TECHNICAL REPORT SERIES TR-E-6

Arriaga, L. (1989) The Daule- Peripe Dam Project, Urban Development of Guayaquil and Their Impact on Shrimp Mariculture.

A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

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International Coastal Resources Management Project

The University of Rhode Island

The Daule-Peripa Dam Project, Urban Development of Guayaquil and Their Impact on Shrimp Mariculture

El Proyecto de la Presa Daule-Peripa, el Desarrollo Urbano de Guayaquil y sus Efectos en la Maricultura del Camarón.

Luis Arriaga

Resumen

El documento está centrado en dos factores considerados importantes para la maricultura del camarón: las operaciones de la presa Daule-Peripa y el desarrollo urbano de Guayaquil, los cuales están ligados al problema del mantenimiento de la calidad del agua en el estuario del río Guayas.

Inicialmente se ofrecen informaciones sobre el sistema fluvial de la cuenca del Guayas y las características del proyecto de propósito múltiple Jaime Roldós Aguilera (Proyecto Daule-Peripa).

El plan para desarrollo agrícola en la Cuenca Inferior del río Daule, comprende 50.000 ha (área entre Palestina y Petrillo), con una primera fase de 17.000 ha orientadas al cultivo de arroz, maíz, soya, frejol, tomate, cebolla e higuerilla, con cultivos alternados de melón, pimentón y sandía. Sobre esta base se estima que habrá un aumento significativo en el uso de insecticidas y herbicidas, en su mayoría compuestos órgano-colorados, órgano-fosforados y carbamatos. A este respecto no existen datos confiables de referencia sobre las concentraciones de pesticidas existentes en organismos, sedimentos y agua en el estuario del Guayas.

De acuerdo a las condiciones de la cuenca aportante a la presa Daule-Peripa, no se espera problemas en la calidad del agua a este nivel; por ello la vigilancia debería centrarse básicamente en la parte baja de la cuenca.

En relación a los efectos del desarrollo urbano de Guayaquil y Eloy Alfaro (Durán), y las descargas de los desechos domésticos e industriales, se presentan informaciones disponibles sobre las condiciones físico, químicas y bacteriológicas proporcionadas por varios autores y por los trabajos sobre modelos de calidad del agua desarrollados en la Empresa Municipal de Alcantarillado de Guayaquil (EMAG), señalando que la presencia de bacterias coliformes fecales, en el curso del río Daule, desde la altura de la Toma, y frente a la parte norte de Guayaquil, sobrepasan los niveles aceptables, según los índices de referencia usados por la EMAG.

Puesto que la construcción de piscinas camaroneras llegan hasta la periferia de la ciudad de Guayaquil, el tratamiento de las aguas residuales se hace cada vez más urgente. Por otra parte, debería establecerse un programa de vigilancia de los pesticidas en el curso inferior del río Daule, puesto que podrían constituir el mayor riesgo para las camaroneras del estuario del Guayas.

Introduction

Shrimp production in ponds has shown accelerated growth in Ecuador during the last decade. It constitutes a very important economic activity, showing its benefits in generation of jobs, foreign currency, and use of areas formerly considered unproductive. At the same time, the industry presents a variety of problems, the consequences of which cannot as yet be estimated: destruction of mangroves, conflicts concerning the use of coastal land, modifications of the coastal ecosystem, obstacles in natural drainage systems, etc.

Numerous studies have analyzed the characteristics of the Ecuadorean shrimp industry, its traditional fishing methods and farming of shrimp in ponds. Besides the industry's problems with collection and production of postlarvae, the availability of areas suitable for the construction of additional ponds and processing and commercializing the final product, additional factors must be considered because of their critical effects on the long-term health of the shrimp industry, especially shrimp farming.

These factors are related to environmental conditions and the quality of water in shrimp breeding and nursery areas. Natural processes such as floods, sedimentation, erosion and predation affect water quality, as do the results of human activity, including domestic, industrial and agricultural sewage, and changes in the natural flow of water due to the construction of dams, reservoirs, flood control projects, or extraction of water for human use and irrigation. Naturally, some of these factors, if adequately managed, can have a positive effect on shrimp farming, such as construction of dams and reservoirs, which permit control of water volumes and protection from floods.

While many of the ideas in this paper may generate additional research, the scope of this presentation is limited to those basic considerations that the author believes are most important:

- the effects of the Daule-Peripa dam (currently under construction) and associated projects on the shrimp industry.
- the impact of urban development on shrimp aquaculture, particularly in Guayaquil, as shrimp farms are already located very close to the suburban limits of the city.

The geographical area referred to in this paper is limited to the areas of shrimp farms located around the Guayas river estuary and the Estero Salado.

The Guayas River Basin

The fluvial system of the Guayas River consists basically of the Daule and Babahoyo Rivers and their tributaries. It drains an area of approximately 33,700 square kilometers (km) and is distributed as follows:

Daule River basin	13,800	km
Babahoyo - Vinces River basin	17,900	km
Taura River and others (10)	2,000	km
	33,700	km

The Guayas River, from the junction of the Daule and Babahoyo Rivers at Guayaquil to its mouth opposite Isla Verde Island, is approximately 56 km long. Parallel to its course lies an extensive body of salt water called Estero Salado, with many inlets and an ample mangrove ecosystem. Tidal influence is present as far as 100 km upriver.

The Guayas River and the Estero Salado are connected at one point by the Estero Cobina, a man-made canal with locks, which permits the transit of small vessels. More open communication exists in the area called the Interior Guayas River Estuary, between the islands of Escalante and Puna. The amount of fresh water entering the Estero Salado is difficult to determine, but constitutes a factor of major importance in the ecological characteristics and processes of the entire area (Twilley, this volume).

The Daule - Peripa Dam Project

The Jaime Roldos Aguilera multiple purpose project (Daule-Peripa Project) has the following objectives:

- to furnish water for irrigation and human consumption in the lower part of the Daule basin, for the Santa Elena peninsula and the province of Manabi.
- to generate hydroelectric power.
- to provide protection against flooding in the lower sections of the Daule basin during rainy seasons.
- to improve the supply of drinking water for the settlements and towns along the shores of the Daule River and the city of Guayaquil.
- to provide an increased flow of water to avoid salt water intrusion in the lower part of the Daule River during dry season.

To meet these objectives, several important projects have been developed, such as canal systems for irrigation of the Santa Elena peninsula and Manabi, hydro-electric plants, etc.

Table 1 indicates the principal technical specifications of the Daule-Peripa Project and reservoir, as provided by CEDEGE (Comision de Estudios para el Desarrolo de la Cuenca del Rio Guayas). The area which drains water into the reservoir comprises 4,025 km (Mendoza, 1983). The reservoir will flood 77 km along the shores of the Daule River and 98 km along the Peripa, plus the lower parts of their tributaries.

The area of deforestation and removal of vegetation matter will comprise 33,750 hectares (ha), and the area to be flooded will cover 27,000 ha. The annual draw-down will be approximately 10 meters, and the flooded area will remain at 18,000 ha.

Agricultural Development Project

The proposed irrigated area comprises 125,000 ha and is located in the lower Daule River basin, the Santa Elena peninsula and the province of Manabi. In the lower Daule section, the irrigated area of 50,000 ha is located on both shores of the Daule River between Palestina and Petrillo.

The first phase of this project (Mendoza et al., 1983) covers 17,000 ha, divided into four sub-projects (San Jacinto, Higueron, El Mate and America). The area will be used for plantations of rice, corn, soybeans, beans, onions, tomatos and castorbeans, besides alternate produce such as cantaloups, peppers and watermelons (Herman, 1986). The number of hectares assigned to each product is shown in Table 2. It must be noted that there will be a progressive incorporation of areas to be irrigated during a period of seven years (1983-1989), according to the rate of development as indicated on Table 3. This is also important from the point of view of a necessary increase of irrigation water flow rate, and the use of pesticides and fertilizers.

Use of Pesticides and Fertilizers

Rice is the main crop in the lower Daule basin. Mendoza established these figures for land use for the year 1981 for the following products:

Rice	6,446	ha (rainy season)
	6,025	ha (dry season)
Coffee	226	ha
Cocoa	254	ha
Others	134	ha (rainy season)
	92	ha (dry season)

Information on the use of pesticides on rice in the area of the agricultural project can be found in Table 4. There is no adequate information available on the use of pesticides on other products. The same table (4) gives an estimate on the use of pesticides on completion of phase one of this project. The estimate is calculated on the basis of normal dosage per hectare in these plantations, and according to the intensity of soil use (Campana, 1986).

The major part of the pesticides indicated on Table 4 are organochlorine and organophosphorus compounds, plus carbamate compounds and other urea-based herbicides. Regarding the possible effects of these pesticides the following must be taken into account:

- Organochlorine pesticides are relatively insoluble in water, but are absorbed readily by particulated matter and easily transported to rivers. The toxic is accumulated in fatty tissue, crustaceans being particularly sensitive to these compounds. Some chlorine insecticides, such as Dieldrin, remain active in soil for an average of eight years (range 5-25 years) and usually are applied in doses of 1 to 3 kilos per ha per year.
- Organophosphorus pesticides are relatively water soluble, less stable than organochlorine types and, therefore, do not persist in the environment. For this reason, the degree of bioaccumulation is not important in these compounds. These compounds, however, are highly toxic to aquatic organisms.
- Carbamates and other urea-based herbicides are moderately water soluble compared to the above groups. These compounds are absorbed by particulated matter and remain in sediments for prolonged periods. They are of minor toxicity to fishes and molluscs, but highly toxic to crustaceans. For this reason, some carbamates have been used for control of crustaceans, which in some cases are considered pests.

One of the problems associated with the use of pesticides is the method of application. For instance, in dispersion from aircraft, only 25 percent of the pesticide may reach its target, while the rest drifts into adjacent areas.

It has not been possible to obtain concrete data on the concentrations of pesticides in the water and in aquatic organisms in Ecuador, or data on tests dealing with rates of tolerance. Experiences in other countries could possibly be used as references. For example, the following average limits of tolerance for white shrimp (*Penaeus schmitti*) were established in bioassays in Venezuela:

Temperature	37.4°C
Ammonia as N	5.3 mg/l
Dissolved Oxygen	1.6 mg/l

The execution of the first phase of the agricultural development project in the lower Daule basin will undoubtedly produce large increases in the volume of pesticides used. It will be of paramount importance to establish a monitoring program, particularly on the presence of organochlorine pesticides and the degree of sensitivity of shrimp to these compounds.

The use of fertilizers, on the other hand, is not considered harmful to aquatic organisms, as long as the fertilizers do not accumulate in waters that flush slowly. In such cases, excessive amounts of nutrients such as nitrogen and phosphorus can induce phytoplankton blooms, followed by deoxigenation and anaerobic collapse (eutrophication). Sediments are also affected by deposits of nutrients, which can be liberated through agitation or turbulence.

Water Quality in the Daule River Basin

Based on the physical, chemical and bacteriological values of the water of the Daule River basin, Mendoza concluded that the water in the upper part of the river is suitable for drinking, irrigation and other uses. This region is part of the supporting sector which drains into the Daule-Peripa reservoir. In the lower section of the Daule River, the water is not suitable for direct human consumption during the dry season, but can be used for irrigation, except for the area below the La Toma, due to salt water intrusion during the dry season.

Water quality values found in the lower part of the Daule River (water treatment plant, La Toma) are shown in Table 5. The high concentration of coliform bacteria calls for attention.

From this data, no problems of water quality in the Daule-Peripa basin are expected. But much attention must be paid to control of contamination from sewage (both domestic and agricultural) in the middle and lower part of the Daule basin.

An additional problem is the potential risk of eutrophication in the Daule-Peripa reservoir (due to excessive accumulation of nutrients) and subsequent phytoplankton blooms. An environmental conservation plan designed by CEDEGE includes the necessity of cleaning and eliminating of excessive plant growth in the reservoir and in the supporting hydrographic system.

Although this paper concentrates on the identification of water quality problems of the Daule River, it is also important to consider information on conditions of the Babahoyo River. A water quality model by EMAG (Empresa Municipal de Alcantorillado de Guayaquil) for the mouth of the Babahoyo River and its confluence with the Daule showed very high values of fecal coliform bacteria during 1979-1980:

fecal coliforms	8.08 x 10>	MPN/100 M1
dissolved oxygen (DO)	6.5	mg/l
free oxygen	6.5	mg/1
chloride	6.949	mg/l

Water Flow in the Daule and Guayas Rivers

The rate of flow of the Guayas River determines processes such as dilution of salt water intrusion, dilution of contaminants, interchange with the Estero Salado system and self-purification before its discharge into the ocean. For this report, no data on direct measurements of flow rates of the Guayas and Babahoyo Rivers were available, but both show wide seasonal variations, especially between the dry and rainy period, as does the Daule River.

The most precise data available correspond to the flow of the lower part of the Daule River. The historic average for this river may be derived from a time series of 32 years (1950-1981). Table 6 shows figures for the average monthly flow rates at La Toma, as published by CEDEGE. Based on this information, the average monthly flow rate is 333.4 cubic meters per second (m^3/sec). A high flow rate of 1.043.6 m^3/sec, is registered in March (rainy season) and a low of 39.9 m^3/sec during November (dry season).

To establish flow rates of the Guayas and Babahoyo Rivers, also indicating their monthly variations, the consistent relationship between the Daule and the Babahoyo has been utilized. The EMAG water quality model indicates that the flow rate of the Babahoyo River is 50 percent higher than the Daule during the dry season, and 100 percent higher during the rainy season.

Table 6 summarizes the average flow rates of the Babahoyo at its mouth, and flow rates for the Guayas at its point of origin opposite the city of Guayaquil. An average flow rate of 30.276 x 10 m^3 per year was established, which is the contribution of the Guayas River to its interior estuary. The discharge of the Taura River and other small tributaries have not been taken into consideration.

The projected Daule River flow rate needed to satisfy the demand for water in the future (year 2006) is the following:

- deviation to the Santa Elena peninsula for irrigation, domestic and industrial use — 24.1 m^3/sec
- irrigation for 17 ha in lower Daule basin (1st phase of agricultural development — 7.0 m^3/sec
- potable water (Guayaquil) — 12.0 m^3/sec
- flow rate necessary to avoid salt water intrusion to La Toma — 28.0 m^3/sec

These figures establish the need for a constant flow rate which is higher than the average figures registered during the dry season (September-December). This problem will be solved with the operation of the Daule-Peripa Project, which will control the flow of water and will provide a constant flow rate of 100 m^3/sec (V. Mendoza, CEDEGE, personal communication).

Urban Development of Guayaquil-Duran and Its Effects on Water Quality

It is frequently stated that the problems which affect the quality of bodies of water in the proximity of Guayaquil (Guayas River and Estero Salado) are caused principally by discharges of untreated domestic and industrial sewage. Only sewage originating from the Alborada residential development, located to the north of the city, receives partial treatment. This critical environmental problem increases continually due to the excessive growth rate of Guayaquil, at present 4.5 percent annually (CLIRSEN, 1985).

Nevertheless, the results of studies by EMAG and the situation presented by the water quality models show a somewhat optimistic picture of the bodies of water which surround Guayaquil.

Actual Conditions of the Estero Salado

N. Campana, (1986) presents an analysis of the average physical and chemical characteristics of the Estero Salado for both the dry and rainy seasons. Table 7 contains data for five different test sites on the estuary. The sites had been selected to show the most relevant variations in the complex system of creeks and canals typical of the Salado. Results indicate that the conditions of contamination in the proximity of Guayaquil show positive signs of improvement as distance from the city limits increases. For instance, at the mouth of the Chongón River close to the quarantine station of the port of Guayaquil, the water is relatively clean.

Also, in the area of the Estero Salado, where most of the shrimp ponds are located, water quality is satisfactory, according to data supplied by EMAG.

Water Quality Models

EMAG has developed water quality models for the Daule and Guayas Rivers and for the Estero Salado to establish the following: concentrations of residual discharges from Guayaquil and Duran into the surrounding bodies of water; water quality produced by the increase of population in this area; and to determine how the above will affect water quality in the future (1996-2006). At the same time, the results of the above studies determine the number of sanitary installations needed to preserve the quality of the environment. The models cover the following parameters (Castagnino, 1983, 1985):

Guayas River	Daule River	Estero Salado
salinity	salinity	salinity
coliform bacteria	coliform bacteria	coliform bacteria
oxygen	oxygen	oxygen
BOD (Biological Oxygen Demand)	BOD	BOD
–	nutrients	phytoplankton
–	toxic elements	–

The principal references utilized in the EMAG models for different uses of water are given in Table 8. The ultimate type of uses for the different areas of the Salado have also been determined:

- areas of esthetic protection
- areas reserved for shrimp mariculture
- recreational areas
- areas of ecological protection
- extraction of potable water

Finally, criteria for the evaluation of the environmental impact of both the positive and negative aspects of the sewer system of Guayaquil have been observed. Local effects (sewage discharge, pumping sites, water treatment plants, odors, etc.), sanitation and other regional effects are all considered by the model.

Impacts at the Site of La Toma

Assuming that the rate of flow of 40 m^3/sec is maintained in the areas above La Toma, the model predicts coliform bacteria concentrations (the critical factor in the water quality of this zone) of 3,886 MPN/100 ml, originating from the discharges from the northern area of Guayaquil. These values are higher than the permissible maximum.

Impact on the Shrimp Mariculture

In this case, the model references correspond to the areas dedicated to shrimp farms in the proximity of the Guayas River (Santay Island and Guayaquil Peninsula). Projecting the volume of discharges to the year 2006, there will be a loading of fecal coliform bacteria equivalent to 3,056.2 and 4.082.1 MPN/100 ml in this zone. Beginning in 1996, then, primary treatment (reduction of 95 percent of coliforms) will be necessary.

Based on an annual population growth rate of 4.5 percent, with 80 percent serviced with potable water and sewage systems, an estimate of 200 liters per day of waste water has been estimated. This waste water will have to be treated in ponds which will be located along the Salado Estuary. These ponds will have the following dimensions and treatment capacities:

	Year 1996	Year 2006
Pond T-1	(13 ha) 12.960 m^3/sec	(15 ha) 21.300 m^3/sec
Pond T-2	(13 ha) 12.960 m^3/sec	(75 ha) 74.868 m^3/sec

Treatment in ponds, or any other system that may be used, must comply with the following standards:

Reduction	Percent
• coliform bacteria	95
• phosphorus	40
• orthosphosphates	40
• carbonaceous BOD	85
• nitrogenated BOD	30

Conclusions

The major risk for shrimp farms, originating from the future operation of the Daule-Peripa dam and associated projects, lies in the use of pesticides from agricultural development. The first phase comprises the incorporation of 17,000 ha of farmland located in the lower part of the Daule basin. Special attention must be paid to control of concentrations of organochlorinated pesticides. So far, it has not been possible to obtain information regarding concentrations of pesticides in waters and in aquatic organisms.

Controls over potential processes of eutrophication in the Daule-Peripa reservoir must also be constructed, even though no significant impact on shrimp aquaculture is to be expected from this source. It is considered more convenient to exercise control of eutrophication in the areas where shrimp farms are located and in the areas of mangrove in the vicinity of Guayaquil.

There is no information available on the interchange between the freshwater system of the Guayas River and the salt water system of the Estero Salado. However, the main interchange takes place in the interior estuary of the Guayas River.

The major risks of contamination originating from the discharges of the city of Guayaquil consist of the high concentration of fecal coliform bacteria, which in some areas of the Daule and Guayas Rivers and the Salado estuary, exceed acceptable levels. These factors indicate the need for treatment of all sewage being discharged into the Guasmo and Durán.

Table 1.
Specifications of the Daule-Peripa dam and reservoir

RESERVIOR SPECIFICATIONS	
<u>Volume of the reservoir</u>	
At normal level (elevation 85 m)	5,500 x 10^6 m^3
Flooded area	27,000 ha
<u>Volumes used</u>	
For flood control	700 x 10^6 m^3
For power generation	3,500 x 10^6 m^3
For irrigation	500 x 10^6 m^3
For sediment control	300 x 10^6 m^3
<u>Dam specifications</u>	
Earth fill	90 m
Height above river bed	78 m
Length of crest	250 m
<u>Spillway</u>	
Maximum natural flow	14,350 m^3/sec
Maximum regulated flow	3,480 m^3/sec
<u>Diversion works</u>	
Number of diversion tunnels	2
Diameter of diversion tunnels	9 m
Length of tunnels	550 m
Discharge capacity of each tunnel	890 m^3/sec
<u>Electric Power works</u>	
Installed capacity	130 MW
Guaranteed capacity	81 MW
Firm annual energy	510 GWH/year
Designed discharge per unit	133.2 m^3/sec
<u>Lateral Dams</u>	
Approximate length	10 km
Approximate volume of dams	5.9 x 10^6 m^3

Source: CEDEGE, Guayaquil

Table 2
Areas of plantations in phase 1 of agricultural project (in ha)

Ciclo Cultivo	Rice	Corn	Soybeans	Beans	Tomatoes	Peppers	Castorbeans	Others (*)	Total Ha
Winter	12,260	1,377	686	-----	-----	-----	619	778	15,720
Summer:									
1st crop	11,011	1,489	928	599	317	289	619	778	16,040
2nd crop	-----	1,499	928	599	317	122	-----	-----	3,465
Intensity of annual soil use									35,225

(*) 70 ha Cotton and 78 ha Sorghum
Source: Adapted from CEDEGE: 1981, Table page 34(3)

Table 3
Progressive incorporation of ageas to be irrigated.
Phase 1 of project (ha)

Years	1 (1983)	2 (1984)	3 (1985)	4 1986)	5 (1987)	6 (1988)	7 (1989)
Hectares 16,040	1,881	1,956	2,032	11,581	13,007	14,437	

Source: CEDEGE

Table 4

Use of pesticides in the area of agricultural development (Daule-Peripa Project) (From, Mendoza, eta al, 1983)

Pesticides		Annual consumption (*)	Consumption of agricultural project (**)
Herbicides			
Propanil:	Winter	39,480	68,656
	Summer	36,708	61,662
Agroxone:	Winter	4,935	8,582
	Summer	4,589	7,708
Gesoprin:	Winter	----	4,131 kg
	Summer	----	8,994 kg
Lazo:	Winter	----	2,058 kg
	Summer	----	8,563 kg
Gesagard:	Winter	----	686 kg
	Summer	----	1,856 kg
Afalón:	Winter	----	-----
	Summer	----	1,198 kg
Ronstar:	Winter	----	-----
	Summer	----	2,219 1
Amiben:	Winter	----	-----
	Summer	----	1,440 kg
Treflan:	Winter	----	-----
	Summer	----	465 kg
Insecticides			
Endrín:	Winter	19,740	17,164
	Summer	18,354	15,415
Folimat:	Winter	3,948	-----
	Summer	3,671	-----
Furadán:	Winter	92,120 kg	19,278 kg
	Summer	85,652 kg	41,972 kg
Azodrín:	Winter	----	8,582
	Summer	----	7,708
Sevín:	Winter	----	2,063 kg
	Summer	----	6,051 kg
	Summer	----	951
Nuracrón:	Winter	----	686
	Summer	----	2,745
Aldrín:	Winter	----	1,029 kg
	Summer	----	4,686 kg
Dorrhan:	Winter	----	-----
	Summer	----	899
Dipterex:	Winter	----	-----
	Summer	----	951
Lannate:	Winter	----	-----
	Summer	----	206
	Summer	----	310 kg
Orthene:	Winter	----	-----
	Summer	----	206
	Summer	----	310 kg

(*) only for rice planatations, which comprise 96 percent of total area cultivated.
(**) with annual intensive soil use of 33,050 ha, including plantings of rice, corn, soybeans, beans, tomatoes, peppers, castorbeans (see Table 2).
Mendoza, et al. 1983

Table 5
Average physical, chemical and bacteriological parameters at LA TOMA site (Daule River), (1980-1982).

Parameter	1980 R.S.	1980 D.S.	1981 R.S.	1981 D.S.	1982 R.S.	1982 D.S.
Temperature (^{o}C)	28.9	27.5	28.0	27.1	28.5	—
Suspended solids (mg/l)	284.0	646.0	153.0	452.0	34.4	—
Settling solids (mg/l)	0.4	1.8	—	0.9	0.2	—
Dissolved solids (mg/l)	194.0	670.0	129.0	1,026.0	---	—
Total solids (mg/l)	478.0	1,316.0	282.0	1,478.0	697.0	—
pH	7.4	7.4	7.2	7.3	7.0	—
Salinity (mg/l)	151.1	501.3	80.3	815.0	90.0	—
Clorides (mg/l)	67.0	282.0	28.0	436.0	37.0	—
Sulfates	82.0	61.0	—	78.0	11.5	—
N-organic (mg/l)	0.415	0.146	0.22	0.208	0.04	—
$N\text{-}NH_3$ (mg/l)	0.04	0.01	—	0.55	---	—
$N\text{-}NO_2$ (mg/l)	0.07	0.03	0.0	0.02	0.07	—
$N\text{-}NO_3$ (mg/l)	4.84	4.26	0.27	2.27	0.78	—
Oxygen (mg/l)	5.85	5.92	6.12	6.22	6.36	—
BOD (mg/l)	2.34	1.44	1.41	1.0	1.30	—
Fecal coliforms (MPN/100 ml)	4,193	25,949	2,614	2,264	3,268	—
Total coliforms (MPN/100 ml)	8,757	62,536	8,440	9,883	7,422	

Source: Data from EMAG, in Mendoza et al
R.S. = Rainy season
D.S. = Dry season
--- = No data

Table 6
Average monthly flow rate of the Daule River (1980-1981) and estimated flow rates of the Guayas and Babahoyo Rivers (m^3/sec)

River	Rainy Season Jan.	Feb.	Mar.	Apr.	May	June	Dry Season July	Aug	Sept	Oct	Nov	Dec	Yr. Aver.
Daule (1) (La Toma)	297.7	689.2	1,043.6	847.9	482.7	231.0	131.1	68.3	54.7	49.4	39.9	65.5	333.4
Babahoyo (2)	595.4	1,378.4	2,087.2	1,695.8	695.4	346.5	196.7	102.5	82.1	74.1	59.9	98.3	640.2
Guayas (3)	893.1	2,067.6	3,130.8	2,543.7	1,448.1	577.5	327.8	170.8	136.8	123.5	99.8	163.8	973.6

(1) Volumes observed by CEDEGE
(2) Estimated volumes (Factors: rainy season - 2.0; dry season - 1.5)
(3) Estimate at junction of Daule and Babahoyo Rivers

Table 7
Values registered in the Salado inlet for
dry season (June-December) and rainy season (January-May), 1985 averages

	T°C	Salinity (mg/l)	D.O. (mg/l)	BODs (mg/l)	P-Total (mg/l)	Fecal Colif. (NMP/100ml)	Total Colif. (NMP/100ml)	pH	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)
<u>Dry Season</u>											
Site (*)											
S4-A (Pte 5 de Junio)	25.7	15,195	3.08	11.50	0.66	94,666	174,166	7.6	0.30	0.01	1.26
S6-A (Pte Calle Portete)	25.5	21,705	3.53	2.54	0.27	2,933	8,916	7.5	0.15	0.08	1.32
S12-B (La Chala)(**)	30.0	13,130	0.0	20.56	1.35	16.6×10^6	123×10^6	7.3	0.85	0.03	2.92
S13-A(Estero Cabina)	25.6	20,916	4.24	1.15	0.18	564	976	7.6	0.01	0.03	1.04
S15-A(Des. Río Chongón)	25.6	21,642	4.97	2.17	0.21	430	447	7.8	0.06	0.001	1.15
<u>Rainy Season</u>											
Site (*)											
S4-A	27.5	18,638	3.07	5.86	0.33	179,833	337,667	7.3	0.37	0.70	1.40
S6-A	27.7	24,431	3.56	0.96	0.14	17,867	54,520	7.4	0.19	0.84	1.47
S12-B	28.4	17,430	0.05	10.22	0.68	$11{,}337 \times 10^5$	$21{,}175 \times 10^5$	7.1	1.06	0.42	2.24
S13-A	28.2	24,458	4.70	0.93	0.09	1,682	2,300	7.4	0.02	0.13	1.15
S15-A	28.2	25,390	6.08	1.33	0.10	4	5	7.7	0.07	0.04	1.26

Data taken from N. Campaña, 1986 (partially)
* see Figure 2
** pumping station (discharge site))

Table 8
Index of references used in water quality models, EMAG

Water use	Fecal coliforms (NMP/100ml) less than...	Dissolved Oxygen (mg/l) more than	Chlorophyll "a" (mg/m^3) less than...
esthetic protection (except coliforms)	–	1.5	50
protection of water sources for shrimp mariculture	3,000	3.5	–
recreation (human contact with water)	1,000	4.0	20
ecologic protection for fish	–	4.0	–
pumping sites for water treatment plants	4,000	1.0	–

Source: Castagniño

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