha), of shrimp ponds.

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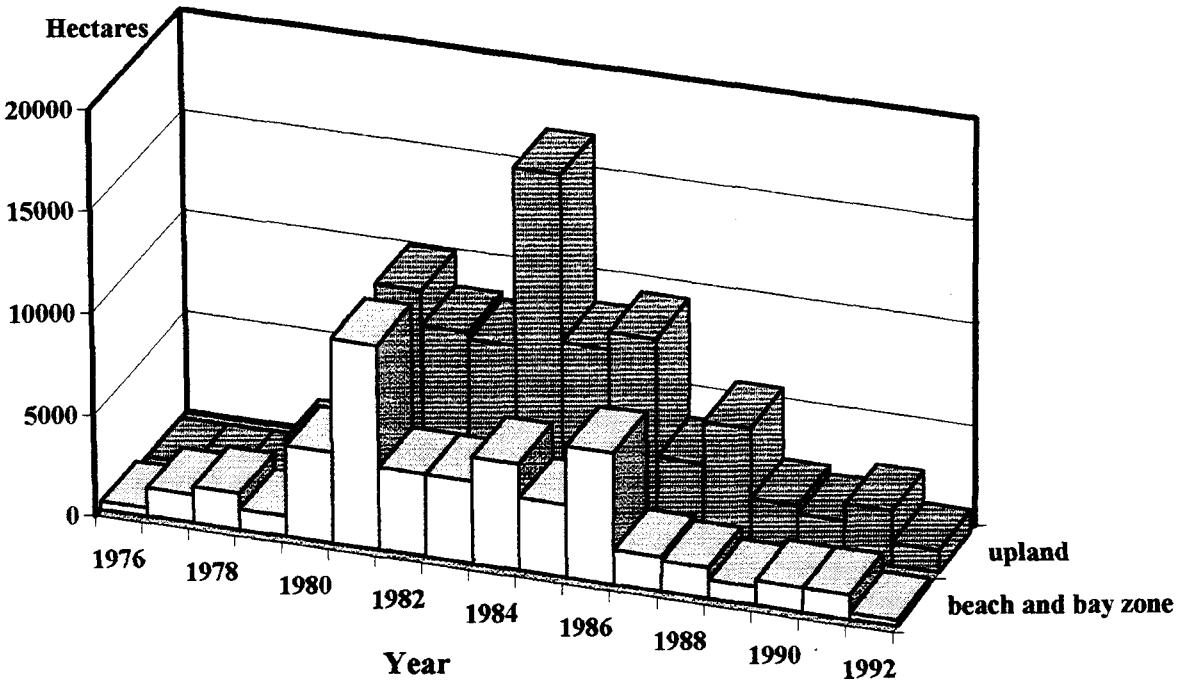


Figure 1. Number of hectares authorized for shrimp farms, by location.

The majority of shrimp farms are in the Guayas and El Oro provinces, bordering the Gulf of Guayaquil.

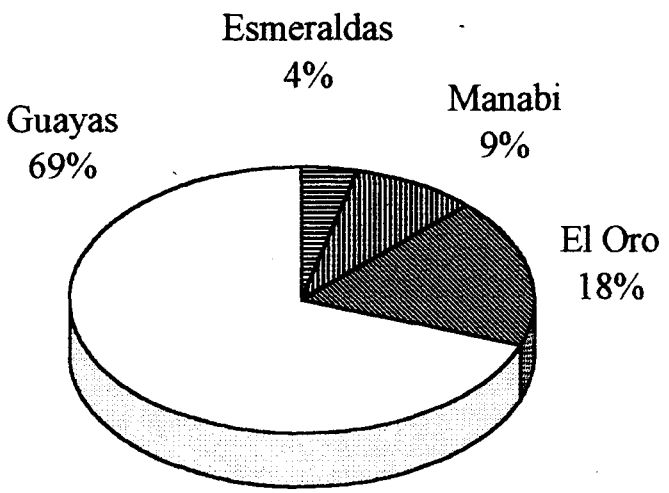


Figure 2. Distribution of shrimp farms by province, 1992.

Nearly half of existing farms are of the extensive type: low-density ponds in which minimal or no supplemental feeding is provided (Figure 3). Relatively few are operating using the advanced technology required for the higher-yielding intensive and semi-intensive farms. National production has grown, mostly due to expansion of cultivated area (Figure 4, Figure 5).

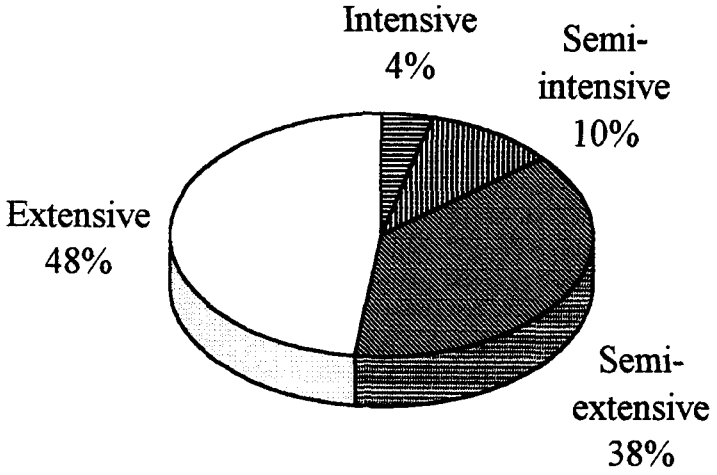


Figure 3. Types of shrimp farms in Ecuador, 1992.

Type of culture	Yields (kilograms of shrimp tails/ha/year)	
	1987	1992
Intensive		1,291
Semi-intensive	272	882
Semi-extensive	544	615
Extensive		405

Source: Cámara de Productores de Camarón (1989 and 1993).

Table 2. Yield per type of culture in 1987 and 1992.

According to the Shrimp Farmers Association (Cámara de Productores de Camarón, 1993), in 1992, some 1,567 firms were involved in the shrimp farming processing and hatcheries, employing 195,000 people. In 1993, approximately 100 shrimp hatcheries were in operation. Overall, however, the employment produced on the farms is relatively low and ranges between 1 and 0.25 people per hectare of shrimp farm (Suárez et al., 1995).

Shrimp exports produce some $500 million per year (Table 3). However, the economic benefits of shrimp farming have flowed primarily to the farm owners. This concentration of wealth has been aided by two factors. First, and most important, the cost of large-scale culture methods that have characterized the industry in Ecuador has put shrimp farming out of reach to all but the wealthy. Second, the industry falls under the Fisheries Law, which requires that all commercial operations should be vertically integrated to include farms, packing houses, and shipping operations (Pérez and Robadue, 1989). This has encouraged the channeling of economic benefits to the wealthier segments of Ecuadorian society and to a number of foreign investors.

Year	Metric tons	Value, US$
1984	21,700	159,840,000
1987	48,912	383,136,000
1990	70,652	340,291,000
1991	103,222	491,371,000
1992	116,315	525,759,000

Source: Cámara de Productores de Camarón.

Table 3. Exports of Ecuadorian shrimp.

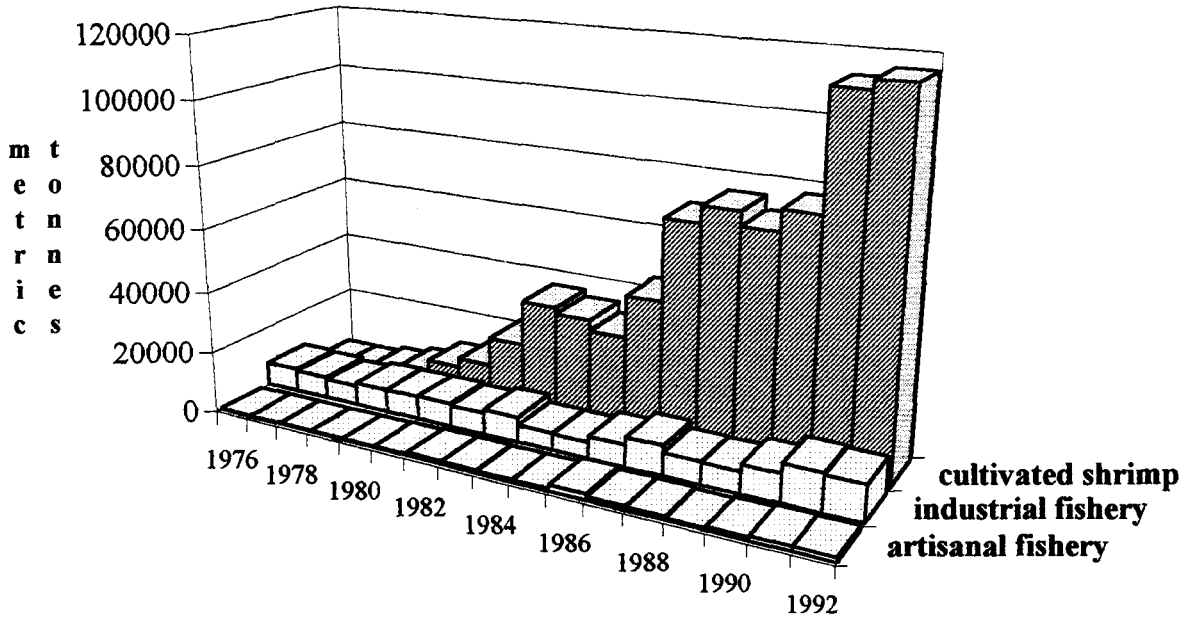


Figure 4. National production of shrimp, by production sector, 1976–1992.

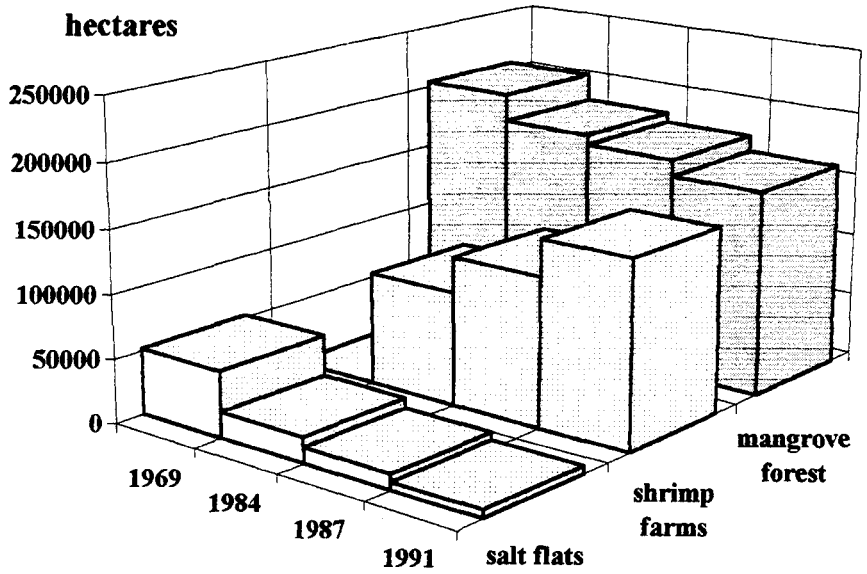


Figure 5. Changes in area of salt flats, shrimp farms, and mangrove forest, 1969–1991.

Social costs and benefits

Shrimp farming has also had major impacts on the poorer segments of society. On the negative side, many thousands of families with largely subsistence livelihoods have been displaced, sometimes forcibly, from the mangroves and estuarine fishing grounds where they had traditionally made their livings (Bravo and Abarca, 1995). Mangrove wetlands, creeks, and flats have either been converted to ponds and intake channels or privatized as buffers to shrimp ponds to which many pond operators do not permit free access. In Bahía de Caráquez alone, communities of mangrove and bay fisherfolk had to migrate to other parts of the coast when shrimp farms destroyed 80 percent of that estuary's mangroves and its once-rich fisheries collapsed. On the positive side, the artisanal fishery for shrimp postlarvae (PL) has been a boon not only to

fisherfolk, but to large numbers of agricultural workers and other low-income groups, some of which have migrated from the Sierra and formed new shorefront communities that are entirely dependent on this new fishery. In two or three days of moon tides, a family of *larveros*—PL fishers—can make as much from this fishery as they can in a month as agricultural workers.

In 1980, the U.S. National Marine Fisheries Service estimated 2,000 to 3,000 *larveros* at work. Sutinen et al. (1989) quoted estimates as high as 90,000 *larveros* by 1985. The Shrimp Farmers Association (Cámara de Productores de Camarón, 1989) estimated 32,000 in 1989, and more recently, the Ecuador National Fisheries Institute examined effort and reported 17,000 people engaged in the fishery during peak periods. Most fishers are part-time and engage in other activities, such as agriculture or other fisheries (Coello et al., 1995).

An additional number of middlemen live by buying PL on the beach and selling to pond operators. The development of this fishery, however, has also led to important social and environmental issues (Coello et al., 1995). Thus, the shrimp farm boom has produced both winners and losers among the poorer segments of society and has certainly brought radical change to the way of life and the structure of communities all along the coast.

Impact on the national budget

Economic returns to the national budget are difficult to estimate. Firms should pay a percent of their net earnings as a tax, but tax evasion is widespread. Ecuador does not have a graduated income tax. A significant proportion of the ponds are sited below the high-water mark, and therefore operate as concessions on public lands. The annual fee for such concessions is less than $10/ha, compared to potential net returns of up to $2,000/ha (Southgate and Whitaker, 1994). In the mid-1980s, the government required growers to export shrimp at a dollar exchange rate some 30 percent below the free market rate. The shrimp industry viewed this as a 30-percent export tax, prompting smuggling on a massive scale. Thus, unlike petroleum, which is a state-owned resource, a relatively small proportion of shrimp export earnings flows to the government to support its programs and meet the annual interest payments on Ecuador's massive national debt.

Impacts on coastal ecosystems

The impacts of shrimp farming on coastal ecosystems may prove to be more profound from a long-term perspective than immediate social impacts may suggest. By 1990, an overflight view would demonstrate that shrimp farming had, in just two decades, engineered every riverine estuary and lagoon along the entire coast, with the exception of the northern reaches of Esmeraldas. The impacts of this development include

- Degraded water quality from the release of nutrients, antibiotics, and other chemicals used in the production process;
- Destruction of wetlands, primarily mangroves, that have been replaced by ponds and water intake channels. Wetlands absorb the nutrients that can produce eutrophic conditions, serve as storm buffers, produce timber, and provide habitat critical to the life cycles of many organisms. They therefore provide services important to both sustainable shrimp farming operations and to estuary uses. Freshwater wetlands have also been affected;
- Diking sand and mud flats and shallow protected waters to make ponds, thereby reducing the area of estuary and its value as a nursery ground for fish and shellfish;
- Alteration of estuarine hydrology by channelization and by controlled flow of water into the ponds;
- Removal of all fish and shellfish, usually in the form of juveniles and larvae, who are carried with the water pumped into the ponds;
- Significant impacts on waterfowl, both in terms of changes in habitat and, on some farms, through the routine shooting of waterfowl that eat, or are believed to eat, shrimp; and
- Problems posed by the introduction of exotic species. There are no controls over the introduction or release of exotic species, and this can have significant effects on the ecology of the affected area.

Another set of impacts is brought by the need for large numbers of wild-caught postlarval shrimp, which are the backbone of Ecuador's mariculture industry, and by demand for the egg-bearing females required by many hatcheries. The combination of heavy fishing pressure by pre-existing trawler fisheries, new fisheries for shrimp postlarvae and egg-bearing females, and losses in estuarine habitat have led to major reductions in shrimp stocks in Southeast Asia, and are likely to eventually reduce the wild stocks in Ecuador.

INITIAL OBJECTIVES AND STRATEGIES IN MARICULTURE: 1985–1987

In its proposal to the U.S. Agency for International Development (USAID) in 1985, the University of Rhode Island's Coastal Resources Center (CRC) recognized that shrimp mariculture is the most powerful agent of ecosystem change in Ecuador's estuaries, and presumed that the industry would be a major focus of the project. This was confirmed in early 1986, when Ecuador's ambassador to the United States contacted the CRC project director and asked for assistance in defining a closed season for the postlarvae fishery. At the time, Ecuador was in an inter-El Niño period of low rainfall and low sea temperatures, and the wild postlarvae used to stock the shrimp ponds were scarce. Advisors to the government had concluded that this scarcity, which had brought crisis to the shrimp mariculture industry, was caused by overfishing in the artisanal postlarvae fishery and decided that annual closed seasons were the best remedy. The PMRC argued that a comprehensive review of the ecological, economic, and technical issues affecting the industry would be more appropriate and useful. The first-year work plan therefore called for drawing together some of the best available international expertise to work with the industry in Ecuador, and formulating an integrated strategy for a sustainable shrimp mariculture industry. This became the dominant activity during 1986.

According to the Year 1 work plan, the objective of the collaborative analysis was "to build consensus on the scope and nature of the problems and opportunities now facing the shrimp industry in Ecuador and, if possible, to lay the groundwork for a coordinated governmental agency-industry strategy for managing the industry."

The major strategies selected for achieving this objective were to

- Use the crisis brought by the scarcity of postlarvae (half the ponds were idle in 1985) to bring together representatives of the government and the industry and internationally renowned specialists to jointly define the issues and a common approach to the problems and opportunities facing the industry. This collaborative analysis would be accomplished through the joint preparation of papers, teaming Ecuadorians with foreign specialists. These papers would then be the basis for a workshop in Guayaquil. Facilitated meeting procedures, which had been successfully used by CRC in similar efforts in the United States and Sri Lanka, would assure that all views were heard and, where possible, consensus achieved through an open but structured process. Simultaneous translation was used, and various social events arranged to promote dialogue. The conference room of the Banco Central in Guayaquil was selected as the only facility large enough to accommodate all the industry representatives that were expected to attend.

- Be ready to follow up immediately with selected activities. The USAID Mission pledged $50,000 for follow-up. Selected activities would actively involve the industry in resource management-related initiatives. Those with the biggest potential for producing tangible short-term impacts would be emphasized.

- Apply a legal/institutional team to an issue-driven analysis of the structure and procedures of the governance system that affects the mariculture industry.

An integrated strategy to promote a sustainable shrimp mariculture industry in Ecuador

The highlights of the ideas generated by the symposium were immediately integrated and summarized in *An Integrated Strategy to Promote a Sustainable Shrimp Mariculture Industry in Ecuador* (Olsen and Figueroa, 1986). The strategy consisted of seven elements (see Annex III for full text of the summary):

1. Maintain water quality in estuaries and near shrimp hatcheries.

Low growth rates and occasional mass mortalities due to poor water quality are already problems for some hatcheries and growout operations. Development trends in coastal watersheds suggest that further reductions in water quality are to be expected unless mitigating actions are quickly taken.

2. Protect and manage the wild shrimp stocks that provide the most abundant and cheapest sources of seed shrimp to the industry.

This requires the protection of critical habitats, including mangroves, and safeguards against overexploitation by fisheries for adult shrimp and PL.

3. Engage in a strategic planning process to optimize the long-term economic vitality of the industry.

Tracking trends in the world shrimp markets, ensuring product quality control, and forecasting the impacts of declining water quality on the industry are all urgent priorities.

4. Overhaul and simplify the permit system governing the siting and operation of ponds and hatcheries.

5. Critically evaluate the impacts of national policy on the shrimp industry, as the policy is applied through the Fisheries Development Law.

6. Initiate a targeted technical assistance program to promote information exchange within the industry.

7. Initiate a public education program to help build support for the measures needed to protect the environmental quality that the shrimp industry requires.

The assessment process concluded that the greatest single threat to the sustainability of shrimp farming was declining water quality brought by a combination of

- Reductions to the absorptive capacity of estuaries, caused by destruction of mangrove wet lands and reductions in water exchange;
- Increased loadings of nutrients from both shrimp pond discharges and untreated sewage from rapidly expanding urban areas;
- Increased loadings of toxics from agrochemicals and industrial wastes; and
- Reduced inflow of fresh water, and reduced periodic freshwater flushes brought by dams and the redirection of river water from estuaries to irrigated agriculture.

Unfortunately, declining water quality and other problems foreseen by the strategy have been borne out in subsequent years as the major issues that threaten the sustainability of the industry.

After the workshop, the project immediately committed to two follow-up tasks:

- Design a research and extension program directed at reducing the mortality of wild-caught PL; and

- Design and implement a coastwide water quality monitoring program (seepage 95)

Mariculture industry response to the initial strategy

Participation of industry representatives in the workshop was very limited, due to a mix of logistical problems and a miscalculation of industry interest in such a broad-based assessment. Shrimp pond operators were highly skeptical of any attempt to address, with government, the resource management issues raised by their industry. They welcomed technical assistance on

specific, immediate problems, such as water quality analysis in specific locations where problems were believed to exist, but not more open-ended activities. Furthermore, in 1987, when the strategy was distributed, the postlarvae were again abundant and the perception of crisis—and therefore the perceived need for resource management initiatives—evaporated. The government canceled the dual exchange rate, ending the tax on shrimp exports, and classified all mangroves as "reserved forest." This made any form of cutting or reclamation illegal—and this again was viewed as all that could reasonably be done by government and a "management program" about that problem. The net result was that there was little interest, on the part of either government or industry, in following up on the strategy as a whole.

Initial PMRC actions

Research on postlarvae mortality began immediately after the workshop. It included experiments at what later became the ESPOL-based National Center for Aquaculture and Marine Research (CENAIM) on the impacts of different handling methods on long-term survival, documentation of the composition of bycatch, and initial trials of extension to *larveros*, including field demonstrations and television spots on the best technologies. Problems with the quality of this work and disagreements over the working style of the consultant led to cancellation of the postlarvae mortality study late in 1987.

A water quality working group (seepage 100), modeled on the mangrove working group, was formed, and began its initial work of synthesizing existing data, identifying water quality "hot spots" and conducting intercalibration exercises.

Research on the ecological services and functions of mangroves was undertaken, funded through the USAID Office of the Science Advisor.

A SECOND ATTEMPT: A NATIONAL STRATEGY TO DIVERSIFY MARICULTURE IN ECUADOR

In the 1980s, the shrimp industry began to experiment with the culture of species other than shrimp. Crayfish, Pacific oyster, mussels, several finfish, and algae have been raised at pilot and small commercial scale. Much of the work has been conducted at CENAIM, funded and partially staffed by the Japanese foreign assistance program.

Experience with a CRC project in Thailand demonstrated that different approaches to mariculture were not only technically possible, but could produce both a more sustainable mariculture industry and a better distribution of the benefits of mariculture within coastal societies. Observations in Thailand and reports from other nations in Southeast Asia suggested the following:

- Dense development of shrimp mariculture farms can have such a large impact on the ecology of the adjoining estuary that the industry collapses, and large areas of formerly productive shrimp ponds have to be abandoned.

- Culture techniques for a wide variety of fish, mollusks, and crustaceans can be adapted to a great diversity of coastal habitats. The livelihoods of traditional fisherfolk and mangrove dwellers have declined, the protein intake of Ecuador's population is falling, and an increasingly high proportion of the population is malnourished. New culture techniques can provide livelihoods for significant numbers of artisanal mariculturists, and can produce food for local use at a reasonable price.

- Shrimp mariculture can be conducted through a wide variety of production strategies that can greatly increase the yield per hectare and also provide greater benefits to the resident population than has occurred in Ecuador. We were intrigued, for example, by the strategies of Aquastar, a multinational company in southern Thailand, that was successfully transforming small-scale rice farms into shrimp farms that provided families with a greatly increased income without depriving them of the ownership of their land.

- Throughout Southeast Asia, fishing pressure for adults, gravid females, and, at the initial stages of shrimp mariculture, shrimp postlarvae, has drastically reduced wild stocks of shrimp.

This experience reinforced concern that the combination of habitat loss and increasing fishing pressure would eventually lead to major declines or a collapse in *Penaeus vannamei* stocks—with disastrous consequences for both the industry and large numbers of artisanal fishermen.

These observations reinforced the conclusion of the strategy released in 1986. They also reaffirmed that major benefits would result from national-level action to bring together the mariculture industry and government to increase the sustainability of the industry from both a social and an ecological perspective. By 1988, the success of a provincial profiling process (seepage 180), and the development of a base of public support for coastal resource management at the community level prompted us to make another attempt to engage the shrimp mariculture industry at a national level.

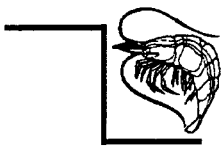
The second strategy was to focus our efforts on diversification of the industry. It began by bringing two eminent people to Ecuador to view the situation and make specific, practical recommendations for action. The first of these was H.T. Odum, who, with his brother, has defined the contemporary science of ecology. He has subsequently developed new approaches to formulating management strategies based on the functioning and characteristics of specific ecosystems. The second, Chua Thia-Eng, pioneered diversified mariculture technologies in Southeast Asia, and subsequently became the director of the mariculture section in the U.N. Food and Agriculture Organization (FAO). At the time of his work in Ecuador, he was director of the International Center for Living Aquatic Resources Management (ICLARM) Coastal Management Project. Our strategy was that these two individuals would provide an impetus for reaffirming the concepts that emerged from the 1986 symposium, and provide specific ideas for a national plan on the concept of diversification within the mariculture industry.

Recommendations of H.T. Odum

Odum confirmed and amplified the concerns of other ecologists who had examined the prospects for a sustainable shrimp mariculture industry from a systems ecology point of view. These studies include an analysis made by Snedaker et al. (1986), and Twilley (1989). Odum argued forcefully that the redirection of river water—and the organic and inorganic matter it contains—into irrigated agriculture would profoundly change the ecology of Ecuador's estuaries, and in many cases could be expected to significantly reduce their productivity. Not only is the volume of fresh water and the nutrients it contains being reduced by the construction of dams in irrigation projects, but the periodic flushes of fresh water associated with El Niño events are being modified. During dry inter-El Niño periods, and when the rainfall associated with El Niño years is moderate, the average flow that these systems receive will be reduced. Odum argues that such changes will reduce the ecological advantage of *P. vannamei*, which is uniquely adapted to a highly variable fresh water-salinity regime. These changes, he says, will also reduce the mangrove production, fish and shellfish production, and associated mariculture production of Ecuador's estuaries. The increased loading of agrochemicals and human sewage that will result from more intensive agricultural production and a growing human population will only exacerbate these impacts. Some of these effects, unfortunately, are already being experienced in the Gulf of Guayaquil.

Odum made a series of observations and preliminary ecological models of shrimp ponds. The recommendations that he made based on an ecosystem analysis of these man-made systems are entirely consistent with those made by Chua a year later. Like Chua, he recommended making the average depth of ponds greater to reduce biological activity on pond bottoms, reengineering the water delivery and flushing systems, experimenting with a number of polyculture techniques to reduce the nutrient loads in pond discharge waters, and managing the ecology of ponds to increase their stability and make better use of predator/prey relationships within these systems.

By far the most novel and controversial observations and recommendations are those stemming from the application of "emergy" analysis to shrimp mariculture in Ecuador (Odum and Arding, 1991). Emergy analysis has been developed by Odum as an accounting tool to calculate the value



of a resource or a product based on its production process. This requires converting all measures of value into a common set of units—usually solar energy equivalents. Emergy analysis is not helpful when attempting to ascribe a market value to a product, but it is a powerful tool for analyzing the relative contributions of nature and human work to producing a product. It offers a means for estimating the value of natural resources, the "work of nature," human work and manmade products all on the same scale, utilizing common units. Traditional economics, on the other hand, ultimately relies on setting the value of something in terms of what people perceive that value to be, either through the forces of the market, or through a number of hedonic, non-market techniques. Neoclassical economics asserts that selfishly motivated individual free choice ultimately leads to maximizing benefits for society. Odum contends that market prices are largely irrelevant when attempting to estimate public wealth. The application of emergy analysis to shrimp mariculture in Ecuador can help elucidate the public policy implications of transforming the natural wealth of Ecuador's estuaries to an export commodity. This is discussed in a paper by Olsen (in press).

Recommendations of Chua Thia-Eng

Chua was accompanied by Pinij Kungvankij, selected for his detailed knowledge of the techniques and technologies of shrimp production in ponds. Chua and Kungvankij concluded that a set of national policies and a national action plan were urgently needed. They were confident that such a plan, if effectively implemented, would have a major positive impact on the industry (Chua and Kungvankij, 1991). Their recommendations can be summarized as follows:

Pond production

Ecuador's very large, irregular, and shallow ponds are inefficient and difficult to manage. Production per unit area in 1990 was approximately 600 kilograms (kg)/ha/year (in two crops). Chua recommended adopting a national goal of increasing the average yield to 1,500 kg/ha/year. He was confident that in Southeast Asia, where government is more effective, and collaboration between government and the private sector has an established tradition, this goal would be readily achievable in four years. He recognized that in Ecuador, the social-institutional climate would make this more difficult. This dramatic increase in production would be achieved by:

- Modifying and standardizing pond design

  - Redesign ponds to standardized shape, 2 to 5 ha in size.
  - Increase the depth of all ponds to 1.8 meters.
  - Improve water exchange and water flow by reengineering channels for intake and discharge waters, aerating ponds, and periodically removing pond sediments.
  - Improve feeds and feeding regimes.

- Reducing the area of ponds from 140,000 ha to 100,000 ha and prohibiting further pond construction

  -Replant reclaimed ponds with mangroves and reestablish greater tidal exchange.

- Stabilizing the availability of postlarvae to assure a base of 30 billion larvae per year from a combination of hatchery and wild caught-sources.

These strategies do not present any unusual technical difficulties. Any problems in implementation lie in the attitudes of the people concerned and in the absence of a tradition of collaborative action—both within the industry itself and between industry and government. Ten strategies are suggested for promoting such collaboration:

- Develop extension projects and demonstration farms to: promote technologies for increasing the productivity of individual ponds; promote small-scale hatcheries; and improve nets for harvesting wild postlarvae.

- Increase the quality and value of wild-caught postlarvae by improving collecting apparatus and establishing government-sponsored or foreign-donor–supported seed banks at harvesting sites.
- Provide government incentives—such as low-interest loans and reduced taxes on highly productive shrimp farms—for the establishment of small-scale hatcheries.
- Replant mangroves in abandoned ponds and unused estuarine areas through foreign assistance projects and community initiatives. Not fewer than 27,000 ha of mangroves should be planted.
- Regularly monitor estuarine water quality and publish the results widely.
- Strengthen the implementation of existing closed seasons in fisheries and strictly prohibit the use of all mechanically assisted means of harvesting shrimp postlarvae.
- Develop a critical mass of technicians in all aspects of hatchery and shrimp pond operations.
- Create a consultative commission for the development of mariculture—composed of representatives of government, the private sector, and research institutions.
- Strengthen both human capacity and facilities of research institutions.
- Encourage the formation of a professional association to promote interaction among scientists, aquaculturists, and fishermen in order to improve the dissemination of technologies within the country.

Diversification of mariculture

Chua and Kungvankij saw many possibilities for diversifying the mariculture industry, thereby increasing its sustainability and distributing benefits more widely within Ecuadorian society. They also recognized that there was no tradition or experience with mariculture for species other than shrimp in Ecuador, and that this was the major impediment to progress. As long as the industry was controlled by individuals whose interest in mariculture is limited to making a substantial profit in an export business, it would be difficult to promote mariculture as a means for providing livelihoods to low-income groups and providing "food for the people." Echoing the recommendations of Odum, Chua saw a number of possibilities for promoting multiculture techniques that would have a direct benefit on shrimp farming by reducing the nutrient loads in shrimp pond discharge waters and thereby improve water quality in a given estuary. A number of suggestions were made for promising species and cultivation techniques. Chua also underscored the need for government to get involved in providing the initial research, extension, and credit to establish new forms of mariculture.

The recommendations of Odum and Chua provided a detailed agenda for action that was far more specific than the more conceptual strategy produced in 1987. The PMRC now had a set of ideas that could be debated at the national level and could lead to a productive relationship with the shrimp industry.

A structured dialogue between industry and government

In 1990, the second attempt was made to engage the shrimp industry. The objective, as in 1986, was to promote a policy dialogue at the national level (track one—see page 15). Representatives of the shrimp industry and the government agencies involved, we hoped, would work together to develop a national plan for a diversified mariculture industry that built on the observations and recommendations of Chua and Odum. We planned to discuss important topics in small working groups that would then present a high-level interinstitutional committee with elements of a plan of action.

The initial response to this initiative was positive, with both government officials and representatives of the industry agreeing that a coherent national strategy—developed through a collaborative process involving both the private and public sectors—was needed. All parties also openly recognized that the lack of trust between the public and private sector would be the principal obstacle to the preparation, and above all the implementation, of any plan. For example, there was considerable concern within the industry that any agreement on the basic characteristics of the industry and the opportunities that lay before it would sooner or later result in increased taxes. At an initial meeting, a spokesman for the industry observed that their primary objective was to maximize the value of exports. He suggested that the agenda should be limited only to those actions that could bring increased short-term earnings to the export of farm-grown shrimp. Thus, once again, the broader objectives of the coastal management program found little support within the industry.

In February 1991, an outbreak of cholera produced a dramatic new threat to shrimp exports. In the atmosphere of a major national crisis, the Committee for the Prevention of Cholera in Bioaquatic Ecuadorian Products was created, through Ministerial Agreement 167. This was also structured as a public/private-sector initiative, with many of the same agencies and individuals that had agreed to serve on the PMRC's interinstitutional committee. This new committee immediately set to work with great efficiency in designing and implementing a program of controls and assurances to protect the sale of seafood products both in-country and in international markets. The work of this committee and its effective collaboration with the ministries of Health and Education, as well as with government agencies involved in the industry, demonstrated that when incentives are high enough, collaboration among several agencies of government and the private sector is indeed possible. The positive impacts of a well thought-out and effectively implemented strategy were equally dramatic.

The epidemic began in February 1991, peaked in April, and then declined. Throughout this period, seafood products were sold, both nationally and internationally. Yet even after this display of effective public/private collaboration, the same agencies and individuals were skeptical of any broad-based attempt to collaborate in the overall development of Ecuador's mariculture industry.

THE THIRD STRATEGY: RESEARCH AND EXTENSION WITHIN THE ZEMS

The special area management zones (ZEMs—see page 149), as microcosms of the situation along the coast, reflected lack of interest by the wealthier segments of society in rethinking resource management: Only a few of the owners of large shrimp farms expressed any interest in an integrated planning process. By contrast, however, interest among user groups and commitment to a process that promised to resolve pressing resource management issues was at times overwhelming. The difference in the focus of national representatives of the shrimp industry and ZEM user groups was obvious. The focus of the industry was sectoral, short-term, and aimed at increasing profits and use of natural resources. In contrast, ZEM user groups had a holistic perspective of the use and management of natural resources. Their aim was to recover or maintain the resource base. Such contrasts were discussed at length at the PMRC's annual self-assessment and work plan formulation workshop in mid-1991. The result was a decision to focus the program's technical efforts on the five ZEMs and thus to once again reformulate our objectives and strategies to address issues raised by mariculture.

In the ZEMs it was clear that mariculture, fisheries, and mangrove management issues would have to be viewed as a closely interwoven set of issues. This was precisely what the project had hoped to do since it began in 1986. In the ZEMs we found large and vocal constituencies clamoring for the same approach that we believed would be most useful. Several aspects of the situation of mariculture development contributed to this need:

- A large portion of these outspoken constituencies were hunters and gatherers—shellfishers, crabbers, *larveros*, artisanal finfishers—who had been seriously affected by recent declines in the condition of estuarine ecosystems. To these people, the increasing scarcity of the resources upon which they depended was all too obvious. Not only did this reduce prospects for a cash income, but the need for money was becoming greater as they were forced to purchase what

they could previously gather. The most dramatic case was in the Rio Chone ZEM, where a large community of estuarine fisherfolk renowned along the coast for their skills as crabbers, shellfishers, and harvesters of estuarine finfish saw, in the space of 15 years, 85 percent of the mangroves and all of the salt flats in their estuary converted to shrimp farms. The great majority of these families had been forced to move to other estuaries along the coast, and the few that remained had to supplement their incomes by working as agricultural day laborers and domestic servants.

- Many groups had been forcibly displaced from traditional fishing and gathering grounds. By giving concessions to use salt flats and mangrove areas for shrimp farming, the concept of "private property" has been introduced to areas used as common property by coastal communities. Not only did shrimp ponds convert former mangrove wetlands to ponds, but they claimed buffer zones around their farms, from which local people have been excluded by armed guards and dogs.

- Many subsistence coastal communities are ill-prepared to enter a market economy. Many people were proud of their abilities as fisherfolk and "mangrove people." In the new context, they have found their knowledge and skills to have little value. This affects their self-esteem, and leaves them without the necessary skills required to pursue other livelihoods. In the case of Bunche, a traditional village of "mangrove people" in the Esmeraldas ZEM, 55 percent of the shellfisherwomen and 13 percent of their husbands are illiterate. Ninety-five percent of the husbands have been unable to find stable jobs and frequently must survive six to nine months with no employment. It is hardly surprising that 84 percent of the shellfisherwomen of Bunche believe that their quality of life has declined since shrimp farms began moving into their estuary (Bravo and Abarca, 1995). In some communities, the sense of poverty has reached profound levels. People have come to believe that there is no escape from a degraded existence. In addition, their low level of education, income, and wealth limited their capacity to initiate alternative activities. The only viable options for these groups have been to intensify the use of the resource or to exploit a new one, for instance, PL.

- Alternative livelihoods in mariculture, agriculture, or tourism all depend on the condition of local ecosystems. It is obvious to coastal people that when both the magnitude and the condition of the resources available to them diminish, their future is bleak. A widespread concern, often expressed at meetings, is for their future and that of their children.

Such attitudes contrast sharply with those of the wealthier and better-educated segment of coastal society. The quality of life of these people does not depend directly on the quality of the local environment. To a considerable degree, they can isolate themselves from environmental degradation, and invest in a variety of activities that can, at least over the short term, maintain quality of life.

Developing the new strategy

In 1990, the first set of practical exercises in resource management (seepage 197) were undertaken. Designed to encourage community structure, the design and execution of these projects was primarily the responsibility of the local people involved. While this strategy often produced excellent results for such activities as solid waste collection and disposal, the results were less than satisfactory when the projects required a greater level of technical competence. Two of these initial practical exercises involved the construction and operation of village collection centers for shrimp PL in Valdivia (Guayas province) and Bunche (Esmeraldas province). Although similar centers are run successfully elsewhere on the coast, both of these projects failed due to poor design and lack of experience in setting up simple administrative procedures. Issues such as the physical design of the facility and ground rules for membership in a community-based center brought conflict and inefficiency. This experience convinced the PMRC staff that its limited resources (one full-time person and a very small operating budget) needed to be directed exclusively at mariculture and fisheries-related activities in the ZEMs. Thus, the conclusions that emerge from the PMRC's self-assessment process demonstrated that the staff lacked the basic information required to understand the priority mariculture management issues in the ZEMs as they are perceived by

the poor. We needed to know whether it was feasible to culture any of the three species of cockles that are traditionally fished in Ecuador's estuaries, or what it would take to restore the abundance of mangrove crab. Perhaps most important, the staff needed to gain experience in offering technical assistance to rural groups. Thus, the objectives of the third and final strategy were to

- Develop the capacity of the PMRC to work on the priority issues posed by mariculture in the ZEMs. This would include providing technical assistance to user groups and developing the methods and tools for working with rural communities. We could then help them to develop their ideas and work with them to identify actions to help them succeed in selected activities. To accomplish this, the PMRC had to obtain the necessary information to understand the major issues posed by mariculture in the ZEMs, including differences in the priorities and points of view of different user groups, such as shellfisherfolk, shrimp growers, larvae fishers, and artisanal finfishers.

- Develop detailed policies and actions for mariculture-related activities in each ZEM that could be incorporated into the ZEM plans.

Implementing the strategy

A mariculture working group

The first step in implementing this third strategy was to assemble a mariculture working group. This drew together individuals from a number of institutions, primarily in Guayaquil, including a number of university students. Building on the experience of the mangrove and the water quality working groups, a set of principles governed the formation of this group:

- The members of the working group did not formally represent their institutions. Those who joined the group did so out of professional interest, and not because they were assigned to the project by their superiors. In several cases, the experience of individual members, however, eventually drew their institutions into the PMRC process and resulted in formal arrangements between the PMRC and that institution.

- The group was supported by a small operating fund assigned each year through the annual work plan design process.

- All members of the working group actively participated in planning the tasks to be carried out each year. All tasks were discussed and revised by the entire group before any proposal was made to the PMRC.

- Once a task had been incorporated into the PMRC work plan, disbursement of funds and administrative decisions required to implement approved tasks occurred quickly (usually within 48 hours).

- Monthly meetings assured that all members of the group were well-informed of ongoing events and felt part of a collaborative learning process.

- Work tasks were based on the priorities of each ZEM, as expressed by the ZEM committee and the ZEM plan.

- A commitment was made to capacity building, since it is the policy of the PMRC to invest in those associated with the program—in this case, by offering training and support to attend relevant local meetings and workshops.

These principles contrast quite sharply with the traditional operating procedures of institutions and foreign assistance projects in Ecuador. The PMRC's strong emphasis on an open and participatory process is unusual and sometimes requires difficult adjustments. For example, the emphasis on involving members of the community in all phases of the working group's activities was particularly difficult for scientists who had never before been encouraged to explain to poor

villagers what they were doing, why they were doing it, and what they hoped to accomplish. In most cases, however, such participants, after an initial phase of adjustment, found this approach highly rewarding, providing them with a sense of purpose and feedback loops that they had not previously experienced. The working group began to assemble in the first months of Project Year 7 (1991). In Year 8, after some initial experience in attempting to provide extension services to PL fishermen and shellfishermen, CRC organized a workshop on extension philosophy and techniques. The approach subsequently adopted by the working group consists of four basic steps:

- Identifying innovators within the target community;
- Focusing efforts to teach a new technique or approach to these selected individuals;
- Providing moral and technical support to the innovators during the period in which they try out and adopt the new techniques or tools; and
- Recycling the experience gained by the extension team and community innovators before promoting wider use within the community or among user groups.

This approach served the working group well in a number of projects involving various groups of fishers in artisanal-scale mariculture activities. A summary of activities carried out by the working group in the ZEMs is given in Table 4.

Some examples of extension and applied research

Cockle growing program

The shellfisherwomen's association of Bunche was very concerned that the populations of *concha prieta* (*Andara tuberculosa* and *A. similis*), a cockle that grows in the mangroves, were diminishing. A decade ago, when the resource was more abundant, the fishers would leave behind cockles less than 3 centimeters long, which have no market value. Today, however, the practice has changed to keeping all shellfish harvested, regardless of size, and using the undersize portion of the catch to feed the family. The question posed to the mariculture group was, "Can you suggest some better way to use these undersized shellfish?" The response of the working group was to experiment with techniques for fattening cockles. One of the members of the team, a member of the biology school at the University of Guayaquil, worked 15 days a month in the community, testing growout of undersized cockles in an intertidal plot near the village and in submerged wooden boxes. The results (Bravo and Abarca, 1995) showed that cockles in the intertidal mud flats grew at an average rate of 0.12 millimeters (mm) per month, which is the expected growth rate under natural conditions. The cockles placed in wooden boxes, however, grew much more rapidly—1.49 mm per month, 1.31 mm per month, and 1.36 mm per month—at densities of 50, 100, and 200 cockles per square meter, respectively. The shellfisherwomen watched these experiments with great interest, but most were unwilling to invest in either form of culture while the experiment was underway. One woman, however, did start her own intertidal fattening plot, but her shellfish were robbed several months later. When the first harvest of cockles grown in boxes was made, there was a surge of interest, and many fishers set about building and seeding growout boxes. In 1992, each box could be built for approximately $3, or considerably less if local materials were used. Eventually, however, the fattening technique was abandoned. The reason given by the fishers is that each box contains the equivalent of a single day's harvest—between 100 and 300 market-sized shellfish—and that the costs and labor of building the box and watching over it for 10 to 12 months is not worth the effort.

Bycatch reduction

A major focus of the working group has been to reduce the mortality of bycatch in the postlarvae fishery. The group worked closely with a research project—initially funded by British foreign assistance, and carried out by the National Fisheries Institute—that documented the size and composition of the bycatch. It was found to be very significant and included large numbers of larval mollusks, crabs, and finfish of economic significance. Unfortunately, numerous efforts to

convince larvae fishermen that they should return the bycatch to the water, rather than dumping it on the beach, had no results. The fishermen pointed out that returning the bycatch to the sea increases their labor, since returning such "rubbish" to the same piece of water in which they and others are actively fishing merely means it will be caught and have to be resorted. An alternative, suggested by Chua, has been to design a new fishing net that allows a proportion of undesired species to escape, and reduces abrasion to the animals concentrated in the end of the net while it is fishing. Such a net was designed, tested, and refined by a member of the working group and has proven popular with a number of fishermen. This therefore provides an example of a tangible success in extension.

Mariculture management recommendation	Action examples in ZEMs (1990–1994)
Public education and awareness program 1991–1993	• Presentations, site visits, school programs, community discussions, simple education materials.
Water quality monitoring 1990–1993	• Focus on needs of Rio Atacames shrimp farmers. • Monitoring program and work with local volunteers in Rio Chone.
Reduce mortality of shrimp postlarvae capture 1992–1993	• San Pedro, Playas: training and extension program for PL fishers. • Shrimp larvae collecting training workshops in all ZEMs in 1992. • Development, testing, and dissemination of new net for *larveros*.
Establish larvae collection centers	• Bunche project to create collection center. • Assessment of *precriaderos* in Canoa and Machala. • Assistance to Valdivia *precriaderos*.
Reforest shrimp canals	• Test in Rio Atacames and initiatives in Rio Chone.
Diversify mariculture	• Identification of issues in Bunche. • Development of fattening techniques for cockles.
Criteria to control impact of shrimp ponds on surrounding areas	• User group agreement among traditional users, authorities, and shrimp farmers, resolution of conflict over shrimp farm water intake canal, Rio Atacames.
Buffer zones around shrimp ponds	• User group agreement, Rio Muisne.
Freshwater aquaculture	• Study of freshwater wetlands in La Segua, Rio Chone, funded by United Nations Environment Programme.

Table 4. Summary of mariculture mangement actions carried out in the ZEMs.

Mariculture and fisheries policies in the ZEM plans

A major feature of the each of the five ZEM plans is policies and proposed activities for mariculture and fisheries. As with the other issues addressed in the plans, the PMRC and the local ZEM committees generated and tested a number of ideas that have national policy implications. A list of the policies and actions proposed in the various ZEM plans is given in Table 5.

Policies	Actions
Atacames-Súa-Muisne ZEM	
3.5.1 Regulate shrimp fisheries in all life cycle stages, from postlarvae to gravid female.	• Reduce mortality of PL fishery. • Study the distribution and abundance of shrimp. • Strengthen and enforce fishing regulations.
3.5.2 Fix the boundaries of shrimp farms and permit no further expansion; create buffer zones and areas for permitting artisanal shrimp, crab, and shellfisheries.	• Control shrimp pond concessions and enforce laws against illegal ponds. • Install buffer zones around shrimp farms.
3.5.3 Provide technical assistance to improve the efficiency of shrimp ponds, laboratories, and *precriaderos* (artisanal postlarvae growout ponds), diversify mariculture, and reduce the impacts of shrimp pond operations.	• Test methods for fish and shellfish culture in the Rio Muisne. • Conduct technical assistance program for shrimp ponds and laboratories.
Bahía de Caráquez-San Vicente-Canoa ZEM	
3.4.1 Prohibit construction of any additional shrimp ponds in the Rio Chone.	• Prohibit the expansion of shrimp ponds. • Protect ecologically important sections of the Rio Chone estuary, such as mangrove islands and freshwater wetlands; set precise boundaries for shrimp ponds. • Provide extension for *precriadero* operators.
4.1.1 Create an estuary management plan for the Rio Chone for the year 2000.	• Strengthen the estuary management process, including committees, working groups, special studies, management options, pilot projects, and public education.
4.3.1 Develop a program to restore the water quality in the Rio Chone.	• Identify point and nonpoint pollution sources. • Develop a water use zoning scheme to guide pollution control. • Create a permanent monitoring program for the estuary. • Implement a pollution source reduction program. • Assure a permanent flow of fresh water to the estuary.
4.4.1 Study the ecology of freshwater wetlands and promote sustainable uses. 4.9.1 Promote sustainable mariculture by improving pond production efficiency, reduce negative environmental impacts, and experiment with new forms of mariculture.	• Investigate the biology of traditional cultivated species, and examine the potential for expanding this activity. • Improve the productivity of artisanal *precriaderos*. • Improve the management of shrimp ponds, by examining critical management intervention points, build shrimp farmer involvement and organization, install a water quality analysis lab. • Diversify mariculture activities, focusing on native species, pilot projects with multiple species mariculture, and local shellfish species.

Table 5. Examples of policies and proposed actions on mariculture and fisheries in the ZEM plans.

- Initiate technical assistance to the industry.

The government of Ecuador greatly expanded ESPOL's coastal laboratory into a center for aquaculture research and development in 1990 through a major donation by the Japanese foreign assistance agency. CENAIM has focused on providing technical information for large-scale producers, and is working on mariculture diversification activities. Up to now, CENAIM has not been able to play a major role in promoting broad-based extension services to those shrimp farmers unable to finance their own teams of shrimp pond biologists and technicians. It also faces the obstacles presented by shrimp farmers' reluctance to share information on operating practices. This sharing of information is the hallmark of effective extension.

- Use public education to promote environmental quality.

The PMRC's collaboration with the Fundación Pedro Vicente Maldonado to strengthen public awareness and education programs in the ZEMs (see page 179) has changed the perceptions, attitudes, and actions of coastal resource users—including the local mariculture industry. A similar strategy has been formulated for the severe conflicts in 1995 over the development of mariculture in northern Esmeraldas province—the source of a heated national debate between industry leaders and environmental groups. The PMRC approach has helped resolve site-specific issues through awareness-building, negotiation, and user group agreements. This work requires adequate staffing, a long-term commitment to monitoring industry activities, supervision of permits and agreements, and reinforcement of the positive image that an open decision-making process creates for both the community and developers. It will be necessary in the future for the sectoral agencies themselves to adopt and carry out regulatory programs in ways that are feasible for farm builders and operators to accept and to implement.

Policies	Actions
Atacames-Súa-Muisne ZEM	
3.5.1 Regulate shrimp fisheries in all life cycle stages, from postlarvae to gravid female.	• Reduce mortality of PL fishery. • Study the distribution and abundance of shrimp. • Strengthen and enforce fishing regulations.
3.5.2 Fix the boundaries of shrimp farms and permit no further expansion; create buffer zones and areas for permitting artisanal shrimp, crab, and shellfisheries.	• Control shrimp pond concessions and enforce laws against illegal ponds. • Install buffer zones around shrimp farms.
3.5.3 Provide technical assistance to improve the efficiency of shrimp ponds, laboratories, and *precriaderos* (artisanal postlarvae growout ponds), diversify mariculture, and reduce the impacts of shrimp pond operations.	• Test methods for fish and shellfish culture in the Rio Muisne. • Conduct technical assistance program for shrimp ponds and laboratories.
Bahía de Caráquez-San Vicente-Canoa ZEM	
3.4.1 Prohibit construction of any additional shrimp ponds in the Rio Chone.	• Prohibit the expansion of shrimp ponds. • Protect ecologically important sections of the Rio Chone estuary, such as mangrove islands and freshwater wetlands; set precise boundaries for shrimp ponds. • Provide extension for *precriadero* operators.
4.1.1 Create an estuary management plan for the Rio Chone for the year 2000.	• Strengthen the estuary management process, including committees, working groups, special studies, management options, pilot projects, and public education.
4.3.1 Develop a program to restore the water quality in the Rio Chone.	• Identify point and nonpoint pollution sources. • Develop a water use zoning scheme to guide pollution control. • Create a permanent monitoring program for the estuary. • Implement a pollution source reduction program. • Assure a permanent flow of fresh water to the estuary.
4.4.1 Study the ecology of freshwater wetlands and promote sustainable uses. 4.9.1 Promote sustainable mariculture by improving pond production efficiency, reduce negative environmental impacts, and experiment with new forms of mariculture.	• Investigate the biology of traditional cultivated species, and examine the potential for expanding this activity. • Improve the productivity of artisanal *precriaderos*. • Improve the management of shrimp ponds, by examining critical management intervention points, build shrimp farmer involvement and organization, install a water quality analysis lab. • Diversify mariculture activities, focusing on native species, pilot projects with multiple species mariculture, and local shellfish species.

Table 5. Examples of policies and proposed actions on mariculture and fisheries in the ZEM plans.

Policies	Actions
San Pedro-Valdivia-Manglaralto ZEM	
3.4.3 Examine options for mariculture, focusing on open sea techniques.	• Study species with potential for cultivation. • Determine the potential larvae supply for cultivation. • Pilot mariculture projects. • Train local people in mariculture.
3.4.4 Reduce contamination from shrimp laboratory discharges.	• Evaluate the impact of laboratory discharges. • Experiment with discharge treatment techniques.
Playas-Posorja-Puerto El Morro ZEM	
3.5.2 Prohibit the construction of new shrimp ponds.	• Increase the efficiency of *precriaderos*. • Improve the efficiency of shrimp ponds. • Develop bivalve culture in the ZEM.
Machala-Puerto Bolívar-Jambelí ZEM	
3.5.4 Create the capacity to deal with shrimp diseases	• Determine extent of problem, develop prevention and treatment of shrimp diseases.

Table 5, continued.

Activities proposed for IDB financing

Although mariculture policies and actions are featured in the ZEM plans, the Inter-American Development Bank (IDB) Coastal Resources Management Project contains only limited funding for shrimp mariculture-related projects. Funds will be available to reduce the negative environmental effects of the activity on estuaries and mangroves, and to contribute to the sustainable use of PL and juvenile shrimp, while also promoting optimal pond operation. The program will finance an analysis of the gravid female shrimp fishery, the operation of hatcheries, and the handling of shrimp postlarvae by artisanal fishermen. Following the diagnostic study, a field extension program will help disseminate selected practices for the industry.

The focus will be on: 1) better methods of capture, handling, and transport of gravid female shrimp and postlarvae to reduce losses due to stress and mortality; 2) optimization of the management of artisanal shrimp hatcheries; and 3) improvements in shrimp pond management to reduce the effects of pond effluents on estuarine water quality while increasing productivity. In each case, the practices will be field tested with the active participation of fishermen, family groups that sort the postlarvae, local merchants, and other operators.

The program to create an estuary management plan for the Rio Chone estuary provides a major opportunity for working directly with large-scale shrimp farmers in order to understand the effects of industry growth on the estuary. The project will establish the decision-making information and tools needed to determine what environmental conditions are necessary for sustainable mariculture in this estuary.

CONCLUSIONS AND OUTLOOK ON THE PMRC'S ROLE IN MARICULTURE MANAGEMENT AND DIVERSIFICATION

The mariculture agenda prepared by the PMRC in 1986 accurately foresaw the problems that Ecuador now faces in sustaining a vital sector of its national economy. The PMRC has tested many of the actions required to promote sustainable mariculture, and has developed strategies that begin to overcome the resistance of the mariculture industry at the ZEM level. However, efforts to spur a productive policy dialogue at the national level have not yet been successful. The PMRC

must remain ready to pursue any opportunities to engage authorities and stakeholders in discussions and joint actions toward effective management of both artisanal and export-driven mariculture production. The framework of work for the PMRC is outlined in the following objectives. Success will require the active collaboration of the shrimp mariculture industry and a number of government agencies.

- Maintain water quality.

In 1994, environmental issues were finally being recognized as important to shrimp farmers, although perhaps too late. An August 1994 report by the U.S. Environmental Protection Agency (EPA) on the Taura Syndrome in the Guayas estuary, for example, stressed the need for a collaborative effort to improve and protect the environmental quality of the Gulf of Guayaquil. The PMRC's experience and accomplishments in fostering collaboration should be examined if this recommendation is followed. The Rio Chone research and estuary management work scheduled for implementation under the IDB project can serve as a national initiative for addressing the full suite of mariculture management issues in a severely stressed estuary.

- Manage wild shrimp stocks.

Development of a management plan that addresses the impacts of fisheries on all stages of the life cycle of shrimp is contingent on expanding the national system for collecting catch-and-effort data, identifying shrimp populations and movements, and correlating trends with environmental and anthropogenic variables. Although the PMRC has incorporated such ideas into its ZEM plans, improving the state of shrimp fisheries management in Ecuador will not be easy. Closed seasons, gear restrictions, and bans on motorized equipment for shrimp postlarvae collection have been difficult to enforce. There is no restriction on the harvest of egg-bearing female shrimp, and conflicts continue between artisanal fisherfolk and commercial boats, which continually violate the eight-mile zone reserved for artisanal gear.

- Optimize the long-term viability of the industry.

The PMRC has been most successful in working to build relationships, in setting innovative policies, and in carrying out joint actions related to mariculture in the ZEMs. The participation of shrimp farmers in program activities at the local level is now increasing, after a long period of disinterest and skepticism. The PMRC has tried to establish cooperative working relationships with ministries and with the shrimp industry to promote the strategies and recommendations first made at the 1986 meeting. However, both government agencies and the mariculture industry have been reluctant to enter into meaningful discussions, except to address a major and immediate crisis.

- Overhaul the permit system.

The mariculture regulatory system needs to be simplified in order to meet site-specific coastal resource management objectives. Decision-making on new and renewed pond concessions must be based on habitat conservation, good shrimp farm construction and operating practices, and promotion of social well-being. Efficient shrimp farms are profitable enough to pay adequate fees for the use of common property, coastal resources, and areas that could then be used to finance effective governance.

- Evaluate the impacts of national policy on the shrimp industry.

A more diversified mariculture industry would produce greater economic benefits and prove more responsive to changes in world markets and technologies. Southgate and Whitaker (1994) point to the low fees charged for shrimp pond concessions in the beach and bay zone as fostering inefficient, unstable operations that damage the environment. The authors view investments in human capacity and the scientific basis for the industry as essential for future success. They note that outside of Guayaquil, shrimp farmers have limited access to testing laboratories, and need to better understand the life cycle of shrimp in order to improve the contribution of hatcheries to the postlarvae supply and to diminish the impacts of overfishing of gravid females.

- Initiate technical assistance to the industry.

The government of Ecuador greatly expanded ESPOL's coastal laboratory into a center for aquaculture research and development in 1990 through a major donation by the Japanese foreign assistance agency. CENAIM has focused on providing technical information for large-scale producers, and is working on mariculture diversification activities. Up to now, CENAIM has not been able to play a major role in promoting broad-based extension services to those shrimp farmers unable to finance their own teams of shrimp pond biologists and technicians. It also faces the obstacles presented by shrimp farmers' reluctance to share information on operating practices. This sharing of information is the hallmark of effective extension.

- Use public education to promote environmental quality.

The PMRC's collaboration with the Fundación Pedro Vicente Maldonado to strengthen public awareness and education programs in the ZEMs (see page 179) has changed the perceptions, attitudes, and actions of coastal resource users—including the local mariculture industry. A similar strategy has been formulated for the severe conflicts in 1995 over the development of mariculture in northern Esmeraldas province—the source of a heated national debate between industry leaders and environmental groups. The PMRC approach has helped resolve site-specific issues through awareness-building, negotiation, and user group agreements. This work requires adequate staffing, a long-term commitment to monitoring industry activities, supervision of permits and agreements, and reinforcement of the positive image that an open decision-making process creates for both the community and developers. It will be necessary in the future for the sectoral agencies themselves to adopt and carry out regulatory programs in ways that are feasible for farm builders and operators to accept and to implement.