Diversity and fish community structure in a Central American mangrove embayment

by

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Abstract: Try net capture data from four key months of a 15 month fish survey were analyzed to characterize species composition and diversity at Jiquilisco Bay, El Salvador. This Pacific coast mangrove embayment presented a mostly uniform habitat and temperature-salinity profile except for the bay mouth area which had significantly higher salinity and a sand bottom.

Sixty one species were captured in these months. Among the dominant families were the sea catfishes, Ariidae, the mojarras, Gerreidae, the croakers or drums, Sciaenidae, several flatfish families and the pelagic Engraulidae and Clupeidae. There existed habitat preferences as some families or species preferred the bay mouth area over the muddy mangrove channels.

The sampling station nearest the bay mouth, with generally greatest capture in terms of numbers, had the lowest species diversity and the lowest evenness or distribution of individuals among species. Its high dominance index was due to the predominance of a few species in large numbers.

Structure and diversity of neotropical fish communities from various habitats have been characterized by a variety of mathematical models. Alevizon and Brooks (1975), comparing coral reefs in Florida and Venezuela, found a higher species diversity and evenness in the fish assemblages of Florida possibly due to the more complex reefs of that area. Weaver (1970) employed MacArthur's information theory formula to characterize species diversity among tidepool fishes at different sites along the Costa Rican Pacific coast. Only at one of his three sampling areas was there a significant positive correlation between species diversity and tidepool diversity. Specifically with estuarine fish communities, Leon (1973), in the Gulf of Nicoya, Costa Rica, used Shannon's information formula to pinpoint increasing species diversity along the salinity gradient from less saline headwaters to the open waters of the Pacific. D'Croz and Averza (1979), using the same index in a rainy season survey of a Panamanian Caribbean estuarine fish community, found that the very low species diversity was correlated only with temperature. Warburton (1978) found an annual variation in species diversity, evenness and richness but no between sites differences in two Mexican coastal lagoon fish communities.

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In a survey of Jiquilisco Bay, El Salvador, a mangrove embayment on the Pacific coast, I used several of these indices to characterize the fish community capture by try net and examine its relationship to temperature, salinity and bottom type.

STUDY AREA

Jiquilisco Bay, with 121 km^2, is the largest mangrove embayment on the Pacific coast of El Salvador. Soft, mudbottomed canals provide a uniform habitat for the fish fauna. Only near the bay mouth does sand replace the mud bottom. The annual mean precipitation, which occurs mainly from May to October, ranges from 1800 to 2000 mm. Peaks in the rains occur in June and October with a temporary halt in July or August.

Besides the natural climatic factors which affect the bay, Phillips and Cole (1978) further implicate the runoff of pesticides applied to nearby cotton fields from August to January as another important factor affecting the fish distribution in the study area. A noticeable decline in fish capture was observed during September 1975 and October 1976 which would presumably have an effect on any analysis of species composition and diversity.

MATERIAL AND METHODS

The six sampling stations were located 3 km to 22 km from the bay mouth (Fig. 1). Depths, at time of sampling averaged 7.0 m (range 1.5 to 13.0). I sampled each station twice per month from September 1975 to November 1976 with a 5 m try net and at a standardized towing time of 45 min.

Temperature and salinity data were collected at the time of sampling. Variations in these parameters among the six stations were examined for statistically significant differences with a one-way analysis of variance (ANOVA) (Steel and Torrie, 1960).

In order to examine changes in species composition during the survey, I took the data from a peak rainy season month (August), a peak dry season month (January) and the two transition months (May and November) for the diversity analysis.

Species diversity was calculated with an approximate equivalent to Shannon's information formula:

$$H' = \frac{C}{N}(N \log_{10} N - \Sigma n_i \log_{10} n_i),$$

where C is equal to 2.302.585, N is the total numbers at a station and n_i is the number of individuals in the i^{th} species (Lloyd *et al.*, 1968).

Species richness (SR), in this analysis, is simply the number of species per station (Franz, 1976).

The evenness component of diversity (J') is calculated by the formula:

$$J' = H'/\log s$$

H' has been previously computed and log s is the maximum possible diversity as defined by Pielou (1966). High diversity implies an even distribution of individuals among the species.

Dominance (D), the final diversity component dealt with here, is based on the percentage contribution of the two most abundant species at a sampling site (McNaughton, 1968).

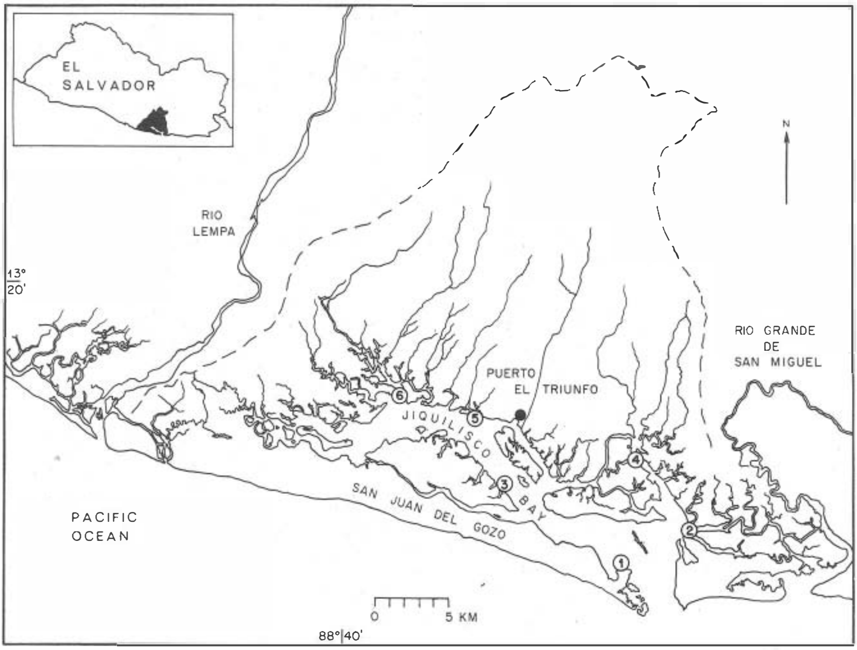


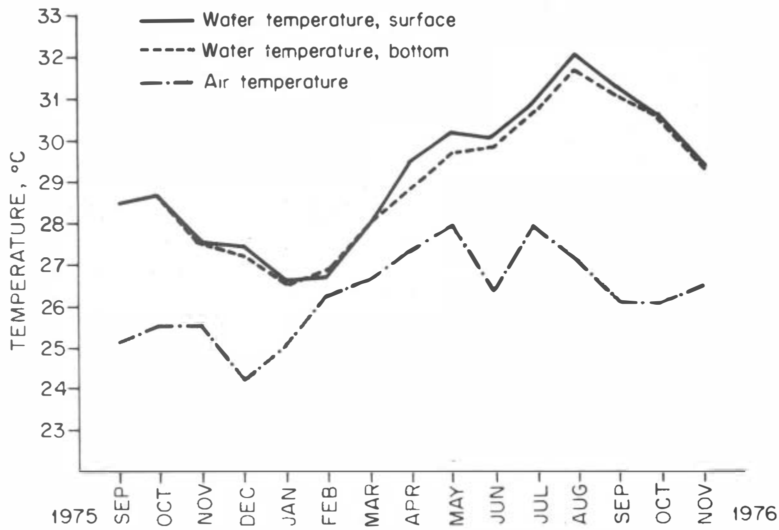
Fig. 1. Map of Jiquilisco Bay, El Salvador, with locations of six sampling stations.

RESULTS

Annual mean temperature calculated for all stations fluctuated approximately 5 C. Water temperature reached a minimum (26.5 C) in January 1976, representing a one-month lag behind the minimum air temperature, and a maximum (32.0 C) in August 1976, one month after the air temperature reached its maximum (Fig. 2). A small negative gradient in annual mean temperature observed from Station 6 (interior) to Station 1 (bay mouth) was not significant (Phillips, 1979; Table 4).

The more important seasonal change was due to the rainy and the dry season sequence. Salinity readings peaked in April 1976 (32.8 o/oo) before the initiation of the rainy season and were minimal in October 1975 (23.1 o/oo) after the heaviest month of rainfall (September 1975, Fig. 2). With a one-way ANOVA, a significant difference ($P < 0.05$) did exist between salinity values nearest the bay mouth (Station 1) and interior stations (Stations 2-6) on an annual mean basis (Phillips, 1979).

A total of 61 species of fish from 27 families were captured in the try net survey (Table 1). The most speciose family was Sciaenidae (eight species), followed by Carangidae (seven species) and Pomadasyidae (five species). These families were not so abundant in terms of numbers of individuals, especially Carangidae (78 individuals) and Pomadasyidae (46 individuals). Among individual species, the



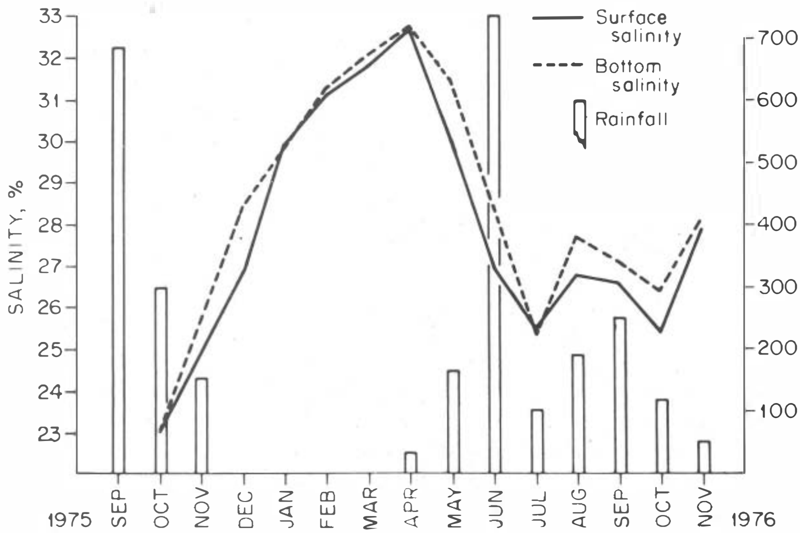


Fig. 2. Upper. Variation in mean air temperature and mean surface and bottom water temperatures in Jiquilisco Bay, El Salvador.
Lower. Variation in mean surface and bottom salinity and mean rainfall in Jiquilisco Bay, El Salvador.

ariid, *Galeichthys jordani*, was captured in greatest numbers, followed by the gerreids *Eucinostomus argenteus* and *Eugerres peruvianus.* The soles (*Achirus* spp.) were abundant except in August and apparently preferred a higher salinity or a sand bottom habitat due to its nearly exclusive capture (98%) at Station 1. Of the other two flatfish families, the Bothidae were numerous in January and November and were common near the bay mouth while the Cynoglossidae, a dominant family only in May, was most abundant at interiormost Station 6. The ariids were captured

TABLE 1

List of species captured in four months (January, May, August and November 1976) and ranked by abundance at Jiquilisco Bay, El Salvador

Galeichthys jordani	938	*Ephinephelus analogus*	13
Eucinostomus argenteus	820	*Bairdiella ensifera*	12
Achirus spp.	598	*Anisotremus pacifici*	11
Eugerres peruvianus	454	*Ophisthonema libertate*	10
Anchoa panamensis *Anchovia rastralis*	218	*Pseudupeneus grandisquamis*	9
		Cynoscion squamipinnis	9
Neopisthopterus tropicus	142	*Lutjanus argentiventris*	7
Symphurus elongatus	110	*Microgobius tabogensis*	7
Rypticus nigripinnis	109	*Brachydeuterus nitidus*	6
Cynoscion phoxocephalus	93	*Ephinephelus multiguttatus*	6
Etropus crossotus	68	*Synodus scituliceps*	5
Stellifer oscitans	62	*Menticirrhus nasus*	4
Batrachoides sp.	57	*Lile stolifera*	4
Chloroscombrus orqueta	57	*Fistularia commersoni*	4
Citharichtys gilberti	52	*Arius steindachneri*	4
Porichthys greenei	50	*Gobionellus sagittula*	4
Sphoeroides sp.	48	*Ophichthus zophichir*	3
Cyclopsetta panamensis	40	*Sphoeroides annulatus*	3
Ophioscion sciera	40	*Enypnias seminudus*	3
Ophioscion typicus	37	*Myrichthys tigrinus*	2
Brachydeuterus leuciscus	26	*Orthopristes chalceus*	2
Bagre panamensis	25	*Selene peruvianus*	2
Polydactylus approximans	21	*Caranx hippos caninus*	1
Symphurus atricaudus	20	*Prionotus horrens*	1
Chaetodipterus zonatus	17	*Pseudobalistes naufragium*	1
Chaetodon humeralis	17	*Trachinotus kennedyi*	1
Parrella lucretiae	15	*Selene oerstedii*	1
Selene brevoortia	15	*Caranx caballus*	1
Micropogon altipinnis	14	*Gymnothorax dovii*	1
Urotrygon asterias	14	*Anisotremus dovii*	1
Hippocampus ingens	14		

in large numbers in May and August exclusively at Station 1. November presented the opposite situation where *G. jordani* was captured in large numbers at interior Station 5. *Cynoscion phoxocephalus,* a favored commercial fish, was the most abundant sciaenid. In January and August sciaenid species were captured throughout Jiquilisco Bay. The clupeid, *Neopisthopterus tropicus,* was abundant in interior stations in May and November. The engraulids were abundant in interior stations in May and August. The remaining family that ranked high in abundance was the Batrachoididae in January, with fairly uniform distribution between the stations and among the two species, *Batrachoides* sp. and *Porichthys greenei.*

Table 3 summarizes the habitat division within Jiquilisco Bay ranked from pelagic schooling families (Engraulidae, Clupeidae), to components of mid-water or bottom (Ariidae, Sciaenidae, Gerreidae) and then strictly bottom fauna (Soleidae, Bothidae, Cynoglossidae). There cannot be a strict division of the water column as such, since all fishes were captured in a bottom-trawling try net.

TABLE 2

Dominant families and their distribution (numbers of individuals) among six sampling stations in four months at Jiquilisco Bay, El Salvador

January 1976

Station	1	2	3	4	5	6
Gerreidae	724	17	9	–	35	28
Soleidae	174	2	6	–	1	1
Batrachoididae	3	13	13	6	4	10
Bothidae	37	2	–	–	4	2
Sciaenidae	2	21	–	–	11	9

May 1976

Station	1	2	3	4	5	6
Ariidae	411	–	–	1	–	–
Soleidae	272	–	1	–	–	–
Gerreidae	11	14	–	60	18	20
Engraulidae	1	–	–	104	–	–
Cynoglossidae	3	–	1	13	3	44

August 1976

Station	1	2	3	4	5	6
Ariidae	369	24	–	2	12	3
Gerreidae	31	20	–	–	170	64
Sciaenidae	–	26	–	111	6	32
Engraulidae	–	16	–	–	20	55
Clupeidae	–	–	–	–	8	80

November 1976

Station	1	2	3	4	5	6
Ariidae	–	–	–	–	132	–
Soleidae	102	–	–	–	–	–
Clupeidae	–	–	54	–	11	1
Gerreidae	4	–	42	–	2	5
Bothidae	27	3	–	–	–	–

TABLE 3

Distribution of dominant families or species among six sampling stations at Jiquilisco Bay, El Salvador

Station	1	2	3	4	5	6
	(bay mouth)			(interior)		
			←	Clupeidae		→
			←	Engraulidae		→
	←	Sciaenidae				→
	Galeichthys jordani					
	Eucinostomus argenteus			*Eugerres peruvianus*		
	←	*Batrachoididae*				→
	Achirus spp.					
					Cynoglossidae	
	Bothidae					

Species richness (SR) or numbers of species tended to be higher at the bay mouth (Station 1) and at interiormost stations (Stations 5 and 6; Table 4).

The diversity component evenness (J'), the distribution of individuals among species, was usually lowest at Station 1 (except for November 1976). The low values were due to great abundance of a few species at that station.

Another diversity component, dominance (D), which calculates the percentage contribution of the two most abundant species, was highest at Station 1, except for November 1976. In January, the High D-value at Station 1, was due to a large capture of the gerreid *Eucinostomus argenteus* (724) and the soles *Achirus* spp. (174) and in August, due to a large capture of *Galeichthys jordani* taken at Station 5.

Fish community structure expressed by Shannon's H' index shows generally lowest diversity occurring at the bay mouth (Station 1) with values as low as 0.60 while those for interior stations reached 2.46. The exception was November 1976 with the higher diversity at Station 1. This high diversity resulted from the lack of dominance in the catch of ariids, gerreids or soles as in the other months. The diversity values are probably not affected by the annual variation in temperature or salinity since they do not differ greatly from the month of minimum temperature and high salinity (January 1976) and the month of maximum temperature and low salinity (August 1976).

TABLE 4

Components of diversity of the fish community captured by try net and calculated for six sampling stations at Jiquilisco Bay, El Salvador, dashes indicate insufficient numbers for computations

	January 1976					May 1976			
Sta.	H'	J'	SR	D	Sta.	H'	J'	SR	D
1	0.99	0.34	18	91	1	0.60	0.19	24	77
2	2.09	0.79	14	42	2	–	–	3	–
3	1.92	0.87	9	48	3	–	–	6	–
4	–	–	2	–	4	1.72	0.58	19	72
5	2.21	0.82	15	44	5	1.72	0.75	10	61
6	2.45	0.83	19	41	6	2.04	0.75	15	51

	August 1976					November 1976			
Sta.	H'	J'	SR	D	Sta.	H'	J'	SR	D
1	0.93	0.48	7	82	1	1.71	0.65	14	61
2	2.46	0.84	19	34	2	–	–	6	–
3	–	–	1	–	3	–	–	3	–
4	2.15	0.78	16	45	4	1.62	0.74	9	–
5	1.64	0.51	25	71	5	0.72	0.30	11	89
6	1.87	0.69	15	54	6	–	–	4	–

A significant negative correlation was observed between H' and dominance ($r=-0.932, P<0.05$). A significant positive correlation ($r=0.928, P<0.05$) was seen between evenness, a derived measure, and species diversity (H'). That evenness is inversely related to dominance is most evident from Station 1 in all four months. The indices indicate that the overall diversity pattern in Jiquilisco Bay is a function of both evenness and dominance.

DISCUSSION

Lowe (McConnell) (1962) attributed the higher catches during the rainy season at inshore areas of the British Guiana continental shelf to a general inshore movement of sciaenids and other species at the time. In a graph of total capture of 98 species of fish for all months of the 15 month survey of Jiquilisco Bay, Phillips and Cole (1978) noted a tendency for low capture during most dry season months

(January-April) and a much higher capture per unit effort in most rainy season months (May-August). The complete data for the survey included numbers from a beach seine, gill nets, cast nets, as well as the try net. The increase in capture during the rainy season was largely due to capture of pre-adult fishes (Phillips, 1979). In the present paper, analysis of the 61 species captured only by try net from four key months did not reflect such an increase in capture. Total numbers of individuals in January, May and August were similar and the November drop in capture was possibly caused by pesticides mixed in bay waters (Phillips and Cole, 1978).

The water temperature prevailing throughout the survey did not at any time vary significantly within the bay system, though the difference between the mean minimum and mean maximum was approximately 5 C. The area near the bay mouth did differ significantly from the interior in terms of salinity and bottom type. The species composition but not dominance remained fairly constant during the four months. Except for Ariidae in November 1975, those families or species preferring the bay mouth (*Eucinostomus argenteus, Achirus* spp., Bothidae, Ariidae) were always found there and those preferring the interiormost stations (*Eugerres peruvianus,* Cynoglossidae, Clupeidae, Engraulidae) were always found there. The sciaenids and batrachoidids were the most ubiquitous of the dominant families. These location trends may be due to the weak salinity gradient or simply that fishes from the nearshore freely enter and leave Jiquilisco Bay. Leon (1973), working also on the Central American Pacific coast noted no change in species composition or large-scale migration in the Gulf of Nicoya, Costa Rica.

The uniformity in the bay ecosystem is further supported by results of computing diversity indices. These did not vary greatly except, again, in November 1976. The Jiquilisco Bay H' values are much higher than the values (0.81-0.90) obtained by D'Croz and Averza (1979) for a Caribbean estuarine system where salinity values fluctuated greatly with rainfall amounts. Warburton (1978) found higher diversity and evenness in Mexican Pacific coastal lagoons during the rainy season and attributed the higher values to increased seasonal migration of non-residents. Leon (1973) observed a pronounced fluctuation in salinity in the Gulf of Nicoya during the rainy season with fresh water influence spreading into the open Pacific. In his study, species diversity increased along the salinity gradient with values (2.295-2.771) similar to or higher than those of interior stations at Jiquilisco Bay.

Jiquilisco Bay, except near the bay mouth, presents a highly homogeneous environment. Neither species composition nor diversity vary greatly in this coastal embayment. However habitat preferences are noted among dominant families and species, and only November presents anomalies to the overall fish community pattern.

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RESUMEN

Datos de captura de peces durante cuatro meses claves de un inventario de 15 meses, fueron analizados para evaluar la composición de especies y su diversidad en

la bahía de Jiquilisco, El Salvador. Esta laguna de manglar de la costa pacífica presentó un hábitat y un perfil de temperatura-salinidad generalmente uniformes con excepción del area de la boca de la bahía, que tuvo una salinidad significativamente más alta y un fondo arenoso.

Sesenta y un especies fueron capturadas en estos meses. Las familias dominantes incluyeron los bagres marinos, Ariidae, las mojarras, Gerreidae, las corvinas, Sciaenidae, varias familias de peces planos y los peces pelágicos de las familias Engraulidae y Clupeidae. Existió una preferencia de hábitat en algunas familias o especies que prefirieron al área de la boca a la de los canales fangosos del manglar.

La estación de muestreo más cerca de la boca, con generalmente la captura más grande en números, tuvo la más baja diversidad de especies y la más baja uniformidad o distribución de individuos entre especies. Su alto índice de dominancia se debió a la predominancia de grandes números de pocas especies.

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