TECHNICAL REPORT SERIES TR-E-6

McPadden, C. (1989) The Ecuadorian Shrimp Trawl Fishery, 1974-1985. In: Olsen, S. and Arriaga, L., editors. A Sustainable ShrimpMariculture Industry for Ecuador. Narragansett, RI: Coastal Resources Center, University of Rhode Island

A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

Edited by Stephen Olsen and Luis Arriaga

International Coastal Resources Management Project

The University of Rhode Island

The Shrimp Fishery

The Ecuadorian Shrimp Trawl Fishery, 1974-1985

La Pesquería del Camarón con Buques de Arrastre, 1974-1985

Charles McPadden

Resumen

Hasta comienzos de los años 70, la producción de camarones en Ecuador consistió en capturas en el mar. El promedio fue de 6.000 a 8.000 t.m., peso entero. Luego ocurrió la expansión de la industria del cultivo de la especie Penaeus vannamei y, en menor extensión, de P. stylirostris. El año de mayor producción fue 1983, con unas 44.000 t.m. de camarón entero. El aumento de este año se debió principalmente a la presencia del evento de El Niño. En los demás años la captura se mantuvo entre 33.000 y 35.000 t.m. de camarón entero, por año.

El número de buques no ha cambiado sustancialmente en este período, pero se incrementó la presión de pesca sobre los "stocks" de postlarvas (pls), debido al aumento de las hectáreas de piscinas en producción (94.000 ha autorizadas, a fines de 1985). La demanda anual de pls se estimó en unos 6,6 x 10^9 pls, con un mínimo de siembra en 1985 de 2,5 - 2,6 pls x 10^9 Durante 1984 y 1985 se ha observado muy bajas capturas de pls.

La flota camaronera se expandió de 30 buques en 1954 a unos 249 en 1985, la mayoría entre 50 y 70 pies de eslora.

En la pesca del camarón blanco (P. occidentalis, P. stylirostris y P. vannamei) en el Golfo de Guayaquil, durante los primeros años dominó P. occidentalis, declina gradualmente hasta 1983 cuando sólo significó el 20% de las capturas. En 1985 aumentó al 37%. En cambio P. vannamei aumentó del 8% hasta un 40%, en el mismo período. En el primer semestre de 1986 la composición por especies de las capturas fue de 54%, 29% y 17% para P. occidentalis, P. stylirostris y P. vannamei, respectivamente. Hacia el Norte del Golfo, desde la Punta de Santa Elena hasta el cabo de San Francisco, las capturas de P. stylirostris forman entre el 20 y 40% de las capturas. Las otras dos especies van del 6 al 25%.

Los datos sobre frecuencias de longitud del camarón blanco, muestran una disminución del promedio (longitud de cola) entre abril y junio, que corresponde al período del reclutamiento a la pesquería. Por otra parte, no se ha establecido correlaciones entre los parámetros ambientales y la abundancia de pls y adultos de camarón. A este respecto, en los laboratorios, el desove exitoso de P. vannamei y P. stylirostris requiere temperaturas entre 25° y 30°C, anotando que las temperaturas en el Golfo de Guayaquil de abril a noviembre usualmente están bajo este rango. El inicio de la época principal de desove está asociada al aumento de la temperatura en el Golfo, debido al ingreso de aguas cálidas del norte. Así, la estación de desove está entre noviembre-abril, que coincide con el período de mayor abundancia de pls en la línea de costa. De abril en adelante, la temperatura en el Golfo baja de 25°C, por influencia de la Correinte de Humboldt. Al Norte, en Esmeraldas por ejemplo, las temperaturas son altas todo el año y el "stock" tiene un período más extendido que en el Golfo.

En el trabajo, el autor analiza otros aspectos de la pesquería, tales como los datos sobre frecuencia de longitudes, las capturas por unidad de esfuerzo y asuntos económicos. Anota que parece prudente reducir el esfuerzo de pesca mediante la implantación de vedas durante el principal período de reclutamiento, no obstante que puede presentar conflictos de intereses entre dueños de buques y cultivadores. Anota varias medidas reguladoras de la pesquería establecidas desde 1977, pero que no han sido totalmente aplicadas.

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Introduction

Until the early 1970s Ecuadorian shrimp production consisted mainly of sea harvest shrimp. Annual production during this period averaged between 6,000 and 8,000 metric tons of whole shrimp. Since then production has steadily increased due to the expansion of the shrimp aquaculture industry which produces white shrimp of the species *Penaeus vannamei* and to a lesser extent *Penaeus stylirostris*.

In 1983 production peaked at an estimated 44,000 m.t. of whole shrimp. This dramatic increase was primarily influenced by the increase in sea catches due to the effect of the El Niño event throughout the year. Since then production has decreased and remained at between 33,000 and 35,000 m.t. of whole shrimp per annum.

Although the number of vessels fishing shrimp has not changed substantially during this period, there as been an increase in fishing pressure on postlarval shrimp stocks due to the increase in hectares (ha) under production. Direccion General de Pesca figures estimate a total of 94,000 hectares of authorizations up to December 1985.

Shrimp growers have relied almost entirely on wild-caught postlarvae (PL) to seed their growout pond, which has resulted in the development of an extensive postlarval fishery in the saltwater creeks (esteros) and along the Ecuadorian coastline. The current annual demand for postlarvae is estimated to be in the region of 6.6 billion[1] and it is estimated that a minimum of 2.5-5.6 billion[2] postlarvae were harvested to produce the 1985 pond-raised shirmp crop.

Poor catch rates in the offshore fishery and a postlarval scarcity on the Guayas coastline after the main breeding period during 1984 and 1985 caused concern in the industry as to whether the decline was due to the heavy fishing pressure on stocks which eventually might lead to the collapse of the trawl and postlarval fisheries. As a result, the trawl fishery was closed from December 15, 1985 to January 31, 1986 during the breeding season for white shrimp. It was also prohibited to fish for postlarvae from June 1 to July 31, 1986.

The lack of information on the fishery became apparent during this crisis period. As a result, a joint Overseas Development Administration/Instituto Nacional de Pesca technical cooperation program was established in 1985 to set up a data base on the trawl fishery and carry out research into the distribution, abundance and spawning of the commercially important shrimp species. This program, combined with research being carried out on postlarval stocks and oceanographic research, would provide the Instituto Nacional de Pesca with a base on which to manage the shrimp fisheries.

The purpose of this paper is to review the trawl fishery using data available at the Instituto National de Pesca up to 1985 with emphasis on the most important group of the white species *Penaeus occidentalis, Penaeus stylirostris, Penaeus vannamei* , and to outline further research and management lines.

Data Sources

Information on total production, fleet size and shrimp exports has been made available through the Dirección General de Pesca, the government agency responsible for compiling statistics on the shrimp industry.

Data on catch rates has been obtained by monthly interviews with shrimp vessel skippers. Monthly data on species composition, length frequency (tail length, measured to the end of the telson), and catch composition by species weight have also been obtained by Instituto Nacional de Pesca from factory samples of the landed catch in Guayaquil.

The catch per unit of effort (CPUE) has been calculated as the average catch per fishing day of the total reported catch per fishing trip. It has not been possible to separate the different commercial shrimp types in the reported catch data. Interview data has been used as a general index of the distribution of fishing effort.

Data on production of the different commercial trip types has been obtained from an analysis of quality control certificates (Certificados de Control de Calidad) held by the Instituto Nacional de Pesca.

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[1] 30,000 ha/2.2 crops per annum, 50,000 PL/ha 50% mortality

[2] 18,222 m.t. of pond shrimp/35 tails/1b, 50 percent to 70 percent mortality

The data analysed are from the fishery in the Gulf of Guayaquil. Although the fishery exists all along the Ecuadorian coastline, insufficient data were available to carry out an analysis of the whole fishery.

General Description of the Fishery

According to Cobo and Loesch (1966), the offshore trawl fishery commenced in 1952, and the catch during that period was consumed locally. It was not until 1954 that the first shrimp were exported to the United States. McPadden (1985) gives information on the fleet size and total landings from 1954 to 1984. The fleet expanded from 30 vessels in 1954 to some 249 registered vessels operating in 1985.

The bulk of the vessels operate out of Guayaquil into fishing grounds in the Gulf of Guayaquil. A small fleet of some 52 vessels based at Posorja at the mouth of the Gulf of Guayaquil operate a day fishery into grounds between Puna and Playas, concentrating on Pomada/Titi shrimp. Other important centers for the trawl fishery are in Esmeraldas in the north, where some 26 vessles are permanently based and which is also fished by vessels from Guayaquil. The Manta/Palmare stretch of the coast is fished by vessels from Guayaquil, and Manta is used as a landing and refueling port. Although no up-to-date data are available on landings by areas, Arana, Freire and Marín (1978) estimated that 66 percent of the 1976 catch was landed in Guayaquil, 24 percent in Esmeraldas, and the rest in Manta and Bahia de Caráquez.

The majority of the vessels are 50-70 feet in length with engines ranging from 220 hp to 440 hp. Most of the vessels are fitted with refrigerated seawater tanks and spend 15 to 22 days at sea per trip. Some of the smaller vessels, mainly those that fish Pomada/Titi, carry ice and can spend up to four days at sea. All vessels use double-rigged otter trawls with mesh sizes of 2 ins. in the main body of the net and 1.4 ins. in the cod end.

The bulk of the production (see Tables 1a,b,c) is white shrimp, which formed approximately 90.3 percent of the production in 1985. White shrimp are generally fished in shallow waters at 5 to 15 fathoms.

Red and brown shrimp formed 1.84 percent of the production in 1985 with red shrimp being the most important of the two. This species, *Penaeus brevirostris* is, fished in depths of 20 fathoms and greater, forms an important fall back for the fleet in times when white shrimp are scarce. In recent years there has been an increase in landings of this species.

Pomada/Titi formed 4.34 percent of the production in 1985 and, as previously mentioned, is an important fishery for the Posorja based fleet. Its production has remained relatively stable over the years. Cobo and Loesch (1966) noted that production of Pomada/Titi was 1352 m.t. in 1964.

Tiger shrimp are caught in the shallow waters in the mouth of the Gulf of Guayaquil and also form an important part of the Posorja fleet landings. Most of the production goes for internal consumption.

Carapachudo shrimp, a species of red shrimp found in relatively deep water, forms an important fishery for the fleet operating in the Esmeraldas area; production from this fishery has been increasing in recent years.

The deepwater shrimp fishery has developed over the past five years. This fishery has not been studied in any detail and little is known of its future potential for expansion.

Total Catch and Catch Per Unit Effort (CPUE)

Very little information exists on fleet operations, distribution of fishing effort, total fishing effort and catch statistics. In the absence of better data, estimates of production have been made for the fishery as a whole using CPUE data for the Gulf of Guayaquil.

Tables 1a,b,c show the total production figures for the different types of shrimp. The methods of estimating the figures and data sources are listed at the end of the table. No data from quality control certificates was available for the period of 1974 to 1978; figures obtained from the Dirección General de Pesca were used for these years. The estimates for sea-produced shrimp have been calculated from CPUE data from the Gulf of Guayaquil allowing a standard 22 fishing days per month and the number of vessels registered per annum. These estimates are problably higher than the real numbers, however,

they are useful in demonstrating trends in the fishery in a general manner, as only limited effort data and no relative CPUE data by shrimp type and area are available.

Of greatest interest is the white shrimp production which appears to have remained relatively stable between 1974 and 1977. After 1977 the production decreased by approximately 1000 m.t. and again remained relatively stable until 1983 when it rose dramatically during the El Niño period. The estimated white shrimp catch during 1984 was extremely low based on the high exports of red and brown shrimp during that year. It is likely that some of the red and brown shrimp exported in 1984 were shrimp held back during 1983 when production was high. The figures have been recalculated allowing for the same production in 1984 and 1985 and is less than 50 percent of the 1974-1977 annual production.

The composition of the white shrimp production for each species has been estimated in Table 1c using weight data from factory samples of the landed catch. Between 1974 and 1977 the overall quantity of *P. occidentalis* and *P. stylirostris* remained relatively stable. There was a gradual increase in the amount of *P. vannamei* until 1977 when the weight in factory samples increased by 40 percent over the 1974 figure.

Between 1978 and 1983 there was a gradual decrease in the amounts of *P. occidentalis* and *P. stylirostris* landed and a corresponding increase in the quantity of *P. vannamei*. By 1982 the amount of *P. vannamei* landed was almost treble the amount in 1974, and landings of *P. occidentalis* had decreased by more than half the original 1974 value. *P. stylirostris* began to decline in 1977 and continued to decline to reach a similar level as the 1974 landings.

1983 was an exceptional year due to the effects of the El Niño phenomenon, and landings of all three species increased dramatically. *P. vannamei* and *P. stylirostris* landings were both some 1000 m.t.. higher than *P. occidentaliss*,which in earlier years dominated the catch.

The low catch rates and consequent low production in 1984 and 1985 mean a further decrease in landings of white shrimp.

During 1985 the amount of *P. vannamei* decreased by 24 percent and *P. stylirostris* by 32 percent of pre El Niño figures. *P. occidentalis* figures decreased by 45 percent during the same period. The overall production of *P. vannamei* during 1984 and 1985 appears to have remained stable, whereas the other two species declined in the landed catch.

Figure 1 shows the average daily catch rate per month from 1980 to June 1986. It has not been possible to allow for differences in fishing power in the various types of fishing vessel nor has it been possible to separate out the different commercial types from the reported catch.

Prior to 1983, catches peaked between the May to July-August period, corresponding to the main recruitment season into the fishery. The 1982, 1984 and 1985 recruitment peaks are not well defined and there appears to have been a general decline in CPUE over that period, except for 1983. Data for 1986 indicate that the CPUE increased after the December-February closure and, although initially higher than that for the past two years, it is declining to a level similar to that of those years.

Species Composition of White Shrimp Catches

The annual species composition of white shrimp catches is shown in Figures 2a and b. From Figure 2a, it can be seen that *P. occidentalis* dominated the catches during the early years in the Gulf of Guayaquil and has gradually declined between then and 1983, when it formed only 20 percent of the numbers sampled. *P. vannamei* , on the other hand, increased from 8 percent to approximately 40 percent during the same period. The percentage of *P. stylirostris* has remained relatively stable between 25 percent to 40 percent of the shrimp sampled. Data for 1985 indicate that the percentage of *P. occidentalis* has increased to 37 percent of the shrimp sampled. In the first six months of 1986, overall species composition was 54 percent, 29 percent and 17 percent for *P occidentalis*, *P. stylirostris* and *P. vannamei* , respectively.

Figure 2b shows the annual species compositions for areas between Punta Santa Elena and Cabo San Francisco. *P. vannamei* forms the bulk of shrimp catches in this area with *P. occidentalis* forming only 6 percent to 25 percent and *P. stylirostris* forming 20 percent to 40 percent of the annual species composition.

Figures 3a-3h compare the monthly species composition for 1974, 1976, 1979 and 1981-1985. It can be seen in Figures 3a-c for the Gulf of Guayaquil in 1974, 1976 and 1979 that the bulk of the shrimp sampled were *P. occidentalis* (40 percent to 90 percent). *P. vannamei* fluctuated between 10 percent and 20 percent of the monthly samples. *P. stylirostris* compositions remained relatively stable,

except during 1976 when it dominated in the catches. A mild El Niño phenomenon was experienced during this year.

In 1981 and 1982, *P. occidentalis* still dominated in the catches but the composition of the samples showed wider fluctuations than in the previous years. In 1983 *P. vannamei* formed the highest percentage, peaking from April to August. A major El Niño event occured during this year. Figure 3g for 1984 shows *P. occidentalis* again as the predominant species in the Gulf of Guayaquil, with *P. vannamei* forming between 18 percent and 36 percent of the monthly composition, a level higher than between 1974-1979. The species composition during 1985 showed wide fluctuations and is markedly differnt from the smooth patterns of the species compositions prior to 1979, with both *P. vannamei* and *P. occidentalis* peaking in the samples. Throughout the 1981-1985 period the percentage of *P. stylirostris* has been relatively stable, fluctuating between approximately 20 percent and 45 percent of the monthly samples.

Data for the species composition of white shrimp catches taken in the areas between Punta Santa Elena and Cabo San Francisco in the north are also shown in Figures 3a-3h. Figure 3a for 1974 shows *P. occidentalis* as the predominant species. From 1976 onwards, *P. vannamei* is the dominant species in the area, with *P. occidentalis* forming the lowest percentage except for the occasional monthly sample. These fluctuations are likely to be the result of misreporting of fishing areas during interviews and small numbers of vessles sampled rather than major changes in species composition.

Length Frequency Data

Length frequency data for factory samples taken in 1985 are presented in Figures 4, 5 and 6.

Data for *P. occidentalis* shows the smallest size ranges entering the fishery from May to July at 70-85 mm tail length. In male samples the mode varied between 105 mm and 125 mm and, in females, from 110 mm to 130 mm. From August onwards the smaller size classes were not encountered in the samples.

Length frequency data for *P. stylirostris* shows the lower size ranges entering the fishery in March-April. A modal progression from May (90-95 mm) to September (105-115 mm) with male samples and from May (90-95 mm) to September 115-120 mm) with females is evident.

In the case of all three species of white shrimp, the smallest size classes entering the fishery during 1985 were in the range of 70-80 mm which corresponds to the commerical grades 41/50-61/70 tails per pound.

For comparative purposes with other authors who have worked on the fishery, the data has been presented in the form of average monthly tail length in Figure 7. All three species show a decrease in the average tail length between April and June, corresponding to the main recruitment period in the fishery. On the average, specimens of *P. stylirostris* and *P. occidentalis* were 14-15 mm larger than *P. vannamei* in the samples taken.

Figure 8 shows white shrimp exports by commercial grade in 1985. The 26/30, 31/35 grades formed the highest portion of the exports and are the most common size ranges harvested by the Ecuadorian pond-raised shrimp industry, which forms the bulk of current exports.

White shrimp with a tail count greater than 60 to the pound formed only 3.12 percent of the exports, while shrimp tail counts greater than 90 to the pound formed 0.47 percent of the 38.7 million pounds of white shrimp tail exported in 1985.

Environmental Aspects

Shrimp stocks have been shown to vary considerably in year to year recruitment, which can be attributed not only to fishing effort but also to environmental conditions.

Rothschild and Brunenmeister (1984) reviewed work on the effects of temperature and salinity on shrimp abundance and growth in the northern Gulf of Mexico. Staples, Dall and Vance (1984) used these parameters to develop a predictive model for the *Penaeus merguiensis* fishery in the southeastern Gulf of Carpentaria.

Although the Instituto Nacional de Pesca carries out oceanographic research, no attempt has been made to date to correlate basic environmental parameters with adult and postlarval shrimp abundance. The Gulf of Guayaquil is strongly influenced by the annual shifts in the warm water front

and the cold waters of the Humboldt Current to the south of the Gulf. The interface between these two bodies of water lies approximately between Punta Santa Elena and Manta (Cucalón, 1983). The warm body of water moves south into the Gulf of Guayaquil, causing a rise in temperature and the onset of the rainy season in November-December each year. The extent of the water movement is variable and, in years when it moves further south than normal, gives rise to what is known as an El Niño event. The effects of this can be clearly seen on shrimp production during 1983.

Successful spawning of *P. vannamei* and *P. stylirostris* under hatchery conditions requires temperatures of 25-30° (degrees Celsius), and temperatures in the Gulf of Guayaquil from April to November are normally below this level. It is not known whether *P. occidentalis* has the same temperature requirements. The commencement of the main spawning season appears to be associated with the termperature rise in the Gulf of Guayaquil due to the ingression of warm water from the north when waters reach 28°C and higher. The spawning season lasts from November to April and coincides with the main period of postlarval abundance on the Guayas coastline. From April onwards, temperatures in the Gulf of Guayaquil drop to below 25°C due to the influence of the cold waters of the Humboldt Current, and spawning drops off in the Gulf of Guayaquil. Areas to the north of the Gulf of Guayaquil, such as Esmeraldas where temperatures are high all the year round, have breeding stocks of white shrimp for a much more extended period than the Gulf of Guayaquil and the Guayas coastline.

It has been suggested that the poor catch rates in the trawl fishery during 1984 and 1985 were partially caused by adverse environmental conditions. Figure 9 shows the CPUE for the trawl fishery and the average monthly rainfall from 1974 to 1985. The rainfall data is from the I.N.O.C.A.R. (Military Oceanographic Institute) meteorological station in Guayaquil. Insufficient time was available to establish the relationship between rainfall and CPUE.

Rainfall in 1984 was high while estimated production was low. It is apparent that rainfall in 1982 and 1985 was lower than normal, and it is possible that environmental factors affected shrimp abundance in these years.

Economic Aspects

Table 2 gives a breakdown of the operational costs, catch and landings of a sample of five vessels. The data were obtained from a fishing company's monthly statements for each of the vessels over a twelve month period in 1985. It can be seen that there is a wide degree of variation between the total landings, operational costs and earnings of the vessels, which are largely attributable to the skill of the skipper and the amount of time spent fishing. Of the five vessels, only two managed to make an overall profit. Operational costs were in the region of 550,000 sucres per month and a minimum catch of 1,424 pounds of shrimp per trip was required to break even. The major operational costs were repair, maintenance and fuel. Given the poor catch rates in 1985, it is likely that only the best vessels managed to cover their operational costs each trip and the fishery was approaching its limits of economic viability.

Another important aspect of the shrimp trawl fishery which helps maintain its economic viability is the shrimp by catch. An extremely well-organized collection and transport system exists between the trawlers and shore-based merchants for the shrimp by catch. Martínez (personal communication) estimates that catch rates of up to 17.7 kg/h of marketable fish can be taken by shrimp vessels. He estimates the relationship between shrimp and saleability by catch to be in the region of 1:4.45, representing earnings of 7,000 to 15,000 sucres per fishing day.

Discussion

Cobo and Loesch (1966), working on the fishery in the early 1960s estimated the maximum theoretical production of wild-caught shrimp to be in the region of 1,500 m.t. to 1,800 m.t. per annum. Since then the fishery has expanded considerably and in the 1970s reached almost twice this figure. From 1977 onwards, production has declined, and during 1984 and 1985, production was the lowest on record. The CPUE for 1986 increased in the months just after the closed season and has gradually decreased to 1984-85 levels. The main decline appears to have been in the levels of the two species *P. occidentalis* and *P. stylirostris*.

The size ranges encountered in the trawl fishery indicate that there is little or no growth in overfishing. Although the data available on catch rates are not enitrely reliable, they do indicate a trend towards a long-term decline in production since 1977, which could be attributed to overfishing rather than short-term environmental effects.

The fleet size has remained relatively constant over this period and it is likely that fishing effort has not increased dramatically. During this period, a major increase in fishing pressure has occurred with the development of the postlarval shrimp fishery which captures postlarvae of *P. vannamei*, *P. stylirostris*, *P. occidentalis* and *P. californiensis*. In the absence of any quantifiable data on the postlarval fishery, and since the overall stock recruitment relationship is not known, it is not possible to say conclusively that the postlarval fishery is affecting stock levels.

The gradual increase in the amount of *P. vannamei* in the catches has been noted by other workers (Cobo and Loesch, 1966; Barniol, 1980). This trend became most marked from 1977 onwards which roughly coincides with the period of increased production due to shrimp farming activities. It should be noted that there was a minor El Niño in 1976. The amount of *P. vannamei* in the catches that peaked during the 1983 El Niño has decreased slightly since then. Indications are that the amount of *P. vannamei* has remained relatively stable during 1984 and 1985. It is worth noting that the fishing effort on postlarvae expanded from 1983 onwards to include fishing for postlarvae on the beaches from Posorja northward.

This author (1985) noted that the species composition of catches from areas to the north of the Gulf of Guayaquil contained a much higher proportion of *P. vannamei* than catches from the Gulf of Guayaquil. Preliminary unpublished data from the current O.D.A./I.N.P. research programme indicate that during 1985-86 virtually no spawning of *P. vannamei* took place in the Gulf of Guayaquil. The author postulated a northerly movement of *P. vannamei* stocks from the Gulf of Guayaquil with the main spawning areas for this species lying from Punta Santa Elena northwards to Sua-Atacames in Esmeraldas. If this proves correct, *P. vannamei* might become susceptible to increases in fishing effort caused by the expansion of the coastal postlarval fishery.

The other possibility is that the El Niño years of 1976 and 1983 have influenced the overall abundances of the dominant species and that the increased abundance of *P. vannamei* can be accounted for by a species interaction between it and *P. occidentalis*. Current research by the Instituto Nacional de Pesca on postlarval distribution and abundance in the Estero Salado should help clarify this.

Management Aspects

It currently appears that the shrimp fishery has declined since 1983. In spite of very low catch rates in the second half of 1985, there was good postlarval availability on the coast during the spawning season. The fishery increased after the closed season and appears to be maintaining itself at a level lower than pre-1983 levels. Although the data available are not entirely reliable, they indicate that the decrease in production has resulted primarily from decreased levels of *P. occidentalis* and *P. stylirostris*.

The management problems are complex. Almost all stages of the penaeid life cycle are targets of fishing activities. Apart from the trawl fishery, there is an artisanal coastal fishery which is evolving into a target fishery for adult broodstock shrimp. Mature males and females are fished along the coast with trammel nets to supply broodstock for shrimp hatcheries. Postlarvae are heavily fished in the esteros and along the coast. Each year this fishery becomes more sophisticated and has expanded to the use of canoes with double butterfly nets fishing postlarvae just offshore during 1986. An extensive fixed or stake net fishery for juvenile shrimp exists in the esteros, though very little is known about it. A recent survey in one of the esteros indicated that up to 25 percent of the smaller branches are being actively fished and almost all the larger creeks have set stakes, indicating that they are periodically fished.

In the long term, a reduction in fishing effort by reduction of the fleet size through wastage would be recommendable. Also, although there is no direct evidence that the fishing fleet's activities alone are causing a decline in population levels, it would be prudent to reduce the fishing effort in the short term by the imposition of a closed season during the main recruitment period. This, however, presents conflicts of interest between the main user groups, the trawl fishery and the shrimp growers. On one hand, a closure of the fishery to protect breeding stocks during the main spawning season from November to March might ensure optimal postlarval harvest, but that would not protect the stocks from possible overfishing by the postlarvae fishery. To ensure any definite benefit, a closure on the

postlarval fishery at some stage during spawning would be needed to allow recruitment of postlarvae into the nursery grounds.

A closure of the estero fisheries during the main recruitment period from April to June is also recommended to allow optimal recruitment into the trawl fishery. This again will present user conflicts as the artisanal estero fishermen harvest most shrimp during this period.

Not much is known of the distribution of fishing effort by the fleet or the effects of closure on fleet activities in areas to the north of the Gulf of Guayaquil where *P. vannamei* is the predominant species. A closure of areas to the north of the Gulf, particularly during the breeding season, would protect spawning stocks of *P. vannamei* and, at the same time, allow the trawl fishery to operate in the Gulf of Guayaquil. Consideration would have to be given to allow the sourcing of mature shrimp to meet the developing hatchery needs.

The Ecuadorian shrimp industry has developed with minimal government control, although recommendations such as stabilizing the fleet size at 160-170 vessels were made by the Food and Agriculture Organization in the early 1970s. In addition, legislation existed in 1977 for a closed season from the mouth of the Rio Balao to the Jambeli point between December and April; it was also prohibited to fish for juveniles in the river mouths in the demarked area. The Acuerdo Ministerial 2305 of August 1984 declared an eight mile zone along the Ecuadorian coast exclusively for the use of the artisanal fisheries.

However, much of this legislation has not been fully enforced. Any attempts at recommended management strategies will undoubtably suffer implementation and surveillance problems, and will not be effective unless measures are made to rectify this situation. In the final analysis, decisions on closures are a combination of political and economic factors. It is unlikely that the industry as a whole will readily accept recommendations as long as the various fisheries remain economically viable and there is no threat to postlarval supplies.

Acknowledgements

I would like to express my gratitude to the Director of the Instituto Nacional de Pesca, Dr. Roberto Jiménez, and the staff of the Institute for their assistance while working in Ecuador; a special word of thanks is due to Mr. José Ortíz, for his patience and efforts while working in the field, and to Biol. L. Arriaga, for translating this paper.

Table 1a.
Estimated Shrimp Production 1974-1985

	White Shrimp *Penaeus vannamei* *P. stylirostris* *P. occidentalis*	Brown Shrimp *P. californiensis*	Red Shrimp *P. brevirostris*	Pomada/Titi *Protrachypenaeus precipua* *Xipopenaeus riveti*	Tiger shrimp *Trachypenaeus byrdi* *Trachypenaeus pacificus* *Trachypenaeus faoea*	Carapachudo *Solonocera* spp.	Deep water *Heterocarpus*		
Year	1 No. of Vessels	2 Total* production (m.t.) (Pond/Sea)	3 Total* production (m.t.) (Sea)	4 Total* production (m.t.) (Sea)	5 Total* production (m.t.) (Sea)	6 Total* production (m.t.) (Sea)	7 Total* production (m.t.) (Sea)	8 Total* production (m.t.) (Sea)	9 Estimated Sea catch (m.t.)* (Gulf)	10 Est. total sea catch (m.t.)*
1974	266								3503	4207
1975	247								4213	4917
1976	241								4119	4823
1977	245								4094	4798
1978	229								3001	3705
1979	250	5072	118	110	644				2476	3120
1980	240	9401	244	213	530	30		8	3323	3891
1981	227	12701	156	23	535			320	2762	3617
1982	230	18958	122	70	616			84	2693	3393
1983	249	25804	540	226	526	9		609	10413	11557
1984	262	19412	724	1254	1127	3	70	869	2553	4622
1985	249	19804	135	273	954	19	391	354	1992	3710
Estimates allowing the same production of Red and Brown in 84 and 85										
1983	249	25804	1013	1207	679	9		609	10413	11710
1984	262	19412	135	273	954	3	70	689	2553	4449
1985	249	19804	135	273	954	19	391	354	1992	3710

DATA SOURCES *(HEAD OFF) # (HEAD ON)

Column No.
1 # Dirección General de Pesca; 2-8 # Certificados de Control de Calidad I.N.P; 9 # C.P.U.E. Data raised to the number of vessels x 22 days fishing/month; 10 # Column 9 + cols. 3-8

Table 1b

Year	No. of vessels	9 Estimated sea catch (m.t.)* (Gulf)	10 Estimated total sea catch (m.t.)*	11 Estimated white sea catch (m.t.)*	12 Estimated total production figures (m.t.) (Pond/Sea)#	Estimated av. monthly catch per vessel (lbs.)* (Gulf)
1974	266	3503	4207	3048	6500	2414
1975	247	4213	4917	3665	7500	3127
1976	241	4119	4823	3584	9000	3133
1977	245	4094	4798	3562	8600	3064
1978	229	3001	3705	2611	9727	2403
1979	250	2476	3120	2248	9006	1816
1980	240	3323	3891	2866	15793	2538
1981	227	2762	3617	2583	20646	2231
1982	230	2693	3393	2501	30032	2147
1983	249	10413	11557	9647	41677	7667
1984	262	2553	4622	575	35096	1786
1985	249	1992	3710	1584	33045	1467
Estimates allowing the same production of Red and Brown in 84 and 85						
1983	249	10413	11710	8193	44112	7667
1984	262	2553	4449	2145	32842	1786
1985	249	1992	3710	1584	33045	1467
	*	(Head Off)	#	(Head on)		

DATA SOURCES

Column No.

9 C.P.U.E. Data raised to the number of vessels x 22 days fishing/month

10 Column 9 + cols. 3-8

11 rows 1-5 allowing white shrimp as 87o/o of the sea catch col. 9 - red and brown exports

12 rows 1-5 estimates from the Dirección General de Pesca; rows 6-15 estimated by summing cols. 2-7 and converting to whole shrimp + col. 8

Table 1c

Estimated white shrimp production by species (1974-1985)

Year	No. of vessels	Estimated white sea catch (m.t.)*	Estimated white species shrimp production by species (m.t.)* *P. vannamei*	*P. stylirostris*	*P. occidentalis*
1974	266	3048	229	828	1991
1975	247	3665	289	1201	2176
1976	241	3584	313	1557	1716
1977	245	3562	362	1424	1911
1978	229	2611	393	633	1585
1979	250	2248	539	588	1125
1980	240	2866			
1981	227	2583	743	667	1152
1982	230	2501	691	887	944
1983	249	9647	3662	3500	2485
1984	262	575	147	161	267
1985	249	1584	525	473	586
Estimated as in Table 1a.					
1983	249	8193	3130	2972	2111
1984	262	2145	549	601	995
1985	249	1584	525	473	586

* (Head off)

Table 2
Shrimp Landings and Operational Costs During 1985

	Total shrimp Landings	Average catch per month	Total value of catch	Average monthly value of catch	Total operational costs per annum	Average monthly Operational costs	Profit/Loss after costs
Vessel No. 1	15,254 lbs.	1,553 lbs.	S/7,137,788	S/648,890	S/7,028,898	S/638,991	S/+133,516
Vessel No. 2	28,758 lbs.	2,397 lbs.	8,707,417	725,618	6,225,009	518,751	+2,527,716
Vessel No. 3	16,118 lbs.	1,394 lbs.	7,795,793	649,649	8,072,021	672,668	-2,958,658
Vessel No. 4	6,904 lbs.	991 lbs.	2,684,797	383,542	4,209,342	601,335	-2,530,084
Vessel No. 5	5,102 lbs.	510 lbs.	2,046,367	204,538	3,035,318	303,523	-1,870,463
Average	14,793 lbs.	1,360 lbs.	5,674,432	522,467	5,714,118	547,055	

Average price/lb. (head off) S/384.
Minimum breakeven quantity/trip 1,424 lbs. of shrimp (head off)

Breakdown of Operation Costs	Percentage of Overall Costs
Repairs and Maintenance	43 percent
Fuel and Oil	38 percent
Insurance	9 percent
Victuals, Crew payments	
Licences, etc.	10 percent

Figure 1. Average Daily Catch/Month

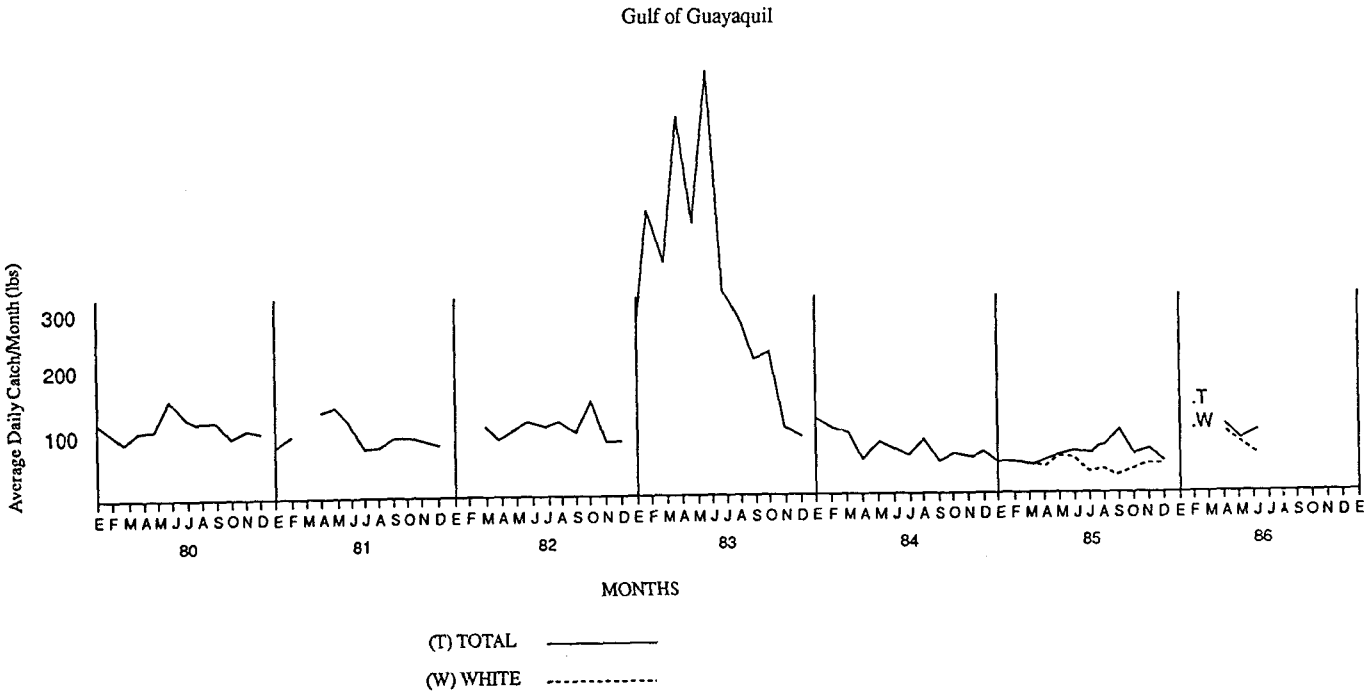


Figure 2a. Mean Annual Species Composition

Gulf of Guayaquil

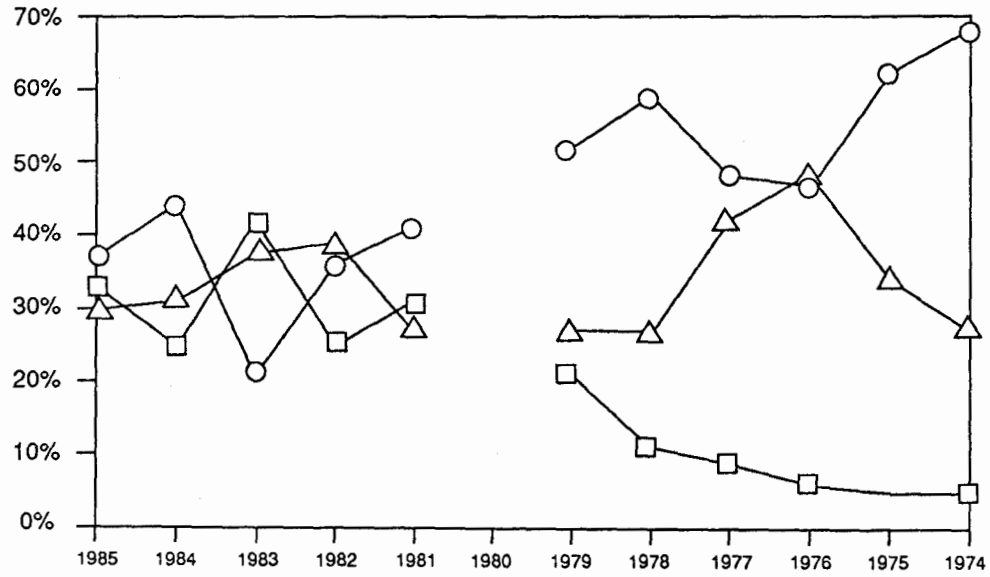


Figure 2b. Punta Santa Elena - Cabo San Francisco

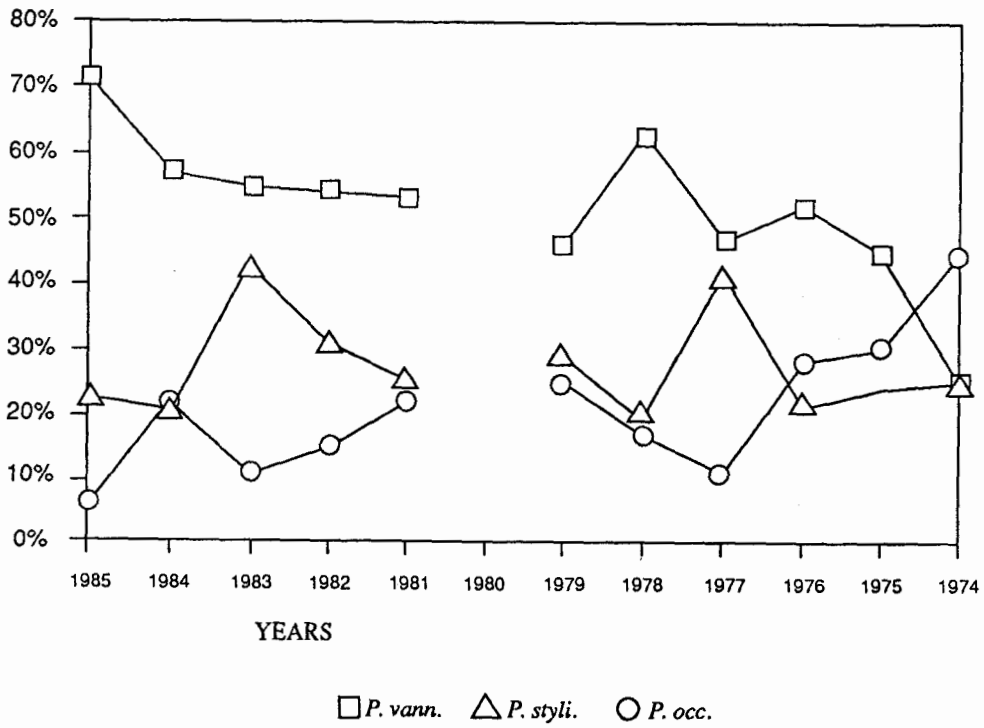
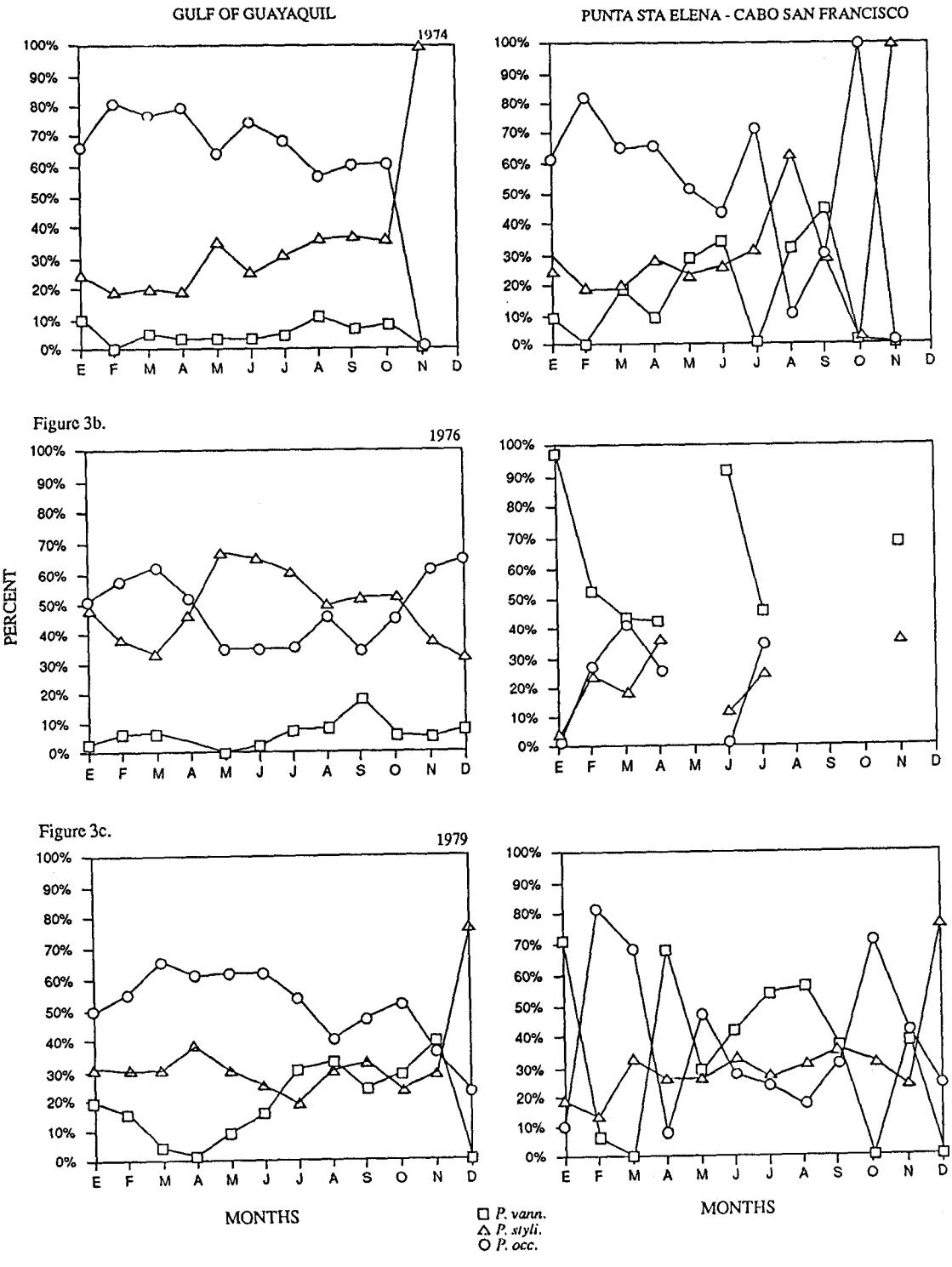


Figure 3a. Monthly Species Composition
White Shrimp



Monthly Species Composition White Shrimp

GULF OF GUAYAQUIL

PUNTA STA ELENA--CABO SAN FRANCISCO

Figure 3d 1981

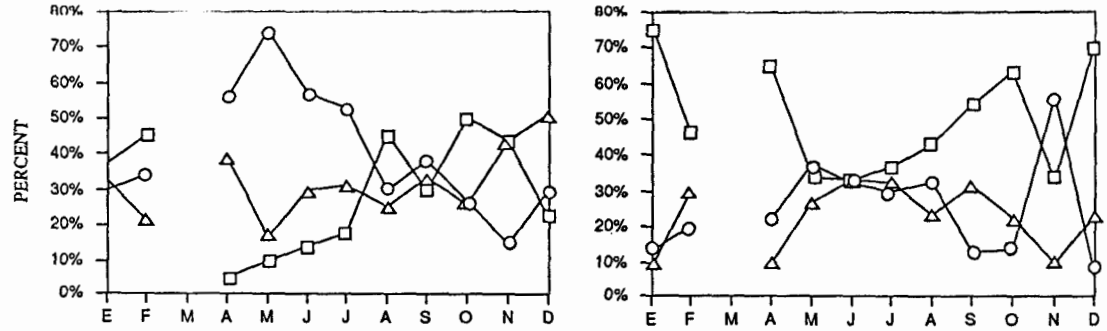


Figure 3e 1982

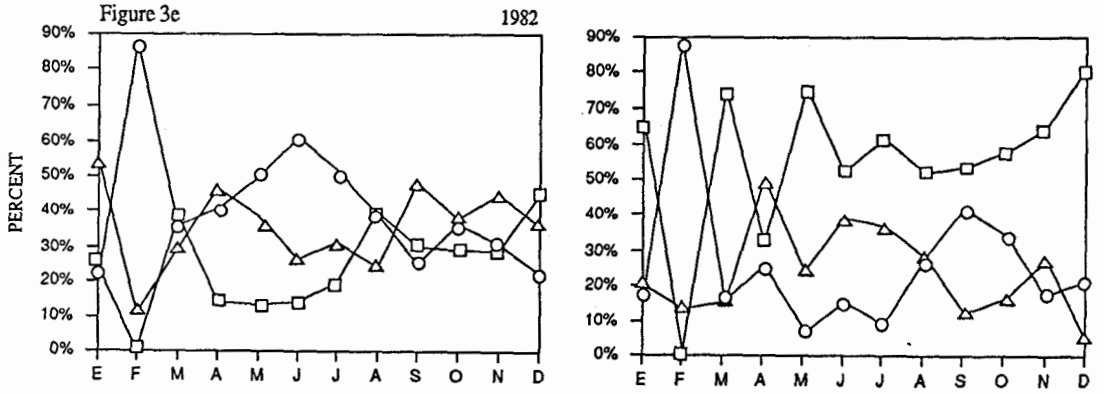
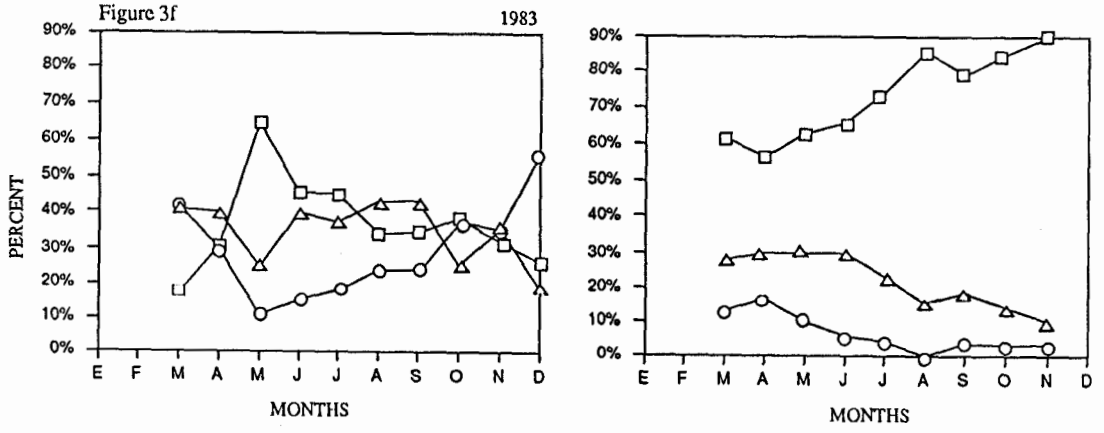


Figure 3f 1983



□ *P. vann.*
△ *P. styli.*
○ *P. occ.*

Figure 5.
Tail Length Frequency
P. Stylirostris 1985

Gulf of Guayaquil

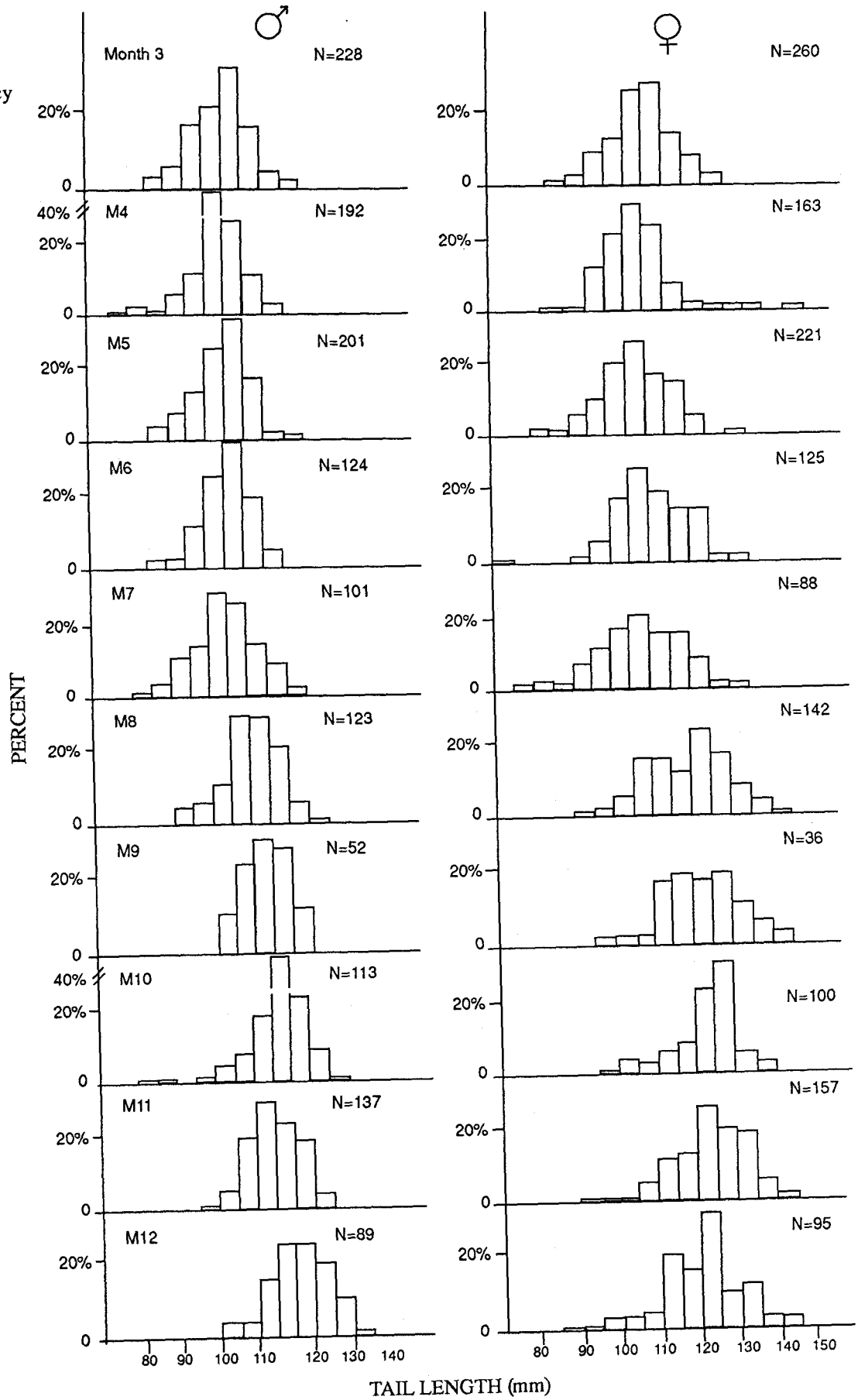


Figure 6.

TAIL LENGTH FREQUENCY
P. Vannamel, 1985

Gulf of Guayaquil

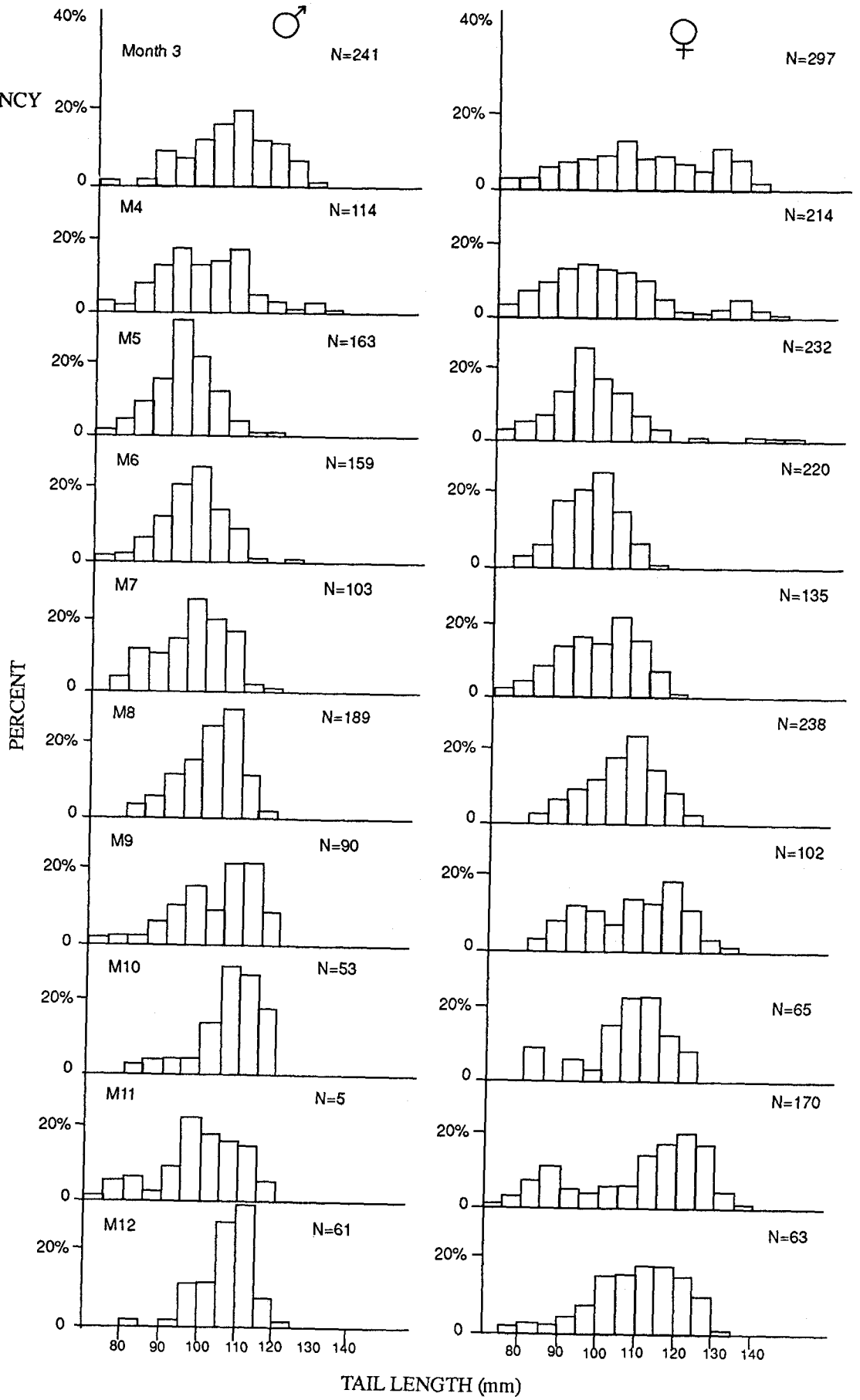


Figure 7. Average Monthly Tail Length - Gulf of Guayaquil 1985

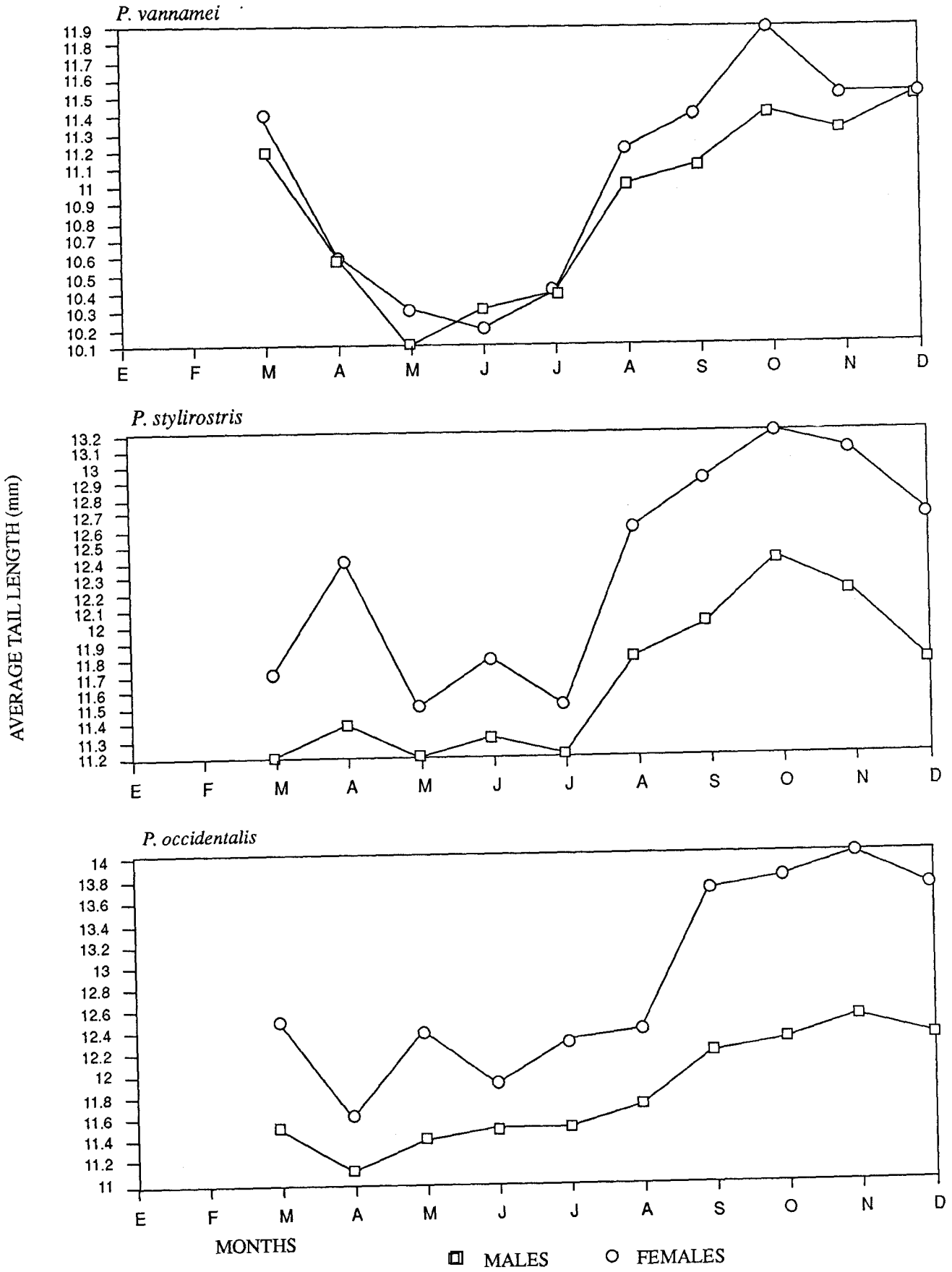


Figure 8. White Shrimp Exports 1985

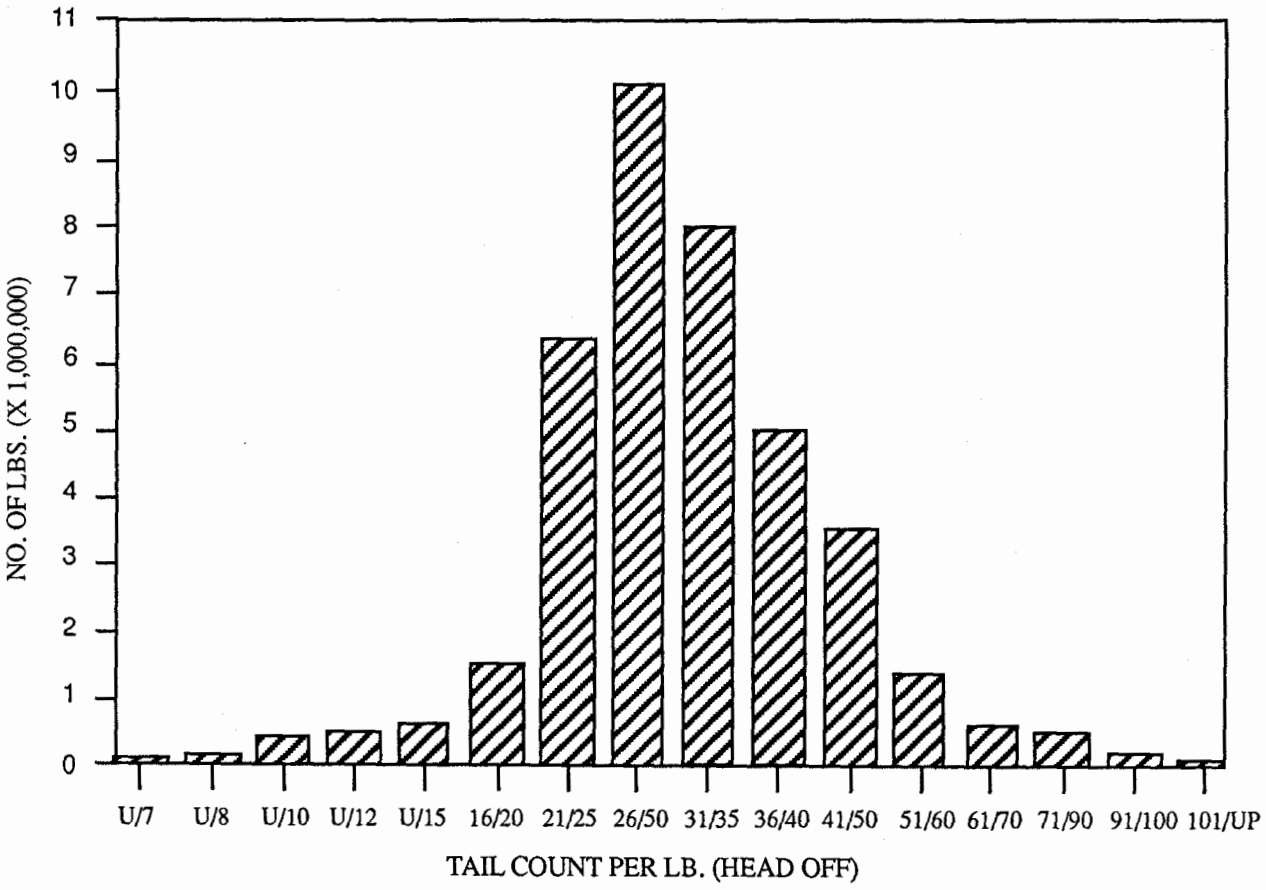
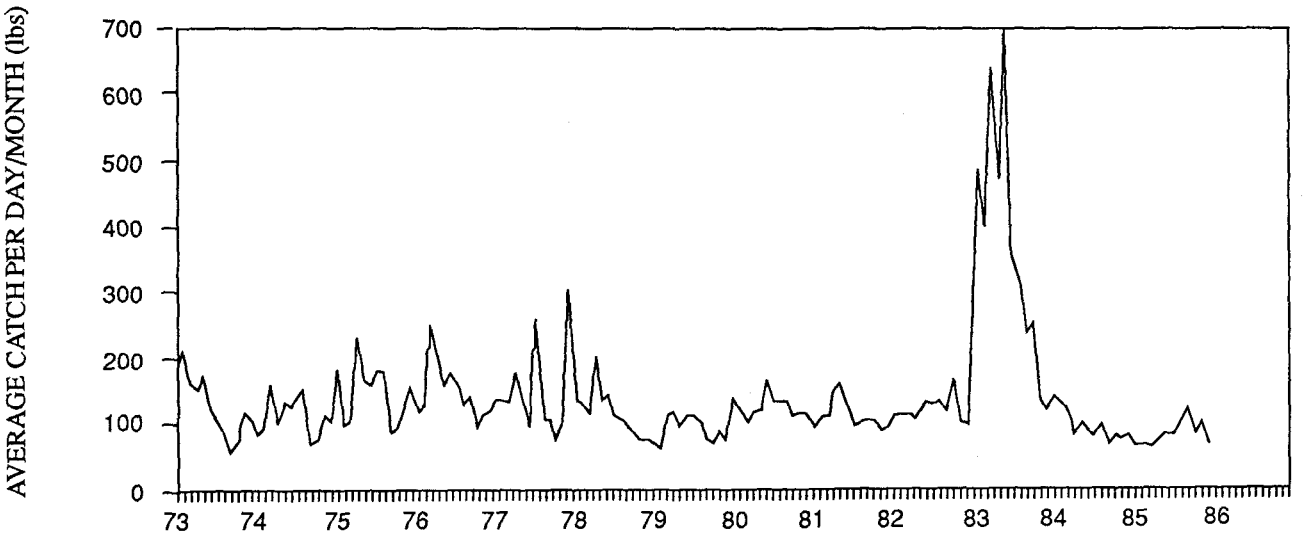
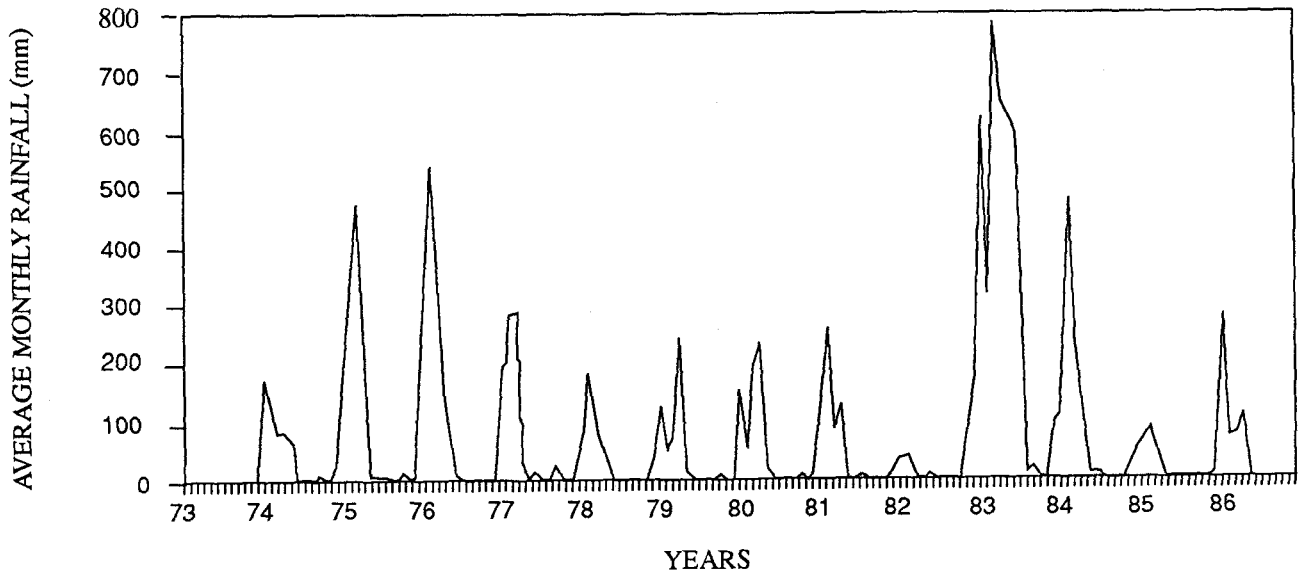


Figure 9. Monthly C.P.U.E. - Gulf of Guayaquil 1973-1985



Average Monthly Rainfall Guayaquil 1974-1986



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