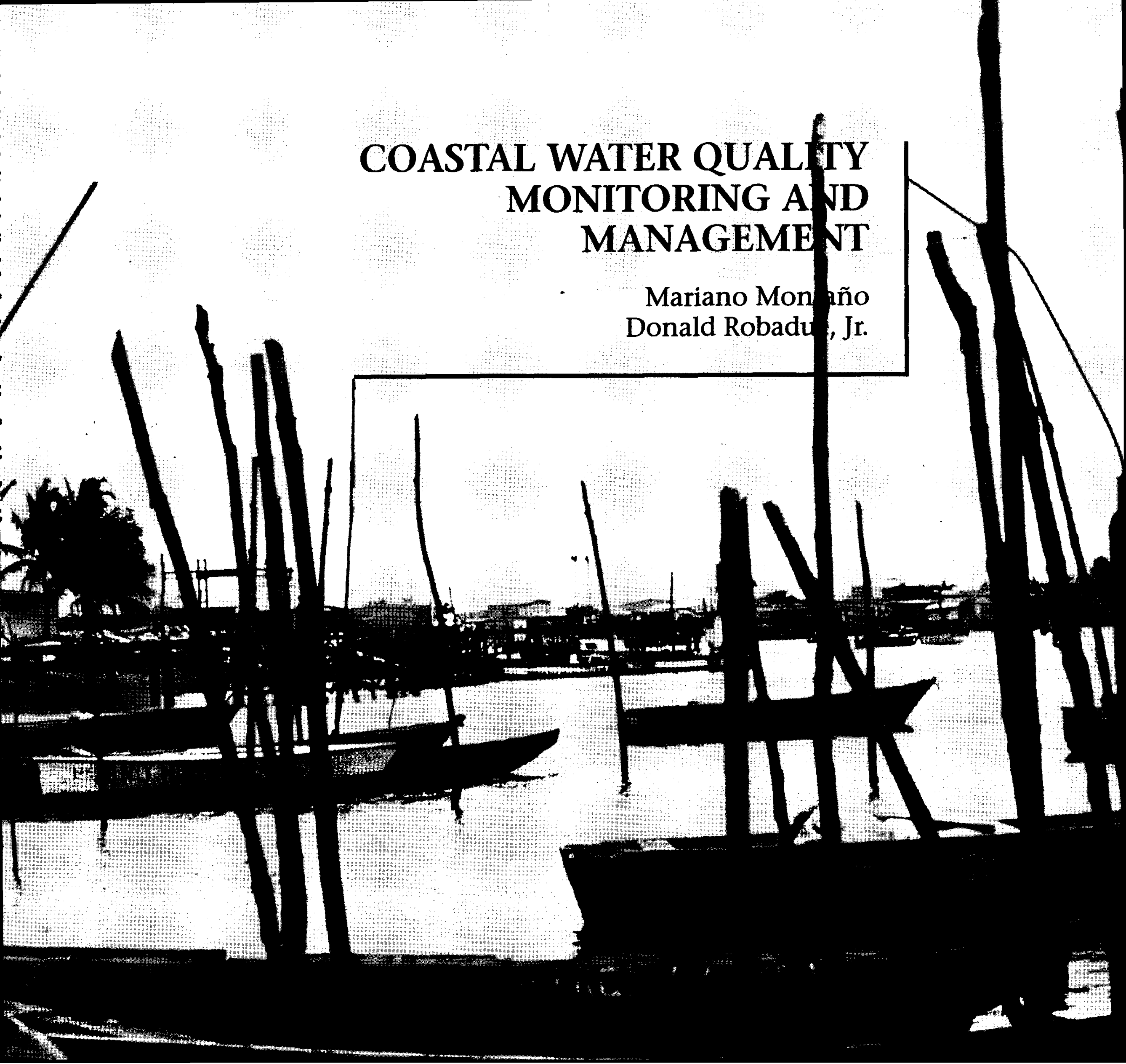

COASTAL WATER QUALITY MONITORING AND MANAGEMENT

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COASTAL WATER QUALITY MONITORING AND MANAGEMENT

Life-giving water flowing from the Sierra through the coastal plain and estuaries to the sea is the central image in the shield on Ecuador's flag. Water is the great pathway that ties Ecuadorians to their environment—in generation of electricity, irrigation of crops, drinking water, industrial production, fisheries, mariculture, transportation, and recreation.

Managing and protecting the quality and quantity of water for present and future generations of coastal people should be a central concern of both citizens and public officials. Unfortunately, this is not the case. Estuaries such as Taura, Rio Chone, and the Estero Salado, which have clusters of shrimp farms, are experiencing environmental problems that are causing a decline in farm-raised shrimp production—a key sector of the coastal economy. The raw sewage of the more than 2 million people living in Ecuador's large and small coastal cities passes untreated into nearby waterways. Hundreds of thousands of Ecuadorian vacationers visit coastal beaches that have few or no sanitary facilities. The result is episodes of high levels of fecal coliform bacteria—an indicator of sewage contamination—in swimming areas. Diversion of freshwater flow from estuaries to agricultural areas is changing the quantity and quality of the coastal waters that serve as nurseries for coastal fish and shellfish. In 1989, Ecuador adopted—but has seldom enforced—regulations that provide the legal basis for setting water quality standards, issuing and enforcing wastewater discharge permits, and requiring environmental impact statements, as well as for financing the construction of publicly owned wastewater treatment works.

The Coastal Resources Management Program (PMRC) has been concerned about coastal water quality since its inception in 1986, initially in relation to the sustainability of the shrimp mariculture industry, which is centered in the Guayas River and its associated estuary. However, the PMRC has wisely not tried to overreach itself by attempting to tackle the problems generated by the Guayaquil metropolitan area. Instead, it has concentrated its initial efforts on monitoring and management in the five special area management zones (ZEMs—see page 149), where it has worked to identify and address water quality problems that are directly tied to the quality of life in coastal villages.

By focusing its resources on a few key issues, the PMRC has begun to overcome some of the important obstacles to water quality management in Ecuador, including

- A lack of credible data and low credibility of Ecuador's water quality analysis laboratories;
- The absence of practical experience linking the technical concerns about pollution control to the needs of coastal resource user groups; and
- The absence of clear priorities that could galvanize a pollution control campaign.

This paper reviews the PMRC experience in the monitoring and management of coastal waters, particularly in the ZEMs. The PMRC is now in a position to get coastal water quality issues on the agenda of national and local governments, as well as play an important supporting role to ensure that the legal and administrative tools already in place are applied effectively in coastal areas.

WATER QUALITY ISSUES ALONG ECUADOR'S COAST

Sustainability of the shrimp mariculture industry

Findings from the 1986 mariculture strategy

In August of 1986, the CRC/USAID Coastal Resources Management Project (CRMP—see page 11) organized its first major activity, an international seminar on the preparation of a sustainable shrimp mariculture strategy for Ecuador. The top priority identified through the shrimp mariculture assessment process was the need to maintain water quality in estuaries and along the open ocean coast where most shrimp larvae hatcheries are located. In fact, the negative effects of declining water quality on shrimp mariculture have become a major economic threat to the industry in the 1990s.

Growing evidence of ecosystem-related problems for the shrimp industry

Since the preparation of the mariculture strategy in 1986, two important episodes have given further weight to the PMRC's concerns. The Gaviota Syndrome appeared during the final months of 1989 and the first half of 1990. It was first seen near shrimp farms on the Isla de Santay in the Guayas River, as well as in the Estero Salado. Later, it was noted in El Oro province, as well as in Bahía de Caráquez, Jama, Cojimíes, and Muisne. The total loss to the shrimp mariculture sector was estimated at $100 million. In afflicted ponds, the shrimp, due to suffocation, leap out of the ponds, where they are easy prey for gulls (*gaviotas*). Shrimp farms that normally had production levels of 90 percent of stocked larvae suffered reduced productivity, which was reflected in larvae survival rates of only 50 to as low as 10 percent. Then, as quickly as it had arrived, the crisis disappeared, without a clear diagnosis of the actual causes, or a strategy to prevent reoccurrence.

The Taura Syndrome has been the focus of attention of the shrimp industry since 1994. After shrimp ponds along the mouth of the Rio Taura were stocked with postlarvae in the winter of 1992, pond owners reported high mortalities and deformities in shrimp. This problem then expanded to impact about 60,000 hectares (ha) of the 100,000 ha of shrimp farms around the Gulf of Guayaquil. The shrimp farmers in the zone found themselves at "the edge of an abyss," with an estimated loss of $170 million per year if the problem persisted. Once again, there is no clear diagnosis of the problem, with studies up to now implicating the fungicides used by banana growers, including Calixin, Benlate, Topsin, and Baycord.

The Taura Syndrome reinforces the conclusion of the PMRC that there is a great need to convene the variety of conflicting actors and responsible agencies to address current water quality issues, and to take a longer-term perspective on water quality management. Unfortunately, up to now, no agency has assumed a leadership role, and the shrimp mariculture sector is repeating its response to the Gaviota Syndrome by hiring experts and trying to place blame on a single culprit or competing industry.

Capability of effective joint action by the shrimp industry

Ecuador's effort to protect the sanitary quality of shrimp exports has been an unquestioned success, and provides a model for addressing other water quality problems. The poor water quality of coastal waters from a microbiological perspective (Montaño, 1993) made the cholera epidemic that struck Ecuador in 1991 almost inevitable. In this case, an aggressive government campaign, coordinated with and assisted by the shrimp growers to prevent and combat the disease was a notable success.

Before the outbreak, the shrimp mariculture sector focused on the shrimp packing sector, adopting intensive quality control practices in the facilities where exported products were processed. As a consequence, importers in the United States and other markets maintained their confidence in the quality of the Ecuadorian product. The program is now managed by the Federation of Shrimp Exporters (FEDECAM), which now has a strong base of experience for confronting similar problems in the future.

Unfortunately, this intense interest in regulating product quality has not extended to the more environmentally based water pollution concerns.

Effects of water pollution on human uses of coastal water bodies

The series of coastal issue profiling workshops held by the PMRC in each coastal province in 1986 and 1987 revealed a variety of local concerns about coastal and estuarine water quality, which continued to worsen during the late 1980s and early 1990s.

Water taken from coastal rivers for domestic use is often contaminated by agricultural pesticides, as well as by industrial and domestic sewage discharges from urban areas. Investments in potable water supply and liquid waste disposal have not kept up with population growth in urban centers, and water pollution control laws have not been implemented. In communities where environmental sanitation projects have been built, education and training in the use and maintenance of the systems has been overlooked, leading to poor administration and failure to recover system costs. In some cases, the facilities are abandoned.

According to the most recent national census, the proportion of coastal residents connected to potable water and sewage disposal systems dropped from 20 to 17 percent between 1982 and 1990. The majority of coastal cities suffer from serious deficits in municipal sanitation services, including solid waste disposal. The situation is most severe in communities of fewer than 5,000 people, where facilities and services are virtually nonexistent.

The heavy use of certain tourist beaches during peak holiday periods (January to March and July to September), combined with poor infrastructure, results in bacteriological contamination of bathing beaches and coastal waters, risking public health and depressing the recreational potential of these areas.

Fish processing plant discharges in Posorja, Chanduy, Monteverde, and Manta, along with shrimp larvae hatcheries in San Pablo, San Vicente-Canoa, and Atacames, are degrading local water quality—in several cases, near important recreation beaches.

Gold mining in the upper watersheds of Guayas province is generating concern about the discharge of mercury into coastal water bodies.

Water body	Type of discharge	Affected activities
Rio Atacames estuary	Residential sewage Shrimp ponds	Tourism Shrimp pond productivity Estuary productivity Shellfishery
Rio Chone estuary	Residential sewage Shrimp ponds	Tourism Shrimp pond productivity Estuary productivity Fisheries
Beaches of Playas-Data de Posorja	Residential and beach goers' sewage Fish cleaning and evisceration	Tourism
Estero Salado (city of Guayaquil)	Residential sewage Industrial waste Urban stormwater	Recreation Shrimp pond productivity Estuary productivity Fisheries
Estero Huayla (city of Machala)	Residential sewage Industrial waste Agricultural runoff	Potable water Estuary productivity Shrimp pond productivity Fisheries Recreation

Table 1. Some specific water quality problems identified by the PMRC.

Difficulty placing water quality on the national agenda

The cholera epidemic, a seemingly critical situation, was not sufficient to gain sustained national attention on the water quality issue. It was responsible for more than 900 deaths in 1991 and 1992, primarily in the margins of the urban areas of Machala, Guayaquil, and Esmeraldas, where more than 48,000 cases were reported in the respective provinces of El Oro, Guayas, and Esmeraldas. The focus of the government of Ecuador's response during this period was general public education and treatment of individual cases to prevent death due to dehydration.

A study team funded by USAID Quito evaluated direct and indirect factors prolonging the epidemic, and found a number of likely pathways for the bacteria—including serious deficiencies in the supply and handling of drinking water, especially in marginal urban areas; discharges of untreated sewage to local waterways; poor personal and food-handling hygiene; and direct contact with contaminated water during bathing or clothes washing (Chudy et al., 1993).

Chudy et al. observed that by late 1992, "The cholera problem was relegated to a position of secondary importance, both by the Ministry of Health authorities and by other organizations that have been involved since the epidemic broke out in 1991. This also applies to the community level."

Limited prospects for major public investments and initiatives for coastal water pollution

Ecuador's basic water law provides the legal framework for controlling water pollution, as well as for conducting a planning process that would enable the setting of goals for individual water bodies, designating uses, controlling discharges, and evaluating results. This law, however, has not been given any practical expression, even in areas of the coast that experience water quality problems. Ecuador also has a legal framework for regulating point discharges of pollution. Unfortunately, two interagency efforts to implement such controls in Guayas province during the 1980s ended in failure when the focus shifted from water pollution control to the procedures, including extralegal maneuvers, for discharge permits. The program was discredited and abandoned.

Even when municipalities are motivated to address their pollution and sanitation problems, they must take on the entire burden of paying for pollution control—even though the environmental resources at stake in many polluted areas have provincial, regional, and, in the case of shrimp mariculture, international importance. There are no urban grant programs of the type that have proven so successful in the United States. According to Chudy et al., Ecuador's capacity to plan and implement water supply and pollution control measures has declined dramatically in recent years. In reviewing the water supply and sewer service agencies in the growing cities of Machala, Guayaquil, and Esmeraldas, the USAID team found inadequate financing, poor cost recovery, and management and administrative problems that lead to failure to adapt to a changing demand for services.

For example, the city of Esmeraldas has a water and sewage system designed for a service area of 30,000 people, while the current population exceeds 170,000.

> The poor performance of utilities also arises from a lax regulatory environment. The Instituto Ecuatoriano de Obras Sanitarios (IEOS) has the sanction of law to set norms and oversee the performance of public water and sanitation utilities. However, IEOS has never actually performed this role (Chudy et al., 1993).

Municipal utilities now face a grave financial situation that further weakens Ecuador's ability to confront the growing pollution crisis. At best, municipal utilities are able to recover from 25 to 40 percent of their operating and maintenance costs from customer billings. Residents receiving water by tank truck delivery pay at least four times more than those receiving piped water. Billing for water and sewer service in Guayaquil did not take place for nearly all of 1992, creating large operating deficits for both the water and sewage service agencies. Illegal connections to water and sewer lines also plague these utilities.

PMRC OBJECTIVES AND STRATEGIES TO ADDRESS WATER QUALITY ISSUES

One obvious issue identified in 1986 was a widespread lack of confidence in the accuracy and comparability of water quality data being generated in Ecuador by shrimp farmers, universities, government agencies, and private laboratories. Shrimp farmers routinely sent water quality samples to the United States for analysis, and national government officials bickered amongst each other about the validity of methods and results. Without an accepted base of information, it was argued, there was no valid way to examine various claims that water quality was deteriorating, that toxic pollutants were entering the marine environment, that shrimp ponds were adversely affected by ambient conditions, or that mariculture itself was contributing to water quality degradation.

The PMRC included water quality monitoring as a new task for the Project Year 2 (1987) work plan. The work was initially called "Estimation of Water Quality Issues Affecting the Shrimp Industry," but was expanded to include "other users of coastal resources" in Year 3 as a direct follow-up to the shrimp mariculture workshop and the provincial workshops. The PMRC set out to

- Identify and assess the significance of water quality problems affecting mariculture, fisheries, and other coastal uses;
- Make recommendations for solving water pollution problems at the national and local levels;
- Assess the in-country capacity to conduct the type of analyses required to monitor important water quality parameters; and
- Design an integrated program for generating baseline data.

The PMRC adopted three strategies to address the problem and the factual basis for a management initiative.

Strategy 1. Design and implement a water quality sampling program focused on issues related to shrimp mariculture.

Following the 1986 shrimp mariculture conference, the PMRC established an interinstitutional water quality working group to review the existing data on water quality, discuss perceived problems, and address concerns about the quality of available data. This group succeeded in standardizing laboratory methods and establishing credibility in the data generated by agencies and by laboratories in both Ecuador and the United States.

Strategy 2. Design an integrated approach to water quality monitoring and promote interagency cooperation through the water quality working group.

A sampling program targeted issues of priority concern to the shrimp mariculture industry, including direct measurements of those water quality variables that may be impacting the operations of the shrimp mariculture industry. The initial focus was on monitoring oxygen, coliform, and nutrient levels.

Strategy 3. Guide and promote public investments and private collaboration in pollution control in the ZEM plans.

The PMRC's work in the ZEMs led it to discover important social dimensions of water quality. This drew greater attention to community concerns over safe drinking water, sewage and solid waste disposal, beach and neighborhood cleanliness, and public health. An integrated approach to water quality concerns linked the concerns of the shrimp industry to those of poor coastal communities, and enabled the PMRC to build local constituencies for coastal resources management.

From 1990 to 1993, the PMRC focused its efforts within the ZEMs, primarily on public education and practical exercises. All five ZEM plans adopted in 1992 contain policies and proposed actions to improve basic services and promote the construction and proper administration of water supply and solid waste and sewage disposal facilities.

THE WATER QUALITY WORKING GROUP

Organization of the water quality working group (WQWG)

The PMRC planned three major tasks for the WQWG to meet its objectives for water quality:

- Assess the strengths and capacity of in-country water quality laboratories.
- Design and implement a water quality sampling program.
- Combine the results of these efforts into the design of an integrated program to generate baseline data and sustained water quality monitoring.

The PMRC saw the importance of improving the in-country capacity to assess water quality problems to provide mariculturists with confidence in the quality of data that these laboratories were providing. Several well-equipped labs had already been identified in Guayaquil. Their major problem appeared to be a lack of operating funds for expendable supplies, and in some cases, funds for laboratory technicians. The author and José Vásconez assessed the capabilities and needs of these labs. The PMRC provided funding for the necessary supplies and manpower so that intercalibration exercises and quality control procedures could be introduced. A technical advisor, Candace Oviatt of the Marine Ecosystem Research Laboratory at the University of Rhode Island Graduate School of Oceanography, collaborated in reviewing available data and designing the intercalibration activities.

The WQWG held its first meeting in March 1987. It was attended by the directors of the major research institutions on the coast. The WQWG has met continuously since then, serving as the focal point for the PMRC's work in water quality. The organizations represented by the members of the WQWG cover a wide range of legal mandates, administrative responsibilities, and research interests pertaining to coastal water quality:

> **The Coastal Polytechnical University**, ESPOL, was the most active academic institution in the group. Its primary interest was in scientific research that advanced scholarship and learning.
>
> **The National Fisheries Institute**, INP, is responsible for developing knowledge and policy proposals regarding fisheries, and for understanding the relationship between water quality and fisheries resources.
>
> **The Ministry of Agriculture**, MAG-DSV, was primarily interested in the relationship between the use of agrochemicals, such as pesticides and fungicides, and coastal resources.
>
> **The Guayaquil Wastewater Administration**, EMAG, is responsible for monitoring and managing the discharge of sewage from the municipal wastewater collection system to adjacent water bodies, including the Rio Guayas and Estero Salado.
>
> Since 1989, **The Ecuadorian Sanitation Works Agency**, IEOS; **Ecuadorian Water Resources Agency**, INERHI, and the **General Directorate of the Merchant Marine**, DIGMER, each share in the jurisdiction required to implement the regulations issued for the Prevention and Control of Environment Contamination. IEOS takes the lead in water bodies used for human consumption, domestic, or industrial purposes. INERHI is the primary agency working on inland and island water bodies. DIGMER is charged with protecting coastal and navigable waters.

The Oceanographic Institute of the Armada, INOCAR, is a part of DIGMER, and conducts basic scientific research in marine waters, as well as maintaining navigation markers.

The Commission for Studies of the Development of the Guayas Basin, CEDEGE, has the lead role in planning and implementing irrigation and dam construction projects in the Guayas estuary and the entire watershed.

The PMRC's role has been to provide technical assistance, training, and some supplies for field research and laboratory analyses. Leaders of the PMRC also maintain contact with the ministries and agencies to discuss national policy issues to protect coastal water quality.

The University of Rhode Island (URI) has provided technical expertise throughout the development of the group.

In addition to the active roles played by these institutions, the WQWG has contacts with the private sector, including the Shrimp Farmers Association.

Maintaining the cohesion of the group has been a constant concern and challenge. In the beginning, it was essential to be creative and persistent in building mutual respect and confidence within a group whose members had considerable mistrust of each other. The researchers were not used to working together, did not have a clear vision of what the group could accomplish, and had only a small budget to use for activities. In view of these uncertainties, the longevity of the group and its important role in the PMRC is all the more remarkable.

The PMRC succeeded in its effort to improve the reliability of water quality analysis and created a commitment among researchers and laboratories to follow standard methods in order to generate comparable results. The WQWG greatly improved the level of confidence in water quality data collected by different laboratories, and helped identify site-specific problems in Estero Santa Rosa, Estero Salado, Rio Chone, and Rio Esmeraldas.

The sampling program initiated by the WQWG monitored oxygen, coliform, and nutrient levels. Overall, Ecuador's water quality was found to be good, but a number of localized problems demanded attention.

The WQWG also demonstrated that it is possible to work with local collaborators on a volunteer basis, even with the mariculture industry. Shrimp farmers in the Rio Chone, for example, collaborated to monitor water quality conditions in the inner estuary. However, the industry as a whole has not shown much interest in the broader water quality issues raised by the PMRC since 1986.

The PMRC did not have the financial resources to expand water quality monitoring coastwide, nor did the WQWG succeed in raising funds on its own for its ambitious proposals. Greater interest in monitoring exists in specific locations where water quality problems are interfering with desired uses.

Intercalibration of sampling and measurement

When the WQWG first began to carry out water quality sampling projects, the discrepancies in the results between laboratories proved to be a great surprise and cause for concern. At the end of February 1988, the group surveyed sections of the Guayas River and the Puerto Bolívar urban waterfront, and were quite surprised at the wide range of measured results from the same samples, in some cases by two orders of magnitude difference.

The participating laboratories then carried out several intercalibration exercises—the only such effort in the country—to test the accuracy of both procedures and equipment in the different organizations. The goal was to attain consistency in results among the labs. In each exercise, a known standard sample was provided to participant laboratories to see how close they could come to the actual value. The first exercise, conducted in June 1988 at the facilities of ESPOL, focused on measurements of nitrate, ammonium, and total phosphorus. Participating organizations were IEOS, ESPOL, EMAG, and INOCAR. The second round focused on nitrate and phosphorus measurements, and was held at the INOCAR laboratory.

Parameter	Range of observed values (µg/l)	Actual value of standard sample (µg/l)	Best result, by group and equipment		
NH_3 ammonium	55.8–66.7*	65	66.7	DIGMER	DR Hach
NO_2 nitrite	18.8–21.2*	21	21.2	EMAG	Super Scan 3
NO_3 nitrate	6.6–6.9*	6.8	6.8	EMAG + ESPOL	
PO_4 phosphate	3.1–3.7**	3.3	3.3	EMAG + ESPOL	
Phosphorus total	40.5–53.6	50	52.9	INOCAR	Leiss PMQ3

* Detection limit = .07
** Detection limit = .15

Table 2. Combined results of intercalibration exercises at ESPOL and INOCAR.

The variation among the participating groups was still between 10 and 25 percent of the actual value, but such a range is acceptable.

At the same time, ESPOL's Chemical Sciences Institute conducted a calibration exercise with the University of Rhode Island on the measurement of heavy metals in sediment samples. Samples were taken from the Guayas River (station RG25) and the Daule River at La Toma station (LT), where the freshwater intake for the city of Guayaquil is located. The results of this exercise showed that the two labs were in close agreement and that the procedures and equipment at ESPOL produce reliable data.

	Zinc		Lead		Copper		Cadmium		Chromium	
µg/g	LT	RG25	LT	RG25	LT	RG25	LT	RG25	LT	RG25
ESPOL	39.6	61.9	6.8	15.2	21.0	45.6	0.25	0.24	25.0	31.0
URI	40.0	60.3	8.6	12.8	21.5	34.7	0.26	0.25	23.4	34.7

Table 3. Heavy metals in sediment samples from the Guayas (station RG25) and Daule (station LT) rivers.

In April 1993 another successful exercise focused on the measurement of nutrients and was carried out at the facilities of CEDEGE.

As a result of this work done under the auspices of the PMRC, intercalibration is now standard operating procedure for the WQWG participating organizations.

Assessing water quality conditions in Ecuador

The most important result of the intercalibration exercises has been the establishment of a new way of addressing water quality issues where the precision and reliability of data can be assured. With confidence in results firmly established, it became possible to move on to the task of surveying water quality conditions in critical areas of the coast.

Approach to conducting the water quality assessment

This WQWG task consisted of two important steps. Step 1 initiated a water quality assessment process that involved; a review of the existing data on water quality—much of which had already been assembled by PMRC staff; a discussion of perceived problems, from the perspective of shrimp farmers and larvae hatcheries; and discussions of water quality problems from the perspective of local scientists, including their concerns about the quality of available data. The WQWG served as the primary forum for these discussions, as well as an important vehicle for identifying contacts with industry and the scientific community.

Step 2 required developing a sampling program that would target issues of priority concern to the shrimp mariculture industry. The first priority was to make direct measurements of those water quality variables that could affect the operations of the shrimp mariculture industry. Problems that had been identified to that date (1987) included concentrations of heavy metals (particularly mercury compounds) and organic chemicals (particularly pesticides) in the vicinity of selected hatcheries and shrimp ponds.

Significant contamination, if found, was expected to be highly localized. Assessments were directed at known "sinks" of these substances, such as fine-grain sediments; long-lived detrital feeders, such as oysters; and predators at the top of the food chain, such as long-lived fish and fish-eating birds.

The WQWG decided to focus their attention initially on measuring oxygen and ammonium levels in control (no-impact) and affected sites. In order to help define ecosystem dynamics, recommended pond monitoring variables included nutrients, turbidity, biochemical oxygen demand, temperature, and salinity. The sampling programs recognized the need to make use of existing field investigation capabilities. It was hoped that in-pond monitoring would be conducted by cooperating shrimp farm managers, many of whom already had the necessary sampling equipment. The sampling protocols developed by the Pond Watchers, a volunteer monitoring group initiated by the University of Rhode Island, were adopted as a model for organizing the program. The WQWG also targeted a few other contaminants of concern, especially petroleum hydrocarbons, to be assessed at control and impacted sites.

Determining baseline water quality conditions

Selecting monitoring parameters

The next step was to identify the most important sections of the coastal zone from the water quality perspective, identify the parameters that should be measured, and then proceed to create a baseline characterization of those areas. Four areas were identified:

Study Block 1: Estero Santa Rosa, Jubones and Siete rivers, 8 stations;
Study Block 2: Estero Salado, Posorja and Playas, 15 stations;
Study Block 3: Rio Chone estuary, 4 stations; and
Study Block 4: Esmeraldas-Teaone rivers, Atacames, Súa and Muisne, 11 stations.

These study areas selected by the WQWG coincided for the most part with the ZEM locations.

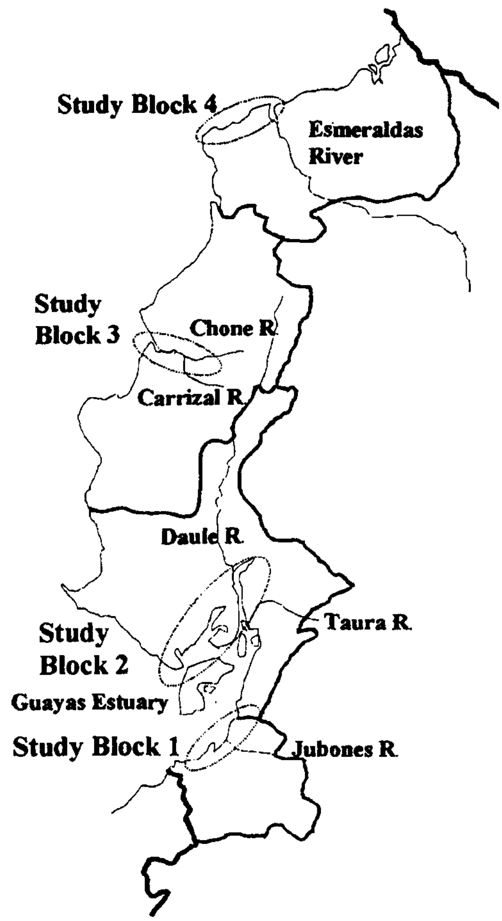

Figure 1. Water quality study areas.

Activities	Indicators of contamination								
	Dissolved Oxygen	Bio-chemical Oxygen Demand	Solids	Micro-organisms (coliform bacteria)	Nutrients	Hydro-carbons	Heavy metals	Pesticides	pH
Urbanization	x	x	x	x	x	x	x	x	x
Tourism	x	x	x	x		x			x
Industry	x	x	x			x	x		x
Agriculture	x	x	x	x	x	x		x	x
Navigation						x			
Exploitation of petroleum	x	x	x			x			x
Aquaculture	x	x	x	x	x	x		x	x
Mining			x				x		x
Fisheries and fish processing	x	x		x	x				
Infrastructure		x	x						x

Table 4. Principal coastal activities and their potential for water pollution.

The responsibility for conducting the analyses of different parameters was assigned to different members of the WQWG, according to the advantages each had in conducting the analysis:

DIGMER and EMAG	Microorganisms
ESPOL	Heavy metals and pesticides
IEOS	Physical and chemical parameters
INOCAR	Hydrocarbons
MAG-DSV	Pesticides

During 1989, sampling was carried out during the winter and summer in each of the four areas of concern. Baseline data on water quality conditions was compiled and presented at a public seminar in August 1990. More than 60 people attended the meeting from the academic community, the press, the city of Guayaquil, the shrimp industry, and water pollution control agencies. The session was cosponsored by the PMRC and the Foundation for Bioaquatic Resources, FIRBA. The findings presented at the meeting were later published in the report *A Study of Ecuador's Coastal Water Quality* (Montaño et al., 1993), which has become a standard reference for researchers and agencies.

Overall results of the sampling effort

About 1,700 data points were produced from the characterization survey. The working group concluded that overall, coastal water quality in Ecuador is very good, but there are many spots that raise concern.

Parameter	Study Block 1 (El Oro)	Study Block 2 (Guayaquil)	Study Block 3 (Rio Chone)	Study Block 4 (Esmeraldas)
Dissolved oxygen (mg/l)	5.3–10.2	3.25–7.85	5.23–7.73	4.3–8.7
Biochemical oxygen demand (mg/l)	0.1–3.2	0.35–14.3	0.85–5.13	0.9–5.1
Fecal coliforms, most probable number per 100 ml.	7–1,000,000	ND*- 1,000,000	ND- 240,000	40–240,000
Nitrite NO_2 (μM)	ND–1.7	0.06- 2.55	0.25- 1.35	0.06- 0.44
Phosphate PO_4 (μM)	0.11- 4.04	0.44- 4.15	0.11- 5.34	0.05- 5.94
Hydrocarbons (μg/l chrysene equivalents)	0.63–2.9	1.02- 3.27	0.6–1.37	0.77- 8.85
Pesticides	ND	ND	ND	
Temperature (C)	21.5–28.9	21.7–27.5	25–28.2	23.2–29.8
pH	7.4–8	7.1–8.5	7.7–8.27	6.8–8.4
Salinity (^{o}/oo)	0.4–30.6	0–25	0.5–34.5	0.4–35

ND = Not detected
μM = Micromolar

Table 5. Range of results of the PMRC sampling program carried out by the water quality working group.

Table 5 shows the lowest and highest values found for the various parameters selected. Stations included freshwater sites from rivers discharging to the coast, as well as estuarine and ocean water. Although the sampling program includes only a portion of the country's coastal waters, the stations include many critical sites that enable the working group to draw conclusions useful for setting management priorities.

Dissolved oxygen. The values of the samples ranged from 3.25 to 10.2 milligrams per liter (mg/l). Taking into account that the values are affected by the time of day of the samples, the lowest values were found in the sites most heavily contaminated by pollution discharges in each block: in the Estero Pilo and Estero Salado, near the city of Guayaquil, which has no wastewater treatment; at Cinco Bocas, in the interior of the Rio Chone estuary, where villagers' latrines are located over the water; and at the outlet of the Atacames River, a tourist area with no wastewater collection or treatment.

Biochemical oxygen demand. This parameter, used to measure the organic loading of municipal wastewater, was from 0.1 to 14.3 mg/l. BOD is a concern when values are 5 mg/l or more (Masterton and Slowinski, 1979). Such elevated levels were found in Playas, near the town center; in Cinco Bocas, which also has low dissolved oxygen, and in the Esmeraldas River in the City of Esmeraldas.

Fecal coliforms. High bacteria levels were found in all the water bodies sampled by the working group. Levels so high as to indicate a water body that is essentially raw sewage are found at the mouth of the Estero El Morro, in the Playas-Posorja-Puerto El Morro ZEM, and in the Esmeraldas River. Gastrointestinal diseases, the most important type of infection in the coastal provinces, can be attributed in part to poor water quality.

The WQWG has placed great emphasis on improving its ability to measure nutrients, which are found in elevated levels near shrimp farms, agricultural areas, and coastal cities.

Nitrite. This nutrient is found in coastal waters and where present at elevated concentrations is usually produced by the oxidation of organic matter and residues from fertilizers. Values ranged from not detected to 2.55 μM. According to the Fundación Natura, uncontaminated water can have up to 0.2 μM of nitrite. This criterion is exceeded in Estero El Pilo, Canal del Morro (near the city of Posorja), Cinco Bocas in the Rio Chone estuary, and at the beaches of Súa.

Phosphate. Phosphate is another nutrient that, at elevated levels, can be attributed to fertilizer and domestic wastewater. Ketchum (1969) recommends 2.8 µg/l as a benchmark maximum value in uncontaminated waters. The surveys done by the WQWG found values ranging from 0.05 to 5.94 µg/l, with the most affected sites including the Jubones River, the mouth of the Estero El Morro, Cinco Bocas, and the Teaone River in Esmeraldas.

Hydrocarbons. The levels of petroleum hydrocarbons found during the sampling program generally were below levels considered harmful. Site-specific problems may exist near petroleum transport terminals and refineries. A recommended maximum for aquatic habitat is 3 µg/l chrysene equivalents, according to the Permanent Commission on the South Pacific (Gutiérrez, 1989). Samples taken by the WQWG had values between 0.6 and 8.85 µg/l. The values generally were less than 3 µg/l, with the exception of the Teaone River near the Esmeraldas refinery, where the highest levels were found.

Pesticides. Pesticides were not detected in water and sediment samples taken during the baseline characterization project. This is not to say that there is no concern about them, given their toxicity and prevalence of use in coastal agriculture (Ulloa, 1989). Attention should continue to be paid to the potential impacts of these substances.

Temperature. This parameter varied 21.5 C to 29.8 C, depending on the time of day, season, and location of the sampling station. Temperatures tend to be higher in Esmeraldas and the Rio Chone than in the Gulf of Guayaquil or El Oro.

pH. Samples showed a range from 6.8 to 8.5. In general, the lower values were found in river stations, with higher values in stations close to the ocean. There were no particular differences among the blocks.

Salinity. Samples varied from 0 to 35 parts per thousand (‰), depending on location of the site closer to rivers discharging to the coast or the open ocean. Sampling sites in Bahía de Caráquez and Esmeraldas showed higher salinities than in El Oro and Guayas due to the strong influence of the Jubones and Guayas rivers in those respective blocks.

Assessing water quality concerns of the shrimp mariculture industry and other national issues

Early work sponsored by the PMRC resulted in an initial compilation of water quality data along the coast by Robert Twilley; an institutional analysis of water quality management by Efrain Perez; and an inventory of current (1987) water quality monitoring activities prepared by José Vásconez. The priority set in the Year 3 (1988) work plan was water quality issues affecting shrimp farms. The WQWG was assigned the task of designing a data collection program that focused on priority problems that would make the best use of the analytical capabilities developed through the intercalibration and sampling work. The PRMC was unable to finance a major initiative in water quality monitoring and management for the coast on its own.

The WQWG was very active in preparing proposals for other sources of funding, but almost none of these was successful. The variety of ideas and initiatives is reflected below. Much of the work in the following projects was aimed at characterizations of the principal water bodies and expanding the knowledge base on the presence of pesticides in the coastal environment—an important concern of the mariculture industry:

- *Integrated Monitoring Plan for Water Quality Pertaining to Ecuador's Mariculture Industry.* Presented to the Association of Shrimp Growers in November 1988.

- *Study and Control of the Impact of Pesticides in the Shrimp Mariculture Industry Using Gas Chromatography.* Presented to the PMRC, the Fundación Maldonado, the National Commission on Science and Technology (CONACYT) and the National Planning Agency (CONADE) in March 1989; to the Agriculture Foundation (FUNDAGRO) in June 1989; and to the Foundation for Bioaquatic Resources in June 1990.

- *Monitoring Water Quality in the Estero Salado Along the Waterfront of the City of Guayaquil.* Presented to the Foundation to Rescue the Estero Salado in April 1989.

- *Evaluation of the Use of Mercury in the Gold Mining Activities of the Siete River.* Presented to the PMRC, USAID Quito, and Fundación Natura in December 1989. The search for funding for this proposal was carried out in part with the researchers from the University of Florida and the U.S. National Institutes of Health.

- *Proposal to Conduct Seminars on Monitoring and Analysis of Water Quality.* Presented to the Ecuadorian Institute of Credit for Education in October 1990.

- *Master Plan for Monitoring and Managing Water Quality.* Presented to the European Economic Community in October 1990.

An additional set of projects focusing on the shrimp mariculture industry was presented to the PMRC's Inter-American Development Bank loan project in May 1992, to the National Commission on Coastal Resources Management, to the Shrimp Producers Association, and to the Fundación Estuarium in Bahía de Caráquez:

- *Evaluation of the Nutritional Potential of Shrimp Ponds Located in the Rio Chone Estuary, by Analyzing Fatty Acids Using Gas Chromatography.*

- *Characterization of the Lipids in the Plankton of the Rio Chone Estuary for Use in Mariculture.*

- *Determination of the Impact of Pesticide Use in Agriculture on the Shrimp Industry in the Rio Chone Estuary*

- *Microorganisms, Gastroenteric Pathogens in the Rio Chone Estuary, and Their Implications for Mariculture, Tourism, Fisheries, and Habitat.*

- *Evaluation of Nutrient Loadings in the Rio Chone Estuary in Relationship to Shrimp Mariculture and Fisheries Habitat.*

- *Analysis of the Water Quality Problems of Shrimp Farmers in the Interior Estuary of the Gulf of Guayaquil. Presented to the City Council of Guayaquil.*

A series of conversations was held in 1990 with CEDEGE, which was preparing a project to control flooding in the lower Guayas basin, to be financed by the World Bank. The idea was to have the WQWG monitor the lower estuary and initiate a pesticides measurement laboratory. These ideas also did not bear fruit.

LESSONS FROM THE WATER QUALITY WORKING GROUP EXPERIENCE

The methods chosen to organize and implement water quality monitoring efforts are a critical factor for success in building reliable sets of information. The WQWG has succeeded in developing intercalibration methods to ensure that measurements being taken by investigators working in different parts of the coast, or at different times, will generate data that enjoy credibility, and therefore merit distribution.

The work of the WQWG has generated several valuable lessons for the PMRC and the nation to consider in addressing the water quality issue.

The working group is a successful setting for creating a productive collaboration among institutions.

The ability of the WQWG to main good relations among a diverse group with a wide range of interests can be attributed to several factors:

- Stability of the role of the members within their own organizations, which allowed them to commit to long-term involvement in the group;
- A multi-institutional focus that brought a variety of perspectives to the group;
- Collegial relationships, including social activities and friendships that were fostered among participants; and
- Effective coordination based on the participatory approach common to all PMRC endeavors, and on the creative use of ideas from organizational management.

It is essential to focus and to prioritize efforts. The scope of water quality issues cannot be underestimated, and was found to require greater resources and support than could be sustained by the PMRC.

The WQWG learned that in order to support its efforts, it was necessary to

- Provide an adequate minimum base of funding;
- Assure communication with and continuing assistance from the international community;
- Facilitate clear thinking about goals and objectives for sampling strategies and proposals for analysis;
- Provide training on water quality management, not only technical analysis; and
- Maintain a full-time coordinator to make best use of the time of the busy researchers.

Although the resources available to the group were limited, the WQWG has advanced in a sustainable, coherent way, moving from monitoring of the simplest parameters to more complex investigations, and sharing resources and knowledge among institutions. In this way, the group was able to use scarce resources to produce considerable benefits.

Focusing on site-specific issues is more likely to build user group and municipal interest and support.

The water quality working group found it valuable to work with local volunteer collaborators, who helped conduct water quality monitoring. Trained volunteer groups, following standardized procedures, can play a crucial role in tracking conditions, highlighting problems, and identifying successes when they occur. For example, the PMRC water quality working group has become involved with more than 10 shrimp farmers in the Rio Chone estuary who are concerned about monitoring water quality conditions in the inner estuary.

Unfortunately, the goodwill shown by individual shrimp farmers did not extend to the Association of Shrimp Growers itself. Although the mandate of the WQWG required it to work for, and along with the mariculture industry, the shrimp farmers as a group have been reluctant to improve the knowledge base of their industry. As a result, the WQWG shifted its attention to working more closely with the technical staff of the PMRC, especially with the mangrove management working group, and with some of the special area management zones—in particular, in the Rio Chone estuary and the Atacames River. The working group assembled information on the Rio Chone and developed research proposals for the Inter-American Development Bank project efforts there. In the Atacames River, the working group contributed to the practical exercises in management, the user group agreement (seeAnnex V), and ZEM office staff training.

Public education should be viewed as an integral part of monitoring.

High schools in Machala have used local water bodies to learn basic chemistry, and with technical assistance and minimal funding can generate credible long-term data. Most shrimp farmers and shrimp laboratories have skilled technicians and chemical analysis equipment that could easily be put to use in the regular monitoring of basic parameters. A major obstacle here is the prevailing reluctance to share information. This could be overcome by getting shrimp farmers to collaborate on the initiatives of a municipality, serve on a ZEM committee, or form a local monitoring group.

There is a strong, unmet need for building a constituency and knowledge base for water quality management in Ecuador.

The PMRC can make major contributions by preparing monitoring protocols, training and organizing local groups, providing technical assistance in data compilation and interpretation, and providing independent verification of local results.

Reports prepared on coastal water quality issues related to shrimp mariculture by the U.S. Environmental Protection Agency in 1994, and for urban areas by USAID's Water and Sanitation for Health project in 1993, confirm the PMRC's own conclusions on the need for a major initiative on coastal water quality in the Guayas estuary and for all major coastal cities. Policies and actions on water quality management are included in all five ZEM plans.

POLICIES AND ACTIONS TO IMPROVE AND PROTECT WATER QUALITY IN THE SPECIAL AREA MANAGEMENT ZONES

The prospects for implementation of Ecuador's basic water law, which calls for setting water quality goals and management plans for all coastal and freshwater bodies, are not good at present. Even in locations where local and national officials are committed to improving water quality, Ecuador's financial situation provides little incentive for municipalities to make major investments in wastewater collection and treatment. Ecuadorian cities do not receive grants or donations for pollution control. Instead, they must repay the loans for wastewater collection and treatment facilities, even though at present they are capable of recovering only 25 to 40 percent of their operating costs. Rural communities are eligible for a combination of grants and loans, but still must repay 50 percent of the costs. In contrast, the U.S. federal government, in its successful drive to clean up rivers, lakes, and estuaries in the 1970s and 1980s, paid the full amount of state costs for planning and design, and up to 75 percent of construction costs for publicly owned treatment works.

The WQWG did not enable the PMRC to become an effective advocate for policy reforms in water quality management, in part because the group remained focused on carrying out its first two tasks—quality control in sampling and water quality monitoring. Its membership was drawn primarily from the technical community, rather than from decision-makers. The group also remained geographically focused on the Rio Guayas and Guayaquil urban area, while the PMRC had its most active field presence along the ocean-facing coast.

For the PMRC, the integrated coastal planning carried out in the ZEMs proved a much more effective way to become involved in water quality management as an issue, since vital economic and social interests such as fisheries, mariculture, environmental sanitation, and tourism were all being discussed by the ZEM committees. As a result, the ZEM plans contain a number of specific measures to protect and improve coastal water quality.

Water quality as a coastal management issue in the ZEMs

Water quality management became an important concern during the development of the ZEM plans, although initially no specific technical work was undertaken to characterize local issues. The ZEMs have many issues in common, but different local circumstances played an important role in shaping both the specific policies and actions contained in the plans.

For example, tourism is one of the most important economic activities in Atacames-Súa-Muisne, so the Atacames beach and the lagoon and small river system behind the beach became a focal point for cleaning up residential discharges and small dumps. However, the presence of shrimp ponds in the river, which continues to suffer from low oxygen levels and sewage contamination, led to a controversy with a shrimp pond owner. The farmer, who had been experiencing water quality problems, attempted to cut a new water intake canal through a mangrove stand. The WQWG sampled the water in the Rio Atacames and the shrimp pond, and concluded that the new, illegal canal would not improve the farm, since the water in the new intake location was just as contaminated as the existing canal site. The ZEM is also located along the route that tankers take after loading petroleum from the refinery in Esmeraldas. This has generated considerable concern about refinery discharges to the Rio Esmeraldas to the east: Local residents wanted the ZEM plan to include actions to examine the potential impacts of hydrocarbon discharges on local fisheries resources.

The Rio Chone estuary in the **Bahía de Caráquez** ZEM faces similar issues, but on a larger scale. The town of Bahía discharges its untreated sewage and storm runoff close to its principal beach. In the slowly flushing interior of the estuary, some shrimp farmers have become concerned about the poor quality of water in locations where pond operators are discharging and pumping from the same stagnant channels. In an incident similar to the mariculture case in Rio Atacames, a shrimp pond operator recently cut four hectares of mangroves to create a new canal closer to the estuary side of the operation.

The high volume of daily water exchange between shrimp ponds and coastal waters is resulting in low oxygen levels and eutrophication. For example, it is estimated that shrimp farms exchange 1,000 cubic meters (m^3) of estuary water per second—25 times the average flow of the Rio Chone. Evidence of eutrophication has been found in Cinco Bocas, in the middle of the most heavily developed section of the estuary. In the Rio Guayas, shrimp farms pump about 1,700 m^3/second, which is equivalent to the average flow of all rivers in the provinces of Manabí, Guayas, and El Oro.

The PMRC intends to prepare a more detailed, integrated water quality and estuary management plan for the Rio Chone.

The **San Pedro-Valdivia-Manglaralto** ZEM has very poor sanitary conditions in some of the coastal villages, making basic sewage and solid waste disposal a priority concern. In addition, the large number of shrimp laboratories in the ZEM, which lies just north of "hatchery row" on the Santa Elena peninsula, has raised local concerns about the direct discharges to the beaches of hatchery effluents, which contain antibiotics and other contaminants. The shortage of fresh water in this ZEM also makes residents conscious and concerned about the need to protect freshwater supplies from contamination. The ZEM plan specifically calls for the establishment of a volunteer water quality monitoring effort.

A principal concern in the **Playas-Posorja-Puerto El Morro** ZEM is water quality along the important tourist beach, as well as the effect of fish processing in Posorja. The problem in Playas is compounded by the presence of fish offloading and cleaning on the beach just a few hundred meters from the tourist area, and the poor stormwater drainage that often floods the fish-waste contaminated section of the beach. This ZEM plan also incorporates a volunteer monitoring proposal.

The **Machala-Puerto Bolívar-Isla Jambelí** ZEM has two types of water quality problems. The first affects the tourist beach on Isla Jambelí, where drinking water is in short supply, and facilities are needed for beach cleanup and sanitation. A much more complex problem exists due to the presence of the city of Machala, where the wastewater from more than 200,000 people finds its way through sewers, storm runoff, and direct discharges to the Estero Santa Rosa. The complex mangrove/mariculture-dominated coastline also receives the river discharges of the Santa Rosa, Jubones, and Siete rivers, which drain the extensive banana plantations of El Oro province, as well as the coastal mountains, where gold mining and soil erosion contaminate the rivers. With extensive shorefront barrios that have no sanitation facilities, this was among the first parts of Ecuador to experience the cholera epidemic of 1991–1992.

AN EXAMPLE OF PROBLEM IDENTIFICATION AND WATER QUALITY SAMPLING ANALYSIS IN THE RIO CHONE ESTUARY

Sampling scheme
The PMRC has sponsored six sampling efforts in the Rio Chone: two in 1989 (May 11 and August 15); two in 1990 (April 9 and October 21); one in 1991 (February 24); and one in 1993 (April 19). In addition, a private firm carried out two sampling runs in 1987 (December 2 and May 12), along with the Manabí Water Project, which did sampling in 1988 (April 7).

Figure 2 shows the location of the WQWG's nine sampling stations. The shrimp industry is located primarily between Puerto Ebano and Barquero. In the last field sampling event, shrimp farm discharges near station 7A were also tested.

Key parameters for monitoring
The water used by shrimp farmers should be monitored for a variety of physical, chemical, and biological parameters, but a few simple indicators reveal much about the overall condition of the water body. Dissolved oxygen is essential, since shrimp take up oxygen through respiration and use it to oxidize the nutrients they consume. Low levels of oxygen stress the juvenile shrimp, retard growth, and, in extreme cases, cause asphyxiation.

Results and conclusions
The table presents the oxygen levels in the sites of greatest concentration of shrimp farms during different seasons. The lowest value encountered was 2.0 mg/l in October 1990, and the highest was 9.2 mg/l in April 1993, in the station near Salinas.

The level of oxygen is affected by changes in seasons and climatic conditions. During the dry period of 1990, dissolved oxygen was low throughout the summer. In the winter of 1993, which had heavy rains, dissolved oxygen was generally higher. Generally, dissolved oxygen is higher in winter than in summer, at high tide rather than low tide, and at the mouth of the estuary, as compared to the interior. Near the shrimp farms at station 7, oxygen levels were consistently depleted.

The nutrients that best indicate a source of contamination are ammonium, nitrite, nitrate, and phosphate. The nitrogen forms and phosphate indicate overfertilization of shrimp ponds. As Table 6 indicates, in 1993 the concentration of ammonium at the discharge of the shrimp pond was four times the level of the nearby estuary, while nitrite levels were twice as high, and phosphate 1.5 times higher.

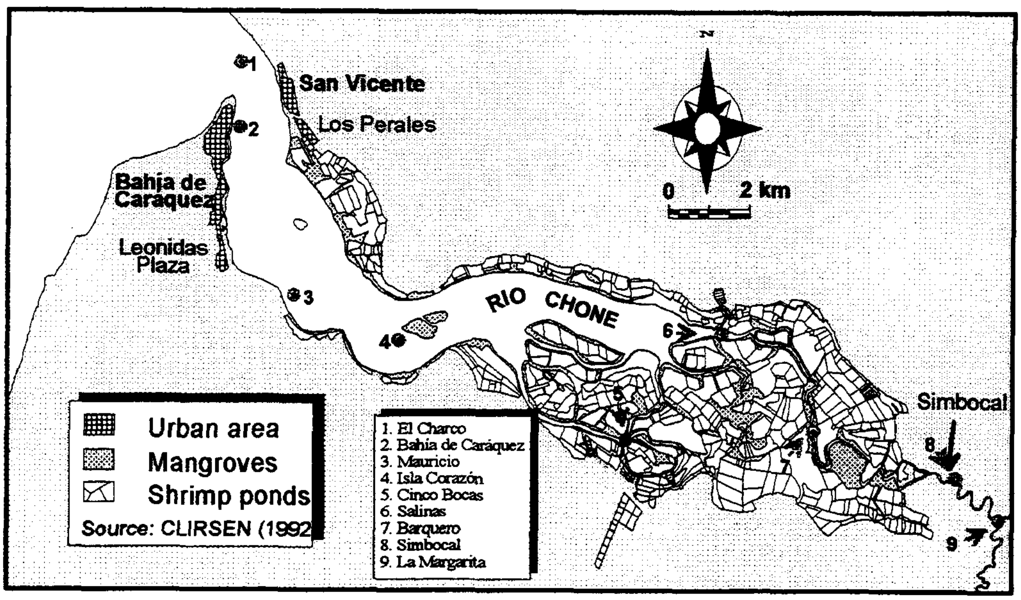

Figure 2. Location of sampling stations in the Rio Chone.

Parameter	Date and site	Station 5	Station 6	Station 7	Station 7A*
Dissolved oxygen	87 Dec 2		6.9	4.7	
(mg/l)	87 May 12		6.2	5.6	
	89 May 11	5.9			
	89 Aug 15	5.2			
	90 Apr 9	4.0	4.0	6.0	
	90 Oct 21	2.7	2.0	4.5	
	91 Feb 24	5.5	6.6	6.6	
	93 Apr 19	8.2	9.2	4.5	3.8
Ammonium	87 Dec 2		1.10	1.70	
NH_3 (µM)	93 Apr 19	ND	0.72	0.67	2.56
Nitrite	89 May 11	0.27			
NO_2 (µM)	89 Apr 15	1.35			
	90 Aug 9	1.03	0.97	0.37	
	90 Oct 21	1.00	1.15	1.00	
	91 Feb 24	0.86	1.08	1.08	
	93 Apr 19	0.49	0.35	0.33	0.62
Phosphate	89 May 11	1.50			
PO_4 (µM)	89 Aug 15	5.34			
	90 Apr 9	4.27	9.26	5.71	
	90 Oct 21	4.18	8.63	10.11	
	91 Feb 24	7.69	15.90	16.01	
	93 Apr 19	4.31	5.07	7.22	11.75

* Discharges from the Telson and Rostrum shrimp farm.

Table 6. Results of sampling in the Rio Chone Estuary

The PMRC has had very little funding for water quality management activities. However, a number of important actions have taken place in some ZEMs, which help indicate the growing interest in and support for water quality monitoring and pollution control. These are discussed in the following section. PMRC work in implementing latrine construction and other basic sanitation projects is discussed by Vasconez (see page 119). A new study of pollution sources and water quality is being undertaken prior to the design of an expanded sewer and wastewater treatment system in Machala—the only coastal city where such a study is being conducted.

Table 7 indicates how the ZEM plans have incorporated local water quality concerns and proposed a wide range of water quality management actions, including site-specific water quality plans, public education, monitoring, and pollution control.

The PMRC used practical exercises such as latrine construction, beach cleanups, and solid waste collection to explore how coastal villages in the ZEMs could improve environmental quality and health conditions through local initiatives. The results of these practical exercises showed the importance of education, involvement, and follow-through in even the smallest project—a feature missing from the many failed sanitation projects along Ecuador's coast.

	Atacames-Súa-Muisne	Bahía de Caráquez-San Vicente	San Pedro-Valdivia-Manglaralto	Playas-Posorja-Puerto El Morro	Machala-Puerto Bolívar-Isla Jambelí
Priority areas	Tourist beaches of Atacames and Súa	Rio Chone estuary	Atravezado, Montañita, Manglaralto, Valdivia	Tourist beaches of Playas, Posorja	Section of Estero Santa Rosa, Huayla, and rivers
Proposed additional water quality planning activities	Set design and siting criteria for latrines and septic systems	Conduct wastewater discharge inventory, create Rio Chone estuary management plan, zone water uses		Set specific environmental criteria, set design and siting criteria for latrines and septic systems	Conduct wastewater discharge inventory, set coastal water quality standards
Education and training for water pollution control	Technical assistance for shrimp ponds and laboratories	Training on operation of water supply and wastewater facilities			Focus on pesticide and agrochemical use, sanitary education
Monitoring and studies	Studies on impacts of chronic hydrocarbon discharges, effects of solid waste on fisheries	Estuary management study program, permanent monitoring program	Water quality monitoring	Water quality monitoring	Water quality monitoring, shrimp larvae disease study
Specific pollution control actions	Pilot tests of centralized treatment, installation of sanitary facilities	Sewer projects for San Vicente, Los Perales, San Agustin, Canoa; sanitary installations for small communities; erosion control	Sewage disposal projects, aquifer protection, treatment of shrimp lab wastes	Identification of appropriate discharge sites, control of fish waste, latrine construction	Effluent control program for urban area

Table 7. Summary of water quality management policies and actions in the ZEM plans.

Environmental sanitation committees have proven to be a key tool for long-term success in improving the conditions of coastal communities. Within the ZEMs, these groups should play the following roles:

- Form part of the special area zone committee and keep it updated on the problems and activities of its location;
- Actively participate in education campaigns related to water and land use and preventing pollution prevention;
- Monitor local water bodies to help prevent contamination and participate in watershed protection activities to maintain the natural water regime; and
- Provide annual reports to both the community and the PMRC.

AN APPROACH TO WATER QUALITY PROTECTION IN ECUADOR'S COASTAL REGION

The key question in water quality management in Ecuador today is whether the PMRC can manage to instigate a much-needed national dialogue on coastal water quality and exert the necessary leadership to generate a commitment to act.

One of the principal reasons for the WQWG's inability to attract significant funding for water quality monitoring is the low level of public awareness or a constituency for water pollution control as an issue in Ecuador. The PMRC has enjoyed success in creating national and local constituencies for integrated coastal management, and has effectively used the ZEMs to make tangible progress in coastal management at the local level. Unfortunately, there has not been a similar effective advocacy campaign for water quality management. If the PMRC were to choose to fill this leadership and policy vacuum, it would have to carry out three new strategies:

- Build public awareness and understanding of coastal water quality issues;
- Select and establish site-specific goals and objectives for priority water bodies; and
- Guide and promote public investments in pollution control.

The PMRC is probably in the best position at present to spark interest in water quality coastwide, and should use the ZEMs to demonstrate how policies can be translated into effective action.

Building public awareness and understanding of water quality issues

The strategy for mariculture set out by the PMRC in 1986 accurately foresaw the onset of water quality as a major challenge to the sustainability of the industry. In 1994, environmental concerns finally reached the foreground for many 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 stressed the need for a collaborative effort to improve and protect the environmental quality of the Gulf of Guayaquil.

From the national perspective, the mariculture industry is probably the most important stakeholder for clean coastal waters. The PMRC has tried to do just what the EPA recommends in building a collaborative effort, and has found it difficult to engage the mariculture industry in productive dialogue at the national level. The PMRC is achieving the most success by working to build relationships, setting innovative policies, and carrying out joint actions in the ZEMs. The participation of shrimp farmers in PMRC program activities at the local level is now increasing, after a long period of disinterest and skepticism.

The PMRC can take the following steps to break through the current barrier of inertia and discouragement that has characterized coastal water quality management in Ecuador:

- Develop water quality monitoring and characterization protocols, and provide training and technical assistance to the WQWG to work coastwide and in site-specific areas to compile and interpret monitoring information.
- Foster local education on water quality and sanitation, and encourage community-based monitoring. Generating public attention and concern is feasible at the local level through talks, field trips, working with schoolchildren, river cleanup activities, short-term water sampling exercises, interviews with tourists on their perceptions of the quality of beaches and tourism, training programs on community and personal sanitation, and response to local issues that pertain to pollution.
- Prepare and disclose the results of identification of local pollution sources by working with national and municipal authorities and the Ranger Corps.
- Publish annual assessments of the status of coastal water quality and pollution control activities in specific reaches of the coast, focusing on the themes of mariculture, tourism, and public health.

Through its work in the ZEMs, the PMRC has found it much easier to build awareness and concern at the local level, even when only small amounts of scientific data could be assembled to provide hard evidence that bolsters arguments on the need to control or prevent contamination of coastal water bodies. This may be due in large measure to the fact that many of the pollution problems faced in the ZEMs are obvious, from the tiny Rio Atacames where residents had traditionally disposed of garbage and raw sewage, to the large coastal city of Machala, which has no wastewater treatment system.

The PMRC needs to work with regional environmental groups to put greater emphasis on water quality issues in provincial governments and national agencies.

Establishing site-specific goals and objectives for coastal water bodies

By putting goals and objectives into place, information on waste loads from all sources can be combined with knowledge of ambient conditions and desired uses in order to accurately assign responsibility to all dischargers. In addition, a site-specific pollution control plan can help convince local and national government that implementation of pollution control laws is worthwhile.

Generating the facts to characterize local water quality concerns is a major challenge in itself, but the PMRC has shown that it can be accomplished. Setting the direction for resolving pollution control problems—especially in the absence of a functioning national pollution control framework, is a more difficult and longer-range task. The PMRC can apply the fundamental elements of the ZEM process to set goals and tangible objectives for the condition and use of coastal ecosystems by

- Designating priority areas for the establishment of water quality standards and promoting local agreements to guide pollution control initiatives; and
- Setting goals for a coastal water body that build on monitoring information, as well as discussing desired uses for a coastal water body.

Data on existing conditions should be compared with water quality standards to determine whether the desired uses can be supported, and what improvements are needed. Areas of concern range from beaches, where bacteria can pose a significant public health problem, to the more complicated and multifaceted water quality issues found in shrimp ponds.

Water quality in and around shrimp ponds can be collected locally, and should be shared, analyzed, and discussed with shrimp farmers, community members, and public officials. More sophisticated questions—such as those about the impact of new technology or industrial processes—need to involve national and international researchers. Many ZEM residents are anxious to find out more about the possible impacts and control options of currently unregulated industrial practices.

The PMRC can start the work of setting and implementing pollution control programs aimed at achieving water quality standards, beginning in its own ZEMs, with the idea that areas of national importance such as the shrimp farms in the vicinity of Guayaquil and the tourist center of Salinas-La Libertad can learn from and model this approach as well.

Guiding and promoting public investments in pollution control

Success in creating new constituencies for water quality management must be accompanied by an increase in national and local capacity to invest in the required solutions. The National Commission for Coastal Resources Management can play the role of catalyst in getting health and sanitation authorities to work together to address the public sector contribution to water quality management by

- Establishing agreements with agencies authorized by the water law to conduct water quality planning for selected areas and to maintain public information and files on the results of these programs;

- Working with the private sector—including shrimp farmers, businesses, port facilities, and other marine user groups—to examine current waste disposal practices and establish viable control strategies, possibly including a transparent permit system; and

- Sponsoring economic and social impact analyses of the importance of improving and maintaining water quality in targeted areas. Identify future economic development options, such as shellfish culture and exports, and new tourism investments, which will depend on a credible method of monitoring and supervising water quality conditions.

Some coastal cities in Ecuador are responding to the need to improve their basic services. For example, during the USAID study, the city of Machala was already preparing to enter into an agreement with the Ecuador State Bank to design and construct new wastewater collection and treatment facilities. Other coastal cities within the ZEMs that are pursuing urban sewage and stormwater management projects include Playas and Bahía de Caráquez. In addition, several municipalities in the fast-growing, tourist-oriented areas of the Salinas peninsula are developing projects. These include Salínas, La Libertad, and Santa Elena.

The financial resources already exist to enable the PMRC, through its Inter-American Development Bank project, to carry out important elements of the three strategies listed above over the next few years. Funds have been allocated for water quality monitoring activities, training and organizing of local monitoring groups, preparation of water quality standards in the ZEMs and other critical coastal areas, and publication of guidelines and status reports on water quality issues on the coast. By themselves, these activities will have a small, positive effect on individual water courses, lagoons, or beaches. When treated as part of a broader strategy, however, these same actions will have a national impact.