Fisheries Resources of Jiquilisco Bay, El Salvador

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INTRODUCTION

The tropical mangrove swamp system plays an homologous role to that of the temperate salt marsh in sustaining nearshore populations of shrimp and fishes. The mangrove detritus is an important food base that sustains organisms both within and without the coastal embayments where they are found (Heald 1971; Odum 1971; Lindall 1973). These systems also serve as important nursery areas for most of the commercially important species. Mangroves, however, are often under severe development pressure that may destroy the very resources upon which residents have come to depend. To date, little attention has been paid to the mangrove swamps in Central America as a factor vital to the offshore fisheries resources. Our study examines a large mangrove estuary, Jiquilisco Bay, in El Salvador (Fig. 1). This area is presently under assault from cotton management practices as well as other activities degrading or destroying the mangroves. Additionally, overfishing for shrimp coupled with under-utilization of shrimp trawler by-catch is threatening an important potential food supply.

Prior Resource Studies

Christey and Wade (1959) studied the Salvadorean fishery potential in 1952-53 prior to the development of the commercial shrimp fishery in 1955. They systematically collected commercial quantities of fish and shrimp and first mentioned that Jiquilisco Bay probably played a role as an important shrimp nursery area. They reported a mean catch per unit effort of 275.5 kg/hr for fish and 27.5 kg/hr for shrimp, with considerable variation by site, depth and time of year. The coast adjacent to Jiquilisco Bay was found to be most productive. Three fish families (Sciaenidae, Pomadasyidae, and Ariidae) were most numerous and widely distributed. Three penaeid shrimp (*Penaeus stylirostris* Stimpson, *P. vannamei* Boone, and *P. occidentalis* Sticets) dominated the harvest, with *P. stylirostris* the most abundant.

By 1967-68, 12 years after the establishment of the commercial shrimp fishery which extensively utilized the shelf, a significant decrease in yield to 75.5 kg/hr for fishes was reported in a survey conducted by Wieme and Cole (1970). No catch per unit effort data exist for shrimp from that study. However, combined figures for the shelf off Guatemala, El Salvador, and Nicaragua indicated that greater numbers of fish were being taken in inshore waters while the invertebrate catches were higher in deeper waters near the edge of the shelf. Overfishing by shrimp trawlers that concentrated on shrimp and discarded fish may have contributed to a decrease in the by-catch (Wieme and Cole 1970).

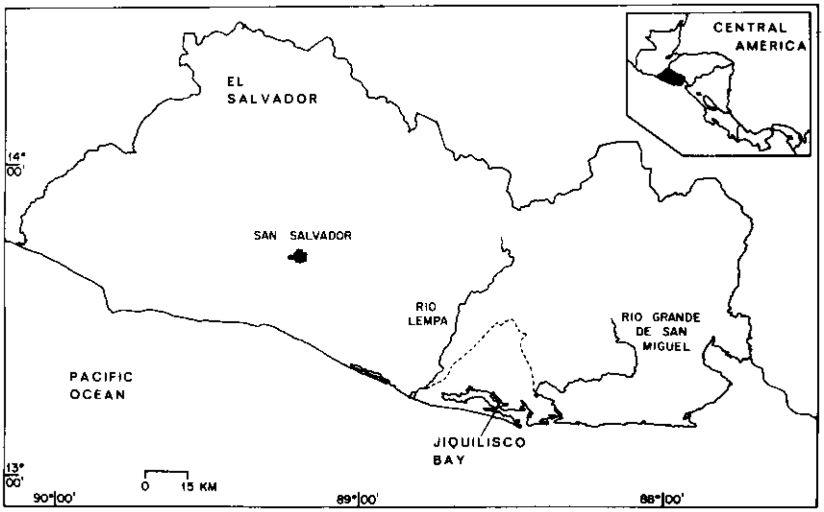

Figure 1. Map of El Salvador, Central America, with location of Jiquilisco Bay.

Commercial Shrimp Fishery

In 1963, eight years after the start of the shrimp fishery, the government of El Salvador established a legal limit of 73 vessels in the state regulated fishery. At present, 63 modern trawlers are based in Puerto El Triunfo in Jiquilisco Bay. Shrimp are processed in modern facilities and transported overseas for sales. Shrimp landings averaged 3,600 metric tons (mt) per year from 1960 to 1975 (Table 1). Although the total catch fluctuated little from 1960 to 1975, there was a large decrease in yield of the three commercially valuable species of white shrimp (*Penaeus stylirostris, P. occidentalis,* and *P. vannamei*) and of pink shrimp (*P. brevirostris*). During the same period, the landings for brown shrimp (*P. californiensis*) did not decrease significantly. The decline in white and pink shrimp was offset during this period by an increase in the catch of camaroncillos (*Trachypenaeus byrdi, T. similis pacificus, T. faoea, Protrachypena precipua, Xiphopenaeus riveti,* and *Solenocera* sp.). The pink and white shrimps enter the estuary in April-May; the brown shrimp does not enter until November and the camaroncillos apparently make little or no use of the bay as a nursery ground (Ulloa 1976).

Presently, no commercial operation exploits the offshore fish resources. Even though fish are captured in great quantities with the shrimp, relatively little is landed. In Puerto El Triunfo only 2 to 4 mt that are unloaded daily with shrimp will later reach the larger urban markets (Tilic and McCleary 1971). Most of the fish by-catch is simply discarded at sea. Wieme and Cole (1970) estimated that 9100 mt were discarded annually while only 1300 mt were retained for sale. Ramirez and Miller (1975) systematically examined the species composition of the by-catch from the shrimp fleet and correlated catch with area, depth, and season. Nine species dominated the catch of the 35 groundfish normally retained for sale. These nine species were members of the families Sciaenidae, Pomadasyidae, Bothidae, Serranidae, Lutjanidae, and Scombridae. Some life stage of each family was collected in the present study in Jiquilisco Bay. Unfortunately specimens from the offshore survey were not retained for verification by systematists and we can not be certain that offshore fishes are also the same species as those taken in this survey.

Artisanal Fishery in the Estuary

The bay supports an artisanal fishery of approximately 250 hand-powered dug-out canoes that are restricted to the bay and the bay mouth. A fishing cooperative at Puerto El Triunfo also uses several fiberglass launches equipped with outboard motors. These fishermen commonly use gill nets and cast nets. The prevailing species captured are the corbina (*Cynoscion* sp.) and the catfish (*Galeichthys* sp.) (Tilic and McCleary 1971). At times of major shrimp migrations, fishermen also capture shrimp in large quantities using a cast net. Fishes captured within the bay are either sold locally or are dried and later transported to major cities in El Salvador.

Possible Pesticide Effects on the Fisheries Resources

Concurrently with the development of the shrimp fleet, the planting of cotton in the Salvadorean coastal plain rose dramatically. Browning (1975) reported an increase from approximately 20,000 hectares in 1951 to 122,000 hectares in the 1964-65 season. Pesticide usage, including chlorinated hydrocarbons and organo-phosphates (Wallace Evans 1974), is widespread in El Salvador and routinely applied to the cotton plantations. Approximately 20,000 hectares of cotton fields are located within the drainage basin of Jiquilisco Bay.

Eight species of shrimp were collected in Jiquilisco Bay during a companion study (Ulloa 1976). Larvae of three species of white shrimp (*P. stylirostris, P. occidentalis,* and *P. vannamei*) and pink shrimp (*P. brevirostris*) enter the bay in April and May. Brown shrimp (*P. californiensis*) enter in November. Pesticides are applied to the cotton fields immediately adjacent to the estuary from August, a time of heavy rainfall, through the end of harvest in January. The larval pink and white shrimp are likely adversely affected early in their life history by pesticide runoff. Butler (1962) demonstrated that shrimp are highly sensitive to pesticides such as toxaphene, DDT, and parathion used on cotton. Brown shrimp do not migrate into the bay until the rainy season is ending. Therefore, they may be far less affected by pesticide runoff. The camaroncillos either do not utilize Jiquilisco Bay or use it very rarely and then only during the dry periods when the influence from pesticides in the bay is at a minimum. Landing statistics provide additional evidence that the shrimp harvest may be adversely affected by these application practices. During the period from 1960 to 1975, total shrimp

Table 1. Annual commercial shrimp landings in El Salvador in metric tons

	Shrimp Production in Metric Tons															
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
White shrimp	2030	1753	1584	1651	1744	1063	1590	1051	1008	1143	1054	794	872	1060	876	903
Pink shrimp	1020	751	551	479	379	439	495	419	357	370	423	435	381	503	410	362
Brown shrimp	196	436	115	93	104	65	94	79	69	91	176	95	40	79	121	181
Subtotal	3246	2940	2250	2223	2227	1567	2179	1549	1434	1604	1653	1324	1293	1642	1407	1446
Camaroncillos	301	926	1505	1282	1237	1592	2404	1954	1357	1621	2169	2260	2225	2155	2310	2699
Grand Total	3547	3866	3755	3505	3464	3159	4853	3503	2791	3225	3822	3584	3518	3797	3717	4145

landings have not fallen but the species mix has changed significantly. White and pink shrimp, most affected by pesticide treatment, have declined most seriously within the total landings. Brown shrimp have been less affected and the camaroncillos have shown a marked increase.

We do not have evidence from the offshore by-catch that there have been changes in the species composition of fishes that might be related to pesticide-caused fish kills during nursery periods in the estuary. The study by Ramirez and Miller (1975) was not designed to provide detailed species listings nor did it examine pesticide residue levels in the by-catch. Keiser et al. (1973) reported high levels of chlorinated hydrocarbons in fish and shrimp samples analyzed from coastal lagoons bordered by cotton fields in neighboring Guatemala. A study is currently underway to report on residue levels in fishes and shrimp in Jiquilisco Bay. Numerous fish kills have been observed during the course of this study. Additional evidence of pesticide-caused fish kills has been reported from the Santa Cruz Porrillo Fish Culture Station, El Salvador, located about 30 km from Puerto El Triunfo. This station is also surrounded by cotton fields and entire stocks of pond fishes have been erradicated during spray programs in 1973, 1974, and 1975.

DESCRIPTION OF STUDY AREA

Jiquilisco Bay (also known as San Juan del Gozo estuary) is the largest estuary of El Salvador; its 121 sq km embraces a 50 km section of the coast between two major rivers, Rio Lempa and Rio Grande de San Miguel (Fig. 1). Weyl (1953) and Gierloff-Emden (1976) discuss the nature of the geological processes that formed the Salvadorean coastal plain and they review the influence of the two surrounding rivers, as well as the tidal action on the physical structure of the bay.

The bay primarily consists of deep, muddy-bottomed canals of varied widths surrounded by mangrove forest. Sand is the principal bottom sediment only along the San Juan del Gozo peninsula and the islands near the bay mouth. The mangrove forest of 18,000 hectares (Servicio de Informatica) is a complex of three species of mangrove trees: *Rhizophora mangle, Avicennia nitidia,* and *Laguncularia racemosa* (OEA, CONAPLAN, MAG-El Salvador 1975). *Rhizophora mangle* predominates along the canal edges with *L. racemosa* or complexes of *L. racemosa-A nitidia* in a landward succession (Gierloff-Emden 1976). Lands adjacent to the mangrove forest have been altered for agriculture or for the installation of salt evaporation ponds. There is strong pressure to reclaim the landward edge of the forest for additional agriculture.

The climate of El Salvador consists of a tropical rainy season (May to October) and a dry season (November to April). Maximum rainfall occurs in June and again in September; normally a temporary halt in rainfall (canicula) occurs sometime in July or August. The mean annual precipitation varies between 1800 and 2000 mm (Gierloff-Emden 1976).

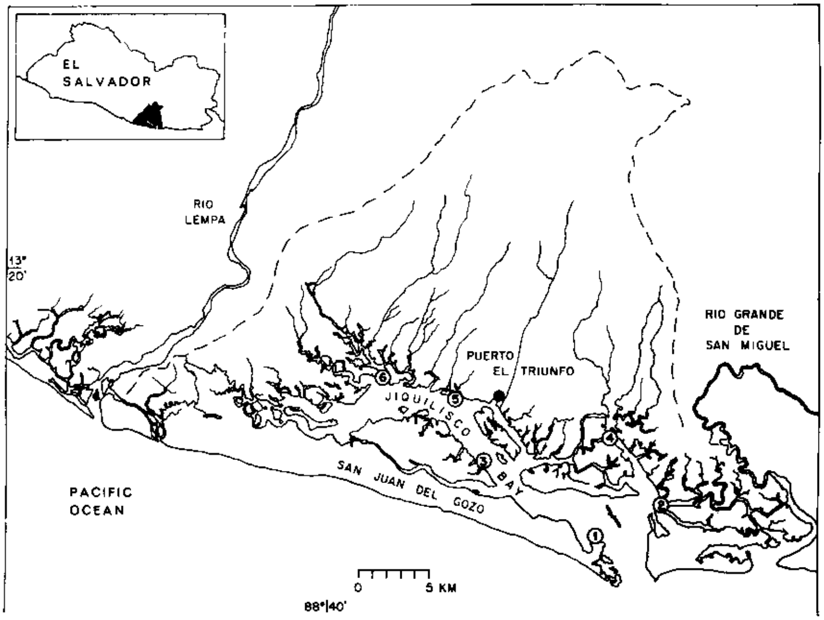

Figure 2. Map of Jiquilisco Bay, El Salvador, with locations of six sampling stations. Area within the dotted line denotes the drainage basin.

MATERIALS AND METHODS

Sampling Stations

Six sampling stations were chosen to sample faunal differences within the bay (Fig. 2). Station *1*, 3 km from the bay mouth, was located along a steeply to gently sloping sand beach contiguous to a coconut plantation. All other stations (*2* to *6*), from 6 to 22 km from the bay mouth, had few physical differences and their shorelines were mangrove forest with muddy bottom and accumulated decomposing mangrove leaves.

Sampling Technique

We sampled twice a month from September 1975 to November 1976 using a 5-m try net. Towing time was standardized at 45 min. Occasionally a beach seine, gill-net, and cast net were used but these data are not reported in this study. The try net is not effective for mugilid and clupeid fishes, important species in the artisanal fishery in the bay.

Depth and surface and bottom temperatures and salinities were recorded at time of sampling. The shrimp catch was concurrently studied by Ulloa (1976).

Fishes were identified primarily by using keys of Meek and Hildebrand (1923-28) and Chirichigno (1974). Voucher specimens are currently being verified. Upon completion of these studies, all specimens will be deposited in the Smithsonian Oceanographic Sorting Center.

RESULTS AND DISCUSSION

Temperature

Mean monthly bottom water temperature of Jiquilisco Bay fluctuated between 26.5° (January 1976) and 32.0°C (August 1976) (Fig. 3 upper). Surface temperatures were usually higher. Water temperatures followed closely the air temperatures (Fig. 3 upper). Mean air temperature (Servicio Meteorologico) was always less than that of the water. Maximum water temperature occurred one month (August 1976) after maximum air temperature. Minimum water temperature occurred in January 1976, also one month after the minimum air temperature.

Salinity

Estuarine salinity is affected by evaporation, runoff and rainfall. Salinities rose during the dry season because evaporation dominated. Only during the rainy period did river discharges materially reduce salinity because the drainage basin is relatively small, containing only 87,000 hectares (Fig. 3 lower). Generally, mean surface salinity (between 23.0 and 32.7 ppt) was only slightly less than bottom salinity (23.3 to 32.8 ppt) indicating complete surface to bottom mixing. There was only a small average salinity gradient between Station *1* (30.3 ppt) and the innermost Station *6* (26.7 ppt). Localized points of low salinity were observed near stream discharges only after heavy rains. Highly turbid water at these periods indicated heavy soil discharge, and likely heavy pesticide discharge, into the estuary. Strong tidal currents quickly mixed these waters and restored the baywide average salinity (28.4 ppt). After the end of the rainy season in November 1975, salinity uniformly increased until the initial rains in April 1976 when average salinity gradually decreased following fluctuations in rainfall.

Tides

Salvadorean tides are semidiurnal. The amplitude of mean spring tide is 2.00 m while mean neap is 1.65 m. Within the estuary, tidal range diminishes inversely with the distance from the baymouth. Tidal currents affect the physical structure of Jiquilisco Bay by deeply scouring the canals. Tidal current velocity in the main canal of the bay has been estimated to reach 4 km/hr (Gierloff-Emden, 1976).

Fish Survey and Discussion

Clark (1971), working in a mangrove estuary in the Everglades National Park, Florida, found differences in catch rate attributable to variation in vegetation density. Those differences had little relation to other environmental factors such as temperature, salinity, tides, or time of capture (day or night). Fish size increased directly with increasing salinity (an observation earlier reported by Gunter, 1956; 1957; Reid and Hoese, 1958), tides and time of capture (day or

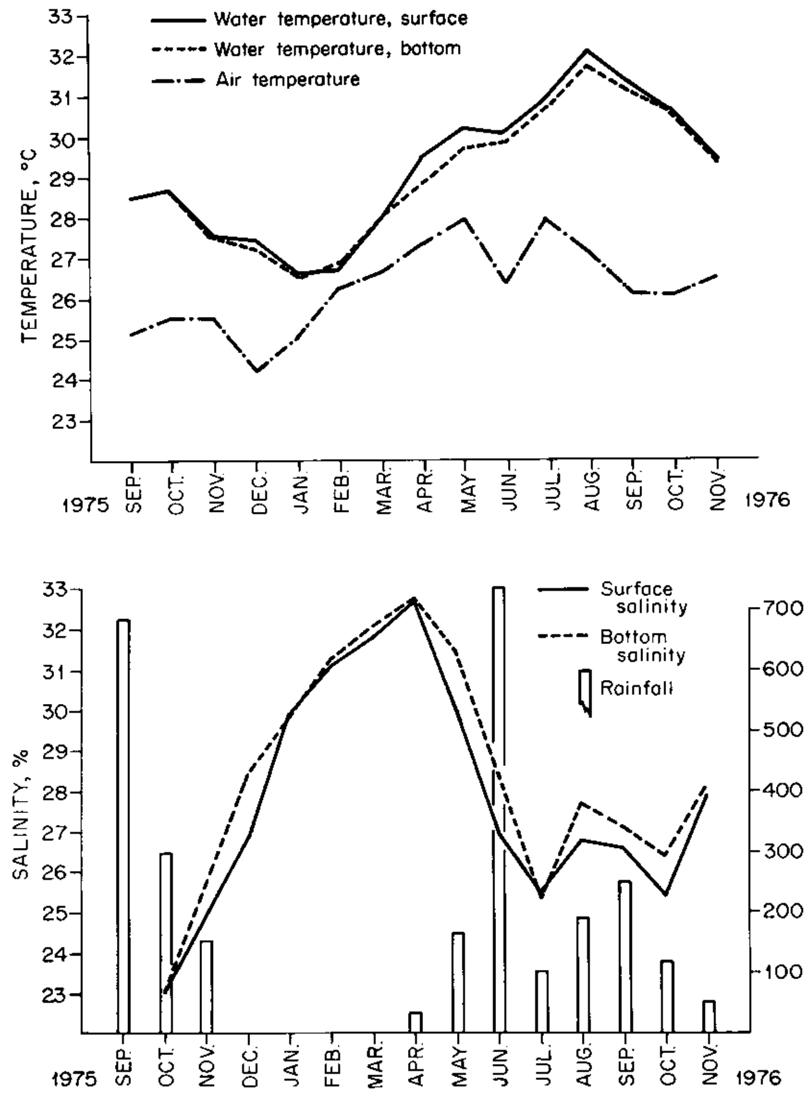

Figure 3 upper: Variation in mean air temperature and mean surface and bottom water temperatures in Jiquilisco Bay, El Salvador. Fig. 3 lower: Variation in mean surface and bottom salinity and mean rainfall in Jiquilisco Bay, El Salvador.

night). Jannke (1971), working on young sciaenids in Everglades National Park, Florida, found no significant relation between catch rate and salinity and temperature at time of sampling for three species examined in detail. Mean bottom temperature in Jiquilisco Bay varied only 5 °C during the course of the study and mean bottom salinity only 9.5 ppt. These variables did not appear to affect catch rates during our study. We were unable to examine variables such as day or night tow differences, tidal stage, or current direction.

Hildebrand (1925) encountered 18 species in 10 families on a 1-day survey at Puerto El Triunfo. Hernandez and Calderon (1974) identified 56 species in a floral and faunal survey from February to July 1974. They did not make detailed observations on fish abundance.

In our study, we have identified approximately 90 species from the 20,000 specimens captured. More than half were captured at Station *1* near the bay mouth. Total numbers of individuals taken at the remaining stations were approximately equal. No species were captured only at the bay mouth station indicating that no decrease in species diversity occurred as one sampled deeper into the system. The results of total capture by trawling for all species for all sampling stations are given (Fig. 4). A minimum capture per hour occurred in September 1975 and again in October 1976.

The application of large quantities of pesticides on cotton fields adjacent to Jiquilisco Bay begins in August coinciding with the onset of heavy rainfall. There is a time lag from the initiation of pesticide application to the time that these pesticides are washed into bay waters. In September 1975, rainfall reached a yearly peak (Fig. 3 lower) while in September 1976 the rainfall was abnormally low, only slightly more than one-third that of 1975. Apparently pesticides reached the bay a month later, resulting in a later minimum capture. Following the months of minimum capture, October 1975 and November 1976, catch rates increased. Excluding these months of likely pesticide influence, capture is generally less in the dry season and greater during the rainy season (Fig. 4). The increased capture during rainy seasons may be due to the presence of a large number of smaller individuals moving into the bay in search of food and safety from predation. Spawning activity may also increase during the rainy season.

We examined the catches of three species excluding pesticide effects in greater detail. The most abundant fish collected during the study was the marine catfish, *Galeichthys jordani,* important in the artisanal fishery. It was captured at all stations in most months but occurred in greatest numbers at Station *1*. Peak abundance at Station *1* occurred in July 1976 (Fig. 5). In Stations *2* to *6*, little or no change in abundance occurred throughout the study. Large numbers of yolk sac fry and juveniles up to 80 mm were captured beginning in May and peaking in July. Most young were taken at Station *1* although lesser numbers occurred at the interior stations. We believe these smaller individuals were spawned prior to May 1976. *G. jordani* was absent from the October 1976 catches suggesting pesticide effects. By November 1976 catfish returned to the system and were captured by trawling and gill nets at Station *5*.

Species of *Cynoscion* were significant in the Jiquilisco Bay artisanal fishery (Tilic and McCleary 1971). Ramirez and Miller (1975) reported catches of *Cynoscion* spp. in the nearshore off Jiquilisco Bay. At least two species of *Cynoscion* have been identified from our studies. Discrepancies between identifications in previous studies and ours exist and thus we can only consider the corbina, *Cynoscion stolzmanni* (Fig. 5). It was more commonly taken in the interior stations (*3* to *6*) than near the bay mouth. Peaks in abundance appear in

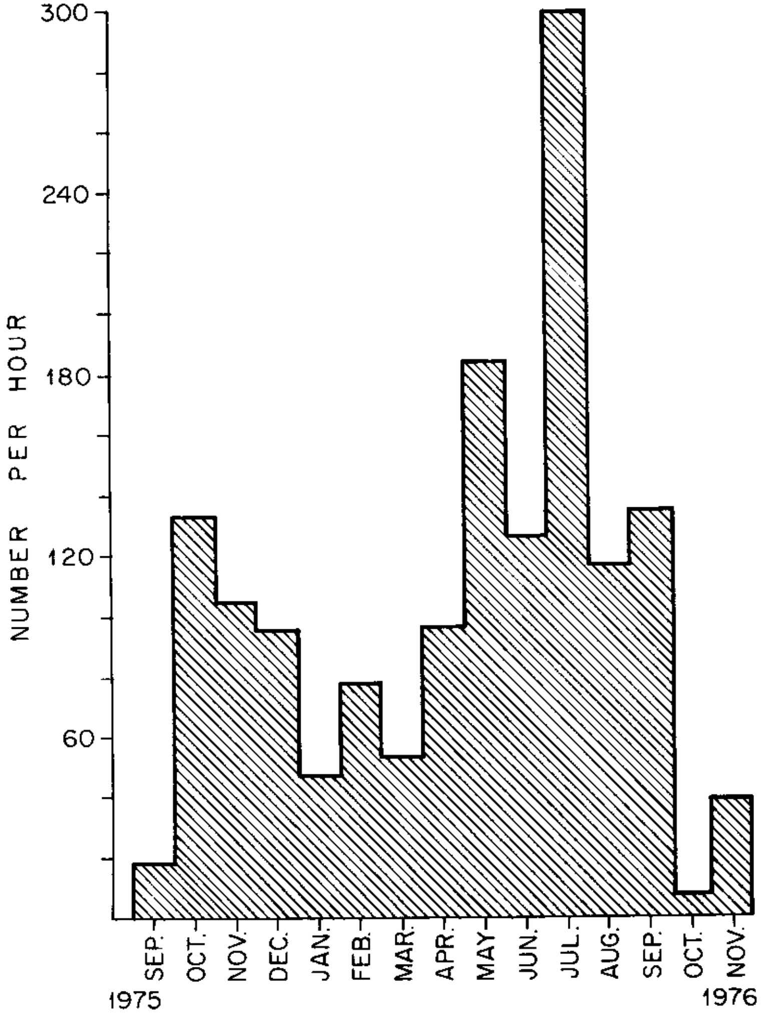

Figure 4. Capture per hour for all species at all stations with an otter trawl in Jiquilisco Bay, El Salvador.

mid-dry season (December 1975 to February 1976) and in mid-rainy season (August-September 1976). After a peak capture in September 1976, only one individual was captured in October 1976. Significant numbers of juveniles (less than 80 mm TL) were present in all 13 months. Sixty percent of all corbina collected were juveniles. Our results suggest year-round spawning with variations in intensity.

The mojarras (family Gerreidae) of the eastern Pacific are currently under taxonomic review (Carl Hubbs, pers. comm.). One of the most abundant fishes

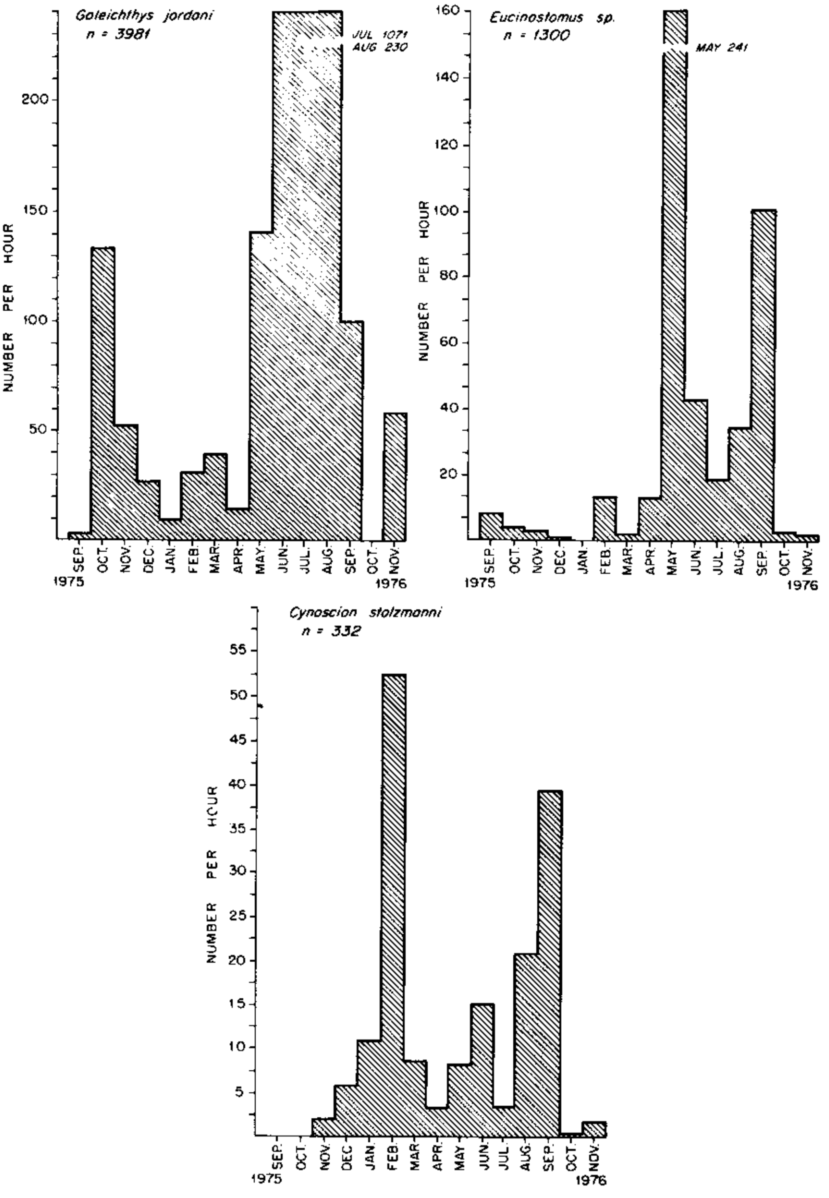

Figure 5. Capture per hour of *Galeichthys jordani, Eucinostomus* sp., and *Cynoscion stolzmanni* with an otter trawl at all stations in Jiquilisco Bay, El Salvador.

was a species of the gerreid genus *Eucinostomus* that is heavily utilized by the artisanal fishery and reported in the offshore shrimp by-catch (Ramirez and Miller 1975). Most specimens in our study were collected at the baymouth

(Station *1*). Although individuals were taken at all stations in the rainy season, specimens were captured only at the baymouth in the dry season. Fishes were most abundant in May and September 1976 (Fig. 5). Smaller individuals were first captured at Station *1* in the latter part of the dry season and had penetrated to the innermost Station *6* by May 1976. Spawning of *Eucinostomus* sp. may occur in the nearshore areas off Jiquilisco Bay prior to the initiation of the rainy season with individuals subsequently migrating throughout the estuary. Pesticides probably account for the decrease in catch after September 1976.

CONCLUSIONS

Our study is preliminary in scope. Limitations during data collection result in obvious difficulties in making more than inferences regarding the results. Studies in other locations supply evidence on the effect of overfishing on fish and shrimp stocks. Likewise ecological damage from pesticides has been documented. Baseline data regarding fish and shrimp utilization of Jiquilisco Bay do not exist for those years prior to the development of commercial shrimping and the intense planting of cotton in the Salvadorean coastal plain. Nevertheless, our results point to a need to evaluate fully the ecological and economic losses suffered by pesticide usage and to investigate further the food potential in the by-catch of the shrimping process. Decrease in the capture of desirable shrimp species warrants a re-evaluation of landing requirements.

SUMMARY

Our study revealed 90 species of fishes utilizing Jiquilisco Bay, El Salvador at various life history stages. The data analysis is preliminary but results implicate pesticide application as causing marked periodic decreases in capture rates for the months of September and October. Capture/h data for all species reached a peak shortly before resumption of the yearly spraying programs for cotton on fields adjacent to the bay. Closer examination of three species documents utilization of the estuary early in their life histories as well as in their adult stage.

Recursos Pesqueros de la Bahía de Jiquilisco, El Salvador

RESUMEN

Nuestro estudio informó de las noventa especies de peces que se utilizan en la bahía de Jiquilisco durante algún período de su vida. El análisis de los datos es preliminar, pero los resultados implican que la captura en los meses de septiembre y octubre disminuye a causa de la aplicación de pesticidas. La captura por hora para todas las especies alcanzó su máximo un poco antes del comienzo del riego anual sobre los algodonales contiguos a la bahía. Se examinaron tres especies que se utilizan el estero tanto en el estado juvenil como en el estado adulto.

ACKNOWLEDGMENTS

We wish to express our appreciation to the personnel of the Servicio de Recursos Pesqueros of the Ministerio de Agricultura y Ganaderia, El Salvador, for material support and cooperation in the present study and the Servicio Meteorologico and the Servicio de Informatica of the same unit for essential data provided to us. We also thank the U.S. Peace Corps, El Salvador, and the Graduate Research Council, University of Massachusetts, Amherst, for providing both funds and facilities.

Contribution No. 50 of the Massachusetts Cooperative Fishery Research Unit jointly sponsored by the U.S. Fish and Wildlife Service, the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Division of Marine Fisheries, and the University of Massachusetts, Amherst.

Addendum added while in Press

Cynoscion stolzmanni in the text has been reidentified as *Cynoscion phoxocephalus* (Labbish Chao, personal communication) and *Eucinostomus* sp. as *Eucinostomus argenteus* (Carl Hubbs, personal communication).

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