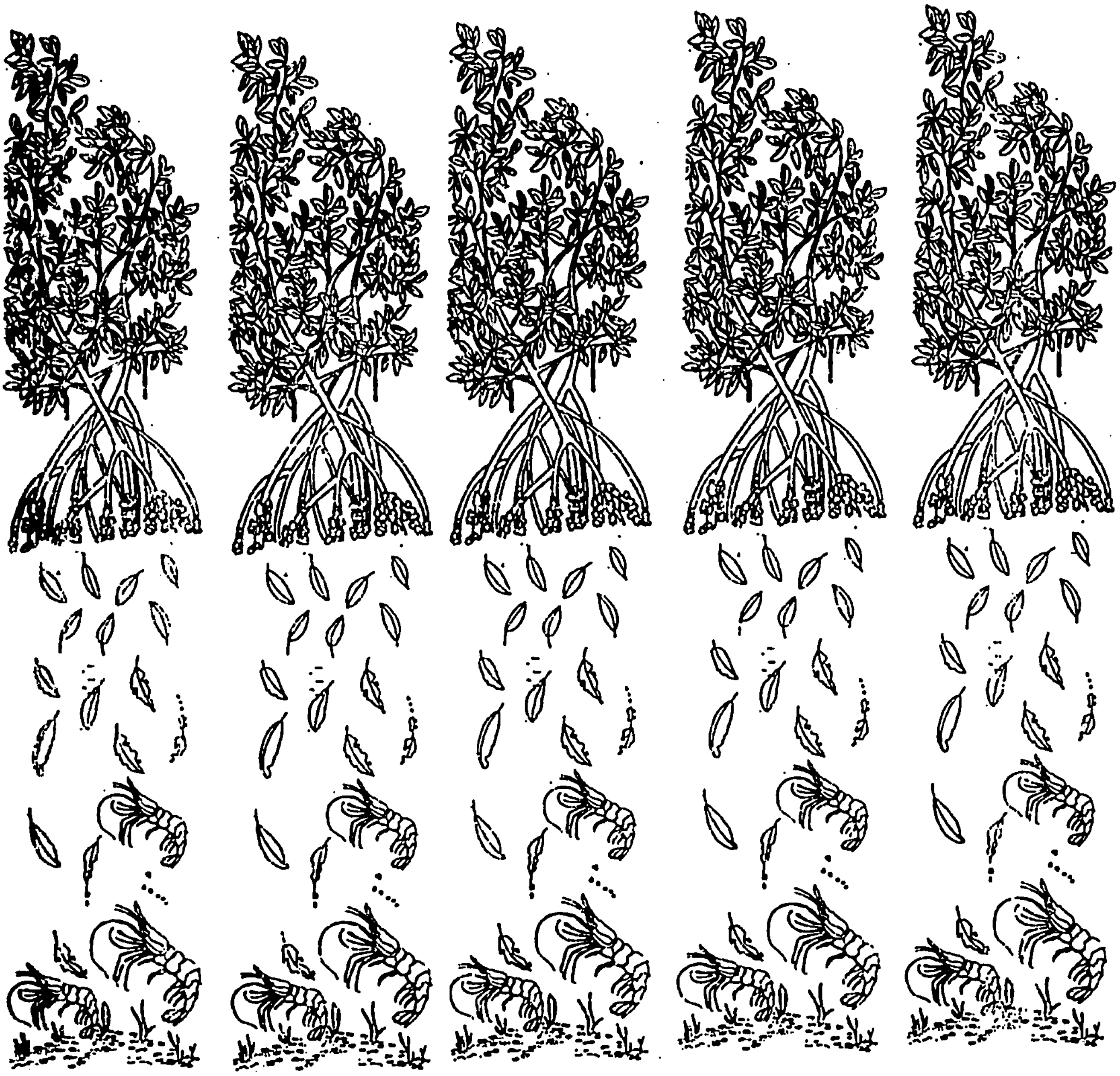
Environmental Study of the Gulf of Fonseca



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Environmental Study of the Gulf of Fonseca

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Acronyms

ALGOSUR	Cooperativa Algodonera del Sur
ACENSA	Azucarera Central S.A.
ANDAH	Asociación Nacional de Acuicultores de Honduras
COAGROVAL	Cooperativa Agropecuaria del Valle
CODDEFFAGOLF	Comité para la Defensa y Desarrollo de la Flora y Fauna del Golfo de Fonseca
COHDEFOR	Corporación Hondureña de Desarrollo Forestal
CONAMA	Comisión Nacional del Medio Ambiente
CREHSUL	Cooperativa Regional de Horticultores del Sur
CRSP	Collaborative Research Support Program
CSPE/OEA	Consejo Superior de Planificación Económica y Secretaría General de la Organización de Estados Americanos
DESFIL	Development Strategies for Fragile Lands
DGECH	Dirección General de Estadística y Censos
DIGEPESCA	Dirección General de Pesca
EDS	USAID Export Development and Services Project
FAO	United Nations Food and Agriculture Project
FPX	Federación de Productores y Exportadores Agrícola y Agro-Industriales Hondureños (Federation of Agricultural and Agroindustrial Producers and Exporters)
IDECASA	Industria de la Carne S.A.
IED	USAID Investment and Export Development Project
GOH	Government of Honduras
PTR	USAID Rural Technologies Project
SAPLAN	Sistema de Análisis y Planificación de Alimentación y Nutrición
SECPLAN	Secretaría de Planificación
SECTUR	Secretaría de Turismo

Executive Summary

Southern Honduras, in particular the Gulf of Fonseca region, is an area characterized by sharp contrasts in its geography and patterns of human utilization of natural resources. Limited by natural factors such as scarcity of good soils, acutely seasonal rainfall patterns, rugged terrain, and constrained estuarine hydrology, the gulf is nonetheless one of the country's most heavily populated areas. It is a region in which industrial agriculture has historically played a major role, and at present it is dominated by two of the most profitable Honduran export activities, shrimp aquaculture and melons. Yet the rural population is one of the poorest in the Western Hemisphere. Although suffering the effects of a long history of environmental degradation, the area continues to serve a vital role in regional and local ecosystem function and merits careful management. Finally, despite the region's economic and environmental importance, geographic information critical to the needs of decision makers is virtually absent.

The advent of shrimp farming in the 1980s and its pervasive influence over the region have greatly sharpened all of the above issues. Controversy undignified by reliable information, occasionally violent conflict, and international focus on the problems of the region have yet to result in better resource management or a clear path to the resolution of problems.

The purposes of the present study were therefore (1) to characterize accurately the disparate aspects of resource use conflicts in Honduras; (2) with shrimp farming as a focal activity, to develop, compile, and analyze information on the region that assists in assessment of the current situation; and (3) to make recommendations and establish preliminary guidelines for developing sustainable resource use management plans for the Gulf of Fonseca area.

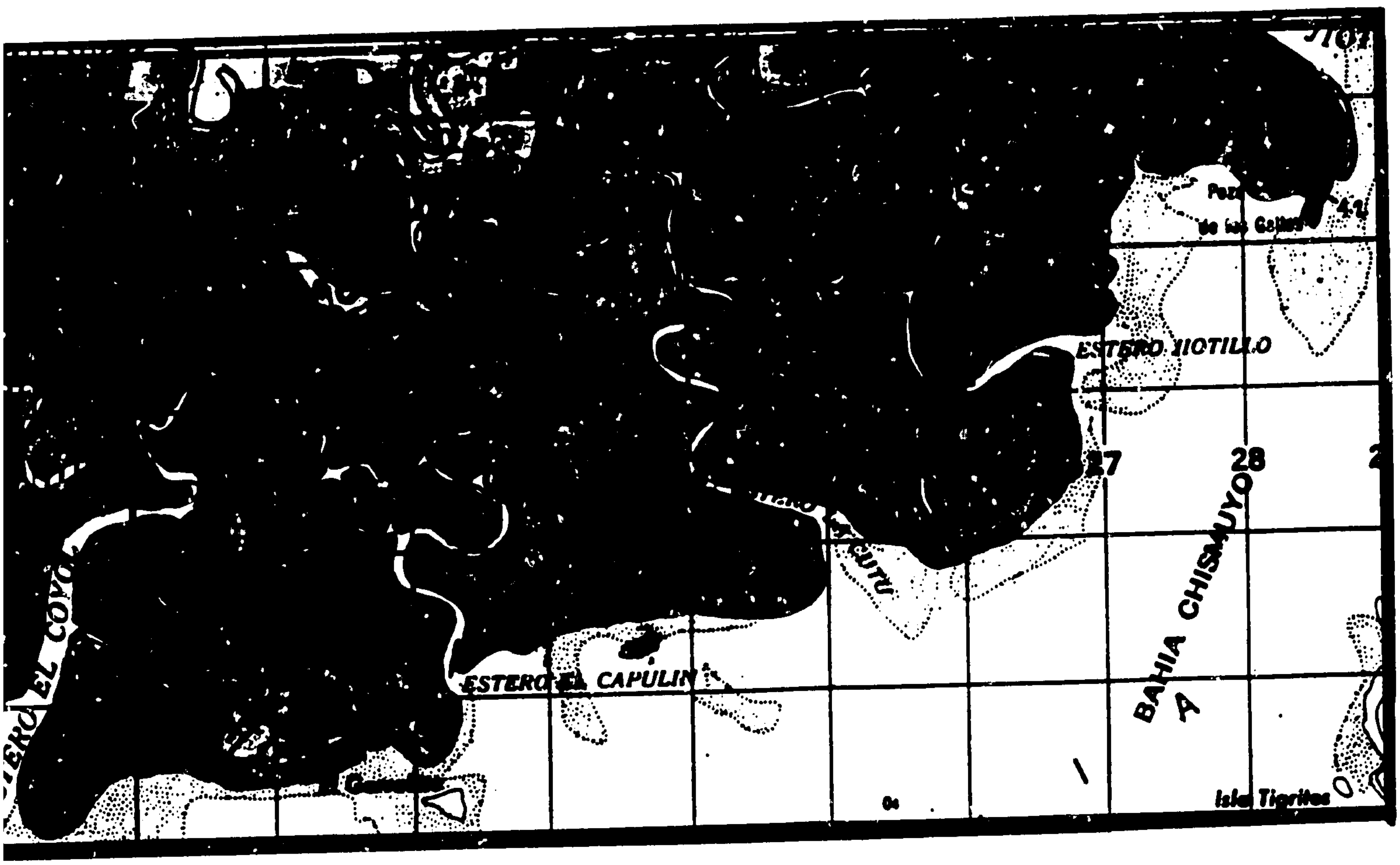
To achieve these purposes, the study developed the following information:

(1) An analysis of the changing natural vegetation and land-use patterns from the early 1970s to 1993 using three data sets derived from aerial photos from the years 1973, 1982, and 1992 (see Executive Summary Figure 1).
(2) An analysis of available physical, environmental, and biological data for the region and to review of the accuracy of those data.
(3) A socioeconomic analysis of the impacts of commercial shrimp farming and other commercial and artisanal uses for the region.
(4) An inventory of the major stakeholders dependent on the gulf's natural resources.
(5) An assessment of the sustainability of the projected growth of the commercial shrimp-farming industry.
(6) A description of mitigation measures and strategic planning for minimizing the social, economic, and natural resource impacts of selected gulf activities while striving for sustainable multiple-use management for the region.

Facing page:
Executive Summary Figure 1.
Overlay of 1992 shrimp fanning on 1973 mangrove forest

1973 LAND USE MAP

1992 LAND USE MAP



SIMBOLOGIA

1. AREAS AGROPECUARIAS
   - 1.1 AGRICULTURA DE IRRIGACION
     - 1.1.1 CAÑA DE AZUCAR
     - 1.1.2 OTROS CULTIVOS (MELON, MAIZ, ARROZ, ETC.)
   - 1.2 AGRICULTURA DE SUBSISTENCIA
   - 1.3 PASTIZALES
2. AREAS BOSCOSAS
3. MANGLARES
4. ZONAS DE INUNDACION
   - 4.1 PERMANENTES
   - 4.2 ESTACIONALES (PLAYONES)
5. ZONAS DE AGUA
   - 5.1 RIOS/ESTEROS
   - 5.2 LAGOS/LAGUNAS
6. CAMARONERAS
7. SALINERAS
8. ZONAS URBANAS/INDUSTRIALES

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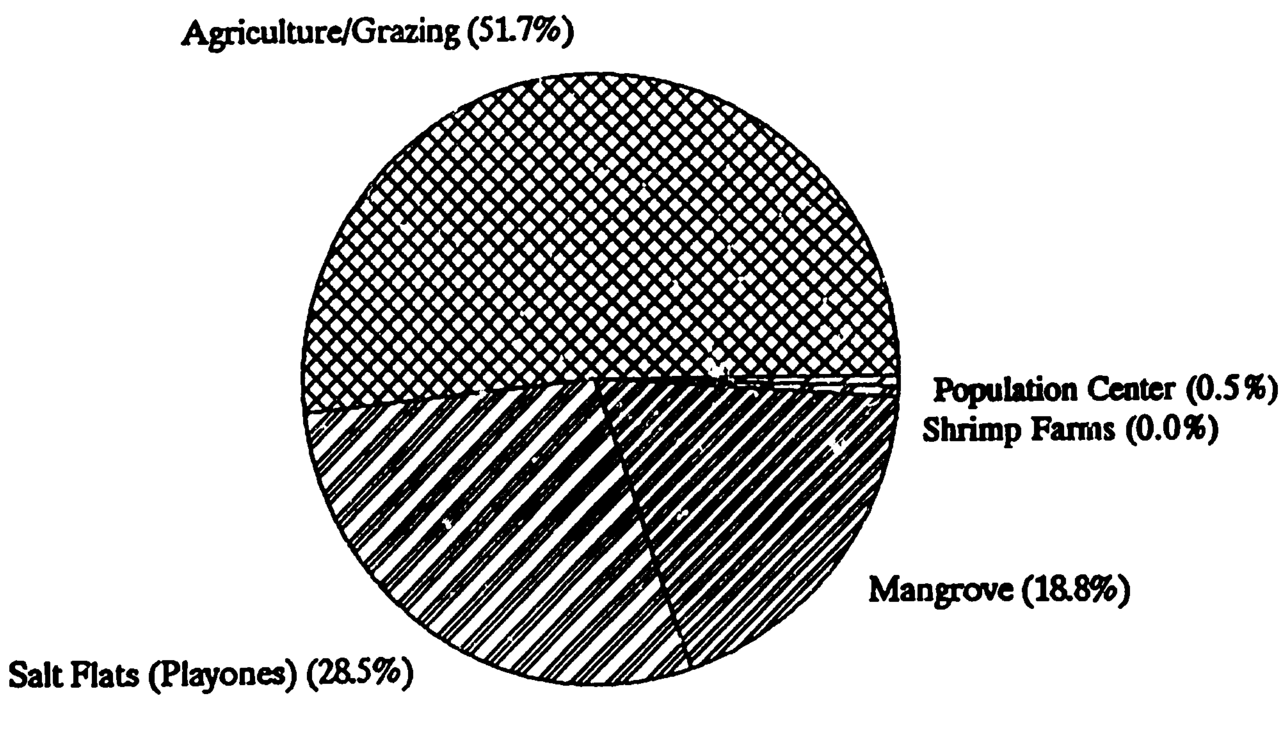
These tasks were accomplished utilizing a combination of analytical methods including aerial photointerpretation and analysis of water quality parameters together with qualitative methodologies such as rapid rural assessment, ground and aerial field observations, interviews with key individuals and interest groups, and extensive review of the available background material.

Key findings can be summarized as follows:

(1) The aggregate land area occupied by constructed shrimp farms has increased from 1,064 to 11,515 ha in the ten-year period between 1982 and 1992.

(2) From 1973 to 1982 the total hectares of high-quality mangrove—defined as those categories other than stress mangrove and dwarf mangrove per the 1987 study by Corporación Hondureña de Desarrollo Forestal (COHDEFOR)—declined from 30,697 to 28,776, representing a loss of 1,927 ha (6 percent). In 1992, the total hectares of high-quality mangrove was 23,937 ha, a further decline of 4,839 ha (17 percent) in the 10 years since 1982 (see Executive Summary figures 1–5).

Executive Summary Figure 2.
Land use by major category in 1973



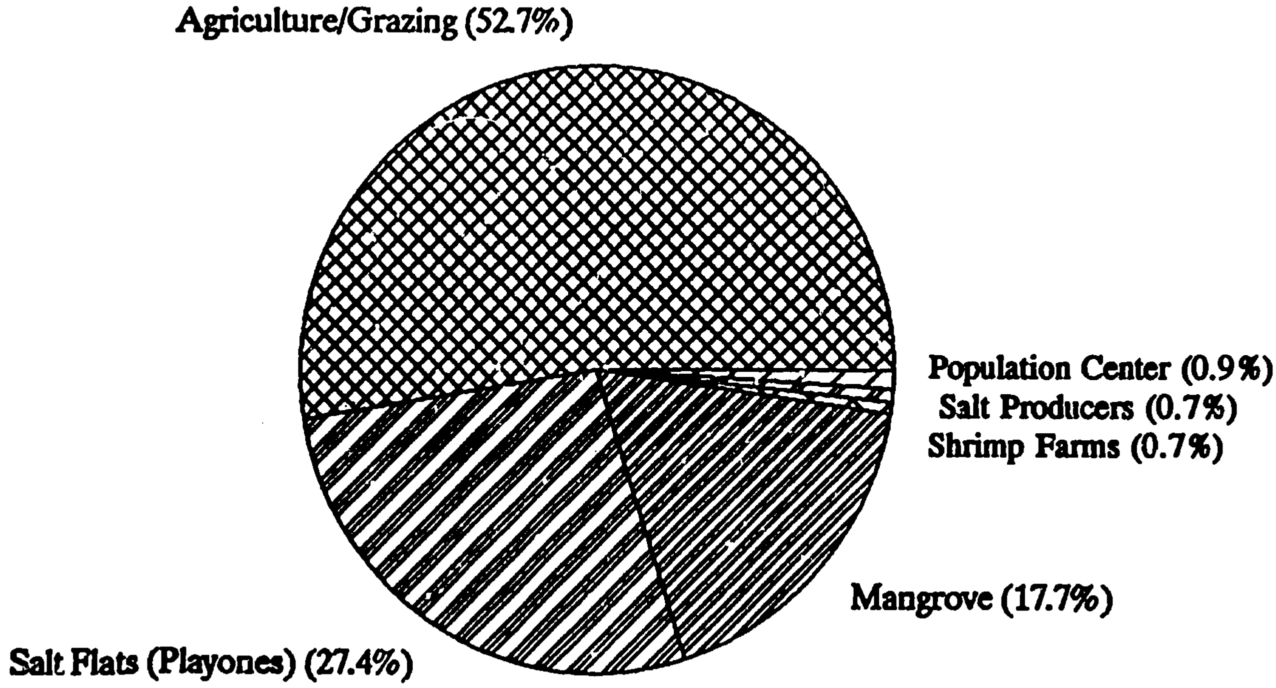
(3) Of the plausible causes for decline in high-quality mangrove cover, the loss of 2,132 of the 4,839 ha lost since 1982 is directly attributable to occupation of former forest lands by shrimp farms. An additional 2,174 ha of dwarf or stressed stands of mangrove associated with *playones* were also occupied by shrimp farms.

(4) The 2,708 ha representing the balance of the 4,839 ha of high-quality mangrove lost between 1982 and 1992 is not readily attributed to a single cause. Government statistics on fuelwood harvest of mangroves over that time period, 250 to 350 hectare equivalents per year, are comparable in dimension to the missing area; although tanbark harvest, alterations to hydrology, and drought may contribute to the overall loss.

(5) There is no significant increase in the amount of agricultural land over the nineteen-year period of the land-use analysis.

(6) At the time of this study, the aggregate area of land awarded in shrimp concessions is 31,419 ha, virtually identical to the combined estimates of the high-quality and marginal mud flat lands existing in the area according to earlier reports.

Executive Summary Figure 3.
Land use by major category in 1982



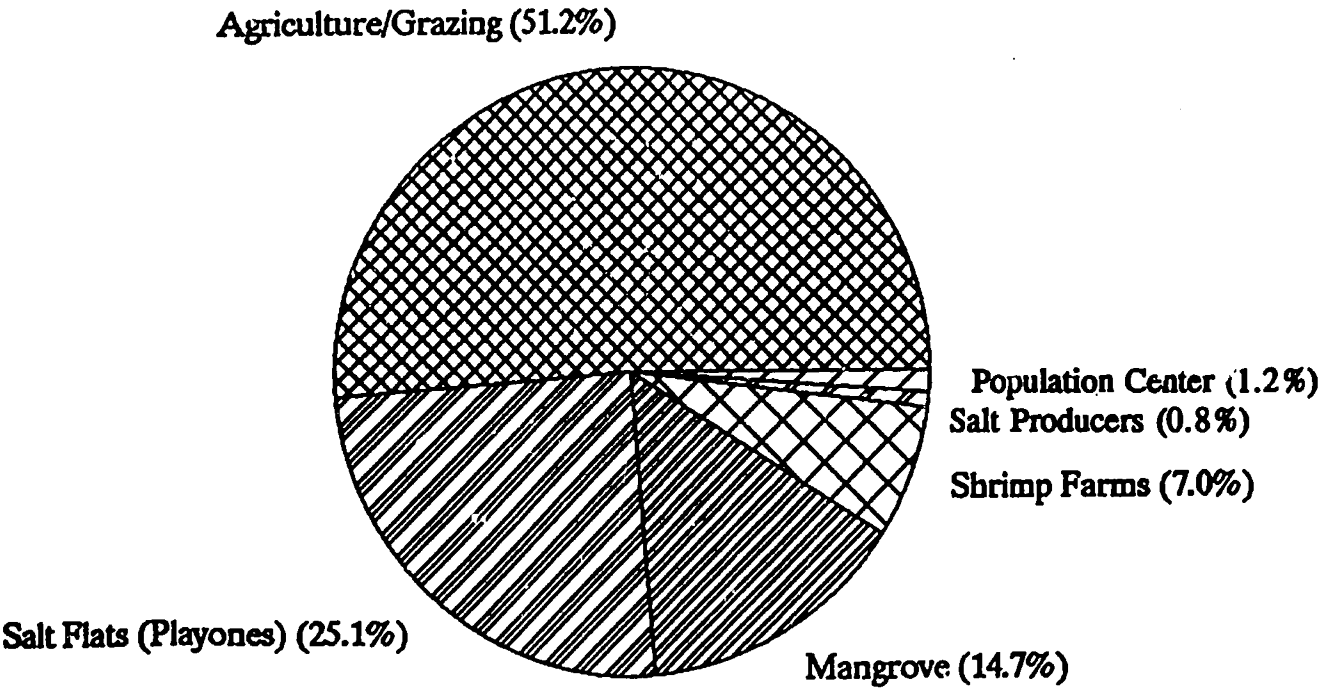
(7) Field observations recognize an increasing tendency for new shrimp farms of the commercial category to be constructed on lands occupied by dense stands of dwarf mangrove, and for artisanal farms to be cut out of stands of higher quality mangrove.

(8) Although wholesale alteration of local hydrology by shrimp farm construction was not evident, localized examples were observed that were of special interest due to their proximity to protected areas.

(9) Postlarvae for pond stocking are abundant, both from the capture fishery and imported stock. Most farms still depend heavily on wild-caught seed, and estimates for total capture from gulf waters range from 1.3 to 3.5 billion per annum.

(10) Fisheries statistics available from the Dirección General de Pesca (DIGEPESCA) for the period 1987–91 seem to indicate a stable or short-term increase in harvest from the gulf by the artisanal fleet. Further analysis points to changes in capture gear and increased efficiency and effort as important aspects of the phenomenon.

Executive Summary Figure 4.
Land use by major category in 1992



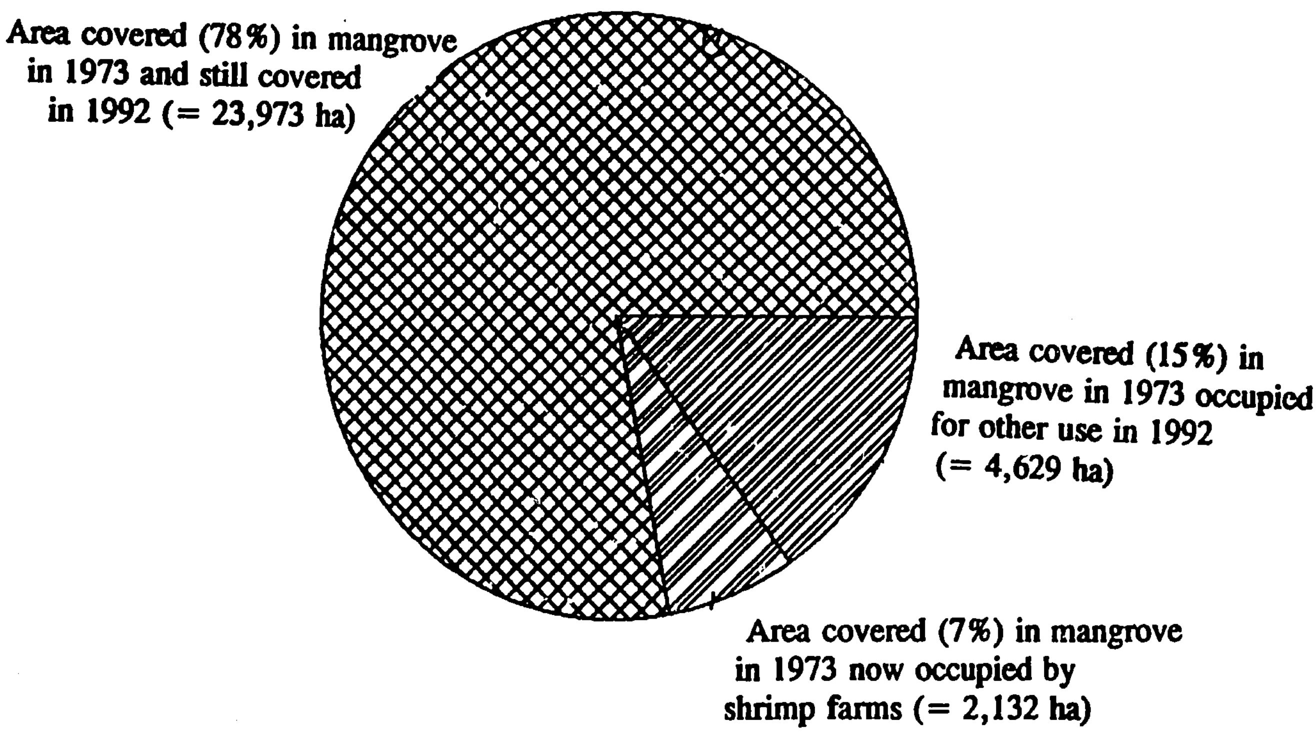
(11) Declining water quality in the shrimp farm zones is a serious concern. The cause of poor water quality of immediate concern is organic loading from shrimp pond effluent, particularly in the San Bernardo area.

(12) Other water quality problems broadly originate with contamination from agriculture. All ten water samples analyzed during this study contained detectable levels of pesticides, some of which were at concentrations approaching dosages lethal for select test organisms according to the scientific literature.

(13) The Choluteca River Basin Agriculture Development Project poses significant risks to ecosystems and the shrimp farm sector in the Gulf of Fonseca due chiefly to the likelihood of elevated salinities and pesticide levels, which either have not been recognized or not been taken seriously by government and the affected sectors.

(14) Although small producers and cooperatives have substantial interest in shrimp farming, limited technical or financial assistance from the government or aid agencies makes their possibilities of success marginal or impossible.

Executive Summary Figure 5.
Mangrove cover in 1973 (= 30,697 ha) converted to other uses in 1992



(15) The negligible costs, and the political and economic connections that are necessary to obtain concessions, have made land speculation profitable and common. Disputes over the vague boundaries of concessions are costly, time-consuming, and have the potential for becoming violent.

(16) Shrimp farms have provided employment opportunities, albeit at near-minimum wages, for substantial numbers of women. Although a more intensive socioeconomic study would be required to determine how women's wages have affected family incomes and welfare, their incomes have not led to substantially better housing or more material goods. Shrimp farms have added to the number of job alternatives for unskilled men.

(17) One cost of the development of shrimp farms is that estuary and lagoon fishermen have seen a reduction in the area they can use. Another cost is that, probably because of changes in hydrology, seasonal lagoons provide fewer fish and shrimp resources than they did in the past.

(18) It is the *perception* of gulf fishermen that the shrimp farms have been responsible for a decline in the fishing harvests and consequently in their earnings as well.

(19) The shrimp industry has not affected wage rates or labor availability for other agroindustries in the region. A few communities have benefited from the assistance of shrimp farms in improving their basic infrastructure.

(20) The urban centers of San Lorenzo and Choluteca have seen substantial business expansion, in part due to the increased economic activity created by the shrimp industry. The much greater vitality in the economy of the region is reflected in new investments in infrastructure.

Major recommendations

(1) Resource management for the gulf will have to take into account multinational needs and cooperative agreements between Honduras, Nicaragua, and El Salvador [national governments].

(2) A master plan for the continued development of the aquaculture sector should be prepared that focuses on the following: **[1,2,3,4,5,6,8]**[1]

- Rationalization of the concession process should be prioritized, including environmental impact requirements for the construction or expansion of farms.
- Local plans to mitigate eutrophication due to organic loading from pond effluent should be developed. These plans would be based on such parameters as area of ponds under production, prevailing pond management practices, local hydrology, and volumes of exchange water.
- Greater analysis of postlarvae capture fishery and associated by-catch.
- Assessment of schemes for generating supplementary income for artisanal fishermen is needed. Such schemes include low-technology aquaculture

[1] **Boldface numerals** in brackets (**[ ]**) refer to support agencies shown in Executive Summary table 1.1.

of mollusks, nontraditional capture fishing methods (e.g. lobster traps), and improved postcapture handling and distribution.

- Incentives for domestic hatchery construction should be introduced.

(3) A fisheries management plan for the gulf should be developed. In the absence of accurate statistical information, a protective attitude must be followed. A limited entry management concept needs to be implemented, and size recommendations need to be enforced. Based on recommendations from the Ministry of Natural Resources and other knowledgeable institutions, seasonal and area closures need to be implemented for finfish species, shrimp, shrimp postlarvae, bivalves, and mollusks. Recommendations on the type of gear used and acceptable fishing methodologies need to be made and transferred to the end user. [2,6,7,9]

(4) In light of existing contamination levels and the dramatic increases that are anticipated, analysis and reduction of pesticide contamination should be focal elements of the water quality initiatives planned for the gulf (e.g. Pond dynamics Collaborative Research Support Program [CRSP]). [6,8,9,10,14]

(5) A complete Environmental Impact Report should be prepared for the Choluteca River Basin Agricultural Development Project. This report must include appropriate mitigation measures, which were not part of the previous Assessment. In light of significant risk to ecosystems in the Gulf of Fonseca that the project poses, implementation should be held in abeyance until appropriate mitigation measures are developed. [9,15]

(6) Protected areas must be delineated and management programs developed for the three major types of ecosystems. [2,3,4,7,12,13]

- Preserve and manage remaining areas of dry tropical hardwood forest as biodiversity areas.
- Establish protected areas within different microenvironmental systems of the mangrove forests. Develop and enforce a management plan for multiple use of these areas.
- Protect and manage freshwater and brackish water wetlands and some of the remaining winter lagoons.

(7) In light of the poor resolution of aerial photos from 1992, new imagery should be taken as soon as feasible. With the new imagery in hand, another mangrove inventory of the detail achieved in 1987 should be undertaken to quantify the loss of forest of different qualities. [2,6]

(8) Assess the danger posed by the importation of live organisms from foreign sources. A better understanding is required of the risks of such importations and diagnostic technologies. [2,6]

(9) Social programs and infrastructure should be developed regionally within the Departments of Valle and Choluteca and financed from already assessed taxes on export products. Tax incentives could be given to companies that assist local communities in the improvement of selected infrastructure needs such as freshwater wells, electricity, schools, and latrines. [Local governments.]

Executive Summary Table 1.1.
Matrix of potential support agencies for proposed recommendations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Recommendation	GOH	DIGEPESCA	COHDEFOR	CONAMA	SECTUR	ANDAH	CODEFFAGOLF	PRIV. FARMS	WORLD BANK	FPX	USAID	CONSER NGOs	PEACE CORPS	CRSP	DEVELOPERS
Aquaculture development plan	●	●	●	●		●									
Shrimp farm concession	●	●	●	●	●			●							
Fisheries management plan		●				●	●		●						
Pesticide sampling		●				●		●	●	●				●	
Environmental Impact Report for Choluteca River Basin Project									●						●
Protected areas		●	●	●			●					●	●		
Mangrove inventory			●	●		●	●				●	●			
Assess risks of importing live organisms		●				●									

1. Background and introduction

The Gulf of Fonseca represents a unique resource in Central America. It is bordered from south to north by the countries of Nicaragua, Honduras, and El Salvador. The gulf and the lands surrounding it are areas rich in biodiversity where extensive stands of mangroves, lagoons, and enclaves of dry tropical forests can still be found. Since the area is bordered by three countries, resource management of the gulf area will have to take into account multinational needs and cooperative agreements in order to be effective. The Gulf of Fonseca offers Honduras its only access to the Pacific Ocean.

Southern Honduras comprises the area that borders the Pacific Coast along the Gulf of Fonseca. The plains around the gulf extend approximately 25 miles inland before they meet the Volcanic Highlands. These inactive volcanic mountains rarely reach altitudes of more than 1,400 m, are extremely steep, and contain many isolated valleys. Part of the lands that surround the gulf also offer the three countries an ideal area for the production of domestic and export crops such as melons. The gulf's hot climate and dry season are good for the production of melons and other crops for lucrative winter markets in the United States and Europe. The warm temperatures, extensive tidal flats, and salt flats (*playones*) also make this area conducive to extensive and semi-intensive shrimp aquaculture production. The dry forest areas are mostly used for cattle production.

Nonirrigated agriculture in the region is quite risky due to the distribution and variability of rainfall. The period between the beginning of November and the end of March is completely dry. Occasional intense precipitation in June and September occasionally causes devastating floods on the plains and landslides in the mountains. Droughts are common even in the midst of the rainy season. Those extremes in rainfall, combined with the hot temperatures of the gulf region, make it a difficult place to live and to practice agriculture (see DeWalt and DeWalt 1982).

Since 1986, USAID/Honduras has promoted the development of nontraditional products in the region, chiefly shrimp and melons. Development assistance for the region has been channeled through Federación de Productores y Exportadores Agrícola y Agro-Industriales Hondureños (FPX) under the USAID/Honduras Export Development and Services Project (EDS # 522-0207).

FPX's support to the shrimp industry has focused on technical assistance to the producers, processors, and exporters. Since 1986, the shrimp aquaculture industry has grown from 1,500 ha of production area to more than 11,000 ha in production in 1993. According to the Central Bank of Honduras, 4 million kg of shrimp produced by the shrimp farm sector were worth $40.2 million were exported in 1992.

1.1. Purpose of the study

Despite its significant economic benefits, development of the shrimp farming industry has generated considerable controversy, both environmental and social. Due to the lack of empirical information, the shrimp producers, environmentalists, and special-interest groups have voiced conflicting views on the shrimp industry's environmental, economic, and social impacts.

The primary purpose of the current study was to develop, compile, and analyze information on the region in order to assess the current situation. A secondary purpose is to make recommendations and establish preliminary guidelines to be used in developing sustainable resource use management plans for the Gulf of Fonseca area.

The study developed the following information:

(1) An analysis of the changing natural vegetation and land-use patterns from the early 1970s to the present using three data sets from aerial photos from 1973, 1982, and 1992.
(2) An analysis of available physical, environmental, and biological data and a review of the accuracy of those data for the region.
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(4) An inventory of major stakeholders dependent on the gulf's natural resources.
(5) An assessment of the sustainability of the projected growth of the commercial shrimp farming industry.
(6) A description of mitigation measures and planning strategies to minimize the social, economic, and natural resource impacts of selected gulf activities while striving for sustainable multiple use management for the region.

1.2. Physical and geographic aspects of the gulf contributing to historic patterns of economic development and conflict

The physical and geographic features of the gulf have been ably characterized in full detail via reports derived from several related studies preceding the current effort (DESFIL 1989: Dickinson et al. 1988; Vega 1989). The region's chief physical characteristics are therefore described in highly summarized form, with emphasis more appropriately given to the features that significantly contribute to the present subject of resource utilization patterns and conflict.

The southern zone of Honduras, which borders the Gulf of Fonseca, includes the Departments of Valle and Choluteca, has a total surface area of about 5,757 km^2 (4,211 km^2 in the Department of Choluteca and 1,546 in the Department of Valle). This total area, representing about 5.2 percent of the national territory, is located between 12°50′ and 13°50′ north latitude, and 86°43′ and 87°48′ west longitude.

Within this large geographic area three broad geomorphic areas can be defined, the mountain regions, the plains, and the coastal zone. Our study area encompassed some 163,000 ha of plains and coastal areas.

The plains area is divided into two distinct zones, an alluvial sedimentary shelf from the coastal area to 15 m above the mean high tide mark, and a higher shelf up to 200 m above the mean high tide mark, which resulted from upward movements of the ancient sea floor.

The coastal area encompasses all the estuarine zone and the areas which are inundated by tidal flow. The coastal area encompasses some 1,000 km^2 of estuaries, islands, and lagoons. This transition zone from land to gulf is more dynamic than the plains or mountain regions and is influenced by the recent and continuous deposition of sediment. The effects of deforestation, inadequate erosion prevention measures, and the damming of major rivers have increased and altered the deposition of sediments loads in this zone and accelerated eutrophication of the area.

Wetlands are the region's most notable regional physical attribute, with estuaries consisting of mangrove forests, creeks, tidal flats, and seasonal lagoons comprising 33 percent of the total hectares in the study area (COHDEFOR 1987a, b). An estuary is the association of terrestrial and marine ecosystems that arise from the entrance of freshwater drainage into the ocean. There are indeed few aspects of the economic development patterns of present interest that do not relate directly to the special characteristics of this zone of transition from upland riverine agriculture to fishing in the open waters of the gulf.

Success in the modern practice of semiextensive shrimp culture is, for example, directly dependent on the physical and biological characteristics of an estuary such as the Gulf of Fonseca. The introduction of fresh water into saline water decreases the affinity of nutrient ions for the soil particles that have borne them from inland areas on river flows. As a result of nutrient release, the fertility of estuaries is characteristically high, producing a correspondingly high degree of primary productivity. This, in turn, comprises the bulk of shrimp nutrition in extensive aquaculture ponds.

The reduction of freshwater velocity upon entrance to the open estuary also causes suspended sediments to drop out, creating mud flats whose morphology is quickly stabilized by mangrove forests. Over time, soil accretion by mangrove root systems and the consequent outward advance of the forest fringe gives rise to extensive barren areas that are a typical feature of a mud flat island's interior. Whether completely bare or occupied by the sparse, climax mangrove vegetation of the upper tidal zone, these areas are ideal locations for shrimp farms from the perspective of clearing costs, perceived low opportunity cost, soil type, topography, and proximity to seawater.

Superimposed on these typical and generally favorable characteristics of a tropical estuary are the gulf's distinctive aspects, of which restricted access to the Pacific Ocean is the dominant feature. Although hydrological studies, which would determine estuarine water residence time, have never been performed, the predominant northeast to southwest flow of the tidal currents is not in ideal resonance with the northwest to southeast morphology of the gulf so far as maximum water exchange with the open ocean is concerned. One dry-season result is the hypersalinity characteristic of a "negative" estuary in which water loss through evapotranspiration is greater than inputs of fresh water. This produces salinities that are significantly higher than the 35 parts per thousand in the open oceans, and even higher yet than the mesosaline range to which most estuarine organisms are adapted. Another result of poor exchange is that the position of nearshore water masses will remain relatively static, flooding or draining the tidal creeks of the upper estuary with water of relatively unchanged quality from one tidal cycle to another. Human inputs of agrochemicals, urban pollution, and shrimp farm effluent therefore accumulate to noxious levels more quickly and remain problematic much longer than in most coastal estuarine systems.

The hilly watersheds of the four principal rivers of the Honduran portion of the gulf, the Choluteca, Nacaome, Goascoran, and Negro, are other major physical determinants of resource availability and utilization in the region. Accounting for 76 percent of the total freshwater input to the gulf (Abarca 1986), these four streams drain areas that offer soils only a few centimeters thick (Dickinson et al. 1985) and, consequently, poor conditions for agriculture. The few areas of relatively rich soil available for food production are found only on the lower floodplains of the rivers (Dickinson et al. 1985), which also places them in close proximity to highways, populations centers, port facilities, and other prerequisites to development. As a result, lands have been grouped into large holdings and traditionally used for industrial crops such as cotton or sugarcane, and more recently for the export production of melons.

1.3. Climate and ecology

Climate. Honduras is located on the path of the trade winds, coming mainly from the northeast, these winds cross the territory from the Atlantic to the Pacific. The winds that arrive to the gulf area have lost most of their humidity. Yearly average humidity at Choluteca is 63 percent. Minimum humidity values are recorded in January and March and fluctuate in the 50 percent values. Maximum values are 82 percent in September (SECPLAN 1989). The climate in this area is classified as rainy with a very dry winter (Zuñiga 1977).

Rainfall patterns in the Gulf of Fonseca area are irregular. Average annual precipitation in the region range from 500 mm in the northeast to more than 2,400 mm in the southwest (Hargreaves 1980). The rainiest month is usually September and the driest is January. A rainy season extends some 5 months (mid May until mid July, and mid August until the end of October). The dry season of 6 months begins in November and ends in April. There is a "short summer" period or Canicula within the rainy season (between July and August). This period is better defined in the region than in the rest of the country.

The highest temperatures are registered in April and the lowest usually in September. The monthly averages fluctuate between 27°C and 30°C (30°C is the annual average).

Ecology. The coastal waters are shallow with a fine silt and sand bottom originating from suspended solids and sediment being carried by the freshwater runoff from the above lands. The fine sediments characteristic of the upper estuarine zone contrast with the coarser sands found in the outer gulf. Given its low depth and limited tidal flushing, the gulf ecosystem is very susceptible to sedimentation and pollution buildup.

This water mass is influenced by the diurnal Pacific tide; the mean vertical tide range in the gulf is 2.3 m according to the tide tables. There is a predominant northeasterly direction for the incoming tide toward the port of San Lorenzo (Bartlett 1992). The outgoing tide has a southeasterly direction along the coastline formed between Punta Raton and Punta Condega, leaving very little exchange capability for the waters eastward of Punta Condega. Little is known concerning the gulf current regime. Studies indicate that in the eastern part of the gulf a surface current velocity of 1 m per second is typical during spring tide, with the potential of 1.5 m per second estimated for ebb tides following heavy rains (USAID 1979)

The coastal mangrove forest and associated estuarine waters and wetlands generally have a high primary productivity and serve as nursery areas for important species of finfish, shellfish, and crustaceans. Mangroves effectively trap nutrients and sediments and stabilize coastlines.

Coastline dynamic. Sedimentation and the seaward movement of mangroves is a naturally occurring process. In the case of the Gulf of Fonseca, the sedimentation rate and changes to the hydrology of the zone have been sped up and altered by a series of events such as deforestation in the highlands and overgrazing and poor erosion control in the plains, the damming of rivers, and the construction of roads, ports, and aquaculture operations.

Quantifiable sedimentation data for the gulf are not available. Limited information can be extrapolated from the dredging activities relating to the port of San Lorenzo and, since the late 1980s, from operating shrimp farms. The shrimp farmers are paying attention to this situation, which is increasing maintenance costs for farm reservoirs. For instance, Granjas Marinas reports dredging the equivalent of 1,000 m^3 per day of suspended silt deposited in their settling reservoir, from their daily pumping operation of 1.6 million m^3 per day. Some farms must run sludge/sediment pumps for ten hours a day in order to keep the reservoirs operating. Pumping costs and machinery wear increase significantly with sedimentation loads because wear and tear are increased dramatically when the sediment load is higher than 0.25 percent of the pumped volume (Crockett 1992).

Sedimentation promotes the movement of the coastline toward the gulf waters, promoting the colonization of mangrove vegetation. As the mangrove belts move forward, they eventually form a barrier that restricts inland tidal influences. This results in the expansion of the salt flat climax community (Salas 1992).

Salt Flats. These are areas influenced only by the highest tides of the month. The limited flow of salt water into and high evaporation rates in these shallow areas promote a high soil salinity, 80–100 parts per thousand and higher (Wainwright 1989). Depending on the salt content of the soil, the salt flats can be colonized only by *Avicennia germinans* (Dickinson et al. 1985). Salt flats constitute the climax community in the gulf coastal areas (Salas 1992). Three types of salt flats (*playones*) can be identified.

(1) Salt flats with vegetation, which are generally located where the tidal influx can flood the land at high tides.

(2) Irregular salt flats, which have vegetation cover only along depressions or canals that retain tidal or rainwater. These are the most productive type of salt flats, at least during the rainy season (Dickinson et al. 1985). They are important feeding grounds for aquatic birds and have been traditionally used by artisanal fishermen during the flooded months to gather juvenile shrimp and fish.

(3) Barren salt flats, devoid of vegetation except for *Salicornia* sp. These areas only get sporadic flooding with the highest tides of the rainy season.

Seasonal wetlands. Seasonal wetlands, referred to as winter lagoons, or "Lagunas de Invierno," are transitional wetlands between the salt marshes and the freshwater wetlands dominated by cattails *Typha* sp. These areas are flooded during the rainy season and go dry during the dry season. The salinity in the winter lagoons ranges from a low of 0 parts per thousand during the wet season to a high of 70 parts per thousand in the dry season (Varela et al. 1985).

These areas bordered by mangrove stands are traditional artisanal fisheries areas used during the winter months. The fishermen exploiting these areas target four species of shrimp, six species of finfish, and two species of crab. These areas are also important resting, nesting, and feeding grounds for the region's avian community. They are also used as nursing grounds for shrimp postlarvae and juveniles.

Estuaries. Mangrove estuaries are important nursing grounds for penaeid shrimp, finfish, and other crustaceans and mollusks. This is partly due to the system's high productivity and physical factors related to the immigration of eggs and zooplankton larvae through tidal movement from offshore to tidal creeks (Dickinson et al. 1988). The most important factors determining the zonal distribution of mangroves are the degree of inundation by tides, the sedimentation pattern, and the drainage efficiency of the soils (Pannier 1977, 1979). In addition, the accretion rate, the chemical dynamics, and soil aeration and compaction determine mangrove distribution in zones of brackish waters. Tidal effects from tide levels to duration of submersion have selective influences on the type of mangroves found.

Sometimes mangroves become progressively interred and, consequently, destroyed by the mobilization of sediments of the bank in which they first established themselves (Pannier 1979). Intensified sedimentation can bury the extensive superficial network of ventilation roots (pneumatophores) of *Avicennia*. When this happens the gaseous exchange necessary to maintain the plant's metabolism is interrupted and the plants die.

Various species of mangrove exhibit graded tolerances to salinity. *Avicennia* spp. is usually considered the most tolerant species. *Rhizophora* spp. on the other hand is adapted to low salinities. The mangroves' responses to nutrient equilibrium is so sensitive that once the ecosystem becomes disconnected from the outside contribution of nutrients (as with altered flows) it loses its natural stability and will either be stressed or die.

Mangrove soils, regardless of their origin, exhibit characteristic factors such as salinity, acidity, and excessive humidity that present management challenges for agriculture or aquaculture operations sited in these locations.

1.4. Social background and history

Population. Honduras had over 4.4 million people in 1988, and the country has had one of the highest population growth rates in the world. During the period 1950–74, growth rates averaged 3.1 percent, and during the period 1974–88 the comparable rate was 3.4 percent (SECPLAN 1988). In recent years, there has been evidence that this rate of growth is slowing. The total fertility rate for Honduras dropped from 7.4 in 1970 to 5.4 in 1989, and the annual growth rate declined from 3.71 percent (1981–82) to 2.96 percent (1988–89). Despite the declining rate of growth, the population of Honduras will continue to grow substantially in the near future because of its age distribution. In 1988, over 57 percent of Hondurans were under 19 years of age. It is estimated that by the year 2000 the population will grow to 6.2 million (SECPLAN 1991:206).

These high rates of growth have meant that population density in the country climbed from 12.2 persons per km^2 in 1950 to 35.6 in 1985 (see Stonich 1986:145). Southern Honduras is the most densely settled region of the country; it comprises only 5 percent of the total area but contains approximately 9.3 percent of the population. Population density there is well above the national average and increased from 29.8 persons per km^2 in 1950 to 63.9 in 1985. Population densities are as high as 160 persons per km^2 in some municipalities (Stonich 1989:277).

Since 1950, population growth in the south has not been as high as in other areas of the country. This is especially due to extensive outmigration and, in part, to an infant mortality rate that is higher than the national average (see below). Since 1974, outmigration from the southern region has averaged 1.3 percent annually. For every two people born in the region, one leaves (DeWalt and Stonich n.d.). Migration of both men and women has occurred. The most popular destinations of these migrants are Tegucigalpa, San Pedro Sula, Yoro, and the "frontier regions" of El Paraiso and Olancho (Stonich n.d.). Considerable migration from the rural areas of the south to the cities of Choluteca and San Lorenzo is also occurring.

In spite of the migration to urban areas, the southern region of the country is still quite rural. As table 1.1 indicates, three quarters of the population in the departments of Choluteca and Valle still live in rural areas. By comparison, at the national level nearly 40 percent live in urban areas.

Table 1.1. Relative distribution of urban and rural population (percentages).

	1974		1988	
	% Urban	% Rural	% Urban	% Rural
Honduras	31.36	68.64	39.42	60.58
Choluteca	17.32	82.68	24.59	75.41
Valle	19.25	80.75	25.42	74.58

Source: *Características Generales, Educativas y Económicas por Departamento*, Tomo I. Censo Nacional de Vivienda 1988. Tegucigalpa: Dirección General de Estadística y Censos, p. xxxiv.

Illiteracy also continues to be a problem in the south as well as in Honduras as a whole. According to the 1988 census, the national illiteracy rate was 32 percent (down from 40.4 percent in 1974). For the department of Choluteca the comparable rate was 36.5 percent, and for Valle it was 34.7 percent.

Nutritional status and infant mortality. The southern region of the country also exhibits very high malnutrition and infant mortality rates. The national planning agency (SAPLAN 1981) estimated in the early 1980s that 41 percent of all southern families did not meet minimum subsistence levels and that families living in "semiurban communities" consumed even fewer calories than rural families (Stonich 1986:152–54). In nine rural communities in southern Honduras studied in 1981–83, 65 percent of the children under 60 months of age were stunted (i.e., less than 95 percent of the standard height for age recommended by the WHO), and 14 percent were under 90 percent of standard weight for height (wasted). Infant mortality averaged 99 per thousand, and 16 percent of all children born in the communities did not survive beyond the age of five (DeWalt and Stonich n.d.). Infant mortality in the country as a whole in 1985 was 61.9 per thousand (SECPLAN 1991:207).

Other indicators of welfare in the south also compare unfavorably with the rest of the country. In 1987, the percentage of houses in the south with dirt floors was 72.2 percent compared with 52 percent at the national level. Over 76 percent of houses did not have a bathroom or latrine, and only 18.2 percent had electricity. At the national level, 43.8 percent had sanitary services and almost 42 percent had electricity (Unión Mundial para la Naturaleza 1992:20).

Economy. Honduras is still predominantly an agricultural country. Agriculture generates about 30 percent of GDP, 75 percent of exports, and 55 percent of employment (CONAMA 1992:67). Southern Honduras is more dependent on agriculture than is the rest of the country. Approximately 70 percent of its population is directly dependent on agriculture for a livelihood.

The south is also characterized by considerable unemployment. While official statistics probably underestimate the problem, they do indicate the unfavorable employment situation in the southern region. The rate of open unemployment in 1988 was far higher than the national average. Among the departments of Honduras, only Gracias a Dios had a higher rate of open unemployment (SECPLAN 1991:134).

1.5. Recent patterns of utilization and economic development

The south of Honduras experienced a substantial expansion of commercial agriculture in the years immediately following World War II. The Honduran state became an active agent of development, creating a variety of state institutions and agencies to expand government services, modernize the country's financial system, and undertake infrastructural projects.

This period of intensified public sector investments coincided with temporarily high prices for primary commodities like cotton, coffee, and cattle on the world market. With the infrastructural development, landowners and investors in the south found it profitable to expand production for the global market.

The cotton boom. It was cotton cultivation that first transformed traditional social patterns of production in southern Honduras (Stares 1972:35; White 1977; Durham 1979:119; Boyer 1983:1). In the late 1940s and 1950s, people from El Salvador began commercial cultivation of cotton in Honduras.[2] Commercial production involved considerable mechanization in land preparation, planting, cultivation, and aerial spraying and was dependent on the heavy use of chemical inputs (especially insecticides and fertilizers).

The indiscriminate use of pesticides in the cotton growing regions remains one of the most pervasive problems for environmental contamination and human health throughout Central America. Water from cotton growing areas shows heavy contamination from DDT, dieldrin, toxaphene, and parathion (USAID 1982). A 1981 study of the levels of pesticide poisoning in the area around the city of Choluteca, Honduras revealed that approximately 10 percent of the inhabitants had pesticide levels sufficiently high to be considered cases of intoxication (Leonard

[2] In 1969, the government of Honduras expelled several thousand Salvadoran immigrants, many of whom had lived in Honduras for over a generation. El Salvador retaliated by invading Honduras. This Soccer War (so called because it occurred shortly after the soccer teams representing the countries competed in World Cup qualifying matches) was widely attributed to "population pressure"—the competition of poor Hondurans and Salvadorans for increasingly scarce arable land. Many analysts concluded that a Malthusian scenario was being played out in which the population had exceeded the carrying capacity of the land. Durham's classic analysis of this situation demonstrated that it was the use and distribution of land, rather than its carrying capacity, that resulted in the problems of food production and inability of families to meet subsistence needs.Durham found that the landless and landpoor agriculturalists unable to rent land in El Salvador comprised most of the migrant stream to Honduras. Mostly renters and sharecroppers, the Salvadorans' access to land depended on the decisions of large landholders rather than on competition with Honduran smallholders. In fact, immigrants and poor Honduran farmers joined forces to challenge a large hacienda owner who attempted to incorporate national lands into his estate. Durham concluded that the land base of poor farmers has decreased to the point of threatening survival only partly as a result of population increase. As he put it, "land use patterns show that land is not scarce for large landholders" (1979:54).

1987:149). Reports show that the land and water contamination from pesticides, as well as high levels of pesticide residues in food supplies, have had substantial effects on human health (Williams 1986; Leonard 1987).

The major social effect of the cotton boom was to increase inequalities in access to land. Large landowners revoked peasant tenancy or sharecropping rights and raised rental rates exorbitantly so that peasants would leave the land. Landowners also laid claim to many wilderness (*montaña*) areas and evicted peasants forcibly from national land or from land of undetermined tenure (Durham 1979; Boyer 1983:94). Increased cotton cultivation thus displaced many poor farmers from the most suitable agricultural lands in the south.

Yet cotton also provided many seasonal jobs during the harvest season. The long-staple cotton grown in the region was largely picked by hand.

The cotton boom ended in the late 1980s. The buildup of pesticide-resistant insect populations and the increasingly high costs for pesticides combined with low market prices effectively ended cotton cultivation in southern Honduras. Although there is some talk of attempting to resurrect cotton cultivation, this time using integrated pest management techniques, there was no cotton planted in the south in 1992.

The cattle boom. The expansion of the cattle industry has probably had the most extensive and devastating environmental impact in southern Honduras (DeWalt 1983; 1986). Between 1960 and 1983, 57 percent of the total loan funds allocated by the World Bank for agriculture and rural development in Central America supported the production of beef for export. During that same period, Honduras obtained 51 percent of the total World Bank funds disbursed in Central America, of which 34 percent was for livestock projects (calculated from table 4.1 in Jarvis 1986:124).

In a context of declining agricultural commodity prices, high labor costs, unreliable rainfall, and international and national support for livestock, landowners reallocated their land from cotton and/or grain cultivation to pasture for cattle (DeWalt 1986; Stonich and DeWalt 1989). Cattle appealed to landowners in Honduras because they could be husbanded with very little labor. With just two or three hired hands and extensive pasture, it is possible to manage a herd of several hundred cattle.[3] In Honduras, land reform programs ironically also encouraged the expansion of pasture for livestock. Landowners who feared expropriation of unutilized fallow and forest land cleared and fenced it and planted pasture as a way of establishing use of the land without substantially increasing labor inputs (DeWalt and DeWalt 1982:69; Jarvis 1986:157).

The expansion of pasture caused extensive changes in land-use patterns in Honduras during the 1960s and 1970s. Expansion took place in the lowlands and foothills where cattle raising traditionally occurred, and also in the highlands where many wealthier peasant farmers

[3] For example, it has been estimated that "coffee requires between 64 and 208 person days per year, while beef-cattle production requires only between 4 and 8" (Guess 1979:48).

augmented cattle production (Durham 1979; Boyer 1983; DeWalt 1983; Stonich 1986). Increased livestock production in the lowlands and the highlands also accelerated the expulsion of peasants from national and private lands (White 1977:126–56; Stonich 1986:139–43). Between 1952 and 1974, for example, pasture in the southern region of the country increased from 41.9 percent of the land to 61.1 percent. Precipitous declines are evident in both fallow land and the amount of land in forest (DeWalt 1985).

Deforestation and serious soil erosion accompanied the cattle boom. It has been estimated that Honduras is losing its forests at the rate of 10,000 ha per year and, if current trends continue, "the forest resource will be exhausted in a generation" (USAID 1990:3). Most of the dry tropical forest in the south has already disappeared and soil erosion rates are alarming.

The cattle boom is still very much alive in southern Honduras. Large and small farmers alike reported that livestock was the one investment that always seemed to pay off. Industria de la Carne, S.A. (IDECASA), located outside of Choluteca, is one of five meat-packing plants in Honduras. Its CARNILANDIA plant has the capacity to process 180 head of cattle per day. It operates year round except in April and May, when livestock weights are very low because of the marked dry season in the south. Its production is exported, with most of the meat going to the United States, Mexico, and Puerto Rico and by-products going to countries as diverse as Japan and Denmark.

Sugar. There are two large sugar mills in southern Honduras. Both are located near the community of Monjerras. The larger of the two, ACENSA, has been a state-owned corporation, but in early 1993 it was in the process of being privatized.

There are presently about 9,000 manzanas (1 manzana = 1.75 acres) planted in sugar cane. A large proportion of this land is owned by the companies themselves. For example, ACENSA owns and manages about 3,500 manzanas of cane. It also buys from about 270 independent producers who control an additional 2,800 manzanas. ACENSA produces about 500,000 quintales (1 quintal = 100 kg) of cane per year, while Azucarera Choluteca produces about 350,000. The cane is processed into molasses and brown sugar for the export market.[4]

There is general agreement that ACENSA has been poorly managed, and there are reports of financial irregularities as well. Nevertheless, the sugar industry is an important source of employment in the region. ACENSA alone employs 450 people year round.[5] During the time of the year when sugar cane is being cut (January through April), approximately 2,100 more workers are employed. When the employment generated by the private producers and the second smaller mill are added, approximately 6,000 people have temporary employment from sugar production. Most of these people come from surrounding municipalities in the south and

[4] Sugar production has never achieved the levels projected for it. The port in San Lorenzo, for example, has tanks designed to allow for the export of 20,000 tons of molasses a year, but in recent years only 3,200 tons have been exported.

[5] Present ACENSA managers acknowledge that this number of employees is much too large and that the number of permanent employees will undoubtedly shrink substantially when the company is privatized.

only temporarily live in and around Monjerras. ACENSA estimates that it generates about $10 million a year for the local economy.

The sugar industry is the only major agricultural operation in the south to have a union. ACENSA managers reported that its workers had a belligerent, strong union. In spite of this, the corporation's managers reportedly have good relationships with the union. Salary scales are negotiated each year. So long as the company can justify its rationale for the level of wage increases, the union has been reasonable in reaching agreement.

Salt. The relatively high concentrations of salt in the waters of the Gulf of Fonseca make commercial salt production viable. Salt makers appropriated some of the mud flats that are national lands to build ponds. The dry season between January and April allows producers to use evaporation from these ponds to elevate the concentration of salt in the water to 20 percent or more. In the past, small ovens, generally fueled with wood from mangrove, were used to boil off the remaining water. It has been estimated that about 3.5 tons of wood were needed to produce each ton of salt. The total amount of wood consumed by the salt industry in the south during 1984 was estimated at 89,200 m^3 (Flores and Reiche 1990:38-39).

In 1984, it was estimated that there were 130 salt-making operations in the south. Each employed an average of seven people. Thus, the amount of direct employment generated would be about 1,000 jobs. The total production of salt was about 25,000 tons (calculated from Flores and Reiche 1990:39).

In recent years, much less salt has been produced using ovens. The new technology, partially supported by loans and technical assistance from USAID, depends completely on solar heat for evaporating the water. After elevating salt concentrations in large ponds, water is put into carefully prepared long, narrow, and shallow (one inch or so) ponds. These ponds are built from bricks (*ladrilio*). The floor of the ponds is either covered with more bricks or, more commonly, lined with black plastic. Within 24 to 48 hours, the intense solar heat has evaporated the water and the salt can be swept into piles and gathered.

Some producers still use ovens for the final evaporation. Reportedly, prices paid for oven-produced salt are about twice what is paid for solar-produced salt. Costs to purchase wood, however, make production with ovens much more expensive. As the Corporación Hondureña de Desarrollo Forestal (COHDEFOR) has moved to protect mangrove, obtaining wood for the ovens has become difficult.

Brick-making and tanning industries. Two other small-scale enterprises in the south are brick-making and tanning. Although neither provides a substantial number of jobs, both are significant because of their relationship to wood utilization and deforestation.

Flores and Reiche (1989:23) report that 90 percent of houses in the southern region use roof tiles and that approximately 40 percent of houses are built with brick walls. Roof tiles and bricks are both produced primarily in small-scale enterprises that use wood for the ovens in which the tiles and bricks are fired. Because many of these enterprises work sporadically or may operate only while a single house in being constructed, it is difficult to determine how many of them there are. Flores and Reiche sampled 55 during their research. These operations employed 253 people and used 907 m^3 of wood per month (Flores and Reiche 1989:29–30).

Currently only two tanneries are operating in southern Honduras. One is located in Orocuina and the other north of Pespire. Previously there was a tannery cooperative in Nacaome. It had loans from a German fund but dissolved about 1986. Both the tanneries that continue operations make leather that is sold to other artisans to make saddles, sheaths for knives and machetes, shoes, and boots. Before the civil war in El Salvador, the tanneries sold a lot of processed hides to shoe manufacturers in that country. There is some expectation that with the peace settlement this market may become important again.

The tanneries were once substantial users of tanbark from mangrove, but the enterprise in Pespire now uses only 25 percent of the amount it used in 1985. That tannery only employs six people full time.

Resource-poor individuals. The appropriation of land for commercial agriculture and for extensive livestock-raising relegated resource-poor individuals to the most marginal areas of the south. Using a shifting cultivation system, peasants in the foothills and highland regions, for example, are increasing their use of the steep slopes. They interplant maize and sorghum for a few years before leaving the field in fallow to regain its fertility.

Increasingly, however, the better-off farmers in the highlands are also converting their land to pasture for cattle. They rent lands in secondary forest to the landless and land poor. These individuals do the difficult work of clearing the brush and trees to plant maize and sorghum for subsistence use. After one or two cropping seasons, the landowner plants pasture. While in the short term the landless benefit from having land on which to plant crops and the landowners benefit from cheap labor to clear fields, in the long term more and more land is converted to permanent pasture. One landless person reported: "Right now we have land available to rent, but each year you can see the land in forest disappearing. In a few years, it will all be pasture and there will be no land available to rent. How are we to produce for our families then? We see what is happening, but we have no choice because our families have to eat now" (DeWalt and Stonich n.d.).

The conversion of land to pasture combined with the rapid growth of population has put increasing pressure on the remaining crop land. As table 1.2 shows, during the past several decades fallowing periods in the south have decreased. Some communities no longer allow fields to rest, while others have decreased the fallowing interval from 15 to 20 years in 1950 to just a few years. This more frequent cropping leads to a depletion of soil fertility and exacerbates the soil erosion problems on the steep slopes.

The other major area settled by resource-poor persons was the coastal region of mangrove, mud flats, estuaries, and seasonal lagoons. Unsuitable for large-scale cultivation or pasture or most other commercial uses, this area became increasingly populated by migrants from other municipalities in the south. Communities like Cedeño, Pueblo Nuevo, San José de las Conchas, Guapinol, and others either were founded or increased rapidly in population during the decades of the 1960s, 1970s, and 1980s.

Table 1.2. Population density, number of years of fallow, and ratio of length of cropping cycle to total cycle (length of cropping plus total length of cycle), 1950–82.

	1950	1976	1982
Pespire communities[a]			
Population density[b]			
(inhabitants/km^2)	35	54.2	74.3
Years of fallow	15 to 20	10 to 15	2 to 6
Ratio	.13 to .16	.16 to .23	.38 to .6
Boyer's communities[c]			
Population density			
(inhabitants/km^2)	63	98.6	>110[d]
Years of fallow	3 to 5	none to 2	none
Ratio	.38 to .6	.6 to 1	1

[a] Calculated from landowner surveys.
[b] Calculated from DGECH 1979; CSPE/OEA 1985.
[c] Boyer 1983.
[d] CSPE/OEA 1985.

Source: DeWalt and Stonich n.d.

The individuals living in these communities survived by exploiting the resources of the coast and the estuaries. Fishing on the open waters of the gulf, fishing in the estuaries or seasonal lagoons, cutting mangrove to supply salt-making or tanning industries, gathering shellfish, and hunting and trapping are among the survival options used by people along the coast. In the past, the only major competition for the coastal resources was from commercial salt-making operations.

Melons and shrimp. In the late 1980s, capitalist investors in southern Honduras began investing in two new nontraditional export crops, cantaloupe and shrimp. Some development of these crops was stimulated by loans and technical assistance provided through the USAID project, Export Development and Services (EDS) Project (522-0207). These loans were channeled through FPX.

During the 1980s, cantaloupe production expanded at a rate of 23 percent per year and shrimp production at a rate of 22 percent (USAID 1990:2). By 1989–90, these two commodities contributed an estimated $25 million in export earnings to the Honduran economy (Meckenstock et al. 1991:4).

Cantaloupes and watermelons are produced on the prime agricultural lands in the south. They are planted at the end of the rainy season in October or November and are harvested from

December through May. Although a few very large producers may have as much as 250 manzanas planted, most operations are much smaller. For example, the median amount planted by the 35 members of the Cooperativa Agropecuaria de Valle was about 5 manzanas in 1992. Approximately 8,000 ha in the south are planted in cantaloupes and watermelons (interview data from the Chamber of Commerce for Choluteca and Valle).
Harvesting and packing cantaloupes and watermelons provide temporary jobs for a large number of people. It is estimated that melons and watermelons provide direct employment for about 11,600 people (Chamber of Commerce for Choluteca and Valle data).

Several cooperatives are involved in cantaloupe and watermelon production in the south. The Cooperativa Agropecuaria Algodonera del Sur (ALGOSUR) was formerly involved in cotton production. The cooperatives have contracts with firms in the United States, which purchase their production. Of the approximately 8,000 ha in melon production, three organizations (SURAGRO, Montelibano, and HONDEX) account for the majority, and they export about 75 percent of all melons exported from Honduras.

In recent years, melon prices have fluctuated considerably from week to week. For this reason, a large number of producers have stopped planting cantaloupes. One cooperative, the Cooperativa Regional de Horticultores del Sur, has gone bankrupt. For the 1993 harvest, only 35 of 75 members of Cooperativa Agropecuaria de Valle were producing; ALGOSUR reported that only 162 of its members had planted, down from about 300 producers in 1992. Nevertheless, in 1992, 4.2 million boxes (of 40 pounds each) of melons, worth $30 million, were exported (Chamber of Commerce for Choluteca and Valle data). Produce that is too small or damaged is sold on the domestic market.

Undoubtedly the most dynamic development in southern Honduras has been the development of the shrimp industry. The mid 1980s saw the development of large-scale farms devoted solely to shrimp production. Some small producers still alternate between shrimp and salt production, while large, capital-intensive shrimp farms are now producing the bulk of the production. Although development documents written in the mid 1980s stressed the importance of incorporating resource-poor households in the shrimp development process primarily through the formation and support of cooperatives (Dickinson et al. 1985), more recent reports conclude that only the larger, more intensive operations are profitable (USAID 1989b).

Parallels in the social processes associated with the recent boom in shrimp mariculture and the earlier expansions of export commodities (cotton, sugar, and livestock) in the region are striking. Past "enclosure movements" in which small farmers were removed from relatively good agricultural land often by force and with the compliance of local authorities are being repeated on the intertidal lands. Intertidal land once open to the public for fishing, shellfish collecting, salt producing, and the cutting of firewood and tanbark now is being converted to private use. Shrimp farms are granted government concessions to develop and exploit these national lands.

The Asociación Nacional de Acuicultores de Honduras (ANDAH) is the organization that represents about 25 of these large producers. ANDAH estimates that about 8,000 ha of semi-intensive shrimp farms now exist and that there are approximately 23,000 more hectares that could be developed as shrimp farms. It is estimated that in 1992, approximately 11,900 people are directly employed by the 25 farms, 6 shrimp packing plants, and 6 ice-making operations.[6] Many people report that the jobs created by the shrimp industry have led many former migrants to return to the south.

In a very short time, the shrimp farms have catapulted shrimp to third position among Honduran exports (behind bananas and coffee). The Central Bank of Honduras reported that shrimp farms in the south sold over 4 million kg of shrimp worth $40.2 million in 1992.

Summary. A number of general trends emerge from this examination of the economic history of southern Honduras since the end of World War II. These are:

(1) Recent decades have seen the expansion of commercialization of agriculture in the region. This expansion has been assisted by national and international policies and economic incentives.

(2) Earlier, the expansion of cotton and livestock in the region led to increasing land concentration. Larger landholders often expelled squatters from national lands and claimed these lands for themselves.

(3) Resource-poor individuals increasingly retreated to, or were left to exploit, marginal lands. These included the steep slopes in the mountains and foothills and the estuarine resources of the coast.

(4) The environment suffered as a result of the exploitation patterns that resulted from these processes. Deforestation, soil erosion, and chemical contamination were among the consequences.

[6] There are huge discrepancies reported concerning employment. The executive director of ANDAH reported 25,000 direct jobs, newspaper articles frequently cite 16,000 jobs, and the Chamber of Commerce of Choluteca and Valle reported 11,900. Another report indicates that the shrimp farms employ fewer than one person per hectare (SECPLAN/DESFIL 1989:179). We have opted to use the Chamber of Commerce figure because it is probably the most realistic estimate.

2. The problem: understanding natural resource management issues in the Gulf of Fonseca

The special physical, ecological, and social conditions described in previous sections have set the stage for perceived and actual conflicts over resource use in southern Honduras. A relatively large and long-suffering local population is crowded in among arid, rocky foothills, large landholdings on the scant productive land, and a seasonally reliable estuarine system. Until recently, the people's movements were also restricted by adjacent civil wars. Into this setting a dynamic, lucrative, new shrimp farming sector has been introduced in recent years, transforming the bleak continental fringes into one of the most productive areas in the country. Rapid development of export-oriented cropland on former sugarcane fields in the uplands paralleled the growth of the shrimp farming sector, replacing marginally profitable sugar plantations as a major source of employment and outside revenue. These physical, biological, and social factors—confined estuarine hydrology, arid climate, extreme poverty, a history of displacement by vested interests, and recent heavy investments of outside capital—have contributed to a highly publicized and contentious pattern of interaction between sectors in the region that has often overshadowed the fundamentally good news of a robust economic expansion.

Environmental degradation is a prevalent theme in public and private discussion of resource-use issues in the gulf, with particular focus on interactions between shrimp farms and traditional fisheries. Displacement of natural, rainy season winter lagoons of importance to local ecological processes by shrimp farm concessions, shrimp farm construction practices allegedly destructive to mangrove forests, and unsustainable production-related activities such as collection of seedstock are often cited by artisanal fishermen to explain their dwindling catches of finfish and shrimp. To a lesser degree, shrimp farmers are also concerned about declining water quality as a result of sediments from degraded watersheds, an escalating load of shrimp pond effluent on hydrologically restricted estuaries, possible pesticide contamination from melon fields, and significant increases in ambient water salinities during the dry season due to draught and the expanding needs of irrigated agriculture.

The conversion of formerly public lands into private shrimp farms has restricted access of a portion of the rural population to artisanal fishing areas that were once of considerable seasonal importance, and has consequently given rise to the greatest concerns and harshest accusations of any single issue. Fearing theft of their valuable product from fishermen who are accustomed to free movement through mangrove and tidal creeks at any hour of the day, shrimp farm managers have fielded patrols of armed guards whose definition of trespass, at least in the minds of the fishermen, extends into the nominally public waterways and fringe beaches of the estuary. Rather than risk confrontation in order to continue pursuit of a declining fishing, many fishermen may have turned to mangrove extraction or other environmentally damaging activities in order to feed themselves.

Poverty, acute and chronic, among the region's rural population is the overarching issue among the various conflicts over resource use in southern Honduras. A history of great social disparity and insecure tenure over land and livelihood are likely contributing to the perception among some rural people that, yet again, benefits from substantive economic development in the region will pass them by. The anticipation of no permanent benefit is also driving grass-roots concern over environmental degradation, since an irreversible loss of natural estuarine health and productivity would leave the marginally employed populace in truly dire straits in the wake of a transitory boom in shrimp farming.

From the perspective of government, private-sector, and donor-community leaders, the controversy that has attended economic growth in the south has proven a difficult management challenge. The conversion of large tracts of marginal, saline land into the labor-intensive production of high-value, hard-currency products such as shrimp has all the characteristics of a major success story. Nevertheless, persistent public criticism on the grounds of sustainability, environmental cost, and social equity has dogged progress; and such criticism has proven resistant to clear definition, to proposals of mitigating measures, and to assimilation into policy and investment decision-making processes. To a certain degree the difficulties are circumstantial. Shrimp farming in the Americas is, after all, an evolving art that is often poorly understood by nonpractitioners. This new technology has also been introduced to a remote estuarine zone that previously attracted little outside interest apart from that related to frontier political worries. A high state of ignorance has resulted, not only of local ecosystem processes and their value but also of the area's geography and prior use. A final circumstance of ongoing importance is the lack of an effective process for assigning public lands for private development as shrimp farms. With little experience in transactions of titled private land, the Department of Tourism was certainly not prepared for its role in the allocation of remote public areas for which major economic interests had suddenly begun to compete. The confusion over location and rights to concessions that resulted from this lack of process continues to vex efforts at rationalizing land use in the region.

USAID's contribution to recent economic development in the gulf has been significant. Through the Export Development and Services Project (EDS), the Mission has made substantial investments in support of expanded shrimp and melon farming in the Gulf of Fonseca, with particularly striking results in both cases. In light of its role, the Mission naturally has an acute interest in gaining a better understanding of the resource issues in the gulf, not only to support its own achievements in light of ongoing controversy but to plan USAID contributions to the region's development appropriately during the remaining half of the EDS project.

In search of improved understanding of major issues, the Mission has noted the spottiness of reliable information of all types, as listed below.

(1) Extent and type of present vegetative cover and recent patterns of change, with particular interest in mangrove, is virtually unknown. The most recent assessment of forest cover in the Choluteca and Valle districts dates from 1984, well before the major growth phase of the shrimp farming sector. Information concerning vegetative cover from the 1970s (i.e., prior to the era of major evaporative salt production, another suspected culprit in mangrove degradation) has been either lost or deemed unreliable. Without such information there is no way to assess prevalent claims of widespread losses of estuarine forest.

(2) The effect of prevalent production practices in the two dominant commodities, shrimp and melons, is difficult to assess. In the case of shrimp farming the capture of wild seed has never been analyzed in terms of present extent, future growth, or predicted impact on stocks of commercial species in the gulf.

(3) Fisheries statistics, or even rudimentary information on landings, effort, and types of capture gear, are either nonexistent or so scattered as to constrain their utility. Reports of a declining artisanal capture fishery can therefore only be evaluated through anecdotal sources, and management plans cannot be developed on any sound basis.

(4) Extent of development of natural areas and consequent impact on local ecological processes and (in the case of migratory birds) international biodiversity cannot be readily assessed because the types of land converted to various uses in recent years and their previous natural function is unknown. The creation of reserves and other forms of conservation initiatives are therefore constrained by lack of relevant information about land use.

(5) Response to widespread concerns about the quality of water in the Gulf of Fonseca presently relies on reports from individuals, whether basic data collected by shrimp farm biologists or qualitative statements by individual fishermen. Collection of baseline reference data, assessment of the type of pollution risk by source, and linking risk to specific effect have never been undertaken.

(6) The true extent of prevailing local attitudes about the gulf and its present patterns of development, which will be crucial in any effort to gauge the actual dimensions of a given issue, are not known. Journalists have held the field in the presentation of public opinion on the aforementioned issues, and by the very nature of their trade they may have presented views from the most estranged segments of the general public. A relative few organizations, all claiming general representation from the rank and file of their respective sectors, have dominated the public debate and controlled feedback to policymakers regarding the direction and depth of public opinion.

The principal problem addressed by the present study therefore is the lack of reliable information about the gulf region. Such information would (1) allow the development of an accurate picture of the subject area in terms of its major natural and economic aspects, (2) permit substantive and representative discussion of issues, and (3) contribute to the formulation of appropriate actions leading to mitigation or effective management.

A second major constraint to constructive dialogue, which is perhaps beyond immediate remedy by the present study, is the absence of any forum that enjoys the confidence of the major participants for discussion of issues and examination of alternatives. Despite attempts to create "dialogue committees" and other fora, the opposing sides in various issues lack opportunities for direct interaction. Without such opportunities, and even with the best of information, the deliberation of potentially serious issues will continue to occur only in the most visible media and may be characterized by high emotion and an atmosphere of accusation and bad faith.

2.1. Direct environmental impacts of shrimp farming

Controversy over the environmental impacts of shrimp farm development in Honduras includes many of the issues typically associated with this activity elsewhere in the world. Public debate and interaction between shrimp farmers and other resource user groups in the Gulf of Fonseca, however, is of an intensity found nowhere else in the Western Hemisphere, doubtless because of the singularly harsh social and geographic character of the area identified in sections 1.2–1.4.

2.1.1. Effects on mangrove forests

Since the era of large-scale brackish water shrimp culture projects began in the late 1960s, several negative environmental consequences have been traditionally attributed to their construction and operation.

As mentioned in previous sections, estuaries are ecosystems enriched by the introduction of freshwater runoff to the sea; typically they are highly productive. The same intermittent influx of fresh water that drives productivity makes estuaries also highly unstable in terms of major water quality parameters; consequently they have a relatively low index of biodiversity. In tropical zones, where most major shrimp farming countries are located, this low diversity is manifested in the fact that mangrove trees are the dominant macrophyte that captures estuarine productivity and supports other ecosystem processes. Since this production supports nearshore fisheries stocks and provides forest products for the large human populations that typically live near estuaries, mangrove forests are resources deserving of conscientious management.

Loss of mangrove forests due to occupation by shrimp farms. Shrimp mariculture originated with the incidental capture and rearing of natural seed stocks in tidally inundated pools on the fringes of estuaries. The industry worldwide has consequently become most firmly established in these same areas. Due to ignorance of soil characteristics in mangrove areas, indifference to those areas' ecological function, or lack of access to cleared land better suited for aquaculture, mangrove forest were often cleared for the construction of ponds during the early era of mariculture development. The selection of mangrove areas not only had the aforementioned environmental consequences but often doomed the farms because of their poor suitability as a pond substrate. Mangrove soils are typically heavily organic and exist under highly reduced (low oxygen) conditions in their natural state. Pond construction dries and oxidizes these soils, such that considerable acidity is imparted to overlying water after the new pond is flooded. Shrimp are naturally adapted to the relatively alkaline conditions of oceanic waters, such that the acidic conditions found in ponds located over mangrove soils can effectively preclude survival and growth. The inevitable failure of many of these ventures contributed to the general idea that abandoned farms (essentially deserts), which displaced productive mangrove estuary to the detriment of local human populations, were a significant risk to shrimp aquaculture development.

Figure 2.1. Typical mud flat employed for shrimp farm construction

Shrimp farms have been sited with considerably greater sophistication in more recent times, such that areas heavily wooded with mangroves are generally avoided. The new siting criteria are intended to avoid not only soil acidity but also the additional cost of clearing timber and draining ponds (mangrove areas are often below low-tide levels, requiring pumps for complete drainage). Preferred sites for shrimp farm development in the Western Hemisphere since the 1980s, a period that includes the major developments in the Gulf of Fonseca, are the barren mud flats above the elevation of the landward fringe of mangroves. Soils of these areas are typically low in organic content, high in the clay content necessary for dike stability and pond impermeability, and sparsely vegetated (figure 2.1). Losses of high-quality mangrove woodlands as a direct consequence of shrimp farm construction are therefore usually limited to those clearings necessary for intake/discharge canals, for access roads, and to straighten the perimeters of ponds whose symmetry would otherwise be disturbed by penetrations of mangrove into salt flat interiors. In Ecuador, a country whose shrimp farming zone shares many gross morphological and ecological characteristics with Honduras, anecdotal information from the mid to late 1980s suggests that approximately 10 percent of mangroves on a given concession are lost during the construction of a shrimp farm.

In addition to direct removal of mangroves, shrimp farm construction can alter local hydrology, which in turn affects mangrove forest. According to Pannier and Pannier (1977) the most important environmental parameters determining the distribution and structure of mangrove forests are the degree and duration of tidal inundation, sedimentation patterns, and the range of ambient salinity. Zonation of mangroves in terms of species and structure is not at all dependent on the succession of species leading to climax state like those found in most forests. Rather, mangrove forest structure is a function of, and is sensitive to, relatively few environmental parameters. In this aspect it is one of the most unique woodland ecosystems in the world.

Although remarkably well adapted to conditions that would be lethal for most other tree species, mangroves are nonetheless quite sensitive to change in the aforementioned factors, which are in turn a direct function of tide patterns. Alteration of local hydrology as a result of shrimp farm development therefore can present a threat to mangrove forests as great as actual clearing them for pond construction. Poorly drained roads crossing many kilometers of mangrove and intertidal zones may not only provide access to remote shrimp farms but also isolate large landward areas from tidal inundation. Shrimp farm perimeter dikes and lengthy intake canal berms may further constrain tidal flows into landward mangrove areas. The consequent drying of soils will increase their acidity and salinity, affecting nutrient availability and osmoregulation and depriving mangroves of daily nutrient inputs borne on the tides. A radical shift in species composition and structure, and perhaps local extinction of the forest, may result in cases of extreme modification of tidal regimes. Although wholesale mangrove destruction in the Western Hemisphere is not described in the relevant literature as a result of hydrological interference by shrimp farms, anyone who has visited major shrimp-growing areas will notice local mortalities of forest fragments due to this phenomenon.

Six species comprise the vast majority of mangrove vegetation in the Gulf of Fonseca: *Rhizophora mangle* and *Rhizophora harrisonii* (red mangrove), *Avicennia germinans* and *Avicennia bicolor* (black mangrove), *Laguncularia racemosa* (white mangrove) and *Conocarpus erectus* (buttonwood) (COHDEFOR 1987). As described in general terms above, the species distribution, structure, and density of mangroves in Honduras is a direct function of tidal inundation, salinity, and sedimentation regimes, with tall (up to 15 m), mature red mangrove dominating the borders of tidal creeks and a prevalence of shorter (less than one m), salinity-stressed varieties of black mangrove on the landward fringes.

The vast majority of shrimp farm construction in Honduras has occurred since the mid 1980s, in good time to benefit from early lessons on the poor qualities of mangrove forests as sites for pond construction. There has nonetheless been common public reference to wholesale destruction of mangrove forests by the rapidly expanding shrimp mariculture industry, a phenomenon for which perceived declines in local fishery catches and other indicators of environmental degradation are often blamed.

Mangrove management and protection has legal status in Honduras via, among other things, the articles of the Fisheries Law of 1959, which prohibit clearing of mangroves on shorelines (DIGEPESCA 1990), and the Forestry Law of 1958, which declared mangroves as Class I Protected Forestry Zones (DIGEPESCA 1990). Though modified by subsequent forestry law, most prominently after the creation of COHDEFOR in 1974, the effectiveness of national forestry legislation has suffered from the lack of clear operational directives, serious questions of tenure, and shortages of trained staff for administration and enforcement (Vega 1989). Under current licensing rules, collection is allowed of 578 m^3 of construction wood, 6,498 m^3 of fuelwood, and 96 tons of red mangrove bark per annum (Dickinson 1988).

With regard to aquaculture development and mangrove areas, the Government of Honduras (GOH) has administrative authority over lands that fall between mean high-tide and 2 km inland. Until recently, this mandate was exercised through the Secretary of Tourism (SECTUR); it has lately been assumed by the Ministry of Natural Resources. Despite this opportunity to influence directly the impact of shrimp farm development on mangrove lands, there has been no direct link between the granting of concessions for farm construction and statutory requirements for mangrove protection, in part because of the lack of clear procedures governing concessions. Concessions nominally *are* granted on land designated as mud flats (*playón*); this arrangement provides implicit protection for mangrove because of the accepted definition of this land type. According to the mangrove classification system used by Pannier in the 1987 COHDEFOR technical report, *playón* is defined as an area where mangrove vegetation less than 3 m in height covers less than 40 percent of the total surface area. However, this definition is of limited usefulness for application or enforcement purposes since the actual limits of concessions are often poorly understood or are agreed upon without prior site inspection, and since mangrove density and height can change with time.

Although the value of mangroves is generally recognized, and their possible destruction is a serious issue for Hondurans, there has been no systematic inventory of mangrove status using data collected since the boom in shrimp farming began in the mid 1980s. The most comprehensive estimate of the extent and quality of mangrove forests in southern Honduras is the 1987 study performed by COHDEFOR, based on 1982 aerial photography. This project differentiated mangroves not only by species but also by a complex matrix of factors that included height, state of maturity, density, and degree of environmental limitation. The figure generated by this analysis, 46,821 ha of mangrove woodlands including stressed, dwarf, and plantation categories, has since served as the benchmark figure in discussions of management options for the region. Though the aerial photographic record of the Gulf of Fonseca extends well into the 1950s, there has been no comparable inventory of forest coverage and quality using this or more recent (i.e., post shrimp farming) data until the present study.

2.1.2. Capture of wild postlarvae

Penaeid shrimp life history is characterized by the migration of subadults from estuaries toward offshore areas, an exodus soon followed by sexual maturation, mating, and spawning. Planktonic larval stages are then completed as the young utilize tidal currents to reverse the direction of adult migration and enter the estuarine areas, where food is significantly more abundant and shelter from predators is more available in such vegetative structures as mangrove root systems.

Extensive and semi-intensive shrimp farms worldwide are highly dependent on the capture of these estuarine postlarval shrimp to fulfill their requirements for seed stock. Harvest is usually performed by artisanal fishermen using a variety of fine-mesh capture gear ranging from hand-held pushnets to large (30 m or longer) bag seines. This practice has led to concern about depletion of shrimp stocks by sustained, heavy fishing pressure. Furthermore, since estuaries serve the majority of nearshore organisms as nursery and feeding grounds, the harvest of postlarvae produces considerable ancillary capture of nontarget species, most of which are destroyed in the consolidation, transport, or receipt of the shrimp seed by client shrimp farms. Although of little direct use to the shrimp farmer, many of these organisms (e.g., young herring, mullet, and seabass) are recuited into important fisheries' populations upon maturity and are important to local economies and nutrition.

No comprehensive studies are available documenting the extent of bycatch from postlarvae harvest in the Americas, though a ratio of 1:5 in target-to-ancillary catch has been reported for Honduras (Foer 1992). In Asia, where seed fishing techniques are quite similar to those of the Americas, a formal study supported by the multinational Bay of Bengal Program established that the species composition of seed fishermen's catch in the Bangladesh-India portion of the Ganges estuary is comprised of only 2 percent of the target tiger prawn (*Penaeus monodon*) postlarvae. According to the same study, the total harvest of wild prawn seed in the West Bengal area of India is estimated at 400 million per annum, which results in the destruction of nearly 20 billion fry or juvenile stages of other species. Most biologists assert that even the highly successful development of culture industry cannot replace a well-managed natural fishery in terms of ability to provide income and nutrition to local human populations, so this massive loss of recruitment stock is viewed with concern wherever shrimp seed fishing is widely practiced.

Despite legitimate apprehension over such profligate waste of resources, a link has never been established between harvest of larval/postlarval marine organisms and a decline in the population of mature adults. Moreover, classical population ecology would suggest that penaeid shrimp and many species of finfish from lower trophic levels may not be nearly as responsive to predation (i.e., fishing) pressure as they would be to critical environmental changes. Within the broad models for population behavior, most invertebrates and many higher animals, of which rabbits are the mammalian archetype, belong to the "r"-selected (r = rate of reproduction) category, channeling most of their energy into the generation of overwhelming numbers of offspring at the expense of developing individual survival strategies and longer life spans (McNaughton and Wolf 1973). The reproductive rates of these animals can also be influenced by changes in environmental parameters as they "venture," with the onset of ideal conditions, to exploit their evolutionary advantage in sheer procreative ability. In essence, it would not be expected that such animals, including penaeid shrimp, would be significantly affected by heavy predation pressure of the early life stages because their particular survival strategy is predicated on heavy mortality of individuals anyway. Yet their sensitivity to the ideal combination of environmental conditions and relatively low individual options for adaptation would place them in grave danger from significant environmental degradation.

The "r"-selected pattern as an explanation for behavior of penaeid populations is indirectly supported by the Ecuadorean experience, where wild postlarvae furnish the majority of seed stock used in that country's 130,000 ha of ponds. Although collapse of the penaeid shrimp populations in Ecuador was believed imminent on several occasions, most notably in 1985, and the cause was variously attributed to overfishing and mangrove destruction, it has subsequently become apparent that the abundance of these animals is much more closely related to climatic factors than any other single parameter.

As consequence of the relatively recent inception of semi-intensive shrimp aquaculture, there are few management schemes for postlarval fisheries that could offer a model for Honduras. Ecuador annually implements a closed season for the harvest of wild postlarvae, coinciding with the advent of the December rainy season and the reproductive peak of the shrimp population associated with the major estuaries in the south of the country. Though common wisdom in that country deems this practice a success, the aforementioned close correlation with annual climatic trends, principally the presence or absence of the "El Niño" phenomenon, renders reliable evaluation difficult. The Polytechnical Institute of Guayaquil, Ecuador, has since the early 1980s successfully sponsored extension programs teaching proper handling of wild shrimp postlarvae with the objective of increasing survival and conserving this resource. Although this effort has not been extended to conservation of by-catch organisms, the aforementioned Bay of Bengal program was able to present this concept to some 400 of the estimated population of 100,000 seed fishermen in the Bay of Bengal. Assessment of this program revealed that most seed fishermen are willing to return by-catch organisms to the water rather than throw them onto the shore if the importance of such conservation can be effectively conveyed.

There is no industrial fishing fleet on the Pacific coast of Honduras, though estimates for the number of full- and part-time artisanal fishermen range from 2,000 to 5,000 (USAID/SECPLAN 1989). These individuals, in the pattern of small-scale fishermen worldwide, use a broad range of strategies to exploit the gulf fisheries, including the harvest of shellfish and crabs among mangroves, cast-net harvest of shrimp and finfish from tidal pools and lagoons, and deployment of trammel nets and fish traps from canoes in the creeks and open waters in pursuit of shrimp and finfish for local sale. Pursuing a livelihood that is never lucrative under the best of circumstances, these individuals are the first to notice any decline in quality or reward for their efforts, serving as watchdogs for trends in the status of the resource.

Data are scarce for the artisanal fishery and virtually nonexistent for the postlarval fishery. Nonetheless the most impassioned discussions of resource-use conflicts in the Gulf of Fonseca region are related to perceptions that, for reasons including those summarized above, shrimp farming is negatively affecting wild finfish and shrimp stocks. Though the primary reason for conflict may relate to access (see 2.2), the fishermen's logic also stems from the inarguable fact that they are returning to port with much less to show for their efforts than in previous times. Based on this direct and painful experience, it is easy for them to assume that unsustainable harvest pressure on wild postlarvae and fish (these same fishermen very well may participate in such harvesting) is a root cause of declining catches.

Like all countries that have developed a semi-intensive shrimp farming industry, the Hondurans rely heavily on wild-caught postlarvae for stocking ponds. Though the organization of fishermen differs from that found elsewhere in the Americas (in that fishermen have traditionally been employees of shrimp farms rather than independent), the methods are similar. The use of small push nets (*chayos*) of 0.5 mm mesh along the margins of small tidal creeks and lagoons (figure 2.2) predominated during the early years, though the expansion of farms, increased stocking densities and consequently greater competition has resulted in more sophisticated gear (e.g. seines) and larger numbers of fishermen entering the practice, with perhaps as many as a thousand engaging in the harvest as of 1991 (Foer 1992).

Figure 2.2. Typical capture method for wild post larvae (chayo)

Dickinson et al. (1988) extrapolated Edward's (1978) calculations of postlarval and juvenile shrimp production in lagoons on the Pacific coast of Mexico, producing a highly qualified estimate of 125 million postlarvae (after mortality of capture) produced per quarter by the aggregate estuarine ecosystems in the Gulf of Fonseca. Extrapolating from the common production practices of 1988, it was estimated that this supply would suffice for 8,000 ha of ponds. Despite this estimated abundance and the increased effort at its extraction, periodic scarcity has still occurred, and importations of postlarvae in numbers representing as much as 40 percent of total stocking requirements have been reported (Foer 1992). Some of this increased tendency to import larvae has not been due to scarcity but rather seed stock quality and other management considerations.

Perhaps the best manner of alleviating pressure on fishery stocks caused by the harvest of shrimp postlarvae is through a successful hatchery sector that can provide farmers with economically competitive alternatives to wild seed. Though the harvest and sale of wild postlarvae is often an important component in the portfolio of income-generating activities available to local artisanal fishermen in these countries, there is considerable benefit in the ready availability to farmers of alternatives.

Virtually all of the imported seed stock is derived from hatchery production outside of Honduras. The prospects, however, for local construction of hatcheries are poor because of local constraints on water quality. Penaeid shrimp require water of oceanic quality during the three-week development from egg larvae to the late postlarval stages that bring sufficient maturity to assure survival in ponds. Water of oceanic quality, though not precluded by the Gulf of Fonseca's estuarine conditions, is rarely encountered. As a result, only one hatchery has been constructed in the region to date.

Though hatchery construction outside the region is a frequently discussed option, only one company, Granjas Marinas de Honduras, has acted upon this option with the completion of their integrated maturation and larval-rearing facilities in Summerland Key, Florida.

2.1.3. Eutrophication of local waters

Aquaculture pond effluent normally does not contain the toxic substances associated with industrial and agricultural wastes. Ponds constantly accumulate organic load, however, in the form of nitrogenous wastes and suspended solids derived principally from shrimp excretion plus decay of uneaten feed and dead plankton. Although some of this material is mineralized by natural microbial processes and cycled back into phytoplankton biomass, the supplemental inputs of feeds used in semi-intensive aquaculture usually produce these organics faster than they can be utilized by primary producers. Surplus material may either accumulate on the pond bottom and contribute to biochemical oxygen demand or remain in solution as ammonia. A high biochemical oxygen demand can result in chronically low levels of dissolved oxygen, and ammonia is toxic to most aquaculture organisms.

To manage this persistent condition and optimize shrimp growth, culture ponds are routinely flushed at a daily rate that averages 5 to 10 percent of pond volume over the 120- to 150-day production cycle. This practice will produce approximately 8 to 16 million gallons of effluent per day per hundred ha of ponds, which must then be discharged into the brackish creeks or oceanic waters surrounding the farm. At harvest time, not only have pond waters reached a maximum organic load prior to complete drainage (i.e., a much greater pulse of effluent as compared to a relatively small daily exchange), but the process of harvesting may further suspend bottom sediments that have heavy organic content in a highly reduced state. Suspension of this reduced material in the water column initiates oxidation, further contributing to biochemical oxygen demand of local waters.

Although mixing and dilution will reduce the impact of effluent after discharge from a few scattered farms, many farms in close proximity may significantly degrade receiving waters. If incoming seawater is already heavily loaded with organic material, its capacity to maintain adequate dissolved oxygen levels, assimilate new organics, and otherwise support shrimp production is greatly reduced. This problem has been recognized worldwide in areas where coastal aquaculture is heavily developed and culture practices tend toward heavy use of feeds and other inputs (Avault 1993; Pruder 1992; Boyd and Musig 1992; FAO 1991).

Consequences may also extend beyond those experienced by local shrimp farming interests because the negative effects on natural waters of an excessive introduction of organics can be significant. In areas with water of naturally low turbidity, increased quantities of suspended solids will decrease sunlight penetration and affect both rooted macrophytic vegetation (e.g., grassbeds) of importance to nearshore fish and invertebrate communities and coral formations important to fisheries and shoreline protection. High biochemical oxygen demand and associated low levels of dissolved oxygen will also affect the survival and growth of estuarine organisms, causing local decrease in stocks in the most severely affected areas. Although Pruder's review (1992) of this problem quotes Ziemann et al. (1990), Bashirullah et al. (1989), and Bailey (1988) as finding no significant local eutrophication effect from the discharge of pond effluent in

Hawaii, Bangladesh, and Ecuador respectively, Chua et al. (1989) does regard this as a problem in several southeast Asian countries.

In Honduras, the Gulf of Fonseca's morphology exacerbates the local potential for this problem. Many farms are located on the upper reaches of tidal creeks that have relatively low volume, low effluent dilution capacity, and virtually no freshwater inflow or significant tidal exchange during the December-April dry season. Tidal creeks in the southeastern portion of the gulf (e.g. Estero Pedregal and Jicarito) are additionally constrained by the poor exchange of water from this area with the Pacific Ocean. Therefore, once an effluent mass has finally been discharged from these creeks, it will have additional high residence time in the local gulf and be subject to continuous reuse by farms. Since this is one of the more accessible areas from Choluteca, shrimp farm development has been high, existing farms will continue to expand, smaller farms will occupy remaining parcels of suitable land, and all may face the prospect of highly degraded water for use in their production systems.

2.1.4. Displacement of seasonal lagoons

A major issue in the Honduran debate on environmental effects of shrimp farming is the unique importance of seasonal lagoons to local ecological processes and livelihoods. Fed by rainwater, these ephemeral pools develop annually on the barren and sparsely vegetated mud flats behind the mangrove fringe. Seasonal peaks in high tides, which result from runoff-elevated water levels in the creeks and rivers, create brackish conditions in the pools and, most importantly, introduce larval and postlarval stages of fish and crustacea. At the close of the rainy season most lagoons become isolated from further contact with open water and begin drying out. From that point forward, the shrinking and eventual disappearance of the lagoon, increasing salinity and temperature, decreasing carrying capacity of the residual pool, and the increasing biomass of the stock move toward final limits unique to each site. The productivity is heavily exploited by migratory bird and human populations in the region, from which the lagoons' ecological utility is derived.

Artisanal fishermen move into the lagoons as shrimp and fish congregate in the final pools of water. Though production per unit area may be low considering the original size of the lagoon, the final concentration of the crop results in relatively high yield per unit effort and total yields that are often in the tens of thousands of pounds, most of which is high-value shrimp. Albeit sporadic, this windfall has traditionally represented an added, important input to the marginal options for earning a livelihood available to these fishermen.

Migrating waterfowl, raptors, and wading birds also derive considerable benefit from the lagoons' productivity. Varela (1985) observed over 71 species associated with lagoons during a 12-day visit to the Gulf of Fonseca in October 1985; a time well in advance of the peak abundance of fall migrants and winter residents (15 species observed during this period were migratory). Dickinson (1985) further speculated that the seasonal pulses of readily available food are probably linked to the success of some critical aspect of the avian life cycle, as is the availability of fish to breeding wood storks from ephemeral pools in Florida. Complete elimination of these pools will no doubt affect both resident and migratory bird populations, the latter of consequence to avifauna of both the United States and Canada.

Identification and classification of several of these lagoons as "artisanal fishery reserves" was first recommended by Varela et al. (1985); one of them, El Guapinol, was identified during the course of this Mission as meriting protected status. Subsequent designation of additional areas as fishery reserves or "wildlife reserves" has continued under the auspices of COHDEFOR via the 1992 Executive Accord No. 1118-92, which declared not only the Guapinol "laguna de invierno" to be a protected area, but the Montecristo, El Quebrachal, Guamerú Teonostal, El Jicarito, and La Alemania areas as well (though criteria used for their selection are not clear). These names denote general localities. The boundaries, present degree of utilization, and, most importantly, overlap with shrimp farm concessions are not known (DIGEPESCA, pers. comm.).

Conflict over the use of these lagoons arises from their high suitability for conversion to shrimp farms. Dry most of the year, the lagoon basins are either sparsely vegetated or totally barren; they are proximate to sources of seawater and generally possess all other favorable characteristics for construction of shrimp farms. As shrimp aquaculture increased in popularity across the Americas in the 1980s and the rush to find suitable sites in Honduras was begun, these lands were distributed to prospective investors via the aforementioned concession arrangement in return for payments ranging from $1.00 to $3.00 per ha, a fee lower by several factors than comparable rentals on agricultural land in the region. This process did not recognize any of the above values for the seasonal lagoons either to wildlife or local fishermen and effectively set the stage for the single most controversial issue in the debate over resource use in the gulf (see 2.2).

2.1.5. Effects on bird populations

Aquaculturists and aquatic birds often have an adversarial relationship because avian predators can result in major crop losses if not controlled. Cormorants comprise far and away the greatest menace to the aquaculturist, descending on shrimp farms in large numbers and consuming 100–200 grams of shrimp or fish per bird during each of several daily feedings. Though cormorants are protected in the United States, aquaculture farms elsewhere in the Americas often employ crews of full-time cormorant hunters, who may destroy many of these birds. Despite this pressure, the population of cormorants in the Western Hemisphere is increasing due to the reduction in usage of persistent pesticides in North America and the advent of large-scale aquaculture over an area ranging from the Mississippi River valley to Peru (Coniff 1991).

In addition to the cormorants, many other species of birds are drawn to aquaculture ponds either to feed on small fish, mollusks, and invertebrates, or to rest on ponds and proximate stands of trees or mud flats during migration. Inexperienced shrimp farm managers may apply indiscriminate pressure on all birds regardless of actual threat, though most operations quickly learn, because cormorants present the real hazard, to disregard the presence of virtually all other species.

Although the degree of threat has never been quantified, the value of wetlands to major bird populations and their large-scale occupation by commercial interests is a situation that creates concern over the effects of predator control, as well as over the displacement of avian breeding, resting, and feeding areas by ponds sited among mangroves, salt flats, and seasonal lagoons.

2.2. Perceived constraints to resource access

The most serious social problem in southern Honduras relates to poor peoples' perceptions that the wealthy have been able, with the assistance of the state, to appropriate common resources for private gain. Until the end of World War II, much of southern Honduras was what local people call *montaña* (wilderness). Resource-poor people were able to clear part of this area on which to plant their subsistence crops and to raise a few livestock. The cotton boom vastly transformed this situation. As we indicated in section 1.5, cotton farmers were able to expel resource-poor farmers from national lands and from lands they were renting or sharecropping.

The current situation with shrimp farms in southern Honduras is seen as another example of the state converting common resources into private property. The national lands along the beaches, mud flats, and estuaries had been a common resource, an area for fishing, hunting, collecting shellfish, gathering wood, and various other uses. Because of concessions granted by the government, these lands are now effectively under the control of national and transnational corporations and are being used for private gain. A small farmer and artisanal fisherman from the region summarized the situation: "First we were evicted from our land—now they are throwing us out of the sea. Where will we go?" This desperation partially accounts for how polarized the conflicts in the region have become.

According to local people, the construction of the shrimp farms, including fences patrolled by armed guards, has had a number of effects. The most important of them are these:

(1) Local people have been prohibited from using large areas declared off limits because of shrimp farm construction. In addition, much land speculation is occurring: private landowners are trying to fence off areas that might be appropriate for shrimp farms or that can be used to pasture animals.

(2) Even some estuaries that are supposed to be open for use by all are contested areas, and companies fearing theft are trying to discourage people from using the estuaries bordering the shrimp farms.

(3) Because of the erection of fences, local people are often forced to take long detours in order to reach boat-launching areas or places that are still open for their exploitation.

(4) Road construction and shrimp farm construction have altered the natural water flows of the region, affecting areas like the rich, seasonal lagoons that hitherto have been used by local people.

(5) The shrimp farm construction and the collection of wild larvae are perceived to have affected recruitment of shrimp and other species.

2.3. Local perception of limited economic benefit from shrimp farming

There is no question that the shrimp farms, packing plants, and associated enterprises have brought an important source of employment to the southern region. Business people, urban dwellers, and persons involved in other agroindustries in the south are nearly unanimous in extolling the benefits of the boom in the shrimp farms. People in the villages nearest to the shrimp farms and others from the coastal villages, however, claim that they have derived few benefits from the expansion of this industry. The most important complaints about the economic effect of the shrimp farms are these:

(1) Many workers on the farms and in the shrimp processing facilities are people from highland farming communities. The companies have not hired the families of fishermen and workers who have derived their living from the Gulf of Fonseca.
(2) The communities that are located close to the shrimp farms have not received any economic benefits. There has been no improvement in their basic infrastructure. Some of their income-deriving activities decreased because of the presence of the shrimp farms.
(3) Although employment is available, especially for women, the jobs are almost all temporary. There is no job security because workers receive only short-term contracts and no fringe benefits (e.g. life insurance, health insurance, etc.).

2.4. Environmental effects of other economic activities in the gulf and special concerns of the shrimp growers

The environmental issues in the gulf have been characterized as a single axis of conflict: shrimp farming negatively affecting both ecological processes and nonaquacultural uses of estuarine resources, thereby devaluing one of the industry's important secondary benefits, its contribution to maintaining environmental quality. Because semi-intensive shrimp farming is closely linked to its parent ecosystem, it is therefore dependent on environmental quality for success. As a result, coastal aquaculture is regarded in some parts of the world as an effective way to vest major economic interest in maintaining coastal environmental quality, and shrimp farming is viewed as an "indicator industry" for the general health of coastal waters.

Aquaculture has played this role to some degree in Ecuador, where in 1990 massive shrimp mortalities of undetermined etiology in that country's $500 million mariculture industry has set the public on a search for possible "environmental" causes such as agricultural chemicals, urban pollution, and large-scale dredging operations (Rosenberry 1990). Before this acute, economic distress was felt among the country's business community (most commercial banks are heavy lenders to the shrimp farming sector), there had been scant attention paid to the status of the Guayas estuary, where the majority of ponds are located.

The Italians may have reached similar conclusions about their own coastal aquaculture and fisheries sectors as evidenced from the following published assessment. "Experience teaches that where the various components of the lagoon reality are not accounted for, fisheries and aquaculture have been the most penalized sector, just because they are directly dependent upon environmental quality. Fisheries and aquaculture are even instruments of environmental conservation: the fishermen are in fact supervisors and permanent witnesses of the environmental status, because their income depends upon it" (Ardizzone et al. 1988).

This statement carries an important message, which has been partially overlooked in the Gulf of Fonseca. Fishermen not only serve as watchdogs of environmental quality, a role they have played very effectively in the gulf, but they could also share a common, vital stake in environmental quality with other aquaculturists and should approach many value questions collaboratively with other aquaculturists. An excellent example of a missed opportunity for such collaboration was observed in Honduras during the highly publicized warnings of dinoflagellate blooms (*marea roja*) in January 1993. The shrimp farmers and artisanal fishermen were both beset by public apprehension over the quality of their products. They could have benefited by acting together to maintain water quality. The crisis served instead, however, as an opportunity for continued public diatribe and further estrangement between the two sectors. As concern mounts regarding other nonaquacultural threats to the Gulf of Fonseca's environmental quality, these "adversaries" may not be able to afford their reflexive antagonism for long.

In the Gulf of Fonseca, fishermen, shrimp farmers, and other natural resource users face an array of potential environmental threats. As amply stated elsewhere in the document, some of the more prominent issues are directly related to the increasing level of aquacultural development in the region, but others are of outside origin.

2.4.1. Sediment loads in freshwater runoff

The steeper regions of the hilly watersheds comprising the major drainages into the gulf have increasingly come under cultivation in recent decades (A.I.D./SECPLAN/DESFIL 1989). This land-use conversion has acted in combination with the squall-like intensity of the rainy season to produce extremely high erosion and sediment transport to the estuarine zone, reaching 13 tons/ha/yr erosion in the upper Choluteca watershed and 168 m^3/sec transported at the level of the Choluteca bridge (Vega 1989). Suspended sediment loads of this order can be of particular concern to shrimp farmers because sediments will quickly drop out of suspension as water velocity slows upon entering shrimp farm intake canals and ponds. Unmanaged sedimentation will gradually fill ponds over the course of one or two production cycles, requiring expensive and frequent pond renovations.

The increased sediment loads may affect many other ecosystem processes as well. As pointed out in preceding sections, increased turbidity due to suspended solids and colloids will reduce sunlight penetration into the seawater column, affecting primary productivity and consequently the trophic structure of estuarine ecosystems. The populations of numerous species of invertebrates and finfish that rely on egg deposition during spawning may also be affected as substrates and eggs are smothered in layers of silt during periods of peak runoff. Finally, as a result of accelerated deposition of mud flats, the very morphology of the estuary may be altered at a rate beyond the adaptive capacity of such natural processes as establishment of mangrove.

2.4.2. The Choluteca River Basin Agriculture Development Project: Potential water quality changes

The proposed Choluteca River Basin Agriculture Development Project has received considerable attention in recent years because of its potential for altering the historic pattern of freshwater runoff into the estuary.

2.4.3. Deforestation unrelated to shrimp farming

According to Vega (1989), significant destruction of upland forests began in colonial times, though Joya (cited by Vega) marks the era of commercial exploitation as dating from the construction of the Panama Canal between 1902 and 1912, in which large amounts of wood were used. Data from these early times are nonexistent because the first reliable estimate of forest cover in southern Honduras dates to the 1952 agricultural census, which listed 73,500 ha of commercial forest in an area of approximately 367,500 ha (i.e., approximately 40 percent of the present study area; Vega 1989). Though reliable data on the extent of forest cover in the southern zone continue to be sparse, it has been reported that no stands of broadleaf forest exist that are commercially interesting (Vega 1989), an estimation reinforced by the closure of numerous sawmills in the area.

Though deforestation was initially caused by the commercial exploitation of the primary, dry, tropical forest, the removal of forest for shifting agriculture, pasture, and fuelwood have been more important factors recently. With the replacement of broadleaf forest by pasture and scrub, and with displaced populations settling in ever greater numbers at the edge of the estuary, extractive pressure on mangroves has increased markedly in recent years. The most significant single usage over the past two decades has been to provide fuel for salt evaporation, ovens, and brick kilns. Additionally, red mangrove bark is used by the local tanning industry.

Widespread deforestation produces the negative effects discussed above, including watershed sedimentation and loss of biodiversity in upland forests plus reduction in estuarine productivity, biodiversity, and morphological stability of mangrove stands. Because xeric forest is one of the most threatened ecotypes in the neotropics, this virtual extinction of the upland broadleaf forest is lamentable not only from the perspective of local ecology and economics but also from the standpoint of regional biodiversity.

2.4.4. Pesticide loads in estuarine food chains due to agricultural intensification

Major pesticide use and abuse first became an issue in southern Honduras following the advent of extensive monocropping, notably the cotton boom of the 1950s (see section 1.5). Though heavy usage of the more persistent, dangerous chlorinated pesticides is no longer practiced (primarily because of the decline in cotton cultivation), concern over pesticides has increased because of the intensification of export-oriented vegetable cultivation in the Choluteca watershed and other portions of the Gulf of Fonseca, including lands at the very margins of the estuarine/shrimp farming zone. Large irrigation schemes such as the Choluteca River Basin Agricultural Development Project will put additional thousands of hectares within the Gulf of Fonseca drainage into various forms of monoculture, contributing further pesticide loads to the load already caused by the expansion of melon production.

In addition to direct impacts on human health, pesticide contamination of soils and agricultural runoff result in the loss of microbial flora, insect fauna, and higher order predators critical to ecological processes and productivity. Estuarine filter feeders, such as locally consumed shellfish, are especially likely to accumulate toxins that are present in seawater, which subsequently can accumulate to detrimental levels in human shellfish consumers. Reliable pesticide data are, like most information on the Gulf of Fonseca, quite sketchy. Nippon Koie (1992) cited figures from 1987 and 1992 Dirección General de Recursos Hídricos data sets that indicated detectable organochloride pesticide residues, including lindane, heptachlor, and aldrin, in the Estero la Jagua and El Purgatorio. The Nippon Koie study (i.e., the environmental assessment for the aforementioned Choluteca River Basin Development Project) listed 21 pesticides that are likely to be used in local irrigated agriculture. Though the study also predicted that the use of these chemicals will increase more than elevenfold after the project is fully developed, the final report asserted that bioacculumation would not be a problem because persistent organochlorides would not be used under the project's production schemes—a questionable conclusion at best.

3. Technical approach to the environmental study

The evaluation and analysis of the environmental study was carried out using the following methodologies:

(1) Collection and review of the bulk of available published and nonpublished information for the region (see references), and the gathering of pertinent data;
(2) A series of interviews and meetings with knowledgeable individuals in the private and public sectors (see appendix A, Persons Consulted);
(3) The review of aerial photos covering the study area for three time periods (1973, 1982, and 1992) and photointerpretation leading to the drawing of land use maps for each of these periods identifying the following uses, listed here after the code used to designate them:

1. Agricultural areas
1.1. Irrigated agriculture
1.1.1. Sugarcane
1.1.2. Other (melons, corn, cotton, rice)
1.2. Subsistence agriculture
1.3. Grazing areas
2. Forested areas (dry forests)
3. Mangrove areas
4. Flood zones
4.1. Permanently flooded (mud flats)
4.2. Ephemeral flood areas (salt flats/*playones*)
5. Water areas
5.1. Rivers and estuaries
5.2. Lakes/lagoons
6. Established shrimp farms
7. Established salt operations
8. Urban and industrial zones

(4) Field investigation in the Gulf of Fonseca area to check the aerial photointerpretation, the accuracy of the land use mapping, and the sampling of water, soils, and tissue in selected areas for coliform bacteria and pesticide residues;
(5) Calculation of mangrove loss directly attributable to shrimp farming using land use maps and COHDEFOR vegetation classifications.

3.1. Definition and description of the study area

For the purpose of the current study, the Gulf of Fonseca area was defined as the area encompassed from the mean low tide mark (waters of the Gulf of Fonseca area), to the 60 meter contour line (Panamerican Highway), to the Nicaragua and El Salvador borders as delineated by the availability of aerial photos.

On the average, 24 flight lines comprising some 400 aerial photos (1:20,000 scale) were analyzed for each year. The areas covered correspond to the following topographical maps: Bahia Chimuyo, San Lorenzo, Amapala, Marcovia, Choluteca, Punta Condega, Santa Maria, Estero Real, and Puerto Morazan. The total surface area of coverage is about 172,000 ha.

The major ecosystems in the Gulf of Fonseca area are (from higher elevation to sea level): remnants of dry tropical broadleaf forests, freshwater or brackish water wetlands, salt flats (*playones*), mangrove forests, estuaries.

Historically the most degraded ecosystem in the zone, and the most endangered, is the dry tropical hardwood forest. These forests have been cut and burned until only a few remaining stands of hardwoods are left. In order to conserve biodiversity in the area, it is imperative that the few remaining areas be preserved and managed as biodiversity areas; they should suffer no human activity other than approved research.

The second area of major concern is the mangrove forests. Because of their high productivity and the lack of other comparable sources of wood in the area, the mangrove forests are being exploited in the region in two major fashions—first, by the use of wood for fuel and construction and of bark for tanning; second, species that inhabit the mangrove areas are exploited as food or to generate income (as is the case with shrimp postlarvae or artisanal fishing) or for recreation (as is the case with sport hunting). Because of their high productivity and contribution to the gulf's ecosystem, protection of the mangrove habitats should be encouraged and enforced. The establishment of protected areas within different microenvironmental systems found within the mangrove communities should have a very high priority. To the detriment of the ecosystem, the current measures and restrictions on mangrove use are not being adequately enforced. With an adequate management plan in place, and with appropriate enforcement, the gulf's mangrove areas can be protected and managed as multiple use areas (see appendix E for a list of economically important plant and animal species of the Gulf of Fonseca region).

The freshwater and brackish water wetlands as well as some of the remaining winter lagoons should also be protected and managed. They are an invaluable source of diversity, larval rearing areas for crustaceans and finfish, and wintering grounds for numerous migratory and resident bird species. Some of the remaining wetlands areas should be protected, and human activities other than tourism should be strictly monitored.

Rational conservation and management of the gulf's ecosystems will add to the quality of life in the area and will ensure long-term sustainability for all users, but only if the right management decisions are made and impartial enforcement is carried out.

3.2. Description of analytical tools

3.2.1. Land use and vegetative cover: time-based analysis derived from interpretations of aerial photography

Aerial photos were obtained from the Instituto Nacional Geográfico for the years 1973 and 1982. A new set of aerial photos was taken under an USAID contract for the 1992 period. Unfortunately, the resolution on the 1992 aerial photos was extremely poor and photointerpretation and mapping of the land use patterns required a major field effort and extensive corrections to the initial photointerpretation.

For all three years, the aerial photos were interpreted using a geoscope and checked by field survey for correctness of interpretation. The interpreted photos were then used to produce land use maps. Based on recognized land use changes that have occurred in the region, three sets of photos were studied as follows:

- The 1973 data set was used as a baseline because at that time shrimp farms in the area were nonexistent and salt production was an active enterprise.
- The 1982 data set represented a time frame during which shrimp farming was in a nascent phase.
- The 1992 data set represents the current situation and the plausible turning point for rational management and use of the gulf's resources.

Once the maps were produced and field checked, area calculation by use type was performed using electronic planimeters. A summary of land use by category and year was compiled for all three data sets.

Changes in land use were calculated by superimposing current information such as area taken up by shrimp farms over the corresponding areas prior to farm construction. The vegetation classification used in the 1987 COHDEFOR report were used in this analysis. In that way, accurate data on mangrove loss by type can be measured.

3.2.2. Field observation of ecological processes and environmental change in the study area

In addition to analysis of land use patterns, qualitative assessments were made of ecological processes and issues in the Gulf of Fonseca area. This was effected via examination of background documents and relevant literature, formal meetings with individuals and interest groups in both Tegucigalpa and the gulf area, and field visits to shrimp farms and mangrove areas, including one low-altitude overflight.

Documents used for assessments are listed in the references section of this report. These include many reports and assessments that have previously been written about the southern region by governmental and nongovernmental organizations, by bilateral and multilateral assistance agencies, by scholars, and by journalists.

Public meetings were held with members of the Asociación Nacional de Acuicultores de Honduras (ANDAH) in Choluteca on January 22 and with representatives of the member communities of the Comité para la Defensa y Desarrollo de la Flora y Fauna del Golfo de Fonseca (CODDEFFAGOLF) on January 23, in San Lorenzo. The attendance list for these meetings is included in appendix A. Each meeting began with a brief summary of the purpose and methodology of the environmental study, which included summary presentation of preliminary findings. The meetings were then opened to discussion focused on issues related to environmental degradation and resource use conflict.

Field visits were made to areas selected on the basis of anticipated impact from major activities at issue: shrimp farms in the San Lorenzo/La Alemania areas to the southeast of Choluteca; shrimp farms and melon growing regions near Punta Raton; and salt producers outside of San Lorenzo.

One low-altitude overflight was made of an area ranging from Rio Negro northward to Bahia Chismuyo and eastward to the project area limits to verify aerial photointerpretation and gain the benefit of large-scale qualitative impressions of mangrove forest health, extent of shrimp farm construction, and any other regional indications of environmental change.

3.2.3. Analysis for pesticides and coliforms: agricultural and urban impact on the gulf

In order to get baseline data on the plausible impacts of agricultural pesticide use within the watersheds that drain into the Gulf of Fonseca, water, soils, and tissue samples were collected throughout the gulf and sent to the Fundación Hondureña de Investigación Agrícola for analysis. In addition, water samples were taken to the government-operated bacteriological lab for total coliform and fecal coliform analysis.

3.2.4. Socioeconomic impact of shrimp farming in the Gulf of Fonseca

The analysis of the socioeconomic impact of shrimp farming was based on four types of social scientific methods: examination of documents and related literature, rapid rural assessment, including interviews with individuals from various groups in the region, collection of recorded data from governmental and private-sector sources in the region, and formal meetings with representatives of the major organizations involved in conflicts.

The documents examined are listed in the references section of this report. These include many reports and assessments that have previously been done about the southern region by governmental and nongovernmental organizations, bilateral and multilateral assistance agencies, scholars, and journalists.

Rapid assessment procedures, including informal, unstructured interviews with individuals purposely chosen to represent the views of interested people and organizations in the southern region, were used. These interviewees included male and female employees of the shrimp farms and packing plants, shrimp farm managers, farmers, fishermen, community officials, aid organizations, ecological organizations, the Chamber of Commerce, government officials, and managers of other agroindustries. People in 10 villages stretching from the Nicaragua border to the El Salvador border were interviewed.[7] Interviews focused on (1) the effects of shrimp farming and other economic development on the region and (2) the attitudes and feelings of the interviewees concerning these developments.

Published and unpublished data on demographic, economic, and political trends were collected from government and nongovernment organizations in the region and in Tegucigalpa. These data aided in determining some quantitative indicators of trends in the region bordering the Gulf of Fonseca.

Finally, the consultants held formal meetings with the two main groups in conflict in the region, CODDEFFAGOLF and ANDAH. Eleven people from various communities were present at the CODDEFFAGOLF meeting, and 20 representatives of various shrimp companies attended the ANDAH meeting (listed in appendix A).

3.2.5. Stakeholder analysis

The major purpose of the methods used in the socioeconomic appraisal was to determine who are the major stakeholders dependent on the natural resources in the Gulf of Fonseca region. The positions of these major stakeholders and the attitudes they have concerning other stakeholders comprise the potential issues of conflict in the zone. These positions and conflicts form the matrix and accompanying analysis that are presented in appendix B.

[7] The social scientist who did these interviews had lived and worked in the region for about a year in the early 1980s. Visits were made to several villages originally studied at that time to determine changes that had occurred during the intervening decade.

4. Findings

4.1. Changes in land use and vegetation

Table 4.1 summarizes the land use and vegetation cover patterns for selected categories for the 1973 to 1992 time period.

Table 4.1. Land use and vegetation cover for the Gulf of Fonseca, 1973, 1982, 1992 (total ha)

Category	1973	1982[a]	1992
Agriculture/grazing	84,570	85,787	83,728
Salt flats (*playones*)	46,569	44,585	40,956
Mangrove[b]	30,697	28,776	23,937
Shrimp farms		1,064	11,515
Salt producers	957	1,122	1,325
Population centers	848	1,542	1,914
Total	163,641	162,876	163,375

a. The good quality of the 1982 aerial photography allowed for the classification of mangrove by species and habitat quality in the resulting COHDEFOR report. The data in the COHDEFOR report (1987) was used to reallocate some of the stressed and dwarf mangrove to *playones* to enable comparison with 1992 and 1973 classification.
b. Mangroves other than stressed or dwarf.

In this report, the mangrove forest categories used by Pannier in the COHDEFOR study are employed to qualify changes in mangrove cover. These categories are "dwarf," "stress," and "mature." *Dwarf* mangroves occupy soils at the outermost limits of soil salinity tolerance, generally in excess of 100 parts per thousand. These stands, often quite sparse, are less than 1 m in altitude (figure 4.1). *Stress* mangroves occupy the outer fringe of the mangrove zonation, where soil salinities are limiting. Stands are low (1 to 3 m) and show such signs of stress as poor flowering and vulnerability to insect attack. This is the transition type between normal forest and dwarf (figure 4.2). *Mature* mangrove stands are growing in zones of frequent tidal inundation and within ideal ranges of soil salinity. Depending on species, these stands may be as high as 15 to 20 m (figure 4.3).

The mangrove loss, by category, directly attributable to the construction of shrimp farms is given in table 4.2. For a total of 11,515 ha of shrimp farms built through the date of photography, the total mangrove loss was 4,307 ha or 37.4 percent.

Figure 4.1. Dwarf mangroves (from COHDEFOR, 1987)

Figure 4.2. Stressed mangrove. Note the machete used for perspective (from COHDEFOR, 1987).

Table 4.2. Mangrove loss between 1973 and 1992 by category due to shrimp farm construction. Sample size: 62 production areas.

Map Codes	Mangrove category	Hectares
AA4M	*Avicennia* stressed/dense	1323.90
AA2J	*Avicennia* dense/young	372.40
AA5E	*Avicennia* dwarf/dense	1282.50
AB4M	*Avicenna* stressed/medium	153.90
ACr	*Avecennia* sparse/regeneration	66.70
Rr	*Rhizophora* regeneration	277.40
RA2J	*Rhizophora* dense/young	136.50
ARr	*Avicennia/Rhizophora* regeneration	395.70
LC4M	*Laguncularia* sparse/stressed	71.30
	Others	226.70
	Total mangrove loss	4,307.00

Note: All mangrove loss due to shrimp farm construction has occurred since 1982.

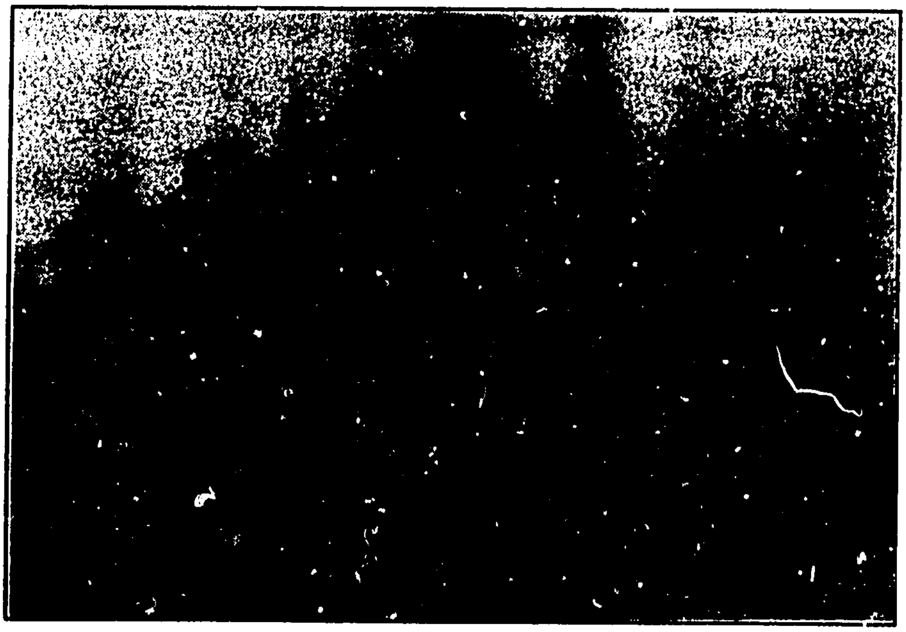


Figure 4.3. Mature stands of Rhizophora (from COHDEFOR, 1987).

Of the 4,307 ha of total mangrove loss, 2,132 ha (18.5 percent) are dense *Avicennia, Rhizophora* and some *Laguncularia* from forested stands bordering *playones* and estuaries. The balance of 2,174 ha (18.9 percent) are lower density stressed, young, or dwarf mangrove associated with *playones*.

The 2,132 ha of dense forest stands lost over the 1973-92 study period due to shrimp farm construction represent 6.9 percent of this type of mangrove cover reported for 1973. In comparison, the total loss of dense mangrove stands since 1973 is estimated at 6,720 ha or 22 percent of original cover. Therefore a substantial part of the mangrove loss for the region (66 percent) can be attributed to factors other than shrimp farming. The estimated loss to mangrove cover for firewood use (*leña*) has been documented at 46,300 m^3 per year. Based on this statistic, the annual mangrove loss to firewood use falls between 250 and 350 hectare equivalents per year (Flores and Reiche 1990).

The loss of mangrove in the region is attributable not only to shrimp farm construction but also to changes in hydrology (both naturally occurring and man made), road construction, the use of mangrove for firewood and construction materials, and the use of red mangrove bark by the tanning industry. Mangrove trees are a renewable resource. Given the opportunity and the appropriate environmental conditions, mangroves will regenerate. Therefore, the actual usage of mangrove is higher than indicated by the amount of mangrove area lost. And, because of the poor quality of the 1992 aerial survey photos, this study cannot accurately assess the density and percent of cover of the remaining mangrove stands.

The loss of dwarf mangrove and stressed mangrove to shrimp farming, however, is much higher than that loss due to other activities because the economic value of dwarf and stressed mangrove trees is negligible. The environmental effects of removing large expanses of dwarf and stressed mangrove from the ecosystem cannot be calculated from the data available. Although these areas are not as productive as healthier macro systems with denser vegetation, it is highly probable that their wholesale destruction will adversely affect overall productivity and evapotranspiration and will increase sediment loading. Such destruction could also negatively affect the survival of the healthier mangrove stands they border. In defense of the shrimp industry, one should also state that the loss of stressed mangrove has somewhat been mitigated, on the farms of some of the more conscientious farmers, by the propagation of mangrove along dikes and unused areas of the *playones* (C. Lara, Granjas Marinas, J. Crokett Cumar, F. Wainwright).

A major portion of the shrimp farm construction that has taken place has been in the San Bernardo zone in areas that have extensive, barren *playones*. Currently, a total of 28,699 ha of shrimp farm concessions have been approved, and another 2,720 ha are being considered for approval. Because responsibility for granting of concessions has shifted from the Officina de Tourismo to DIGEPESCA plus the overall difficulty in dealing with untitled and unsurveyed lands and the recently realized economic value of concession rights, a certain amount of overlap exists between concessions: some concessions rights have been granted to more than one applicant. Under the current laws, the rights to a concession lease cannot be legally sold. Selected entrepreneurs, however, have managed to get around the law by remaining minority partners in the new venture, thereby opening a lucrative alternative to land speculation in the gulf.

The result is that, of the estimated 31,000 ha of lands under concession status, only some 12,000 ha of shrimp farms have yet been built. A significant portion of the remaining concessions are located in areas with higher vegetation cover than was found in the areas developed so far. This means that the amount of mangrove that could be destroyed by construction of the remaining 19,904 ha of lands conceded would be significantly higher than what has been taken so far. Although the removal of some 2,174 ha of low-density and stressed mangrove might not have had a serious adverse impact on the ecology of the area, the removal of some 10,000 ha of additional dwarf, stressed, and forested stands of mangrove is significant and should be appropriately regulated.

The development of an environmentally sound master plan, and the requirement that sound environmental impact reports be prepared for all new shrimp farms and expansions of current farms, should minimize the adverse impact of future development of shrimp farming. This procedural approach should not be viewed as imposing restrictions on shrimp farming. It should be used to direct environmentally and economically sound industry development and to protect the already thriving operators from the plausible and documented effects of high biochemical oxygen demands and disease possibilities associated with overdevelopment of aquaculture operations within a limited geographic area.

4.2. Field observations of ecological processes and environmental change

Views on the environmental impacts resulting from shrimp farming and other changes in land-use patterns in southern Honduras are divergent, as noted below.

4.2.1. Direct effects of shrimp farming

As indicated previously, the shrimp farming sector has enjoyed robust growth over the past several years, and the impact of this dynamic sector has created many of the issues identified in this report.

4.2.1.1. Effect on mangrove forests

Occupation of barren areas by large farms. For the reasons presented in section 2.1.1 and further predicted in background literature, relatively little invasion and destruction of the higher quality mangrove categories (those classified as mature, young, and regenerating in the 1987 COHDEFOR study) by industrial shrimp farm development is apparent. High quality land for shrimp farms and high quality mangrove forest have mutually exclusive characteristics, which means that the larger, better connected and better capitalized investor groups will enjoy first pick of the unforested property available for development. The interiors of larger mud flats, barren of any vegetation, are the sites of heavy concentration of shrimp farm construction on all major farms visited, in effect an observance of the recommendation made by Dickinson (1988) for an undisturbed belt of forest 50 m wide paralleling waterways. Clearing of mature mangrove within this belt, consisting of mature *Rhizophora* and *Avicennia* spp., had taken place for the installation of pumping stations and openings for drainage canals on all farms visited, constituting a maximum of 10 to 20 ha per site.

On two of these farms, Granjas Marinas San Bernardo and Aquacultura Fonseca, perimeter dikes were also constructed well within the mangrove fringe, often leaving a margin of barren land several yards wide between the trees and the ponds. Though conservation and protection for mangrove resources were the cited reasons for this practice, which gives the appearance of "wasted" land otherwise suitable for ponds, the additional open area also obviously serves as a security buffer between the tidal creeks/mangroves and the farm perimeter, a laudable characteristic in its own right given the tension that characterizes nocturnal encounters between fishermen and farm guards.

Occupation of dwarf forests by new farms. Because the best sites had long since been occupied by large ventures, the extensive removal of the lower classes of mangrove—classified as stressed and dwarf by Pannier during the aforementioned report—was expected and apparent on newer farm construction sites during the field visits. Many of these areas meet the Pannier classification of *playón* by virtue of low density (i.e., less than 40 percent cover), but others had considerably heavier densities of the dwarf and stressed varieties and were nonetheless being converted to farms (figures 4.4, 4.5). Though they are by definition mangrove forest, even the more heavily covered stands of dwarf and stressed mangrove have not been biologically active enough to manifest heavy litterfall and acid sulphate soils, which would be poor conditions for shrimp farm pond construction. Infrequent tidal flooding and high soil salinities, the root cause of the dwarf condition and low biological activity, also limit the contribution of the dwarf and stressed stands to estuarine productivity and shelter for larval aquatic organisms. Their shrubby structure furthermore limits the value of the dwarf stands as timber or as roosting sites for birds. For all the above reasons, the development of shrimp farms among the dwarf stands has been an accepted practice since the mid-1980s (Dickinson et al. 1985).

On the other hand, the regeneration time for the stressed and dwarf classes is very long; if abandoned after clearing, such areas would not be fully recovered for many years. Furthermore, there is some question at present whether some of the dwarf black mangroves may represent a separate species instead of environmentally limited representatives of *Avicennia germinans* (Cruz, pers. comm.)

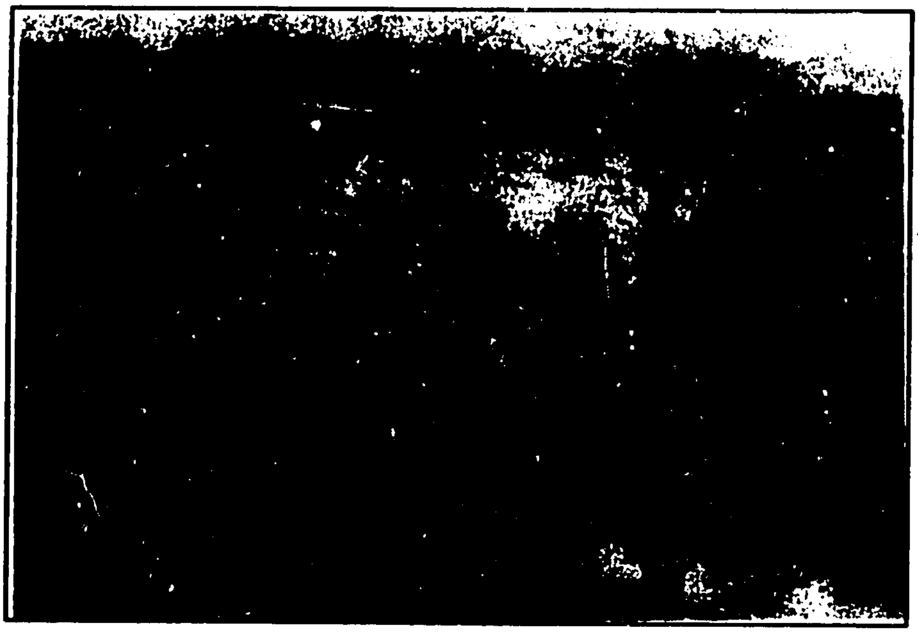


Figure 4.4a, b. Dwarf mangrove being cleared for shrimp farm construction.

The massive removal of these stands for shrimp farms will reduce local biodiversity, which argues for their strengthened protection.

Occupation of mature forest by artisanal farms. Several farms were observed under construction by artisanal operators in higher mangrove stands, examples of "loser takes the hindmost." These farms typically featured dikes that were hand-constructed from mangrove soils, cut straight through mature stands of *Avicennia*, and often located on the border of *playones* occupied by large farms (figures 4.5, 4.6).

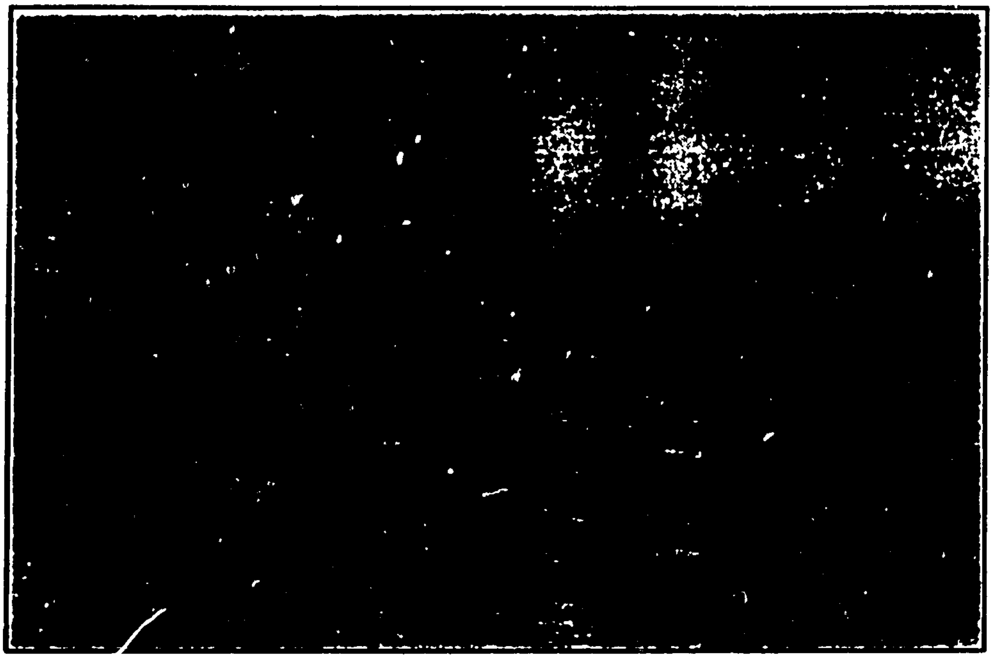


Figure 4.5. Additional dwarf mangrove being cleared for shrimp farm construction. Note that clearing stops short of taller stands.

The width and steep slope of these dikes suggest that the structures were intended to isolate the surrounded forest from tidal inundation rather than to serve as pond berms. As explained elsewhere in the document, drastic alteration of tidal regimes will kill mangroves in the affected area, facilitating burning and eventual clearing of the site. These ponds were quite small, approximately 5 to 50 ha, though their potential for negative environmental impact is quite high because of the high value of the displaced mangroves and the immediate hydrological effects of dike construction on surrounded forest.

Figure 4.6. Artisanal shrimp farm construction (left) opposite a large shrimp farm (en route to Punta Ratón).

Figure 4.7. Handmade berms constructed through stressed and mature mangroves.

Aerial survey showed some 400 ha of artisanally constructed farms (see section 4.1). Though the photographic resolution was not good enough to show berms of the type shown in figure 4.7, the tendency for artisanal operations to use less desirable land (i.e., mangrove) implies that these farms have a disproportionate effect on the estuarine forests. When pond management problems and the possibility for failure arising from mangrove soil acidity are considered in conjunction with the heavy labor of hand construction on wet soils plus the environmental damage by such construction, these small farms have a tragic aspect.

Finally, it should be noted that mangrove soils do not become acidic until they are thoroughly dried and oxidized. In Southeast Asia small, family-owned ponds are often constructed among mangroves without disturbing or drying soils, and a generous stand of mature trees is left in the pond's interior. Under this scheme (*Tumpak Sari*) the intact though highly reduced substrate does not interfere with pond water quality, the fertility of which is further enhanced by litterfall from the remaining trees. Production of tiger prawns (*Penaeus monodon*) from these ponds can be quite high, over one tonne per hectare, resulting in this system's reputation as an excellent example of sustainable aquaculture development.

Alteration of local hydrology by shrimp farm construction. Some local alteration of hydrology was noted from the ground and air during field visits. In one notable case the construction of an access road to a large shrimp farm, despite culverts placed at approximately 0.5 to 1.0 km intervals, impounded freshwater drainage from the landward side. This action in effect lowered salinity in the upland brackish water marsh and created a corresponding rise in salinity on the seaward side (8 and 42 parts per thousand respectively at the time of visit in January). Though it is difficult to estimate the extent of the original marsh, there was no freshwater vegetation in the high salinity area, in sharp contrast to the upland side of the road (figure 4.8., page 53). The altered biological function of the area was evident in the use of only the brackish side by large flocks of egrets, wading birds, and ducks at the time of visit (figure 4.9., page 54).

During the flyover, at least one large area, about 100 ha, of dead mangrove was observed on the seaward side of this site not far from the road (figure 4.10, page 54). The affected trees appeared to be of the stressed and sparse-mature categories, which once were in soils within the limit of mangrove salinity tolerance. The constraint to freshwater entrance to the area, perhaps caused by the presence of the road, likely raised soil salinities enough to cause this mortality among the mangroves.

This observed case of altered hydrology is of distinct significance not only for illustrative purposes but also because the brackish water area has provisional designation as "La Alemania" protected area under COHDEFOR's initiative for the creation of reserves from a series of seasonal lagoons. Although this was the most striking example of affected hydrology, one additional road was spotted during the 90-minute flyover (leading to the Río Nacaome area) that was unculverted and that bisected mature stands of *Avicennia*.

4.2.1.2. Postlarval fishery

Honduran mariculture is still dependent on wild postlarval shrimp fishery to meet the bulk of seedstock requirements for the target species *Penaeus vannamei*, with the remaining animals imported from hatcheries. Figures given to the team during farm visits ranged from 20 percent to 100 percent reliance on wild postlarvae, while the estimate, at the national level, commonly used by ANDAH representatives is 60 percent reliance on wild seed (Jonathan Espinosa, pers. comm.). The latter figure is supported by DIGEPESCA (1993) data from interviews of 16 shrimp farms, which indicated that 59 percent of the 6,190 ha represented in the survey were stocked with wild-caught postlarvae (table 4.3., page 52).

These figures must be combined with the aggregate consumption of seed stock for the whole country in order to contemplate the potential impact of postlarvae capture. The calculation of aggregate consumption in turn requires the assumptions summarized in table 4.4.

The calculations listed in table 4.4. indicate that, under present methods, approximately 3.3 billion postlarval shrimp are used annually for pond stocking, which is 3.3 times more than the Dickinson et al. (1988) estimates for the entire natural production from the gulf estuary (i.e., 250 million postlarvae every three months, or one billion per year, counting 50 percent mortality of capture; see 2.1.2). The 1988 figure was *highly* conjectural and based on the comparison of a relatively less productive ecosystem on the coast of Mexico to more productive mangrove estuaries of the gulf area. Given the conjectures that characterize both sets of calculations, it is not surprising that they differ by a factor of 3. The estimates calculated in the present study are conservative. For example, by increasing capture and nursery survivals to 80 and 70 percent respectively (a reasonable assumption in light of progress observed in methodology), the total number of wild seed captured to stock the 5,000 ha of semi-intensive and 4,000 ha of extensive ponds is only 1,300 and 500 million respectively, for a total of 1.8 billion annually.

Table 4.3. Summary of Gulf of Fonseca shrimp farms' wild larvae use (in percent) and labor requirements source data sent to DIGEPESCA, 1993.

Company name	Area in production (ha)	Percent wild larvae	Permanent employees
Aquacultivos del Sur	32.00	100	12
Inversiones Marinas	126.75	30	50
Aquacultivos de Honduras	602.00	80	125
Acuatec	103.10	80	22
Culcamar	362.00	50	60
Sea Farm de Honduras	300.00	80	80
Aqua Marina la Jagua	54.00	70	14
Hondufarm	200.70	70	66
Granjas Marinas S.B.	2186.85	50	350
Cadelpa	400.00	80	80
Aquacultura [illegible]nseca	435.00	80	92
Cultivos de Camarones	106.00	60	17
Crimasa	280.00	40	80
Cultivos del Mar del Sur	40.00	100	7
Cultivos Marinos	613.00	45	175
Cultivadora de Camaron	340.00	60	58

Table 4.4. Calculation of current postlarvae usage

Production scheme	Total ha	#/ha 1st crop	#/ha 2d crop	Survival: nursery	Survival: capture	Total postlarvae captured
Semi-intensive	5,000[a]	100,000[b]	50,000	60	50	2,500 million
Extensive	4,000	50,000	50,000	N.A.	50	800 million
Total per annum						3,300 million

a. The approximately 8,000 ha of ponds owned by members of ANDAH, representing the largest and most sophisticated producers, are all grouped in the category of semi-intensive. This area is reduced to 5,000 ha to represent the 60 percent of these ponds stocked with wild seed. The balance of approximately 4,000 ha is comprised of small/artisanal farms and seasonally productive salt farms, all of which are assumed to be 100 percent dependent on wild seed and extensive production methods.

b. Numbers are for *Penaeus vannamei*.

Figure 4.8. Freshwater impoundment's effect on upland side of access road to shrimp farm. Salinity difference is 34 ppt between left and right sides (night cattails).

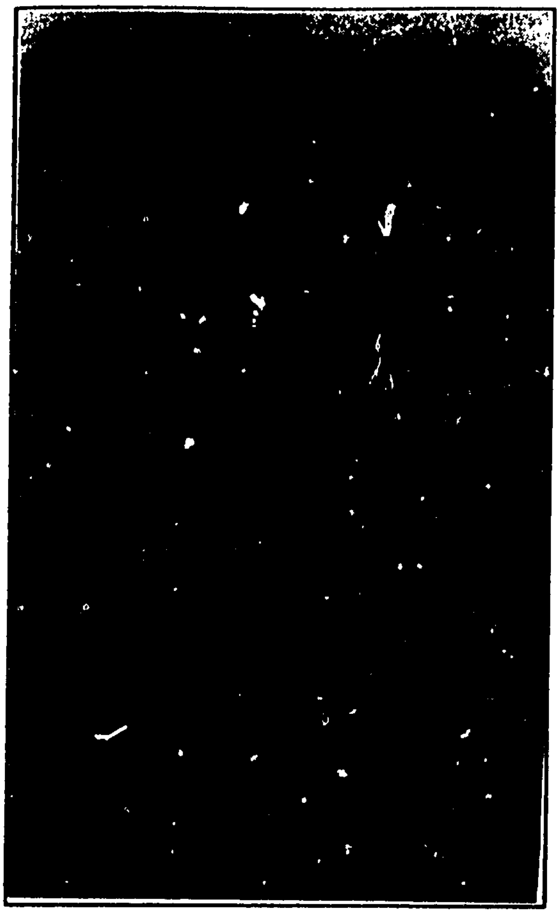


Figure 4.9. Utilization of affected marsh by birds. Lower portion of the marsh is 8 percent saline, and upper portion is 42 percent.

Figure 4.10. Dead mangrove near Estero San Bernardo.

Price is another parameter for estimating relative availability that is linked directly to demand and supply of postlarvae. In all countries with a well-developed shrimp farming sector, the cost of wild postlarvae to the farm owner is very responsive to availability and may fluctuate severalfold over 12 months. In Honduras, the price of postlarval *Penaeus vannamei* in 1988 ranged from $1.90 to $2.50 per thousand animals (Dickinson et al. 1988; Jonathan Espinosa, pers. comm.). Information from interviews conducted during the field trip in 1993 indicated, however, that the price of wild-caught *P. vannamei* ranged from only $1.40 to $2.10 per thousand animals during the previous 12-month period, an average decrease in price of 30 percent despite an estimated increase of 250 percent in the area of ponds under cultivation during this period. The decrease in price reflects increased availability to the farmers, an observation borne out by the opinions voiced by both fishermen and farmers during the field visit.

The apparent increase in availability is partly due to the estimated 600,000,000 postlarvae imported from hatcheries, though seasonal abundance may play a role as well. As this report was being prepared, the capture of wild seed was virtually suspended because of lack of demand, even though prices had declined as low as $1.40 per thousand. In any event, the current abundant supplies of postlarvae indicate that the population has not yet been damaged by the current level of fishing pressure exerted in the past several years, though longer-term effects are difficult to project. Certainly fishing pressure is still quite strong, as evidenced by the fact that Granjas Marinas San Bernardo used 31 boats in postlarval capture operations at the time of the field visit, even though their Florida-based hatchery is of sufficient capacity to assure their needs.

The impact of this pressure on the populations of other aquatic organisms is difficult to assess (figure 4.11). Using the higher estimate of postlarval usage—3.5 billion wild *P. vannamei*—and the ratios of 1:5 and 1:50 for ratios of postlarvae to by-catch (Foer 1992 and the Bay of Bengal program respectively; see 2.1.2), there is a corresponding range of 15 to 150 billion larval, postlarval, fry, and fingerling stages of organisms of other taxa lost annually from the capture of wild seed stock in Honduras. This figure is arrestingly large and very difficult to interpret for management purposes. Many of these taxa will be of the "r"-selected category and ultimately will be little affected by this shrimp harvest pressure. The higher order predator fishes may be negatively affected if in the larval stage of their developmental cycle they are at significant risk of capture.

Figure 4.11. Typical mixed catch of juvenile and postlarval shrimp, plus by-catch organisms.

4.2.1.3. Shrimp pond effluent

Local eutrophication. Several shrimp farmers, particularly those in the San Bernardo area, indicated that degraded water quality was a serious concern in the effective management of production operations. For reasons indicated in 2.1.3, the effluent from production ponds has high residence time in the narrow, poorly flushed tidal creeks of these areas and is frequently repumped by farm intakes. On one farm the organic load from shrimp pond drainage was so high, and the biochemical oxygen demand was so elevated, that dissolved oxygen content of water in the creek that supplied intake water was routinely less than 0.5 ppm (Jack Crockett, pers. comm.). By way of reference, the solubility of oxygen in water (a physical function of temperature and salinity) of the expected quality found in the upper reaches of these tidal creeks is from 6.0 to 8.0 ppm, or 90 percent greater than actually reported. Most warm-water aquatic macroorganisms will not suffer if dissolved oxygen levels routinely reach 5.0 ppm (Wheaton

1977). Lesser values result in increasing stress to the animals, becoming lethal at thresholds ranging from 1.0 to 3.0 ppm, depending on the taxon.

Mitigation and management of these conditions is not easy. Boyd and Musig (1992) provided six possible mitigation measures, some of which are already practiced on Honduran shrimp farms: (1) improve the quality of input water feeds (i.e., to improve stability in water); (2) use feeding practices that reduce the quantity of uneaten food, which in the case of shrimp means a more even distribution; (3) employ efficient aeration techniques; (4) exchange no more water than necessary; (5) do not dispose of sediment from pond bottoms in effluent canals; and (6) dry pond bottoms thoroughly between crops.

The authors further suggest that coordination between the aquaculture sector and the local government is necessary to determine upper limits and to regulate feed input by taking into account total local area of ponds under production, their arrangement in the area, local hydrology, and volumes of water pumped into the ponds. Under this scenario the quality of effluents could serve as the indicators of interest for regulatory purposes.

Other mentioned effects of shrimp pond effluent. Local groups of fishermen, when interviewed, expressed concerns regarding the effects of two common aquaculture chemicals on wild estuarine organisms, rotenone and quicklime.

Rotenone. Chemical rotenone is a fisheries management tool employed to eradicate unwanted fish from aquaculture ponds or natural bodies of water. It is the most widely and routinely used piscicide in the United States (Schnick 1974). Found naturally in the roots of a variety of wild plants (family Leguminosae) and used as a piscicide by subsistence cultures throughout the tropics, rotenone blocks oxygen absorption across gill membranes, thereby causing suffocation. By design the substance is highly degradable under natural conditions, demonstrating a half-life of active ingredient of less than 24 hours in warm water earthen ponds (Gilderhus et al. 1988).

A piscicide's utility to shrimp farming is the elimination of unwanted wild fish fry and juveniles that otherwise might compete or prey upon the culture animals. Application in effective minimum inputs is most convenient at those junctures in the production cycle when animals are concentrated, including the time of transport and acclimation of wild postlarvae and the time of transfer of juvenile shrimp to growout ponds. Application may also be made to growout ponds if significant numbers of introduced finfish appear during the production cycle. The farm managers interviewed during field visits in Honduras visits either did not admit to any use of rotenone in their operations or described its use only in acclimation and transport stages of wild-seed reception. No facility described the use of rotenone to eradicate fish from growout ponds.

The first two interventions are the most practical and economical because the postlarval or juvenile shrimp are concentrated in a comparatively small volume of water during transport. For costs reasons alone, the use of the chemical to eradicate fish from growout ponds is not practical. Though Rotenone is effective on many finfish at 1.0 ppm dosages, effective mortality among many fish, particularly nonscaly, air-breathing species, may require applications as high as 5.0 ppm. Powdered rotenone of 5 percent activity costs $2.50 to $3 per pound in Central America, so application at a 5 ppm dosage active ingredient to a half-drained (to concentrate animals), 20 ha pond would cost $55,000, a prohibitive sum. The chemical might find use in the eradication of fish from low-lying, poorly drained parts of pond bottoms between harvests, but even this relatively low-input usage would cost hundreds of dollars, and cheaper alternatives such as quicklime are available. In any event, rotenone used in poorly drained areas will not make its way into an effluent stream and the receiving watershed.

Quicklime. The widespread use of quicklime (*cal viva*) in aquacultural operations was frequently mentioned by artisanal fishermen as a source of pollution from shrimp farms and was considered harmful to the health of the aquatic ecosystem.

Lime (CaO) has many forms of beneficial application in aquacultural systems. Addition of lime to pond water will increase buffering capacity against changes in pH, and in freshwater may increase hardness in waters where there is limited natural availability of divalent cations needed for osmoregulation by culture organisms. In dilute form, lime is essentially a benign chemical to aquatic organisms, including the anhydrous form that is of concern in Honduras, and its addition to ponds containing live animals is common. In the latter operation, the lime is hydrated in a separate container to release the heat of reaction before introduction to the culture water.

According to farm managers interviewed during the field trip, the most common use of lime in Honduran aquaculture is to treat pond bottoms between crops to neutralize the acidity resulting from the buildup of organic matter during production cycles. A major secondary benefit of this practice is the temporary sterilization of the soil and residual puddles of water because of the comparatively high concentration of the caustic substance and the high release of heat during the reaction process, a method of eradicating unwanted fish much less expensive than the use of rotenone.

In summary, the routine use of lime in aquaculture operations should not pose an environmental threat to the ecosystems of the adjacent waters. If large amounts of lime are added to effluent water as it is being released, it is possible that the acute alkalinity and heat of hydration could negatively affect organisms in the immediate vicinity of the pond, though such use would have no utility to the shrimp farm. There is no residual effect of lime caused by accumulation in receiving waters because it is quickly absorbed into the natural carbonate-bicarbonate buffer system.

4.2.1.4. Displacement of seasonal lagoons

A number of farms have been built on or at the edge of what used to be seasonal or winter lagoons. In 1982 it was estimated that about 632 ha of seasonal lagoons were available to artisanal fishermen. It is apparent from current concession maps and occupied shrimp farm areas that about one third of that area will be physically lost. Access to some of the remaining areas could be curtailed by the fencing and control of access roads. The possibility exists that changes in the hydrology of the area because of further development of both shrimp farming and agriculture (pastures) will impede water flow to the winter lagoons and thus reduce their productivity.

The most violent confrontations in southern Honduras have occurred between shrimp farms and communities whose members engage in exploiting the estuaries and seasonal lagoons.

4.2.1.5. Special concerns of the shrimp farming sector

Other than rising production costs and the softness of the international shrimp markets, local entrepreneurs have raised a couple of recurring concerns. These are as follows:

The shrimp farmers are concerned about shrimp being stolen from ponds and by destruction of their property. They are troubled by the claims of local communities about boundaries and demands for routes to access estuaries and other resources. The farmers have built fences and hired armed guards to patrol their boundaries. These are expensive measures and have resulted in violence and at least one death. The shrimp farmers feel that they have to protect their substantial investment.

Farm managers are also concerned about current water quality and the effects of future development on water availability and quality. ANDAH, through the USAID-supported CRSP, has taken steps to monitor water quality by funding a comprehensive intake and effluent water quality monitoring and evaluation program for its members.

4.2.1.6. Cautionary note on the importation of foreign brood or larval stocks for hatcheries

The use of nonlocal algae, nauplii (i.e., yolk fry of shrimp), postlarvae, or broodstock can shorten the development time of a nascent penaeid hatchery sector. This is the case especially for hatcheries that are directly linked to growout ponds. In those cases, the overwhelming need for seed stock can drive all decisions regarding hatchery management.

The use of brood or seed stock from foreign sources does offer short-term advantages, but it may carry a corresponding degree of risk as well. Disease organisms affecting shrimp include viruses, fungi, bacteria, protozoans, and all other pathogens common to the animal kingdom. While diagnostic methods may be well developed for particular diseases, many shrimp pathogens (especially viruses) are still unidentified or may require elaborate procedures for detection. Quarantine methods are therefore of very limited practicality because imported nauplii or postlarvae must be stocked quickly in order to survive. By the time pathogenic diseases are detected among foreign-sourced seed, the animals have already either perished or experienced significant contact with the local ecosystem.

The disease risk to a given region posed by foreign-sourced shrimp has not been well quantified; but strong suspicions exist that the exchange of brood or seed stocks has occasionally introduced serious pathogens to wild populations of shrimp. Perhaps the best known case is the introduction of the IHHN virus to the commercially important wild populations of *Penaeus vannamei* and *P. stylirostris* in the Gulf of California via the importation of brood stock from southeast Asia (see appendix F).

It is therefore strongly recommended that the Government of Honduras assess the actual danger posed by the importation of live organisms from foreign sources until the risks and diagnostic methodologies are better understood. On anecdotal grounds, it is an article of faith that shrimp farms, and even new shrimp farm sectors, undergo a "honeymoon" period of relative freedom from serious disease problems. After several years of production, and especially under circumstances of increasing intensity of production, latent diseases may appear to the detriment of the entire sector. The Honduran shrimp farming sector is presently importing seed stock from several foreign countries, including those with history of widespread disease problems such as Ecuador. Either the government of Honduras or private growers' organizations such as ANDAH should support the development of a plan to manage the risks of importing pathogens, a plan that will incorporate state-of-the-art methodologies for controlling diseases in crustaceans.

4.3. Direct effect of other economic activities

Although the focal economic sector in the present study is shrimp aquaculture, various other activities have significant effects on the region's environment.

4.3.1. Export agriculture

The greatest threat to the gulf is contamination of the area by the misuse or indiscriminate use of pesticides. The estuarine ecosystem and the gulf, by virtue of its shallowness and low exchange rates, are susceptible to pollution.

There is little historical information and few data on the levels of contaminants in the gulf. High mortalities of finfish were reported in the 1970s as being linked to pesticide use by cotton growers (Dickinson et al. 1985). Independent studies carried out by a shrimp farm off Estero El Purgatorio found levels of lindane at 23 and aldrin at 45.8 parts per thousand. Our current analysis of water, soils, and tissue samples for the gulf area indicated the following:

(1) All 10 water samples had detectable levels of heptachlor, aldrin, lindane, endosulfan, or malathion. This indicates gross misuse of products and cause for concern because some of the levels approached the lethal concentration for aquatic environments (appendix C).

(2) Two tissue samples (clams) had accumulated detectable levels of endosulfan and aldrin (0.002 ppm)

(3) Two soils samples taken from the estuarine zone of the Choluteca and Negro rivers had detectable levels of mevinphosphate, a pesticide used in the control of insects on fields, vegetables, and fruit crops. Appendix table C-1 shows the sample locations and individual data results.

The alterations caused by agricultural activity in the neighboring regions are of the utmost importance to mangroves because they have a great ability to accumulate complex chemical molecules (Walsh 1973). Compounds derived from agricultural pesticides could persist in fluvial waters because of the relatively low biodegrading capacity of mangrove soils, which are poor in oxygen (Pannier 1979).

With increased production of export quality agricultural products and the projected increases in acreages in irrigable lands, pesticide use in the region will increase. It is essential that all pesticides, herbicides, and related chemicals be applied in a manner fully consistent with the use for which they were intended and with consideration for protecting the entire environment. That this is not presently the case in Honduras is demonstrated by recent export product rejections and by our own field observations of growers cleaning their spraying equipment in freshwater canals and rivers. Nonapproved pesticides should be taken off the shelves and the proper use of approved chemicals should be encouraged.

4.3.2. Damming of rivers and waterways

The damming of important waterways will have a negative impact on the Gulf of Fonseca. Impacts will include higher salinities, lower productivity in estuaries and mangrove areas, and increases in pesticide loads from increased agricultural production.

Below are summaries of observations included in Enrique Ramirez' environmental data analysis and impact review of the Choluteca Dam project. Ramirez was a consulting biologist on the 1992 environmental assessment team for the dam construction. His comments were submitted to Nippon Koei, Ltd., for use in their final environmental assessment plan and again submitted to the Environmental Study Team for use in the present report.

- A flood control dike planned for the agricultural area may alter the hydrology of the Choluteca River, possibly leading to flooding in the lower reaches of Estero El Purgatorio.
- Salt flats will accumulate higher loads of pesticides than at present during their seasonal flooding.
- Estuarine and marine organisms occupying higher trophic levels will be affected by the biomagnification of pesticides.
- The increased herbicide and pesticide load from the drainage area will negatively affect mangroves, which are a class of vegetation both sensitive to defoliants and herbicides and predisposed to accumulate pesticides and heavy metals in tissues.

- The increased presence of pesticides and herbicides will have a detrimental effect on the survival, disease resistance, growth rate, and abundance of fish, mollusks, and both wild and cultured postlarval shrimp, affecting aquaculture and artisanal fisheries.
- Wildlife, especially higher order birds, mammals, and reptiles, will suffer negative long-term effects because of bioaccumulation of pesticide residues through the ingestion of aquatic feeds.

Osmond Barnaby, consultant to J.D. Associates, added observations on the flooding of the lower Choluteca and El Purgatorio estuaries. He commented that since the flood control dike only protects the lower limit of the agricultural area, the saline lands further seaward of the dike will be flood prone. In 1986, when the initial project design was developed, there were no shrimp farms in the affected area and the flood risk was not considered an issue. In 1993 there are shrimp farms in the affected area. Barnaby's comments on salinity increases caused by the project are summarized in table 4.5.

Table 4.5. Salinity increases

Month	Salinity average at Pedregal in parts per thousand	Estimated eventual flow reduction from historical levels in La Jagua estuary in percent
March	37	54[a]
July	18	19
November	9	42
December	18	69

a. If a 54 percent reduction in freshwater flow to Pedregal occurs in March as predicted, salinities could range between 37 to 80 parts per thousand, producing deleterious effects on virtually all aquatic organisms.

It is obvious that negative impact mitigation measures still need to be addressed with regard to the Choluteca project. The project promises added economic benefits for strategically placed private and governmental parties and special interest groups, but it threatens a thriving shrimp farming industry, the fragile gulf ecosystem, and all the people who depend on that system's productivity for survival. The real trade-offs between these potential winners and losers need to be impartially evaluated.

4.3.3. Salt producers

The impact of salt producers on the ecology of the gulf and mostly of the Mangrove areas is twofold. First, since 1973 an estimated 630 ha of mangrove have been cut to make a place for the construction of salt operations. This is equivalent to 47.5 percent of the 1,325 ha of salt ponds currently in operation. Second, and of much greater importance, is the amount of mangrove wood that has been destroyed to be used as fuel for the production of salt. Prior to conversion to solar energy, and as late as 1984, the average yearly use of mangrove wood for salt production was estimated at around 89,000 m^3 (Flores and Reiche 1990).

4.3.4. Tank farms and related port activities

The fuel tank storage farm that has been built near the port of San Lorenzo, like all such storage facilities, is an accident waiting to happen. A cursory review of the facility indicates that all the proper containment measures have been used. Nevertheless, spills occur and will continue to occur as long as tanker vessels are loaded and unloaded. Since the products to be handled are refined, their effects on the ecosystem, in the event of a spill, will be minimal. The soft bottom of the gulf almost negates the possibility of a spill even if a small tanker was to run aground in the approach channel.

The dredging activity required to keep the port's approach canal at maximum depth has somewhat altered the hydrology of the immediate area. No major impacts, other than stress, directly attributable to this activity were observed on the adjacent mangrove ecosystem. Impacts due to oily residues and waste water dumping from activities related to the port were observed in the immediately adjacent areas, especially at low tide.

4.3.5. Fisheries

Honduras shares access to the Gulf of Fonseca with Nicaragua and El Salvador. The Honduran territorial waters within that zone cover an area about 163 km long and 40 km wide (Mirna Marin, 1992).

There is no industrial exploitation of the Gulf of Fonseca fisheries resources. Fishing in the gulf is conducted by an artisanal fleet and to a lesser but unquantifiable extent by a multitude of subsistence fishermen and gatherers. The artisanal fishermen target shrimp, finfish, mollusks, and, to a lesser extent, crabs and lobster. Accurate statistical information on capture by species and size class is not available. The catches are mostly reported by classes and value and are of little use for management or conservation purposes. Ongoing investigation of landings by species and size for selected fishermen are currently being undertaken. If carried out over a few years, those studies would yield usable information (Gustavo Cruz, Universidad Autónoma de Honduras, pers. comm.).

According to the 1990 DIGEPESCA census, an estimated 2,875 artisanal fishermen and some 15,250 people are somewhat involved with the gulf's fisheries.

Reliable data with respect to the landing statistics and effort in the gulf are nonexistent. Data collected by DIGEPESCA are underestimated inasmuch as they only take into consideration information collected in certain areas. Little information is available with respect to the catches of the subsistence fisheries. Landings by year for the period 1988 to 1991 are given in table 4.6. The landings prior to 1988 are reported as global landings for both coasts and are of little value. The trend in the 1979 to 1987 landings is as follows: a rise in yearly landings peaking in 1984 at 1,877 tons for all species and dropping to about 794 tons in 1987. DIGEPESCA estimates that about 48 percent of the artisanal vessels operate in the gulf area giving landing estimates for the region at about 317.6 tons for 1987.

Table 4.6. Landings from Gulf of Fonseca artisanal fishery[a]

	Landings by year (in tons)			
Description	1988	1989	1990	1991
Shrimp	33.7	67.6	42.2	340.2
Titi shrimp	1.7	1.6		
Lobster			1.1	2.4
Crabs	2.8	20.8	7.7	7.2
Curiles	95.3	306.7	5.6	2.0
Clams	2.5	2.4	6.2	2.9
Turtle eggs	2.1	25.6	3.6	3.9
Finfish	193.9	165.2	385.8	278.9
Total	332.0	589.9	452.2	637.5

[a] Source: DIGEPESCA.

Although the total landing statistics appear to indicate a stable fishery, one needs to consider that the level of effort has increased and that changes in fishing gear have occurred.

The effort level has gone up in two major ways: (1) the average licensed fisherman will spend more time fishing, and (2) with the official reduction in sale of fishing licenses, only the most efficient vessels and fishermen continue to operate in a legal manner. Therefore the average efficiency of the fishing vessels in the licensed fleet has increased.

Major changes in the gear used have taken place since 1988 or perhaps 1986. The use of *trasmayos* has increased. These nets are not only very efficient but are nonselective. Unless mesh size, net length, and area of permitted use are strictly regulated, the use of these nets can lead to the rapid depletion of certain species through overharvesting and the harvesting of individual year classes prior to maturity.

Therefore the catch per unit effort (CPUE) has in reality dropped. From our interviews with fishermen, it is also apparent that the size of individual fish has also followed a downward trend. Both the drop in catch per unit effort and in size of the fish taken indicate overexploitation of the resource. It is unfortunate that information that would permit calculating accurate catch per unit effort and individual fish size and year classified by species is lacking.

The underlying conclusion is that the resources are being depleted. This is very apparent in the landing statistics for crabs, snails, and clams. Overexploitation of clams, snails, and oysters in the gulf has reached a critical stage at which certain species are in need of protection (Marin 1993).

Studies carried out by DIGEPESCA in 1987 indicated that the majority of the landings for crabs and curiles (a molluscan species) were made up of individuals below the minimum recommended size. This directly indicates not only overexploitation but also the problem that a higher than sustainable number of individuals are removed from the breeding population prior to reaching sexual maturity. The drop in landing of titi shrimp, a species that was usually captured in winter lagoons, also points to the loss of access to traditional fishing grounds. The fact that these off-size or short landings occur routinely indicates the lack of enforcement capability and the serious need for alternative employment for the artisanal fishermen in that zone.

With the resolution in political conflicts in both Nicaragua and El Salvador, it is probable that fishing efforts in the gulf will increase in the coming years to the added detriment of currently overexploited populations. Serious consideration must be given to the rational management of the resources.

Management of the Gulf of Fonseca will only be biologically and economically viable if it is undertaken as a three-country endeavor. Meanwhile, serious consideration for resolving the artisanal fishermen's plight in the Gulf of Fonseca must be undertaken. Plausible solutions and alternatives are advanced as follows:

(1) Fleet size and gear restrictions based on developing maximum sustainable yields for selected high-value species must be put in place. Fines and loss of gear should be strictly enough enforced to warrant the fishermen's compliance.

(2) Area and seasonal closures must be put in place for all overexploited species as well as for shrimp postlarvae.

(3) Temporary allocation of exploitation rights for selected species or areas could be given exclusively to artisanal fishermen's cooperatives. This would stimulate the formation of cooperatives, assist in the delineation of fishing areas for each co-operative, and increase management and enforcement capabilities within a selected area. For example, if a cooperative were given the exclusive right to exploit clams within a selected and well-defined area (a particular mud flat), the fishermen could be induced, with minimal governmental assistance, to manage the

area as a private resource and maintain the reproductive capacity of the clam populations.

(4) Raft aquaculture for oysters and mud flat culture for clams could be developed at a low cost and be initially limited to cooperatives in certain zones, generating not only hard currency but employment.

(5) The installation of small government-sponsored purification plants could assist the local industry in developing export markets for selected bivalves. If price increases can be achieved, it will be easier to put management restrictions in place.

(6) Alternative fishing methods such as crab pots and lobster traps can be introduced. The initial costs of materials and training in using them should be absorbed by governmental or development agencies. Regulations on their use and the level of allowable efforts can be determined by DIGEPESCA.

(7) Improvements in product handling and distribution methodologies through the formation of adequate centers for collection and sale would stimulate price increases by improving the product and signaling its better quality. Part of the funding for construction and operation of the centers could come from a portion of the revenues already collected by the government on shrimp exports.

(8) In the field, training sessions on use of selected gear and equipment as well as basic resource management should be held regularly.

4.4. Protected areas

The establishment of protected areas for the Gulf of Fonseca needs to be re-evaluated in light of two important factors: (1) biodiversity needs to be maintained for the overall health and productivity of the system; and (2) natural resources in the gulf area need to be managed as renewable resources, particularly because of the historical exploitation of those resources and the industries now thriving there.

These natural resources have a real economic potential and will continue to do so if they are regulated under a multiple-use, maximum-sustainable-yield management program. This means an evolution of the current development process toward a more equitable and manageable system, which should include the following components:

(1) Fishing and postlarvae capture management areas with closed seasons, gear restriction, and limited entry management.

(2) Protected areas (Type A) where no harvesting is allowed. These areas are to remain as corridors or repopulation areas for the gulf. The dry tropical forest areas would fall in this category as would selected mangrove areas. The proposed reserve mapped by Granjas Marinas, on their own concession, should fall within this category, as should the cooperative area near Aquacultura Fonseca.

(3) Protected areas (type B) where only certain activities are allowed. For instance in selected winter lagoons only certain types of artisanal fishing would be allowed during a preprescribed period as predicated by the Ministry of Natural Resources

> **or DIGEPESCA. Hunting leases could be allocated in specially managed wetlands for migratory waterfowl (see appendix D, maps 1–6).**

The areas indicated in the maps of appendix D are by no means the only zones that should be afforded protection. The foresight demonstrated by COHDEFOR in trying to protect and manage the mangrove forest should be reinforced by more restrictive laws, stiffer penalties, and better enforcement capacity. The gulf's natural resources belong to all Hondurans, and the viability of the gulf ecosystem depends on the rational use and management of these resources. Proposed or suggested protected areas where concessions have been granted but where no economically viable operation has been built should be reevaluated in light of current management needs. Concessions that have not been developed within the originally agreed upon time should be replaced in the government trust.

4.5. Socioeconomic trends

4.5.1. Analysis and description of region's population directly involved in shrimp farming

Views differ widely on the socioeconomic effects of the growth of the shrimp industry on the region surrounding the Gulf of Fonseca. In this section, we will present the broad claims made by various interest groups in the region, then attempt to look further at the claims by focussing on different stakeholders in the region.

At a general level, the managers and developers of large shrimp farms, through ANDAH, note the substantial employment benefits of the approximately 8,000 ha now in shrimp farms. ANDAH estimates that 25,000 people are directly employed in the shrimp industry. Estimating that there are approximately six people per local family, they estimate that the livelihoods of 150,000 people depend on the shrimp farms and packing plants. If these figures were accurate, then 36.1 percent of the 415,449 people in Choluteca and Valle departments (1988 census) would be dependent on the shrimp farms. ANDAH and shrimp farm managers also claim that wages in the region have increased because of the increased competition for labor. They report that it is almost impossible, for example, to find domestic servants in Choluteca and San Lorenzo because so many women are employed in the shrimp industry.

The claims of ANDAH have received wide currency in the region. Municipal officials, business leaders, and even resource-poor people talk about how much the shrimp industry has injected dynamism into a dying zone. One business leader said that before the shrimp farms began, the southern region was desolate (*soledad*). Other people used words like "sad," "remote," and "poverty-stricken." Recognizing the extent of out-migration from the zone, business and political leaders have mounted a public relations campaign to reflect the new vitality of the south. Their theme is *"Volvamos al Sur"* (Let's Return to the South). It is reported that business activity has increased substantially in the region and that there are many economic multiplier effects from the shrimp farm activities.

CODDEFFAGOLF is the strongest organization that has been disputing the claims of ANDAH and the shrimp farmers. CODDEFFAGOLF emphasizes that it is an ecological organization, but its leaders and members cannot help commenting on some of the social and economic issues. They note that the estimate of 25,000 employees is vastly inflated. They also emphasize that most of this employment is temporary, that workers do not have benefits or job security, and that the shrimp industry will not allow for the formation of unions. They scoff at the claims of higher wages in the zone, noting that the shrimp farms and packing plants pay only minimum wage or pay workers on a piecework basis.

Fishermen in CODDEFFAGOLF complain that their livelihoods are threatened by the disappearance of fish and shrimp from the waters of the gulf and its estuaries. They attribute this to the unnecessary killing of larvae that occurs when wild shrimp larvae are gathered to stock the ponds.

These two positions represent the most global claims and counterclaims concerning the effects of the shrimp industry. Our analysis tried to sort out some of the claims and counterclaims by examining different groups whose livelihoods depend on the natural resources of the Gulf of Fonseca. Disaggregating the costs and benefits in this way allows for a clearer view of the most significant conflicts over resources and the potential for mitigation of these conflicts.

Shrimp farms. Shrimp farms have had varying degrees of success and failure in the region. The USAID Export Development and Services (EDS) project was supposed to work with small- , medium- , and large-scale shrimp operations. Small-scale shrimp farming was also a goal of the USAID Rural Technologies Project. This latter project worked with operations that used the same ponds to produce salt during the dry season and shrimp during the rainy season.

Recent reports conclude that only the larger, more intensive operations are profitable (FPX 1989b) and USAID work with smaller operations has essentially ceased. There are still quite a number of small shrimp producers (in the region of La Brea, for example, there are seven producers) and many more people who are interested in producing shrimp.

One producer with 8 ha of ponds near La Brea reported that he had received technical assistance and loans from USAID Rural Technologies Project. Although he repaid the loans, he was denied further credit for what he perceived as "political reasons." The dikes around his pond are all constructed by hand; to kill juvenile fish in his ponds, he uses a poison from a native tree called *carambolillo*. In 1992 he harvested shrimp twice and obtained a yield of about 300 pounds per ha.

Typical of the experience of those who see shrimp farming as a potentially profitable business is that of a cooperative of fishermen near Cedeño. They received a small amount of credit (from an Inter-American Foundation project run through CODDEFFAGOLF) to start a salt-making and shrimp-farming operation. They reported that because the loans were not sufficient to actually begin production, the ponds sit empty. Another such example is that of an agrarian reform cooperative. They have an area appropriate for shrimp farming but have been unable to get credit to develop it. They are now exploring the possibility of selling the area to a large, private company. The members of the cooperative are afraid that, because they are unable to utilize the area, the government will grant a private company a concession to the land. The government has not been sympathetic to the needs of small farmers and the vast majority of concessions are given to large companies or to individuals who have political influence.

Even some larger companies have not done well with shrimp farms. The technical requirements and large initial capital costs have produced financial difficulties for some companies. Transfers of ownership are not uncommon. Although concessions are not supposed to be transferred, companies will purchase the shares of another company or enter into joint operations, thus effectively gaining control of the concession and the improvements made to it. The potentially large profits to be made from shrimp farming has made land speculation common. Many people cited the example of a politically powerful individual who obtained several concessions, cleared parts of them (including destroying areas of mangrove), and then sold the rights to other companies. Allegedly, this person never had the intention of shrimp farming but made large sums of money through land speculation. Other examples of land speculators abound.

Because the concession boundaries are not well delineated, companies often come into conflict with one another and with communities about ownership. Several managers of shrimp farms complained about the legal fees made necessary because of these cases of contested ownership. Courts and the government have been of little help in resolving these disputes, so increasingly the companies are attempting to settle conflicts through compromise, negotiation, and payoffs.

In summary, in terms of the economic costs and benefits for the shrimp industry, we can conclude that:

(1) Profits are being made in the shrimp industry. The profits are generally confined to the larger companies, especially those that have sufficient capital.

(2) Although there is substantial interest in shrimp farming among small producers and cooperatives, the lack of technical or financial assistance from the government or aid agencies makes their possibilities of success marginal or impossible.

(3) The negligible costs, and the political and economic connections that are necessary in obtaining concessions, have made land speculation profitable and common.

(4) Disputes over the vague boundaries of concessions are costly, time-consuming, and becoming potentially violent.

Employees. Previous research has indicated that approximately 70 percent of employment in the shrimp industry is of temporary workers (SECPLAN/DESFIL 1989:179). Of the temporary workers who work in the processing plants, approximately 95 percent are women. Primarily young and single, most are employed deheading, classifying, and packing.[7] One community reported that women were also occasionally hired to get rid of fish in the ponds. A line of women wade chest deep through the pond, chasing the fish into gill nets strung across one end of the pond. Because women work in unskilled jobs, their lack of education (few have gone beyond the sixth grade) does not affect their employability.

Temporary workers are not hired directly by the companies. Instead, to get around what the companies consider restrictive labor laws in Honduras, contractors are used to recruit the women. Women sign 90-day contracts, then are not allowed to work for a few days before beginning another contract. Thus they are kept in a permanent status of temporary worker. Some workers are paid on a piece rate according to the number of pounds of shrimp processed. Other companies pay wages of 17.50 lempiras per day, the minimum wage specified by Honduran law. Women reported that, if they fulfilled their contracts, they were paid a bonus at the end of each 90 days. Wages are thus about $90 to $100 per month. Because the women are temporary employees, no fringe benefits are included in their working agreements.

The normal work schedule is 8 hours a day Monday through Friday and 4 hours on Saturday. If they work more than 8 hours a day, they are paid overtime. Women in one community reported that they were picked up by company trucks at 4 a.m. and returned home at 4 p.m. In some companies, women work during the night rather than during the day. Because not all of the shrimp companies have a sufficient number of ponds to have continual harvests, or to harvest all year round, there may be weeks or months during which the women have no work.

Working conditions appear to be safe. Women wear rubber boots and uniforms that consist of a shift, hat, and mask. They are given rubber gloves, but most are not worn because the women say they affect their dexterity and slow them down. Women complain about the effects of the chlorine and cold on their hands. One of the main factors making some companies more attractive employers than others has to do with the transportation. All of the women are picked up and dropped off near their communities. Some companies use large, open trucks in which the women are exposed to dust and the elements. Women prefer to work for companies that transport them in old school buses.

Women seemed to be generally unanimous in expressing that the shrimp farms had brought positive benefits for them. They have few alternatives for employment. Most indicated that they would have nowhere to work if it were not for the shrimp processing plants. Otherwise, the primary employment for some of them in the communities is a few months' work in the cantaloupe

[7] A small percentage of the shrimp is now being shelled. One shrimp farm manager indicated that he thought an increasing percentage of shrimp will eventually be sold already shelled. Some markets in Europe exist for shrimp with heads on. Thus, the industry is diversifying the ways it packs shrimp.

harvest or in the cantaloupe packing houses. Their other option is to migrate to the cities to work as domestics.

Few women were able to articulate how wages from the shrimp farms had improved their lives. Most indicated that their wages went mainly to purchase food for their family. We did not see substantial improvements to, or substantially more possessions in, the houses of women who were working in the shrimp industry.

Men are also employed as temporary workers. The main jobs they do are harvesting the shrimp, transporting shrimp and ice, cleaning out the ponds, feeding the shrimp, and gathering wild shrimp larvae. These men also work through contractors, and their wages are similar to those earned by women. One difference among companies relates to the larvae gatherers (*larveros*). Some work on their own, with their own boats and other equipment. They are paid on the basis of the number of larvas they catch. Other companies own own boats and equipment, which they lend to teams to gather larvae. The costs of gasoline, ice, and other supplies are deducted from the amount paid for larvae collected.

Approximately 30 percent of people are permanent employees. They have acquired better training and are employed as the administrative and technical personnel. Approximately 95 percent of them are male. Only the office secretaries and a few packing plant supervisors are women. Managers report that many of the carpenters, electricians, masons, and other people with skills had previously emigrated from the area. With work opportunities on the farms, they have returned to the south.

The technicians are a multinational group. Many of them come from other Latin American countries that have an already established shrimp farm industry—Panama, Costa Rica, and Ecuador. Because some of the capital invested is from the United States, many U.S. citizens are employed in top positions.

These workers have substantially more rights under Honduran labor laws, including being paid an extra month's wages at the end of each year and receiving generous severance pay when they leave their job. Indeed, one of the concerns expressed by some shrimp farm managers is that, whenever an individual has a large economic necessity, they quit their job to obtain severance pay.

Shrimp farm managers express substantial paranoia about unions. They report that all enterprises in Honduras with unions are constantly racked by conflict and problems. Their alternative to unions are solidarity groups (*solidarios*). These groups are much like credit unions. They have funds to make loans to members and stores that sell food staples and consumer goods at favorable prices. Each member can contribute to a housing fund to which the company also contributes, and they have life insurance protection and other fringe benefits. Although some of the companies maintain that they are thinking of extending some of these benefits to their unskilled workers, none have yet done so.

In summary, in terms of economic costs and benefits for employees, we can conclude that:

(1) **Shrimp farms have provided employment opportunities, albeit low-paid and without fringe benefits, for substantial numbers of women.**

(2) **Although a more intensive socioeconomic study would be required to determine how women's wages have affected family incomes and welfare, their incomes have not led to substantially better housing or more material goods.**

(3) **Shrimp farms have added to the number of job alternatives for unskilled men.**

(4) Permanent employees, organized into solidarity groups, have good wages and benefits and have benefited most from the expansion of employment in the shrimp industry.

(5) Honduran labor legislation has led shrimp farms and processors to use independent contractors to circumvent laws.

(6) Workers are unable to organize unions for their own protection because of the strongly antiunion attitudes of the shrimp farms and processors. Shrimp farms and processors use independent contractors, who take advantage of the excess labor supply in the region to provide most of the unskilled workers.

Estuary and lagoon fishermen. Three fishermen have already been killed and, in at least one case, it is apparent that a guard or guards from one of the large shrimp farms is responsible (CODDEFFAGOLF 1991:2). Many other fishermen have reported being harassed or threatened by shrimp farm guards. As a consequence, they can no longer use estuaries near the shrimp farms for gathering shellfish or for fishing.

Shrimp farms claim that they have experienced substantial thefts from their ponds and are spending substantial sums on fences and security guards. Fishermen are being deprived of the rights to use resources and to cross areas to which they once had open access. Some of the shrimp farms have expanded into the seasonal lagoons, and their construction has resulted in an alteration of the hydrology of the region. Several of the seasonal lagoons are now smaller than in the past and have seen a reduction in the number of shrimp and juvenile fish that are found in them.

Estuary and lagoon fishermen also report that their catches have diminished substantially in recent years because of the destruction of larvae by larva gatherers. It is a common practice, among some unknowledgeable larvae collectors, to throw all but shrimp larvae into the mud to die. The perception is that this has caused a large decrease in the number of fish and shrimp. Some communities have put up signs prohibiting larvae collecting and threatened the larvae collectors with violence if they come into waters near the village. They are doing this to try to protect what they see as their livelihood. At the same time, fishing equipment has become more efficient and the number of people fishing has increased. Therefore it is not clear to what extent the drop in catch is related to exploitation of larva or to fishing pressures.

It is also important to emphasize that many the persons who are employed as larvae collectors are also fishermen. This is especially true in the areas with the greatest concentrations of shrimp farms. Thus, while some members of the community decry the strategies of the shrimp farms, other people are earning money by engaging in larva collecting.

It is apparent, however, that estuary and lagoon fishermen have borne a heavy cost because of the expansion of the shrimp farms. Some of them now have to travel circuitous routes to get to locations to launch their boats. They now have to avoid estuaries near shrimp farms because of the risk of being shot. Areas they once used for fishing, hunting, or gathering firewood are now behind the fences of the shrimp farms.

In summary, we can conclude that (1) a cost of the development of shrimp farms is that estuary and lagoon fishermen have seen a reduction in the area they can use; and (2) another cost is that, probably because of changes in hydrology, seasonal lagoons provide fewer fish and shrimp resources than they did in the past.

Gulf fishermen. The fishermen who work in the open gulf also report that their catches have diminished substantially. These claims are also difficult to validate. Fishing equipment has changed substantially during the last 15 years. Trammel nets are much more efficient at catching fish and shrimp, and fiberglass boats with more powerful motors are also being used. At the same time there has been a large increase in the number of fishermen. It is now estimated that there are 7,000 fishermen along the south coast.

Another complaint of the gulf fishermen, articulated through officers of their association, Asociación de Pescadores Artesanales del Golfo, is that they have not been employed by the shrimp farms. They say that they have always been able to earn much more money (40 to 60 lempiras a day) by fishing and are unwilling to work for the "slave wages" paid by the shrimp farms. With declining catches in the gulf, more of them seem interested in working on shrimp farms, but they expect higher wage rates. They report that people from the hills who are willing to work for such low wages and they they drive down the wage rates for everyone.

In summary, it is the *perception* of gulf fishermen that the shrimp farms have been responsible for a decline in fishing and consequently in their economic revenues.

Other agroindustries. It is commonly asserted by ANDAH and shrimp farm managers that wage rates have been driven up in the region. Melon producers, people in the cattle raising and meat packing industries, managers of the sugar mill, salt producers, and other agroindustries in the south reported that labor was still abundant. None reported that they had been forced to raise salary rates in order to attract workers. Small agricultural operations report that they are still able to attract occasional day workers for 10 to 12 lempiras for a 6-hour day.

The major effect of the jobs and wage rates of the shrimp farms is probably on the agrarian reform cooperatives in the region. These cooperatives were mainly formed during the 1970s but have always lacked the capital, organization, and markets to privide their members with a decent and secure income. Consequently, many of the original members of the cooperatives have dropped out in order to migrate or to work as wage laborers. Several cooperatives visited had fewer than half their original members. The shrimp farms have accelerated the disintegration of the agrarian reform cooperatives. When they can obtain credit to plant, the cooperatives pay their members 10 lempiras a day to work. Because the shrimp farms pay more and provide steadier work, cooperative leaders reported that many members had decided to give up their land rights to work on the shrimp farms.

The claim that female domestic servants were difficult to find in Choluteca could not be verified. This was asserted frequently by people involved in shrimp farming. In the absence of other information, we conclude that (1) the shrimp industry has not affected wage rates or labor availability for other agroindustries in the region, and (2) a major effect of the employment and wage rates on shrimp farms has been to accelerate the dissolution of agrarian reform cooperatives.

Rural communities. Communities along the coast of southern Honduras are poor and relatively lacking in infrastructure. Although all of the communities visited have schools that offer the basic six primary grades (see table 4.7), most do so in only two or three classrooms. Electricity has reached some communities but not others. A network of medical centers has been established so that most villages are relatively close to a community that has such a facility.

Table 4.7. Communities visited and availability of basic facilities.

Community	Schools	Electricity	Potable Water	Medical Center
Los Prados	6th grade	Yes	No, Pump broken, purchase well water	Yes
La Cuchilla	6th grade	No	No	Los Prados (6 km)
Valle Nuevo	Nearby community; 6th grade	Being installed	No	Nearby community
Agua Fria	6th grade	Yes	Yes	Nearby community
La Brea	Nearby community, 6th grade	Yes	No	Nearby community
Cedeño	6th grade	Yes	Yes	Yes
El Tulito	6th grade	Yes	No, salty water	Nearby community
Santa Erlinda	Nearby community, 6th grade	No	Good wells	Nearby community

The biggest problem among the communities is access to water. Several of the communities use wells that dry up during the dry season. By January, for example, people in La Brea are already hiking several kilometers to Agua Fria to get water for their domestic needs. By February or

March, as wells dry up in Los Prados, people are forced to purchase water from a neighbor who has a deep, more reliable well. In some communities like El Tulito and La Isla del Mango, wells that previously provided good drinking water are now becoming salinized and are not usable. Speculation about the causes of this focuses on the destruction of mangrove and the effects of shrimp farm construction.

The other basic need that is difficult to secure is cooking fuel. While an occasional vehicle hauling wood is encountered on the roads in the rural areas of the south, it is much more common to see people with using goat carts to haul wood or carrying wood on their backs. People in a number of communities complained that, since the construction of the farms, they have lost access to nearby supplies of cooking fuel. The distance they have to travel to get wood has increased and, as a consequence, for those who purchase wood the price has increased. In at least one case, it was reported that wood had increased in price from 10 lempiras a cart load to 40 lempiras a cart load.[9]

Several community officials commented that they have asked the shrimp farms to assist them in acquiring some of the community's needs. The attitude seems to be that the shrimp farms "owe" the communities something. In some cases, the shrimp farms have responded positively. In Los Prados, for example, Acuicultura Fonseca built several new classrooms for the school. In La Cuchilla, Granjas Marinas has sponsored community sports teams, transported construction materials from Tegucigalpa, and given other kinds of assistance. Access roads constructed or improved by shrimp farms have benefited other villages. In several communities, the shrimp farms assisted in the construction of latrines, a project that took on special urgency when cholera was discovered in the area. In other communities, however, people are quite bitter because the shrimp farms have not undertaken any such development activities.

Much employment has been created in communities located near the shrimp farms. Authorities in several villages mentioned that many former migrants were returning because of increased employment opportunities. Combined with the increasing population, this resulted in a boom in construction with many new houses being built. This demand for new housing is also causing social conflict because there is a scarcity of land on which to build. In El Tulito, some poor families have constructed dwellings on the road right-of-way. In another case, a family is squatting on property that the community had allocated for a health center. In Cedeño, a whole squatter settlement has been established on the lands of an agrarian reform cooperative. The land was invaded after the cooperative sold some of the land for a shrimp larvae hatchery. The town government tried to purchase part of the land for building sites but could not raise sufficient funds. It encouraged the land invasion after negotiations broke down.

The shrimp farms themselves are affected by the lack of infrastructure in the region. The lack of electricity is a major limitation, making it necessary for shrimp farms to have their own gene-

[9] Flores and Reiche report that a goat cart of wood contains about .4 cubic meters of wood

rators. In at least one case, one of the farms is constructing a substation that it will turn over to the government-run electric utility. Some communities without electricity are hoping to benefit from the pressures for electricity brought by the companies.

In summary, (1) a few communities have benefited in improving their basic infrastructure from the assistance of shrimp companies; (2) for some communities, a major cost of shrimp farm development has been to make access to wood supplies more difficult and/or more expensive; (3) in a few communities, water supplies have become salinized, perhaps because of salt water intrusion from shrimp farm construction; and (4) returned out-migrants and the increasing population have created a construction boom in several villages, though the lack of house sites is causing conflicts over land.

Urban communities. The urban communities of the south coast, especially Choluteca and San Lorenzo, have benefited from the development of the shrimp farms and increased melon production. Most of the offices of the shrimp companies, and several of the shrimp packing plants, are located on the outskirts of Choluteca. The largest packing plant and some offices are located in San Lorenzo. Some melon packing plants are located in rural communities while others are located on the fringes of the larger urban areas.

The Chamber of Commerce for Choluteca and Valle reports that the spin-off benefits of the increased construction and employment have been substantial. The Chamber's executive director says that the municipal authorities report 3,000 new businesses being created in Choluteca since 1990 alone. In San Lorenzo, more precise data on new business creation was provided by the municipal authorities. Since 1986, 407 new businesses were registered. Much of this new business activity occurred between 1988 and 1990. These new businesses are reflective of the increased commercial activity in the zone, much of it due to the dynamism created by the expansion of shrimp farming.

Another indicator of business expansion in the zone is that the infrastructure of the region is being improved. The Panamerican Highway is being upgraded. With relative peace in Central America and new attempts at regional integration, much more traffic is expected from Nicaragua and El Salvador along this artery. Two industrial parks are in being created and the small regional airport will soon be paved and improved, in part because the airport is now receiving direct flights of shrimp postlarvae from Miami.

The Chamber of Commerce itself was relatively moribund until recently. With business expansion and greater prosperity, the business community has been more willing to provide support. As a result, the Chamber has become very active, sponsoring an annual fair, promoting the zone through publicity campaigns, and lobbying the national government to create industrial parks in Choluteca and Valle.

The return of out-migrants and the increased number of jobs in Choluteca and San Lorenzo in the shrimp packing plants is likely to have increased the size of those cities. Business and political leaders in those cities agreed that this was the case. The 1988 census indicated that both Choluteca and San Lorenzo were growing much faster than the rural areas of those departments and much faster than other *cabaceras* (county seats) of municipalities along the coast (see table 4.8). This was especially true of Choluteca, which increased over 50 percent in population since the 1974 census.

In summary, (1) the urban centers of San Lorenzo and Choluteca have seen substantial business expansion, in part due to the increased economic activity created by the shrimp industry; (2) the much greater vitality in the economy of the region is reflected in new investments in infrastructure such as industrial parks and improving the airport and highways; (3) the cities in which shrimp processing is concentrated have experienced rapid increases in population.

4.5.2. Description of attitudes of various stakeholders

Appendix B organizes in a matrix the real and potential conflicts that exist among the different stakeholders in the region surrounding the Gulf of Fonseca. The major groups that are affected or that could potentially be affected by the environmental and social processes in the region are listed. The major issues or conflicts that link them with other stakeholder are found at the intersection of the rows and columns. In all cases, the claims or complaints are made by the groups listed across the top of the chart. Those against whom the complaints are lodged are found on the side of the chart.

It is important to emphasize that these groups are not mutually exclusive. That is, some of the same individuals may be involved both as commercial farmers, salt producers, and investors in one of the shrimp farms. In the same way, woodcutters may be landless individuals and are clearly members of communities in the zone. It is important, however, to analyze the conflicts and issues in terms of group interests even though some individuals may belong to more than one group.

For purposes of this analysis, we have also lumped some groups together. For example, we did not find that the interests or attitudes of sugar producers were substantially different from melon producers or cattle producers. Therefore they are all placed in the category of commercial farmers.

In the following sections, the most important issues and conflicts among these groups will be highlighted. Issues that we consider less important are included in the chart for completeness but will not be extensively discussed.

Shrimp farms. For many people in the zone, the shrimp farms seem to hold substantial power and sway. This derives from their economic might and the political influence they can therefore muster. The shrimp farms, however, do have problems and complaints against many of the other groups in the region.

Table 4.8. Population and growth in municipalities bordering the Gulf of Fonseca, southern Honduras, 1974–88.

	Rural population 1974	Rural population 1988	Increase (in percent) 1974-88	Municipal seat population 1974	Municipal seat population 1988	Increase in percent 1974-88
Honduras[a]	1,823,769	2,573,617	29.1	833,179	1,674,944	50.3
Department of Choluteca	149,313	215,379	30.6	44,023	80,105	45.0
Choluteca	23,175	34,331	32.5	26,152	54,481	52.0
Marcovia	15,654	27,490	43.1	965	1795	46.2
Department of Valle	67,923	84,073	19.2	23,978	35,892	33.2
Alianza	6,280	6,938	9.5	624	838	25.5
Amapala	3,319	5,468	39.3	2,274	2,422	6.1
Nacaome	22,879	28,741	20.4	6,159	9,801	37.2
San Lorenzo	3,854	5,563	30.7	9,467	15,603	39.3

a. Data for Honduras as a whole are for urban areas and rural areas rather than for the municipal seat and the rural areas of municipalities.

The major points of conflict are between the shrimp farms and estuary communities and fishermen. The root of much of the conflict between communities and the shrimp farms has to do with the uncertain ownership status of some lands and, especially, the indefiniteness of some boundaries of the shrimp farms. Boundary disputes are particularly intense around the seasonal lagoons, which are both potential areas for shrimp farm expansion and extremely important to the subsistence of local communities. The inability of the government to step in to resolve these disputes is a source of concern to both the shrimp companies and the communities. One recent solution that is being tried by one of the shrimp companies is to demarcate one of these seasonal lagoons and propose to manage it (Wainwright 1993).

This is related to the other stakeholder with which the shrimp farms take issue, the government. The shrimp farms would like to see the Honduran government be more consistent with regard to policies in the region. The concession-granting process has passed from one agency to another and, in some cases, concessions to the same area have been granted to different companies. Demarcation of the boundaries of the seasonal lagoon reserve areas is complicated because it has not been clear which ministry or agency has control over the process. Thus the boundary disputes linger on.

The shrimp industry also complains about what they consider to be restrictive labor legislation. Their desire to avoid having to pay severance pay and other benefits has led them to the use of contractors to supply most of their labor force as temporary laborers. Shrimp farms report that whenever permanent employees have a cash need, they arrange to get fired in order to collect severance pay. Then they simply move to work for another company, costing their former employer what was invested in training them.

One longer term issue or dispute relates to heavy sediment loads in the waters in the estuaries. There is no question that soil erosion from highland farms affects these sediment loads. The main supply channels on all the shrimp farms require constant dredging, which is costly, to keep them open. Where the sediment is dumped will soon become a major problem. Shrimp farms would like to see measures taken to reduce erosion caused by highland farmers.

Female workers. Because female workers in the shrimp industry are almost all temporary workers, their concerns and complaints center mainly on their tenuous status. It is important to emphasize that in conversations with women who worked on the shrimp farms or in the packing plants, they did not talk about complaints or problems. Most emphasized that they were pleased to have a source of employment.

In part, there is a reticence among the workers that comes from intimidation by the shrimp farms and packing plants. This came through in a National Public Radio segment broadcast in 1992. Women who talk about forming a union or who try to organize for better working conditions are fired (National Public Radio 1992). During our work in the zone, a shrimp farm manager reacted angrily when he found out that we had been talking with female employees. Although ANDAH and the shrimp farms had been apprised of the purpose of our study, when a previously cooperative manager was informed by someone that we were interviewing women he became angry and refused to cooperate further. Given this sensitivity on the part of the managers and the lack of alternative employment possibilities for the women, it is not surprising that women do not openly voice their complaints.

Larvae collectors. Some larvae collectors do complain openly about the shrimp farms and the way they count larva. This complaint occurs in all other countries in which wild larvae are collected for use in the ponds. The small size of the larvae, and the need to use a sample to estimate number of larvae in a container, creates substantial room for negotiation and disagreement.

Although this does not yet seem to be an issue, the increasing use of hatchery-raised shrimp larvae may affect the demand for wild larvae. Larvae are now being flown in from Miami and Ecuador; there is one small hatchery in operation in Cedeño and at least two others are being planned for construction.

The other major dispute of larvae collectors is with estuary and open gulf fishermen and with coastal communities. Larvae collectors are blamed for the declining quantities of shrimp and fish found in the estuaries and in the gulf. It is claimed that the larvae gatherers are destroying too much of the juvenile population of both shrimp and fish.

Until recently, these complaints were only vocal. Last year, however, people from Zacate Grande, Puerto Grande, San Carlos Inglaserra, Violín, and other communities burned boats, motors, and a storage shed in La Brea. These actions were taken against a Granjas Marinas larva-gathering operation. Community members were demanding that larvae collectors stay out of the waters around their communities.

Signs have been posted around many communities. One in Valle Nuevo in the municipality of Alianza reads: "Probido netamente camaroneros y larberos en esta sona de Valle Nuevo" (Shrimp farmers and larva collectors are prohibited in this zone of Valle Nuevo).. Larvae collectors in boats are threatened with violence if they pursue their activities in the waters near these communities.

Estuary fishermen. Estuary fishermen and the communities from which they come have been the most vocal and demonstrative opponents of the shrimp farms. There are three bases for their protests. They dispute their exclusion from areas to which they once had open access for fishing, hunting, cutting mangrove, and collecting shellfish. They are also blaming the shrimp farms for destroying, through the larvae collecting that they promote, the fish and shrimp populations. Finally, they accuse the shrimp farms of illegally expanding into the seasonal lagoons and affecting the flow of water into these seasonal lagoons.

Blocking roads, burning boats and motors, and burning buildings connected to the shrimp farms are among the protest methods being used by estuary fishermen. Ironically, as noted above, they are now also denying the shrimp farms and larvae collectors access to common resource areas.

Compared with the conflicts with shrimp farms, other disputes of the estuary fishermen are relatively minor. They are concerned about the destruction of mangrove, a resource important to their own success. Therefore they have some degree of conflict with salt producers, woodcutters, and bark harvesters. But because estuary fishermen often have these two latter activities as secondary occupations, these conflicts are not open or severe.

Estuary fishermen also come into conflict with the open gulf fishermen. They see that the purchase of bigger boats with more powerful motors and the increased use of trammel nets may result in fewer fish and shrimp in the estuaries. They would like to see the government provide some control over the overfishing so long as the controls do not adversely affect them.

Open gulf fishermen. There are estimates that there are approximately 7,000 fishermen along the south coast of Honduras. The fishermen who work in the open waters of the Gulf of Fonseca are more likely than estuary fishermen to pursue fishing as a full time occupation. A recent Japanese study found that about 63 percent of open gulf fishermen consider themselves full-time fishermen (CODDEFFAGOLF 1991:10).

Open gulf fishermen share many of the same concerns regarding the shrimp farms as the estuary fishermen, and they have often protested alongside the estuary fishermen. Because they are exploiting the same resources, however, they also sometimes accuse the estuary fishermen of overfishing. They note that some estuary fishermen now use dynamite as a fishing technique, a tactic that destroys many juvenile fish and larvae as well as larger fish.

Several fishermen from coastal communities noted that it is becoming increasingly difficult to find house sites. There are also communities in which water erosion is destroying houses and house sites. The fishermen would like to see the communities do more to assist them in securing house sites or protecting the houses they have already built.

Highland farmers. The 1974 agricultural census reported that there were over 25,000 farms in the departments of Valle and Choluteca. Of these, 63 percent were less than 5 ha in size (Vega 1989:45). Most of these small farms are located in the foothills and mountainous areas.

Highland farmers who practice shifting cultivation are blamed by many for the increased sedimentation of estuaries. Because they are so dispersed and far away, however, conflicts with them are rarely open. The main sources of conflict for highland farmers relate to competition for markets with agrarian reform communities and commercial farmers. Highland farmers feel that the government has largely forgotten forgotten them so far as providing infrastructure or incentives for production are concerned.

Agrarian reform communities. There are more than 300 agrarian reform communities in the departments of Choluteca and Valle. Each had about 30 members. Thus approximately 9,000 heads of families are potential members of the cooperatives. Agrarian reform cooperatives were granted national lands or expropriated lands during the 1970s. Consolidación de la Reforma

Agraria de la Zona Sur is a European Community sponsored project that has been working with agrarian reform communities in the south since 1987. It is working in collaboration with the Agrarian Reform Ministry. The purpose of the project is to assist in the consolidation of the agrarian reform communities. Although their goal is to work with 70 communities, their diagnostic study of 190 groups found only 47 that were still sufficiently strong and organized to warrant projects. Most communities have not achieved an economically viable status and have experienced a loss of members to wage labor jobs.

The agrarian reform cooperatives do not have any overt conflicts with any of the other groups. Leaders express frustration with the lack of government support for the communities, citing lack of credit and lack of infrastructure as problems hindering their development. Even efforts to provide such assistance have not had good results. Consolidación de la Reforma Agraria de la Zona Sur, for example, was assisting the cooperatives in producing cantaloupes and watermelons through the Cooperativa Regional de Horticultores del Sur, which is bankrupt because of marketing problems.

Some cooperatives have lands that border mud flats and beaches that are suitable for shrimp farm development. They have been unable to get concessions and credits to develop these.

The landless. Despite the agrarian reform in the south, there are still a large number of landless individuals. In one highland community of the south studied in 1981, for example, over 50 percent of the people were renting or borrowing land rather than owing it themselves (DeWalt and DeWalt 1984:23). This is thus a very large group of individuals.

The landless comprise a large labor pool for the commercial agriculturalists, the aquaculture industry, the salt-making operations, and other enterprises in the south. Not surprisingly, their main sources of dissatisfaction are with the terms of their employment: low wages, lack of job security, and the scarcity of job opportunities. A word commonly used by landless individuals to characterize their employment situation was "slavery" (*esclavitud*). They continue to press the government for access to land. At the opening session of Congress while we were in the field on this study, a large group of landless held a demonstration demanding access to land. Land invasions occasionally occur. Nevertheless, as noted in the section on agrarian reform communities, many people have opted to give up their land rights in order to devote themselves to wage labor.

Individuals without access to land have had problems getting access to house sites in some communities. Even in rural areas, squatting on land and even squatter settlements are becoming issues with which communities must deal.

Commercial farmers. Land tenure in the southern region is still extremely skewed despite the agrarian reform (see DeWalt and DeWalt 1984). Large cattle ranches, sugarcane producers, cantaloupe and watermelon producers, and other farms occupy most of the region. Commercial farmers have few overt conflicts with other groups. Perhaps the most serious conflict is between a few commercial producers and rural agrarian reform communities. The disputes revolve mainly around unclear land boundaries.

Commercial farmers also have to face the prospect of land invasions by the landless. Recent governments, however, have not been sympathetic to the calls for continuing agrarian reform. Most farmers therefore view land invasions as a nuisance rather than as much of a threat.

Salt producers. It is estimated that there are 130 small, medium, and large producers dedicated to the production of salt (Flores and Reiche 1989:33). Several of the medium and large salt producers also produce shrimp in their ponds during the rainy season. The salt producers' main problem has been with the government's efforts to prevent the cutting of mangrove. The Rural Technologies Project, however, was very successful in introducing the production of salt using only solar evaporation. Few salt producers now use wood-fueled ovens to evaporate salt.

Woodcutters. Virtually all rural households in the south and many urban households use wood as the principal cooking fuel. Securing this fuel is one of the principal difficulties for most households. In addition, brick making, salt production, the sugar refining, and other industries in the south have used or still do use a substantial amount of wood. Because most of the dry tropical forest has already been eliminated on the coastal plain and in the highlands, mangrove species provide the bulk of this fuel. The elimination of this resource because of woodcutting is one of the principal environmental threats in the region.

There are many people who make a living, working full- or part-time, cutting and transporting wood. Some gulf and estuary fishermen admitted, for example, that because of the decrease in fish and shrimp populations, they are engaged in the illegal cutting of mangrove. In addition, most rural households try to provide this resource for themselves. Thus, there are many individuals cutting or gathering wood.

For those who cut wood, the main conflict is with the government of Honduras, especially with the COHDEFOR, which attempts to regulate woodcutting in the country and requires people to obtain permits. In practice, few people acquire these permits unless they are going to transport wood long distances or use it in an industrial setting that is easily policed. COHDEFOR lacks the personnel and resources effectively to regulate timber cutting in the areas where it occurs. Nevertheless, the threat of large fines is always present. These regulations have greatly decreased the market for wood in the salt and tanning industries.
Several communities have been cut off from their traditional sources of wood supply by the fences erected by the shrimp farms. They complain about the distance they have to travel to get access to wood and about its cost if they must purchase it.

Tanning industry. Only two tanneries, employing fewer than 20 persons each, remain in the region. The tanning industry once created a large demand for the bark of the red mangrove (*Rhizophora mangle*), which it used in processing leather. A tannery near Pespire, for example, reported that it used 24 tons of mangrove bark a year. As COHDEFOR began enforcing regulations and requiring permits, it drastically reduced the amount of bark used. The owner reported that it costs 200 lempiras per ton to get a permit from COHDEFOR, 200 lempiras for the people who cut it, and 250 lempiras for transportation from Guapinol to the tannery. The tannery now uses only 6 tons of red mangrove bark per year.

The primary substitute for mangrove is *nacascolo*, a seed from a tree that is quite common in the region. It grows especially well near Orocuina, the location of the other major tannery in the region. The tannery near Pespire used 40 tons of nacascolo last year, at a total cost of 9,000 lempiras. Some mangrove is still used because it makes the leather stronger.

Although the tanneries would prefer to use more mangrove bark, they do have an acceptable substitute and can still obtain permits for obtaining some mangrove. Their main irritation is with COHDEFOR because it regulates the forest, but this conflict is not serious.

Communities. Rural communities on the south coast have a number of serious conflicts with other groups. Disputes with the shrimp industry are common in the communities near the farms. Some communities complain about the salinization of their wells and others about the unwillingness of the shrimp farms to assist them in improving their infrastructure. Communities that are located along the coast complain that the shrimp companies and the larvae collectors are destroying shrimp and fish larvae. As noted earlier, people from these communities have been involved in destroying shrimp company property and in excluding larva collectors.

Still other communities are in conflict with private land owners who are attempting to enclose lands that are part of the seasonal lagoons designated as reserve areas. People from two agrarian reform communities, for example, are now camping in the Laguna Alemania to try to prevent a large landowner from extending his pastures into the area. They report that this landowner and his politically powerful brother have threatened them with pistols.

This last problem relates to the inability of the government to demarcate the boundaries of the reserve areas. Communities are frustrated with the lack of action on the part of the government to give them assistance and protection in dealing with powerful shrimp companies and commercial farmers.

Government. The national government is, of course, made up of many different ministries and agencies. One of the difficulties in attempting to resolve the resource and social conflict issues for the Gulf of Fonseca region is that the roles and responsibilities of these ministries and agencies have not been well defined. In addition, the legislative framework for natural resource management is in a state of flux, and ministry and agency responsibilities are being shifted (Siirila 1991:20-21). At the same time, because Honduras is attempting to shrink its bloated bureaucracy, the general situation with regard to laws and law enforcement is chaotic.

On a general level, there are conflicts and problems with all of the groups because of the demands they are making on the government. All blame the government for unsatisfactory policies or for actions it is not taking. Although this may be a natural state of affairs, it is particularly problematical in southern Honduras. The national government has intervened sufficiently to create many difficulties (granting concessions to the shrimp farms, enacting an agrarian reform, declaring reserve areas, etc.) but not sufficiently to bring order and orga-nization to the processes occurring.

5. Recommendations

After years of seemingly uncurtailed exploitation, renewable resources and productivity of the Gulf of Fonseca area are quickly approaching the point of severe environmental degradation. Ranching, exploitation of the mangrove resources, development of nontraditional agriculture and aquaculture, overexploitation of the coastal and fisheries resources have all contributed to the degradation and decline in natural productivity for the area.

The physical, environmental, and biological forces that define the Gulf of Fonseca ecosystem do not recognize imposed geographical boundaries. Therefore effective management of the Gulf of Fonseca will have to be undertaken by each bordering country within the guidelines of a mutually agreed upon multiple and sustainable use management plan.

Development of the plan will have to take into account each country's rational development needs within the maximum sustainable yield concept. Acceptable degradation to the ecosystem, mitigation measures to be implemented, and enforcement constraints will have to be delineated. The master plan should, at a minimum address the following points:

(1) A plan for the development of the aquaculture sector.
(2) A multiple use management plan for the remaining mangrove areas based on regrowth and rejuvenation rates for the area and the establishment of protected areas.
(3) A management plan for the fisheries resources in the gulf that takes into account the various species management needs and the requirements for intraspecies management. The management plan needs to be flexible and responsive enough ultimately to allow for allocation of quotas and changes of seasonal closures based on recruitment and survival information.
(4) An agriculture development and monitoring plan that would follow acceptable guidelines with respect to water usage, land development, and farm chemical use and regulations.
(5) The development of an environmentally acceptable watershed management plan.

With respect to the management plan for Honduras, the management needs and solutions to the problems are much easier to identify, as summarized in the following major recommendations.

Currently, there is a lack of direction and accountability within Honduran government institutions with respect to decision making on environmental and developmental issues. A watchdog agency with enforcement capabilities needs to be formalized. With great foresight on the part of the president, Comisión Nacional del Medio Ambiente (CONAMA) has been formed, but it needs to be elevated to the appropriate ministry level and given an adequate operational budget. This will allow it to direct the formulation of environmental criteria and management plans (in cooperation with other leading agencies) and give it the enforcement capabilities to implement those plans, with focus on the following immediate concerns.

(1) An aquaculture development plan needs to be developed. Government encouragement such as tax incentives and duty free import quotas should be given to the shrimp industry to stimulate hatchery development in Honduras. This includes larval-rearing labs in the gulf region and possibly maturation hatcheries on the Caribbean side.

(2) A review of the shrimp farming concession process needs to be undertaken. Based on current information, the development of the entire hectarage already under concession would result in major environmental damage to the Gulf of Fonseca area, with impact most immediately felt in water quality and revenues to shrimp farms.

(3) The loss of mangrove (actual or vegetation cover) needs to be curtailed. This would mean the development of a comprehensive management plan for the region that would allow for the selected harvesting of known quantities of mangrove wood for fuel and construction and the development of approved concessions.

(4) An environmental impact study and report should be required prior to permiting for any future shrimp farms or additions to or new construction on existing shrimp farms. Development permits should be regulated within the context of an approved regional plan. An interim development ceiling not to exceed 2,000 ha per year for the 1993 and 1994 should be put in place as an emergency measure. Permit fees and appropriate mitigation measures or fees could be used to acquire corridors, establish plantations, and develop reserves. Incentives to aquaculture operations that develop a reserve area within the context of the management plan could be given in the form of tax credits.

(5) Protected areas must be delineated and a management program for each area developed. The delineation of wildlife corridors and multiple species management and habitat conservation units in the interest of biodiversity must be an integral part of protected area delineation.

(6) Multiple use management areas need to be delineated. These would include artisanal fishing grounds, postlarvae capture areas, and subsistence gathering areas.

(7) A fisheries management plan needs to be developed for the gulf. In the absence of accurate statistical information, a protective attitude must be followed and an accurate data collection system must be implemented. A limited entry management concept needs to be implemented, and size recommendations need to be enforced. Based on recommendations from the Ministry of Natural Resources and other knowledgeable institutions, seasonal and area closures need to be implemented for finfish species, shrimp, shrimp postlarvae, bivalves, and mollusks. Recommendations on the type of gear used and acceptable fishing methodologies need to be made and transferred to the end user.

(8) Supplementary income-generating schemes for artisanal fisherman need to be evaluated and field tested. These would include low-technology aquaculture of

mollusks and bivalves, nontraditional fish capture methods, and improved post-capture handling, distribution, and marketing methods.

(9) Regional development of social programs and infrastructure should be funded for the departments of Valle and Choluteca from already assessed taxes on export products. Tax incentives could be given to companies that assist local communities in the improvement of selected infrastructure needs such as freshwater wells, electricity, schools, and latrines.

(10) A monthly water sampling program needs to be started in the gulf. Water samples should be taken, at a minimum, at marked sampling sites as indicated in appendix figure C-1. The samples should then be analyzed for pesticides. Determination of plausible users and sources of contamination should be investigated as required in areas where water samples show levels of pesticides higher than are acceptable.

Appendix A. Persons interviewed

Government of Honduras

Maria Antonieta Bogram, directrice, Ministry of Tourism
Dr. Median, director, CONAMA
Gustavo Cruz, biologist
Dr. Sherry Pilar Thorne, biologist

COHDEFOR

Edas Muñoz

University of Honduras Biology Department

Dr. Mirna Marin

USAID

Marshall Brown
Rafael Rosario
Del McCluskey
Margarett Harritt
Emil Faulk
Wes Kline
Jorge Betancourt (Peace Corps, Director for Environment)
Virginia McEntyre (Peace Corps, Protected Areas)

ANDAH meeting

Freddy Araujo, CULCAMAR
Mario Castro, CRIMASA, gerente producción
Roberto Chomorro, USAID/FPX, asesor acuícola
Roberto Corrales, Empacadora San Lorenzo, gerente planta
Gustavo Cusulá, ANDAH, director administrativo
Gustavo Adolfo Flores, Empacadora Pacific, jefe de producción
Luis Funez, USAID/FPX, ténico, camarón
Cornelio Lara, USAID/FPX, asesor técnico
Rafael Molina, PROMARSA, gerente
Marcos Moya, HONDUESPECIES, gerente producción
Enrique Niño, CRIMASA, subgerente
Francisco Orozco, USAID/FPX, técnico, camarón

Anselmo Sánchez, LARVITEC, gerente general
Miguel Solís, Cordova Empacadora Pacific, gerente
Werner Volk, Empacadora San Lorenzo, gerente general
F.W. Wainwright, consultor
Alberto Zelaya G., USAID/FPX, jefe de departamento, Camarón

Others

Gustavo Adolfo Aguilar, jefe de finanzas (ACENSA sugar mill, on road to Cedeño)
Javier Amador, Gerente Administrativo, Cultivos Marinos
Amilcar Amaya, president of the fishermen's organization, Asociación de Pescadores Artesanales del Golfo (APAGOLF)
Dario Rodriguez Bejarano, Natural Resources Evaluation Remote Sensing
Lic. José Manuel Chajín, vice presidente (ACENSA sugar mill, on road to Cedeño)
Hector Corrales, sub-gerente general, Granjas Marinas, S.A. de S.V.
Jack Crockett, gerente general Cultivos Marinos, S.A. de S.V., Choluteca, Honduras
Gustavo Cruz, consultor, Comisión Nacional del Medio Ambiente y Desarrollo
Jonathan Espinosa O., director técnico, Asociación Nacional de Acuicultores de Honduras (ANDAH), Tegucigalpa
Marco Tulio Flores, director ejecutivo, Cámara de Comercio e Industrias del Sur, Choluteca, Honduras
Carlos Lara, gerente general, Granjas Marinas, S.A. de S.V.
Jorge Varela Márquez, director ejecutivo, CODEFFAGOLF; president, FED-AMBIENTE
Lic. Pedro Martinez, Secretaría de Recursos Naturales, Choluteca, Honduras
Ricardo Matamoros, jefe de control de calidad, Granjas Marinas, S.A. de S.V.
Carlos Medina, M.D., director ejecutivo, Comisión Nacional del Medio Ambiente y Desarrollo
Oscar Midence, Jefe de Personal de Descabezado, Granjas Marinas, S.A. de S.V.
Cleto Montoya, director ejecutivo, Asociación Sureña para la Conservación de la Naturaleza, Choluteca, Honduras
Juan Muñoz, Jefe de Aclimatización, Granjas Marinas, S.A. de S.V.
Becky Myton, biologist, Universidad Nacional Autónoma de Honduras and the Comisión Nacional del Medio Ambiente y Desarrollo
Lic. Jorge Humberto Ramos, Instituto Nacional Agrario, Proyecto CORASUR, Choluteca, Honduras
Pilar Thorne, consultor, Comisión Nacional del Medio Ambiente y Desarrollo
Dagoberto Torres, accountant from CONADE (ACENSA sugar mill, on road to Cedeño)
Jorge Velázquez, contador, Cooperativa Agropecuaria Algodonera del Sur, San Lorenzo, Valle

Appendix B. Matrix of stakeholders: conflicts and complaints

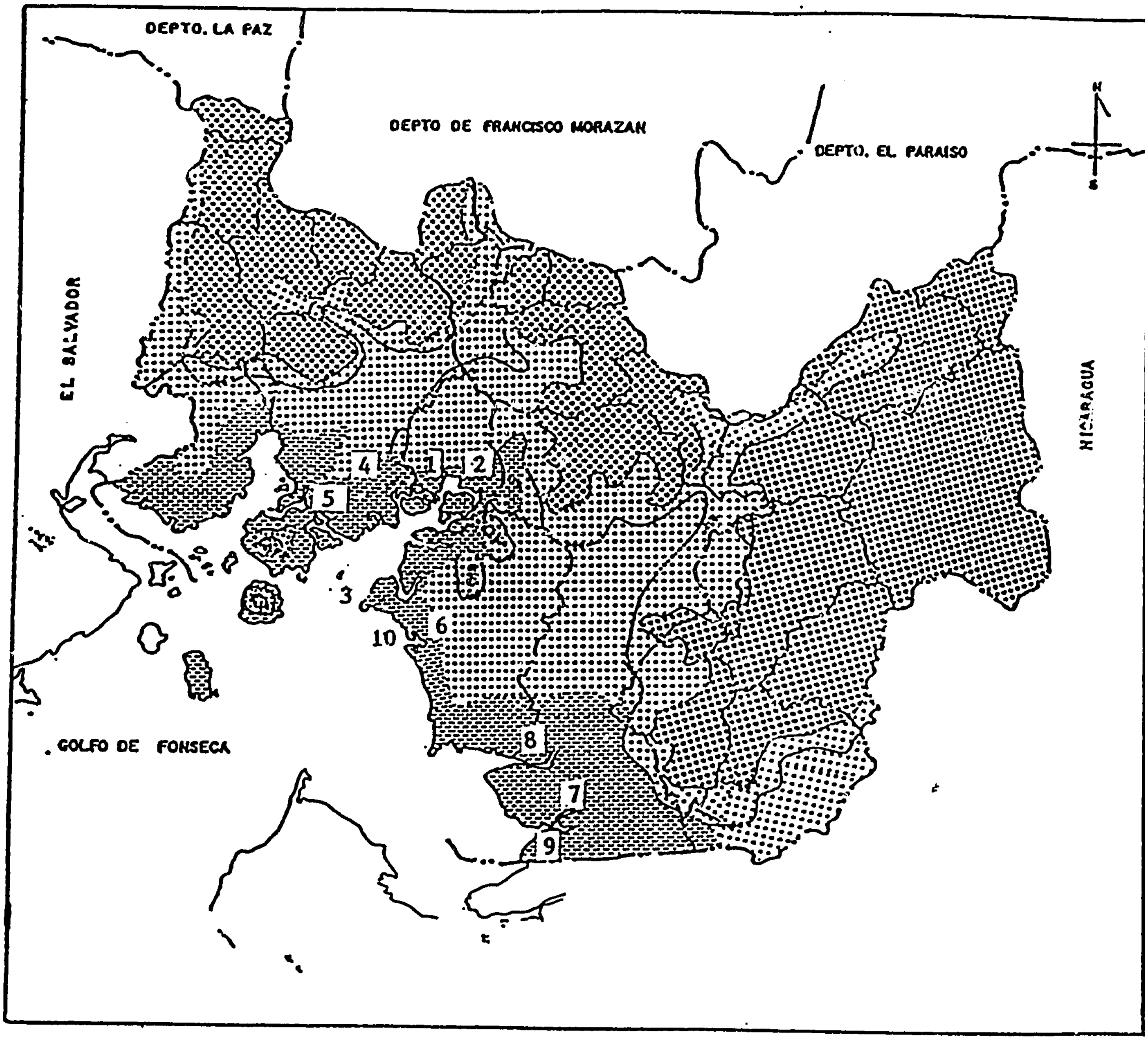
Appendix B.
Matrix of Stakeholders' Conflicts and Complaints

	Shrimp farms	Female workers	Larvae collectors	Estuary fishermen	Open sea fishermen
Shrimp farms		Complaints about job conditions, wage rates, and job security	Larvae counting; job security	Access to estuaries; destruction of larvae; changes in hydrology	Destruction of shrimp and fish larvae
Female workers	Reliability; ingratitude				
Larvae collectors	Ingratitude; complaints about larvae counts			Destruction of fish and shrimp larvae	Destruction of fish and shrimp larvae
Estuary fishermen	Shrimp stealing; destruction of property		Denial of access to some areas; conflict over larvae		Overfishing
Open sea fishermen	Complaints about fish disappearance		Overfishing of shrimp brood stock	Overfishing	
Highalnd farmers	Soil erosion leading to increased siltation		Siltation of breeding areas from soil erosion	Soil erosion and siltation of lagoons and estuaries	Soil erosion and siltation of breeding grounds of fish and shrimp
Agrarian reform communities	Competition for land and *playones*		Denial of access to some areas	Pesticide dumping; soil erosion	Pesticide contamination of breeding areas
Landless	Demands for jobs				
Commercial farmers	Competition for workers; pesticide contamination		Destruction of larvae because of pesticides	Pesticide dumping; attempts to fence seasonal lagoons	Pesticide contamination of breeding areas
Salt producers	Competition for *playones*		Destruction of shrimp breeding areas	Destruction of fish and shrimp breeding grounds	Destruction of fish and shrimp breeding grounds
Woodcutters	Mangrove destruction		Destruction of shrimp breeding areas	Destruction of fish and shrimp breeding grounds	Destructin of fish and shrimp breeding grounds
Tanning industry	Mangrove destruction			Destruction of fish and shrimp breeding grounds	Destruction of fish and shrimp breeding grounds
Communities	Conflicts over land boundaries and access		Denial of access to some areas	Water pollution	Lack of housing sites; lack of protection of house sites
Government	Restrictive labor legislation; lack of infrastructure; failure to fix boundaries	Lack of labor protection	Lack of labor protection	Lack of environmental law enforcement; selling of rights to common aeras	Lack of environmental law enforcement

Highland farmers	Agrarian reform communities	Landless	Commercial farmers	Salt producers	Woodcutters	Tanning industry	Communities	Government	
	Appropriation of all lands for shrimp farms; lack of employment opportunities	Wage rates; lack of job security	Competition for labor	Competition for *playones*	Mangrove destruction; fencing of lands	Mangrove destruction; fencing of lands	Salinization of water; lack of jobs; no assistance with infrastructure	Demands for services and infrastructure	**Shrimp farms**
								Demands for labor protection	**Female workers**
	Destruction of fish and shrimp larvae						Destruction of fish and shrimp larvae	Destruction of fish and shrimp larvae	**Larvae collectors**
								Overfishing	**Estuary fishermen**
								Overfishing	**Open sea fishermen**
	Competition for markets							Resource destruction because of farming practices	**Highland farmers**
Competition for markets			Competition for land					Demands for subsidies, services, and infrastructure	**Agrarian reform communities**
Pressure for land reform; invasions of land	Invasions of land		Pressure for land reform; invasions of land; unwillingness to work					Demands for land; land invasions	**Landless**
Competition for loans and markets; unfair competition	Competition for loans and markets	Lack of employment; low wage rates					Attempts to enclose more lands	Demands for subsidies, services, and insructure	**Commercial farmers**
		Low wage rates			Competition for mangrove	Competition for mangrove	Destruction of mangrove	Destruction of mangrove	**Salt producers**
	Destruction of wood sources					Competition for mangrove	Destruction of mangrove	Destruction of mangrove	**Woodcutters**
	Destruction of wood sources				Competition for mangrove		Possible pollution of water	Destruction of mangrove	**Tanning industry**
		Lack of housing sites	Conflicts over land boundaries	Competition for land				Inability to organize and plan own development; dependency	**Communities**
Lack of incentives for production; lack of infrastructure	Lack of incentives for production; lack of infrastructure; lack of technical assistance	Lack of land reform; failure to generate employment	Lack of incentives, subsidies; lack of infrastructure	Regulation of mangrove cutting; lack of infrastructure	Restrictions against mangrove cutting; lack of alternative employment opportunities	Restrictions against mangrove cutting; lack of market opportunities	Failure to resolve disputes; lack of infrastructure		**Government**

Appendix C. Analyses of tissue, water, and soils

Figure C-1.
Sampling Locations



1. San Lorenzo (town)
2. San Lorenzo (port)
3. Punta Ratón
4. Estero Esterón
5. Coyolito
6. Río Choluteca
7. Estero San Bernardo
8. Estero Pedregal
9. Río Negro
10. Punta Ratón

Table C-1. Results of analyses of tissue, water, and soil samples

Tissue samples (clams)

Sample number[1]	Observations
1	No detectable residues
7	Endosulfan II, 0.002 ppm
8	Aldrin, 0.002 ppm
4	No detectable residues
5	No detectable residues

Water samples

Number	Location	Observations
1	San Lorenzo (town)	Heptaclor, 0.056 ppm Aldrin, 0.067 ppm
2	San Lorenzo (port)	Heptaclor, 0.040 ppm Malathion, 0.073 ppm
3	Punta Ratón	Heptaclor, 0.033 ppm
4	Estero Esterón	Heptaclor, 0.035 ppm Malathion, 0.056 ppm
5	Coyolito	Heptaclor, 0.027 ppm Aldrin, 0.034 ppm Heptaclor epoxido, 0.14 ppm
6	Río Choluteca	Lindane, 0.17 ppm Heptaclor, 0.048 ppm
7	Estero San Bernardo	Lindane, 0.25 ppm Heptaclor, 0.033 ppm Aldrin, 0.44 ppm Malathion, 0.140 ppm
8	Estero Pedregal	Lindane, 0.076 ppm Heptaclor, 0.088 ppm Aldrin, 0.069 ppm Malathion, 0.22 ppm Endosulfan I, 0.30 ppm
9	Río Negro	Heptaclor epoxido, 0.081 ppm
10	Punta Ratón	Heptaclor, 0.027 ppm

Soil samples

Number	Location	Observations
7	San Bernardo area	Mevinphos found
4B	Agua Fria area	Mevinphos found
3	Punta Ratón area	No detectable residues
1	San Lorenzo area	No detectable residues

[1] Sample numbers for lab reference only.

Table C-2. Observed lethal concentrations of selected chemicals in aquatic environments

Chemical	Organism Tested	Lethal Concentration, mg/L	Exposure Time, hr
ABS (100 percent)	Fathead minnow	3.5–4.5	96
ABS (100 percent)	Bluegills	4.2–4.4	96
Household syndets	Fathead minnow	39–61	96
Alkyl sulfate	Fathead minnow	5.1–5.9	96
LAS (C12)	Bluegill fingerlings	3	96
LAS (C14)	Bluegill fingerlings	0.6	96
Acetic acid	Goldfish	423	20
Alum	Goldfish	100	12–96
Ammonia	Goldfish	2–2.5 NH_3	24–96
Ammonia	Perch, roach, rainbow trout	3N	2–20
Sodium arsenite	Minnow	17.8 As	36
Sodium arsenate	Minnow	234 As	15
Barium chloride	Goldfish	5000	12–17
Barium chloride	Salmon	158	...
Cadmium chloride	Goldfish	0.017	9–18
Cadmium nitrate	Goldfish	0.3 Cd	190
CO_2	Various species	100–200	...
CO	Various species	1.5	1–10
Chloramine	Brown trout fry	0.06	...
Chlorine	Rainbow trout	0.03–0.08	...
Chromic acid	Goldfish	200	60–84
Copper sulfate	Stickleback	0.03 Cu	160
Copper nitrate	Stickleback	0.02 Cu	192
Cyanogen chloride	Goldfish	1	6–48
H_2S	Goldfish	10	96
HCl	Stickleback	pH 4.8	240
HCl	Goldfish	pH 4.0	4–6
Lead nitrate	Minnow, stickleback, brown trout	0.33 Pb	...
Mercuric chloride	Stickleback	0.01 Hg	204
Nickel nitrate	Stickleback	1 Ni	156
Nitric acid	Minnow	pH 5.0	...
Oxygen	Rainbow trout	3 cc/liter	...
Phenol	Rainbow trout	6	3
Phenol	Perch	9	1
Potassium chromate	Rainbow trout	75	60
Potassium cyanide	Rainbow trout	0.13 Cn	2
Sodium cyanide	Stickleback	1.04 Cn	2
Silver nitrate	Stickleback	70 K	154
Sodium fluoride	Goldfish	1000	60–102
Sodium sulfide	Brown trout	15	...
Zinc sulfate	Stickleback	0.3 Zn	120
Zinc sulfate	Rainbow trout	0.5	64
Pesticides			
1. Chlorinated hydrocarbons			
A Aldrin	Goldfish	0.028	96
DDT	Goldfish	0.027	96
DDT	Rainbow trout	0.5–0.32	24–36
DDT	Salmon	0.08	36
DDT	Brook trout	0.032	36
DDT	Minnow, guppy	0.75 ppb	29
DDT	Stoneflies (species)	0.32–1.8	96
BHC	Goldfish	2.3	96
BHC	Rainbow trout	3	96

Chemical	Organism Tested	Lethal Concentration, mg/L	Exposure Time, hr
Chlordane	Goldfish	0.082	96
Chlordane	Rainbow trout	0.5	24
Dieldrin	Goldfish	0.037	96
Dieldrin	Bluegill	0.008	96
Dieldrin	Rainbow trout	0.05	24
Endrin	Goldfish	0.0019	96
Endrin	Carp	0.14	48
Endrin	Fathead minnow	0.001	96
Endrin	Various species	0.03–0.05 ppb	...
Endrin	Stoneflies (species)	0.32–2.4 ppb	96
Heptachlor	Rainbow trout	0.25	24
Heptachlor	Goldfish	0.23	96
Heptachlor	Bluegill	0.019	96
Heptachlor	Redear sunfish	0.017	96
Methoxychlor	Rainbow trout	0.05	24
Methoxychlor	Goldfish	0.056	96
Toxaphene	Rainbow trout	0.05	24
Toxaphene	Goldfish	0.0056	96
Toxaphene	Carp	0.1	...
Toxaphene	Goldfish	0.2	24
Toxaphene	Goldfish	0.04	170
Toxaphene	Minnows	0.2	24
2. Organic phosphates			
Chlorothion	Fathead minnow	3.2	96
Dipterex	Fathead minnow	180	96
EPN	Fathead minnow	0.2	96
Guthion	Fathead minnow	0.093	96
Guthion	Bluegill	0.005	96
Malathion	Fathead minnow	12.5	96
Parathion	Fathead minnow	1.4–2.7	96
TEPP	Fathead minnow	1.7	96
3. Herbicides			
Weedex	Young roach	40–80	1 month
Weeda Zol	and trench	15–30	1 month
Weeda Zol T.L.		20–40	1 month
Simazine (no plants present)	Minnow	0.5	<3 days
Atrazine (A361) (plants present)	Minnow	5.0	24
Atrazine in Gesaprime	Minnow	3.75	24
4. Bactericides			
Algibiol	Minnow	20	24
Soricide tetraminol	Minnow	8	48

Source: McGauhey, Engineering Management of Water Quality, McGraw-Hill, copyright 1968

Appendix D. Maps

FIGURE ONE

GULF OF FONSECA RESERVE AREAS

ACTUAL , PROPOSED OR SUGGESTED

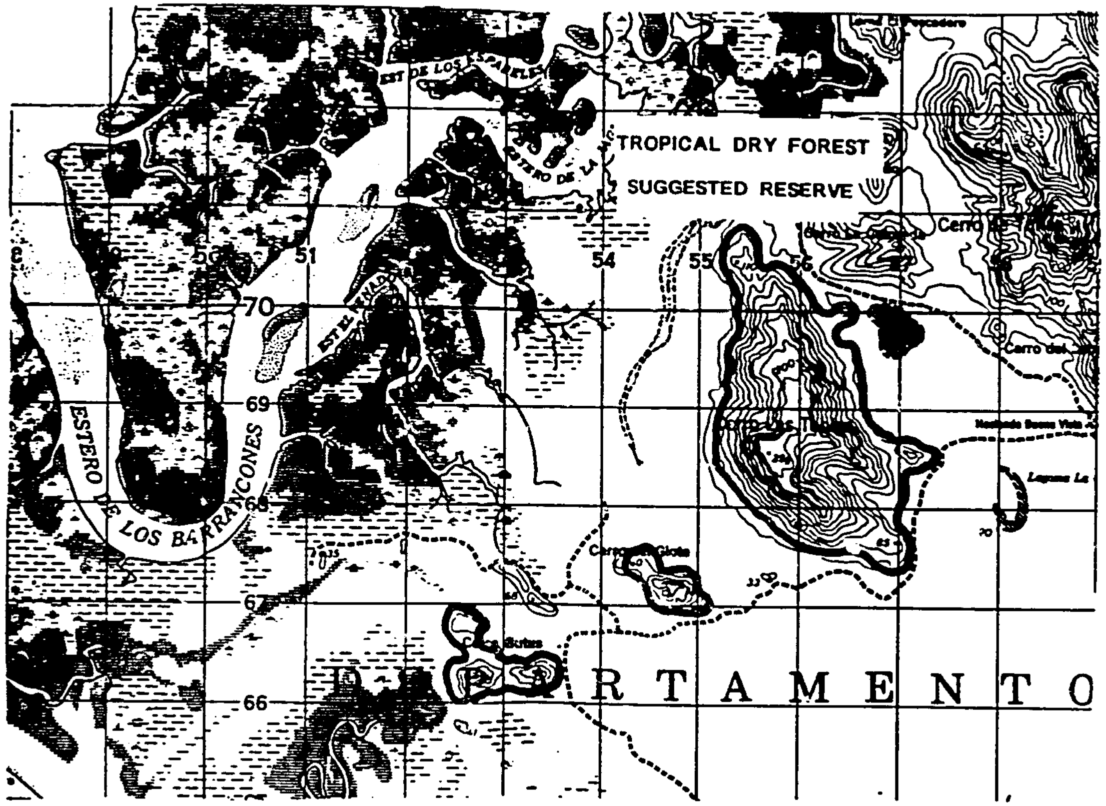


FIGURE TWO

GULF OF FONSECA RESERVE AREAS

ACTUAL, PROPOSED OR SUGGESTED

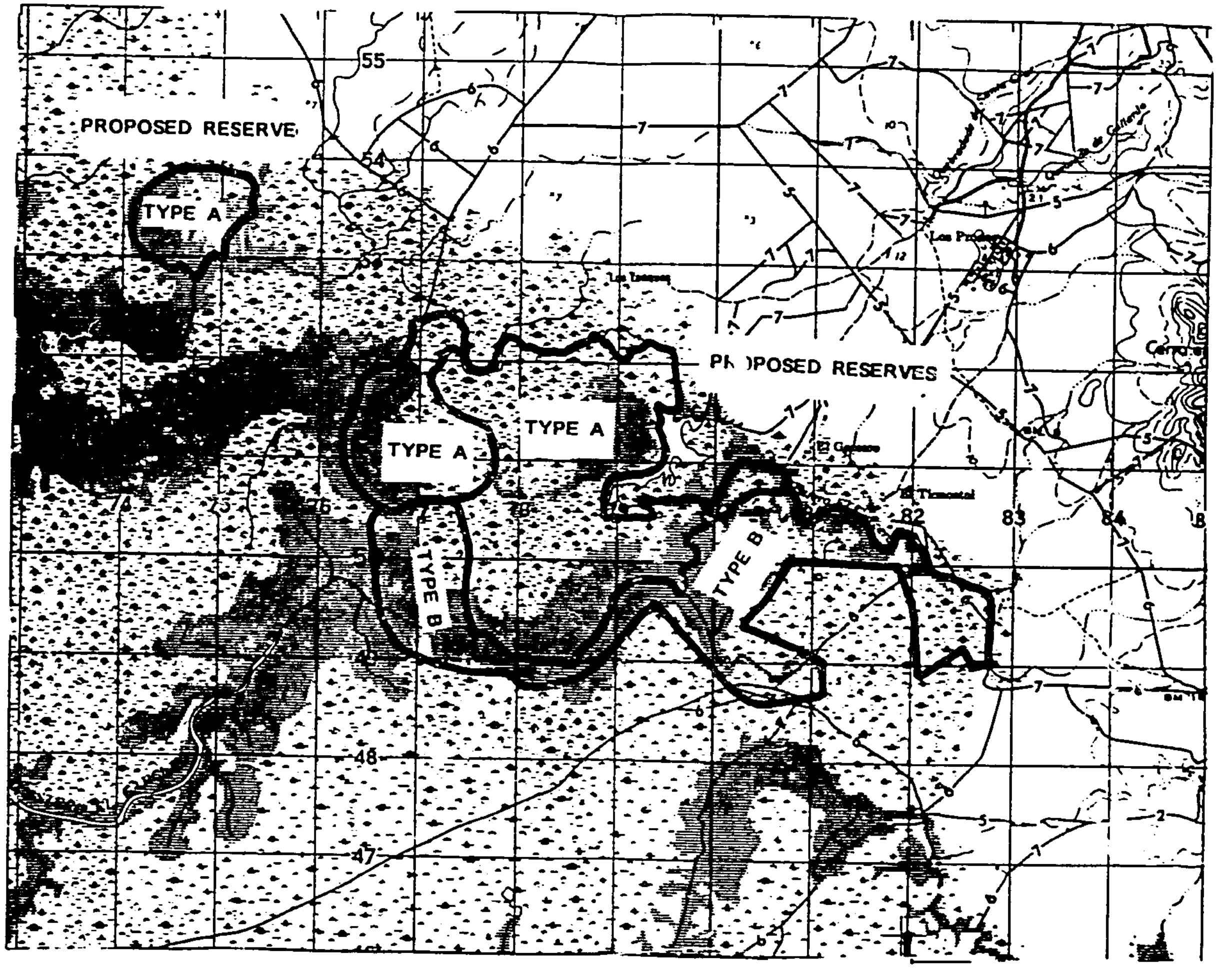


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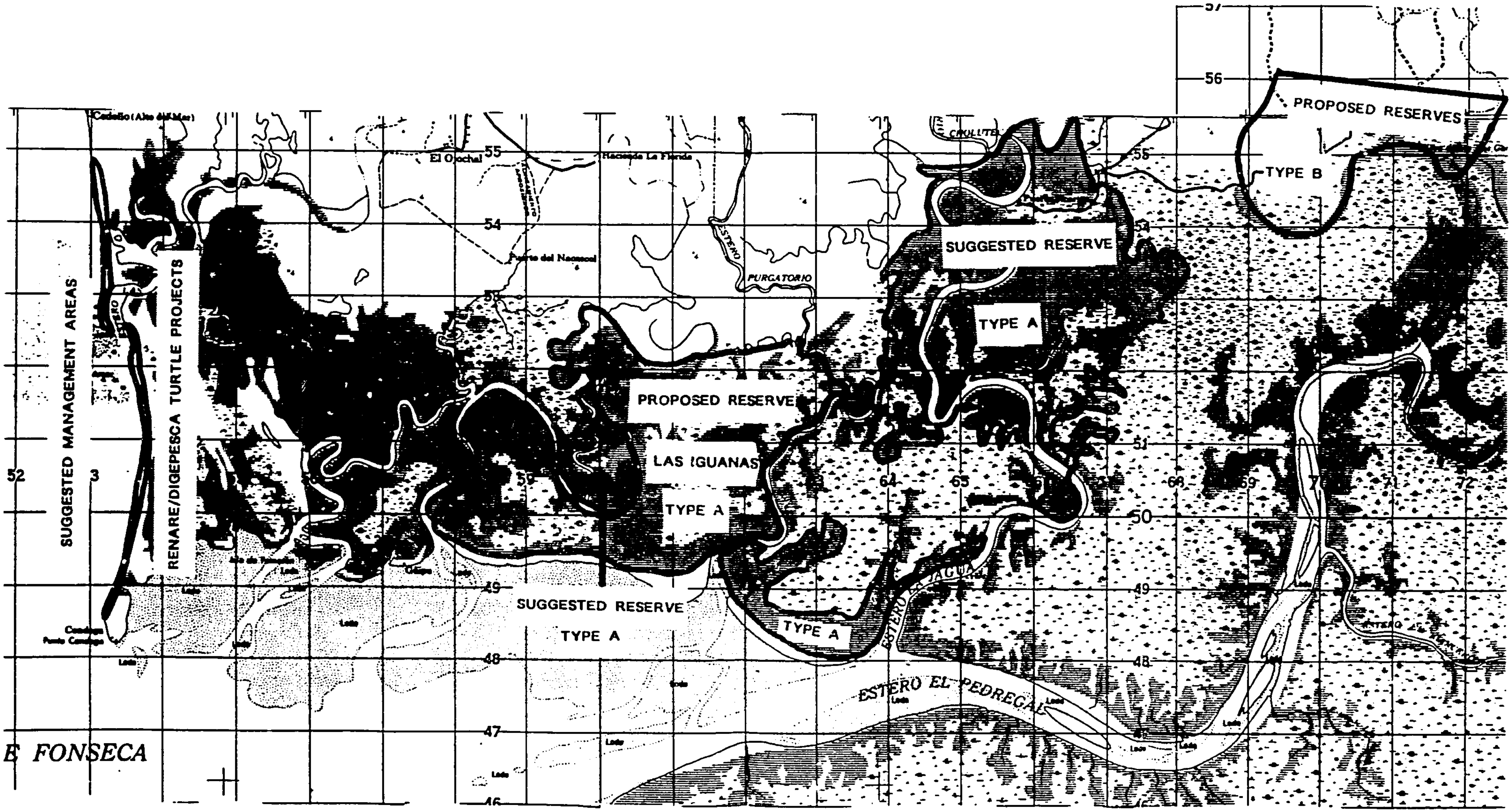
FIGURE THREE

GULF OF FONSECA RESERVE AREAS

ACTUAL , PROPOSED OR SUGGESTED



BEST AVAILABLE COPY

FIGURE FOUR

GULF OF FONSECA RESERVE AREAS

ACTUAL , PROPOSED OR SUGGESTED

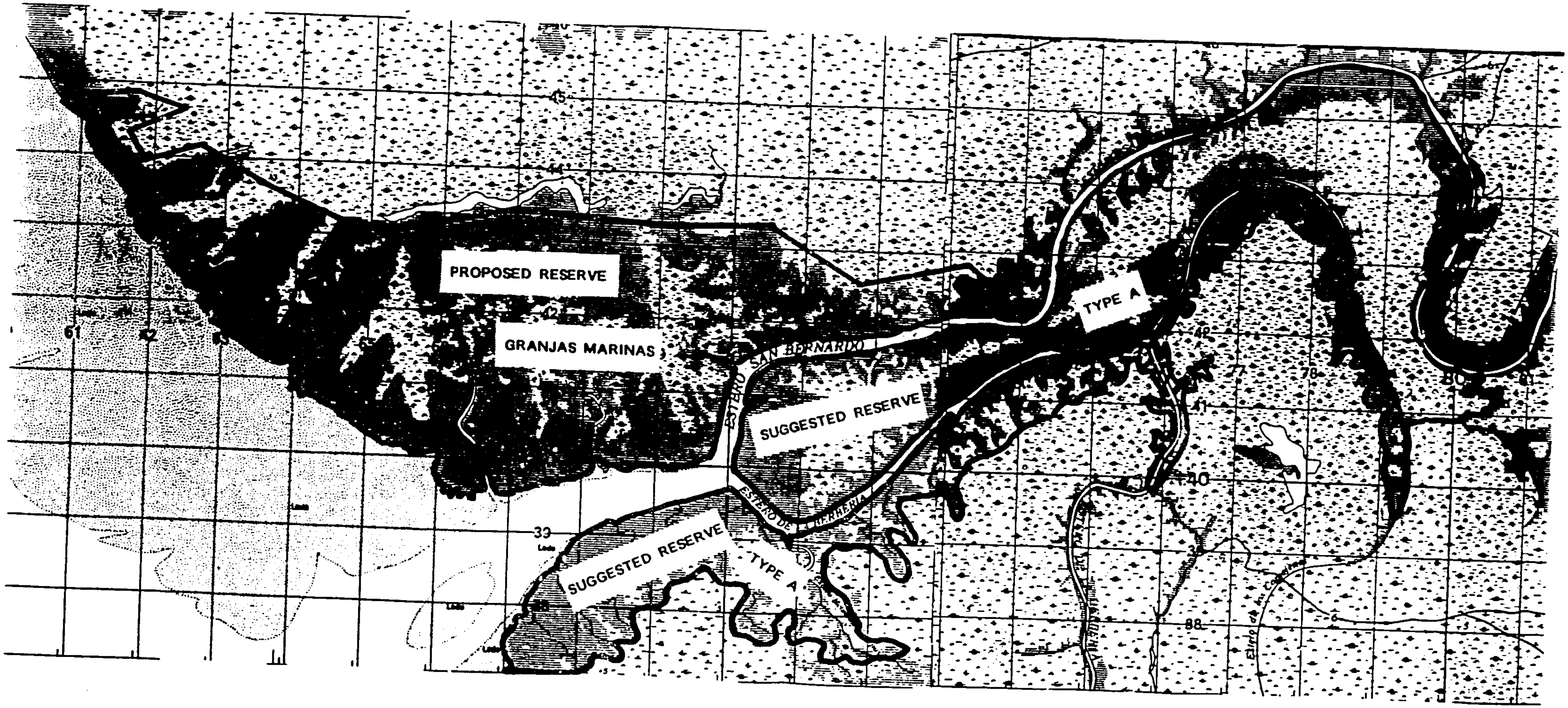


FIGURE FIVE

GULF OF FONSECA RESERVE AREAS

ACTUAL , PROPOSED OR SUGGESTED

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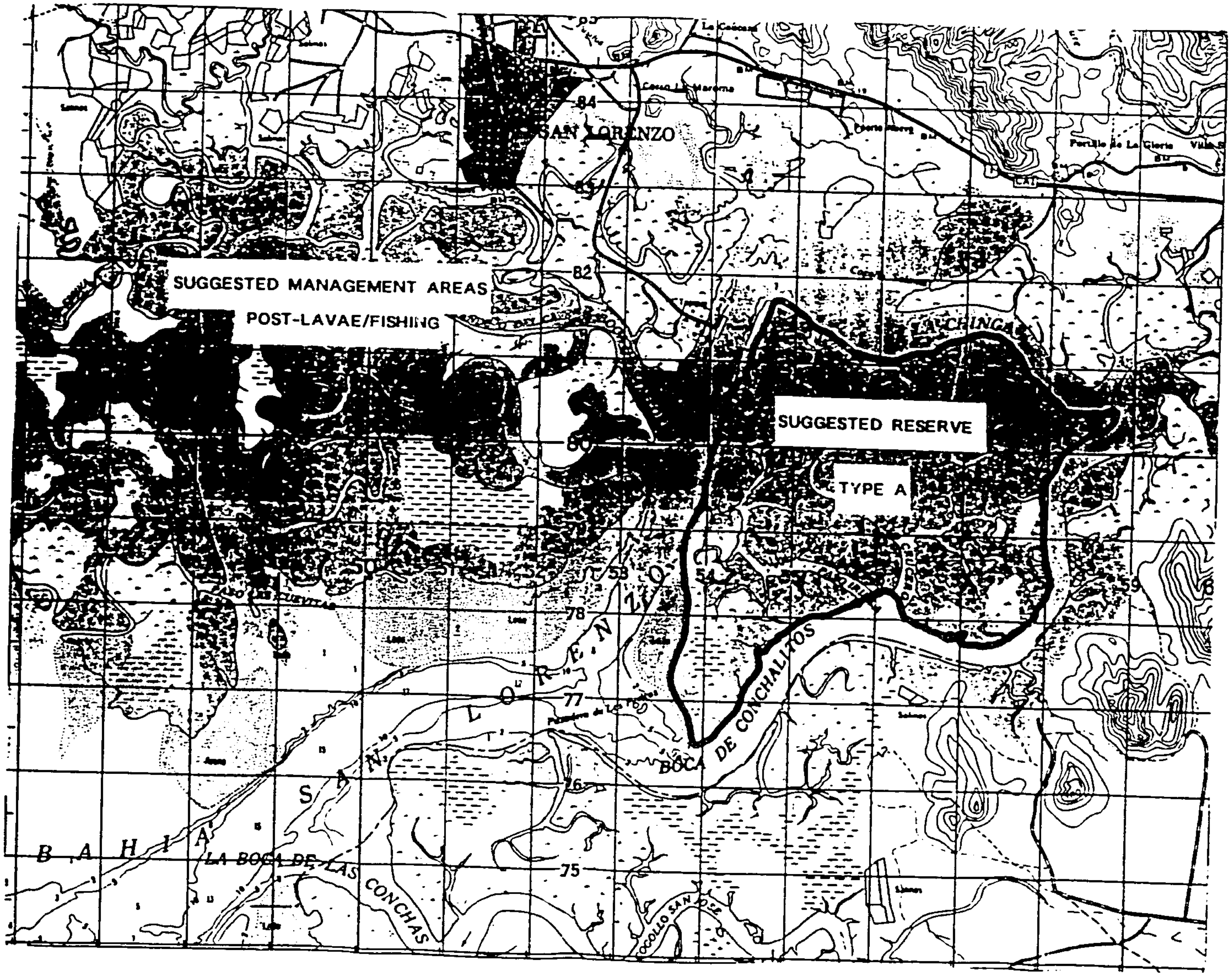
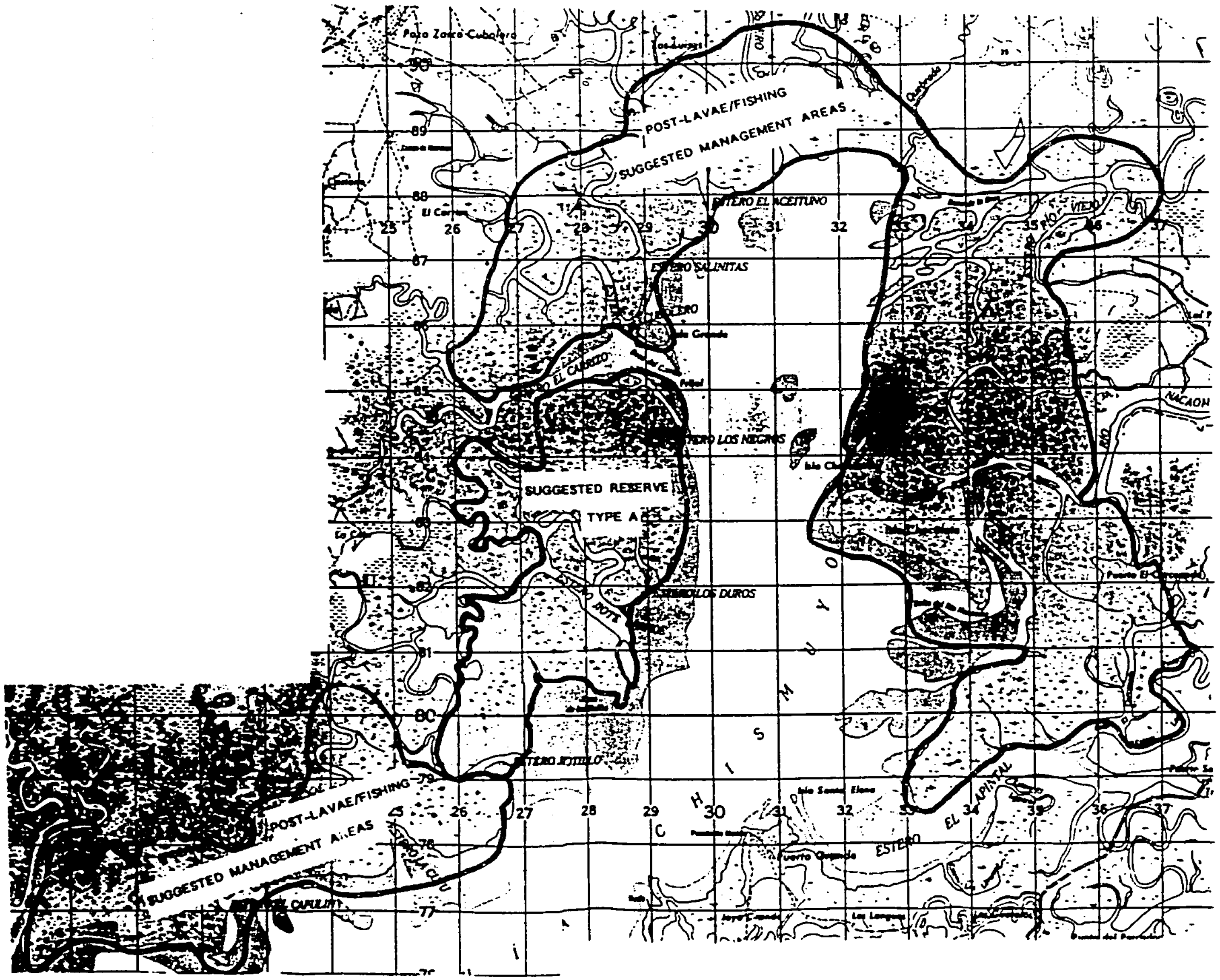


FIGURE SIX

GULF OF FONSECA RESERVE AREAS

ACTUAL , PROPOSED OR SUGGESTED



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Appendix E. Economically important plant and animal species of the Gulf of Fonseca region: common and scientific names

	Common Name	Scientific Name
Mangroves		
	Mangle Rojo	*Rhizophora harrissonii*
	Mangle Rojo	*Rhizophora mangle*
	Curumo Blanco	*Avicennia bicolor*
	Curomo Negro	*Avicennia germinans*
	Mangle Blanco	*Laguncularia racemosa*
	Botoncillo	*Conocarpus erectus*
Birds[1]		
	Aguilucho, Galivan Negro, Cola Blanca	*Buteogallus anthracinus* (rare)
	Gallinita de Agua	*Porphyrula martinica* (rare)
	Gallito de Agua	*Jacana spinoza* (rare)
	Alzaculito Playero	*Charadrius semipalmatus* (rare)
	Paloma Azulona	*Columba flavirostris* (rare)
	Sorzai	*Turdus grayi* (rare)
	Piche	*Dendrocygna autumnalis* (economic)
	Codorniz	*Colinus nigrogularis* (economic)
	Paloma Ala Blanca	*Zenaida asiatica* (economic)
Reptiles and Amphibians		
	Lagarto	*Crocodylus acutus* (endangered)
	Lagarto	*Caiman crocodilus* (threatened)
	Iguana	*Iguana iguana* (threatened)
	Golfina	*Lepidochelis olivacea* (endangered)
	Carey	*Eretmochelys imbricata* (endangered)
	Boa	*Boa constrictor* (endangered)
	Garrobo	*Ctenosaura similis* (economic)
Mammals[2]		
	Jaguar	*Felix onca* (endangered)
	Puma	*Felix concolor* (threatened)
	Tigrillo	*Felix pardalis* (endangered)
	Conejo Cola Blanca	*Sylvilagus floridanus* (economic)

[1] A detailed list of endemic and migratory species of the Gulf of Fonseca area has been prepared by Varela et al. (1985). For Honguras generally, including the gulf area, see the list prepared by Pilar (1987).

[2] Ten other species of mammals common to the southern coast of Honduras have been reported by Varela et al. (1986).

Venado Cola Blanca	*Odocoelleus virginianus* (economic)
Commercial Finfishes[3]	
Wiche	*Arius* sp. and *Ariopsis* sp.
Peperechin	*Albula vulpes* and *A. nemoptera*
Peje Chanco	*Pseudobalistes* sp.
Sapamiche	*Batrachoides* sp.
Peje Aguja	*Strongulura* sp.
Jurel	*Hemicaranx* sp.
Jurei	*Carnax vinctus*
Tiburon	*Rhyzopri*ⁿ*odon longuirio*
Robalo	*Centropomus pectinatus*
Robaio Ayante	*Centropomus robalito*
Robaio Aleton	*Centropomus nigrecens*
Sardina	*Lile stolifera*
Usugo	*Dormitatus maculatus*
Chopa	*Chaetodipeterus zonatus*
Sardina	*Anchoa* sp.
Caguacha	*Diapterus brevimanus*
Pargo Petate	*Lutianus* sp.
Pargo Guacamayo	*Lutianus colorado*
Pargo Mulato	*Lutianus novemfasciatus*
Pargo Berrugato	*Lobotes pacificus*
Lisa	*Mugil curema*
Peje Gato	*Polydactilus approximans*
Ruco Rayado	*Anisotremus* sp.
Ruco Cabezon	*Genuatremus* sp.
Ruco Negro	*Pomadasys macracanthus*
Ruco Dorado	*Haemulon scuderi*
Pancha Curbina	*Stellifer* sp.
Babosa Pinchada	*Cynoscion* spp.
Pancha	*Bairdiella* sp.
Pancha Rayada	*Paraionchurus* sp.
Pancha Coneja	*Menticirrhus nasus*
Macarela	*Scomberomorus* sp.
Picuda	*Sphyraena ensis*
Pez sapo	*Sphoeroides* sp.
Cuyamel	*Juturus pichardi* (threatened)

[3] Nineteen other species identified by Varela and Callejas (1987) are not considered commercially valuable.

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Mollusks		
	Curil	*Anadara tuberculosa*
	Casco de Burro	*Anadara grandis* (endangered)
	Oysters	*Crassostrea* sp. and *Ostrea* sp.
	Ubre	Gastropoda
Crustaceans		
	Camaron	*Penaeus vannamei*
	Camaron	*Penaeus stilyrrostris*
	Camaron	*Penaeus occidentalis*
	Langostino	*Macrobrachium* sp.

Appendix F. The IHHN Shrimp Virus

In recent years, there has been concern over declining catches of shrimp in the Sea of Cortez [Gulf of California]. Possible causes for the declining offshore catch are being debated. They include: (1) overfishing to the extent that the sustainable yield in the Gulf has been exceeded, (2) timing and insufficient duration of the closed season, (3) ineffective monitoring and enforcement of the closed season, (4) excessive pollution in bays and estuaries, (5) the reduced flow and increased salinity of water flowing into the northern Gulf from the Colorado River, (6) adverse effects of El Ñino [15.5.1], and finally, (7) the introduction of a new disease into the offshore shrimp fishery. The newly introduced disease, a virus, is referred to as "infectious hypodermal and hematopoietic necrosis" (IHHN). IHHN [16.5.18] occurs in some wild stocks of penaeid shrimp. Shrimp that are fished commercially in the Sea of Cortez are all in the genus *Penaeus*, colloquially termed "blues" (*Penaeus stylirostris*), "whites" (*P. vannamei*), and "browns" (*P. californiensis*).

While IHHN is now found in shrimp populations in the Sea of Cortez (first detected in 1990), it probably isn't indigenous to the area. Scientists working on IHHN don't know where it originated. Some data suggest that it originated in Southeast Asia and that it was introduced into the Americas in the early 1970s. Other scientists believe that IHHN also occurs in wild shrimp on the Pacific side of Central and South America and that the virus now in Mexico may have come from there. It is known to have been present in a shipment of shrimp which was imported into Sinaloa in 1987 and could have been introduced into Mexico as many as two years earlier by the developing aquaculture industry.

Shrimp were imported because farm ponds had been built and not enough seed was available for stocking aquaculture facilities from local sources, either from the wild or from hatcheries. Following importation, the virus spread from one aquaculture facility to another as farmers purchased contaminated postlarvae and broodstock. Many farms discharge effluent directly into estuaries, and, at times, the effluent contains small quantities of postlarval shrimp from hatcheries or larger shrimp from growout ponds. Also, periodic heavy rains have been known to cause ponds to overflow their banks, thus releasing shrimp into bays and estuaries. This type of occurrence was a likely source of contamination of wild stocks in the Sea of Cortez. Over recent years, IHHN and other penaeid diseases have spread to shrimp farms and offshore fisheries worldwide.

The virus inhibits normal development of the cells which form the shell of the shrimp (hypodermal) and blood cells (hematopoietic). In addition, the virus affects nerve tissue. The net effect of this is a weakened condition in which infected shrimp may more readily die from environmental stress (rapid changes in salinity resulting from heavy rainfall, low oxygen levels, and pollution) or predation. Eventually, in the absence of environmental stress or predation, the inhibition of cell development itself can kill infected shrimp. The rate of mortality in diseased shrimp varies greatly from species to species.

From observations made on shrimp farms, it is known that blue shrimp are very susceptible and may suffer heavy mortalities, especially in young shrimp and under crowded conditions. Farms may lose 80 percent or more of the shrimp in their nursery tanks.

From David Moore, *World Shrimp Farming*, July 1991. Reprinted by permission of the author.

White shrimp on the other hand are more resistant to the virus; however, even with this species farm losses are typically 20 percent or more of production as measured by growth and survival. The virus has been detected at low levels in wild brown shrimp, however, not much is known about the effects on this species. Farmers have not worked with browns as much as with the other species because preliminary work years ago indicated slower growth. The virus has not been detected in all species of penaeid shrimp and has not been found in any marine life other than shrimp.

Over the several years since the virus has been identified, there has been no evidence that infected shrimp are unsafe to eat. In laboratory studies IHHN virus showed no signs of growth or cytopathic effect (CPE) in baby hamster kidney cell culture (a mammalian cell line which supports the growth of many human viruses and shows CPE as a result of that growth). IHHN virus also did not grow in a number of warm and cold water fish and insect cell lines. Given that farm-raised shrimp now make up 25 percent of world production and that IHHN is relatively common in farm stocks around the world as well as occurring in nature, it is probable that infected shrimp have been consumed by man for many years with no reported ill effects. While there can be no proof that the virus has no effect on man until further scientific studies are run, given what we do know, it seems highly unlikely that there are any risks. There are other examples within the animal husbandry industry in which virus infected animals are routinely marketed for human consumption. Trout, catfish, chickens, and cattle suffer from a variety of virus diseases that are of no concern to regulatory agencies.

Is this virus disease the cause of the declining catch from the Sea of Cortez in recent years? Not enough is known about the effects of IHHN in nature to answer this definitively. We do know that young shrimp, sick with IHHN virus, have been collected from bays and estuaries in the Sea of Cortez since mid-1990. In addition, adult shrimp with IHHN have been found in open ocean samples. Considering sample results and what is known about IHHN's effects on inland farm production, it seems probable that the virus is playing a role in the decline of the catch of blue shrimp. Young shrimp in bays and estuaries would experience the heaviest mortalities. Not enough is known to speculate on the effects on the catch of browns. The catch of whites may be reduced, but probably not significantly, thus if fewer whites are being caught, other causes such as fishing in excess of the sustainable yield (as mentioned in paragraph one) should continue to be investigated. Consideration of these other causes should also not be neglected in assessing the catch of marine organisms such as fish, which are not known to be susceptible to IHHN, because they have declined as well.

While it would be difficult to predict the long-term effects of the virus, particularly as it affects the catch of the more susceptible blue shrimp, there is some basis for optimism. Shrimp which survive the virus may be surviving because of a genetic resistance. If this is the case, this trait may be passed on to their progeny, and, over a number of years, a strain of shrimp with some resistance to the virus may develop naturally, resulting in a degree of recovery of the blue shrimp fishery. In the short term, with less competition from blue shrimp, it is likely that there will be some encroachment into their habitat by whites and browns resulting in a gradually increasing catch of those species.

Sources: 1. Correspondence from David Moore (Environmental Research Laboratory, 2601 East Airport Drive, Tucson International Airport, Tucson, AZ 85706-6985, phone 601-741-1990, fax 601-573-0852), dated March 19, 1991. 2. IHHN Shrimp Virus: Its Introduction into Mexico and the Sea of Cortez, David Moore. Received March 23, 1991. Reprinted by permission of the author.

Selected references

"Agriculture Development Plan." 1986. Technical paper no. 9. Nippon Koei, Ltd., and CINSA-ICS.

"Agricultural Sector Strategy Paper." 1990. Tegucigalpa: USAID Office of Agriculture and Rural Development.

A.I.D./SECPLAN/DESFIL. 1989. Perfil Ambiental de Honduras.

"Análisis de la Situación Nutricional durante el Período 1972–1979." 1981. SAPLAN (Sistema de Analisis y Planificación de Alimentación y Nutrición). Tegucigalpa: Consejo Superior de Planificación Económico. Mimeographed.

Ardizzone, G.D., S. Cataudella, and R. Rossi. 1988. *Management of Coastal Lagoon Fisheries and Aquaculture in Italy*. FAO Fisheries Technical Paper no. 293; 103 pp.

Avault, James W. 1993. "Aquaculture: Environmental and Conservation Considerations." *Aquaculture Magazine*, January/February, 64–67.

Bailey, C. 1988. "The Social Consequences of Tropical Shrimp Mariculture Development." *Ocean Shoreline Development* 11:31–34.

Boyd, Claude E. 1992. "Shrimp Pond Effluents: Observation of the Nature of the Problem on Commercial Farms." *Proceedings of the Special Session on Shrimp Farming*. Baton Rouge, La.: World Aquaculture Society, 195–97.

Boyer, Jefferson. 1983. Agrarian Capitalism and Peasant Praxis in Southern Honduras. Ann Arbor, Michigan: University Microfilms. Ph.D. diss.

Castenada, Catherine, and Zoila Matamoros. 1990. "Environmental Analysis for the Investment and Export Development Project." USAID project document, 60 pp.

"Choluteca River Agricultural Development." 1986. Sector Report no. 6: Hydrology. Nippon Koei, Ltd., and CINSA, 132 pp.

Chua, T.E. 1989. "Will Coastal Management Programs Work in Southeast Asia?" in *Coastal Area Management in Southeast Asia: Policies, Management Strategies, and Case Studies*, edited by T.E. Chua and D. Pauly (Proceedings of the Asian/U.S. Policy Workshop on Coastal Area Management, Johore Bahru, Malaysia, October 24–27, 1988), ICLARM Contr. (543): 231–40.

CODDEFFAGOLF (Comité para la Defensa y Desarrollo de la Flora y Fauna del Golfo de Fonseca). 1993. Boletín Informativo no. 13. Tegucigalpa: CODDEFFAGOLF.

[3EM DASH]/Mision Técnica del Japon. 1991. "Encuesta para los Recolectores—Proveedores del Golf de Fonseca." Tegucigalpa: CODDEFFAGOLF/Mision Técnica del Japon.

COHDEFOR. 1992. "Propuesta para el Desarrollo de la Administración Forestal del Estado y Determinación de los Requerimientos de Recursos Humanos y Niveles Salariales." Tegucigalpa: Departamento de Planificación, December.

"Collaboration for Sustainable Development in the Gulf of Fonseca." 1992. Morrilton, Arkansas: Winrock International Environmental Alliance, October.

Comisión Nacional del Ambiente. 1992. "Ley General del Ambiente." Tegucigalpa: Presidencia de la República, September.

CONAMA (Comisión Nacional del Medio Ambiente y Desarrollo). 1992. "Honduras Environmental Agenda 1992." Tegucigalpa: CONAMA.

Conniff, Richard. 1991. Why Catfish Farmers Want to Throttle the Crow of the Sea. *Smithsonian* 22(4): 44-55.

"Conservación de los Ecosistemas Costeros del Golfo de Fonseca." 1992. Project proposal prepared for Agencia Danesa para el Desarrollo Internacional. Tegucigalpa: Unión para la Naturaleza Mundial.

CONSUPLANE (Secretaría Técnica del Consejo Superior de Planificación Económica). 1982. *Las Regiones: Planificación*. Tegucigalpa: CONSUPLANE.

Cruz, Gustavo Adolfo. 1986. *Guia de los Parques Nacionales, Refugios de Vida Silvestre, Reservas Biológicas, y Monumentos Naturales de Honduras*. Tegucigalpa: Asociación Hondureña de Ecología.

CSPE/OEA (Secretaria Técnica del Consejo Superior de Planificación Económica y Secretaría General de la Organización de Estados Americanos). 1982. "Projecto de Desarrollo Local del Sur de Honduras." Tegucigalpa: CSPE/OEA.

DAFCA-PAFT-CA, Proyecto CE-1. 1991. "Plan de Acción Forestal Tropical para Centro-america, Conservación de los Recursos Costeros del Golfo de Fonseca," 47 pp.

DeWalt, Billie R. 1983. "The Cattle Are Eating the Forest." *Bulletin of the Atomic Scientists* 39: 18-23.

——. 1985. "Microcosmic and Macrocosmic Processes of Agrarian Change in Southern Honduras: The Cattle Are Eating the Forest." In *Micro and Macro Levels of Analysis in Anthropology: Issues in Theory and Research*, edited by Billie R. DeWalt and Pertti J. Pelto. Boulder, Colo.: Westview Press, 165-86.

——. 1986. "Economic Assistance in Central America: Development of Impoverishment?" *Cultural Survival Quarterly* 10: 14-18.

——. 1984. "Sistemas de Cultivo en Pespire, Sur de Honduras: Un Enfoque de Agroecosistemas." Tegucigalpa: Instituto Hondureño de Antropología e Historia, Estudios Antropológicos e Históricos no. 4.

DeWalt, Billie R., and Kathleen M. DeWalt. 1982. "Cropping Systems in Pespire, Southern Honduras." Farming Systems Research in Southern Honduras report no. 1. Lexington, Kty.: University of Kentucky Department of Anthropology.

DeWalt, Billie R., and Susan C. Stonich. 1992. "Inequality, Population, and Forest Destruction in Honduras." Paper presented to the International Union for the Scientific Study of Population Seminar on Population and Deforestation in the Humid Tropics, Campinas, Brazil, December 2.

Dewalt, Kathleen M., and Billie R. DeWalt. 1987. "Nutrition and Agricultural Change in Southern Honduras." Food and Nutrition Bulletin 9(3): 36-45.

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———. 1989. "Incorporating Nutrition into Agricultural Research: A Case Study from Southern Honduras." In *Making Our Research Useful: Case Studies in the Utilization of Anthropological Knowledge,* edited by John van Willigen, Barbara Rylko-Bauer, and Ann McElroy. Boulder, Colo: Westview Press.

DGECH (Dirección General de Estadística y Censos). 1954. "Censo Nacional Agropecuario 1952." Tegucigalpa: Dirección General de Estadistica y Censos.

———. 1968. "Censo Nacional Agropecuario 1965." Tegucigalpa: Dirección General de Estadistica y Censos.

———. 1976. "Censo Nacional Agropecuario 1974." Tegucigalpa: Dirección General de Estadística y Censos.

———. 1988. *Características Generales, Educativas, y Económicas por Departamento.* Vol. 1: *Censo Nacional de Vivienda 1988.* Tegucigalpa: Dirección General de Estadística y Censos.

Dickinson, Joshua C. III, ed. 1982. Honduras: Environmental Profile, a Case Study. McClean, Va.: JRB Associates (AID/SOO/PDC C-0247), 201 pp.

Dickinson, Joshua C., et al. 1985. "Environmental Assessment of the Small-Scale Shrimp Farming Component of the USAID/Honduras Rural Technologies Project." Gainesville, Fla.: Tropical Research and Development, Inc.

Dickinson, J.P., P.V. Vergne, C. Villeda, et al. 1988. "Study of the Honduran Shrimp Industry." Gainesville, Fla.: Tropical Research and Development.

DIGEPESCA. 1993. "Summary of Gulf of Fonseca Shrimp Farms Wild Larvae Use Percentages and Labor Requirements." Source data sent to DIPESCA.

Durham, William. 1979. *Scarcity and Survival in Central America: Ecological Origins of the Soccer War.* Stanford: Stanford University Press.

"Environmental Assessment: Land Use and Productivity Enhancement Project (522-0292)." [n.d.] Tegucigalpa.

Flores, Juan, and Carlos Reiche. 1990. "El Consumo de Leña en las Industrias Rurales de la Zona Sur de Honduras." Turrialba, Costa Rica: CATIE.

Foer, Gordon. 1992. "Profile of the Coastal Resources of Honduras." In *Central America's Coasts: Profiles and an Agenda for Action*, edited by Gordon Foer and Stephen Olson. Narraganset, R.I.: University of Rhode Island Coastal Resources Center, 165–97.

FPX. 1989. Plan de Desarrollo del Camaron en Honduras. Tegucigalpa: USAID/Honduras.

Gilderhus, P.A., V.K. Dawson, and S.L. Allen. 1988. "Deposition and Persistence of Rotenone in Shallow Ponds During Cold and Warm Seasons." Lacrosse, Wis., US Fish and Wildlife Service, National Fisheries Research Center, publ. no. 95, 7 pp.

Gonzalez, J.R., et al. 1987. "Situación de la Carcinocultura en la Costa Sur de Honduras." Tegucigalpa: RENARE. (Cited in SECPLAN/DESFIL 1989).

Guevara, R. 1991. "Ponencia sobre la Acuicultura en Honduras, con Enfasis en el Cultivo de Camaron." Tegucigalpa: Vice Ministro de Recursos Naturales de Hondnias, 10 pp.

Hargreaves, George. 1980. "Monthly Precipitation: Probabilities for Moisture Availability for Honduras." Logan, Utah: Utah State University Report.

"Honduras Environmental Profile." 1979. USAID/LAC and University of Arizona.

Jarvis, Lovell S. 1986. "Livestock Development in Latin America." Washington, D.C.: World Bank.

Klein, Duke, and Paul Purdy." 1976. "Observaciones Preliminares sobre la Familia Psittacidae (Guaras, Loras, y Pericos) en Honduras." Tegucigalpa: Secretaría de Recursos Naturales, Dirección General de Recursos Naturales Renovables, Departamento de Vida Silvestre.

Leonard, H. Jeffrey. 1987. *Natural Resources and Economic Development in Central America.* New Brunswick, N.J.: Transaction Books.

McNaughton, S.J., and Larry L. Wolf. 1973. *General Ecology.* New York: Holt, Rinehart and Winston, Inc.

Meckenstock, Dan, David Coddington, Juan Rosas, Harold van Es, Manjeet Chinman, and Manuel Murillo. 1991. "Honduras Concept Paper: Towards a Sustainable Agriculture in Southern Honduras." Paper presented at the International Sorghum/Millet Collaborative Research Support Conference, July 8-12, Corpus Christi, Texas.

Mendola, D., and E. Ramirez. 1985. "Importancia Económica de los Huevos de la Tortuga Golfina (*Lepidochelys olivacea*) en Honduras." Tegucigalpa: Secretaría de Recursos Naturales, Dirección General de Recursos Naturales Renovables, Departmento de Investigación Aplicada, February.

Michigan State University, CRIES Project. 1984. Resource Assessment of the Choluteca Department. Tegucigalpa: Ministerio de Recursos Naturales de Honduras.

Minarik, Cynthia. 1985. "Importancia Económica de los Huevos de la Tortuga Golfina (*Lepidochelys olivacea*) en Honduras." Tegucigalpa: Secretaría de Recursos Naturales, Dirección General de Recursos Naturales Renovables, Departmento de Investigación Aplicada, February.

Morales, L., and E. Nieto. 1990. "Censo de Pescadores Artesanales en el Oceano Pacifico de Honduras (Golfo de Fonseca)." Informe al Director General de RENARE, 12 pp.

National Public Radio. 1992. "All Things Considered." Series on vanishing homelands, transcript of program broadcast April 18.

"Observaciones Generales sobre Manejo de Palomas Migratorias en Honduras. 1976. Tegucigalpa: Departamento de Vida Silvestre.

DIGEPESCA/SECPLAN (International Coordination Group). 1990. "Diagnóstico del Sector Pesquero de Honduras." In *Fisheries Economics and Planning*, edited by Interinstitutional Coordination Group, OLDEPESCA/SECPLAN/DIGERENARE. Tegucigalpa: Ministry of Planning (SECPLAN), 235 pp.

Pannier, F., and R. Pannier. 1977. "Interpretación Fisioecológica de la Distribución de Manglares en las Costas del Continente Suramericano." *Interciencia* 2(3): 153-62.

Pease, Norman L., Rolf Juhl, and Donald McCreight. 1983. "Honduran Fisheries Survey." May.

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"Perfil Ambiental de Honduras 1989." 1989. Tegucigalpa: SECPLAN (Secretaría de Planificación, Coordinación, y Presupuesto) and DESFIL (Development Strategies for Fragile Lands).

"Perfil del Proyecto: Protección y Dessarrollo de los Manglares/Golfo/Fonseca." 1984.

"Plan de Desarrollo del Camaron en Honduras." 1989. Tegucigalpa: USAID/Honduras, 1989.

"Proyecto: Ley General de Pesca." 1986. Tegucigalpa: DIGEPESCA.

Pruder, Gary D. 1992. "Marine Shrimp Pond Effluent: Characterization and Environmental Impact." Proceedings of the Special Session on Shrimp Farming, World Aquaculture Society, 187-89. Baton Rouge, Louisiana.

Purdy, Paul C. 1976. "Observaciones Generales sobre Manejo de Palomas Migratorias en Honduras." Tegucigalpa: Dirección General de Recursos Naturales Renovables, Departamento de Vida Silvestre.

"Resource Assessment of the Choluteca Department." 1984. Prepared for Michigan State University, CRIES Project, and Ministerio de Recursos Naturales de Honduras.

Rosenberry, Bob. 1990. "Major Mortality Problem Hits Ecuadorean Shrimp Ponds." *World Shrimp Farming*, 15(5): [n.p.].

———. 1991. Urgencias y Esperanzas: Datos Prioritarios para los Retos del Noventa. Tegucigalpa: SECPLAN.

Schnick, R.A. 1974. "A Review of the literature on the Use of Rotenone in Fisheries." Lacrosse, Wisc., U.S. Fish and Wildlife Service, Fish Control Laboratory. NTIS, no. PB-235 454, 130pp.

Scura, Edward D. 1988. "Export Development at Enterprise Level of Shrimp and Shrimp Products from Central American Countries." New York: International Trade Center (UNCTAD/GATT), October.

Secretaria de Recursos Naturales. 1987. "Situación de la Carcinocultura en la Costa Sur de Honduras." Tegucigalpa: Dirección General de Recursos Naturales Renovables, Departamento de Planificación, March.

Shotton, R. 1988. "Export Development at Enterprise Level of Shrimp and Shrimp Products from Central American Countries." New York: International Trade Center (UNCTAD/GATT), November.

———. 1987. "Report on a Mission to Analise Factors Affecting the Shrimp Industry in Honduras." New York: International Trade Center, December.

Siirila, Erkki J. 1991. Coastal Area Management in the Gulf of Fonseca. Newcastle-upon-Tyne, England: University of Newcastle-upon-Tyne Department of Biology Centre for Tropical Coastal Management Studies.

Stares, R.C. 1972. "La Economia Campesina en la Zona Sur de Honduras, 1950-1970: Su Desarrollo y Perspectivas para el Futuro." Informe presentado a la Prefectura de Choluteca, Honduras.

Stonich, Susan C. 1986. Development and Destruction: Interrelated Ecological, Socioeconomic, and Nutritional Change in Southern Honduras. Ph.D. diss., University of Kentucky. Ann Arbor, Mich.: University Microfilms.

———. 1989. "The Dynamics of Social Processes and Environmental Destruction: A Central American Case Study." *Population and Development Review* 15: 269-96.

———. 1991. "Rural Families and Income from Migration: Honduran Households in the World Economy." *Journal of Latin American Studies* 15(2): 131-61.

———. n.d. "Enduring Crises: The Political Ecology of Poverty and Environmental Destruction in Honduras." In press.

Stonich, Susan C., and Billie R. DeWalt. 1989. "The Political Economy of Agricultural Growth and Rural Transformation in Honduras and Mexico." In *Human Systems Ecology: Studies in the Integration of Political Economy, Adaptation, and Socionatural Regions*, edited by S. Smith and E. Reeves, 202-30. Boulder, Colo.: Westview.

"Strategic Considerations for the Agricultural Sector in Honduras." 1989. Tegucigalpa: Office of Agriculture and Rural Development, USAID/Honduras, draft copy.

Sundheimer, Paul. 1977. "Renewable Natural Resources." October.

Unión Mundial para la Naturaleza Mundial. 1992. "Conservación de los Ecosistemas Costeros del Golfo de Fonseca" (project proposal prepared for Agencia Danesa para el Desarrollo Internacional). Tegucigalpa: Unión para la Naturaleza Mundial.

USAID (United States Agency for International Development). 1989. *Strategic Considerations for the Agricultural Sector in Honduras*. Tegucigalpa: Office of Agriculture and Rural Development, USAID/Honduras.

———. Agricultural Sector Strategy Paper. Tegucigalpa: Office of Agriculture and Rural Development, USAID/Honduras.

"Urgencias y Esperanzas: Datos Prioritarios para los Retos de Noventa." 1991. Tegucigalpa: SECPLAN (Secretaria de Planificación, Coordinación, y Presupuesto).

Varela, Jorge, and A. Callejas. 1986. "Lista de Pesces, Mamiferos y Reptiles del Golfo de Fonseca." Tegucigalpa: Honduran Ecology Association, 1 p.

Varela, Jorge, and Wilberto Aguilar. 1988. "Plan de Manejo para los Recursos Costeros del Golfo de Fonseca." Tegucigalpa: Asociación Hondureña de Ecología.

Varela, Jorge, Carlos A. Cerrato, and Jeremias Milla. 1985. "Identificación y Mapeo de las Areas de Pesca Artesanal y de Habitat de Aves Migratorias en el Golfo de Fonseca." Tegucigalpa: Asociación Hondureña de Ecológica.

———. 1987. "Identificación y Mapeo de las Areas de Pescal Artesanal y de Habitat de Aves Migratorias en el Golfo de Fonseca." Follow-up to the environmental assessment of the small-scale shrimp farming component of USAID/Honduras Rural Technologies Project, 11 pp. and annex.

Vega, Alberto. 1989. "Medio Ambiente y Desarrollo en la Zona Sur de Honduras." Tegucigalpa: Dirección General de Planificación Territorial, Proyecto de Estrategias de Desarrollo para Tierras Fragiles (DESFIL).

———. 1989. "Programa de Gestión Ambiental Estudio de Caso: Medio Ambiente y Desarrollo en la Zona Sur de Honduras." DESFIL project. Gainesville, Fla.: USAID/DESFIL and Tropical Research and Development, Inc.

Wainwright, F.W. 1993. "Caracterización Biofísica y Declaratoria como Area Forestal Protegida del Refugio de Vida Silvestre San Bernardo, en el Municipio de Choluteca." Choluteca, Honduras: Granjas Marinas San Bernardo.

———. 1992. "Evaluación de Plantaciones de Avicennia Nitida (Jacq) y Establecimiento de una Zona de Refugio Vida Silvestre en el Area de Influencia Finca Acuicola 'Cumar' (Choluteca, Honduras: San Bernardo, Municipio de Choluteca, Departamento de Choluteca)." Choluteca, Honduras: Cultivos Marinos, SA "Cumar."

White, Robert A. 1977. "Structural Factors in Rural Development: The Church and the Peasant in Honduras." Ph.D. diss. Cornell University.

Williams, Robert G. 1986. "Export Agriculture and the Crisis in Central America. Chapel Hill: University of North Carolina Press.

Young, Kendal. 1990. "Lists de las Aves de Honduras." Tegucigalpa: Peace Corps/Honduras. 12 pp.

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