Diel and monthly variation in abundance, diversity and composition of littoral fish populations in the Gulf of Nicoya, Costa Rica

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Abstract: Approximately 5,500 fishes weighing more than 62 Kg and representing 61 species were captured at four-week intervals at a mangrove and a beach site at Punta Moreles, Gulf of Nicoya, Costa Rica, from May 1980 to April 1981. Day and night samples were taken equelly. *Anchoa panamensis* comprised 23% of the total number of individuals, whereas *Mugil curema* acounted for 21%of total biomass.

Capture trends were similar for numbers of species and individuals and total biomass throughout the study. The only significant capture data difference was between mangrove (greater) and beach habitats in terms of numbers. Large numbers of juvenile engraulids, atherinids and gerreids were correlated negatively with lower salinity from August to October. The mullet, *Mugil curema,* apparently favors higher salinities of the dry season and accounts for the increase in biomass at the beginning and end of the study. In spite of these seasonal differences, H' diversity varied little, with a mean of 2.72 for numbers and 2.98 for biomass.

Percentage similarity (PS) values between sites, times and sampling periods were generally low but only rarely significantly so. The moderately low seasonal change in PS values coupled with a stable and high annual H' diversity indicate that the littoral fish populations are not presently adversely stressed by environmental contamination input into the Gulf of Nicoya.

The Gulf of Nicoya, Costa Rica, ranks among the larger Central American Pacific coast estuaries. Within Costa Rica, it supplies roughly 90% of the commercial fish landings (Estes, 1976). At the same time, there is residual chemical contamination input from the agricultural activity on lands surrounding the gulf. The area is also influenced by heavy commercial and tourist activity. The Gulf of Nicoya, subjected to a variety of conflicting interests, as a unit is characterized by nearly a complete lack of resource management (Blair, 1979).

Various aspects of the fisheries resources of the Gulf of Nicoya have been documented in a number of studies. Britton (1966) described a small collection of shore zone fishes. Erdman (1971) published life history notes on 55 species collected from an important coastal fish market. In a more comprehensive study, Peterson (1956) developed keys and supplied ecological data on the abundant pelagic engraulid and clupeid species. Demersal fish inventories have also been conducted, defining faunistic areas based on fish communities or associations (León, 1973), and analyses of abiotic parameters affecting fish distributions (Bartels, 1981). Fish diversity has been calculated based on the information theory formula H' (León, 1973; Bartels 1981), though such analyses have not previously been carried out on any littoral zone fish communities in the Gulf of Nicoya.

The purpose of the present study was to compare the shallow-water fish communities of a beach site and a mangrove site; and to determine diel and monthly variation in abundance, diversity and species composition within and between the two sites in the Gulf of Nicoya. Also, the analysis tested in a tropical estuary the hypothesis developed by Haedrich (1975) for temperate estuaries and bays. Haedrich demostrated, in a survey of nine Massachusetts estuaries, that in areas of low annual diversity (0.4) there is high similarity or overlap with little seasonal change. On the contrary, high annual diversity (2.4) was accompanied by lower similarity (high seasonal change). Low diversity defined highly contaminated habitats whereas high diversity characterized lesser contaminated areas. Since the Gulf of Nicoya is surrounded by agricultural lands where the use of a wide range of chemicals is prevalent, and it does receive industrial and human contaminants from a major port city, the fish populations may be expected to suffer from some degree of environmental stress. Therefore, the diversity and similarity values may be expected to be at a low or an intermediate level compared to an undisturbed tropical estuary as a result of this environmental stress. Comparisons were made, where possible, between diversity and similarity values from other tropical fish investigations (León, 1973; Warburton, 1978b, Bartels, 1981; Phillips, 1981), and studies published from temperate estuaries (Dahlberg and Odum, 1970; Haedrich and Haedrich, 1974; Stephens *et al.*, 1974; Allen and Horn, 1975; Haedrich, 1975; Horn, 1980).

MATERIAL AND METHODS

The Gulf of Nicoya is located on the Pacific coast of Costa Rica (10°N, 85' W) and encompasses an area of approximately 1530 km^2 (Fig. 1). The shoreline of the inner gulf, north of Puntarenas, is generally characterized by mangrove forest, whereas the outer gulf ranges between rocky outcroppings separated by sandy beaches. Freshwater drainage into the inner gulf area comes mainly from the Tempisque River, and is greatest during the rainy season from May to November. Tides, of 3 m average height, serve to periodically flush the gulf system.

The study was conducted at Punta Morales, a rocky peninsula projecting into the inner gulf on its eastern shore. The sandy beach sampling site was located at the south side of the peninsula and the mangrove sampling site at the north side (Fig. 2).

Samples were taken monthly (four-week intervals) from May 1980 to April 1981, totaling 13 sampling periods. Surface water temperatures and surface salinity were recorded at the time of sampling (Fig. 3).

Annual fluctuations of mean values ($\ddot{x}$ ± 1SD, n = 13) for temperatures were 28.7 ± 2.8 C at the beach site, 29.1 ± 3.7 C at the mangrove site; 30.3 ± 3.8 C during day samples and 27.2 ± 2.1 C during night samples. Tested with a one-way ANOVA, there was no significant difference ($P \leqslant 0.05$) between beach and mangrove temperatures throughout the study, but there was a highly significant difference ($P \leqslant 0.05$) between higher day and lower night readings. Annual mean salinities were 24.2 ∓ 6.9 ‰ at the beach site, 11.8 ‰ at the mangrove site; 24.4 ∓ 8.4 ‰ during day samples and 24.3 ∓ 10.5 ‰ during night samples. There were no significant differences ($P \leqslant 0.05$) testing between sites or times during a sampling period.

Fish samples were collected with a beach seine 25 m long by 1.5 m deep with a 0.5 x 0.5 x 3 m bag. The net had a uniform stretch mesh size of 13 mm. The net was set out by hand perpendicular to the shore, entering to approximately 20 m distance to circle around and return to the shore. This was repeated each time. Samples at both sites were taken on outgoing and on incoming tides both during the day and night, thus totaling 16 hauls per sampling period. All specimens captured were identified, measured for standard length (SL) and total length (TL) and weighed (g).

During the first three sampling periods, night mangrove samples could not be taken. Therefore, for these periods, in the analysis of day and night differences the two mangrove day samples were eliminated, leaving a comparison only between beach day and night samples. Likewise, in the analysis of beach and mangrove differences the two beach night samples were eliminated leaving a comparison only between beach day and mangrove day samples.

Species diversity was calculated with an approximate equivalent to the Shannon-Weiner information function H'.

$$H' = \frac{C}{N} (N\log_{10} - n_i \ \Sigma \log_{10} n_1),$$

where C is equal to 2.302585 (base of the natural logarithm), N is the total number of specimens in the sample and n_1 is the number of individuals in the i^{th} species (Lloyd *et al.*, 1968).

The percentage similarity index (PS of Whittaker and Fairbanks (1985) and its interpretation by Horn (1980) quantify changes in species composition of individuals and biomass sites (beach, mangrove), between times (day, night) and among the 13 sampling periods. When the percentage similarity value is 0, there are no species in common between the two samples in question. When the percentage simi-

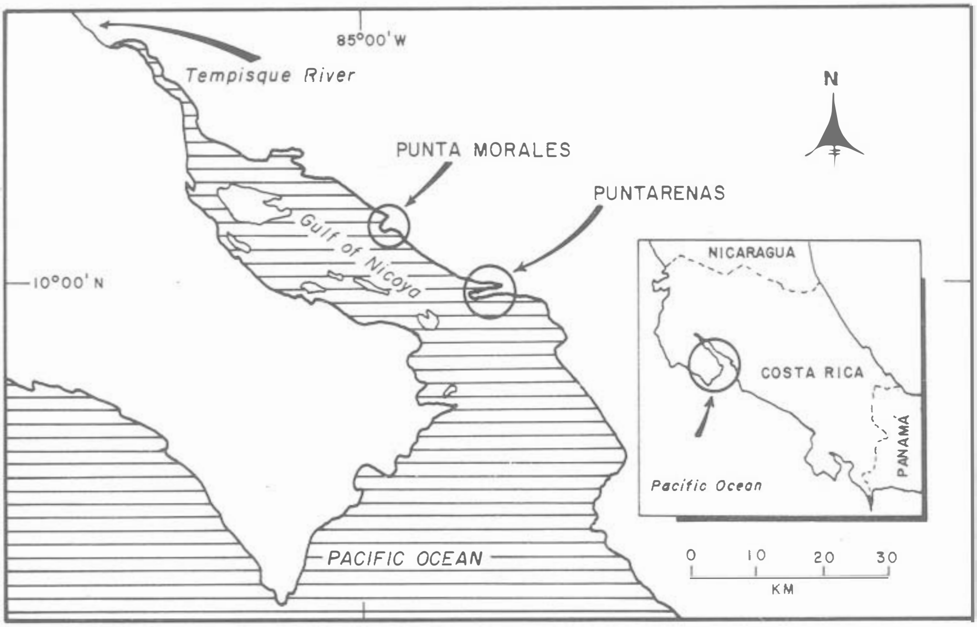

Fig. 1. Gulf of Nicoya, Costa Rica.

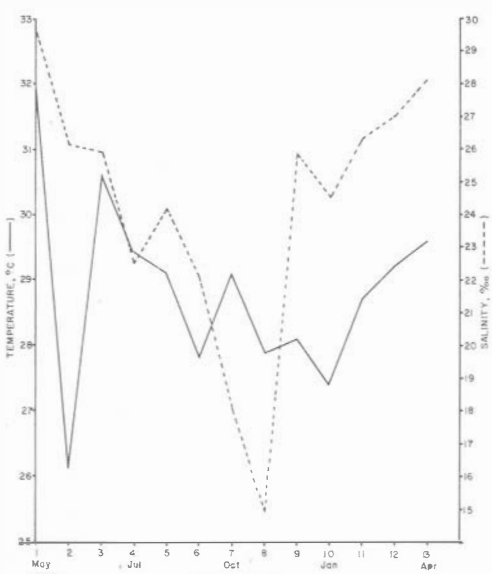

Fig. 3. Annual variation in temperature and salinity at Punta Morales, Costa Rica.

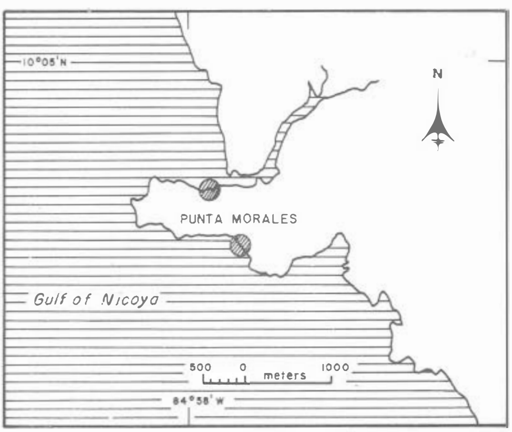

Fig. 2. Locations of the mangrove sampling site (north) and the beach sampling site (south) at Punta Morales, Costa Rica.

larity value is 100, the species composition is identical between the two samples. The formula is,

$$PS = 100\,(1.0 - 0.5\ \Sigma_i\ /\ P_{ia} - P_{ib}/),$$

where P_{ia} is the proportion of the importance (individuals or biomass) of the i^{th} species in sample a, with P_{ib} likewise defined for sample b.

RESULTS

During a one-year collection comprising 13 sampling periods, 5,553 fishes weighing 62,439 g were collected. Of the 61 species, the anchovy, *Anchoa panemensis,* comprised 23%of the total number of individuals, while the 11 most abundant species (Table 1) contributed 84%of the total. *Mugil curema,* a mullet, accounted for 21% of the total biomass, while the same 11 species included 76.3% of total biomass.

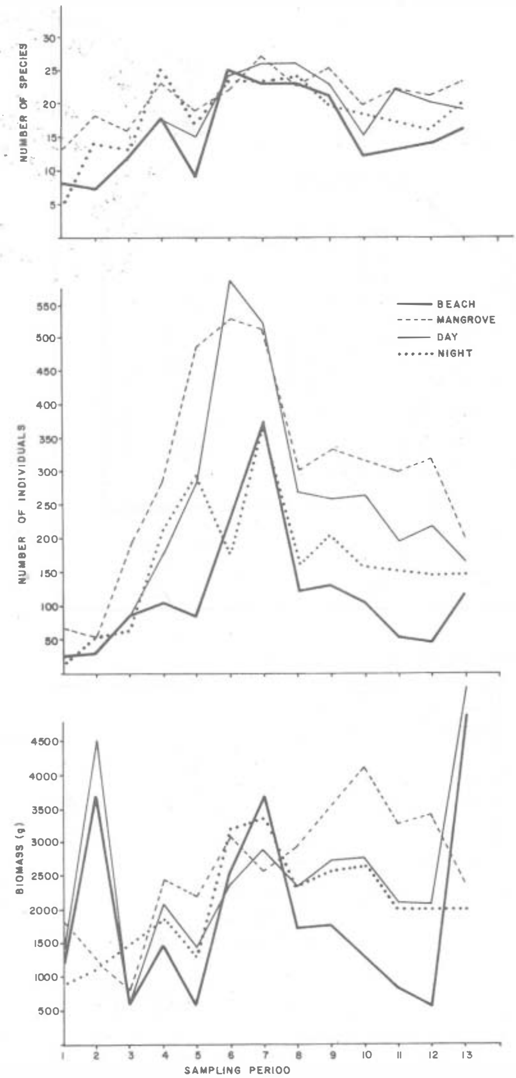

Fig. 4. Annual diel and site variation in number of species (upper), number of individuals (middle) and biomass (lower) for 61 fish species.

TABLE 1

Numbers and biomass of the eleven most abundant fish species at Punta Morales, Costa Rica

Species	No.	Rank No.	Biomass (g)	Rank Biomass
Anchoa panamensis	1,280	1	7,619.9	2
Diapterus peruvianus	669	2	2,061.4	8
Anchovia macrolepidota	667	3	2,014.0	9
Melanris guatemalensis	579	4	2,940.4	6
Centropomus unionensis	431	5	4,415.1	5
Mugil curema	243	6	12,847.0	1
Hyporhamphus synderi	202	7	1,360.2	11
Arius furthii	190	8	4,606.2	4
Anchoa lucida	187	9	2,372.2	7
Lile stolifera	177	10	1,801.1	10
Sphoeroides annulatus	63	11	5,643.0	3
Totals	4,688		47,635.5	

The most speciose of the 28 families of the study were Sciaenidae, the croakers (9 spp.), Engraulidae, the anchovies (7 spp.), Carangidae, the jacks (6 spp.) and Pomadasyidae, the grunts (4 spp.). The number of species captured in each of the 13 sampling periods ranged from 19-36 ($\bar{x}$ = 28). Nearly equal numbers of species were captured in the day samples (48) as in the night samples (49) though somewhat more were taken in mangrove samples (49) than in beach samples (40). In the initial three months, where fewer replicate seine hauls were taken, the numbers of species were only slightly lower than the middle of the sampling period (September-December). The species numbers dropped slightly in the final part of the study (Fig. 4). The graph of numbers of individuals shows a similar trend with low numbers in the beginning, a large increase in the mid-study period (August-October) and a dropping-off at the end of the study.

The comparison between the numbers and biomass curves is especially significant when the rainy and dry seasons are separated. In both the beginning and the end of the study period, which corresponds to the dry season, mullet, *Mugil curema*, (ranked 1 in biomass, but 6 in numbers) accounted for all four day and beach peak captures. *M. curema* appears to favor the higher salinity months when the Gulf of Nicoya system presents a more marine environment due to low fresh water input. Though found from juvenile to adult stages, the high biomass relative to the low numbers in the dry months illustrates the fact that most mullets captured were adults.

A clear contrast are the mid-study months from August to October. Referring to the temperature-salinity regimen (Fig. 3), the increase in capture during this time can be correlated negatively (r= -0.63) to the abrupt decrease in salinity. The large increase in numbers compared simultaneously with a smaller increase in biomass would indicate the presence of either juvenile fishes or simply smaller species in adult or juvenile stages. And in fact the mid-study peak at the mangrove site was due to high captures of juvenile and adult anchovies, *Anchovia macrolepidota* (August, September), juvenile and adult silversides, *Melanirus guatemalensis,* and juvenile

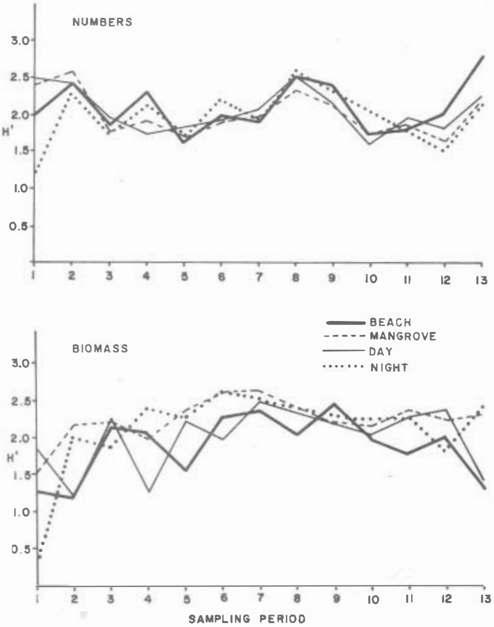

Fig. 5. Annual diel and site variation in H' diversity for numbers (upper) and biomass (lower) of 61 fish species.

mojarras, *Diapterus peruvianus* (October). In the day samples, *Anchovia macrolepidota* and *D. peruvianus* (September), and juvenile

TABLE 2

Day-night and beach-mangrove comparisons for fish samples in 13 sampling periods and total collections with their respective percentage similarity values (PS). The difference column is based on the Wilcoxon signed-ranks test for paired values (P ≤ 0.05, twotailed) performed on the species pairs

Sampling Period	Day (Numbers)	Night (Numbers)	PS	Difference
1	27	11	7.4	NS
2	31	53	29.6	NS
3	88	64	51.4	NS
4	183	211	33.0	NS
5	282	291	76.1	NS
6	587	177	22.1	NS
7	522	367	47.2	NS
8	267	157	59.0	NS
9	259	206	44.8	NS
10	263	160	34.0	NS
11	198	154	35.0	NS
12	219	147	63.8	NS
13	166	150	28.0	NS
Totals	3,092	2,148	57.9	NS

Sampling Period	Day (Biomass)	Night (Biomass)	PS	Difference
1	1,244,9	872.2	20.2	NS
2	4,586.4	1,120.1	19.1	NS
3	610.4	1,498.2	35 5	NS
4	2,085.3	1,886.9	23.4	S(D > N)
5	1,441.6	1,313.2	64.1	NS
6	2,339.9	3,215.0	19.6	S(N > D)
7	2,916.0	3,374.1	45.2	NS
8	2,339.8	2,317.0	51.9	NS
9	2,711.5	2,594.7	40.7	NS
10	2,761.4	2,697.6	42.4	NS
11	2,115.3	1,996.4	26.1	NS
12	2,048.4	1,925.2	38.7	NS
13	5,278.8	1,997.7	30.7	NS
Totals	32,539.7	26,809.3	48.0	NS

Sampling Period	Beach (Numbers)	Mangrove (Numbers)	PS	Difference
1	27	68	16.9	NS
2	31	54	28.9	NS
3	88	191	44.6	NS
4	105	289	42.0	NS
5	86	487	37.6	NS
6	235	529	22.1	NS
7	375	514	33.2	NS
8	122	302	31.8	NS
9	132	333	48.9	NS
10	104	319	20.6	NS
11	52	300	9.3	NS
12	45	321	46.8	NS
13	115	201	21.2	NS
Totals	1,497	3,908	50.7	NS

Sampling Period	Beach (Biomass)	Mangrove (Biomass)	PS	Difference
1	1,009.9	1,857.4	9.3	NS
2	3,712.1	1,255.9	22.3	S(B > M)
3	,610.4	,809.0	47.2	NS
4	1,489.7	2,482.5	60.0	NS
5	,581.2	2,174.6	40.1	NS
6	2,522.2	3,092.7	31.3	NS
7	3,711.5	2,578.6	40.8	NS
8	1,706.7	2,950.1	33.0	NS
9	1,749.9	3,556.3	48.6	NS
10	1,325.6	4,133.4	25.2	NS
11	,834.7	3,277.0	10.2	NS
12	,562.3	3,511.1	43.7	NS
13	4,871.3	2,405.2	26.4	S(B > M)
Totals	24,687.5	33,984.0	44.4	NS

and adult *Anchoa panamensis* (October) accounted for the excessive peak in capture during that time period. The peaks of the night samples were due to *D. peruvianus* (October), and at the beach site, *Anchoa*

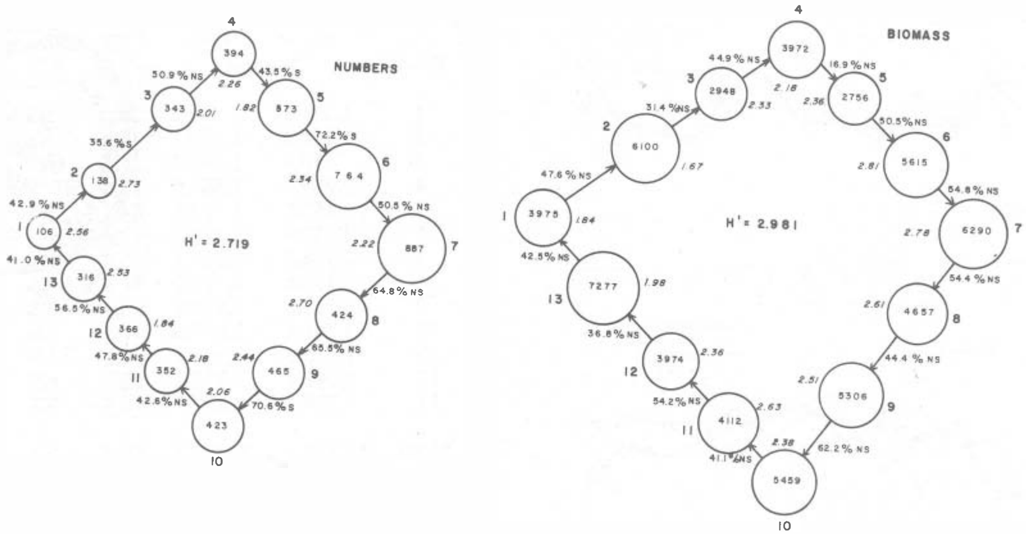

Fig. 6. Indices calculations from each of 13 sampling periods on fish numbers (upper) and biomass (lower): annual H' diversity is in the center; the area of each circle is proportional to the sample size; sampling period H' diversity is indicated in italics to the inside of the circle; and the percentage on the connecting arrow is the PS value between sampling periods, indicating in paranthesis the significance (S) or non-significance (NS) (Wilcoxon signed-ranks test for paired values, P ≤ 0.05, two-tailed).

panamensis, Arius furthii, the marine catfish, in juvenile and adult forms and juvenile leatherjackets, *Oligoplites saurus* (October). This complex of species obviously favors and dominates in estuarine conditions. Finally, treated with a one-way ANOVA, there was no significant difference (P≤ 0.05) between day and night but there was a significant difference between numbers of individuals captured at beach and mangrove (greater) sites at the 5% level.

Mean species diversity H' ranged from a low of 1.87 (beach, biomass) to a high of 2.23 (mangrove, biomass). Figure 5 demonstrates that there was virtually no annual variation in numbers diversity, and that peak or drop trends in H' were similarly reflected in day, night, beach and mangrove samples. Biomass diversity was similar in value and in its lack of annual variation.

The percent similarity (PS) values were greater for numbers (57.9% , 50.7%) than for biomass (48.0% , 44.4%), though not significantly so (Table 2). In terms of individuals, greater numbers were captured in day than in night samples (NS) and in mangrove than in beach samples (S). The same result was found in total weight, with a greater biomass in the day (NS) and mangrove (NS) samples. Upon scanning Table 2 two important observations can be made. The calculated percentage similarity values in general are low between day-night and beach-mangrove samples. But at the same time, of 56 paired calculations, only 4 biomass pairs differed significantly using the Wilcoxon signed-ranks test. In sample period 4 (July), though 4 individuals of the puffer, *Sphoeroides annulatus,* were taken in each of the day and night samples, their day weight (1278 g) as adults was much greater than their night weight (85g) as juveniles. In sampling period 6 (September), a large number of species were captured only at night or in greater numbers at night, producing significantly different night biomass captures. In the beach-mangrove biomass comparisons, in sampling period 2 (May-June) a moderate beach capture (20 individuals) of adult mullets, *Mugil curema,* contributed 3,372 g whereas 11 juveniles of the same species captured in the mangrove contributed only 260.9 g. Finally, a moderately large beach capture of the silversides, *Hubbesia gilberti,* and the anchovy, *Anchoa lucida,* apparently produced a significant difference for beach-mangrove samples in sampling period 13 (April).

Figure 6 illustrates percentage similarity between periods for numbers and biomass. There was a significant difference in only 4 of 13 pairs in terms of numbers of indi-

viduals. From sampling periods 2 to 3 (May-June to early July), the difference is due to an increased abundance (numbers) of *Anchoa panamensis, Anchovia macrolepidota* and *Melaniris guatemalensis* in July.
Between periods 4 and 5 (early July to late July), this difference appears to be due to an increase in numbers of *Anchovia macrolepidota.* The remaining two period pairs, 5-6 (August to September) and 9-10 (December to January) did not present any outstanding trends in terms of species dominance changes from one period to the next. Though the PS values varied for biomass over the entire study period, no significant differences were found for paired values of adjacent months.

DISCUSSION

Species diversity and composition: The results of this study indicate that the littoral fish populations in the Gulf of Nicoya are stable on an annual basis with a moderately high diversity, a finding substantiated by other Pacific coast studies in tropical America and in direct contrast to temperate estuarine population structure. With annual diversity on numbers at 2.72 and on biomass at 2.98, the values were somewhat below Caribbean Virgin Islands reef patches (3.3), expected to be the most highly diverse of marine environments (Haedrich, 1975). Yet the Gulf of Nicoya values were well above those of results for the central California coast study by Horn (1980) where H' was between 0.79 and 1.91, or in southern California with 0.47 as an annual diversity (Allen and Horn, 1975). Other such temperate estuarine studies revealed similarly low diversity; H' from 0.65 to 2.08 for Los Angeles harbor (Stephens *et al.* 1974), 0.13 to 0.91 for Upper Galveston Bay, Texas (Bechtel and Copeland 1970), 0.7 to 1.6 for Georgia sounds (Dahlberg and Odum 1970) and 0.33 to 1.03 for the Mystic River estuary, Massachusetts (Haedrich and Haedrich 1974).

In these temperate studies, the lower diversities were due to a much greater dominance of a few species than in the present study. In Horn's (1980) survey, shore sampling yielded three species, *Atherinops affinis, Cymatogaster aggregata* and *Leptocottus armatus,* which accounted for nearly 82% of the total for individuals, while 84% of the biomass was due to *Mustelus californicus, A. affinis* and *C. aggregata.*

Allen and Horn (1975) reported that in their beach seine collections of Alamitos Bay, California, the northern anchovy (*Engraulis mordax*) made up 90% of the catch and only four species, *E. mordax, Atherinops affinis, Anchoa delicatissima* and *Cymatogaster aggregata,* comprised 99%of the catch.

In a surf zone habitat in the northern Gulf of Mexico, Modde and Ross (1981) found high dominance in numbers (80.2%) by two clupeiform fishes, *Anchoa lyolepis* and *Harengula jaguana.*

In demersal fish studies of the Gulf of Nicoya, León (1973) calculated H' diversity values ranging from 2.295 at the inner gulf to 2.771 seaward, values similar to those of the present study. Also, he found little seasonal variation in the composition of the 145 species. Having sampled with a trawl, his shallow, less saline sampling areas were dominated by Sciaenidae and Ariidae, whereas in muy study clupeiform and atheriniform fishes dominated, species which are not efficiently captured with trawling gear.

Bartels (1981), also working in a Gulf of Nicoya demersal fish study, calculated H' values with a broader range between 0.671 and 3.163. Of the 214 species captured, again sciaenids and ariids dominated the catch. He also found no significant seasonal changes in numbers, biomass, percentage occurrence or diversity in fishes.

In El Salvador, Phillips (1981) found dominance by the ariids, gerreids and sciaenids as well as engraulids and clupeids in a fish study of a mangrove embayment, Jiquilisco Bay. H' diversity values varied between 0.99 (seaward) to 2.46, with values generally in the latter part of the range. The low seaward diversity was due to the abundant marine catfish, *Galeichthys jordani.*

Finally, in a similar environment of coastal embayments along the Mexican Pacific coast (Guerrero),Yañez-Arancibia (1978) encountered dominance by the ariid, *Galeichthys caerulescens* (21.4% by numbers), *Mugil curema* (17.8%) and *Diapterus peruviamus* (11.5%). H' values were from 1.524 to 2.534. Warburton (1978a; 1978b), sampling slightly to the north in the Huizache-Caimanero lagoon system (Sinaloa), found that the dominant fish species in terms of biomass were the mullet, *Mugil curema,* the anchovy, *Anchoa panamensis* and the catfish, *Galeichthys caerulescens.* It is interesting to reiterate that in my study the first two species are identical in biomass importance and that the marine catfish, *Arius furthii,* was ranked fourth. In terms of numbers, *G. caerulescens* was displaced by the herring, *Lile stolifera,* in Mexico, whereas the same species ranked tenth by numbers and biomass at Punta Morales.

Annual and seasonal variation and environmental factors affecting capture: Temporal changes in fish abundance and composition are the rule in temperate estuaries as reviewed by Modde and Ross (1981). In their northern Gulf of Mexico study they found late spring and summer and then late winter peaks in fish numbers in which clupeiform fishes dominated. Capture differences were usually due to diel changes (tide, time of day) rather than temperature which was an important factor in the capture of the carangid, *Trachinotus carolinus,* and the sciaenid, *Menticirrhus littoralis.*

Numbers of species and individuals were again greatest in the summer months from May to September and highly correlated with temperature in Alamitos Bay, California (Allen and Horn, 1975).

In tropical and subtropical areas changes in seasonal abundance also can occur. At Punta Morales, a rainy season peak abundance, especially of certain engraulid and atherinid among other species, was observed. This indicates a preference for estuarine conditions among these fishes and to some extent a juvenile migration into the upper estuarine areas.

In subtropical Moreton Bay, Australia, juvenile fishes were recruited mainly in the rainy season and preferred shallow water areas. Salinity and temperature were found not to be important. Instead turbidity, which may relieve predator pressure, and increase food supply, brought on by the rains, were considered the most important factors in increased abundance (Blaber and Blaber 1980).

Both León (1973) and Bartels (1981) reported little or no seasonal or annual change in species composition or abundance in the Gulf of Nicoya. Bartels states that apparently rainfall has no major effect on fish population and that there is an absence of seasonal stress in this tropical estuary. Phillips (1981) noted the same absence of seasonal stress in Jiquilisco Bay, El Salvador in terms of species composition, abundance and distribution. But in an analysis of annual catch per unit effort in the same mangrove lagoon, Phillips and Cole (1978) reported a large increase in rainy season catch due mainly to pre-adult fishes. The relation between lower salinity (rainy season) and high pre-adult capture may be secondary and more dependent on the factors proposed by Blaber and Blaber (1980). Phillips and Cole (1978) used a small-mesh trawl which captured sizes that León (1973) and Bartels (1981) may likely have missed with their larger-mesh shrimp trawls.

Environmental quality: Haedrich (1975) first proposed the combined use of H' diversity and PS values to describe environmental quality. When an estuary does not suffer from pollutional stress, many species will use it, resulting in a low seasonal and annual similarity in species composition and high species diversity. The low similarity would be due to much seasonal/annual movement and migration of fish populations into and out of the estuary, according to Haedrich's temperate estuary model. On the other hand, any pollutional stress would tend to decrease the utility of the estuary by an increasing number of species, finally leaving only the most resistent species and thereby lowering diversity and increasing seasonal similarity (PS). In his survey of nine Massachusetts estuaries, high PS ranged from 75-85% for a polluted zone, whereas low values ranged from 16-69% for an uncontaminated zone.

In a test of the model along the temperate central California coast, Horn (1980) found that Morro Bay was a relatively unspoiled habitat due to high total diversity (1.63 numbers and 1.59 biomass) and a wide range of fairly low PS values (24-64% numbers and 21-76% biomass). In addition, he reviewed other California estuarine fish studies and pointed out a situation not considered by Haedrich, that low H' diversity combined with variable PS similarity is indicative of a high seasonal abundance of one or a few species.

At Punta Morales, the high annual H' on numbers (2.72) and on biomass (2.98) combined with the variable PS values on numbers (35.6-72.2%) and on biomass (16.9-62.2%) indicate that in spite of the agricultural runoff and commercial activity in the Gulf of Nicoya, the fish populations are diverse and abundant, throughout the year.

CONCLUSIONS

The Punta Morales littoral zone presents moderate seasonal or annual changes in fish species composition as demostrated by the moderately low to medium and moderately variable PS values. This is similar to other tropical estuarine studies in spite of the fact that changes in species composition have not been analyzed quantitatively in the past.

The H' diversity values are consistent with other Gulf of Nicoya and tropical American Pacific studies, yielding higher H' values than temperate estuaries.

Though the seasonal species composition is more stable and the H' diversity values higher than temperate estuaries, the littoral zone at Punta Morales was dominated mainly by a few atheriniform and clupeiform species, similar to temperate estuaries.

At Punta Morales, numerical and biomass dominance by a few species is less skewed than in temperate estuaries where there are still fewer dominants.

Based on Haedrich's (1975) hypothesis, the fish populations at Punta Morales do not appear to be presently affected adversely by environmental stresses as might be expected by the intense agricultural and commercial activity in the area. In that Punta Morales is located in the upper reaches of the inner gulf, where the greatest agricultural runoff may be expected, a similar lack of environmental stress may be the rule throughout the gulf system.

As the area is subjected to increasing population pressure and agricultural activity, it will be necessary to monitor changes in the fish populations due to their importance in the area economy.

RESUMEN

Se capturó aproximadamente 5,500 peces con un peso mayor de 62 kg y que representaron 61 especies en un sitio de manglar y otro de playa a intervalos de cuatro semanas en Punta Morales, Golfo de Nicoya, Costa Rica, de mayo de 1980 a abril de 1981, en muestreos diurnos y nocturnos. *Anchoa panamensis* representó 23% del número total de individuos, mientras que *Mugil curema* abarcó 21% de la biomasa total.

Las tendencias de captura fueron semejantes para el número de especies, el número de individuos y la biomasa total a través del estudio. La única diferencia significativa fue entre el manglar (mayor) y la playa en cuanto a números.

Se correlacionaron negativamente un gran número de juveniles en engraúlidos, atherínidos y gerreídos con las bajas salinidades de agosto a octubre. Aparentemente la presencia de la lisa, *Mugil curema,* estuvo favorecida por las más altas salinidades de la época seca y explica el incremento en la biomasa al comienzo y al final del estudio. A pesar de estas diferencias estacionales la diversidad H' varió poco, calculándose un promedio de 2.72 para números (individuos) y de 2.98 para biomasa.

Los valores de porcentaje de similitud (PS) entre sitios, tiempo y período de muestreo generalmente fueron bajos pero rara vez de manera significativa. El cambio estacional moderadamente bajo en los valores PS, junto con una diversidad H' alta y estable, indican que las poblaciones litorales de peces no se ven afectados por la contaminación en el Golfo de Nicoya.

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