CEER – T-071

A STUDY OF FISH POPULATIONS IN THE ESPIRITU SANTO RIVER ESTUARY

IRIS N. CORUJO FLORES

TERRESTRIAL ECOLOGY DIVISION

SUBMITTED AS A DISSERTATION TO
THE FACULTY OF NATURAL SCIENCES

of the

UNIVERSITY OF PUERTO RICO, RIO PIEDRAS

AS PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO – U.S. DEPARTMENT OF ENERGY

A STUDY OF FISH POPULATIONS IN THE ESPIRITU SANTO RIVER ESTUARY

IRIS N. CORUJO FLORES
TERRESTRIAL ECOLOGY DIVISION

SUBMITTED AS A DISSERTATION TO
THE FACULTY OF NATURAL SCIENCES

of the

UNIVERSITY OF PUERTO RICO, RIO PIEDRAS

AS PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

MAY 1980

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
Operated by
THE UNIVERSITY OF PUERTO RICO
for the
U.S. DEPARTMENT OF ENERGY

ABSTRACT

The frequency and relative abundance of fish species found in the Rio Espiritu Santo River estuary was determined through a one year sampling program. Thirty families comprised of 60 species were recorded from different localities in the estuary. The piperfish *Pseudophallus mindii* (Meek and Hildebrand) and the blenny *Lupinoblennius dispar* Herre are new records for the literature fishes from Puerto Rico.

The temporal and spatial distribution of fishes inhabiting the estuary were related to salinity and biotic components such as species specific reproductive cycle, trophic relations and habitat preference. The temporal changes in relative abundance resulted primarily from the migratory behavior of many species. These migrations were related to the reproductive condition of the species and emphasized the spawning ground function of the estuary. Spatial changes in abundance were related to salinity and/or trophic relations of the species observed.

ACKNOWLEDGEMENTS

The author is grateful to the many persons who have contributed in one way or other to this study: to the members of the thesis committee for their contributions and assistance. This study would not have been possible without the many generous gifts to their time and knowledge. I wish to thank: Iván Rosa for lending his valuable field assistance; Drs. Richard Clements and Arthur McB. Block for the provision of laboratory facilities and helpful comments of the manuscript; Lourdes Fuentes for her assistance in the analyses of water samples.

I am grateful to Donald S. Erdman, Joseph Kimmel and C.E. Dawson (Gulf Coastal Research Lab. Mississippi) for aid in fish identification.

Sincere thanks are due to the personnel of C.E.E.R., particularly to Elvira Cuevas, José Colón, Miguel Canals, Alejo Estrada, Félix Santos, Manuel Rivera, Ana y Sylvia Correa, Luis F. Baez and Néstor Rosario for their help.

Finally, for the encouragement support and cheerful assistance given throughout the study by my husband Rómulo, I am especial grateful.

DEDICATORY

TO MY MOTHER

TABLE OF CONTENTS

List of Tables and Figures

Introduction

An estuary has been defined as a semi-enclosed coastal body of water which has a free connection with sea water and within which sea water is measurably diluted with fresh water derived from land drainage (Pritchard, 1967). This mixing of fresh and salt water causes the salinity to vary in time and space. Salinity variations in time are caused by tidal fluctuations, which result in marked salinity variations during a 24 hour period. Also, the salinity varies with the amount of freshwater runoff. The input of freshwater to the estuary helps to maintain the salinity gradient and without it, the entire estuary could become hyper-saline. On the other hand, too much freshwater inflow may cause the entire estuary to become exceedingly fresh and destroy the salinity gradient. Thus the interaction of these two components, tidal fluctuations and freshwater runoff cause temporal and/or seasonal change in the estuarine environment. The most important effect of these changes is the potential stress on individual organisms inhabiting the estuary. Although, all organisms possess, in some measure, the ability to adapt or adjust to changing environmental conditions; estuarine organisms must constantly face these drastic changes. To accommodate themselve to a changing environment, the animal has two alternatives, it can migrate to suitable environment or it can remain in one place, after having developed the physiological adaptation for survival (Vernberg and Vernberg, 1976). The animals with the highest capacity for adjustment to changes in the environment are those that persist in abundance.

These changes, brought about mainly by the mixing of fresh and salt water, tend to produce a nutrient trap, and this has been related to the high primary productivity of estuarine waters (Schelske and Odum, 1961; Haedrich and Hall, 1976). The large quantity of nutrients trapped and recirculated in the estuary provides suitable conditions for a high primary productivity. This capacity for primary productivity is of utmost importance since biota in the estuary are either directly or indirectly dependent upon it for their subsistance. Even under highly productive conditions, food availability may be as important as salinity in controlling number and distribution of animals in the estuary.

Many of the temperate estuarine fish species are not permanent residents but spend only part of their life cycle in the estuary causing seasonal variations in the fauna (McErlean et al., 1973; Frame, 1974; Livingston, 1976). Organism may be moving to or from estuaries in search of spawning ground (Bechtel and Copeland, 1970; Cronin and Mansueti, 1971) or to better feeding ground (Diener et al., 1974; de Sylva, 1975) and such movement may also be a direct response to physical environmental gradients as well as a function of the species evolutionary history.

The estuary provides a transitional area for those fishes whose life cycle includes both a marine and a freshwater phase. An interesting tropical example is the migratory species of goby, Sicydium plumieri, which changes its habitat preference with its life stage. Sicydium plumieri (Fam. Gobiidae) lives as an adult in freshwater, but in its post-larval phase has been caught in the Añasco River estuary (Erdman, 1960). Another fish species which exhibits some estuarine tendency is the jack, Caranx latus (Fam. Carangidae), which feeds and matures in the sea, but young individuals are frequently found inshore and around river mouths (Erdman, 1972). In Puerto Rico, the estuaries (i.e. river mouths) and mangrove swamps have a major nursery function (Austin, 1971). Young fishes congregate in these areas and benefit from the availability of food and the protection fron predators. Thus, the increase in the number of individuals of a given species in a locality may be caused by an influx of young recruits (newborn) raised in that locality or a migration of young or older individuals. As a direct consequence of these considerations, the estuarine environment is necessary for the maintenance of coastal commercial and sport-related species of fish during all or parts of their life.

Species diversity can be defined as the number of species in an area or as a mathematical expression that deals with the relationship between species and the number of individuals (Wilhm, 1968). The analysis of natural communities based on the distribution of organisms within species can reveal information about the community (Margalef, 1958) and many diversity indices have been proposed using this concept (Pielou, 1966).

The diversity index based on Information Theory describes the average degree of uncertainty of occurrence of a particular event; the greater the number of events, the greater the degree of uncertainty for predicting the occurrence of a particular event (Cox, 1976). Species diversity can be used as a tool to compare faunal diversities from area to area.

Diversity indices have been used as a measure of environmental quality and as indicators of pollution, where lower diversity values are indicative of stress (Bechtel and Copeland, 1970; McErlean et al., 1973; Tsai, 1973: Denocourt and Stambauch, 1974). The net result of pollution is to cause a redistribution of the number of individuals within species or in severe cases, the loss of species from an area. This may occur because pollution intolerant organisms undergo a reduction in population density or merely leave the area whereas tolerant organisms often increase in number using up the available space necessary for survival.

Physically, estuaries are influenced principally by variations in river flow and by tidal movement. The estuarine animals adapt to this environment in two ways: they evolve a high plasticity and/or migrate at critical times of their life cycle to a suitable area. It is known that migrations to various areas for spawning frequently helps to assure survival of the larvae and the young of the year. Since migrations and spawning can affect the diversity of fish populations in the estuary, knowledge of the life history of the species involved is necessary to determine population fluctuations. One must know the normal fluctuations of the fish populations in the estuary in order to detect natural alterations in the structure (migrations, newborn) of the populations as well as those brought about by man-made changes (canals constructions, dams, industrial and real estate development and/or pollution).

Industrialization and real estate development have become a major concern in Puerto Rico's economy. Many municipalities have begun an unprecedented growth cycle with respect to industrial development and human population. This investigation is an attempt to obtain reference data on relatively undisturbed fish populations in the Espiritu Santo

River estuary, which is located contiguous to the municipality of Rio Grande.

The objectives of this study were:

a. To identify and describe the fish populations of the Rio Espiritu Santo River estuary.

b. To determine the temporal and spatial distribution of the species in the estuary.

c. To assess the relative abundance and species diversity of fish populations.

d. To evaluate the effects of selected physical, chemical and biological factors on fish distribution.

The study area

The estuary of the Rio Espiritu Santo River is located in the Municipality of Rio Grande in the northeastern sector of Puerto Rico. It is approximately 20 miles east of San Juan.

The river proper and its tributaries originate in the Luquillo National Forest at elevations in excess of 900 meters. The main tributaries are Quebrada Sonadora, Quebrada Grande and Quebrada Jiménez. The Rio Grande, to the west, eventually joins the Rio Espiritu Santo in the estuary (figure 1). The overall length of the Espiritu Santo River from its origin to the Atlantic Ocean is approximately 21 Km., and the drainage area above the estuary is approximately 25 $Km.^2$ (Cuevas and Clements, 1975).

The estuary extends landward approximately 7 Km. with Highway PR 3 as the southern limit. The coastal plain provides four additional freshwater inputs; Rio Grande, Caño Castañón, Quebrada Juan González and Caño

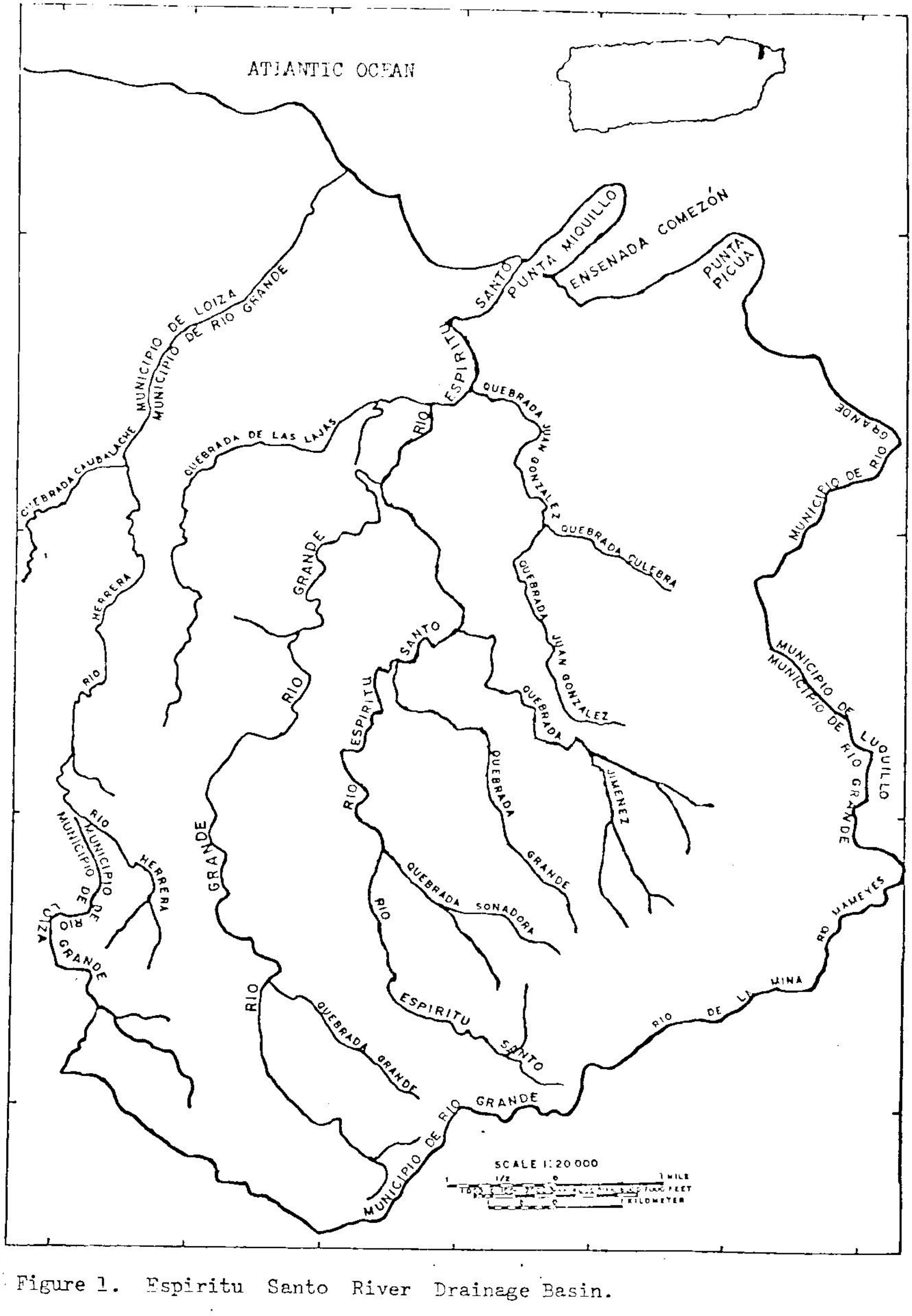

Figure 1. Espiritu Santo River Drainage Basin.

San Luis. Caño Castañón receives the discharge from a secondary sewage treatment plant of the Municipality of Rio Grande, a daily input of about 0.8 million gallon per day. A fringing mangrove forest dominates both sides of the river from approximately 2 Km. inland to its mouth (Cuevas and Clements, 1975).

The width of the estuary varies between 12 and 55 meters while the depth range from 1 to 6 meters (Bhajan, pers. comm. 1977; Goldman, 1978 unpublished). The geological substrate consists mostly of swamp deposits, but also terrace alluvium deposits are found in the upper section of the estuary.

The mean annual rainfall varies from over 4,000 mm (157 inches) at the higher elevations of the basin to about 1,650 mm (65 inches) in the coastal plain. Under normal flow conditions, the estuary is stratified with surface freshwater underlain by a salt-water wedge and the halocline found at depth of approximately one meter (Goldman, 1978 unpublished). Under high flow conditions such as those obtained after heavy rainfall in the watershed, there is less stratification and fresh water may completely dominate as much as the upper half of the estuary.

The study area was divided into eight stations based upon preliminary field observations. The sampling stations established for this study were located throughout the estuary system and included a wide variety of habitats (figure 2).

Station 1

Station 1 was located up-stream before the bridge on Highway PR #3, approximately 14.7 to 14.9 Km. from the river origin. This part of the

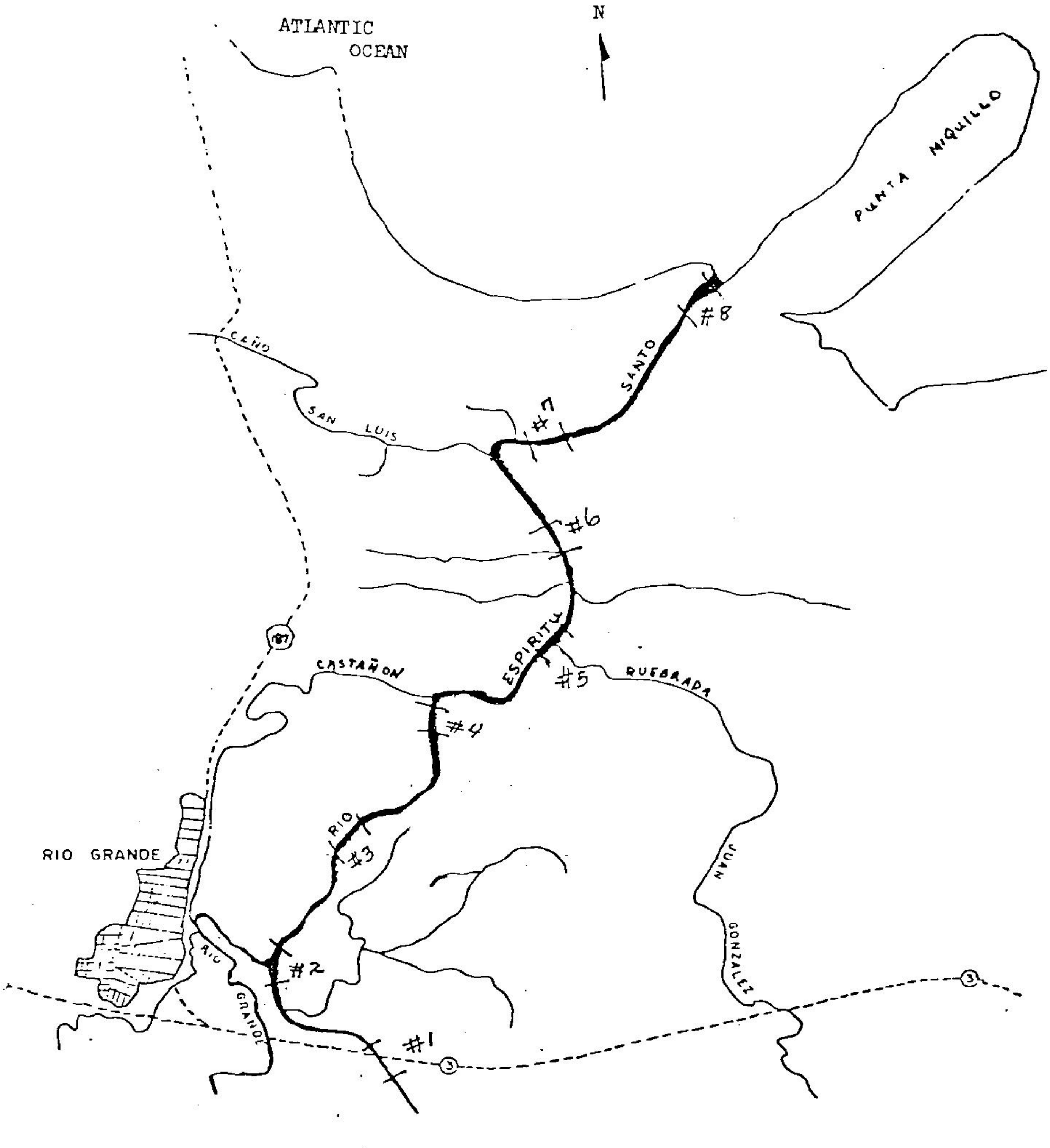

Figure 2. Rio Espiritu Santo Estuary showing sampling stations

river has a mean depth of 2 meters and width of 22 meters at base flow conditions. The substrate is mainly gravel. Elevation is 5 meters. Adjacent land is dedicated to farming minor crops.

Station 2

Station 2 was located approximately 15.7 to 15.8 Km. from the river origin, below the confluence with the Rio Grande. This part has a mean depth of 3 meters and a width of 32 meters. The substrates consist of gravel, very fine sand and clay. Adjacent lands are dedicated to pasture.

Station 3

Station 3 was located approximately 16.5 to 16.6 Km. from the origin. This part has a mean depth of 5 meters. It is approximately 38 meters wide and the bordering land is dedicated to pasture.

Station 4

Station 4 was located approximately 17.3 to 17.4 Km. from the origin. It is approximately 40 meters wide with a depth of 4 meters. Substrate is mainly gravel. Bordering land vegetation consists of grassland and mangroves. Quebrada Castañón, which transports secondary sewage plant effluents, drains into this area. Adjacent land area is largely undeveloped, overgrown tropical old-field or flood plain.

Station 5

Station 5 was located approximately 18.0 to 18.1 Km. from the river origin, at the confluence with Quebrada Juan González. The bordering vegetation consist of mangroves, but open shore is found around dock area. This area is approximately 6 meters deep. At base flow conditions, this part of the river is 35 meters wide.

Station 6

Station 6 was located approximately 18.8 to 18.9 Km. from the river origin, about 50 meters from the Quebrada Juan Gonzâlez confluence. This part is approximately 6 meters deep and 42 meters wide. The substrate consists mainly of silt, clay and coarse sand. Rhizophora mangle borders both sides of this area.

Station 7

Station 7 was located approximately 19.6 to 19.7 Km. from the origin, above the Caño San Luis confluence. The mean depth of this area is 5 meters and its substrate consists mainly of silt, clay and coarse sand. It is about 38 meters wide. The intertidal vegetation consists of a mangrove association.

Station 8

This station was located at the river mounth, and is approximately 20.4 to 20.5 Km. from the origin. The intertidal vegetation is typified by a mangrove association although many of the mangrove stands have been removed within the past 20 years. The substrate consists mainly of silt, clay and sand with some gravel. The bottom line slope is smooth, but it become steeper at 4 meters from the shore line. This area is approximately 50 meters wide at base flow conditions.

Methods and Materials

The fish populations study was done in conjunction with others estuarine studies of plankton, crustacea, molluscs, benthic organisms, sediment composition and water quality. The sampling stations selected correspond in general to those of the other studies.

Each station was sampled monthly for a period of one year to determine species present and to study the spatial and temporal distribution of the species. Each station was sampled with nylon monofilament, sinking, gill nets of 30.48 meters long and 1.83 meters wide. Four different mesh sizes, 1.27 cm., 2.54 cm., 5.08 cm., and 7.62 cm. square mesh were used, since each mesh size is designed to catch fish of a specific size range. Collection efforts were standardized by sampling during early morning hours between 700 and 1100. At each sampling station, the nets were set by attaching the proximal line of the net to a stationary shore holder. These holders were placed on alternating shores. The nets were stretched at a 45 degree angle across the station, sloped toward the fresh water flow. The distal part of the net was held in position with floats (floating line) and with weights (bottom line) to keep the net vertical. The nets with 5.08 cm. and 7.62 cm. square mesh were placed on opposite shores, each at either extremity of the station. Nets of 1.27 cm. and 2.54 cm. square mesh were placed between the 5.08 cm. and 7.62 cm. square mesh net but on opposite shores from each other and on alternate shores from the smaller meshes. Each gill net was set for a period of one and a half hours and then retrieved. The fishes were removed as the net was hauled. Live specimens were transferred to a container of water for further processing. After all fishes were removed, they were identified, weighed and the total (TL) and standard lengths (SL) were recorded. Those specimens requiring verification of identification were preserved for analysis. Measurements were done first on healthy fish, after which each was tagged with lock-on spaghetti tags and released as part of study of migrational patterns. This latter study is not reported here and it is part of the program of the Department of Natural Resources which kindly supplied the tags. The remaining fishes were measured and their stomachs were extracted and preserved in 10% formalin in the field. Stomach content samples were labeled with location of capture and species information. In case of large individuals, examination of gonads were done in the field and these were extracted, labeled and preserved in Gilson's fluid. Gonads from the small fishes were examined in the laboratory. While the gillnets were in place, a dip net was used to collect small fishes along the shore and under the intertidal vegetation. The specimens collected were immediately preserved in 10% formalin. Identification, measurements and extraction of stomach and gonads were done in the laboratory using a binocular dissecting microscope.

Additional information (creel-census) was obtained from fishermen that were fishing concurrently in the sampling area.

Water samples were taken at each station and stored in polyethylene bottles after all nets were retrieved. In the laboratory salinity was determined with a Bausch and Lomb temperature compensated refractometer. Salinity measures below detectable limits with the refractometer were determined by a standard MohR titration with silver nitrate ($AgNO_2$). Water temperature was recorded in situ with a Kemmerer water sampling bottle equipped with a calibrated thermometer.

Feeding habits of fishes were determined by the analyses of the stomach contents from selected individuals. Stomach contents analyses were done using either of two methods depending upon the size of the fish stomach. For small fishes quantification of stomach contents was done using a binocular dissecting microscope and a petri dish fitted with a piece of coordinate graph paper. The percentage of the total volume of the various food items encountered was determined by grouping the components of a particular food item and counting the number of squares in the petri dish that the food item filled. The number of squares that the item filled was divided by the total number of squares covered by the entire stomach contents to obtain the fraction of the total stomach contents examined that each item constituted.

For large fishes the quantification of stomach contents was done by immersing the individual food items in a graduated cylinder or in a calibrated glass tube filled with a known quantity of water to determined the volumetric displacement, after which the water displacement for all items together was calculated.

The mean volume of a particular food item obtained by either method was determined by adding the fractions that the food item was found in each stomach, and then dividing by the number of fish with food in their stomachs.

Gonad condition was utilized to determine each species' reproductive condition. The following criteria were used to classify gonad condition:

Immature or inactive: gonads small and undeveloped ovaries or testis.

Mature: eggs visible to the naked eye or enlarged gonads; the gonads from small fishes showed small eggs attached to the ovarine wall and larger eggs in the middle portion of the ovary.

Ripe: specimens showing running milt or expelling ova with or without the application of light abdominal pressure; gonads from small fishes greatly enlarged, or ovary filled with large eggs.

Species diversity was determined by Brillouin's formula as presented by Lloyd, Zar and Karr (1968) which is:

$$H = c/N \ (\log N! - \Sigma \log n_i!)$$

where N is the total number of individuals in the collection, n_i is the number of individuals in the i^{th} species in the collection and C is a factor to convert logarithm base 10 to the logarithm base desired. Logarithm to the base 2, or bit per individuals was used to compare within and between samples and the scale factor used was C = 3.21928.

Results and Discussion

The mean and the range of salinity and temperature values for each station are showed in Table 1. Temperature in the estuary is influenced by both fresh and salt water input which cause temperature variations depending upon the station location. Salinity range was also dependent on station location, and approached sea water concentration at station

Table 1. Summary of surface and bottom salinity and temperature

	BOTTOM				SURFACE			
	Salinity (0/00)		Temperature(C)		Salinity (0/00)		Temperature(C)	
Station	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1	8.46	0.05-33.40	25.8	24-27	0.08	0.00-0.59	24.8	24-26
2	21.92	0.28-28.80	26.7	24-29	0.23	0.02-0.59	25.3	24-28
3	24.59	0.12-36.20	26.5	23-30	0.78	0.04-2.11	25.5	23-29
4	24.86	1.60-34.60	27.8	25-30	1.25	0.01-3.63	25.9	24-28
5	29.10	22.80-33.40	27.6	26-30	2.39	0.62-6.33	26.0	26-29
6	29.98	24.30-35.20	27.3	25-29	2.05	0.41-5.49	25.4	23-28
7	29.75	25.09-35.80	28.0	26-30	4.94	1.27-11.42	26.0	24-29
8	31.77	29.21-35.20	28.1	26-30	5.12	1.80-8.62	26.5	25-29

8 and freshwater at station 1. Salinity concentration values varied with tidal position (Table 2). Low salinity values usually occurred when there was a large freshwater input from the mountains as a result of a heavy rainfall.

Fishes of the Espiritu Santo River estuary

A total of 1,306 specimens representing 60 species and 30 families were caught in 106 collections from eight localities in the Espiritu Santo River estuary. Of these 106 collections, 96 were done in the morning between 0700 and 1100 hour (regular sampling) and 10 optional sampling at different times for selected localities. These optional samples were collected during the late afternoon and evening for station 5 on March 29, 1977; late afternoon for station 2 on May 29, 1977 and at dawn for station 7 on July 22, 1977. The listing of scientific and common names of the species identified is presented in Appendix Table A. Phylogenetic order of families used here basically follows that of Greenwood et al., (1966). Genera and species are listed in alphabetical order within each family.

Species temporal and spatial distribution are shown in Table 3 and Table 4, respectively. These data will be discussed with respect to the information obtained relative to each species. Most species data included information on the number of individuals collected, followed by the size range of the standard length in millimeters. Data on stomach contents and reproductive conditions were also included.

Table 2: Mean and range of bottom and surface salinity (0/00) at each station

	BOTTOM				SURFACE			
	High tide		Low tide		High tide		Low tide	
STATION	mean	range	mean	range	mean	range	mean	range
1	19.5	3.4-33.4	0.1	0.0- 0.2	0.0	0.0-0.0	0.0	0.0-0.0
2	26.8	24.6-28.8	4.8	0.3- 9.4	0.4	0.0-1.3	0.0	0.0-0.0
3	29.7	25.2-36.2	14.4	0.1-30.0	1.0	0.2-2.1	0.4	0.0-1.1
4	30.7	30.4-31.6	22.4	1.6-34.6	1.8	1.0-2.7	0.8	0.0-3.6
5	31.2	26.1-34.0	28.1	22.8-32.4	2.7	0.7-6.3	1.9	0.2-5.9
6	33.2	31.0-35.2	27.4	24.3-29.7	2.5	0.8-5.5	2.2	0.4-3.0
7	29.9	25.1-35.8	29.4	27.9-30.6	5.5	1.3-11.4	3.8	1.3-8.0
8	32.2	29.6-35.2	31.6	29.2-34.0	5.7	2.3-8.6	3.9	1.8-4.9

Table 3. Monthly distribution and abundance of fish species in the Espiritu Santo River estuary (1977-1978). (Number of specimens collected in optional samples in parenthesis)

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Myliobatidae												
Aetobatus narinari			3	1								
Elopidae												
Elops saurus	1		1								1	
Megalopidae												
Megalops atlantica				(3)		2				4		
Anguillidae												
Anguilla rostrata										1		34
Clupeidae												
Harengula humeralis											4	
Opisthonema oglinum	28	55(11)	16	2	1				3		8	13
Engraulidae												
Anchoa hepsetus				5								
Anchovia clupeoides	12		3	6	3	10		1				
Cetengraulis edentulus	3		8		3	(1)	2		4	18	3	
Belonidae												
Strongylura timucu				1			1			1		
Poeciliidae												
Poecilia vivipara										7		
Syngnathidae												
Oostethus lineatus	3	4	7	5	7	7	8	6	8	13	11	35
Pseudophallus mindii						1		1				
Centropomidae												
Centropomus ensiferus	2	3	3	6(1)	4	5	3		1	1		1
Centropomus pectinatus							2					
Centropomus undecimalis	2	1(4)	2	9	1	3		1	1	4		

Table 3. (Cont.)

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Carangidae												
Caranx hippos	1				1	1						
Caranx latus	3		2	2	1	1	1	1	3	1		
Chloroscombrus chrysurus		2(1)	1	3	1	4						
Selene vomer			1	1								
Trachinotus goodei				1		1						
Lutjanidae												
Lutjanus apodus				3								
Lutjanus griseus				1								
Lutjanus jocu				1			1	1	1			
Gerridae												
Diapterus olisthostomus							1		2			
Diapterus rhombeus	2	5(1)	4	7	18	1		1		1		3
Eucinostomus lefroyi						1(1)						
Eucinostomus melanopterus						1			1			
Eugerres plumieri	1	1(1)	3	9	1		1	1		1	4	
Gerres cinereus	2	(1)			2	3				1		
Pomadasyidae												
Pomadasys crocro										1	2	
Scianidae												
Bairdiella ronchus	4	3(12)	2	5(1)	2	4	11			5	2	
Cynoscion jamaicensis				5		4						
Larimus breviceps				4		1						
Micropogon furnieri			2	11	3	(1)				1	1	
Ephippidae												
Chaetodipterus faber		1										
Cichlidae												
Tilapia mossambica	1	1		2	4	1			1	4	1	2

Table 3. (Cont.)

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Mugilidae												
Agonostomus monticola					1		1	11		1		1
Mugil curema	40	10	10	12(3)	8	1	2	2	2	6	5	2
Mugil liza						1	1					
Sphyraenidae												
Sphyraena barracuda											1	
Sphyraena guachancho		(1)		1								
Scaridae												
Scarus sp.									1			
Polymenidae												
Polydactylus virginicus		(3)	2	3	2						1	
Bleniidae												
Lupinoblennius dispar			2				6	3		8	2	
Eleotridae												
Dormitator maculatus		1			1		65			20	6	22
Eleotris pisonis	3	6	5	3	2	2	9	8	8	12	18	69
Gobiomorus dormitor	3	3	2	2	2	2	4	14	3	27	10	20
Gobiidae												
Awaous tajasica							1		1			
Bathygobius soporator			1			1	5	11	4	3	2	2
Gobionellus boleosoma				1	1		2	2	2			1
Gobionellus oceanicus				1								
Gobiosoma spes							5	12	4	3	3	
Trichiuridae												
Trichiurus lepturus		(1)			2	9						
Scombridae												
Scomberomorus regalis	3				3	1(2)						

Table 3. (Cont.)

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Bothidae												
Citharichthys spilopterus		1				1						
Soleidae												
Achirus lineatus			1	1								
Cynoglossidae												
Symphurus plagiusa	1											
Tetraodontidae												
Lagocephalus laevigatus	1			4								
Sphaeroides testudineus	1	1	1				2			3		2

Table 4. Spatial distribution and number of individuals (n) of fish species in the Espiritu Santo River estuary. (Optional samples not included).

SPECIES	STATION 1	2	3	4	5	6	7	8
Aetobatus narinari			1		3			
Elops saurus		1		1				1
Megalops atlantica		2		4				
Anguilla rostrata	5	1	1		24	4		
Harengula humeralis								4
Opisthonema oglinum	3	28	28	14	11	4	22	16
Anchoa hepsetus							5	
Anchovia clupeoides		12			13	9	1	
Cetengraulis edentulus	5	6	6	6	6	8		4
Strongylura timucu	1					2		
Poecilia vivipara				1	6			
Oostethus lineatus	25	24	26	23	10	6		
Pseudophallus mindii	2							
Centropomus ensiferus	3	6	4	1	8	1	3	3
Centropomus pectinatus			1	1				
Centropomus undecimalis	1	4	3	4	5	7		
Caranx hippos						1	1	1
Caranx latus	6	1	1		3	2	1	1
Chloroscombrus chrysurus			2	1		1	3	4
Selene vomer							1	1
Trachinotus goodei				1			1	
Lutjanus apodus							3	
Lutjanus griseus							1	
Lutjanus jocu					1	2		1
Diapterus olisthostomus			3					
Diapterus rhombeus		14	5	4	3	3	3	10
Eucinostomus lefroyi			1					
Eucinostomus melanopterus		1		1				
Eugerre plumieri	2	2	10	1	1	4	1	1
Gerres cinereus	1	3	2		2			
Pomadasys crocro	2	1						
Bairdiella ronchus	4	3	3	13	4	5	4	2
Cynoscion jamaicensis					1		8	
Larimus breviceps					2		3	
Micropogon furnieri				1	2	9	1	5
Chaetodipterus faber						1		
Tilapia mossambica			3	8	4		1	1
Agonostomus monticola	14	1						
Mugil curema	7	36	17	5	5		6	24
Mugil liza					1	1		
Sphyraena barracuda		1						
Sphyraena guachancho							1	

Table 4. (Cont.)

SPECIES	STATION 1	2	3	4	5	6	7	8
Scarus sp.								1
Polydactylus virginicus					2	2	1	3
Lupinoblennius dispar					4	14	3	
Dormitator maculatus	4	1	15	75	11	7	2	
Eleotris pisonis	20	30	17	48	11	19		
Gobiomorus dormitor	35	28	5	17	7			
Awaous tajasica	2							
Bathygobius soporator					7	12	6	4
Gobionellus boleosoma				1	4		4	
Gobionellus oceanicus		1						
Gobiosoma spes					4	23		
Trichiurus lepturus						1	10	
Scomberomorus regalis					1	2		4
Citharichthys spilopterus			1			1		
Achirus lineatus					2			
Symphurus plagiusa					1			
Lagocephalus laevigatus					3	1		1
Sphaeroides testudineus								10
TOTALS	142	207	155	231	172	152	96	102

Species Accounts

Class Chondrichthyes

Order Lamniformes

None collected, but several small ones observed at station 4 and one larger individual was observed during dawn sampling on July 22, 1977. Fisherman reported sharks up to station 2.

Order Rajiformes

Family Myliobatidae

Aetobatus narinari (Euphrasen)

Four specimens were collected three males in April and one female in May. The food of this eagle ray had been reported to consist of molluscs (Nichols, 1929; Cervigón, 1966; Randall, 1967) which are crushed by the dental plates and the soft parts are swallowed free from shell fragments. The stomach contents of four specimens from the Espiritu Santo River estuary were 100% molluscs. No reproductive information was available from these collections but embryos in terminal stages of development had been found from July to August (Erdman, 1976).

Class Osteichthyes

Family Elopidae

Elops saurus Linnaeus 3:218-395 mm SL

Erdman (1972) reports that ladyfish occurs in fresh and saltwater. In the Espiritu Santo River estuary, it is found from station 2 to 8 (river mouth), but also occurs in channels connected to the estuary (fisherman, personal communications). The ladyfish reportedly feed fish and crustaceans (Cervigón, 1966; Austin and Austin, 1971; Odum and Heald, 1972) and also on plant fragments and Pelecypods were found in stomach of two of three estuarine ladyfish examined. No reproductive information was available from specimens examined. The ladyfish spawning occurs in the sea and young leptocephallus enter rivers in September (Erdman, 1972).

Family Megalopidae

Megalops atlantica Valenciennes 9: 285-628 mm SL

Tarpons were not common throughout the year, but fishermen report tarpon of 110 pounds caught with hook and line. Three tarpon were caught during night fishing at station 2 on May 29, 1977. Stomach contents analysis reveals tarpon feed on decapod larvae (36.93%); shrimps (16.40%), crabs (13.08%), and on fish (33.60%). The tarpon spawning occurs in the sea, moving to open waters to spawn from late April to August (Erdman, 1960).

Family Anguillidae

Anguilla rostrata (Le Sueur) 35:42-195 mm Tl

Freshwater eel became abundant in January, but the largest individual (195 mm Tl) was collected in November at station 1. The freshwater eels were collected along the shore, mainly under the water hyacinth (Eichornia crassipes) root system. The arrival in the estuary is readily evident but departure was not recorded probably because larger individuals move along the deepest part of the estuary. Odum and Heald (1972) found that eels (50-200 mm) feed on amphipods and isopods in the North River estuary. Diptera larvae, Cladocera, Ostracods, and water hyacinth roots were also found in the stomachs of eels taken from the Espiritu Santo River estuary (Table 5). Freshwater eel reproduction takes place in the sea (Bohlke and Chaplin, 1968).

Family Clupeidae

Harengula humeralis Cuvier 4:134-152 mm SL

Only four individuals were caught during December at station 8. The stomach of the four caught contained 100% fish remains (one with anchovy). All specimens collected were female with small gonads. Erdman (1976) states that females with ripe ova can be found from March to May.

Opisthonema oglinum (Le Sueur) 137:86-224

The occurrence of these species in the estuary seems to be cyclic since a high number of individuals were caught during February, March and April 1977 and in January 1978. Eleven specimens were caught during March when sampling at night and 55 specimens were taken during regular sampling for that month. The highest number of individuals was caught at station 2 during the dry season, with full stomachs containing decapod larvae. Other items encountered in the stomach of these specimens were algae, diatoms, small crustaceans and fish larvae (Table 5). The thread herring reproduction takes place in March (Martin, 1974) although not all individuals collected in the Espiritu Santo were sexually mature.

Family Engraulidae

Anchoa hepsetus (Linnaeus) 5:89-199 mm SL

This species was collected only once at station 7 during May. All specimens had stomachs full of unidentifiable fish remains and all were ripe females. This species is preyed upon by *Sphyraena guachancho*.

Anchovia clupeoides (Swainson) 35:79-170 mm SL

A. clupeoides (*Anchoa producta* Poey) was caught quite frequently from February to July. A single catch at station 2 during July might be due to the presence of decapod larvae (66.50%) which were found among other stomach contents. The anchovy food items also included algae (5.52%) ostracods (6.39%) copepods (8.89%) and amphipods (12.70%). Specimens with enlarged gonads were found on May and July.

Cetengraulis edentulus (Gunther) 42:87-116 mm SL

This species was collected periodically in the estuary, at all stations. The whalebone anchovy was collected frequently but without a seasonal pattern. Its presence in the estuary seems to be regulated by salinity. In June several individuals were collected at station 2 and in November at station 1, but were not present at these stations when salinity was low. This species is a filter feeder, feeding on minute planktonic organism (Fisher, 1978). It feeds mainly on decapod larvae in the estuary. Gonzâlez and Vilella (1976) found whalebone anchovy with developed ovas from April to June in Piñones lagoon.

Family Beloniade

Strongylura timucu (Walbaum) 3:335-350 mm SL

Only three individuals were collected, but more were seen swimming between station 5 and 7. Some individuals were seen jumping from the water; this activity is considered to be feeding behavior. Stomach analysis revealed insects such as Hemiptera and Hymenoptera. One specimen caught on November at station 6 under a water hyacinth had stomach full of *Anguilla rostrata* remains. All specimens captured were female and in May one females (348 mm SL) caught at station 1 showed ripe gonads.

Family Poeciliidae

Poecilia vivipara (Bloch & Schnider) 7:11-30 mm SL

This species was collected only in November, after heavy rains (53.66 mm). It is likely that individuals of this species came from adjacent channels that drain into the estuary. One stomach examined revealed the remains of small crustaceans. Three of the seven caught were females with embryos (one contained 32 embryos). Martin (1974) mentioned that this family is a perennial breeder.

Family Syngnathidae

Oostethus lineatus (Kaup) 114:14-155 mm SL

Gilmore (1977) described the opossum piperfish as a euryhaline fish that is commonly found in freshwater and estuarine areas. This species was collected all year at stations 1 through 5. It was less frequently encountered at station 6, and it was observed at this station in January perhaps due to the presence of water hyacinth at the station. The water hyacinth transports this and other species such as *Eleotris pisonis* to lower sections of the estuary. *O. lineatus* was more common along shore at the above mentioned stations. It seems to avoid predation by a camouflaging with bordering vegetation, since most species captured were taken in the grass covers of the shore. Stomach analyses showed that they fed on various items (Table 5), but of special interest was that the females stomachs contain large numbers of eggs. It is still to be determined if eggs found in females stomachs belonged to their own species or to others species. Spawning population were very much in evidence. Various brooding males were captured with eggs attach to different parts of the body, but only those in the brood pouch were fertilized. Reproductive activity increased between September and January. After hatching, juveniles are carried downstream and develop at higher salinity (Gilmore, 1977). Some juveniles were collected in plankton samples (Bhajan, personal communication, 1977) in October.

Pseudophallus mindii (Meek & Hildebrand) 2:94-97 mm SL

This species had not been reported in Puerto Rico before (Dawson, personal communication, 1977). Boeseman (1960) reported that *P. mindii* occurred in the same habitat as *O. lineatus* in Trinidad. Both specimens collected in the Rio Espiritu Santo river estuary were caught along the shore line at station 1, and both were males and carried embryos on their caudal pouches. One captured in July showed less developed embryos than the ones captured in September. Stomach analysis of one specimen revealed that it fed on insect larvae such as Diptera and Odonata.

Family Centropomidae

Centropomus ensiferus Poey 30:97-234 mm SL

This species is the most abundant snook in the estuary and occurred at all stations. Swordfin snook fed mainly on shrimps (52.25%, especially on *Macrobrachium sp.*). Others food items encountered were fish remains (22.31%), mollusc (8.70%),crabs (13.74%) and plant leaves (3.00%). Vascular plant leaves found in the stomachs which also contained shrimps suggest that this item probably was ingested accidentally when the shrimps were captured. During April a male and female were caught at station 1 and both showed ripe gonads. Others mature individuals were caught during June.

Centropomus pectinatus Poey 2:104-148 mm SL

This species occurred only in August, after heavy rains. Only one individual had food in its stomach and the items were 100% shrimp remains. Both individuals showed no evidence of sexual maturity and nothing is known about where and when this species may spawn (Fisher, 1978).

Centropomus undecimalis (Bloch) 28:24-318 mm SL

This snook occurred in the estuary as both juveniles and young adults from stations 1 through 6. Four individuals were caught during the night sampling at station 5. Stomach analyses of 16 stomachs revealed this species fed chiefly on shrimps (64.53%). Other food items encountered were fish remains (19.69%), vascular plant leaves (5.98%) crab (9.11%) and molluscs (0.69%). None of the specimens collected had mature gonads. Austin (1971), Erdman (1976), Fisher (1978) reported that spawning takes place from April through September. One individual of 206 gms. and 295 mm SL was captured while it was swimming on the surface. Its viscera were full of a yellow liquid (probably derived from fats), its stomach was empty and a silvery plastic band was found attached to its gill, which no doubt interferred with the regular feeding of this fish.

Family Carangidae

Caranx hippos (Linnaeus) 3:145-325 mm SL

Crevalle jack were caugt at stations 6 to 8. Cervigón (1966) cites them as coastal pelagic, but juveniles can be found in mangrove areas. This species is said to feed chiefly on fish, crabs, squid, shrimp and smaller invertebrates (Odum and Heald, 1972). Of three stomachs examined in this study, only two had food, 100% fish remains in both cases. Crevalle jack with ripe gonads were found by Munro et al. (1973) in July, 1970, Port Royal, Jamaica, but no individuals collected from the Espiritu Santo River estuary had developed gonads.

Caranx latus Agassiz 15:58-163 mm SL

The horse eye jack was collected at most sites in the estuary and was the most common member of its family. Stomach analyses revealed it fed on shrimps (such as *Xiphocaris sp.*) and on fish. The stomach analysis of one individual revealed anchovy remains. The anchovy had fed on small neritiid snails. No individual collected had developed gonads, but there are literature reports that reproduction takes place from February through August (Munro et al. 1973; Erdman, 1976).

Chloroscombrus chrysurus (Linnaeus) 12:104-156 mm SL

Cervigón (1966) described the bumper as a coastal pelagic, but small individuals can be found in areas surrounded by mangroves. The bumper were collected from March to July. Two individuals were collected at station 3 during high tide in March and one was collected during night sampling at station 5. This species is said to feed on planktonic crustaceans (Cervigón, 1966). Specimens from the Espiritu Santo River estuary had empty stomachs. Martin (1971) found fish remains in specimens collected from Jobos Bay, Puerto Rico. No reproductive data for this species was available from this study, but Fisher (1978) reported spawing probably occurred in spring and summer for the Caribbean area.

Selene vomer (Linnaeus) 2:69-160 mm SL

Lookdown were collected in April and May at stations 7 and 8. This species is said to feed chiefly on small crabs, shrimps, fish and worms (Fisher, 1978). Specimens collected during this study had empty stomachs. Munro et al. (1973) reported one ripe running male at Port Royal reef Jamaica in April 1971. Martin (1972) reported enlarged ovaries in a 21 cm. female. No reproductive data were available from this study.

Trachinotus goodei (Bloch) 2:198-206 mm SL

This species can be qualified as a sporadic visitor in the estuary. Randall (1967) reported that this species is common in shallow to moderate deep water around reefs, feeding on small invertebrates. One stomach examined revealed mangrove oysters and vascular plant tissues, which probably was ingested along with mangrove root oysters. Specimens collected showed no evidence of sexual maturity.

Family Lutjanidae

Lutjanus apodus (Walbaum) 3:119-154 mm SL

This snapper is typical of shallow coastal waters (Randall, 1967). The three specimens collected from the Espiritu Santo River estuary were caught with hook and line using shrimp as bait. This species is said to feed on crabs, fish, shrimps and octupuses (Randall, 1967; Cervigõn, 1966), but juveniles feed on amphipods and copepods (Austin and Austin, 1971). Austin (1971) suggests that spawning takes place between February and April.

Lutjanus griseus (Linnaeus) 1:112 mm SL

Only one gray snapper was captured by hook and line during the same sample period that *L. apodus* were taken. Its stomach contained only shrimps used as bait. Randall (1967) stated that juvenile specimens in seagrass beds feed on small cruataceans while large individuals feed on shrimps, crabs and fishes. Sexually mature specimens were reported as occurring May through September (Erdman, 1976).

Lutjanus jocu (Bloch and Schneider) 4:103-263 mm SL

Four individuals of this species were collected during this study but more were seen between mangrove roots when water was clear. Two stomachs examined revealed shrimp and crab remains (*Callinectes sp.*). There was no evidence of sexual maturity in the specimens collected.

Family Gerreidae

Diapterus olisthostomus (Goode and Bean) 3:90-113 mm SL

Specimens of Irish pompano were collected at station 3 in August and October and all had empty stomachs. Austin and Austin (1971) found 100% plant material in six specimens collected from mangroves in western Puerto Rico. No reproductive data were available from specimens collected but Martin (1972) found a male with enlarged testes in September in Jobos Bay, P. R.

Diapterus rhombeus Cuvier 43:51-142 mm SL

The rhomboid mojarra was found to be more prevalent during seasons of low flow. Only one individual was collected during night sampling at station 5 in March. Stomach analysis revealed algae and plant material (23.43%), worm fragments (9.71%), small crustaceans (40.86%), oysters (11.43%), and unidentified material (14.57%). No reproductive data were available from specimens collected, but spawning had been reported as occurring during June and July (Austin, 1971).

Eucinostomus lefroyi (Goode) 2:71-76 mm SL

One specimen of this species was collected in July at station 3 where bottom salinity was 36.2 ppt. Another was collected during the dawn sampling at station 7 in July. The stomachs of the two specimens examined revealed it fed on pelecypods (44.5%), small crustaceans (50.00%) and other unidentified material (5.50%). No information on spawning period was available from this study.

Eucinostomus melanopterus (Blecker) 2:67-74 mm SL

Erdman (1972) cites this species as a freshwater mojarra. Two specimens were collected, one at station 4 in July and the other at station 2 in October. Both stomachs examined were empty. No evidence of sexual maturity was available from specimens collected.

Eugerres plumieri (Cuvier) 23:960280 mm SL

The striped mojarra occurred in all localities sampled in the estuary, but it seemed to prefer fresh to brackish waters. When the water was clear, it was possible to see striped mojarra feeding on the mangrove root oyster communities, where fisherman caught them with harpoons. Large quantities of oysters were found in stomach analysis (they ingested everything that is found in the oyster community). Ripe or near ripe gonads were found from March to May. One female (800 gms., 280 mm SL) was caught at station 5 during night sampling on May showed full ripe ova.

Gerres cinereus (Salbaum) 9:58-134 mm SL

The yellow fin mojarra was found in the upper areas of the estuary during low flow conditions. One individual was caught during the night sampling in March. Randall (1967) and Austin and Austin (1971) reported that the yellow fin mojarra feeds on crabs, pelecypods and gastropods as main food items. Five stomachs examined during this study revealed the following food itmes: amphipods (43.46%), pelecypods (45.07%), polychaetes (6.25%) and insect larvae (5.23%). No specimens with mature gonads were collected. Kimmel (1979) reported sub-ripe gonad conditions occurring between March and September for Guayanilla Bay specimens.

Family Pomadasyidae

Pomadasysis crocro (Cuvier) 3:15-17 mm SL

All individuals of this species were captured along the shore line vegetation at stations 1 and 2. All stomachs examined revealed 100% shrimps. No information on reproductive condition was available from this study but Erdman (1972) reported that near ripe females can be found in March.

Family Sciaenidae

Bairdiella ronchus (Cuvier) 51:82-192 mm SL

The ground drummer is the most common Sciaenidae in the estuary. Cervigón (1966) stated that this species completes its life cycle in lagoons. Most adults examined had been feeding on shrimps, small fishes were also found. Vascular plant leaves were found in stomachs containing shrimps. Small ones (82-87 mm SL) fed on Amphipods and insect larvae. Table 5 summarizes stomach contents. Ripe or near ripe gonads were found from February to August. Eleven individuals (10 male and a female) were caught in March during night sampling at station 5, all had running gametes.

Cynoscion jamaicensis (Vaillant and Bocourt) 9:205-242 mm SL

This species was collected only during May and July at the lower part of the estuary. Eight stomachs were examined but only 5 contained food. Stomach analysis revealed 100% fish remains. The low frequency of occurrence in the samples and the evidence of ripe and near ripe gonads suggests that this species used the estuary as a spawning ground. Erdman (1976) indicated that this species spawned year-round.

Larimus breviceps Cuvier 5:146-168 mm SL

This species was found only during May and July at the lower part of the estuary. As with _C. jamaicensis_, ripe gonads suggest this species enters into the estuary to spawn. All stomachs examined were empty. Fisher (1978) reports that this species feeds on small shrimps.

Micropogon furnieri (Demarest) 19: 155-355 mm SL

The croaker was found only from statins 4 to 8. Austin (1971) mentions that this species prefers high salinity and open waters. One individual was caught at station 4 when bottom salinity was 30.4 ppt. Another one (644 gms., 326 mm SL) marked with a tag in May 31, 1977 at station 8 was recaptured by one fisherman on June 22, 1977 in the Punta Miquillo beach area. This suggest that this species, which was first captured in the estuary in April, were leaving the estuary in July, after which only two specimens were caught. Of nine stomachs examined, five contained the following items: shrimp (72.99%), crab (9.38%), fish remains (6.90%) and plant materials (7.29%). The spawning period probably occurs from June to November (Martin, 1972; Erdman, 1976).

Family Ephippidae

Chaetodipterus faber (Brossonet) 1:206 mm SL

This species was collected only once at station 6 during high tide. The specimen collected had an empty stomach and immature gonads. This species feeds on a great variety of food items such as sponges, zoantharians, worms and algae (Randall, 1967; Martin, 1972). Reproductivity activities occur from May to October (Erdman, 1976).

Family Cichlidae

Tilapia mossambica (Peter) 17:212-342 mm SL

The tilapia was imported to the island in 1958 from Alabama for fish culture purposes (Erdman, 1972), and subsequently spread to open waters. Gonzâlez and Vilella (1876) reported that the tilapia occurred in the Piñones lagoon. Various mature males and a spent female (222 mm SL) were caught, but young individuals were not collected. Probably this species came into the estuary from adjacent channels that drain into the estuary. Tilapia are bottom feeders. Stomachs analyses reveals large quantities of diatoms, filamentous algaes and detritus. Erdman (1976) reported this species as a year-round spawner.

Family Mugilidae

Agonostomus monticola (Bancroft) 15:32-234 mm SL

The mountain mullet develops eggs in summer and the eggs or young larvae are washed to the sea (Erdman, 1972). The first specimen collected was in June, a ripe female of 234 mm SL. In August a small one (32 mm SL) was collected at station 2. Erdman (personal communication, 1977) mentioned that this specimen had recently returned from the sea. The mountain mullet becomes abundant in September after the heavy rains when they try to return to upper areas. This suggest that probably they were displaced from their prefered areas to lower areas by the large amount of freshwater runoff or they were returning to their habitat after reproduction. Males from 83-96 mm SL caught in September showed running gametes and a female of 216 mm SL was spent. The mountain mullet feed on shrimps (33.33%), adult insects (50.00%) and on plant material (seeds, 16.67%).

Mugil curema Valenciennes 103:98-280 mm SL

The white mullet is more abundant than the data suggest. Schools of white mullet has been seen moving along the estuary. The white mullet have a muscular stomach that grinds the food items obtained from the benthic layer. These food items consist primarily of benthic diatoms, blue green and filamentous algae, plant detritus and inorganic sediment particles. Stomachs and vicera of mullet taken from the estuary exhibited large quantities empty diatom frustules and algae which gives a greenish appearance to the intestines. However, in April, various individuals collected at station 8 showed different stomach contents, not only in food items but also in intestinal color. From March to May nearly ripe females were captured. Fisher (1978) stated that spawning occurs in the sea, Erdman (1976) reported spawning occurring in September. These facts explain the low number of M. curema collected during these months (Table 3).

Mugil liza Valenciennes 2:358-473 mm SL

Liza were found in the mangrove areas, but fisherman reported that they are more common in the adjacent channels such as Quebrada Juan Gonzâlez. Just as M. curema, liza also fed on algae and other organic materials. Liza spawning occurs in January (Erdman, 1976).

Family Sphyraenidae

Sphyraena barracuda (Walbasum) 1:312 mm SL

Only one individual was collected at station 2 when bottom salinity was 26.1 ppt. Its stomach was full of unidentified fish remains. Munro et al. (1973) reported ripe females in April and May at Pedro Bank, Jamaica.

Sphyraena guachancho Valenciennes 2:298-299 mm SL

The presence of this species in the estuary may have been caused by the search for food. Once guachanche was caught during late afternoon while trying to prey on shrimp which sought protection under the water hyacinths (water was clear enough to see this prey-predator act). The other guachanche was caught at station 7 and its stomach contained *Anchoa hepsetus*. Martin (1972) reports a female with enlarged ovaries in December.

Family Scaridae

Scarus sp.

One parrotfish was taken at station 8, but blue crabs (*Callinectes sp.*) destroyed it, leaving only the head and dorsal spines.

Family Polynemidae

Polydactylus virginicus (Linnaeus) 11:96-193 mm SL

The threadfin occurred in the mangrove areas. They were collected first at station 5 on March 29, but from May to June were found only at stations 6 to 8. They were taken at station 8 once again in December. Stomach analyses revealed shrimps (57.14%) and fish remains (42.86%). Three individuals collected during night sampling at station 5 showed ripe gonads. Near mature gonads were found from March to May.

Family Blennidae

Lupnoblennius dispar Herre 21:9-24 mm SL

This blenny occurred in the oyster communities associated with mangrove roots. It was found with *Gobiosoma spes* in most catches. Blenny presence in the estuary seem highly dependant on the oyster community since when the oyster community becomes scarce in January, no blennies were found. The blenny feeds on isopods, amphipods and algae. This species is not common in all mangroves in Puerto Rico, but seems to favor those areas where mangrove roots are heavily colonized by oysters and the red algae Acanthophora (Kimmel, personal communication, 1979). Mature females were found from August to November. Sexual dimorphism present in this species is described by Dawson (1970).

Family Eleotridae

Dormitator maculatus (Bloch) 115:10-120 mm SL

This species became abundant in August when 65 individuals were caught and many more were seen. All individuals caught during that sample showed running gametes. During the spawning time this species behaves carelessly, becoming easy prey to larger fishes. One Centropomus was observed feeding on them but yet they did not seek protection. The reproductive ritual consists of the female and male getting close to each other on a mangrove root or on a water hyacinth mat and then releasing the gametes. The male showed reproductive colors such as bright yellow and red in different parts of the body such as the dorsal spines. Females retain their regular colors. There was a high incidence of liver parasites among individuals examined. Individuals of this species can be used as aquarium pets.

Eleotris pisonis (Gmelin) 145:13-132 mm SL

The spinycheek sleeper is an euryhaline species inhabiting fresh and brackish water (Bohlke and Chaplin, 1968). Most individuals were collected among river shore vegetation or under the water hyacinth roots. It was abundant from stations 1 to 4, but less common at stations 5 and 6. Its presence in the latter stations was due mainly to the movement of water hyacinth into these stations. The spinycheek is a voracious species (Table 5). The larger ones feed on small fishes, shrimps, molluscs, such as *Nerita sp.*, and the small individuals (13-20 mm SL) on insect larvae such as *Diptera*, cladocera and amphipods. Mature individuals were collected from July to December and many small ones were found at stations 6 and 7 during December and January.

Gobiomorus dormitor Lacepede 92:14-362 mm SL

This species was collected from stations 1 to 5, but it was more abundant at stations 1 and 2. Small individuals were collected among shore vegetation, but larger ones were collected in deeper waters. The bigmouth sleeper feeds mainly on shrimps and the juveniles on diptera larvae, small crustaceans and on smaller fishes. Erdman (1972) mentioned that females with developing eggs can be found from March through June, but ripe females were caught up to September. During November, small ones (14-19 mm SL) were collected.

Family Gobiidae

Awaous tajasica (Lichtenstein) 2:201-210 mm SL

The river goby was collected only at station 1 after periods of heavy rains during August and October. One stomach examined reveals shrimps (89.00%), vascular plant leaves (8.00%) and unidentified material (3.00%). No evidence of sexual maturity was available from specimens examined. Post-larvae are found in September (Erdman, 1976).

Bathygobius soporator (Valenciennes) 29:13-68 mm SL

The frillfin goby was collected mainly among oyster communities associated with the mangrove roots, but also was found along the shore at station 5. They feed on amphipods, isopods, small fishes, such as blennies and to a lesser degree on filamentous algae and other food items (Table 5). A ripe females (68 mm SL) was collected in August.

Gobionellus boleosoma (Jordan and Gilbert) 9:18-39 mm SL

The darter goby had been found among shore-line vegetation at station 5 and under water hyacinths at stations 4 and 7. Stomach analyses revealed algae, diatoms, and vascular plant remains. Males with breeding colors were found in November. Similar results are reported by Erdman (1976).

Gobionellus oceanicus (Pallas) 1:136 mm SL

This species was collected only once at station 1 when bottom salinity was 26.6 ppt. Stomach analysis revealed that it fed on filamentous green algae. No information on reproductive activities was available for this species.

Gobiosoma spes (Ginsburg) 27:11-22 mm SL

This goby occurred in the same habitat as L. dispar. G. spes. feeds on amphipods and isopods which were abundant in the mangrove oyster communities. Various mature females were found in October.

Family Trichiuridae

Trichiurus lepturus Linnaeus 12:403-787 mm SL

This species occurred in the lower part of the estuary. Of twelve stomachs examined, only three were empty. The food items consisted mainly of fish remains (88.88%), but shrimps remains (11.11%) were also found. A male caught during the night sampling at station 5 nearly ripe gonad and eight of nine specimens captured in July at station 7 showed ripe gonads.

Family Scombridae

Scomberomorus regalis (Bloch) 9:224-528 mm SL

This species was collected in the lower part of the estuary and occurred only in February, June and July. The cero feed on fish. In June and July most specimens examined contained anchovy which in turn had fed on decapod larvae. Two mature females were caught in February. Erdman (1976) mentions that this species has an extended spawning period. All fishes collected showed isopods attached to the gills.

Family Bothidae

Citharichthys spilopterus Gunther 2:103-106 mm SL

The bay wiff were caught first at station 6 in March. Later, a single individual was collected at station 3 in July when bottom salinity was 36.2 ppt. One stomach examined contained plant material (13.16%), shrimps remains (23.69%), crab fragments (34.21%) and fish (28.95%). Austin and Austin (1971) found 100% fish in one specimen. No information on reproductive condition was available from specimens collected.

Family Soleidae

Achirus lineatus (Linnaeus) 2:111-113 mm SL

The lined sole was collected only at station 5 in April and May. One individual was caught while a blue crab, Callinectes sp. fed on it. One stomach examined was empty. Odum and Heald (1972) found amphipods, mysids, diptera larvae, worms and foraminifera in specimens from North River estuary in Florida. No reproductive data was available for specimens collected but Erdman (1976) reports reproduction occurring in July.

Family Cynoglossidae

Symphurus plagiusa (Linnaeus) 1:109 mm SL

This specimen was collected in February 1977. The contribution of this species to the ichthyofauna of the Espiritu Santo River estuary cannot be established because of its low frequency of occurrence in the samples. Austin (1971) stated that this species lives with muddy bottom, and high salinities. The tongue fish has been describe as a nocturnal feeder, feeding mainly on polychaetes and crustaceans.

Family Tetradontidae

Lagocephalus laevigatus (Linnaeus) 5:111-150 mm SL

The smooth puffer was collected in the lower part of the estuary. Three stomachs examined contained Pelecypods (96.67%) and vascular plant wood (3.33%). The wood was probably taken incidentally along with pelecypods from the mangrove roots oyster community. Two ripe females (149 and 150 mm SL) were caught in May at station 5.

Sphaeroides testudineus (Linnaeus) 10:32-59 mm SL

This species was abundant in open shallow waters near the shore at station 8, but many more were observed hidden under mangrove roots. Austin and Austin (1971) found crustacea and gastropoda in two specimens examined, but other food items were found in stomachs examined from the estuary. Erdman (1956) suggests spawning occurs in February.

Trophic levels

The quantitative data for the stomach contents of various species collected in the Rio Espiritu Santo River estuary which were discussed individually in the previous section and are summarized in Table 5. Food items in the stomachs examined indicate whether a given fish species is a consumer of (1) primary level (2) secondary level, or (3) tertiary level. Some species were found to participate in more than one trophic level and their diet appears to depend on several factors. Some of these factors are fish size or age, habitat and/or seasonal abundance of prey (de Sylva, 1975).

The primary consumers are organisms which feed on plant material and/or detritus and they can obtain additional nourishment from micro-organisms ingest during the feeding activities. Also, inorganic materials such as sand grains can be ingested by these consumers. Some primary consumers obtained during the sampling were Mugil curema, Tilapia mossambica, and others. Some species were found to be partially primary consumers such as Sphaeroides testudineus.

According to stomach contents analyses, most species collected belong to the group of the secondary consumers. These organisms feed on insects, crustaceans, molluscs, and also on herbivorous fish. These

Table 5. Stomach contents of some fishes examined.

SPECIES	SIZE RANGE (mm SL)	NUMBER EXAMINED	NUMBER WITH CONTENTS	FOOD ITEMS: DIATOMS AND/OR ALGAE	VASCULAR PLANT MATERIAL	ORGANIC DETRITUS	CLADOCERONS, OSTRACODS AND/OR COPEPODS	ISOPODS	AMPHIPODS	DECAPODS LARVAE	SHRIMPS	CRABS	INSECTS	INSECT LARVAE	PELECYPODS	GASTROPODS	FISH	FISH EGGS OR LARVAE	UNIDENTIFIED AND/OR MUD
<u>E. saurus</u>	218-395	3	2		29.16						20.85				25.00		24.99		
<u>A. rostrata</u>	48-195	18	12			8.33	33.33	4.57	3.33					39.43					11.00
<u>O. oglinum</u>	86-224	29	27	2.46			9.44			76.20								4.50	7.40
<u>A. clupeoides</u>	79-170	11	9	5.52			15.28		12.70	66.50									
<u>C. edentulus</u>	92-116	10	10				5.60		6.40	88.00									
<u>S. timucu</u>	335-350	3	3										66.67				33.33		
<u>O. lineatus</u>	14-155	90	55		0.20		5.46	6.36	2.12	6.37	36.82			23.89				5.45	13.32
<u>L. jocus</u>	119-154	4	2								50.00	50.00							
<u>B. ronchus</u>	82.192	22	17		0.17				12.60	1.98	48.45	5.04		12.29			17.12		2.35
<u>M. furnieri</u>	156-355	9	6		7.29					1.37	71.62	9.38					6.90		3.45
<u>L. dispar</u>	16-24	7	5	24.00				6.00	40.00										30.00
<u>E. pisonis</u>	13-53	95	54	0.31			12.77	1.85	3.24		38.68			23.70	2.31	12.70	2.59		1.85
<u>G. dormitor</u>	16.362	71	44	2.03			16.67	1.25	1.32	1.50	20.49		2.27	39.02			13.18		2.27
<u>B. soporator</u>	9.68	21	12	4.17				17.50	59.17		8.33			2.50			8.33		
<u>G. spes</u>	34-59	19	13	2.40			1.00	44.80	51.35										
<u>S. testudineus</u>	32.59	10	7	26.80							11.80					12.70			48.70

carnivorous species may feed on only one prey item or can include a more variable diet. Although many secondary consumers examined may not be commercially important species, they do play an important role in the transference of energy to the tertiary consumers. Tertiary consumers were found to be mostly migratory species, utilizing the estuary at different times, thus reducing interspecific competition at this level.

There are two basic type of estuarine food webs (Odum and Heald, 1975) one based on vascular plant detritus, and the other on phytoplankton. The results of the stomach content analyses indicated that both types of food webs are present in the Rio Espiritu Santo River estuary.

Number of species

The number of species obtained in each sampling period is given in Table 6. The graphic representation of these results is shown on Figure 3. This is a tridimensional representation in which the axes are station number, time and number of species in the X, Y and Z directions, respectively. The effect of presenting collection data in this manner is to allow a visual presentation of both spatial and temporal variations in the number of species collected during a one year period.

The stations sampled in the estuary show striking variations in the number of species, and in the number of individuals collected at different dates. Spawning, recruitment of juveniles, feeding migrations and/or displacement caused by abiotic conditions greatly influence the spatial and temporal distribution of ichthyofauna observed in the Espiritu Santo River estuary during the year of sampling. Variations in the number

Table 6. Number of species per station per month

	Station							
	1	2	3	4	5	6	7	8
February	2	6	10	3	8	5	1	5
March	3	4	8	4	3	4	4	3
April	4	8	6	2	8	4	2	7
May	2	8	5	2	11	11	14	3
June	2	5	8	5	8	1	8	6
July	6	11	3	2	4	3	4	2
August	2	5	5	6	5	7	0	5
September	6	5	3	2	1	3	4	2
October	4	6	2	4	5	2	2	1
November	10	5	4	11	5	5	1	4
December	5	6	2	8	2	2	3	6
January	6	7	5	8	6	5	2	2

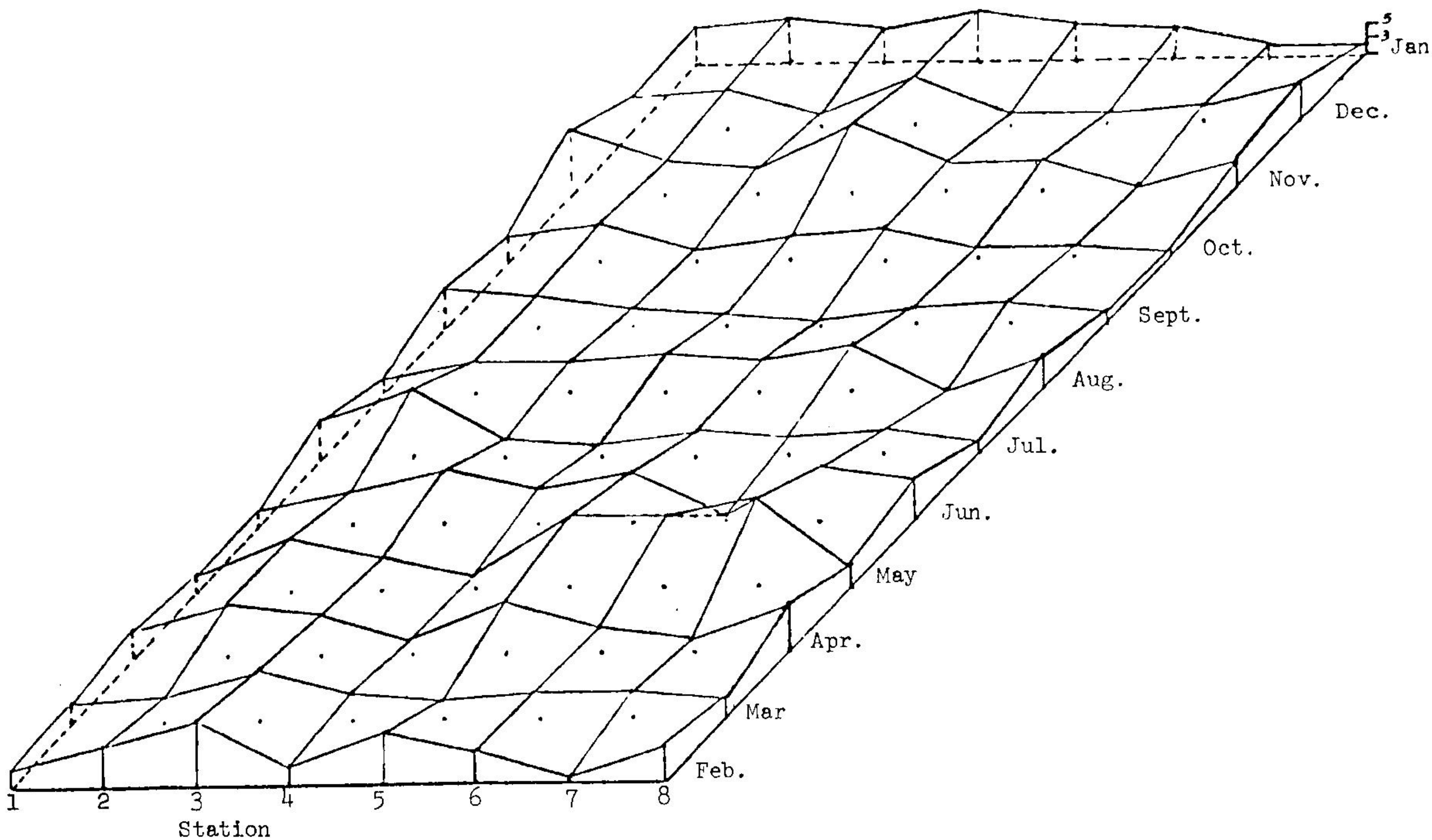

Figure 3. Number of species (S) caught per collection.

of species in a particular locality at a particular time can be explained in terms of one of these isolated factors (spawning, etc.), although in other cases, more than one factors seems to be involved.

A low number of species was observed at station 1 from February to July (Figure 3). This period corresponded to the dry season, when salinity rose due to the low river flow. A slight variation in this station was observed after September due to the rainy season, when, after heavy rains, this station exhibited its natural tidal fluctuations. Species like Awaous tajasica appeared in samples at station 1 after heavy rains.

Station 4 was located in the zone near the exit of Caño Castañón, which discharges the effluents from the Rio Grande Secondary Sewage treatment plant. During the low flow period, February to July, a low number of species was observed at this station. After the onset of the rainy season in August, the number of species increased and Dormitator maculatus released its spawn in this area. The increase in the number of species may have been due to several factors acting separately or in combination. One possible explanation for the observed increase in the number of species involves the quality of the water and habitat in and around this zone. Due to the discharge of the sewage effluents and the nature of the estuary during period of low freshwater input, it is possible that a combination of factors may make this zone a relatively unfavorable habitat. Because of the low flushing rates, the input from Caño Castañón may have resulted in reduced oxygen levels brought about by the biochemical oxygen demand (BOD) and/or the carbon oxygen demand (COD). Also the load of particulate material found in this areas was so heavy during periods of low flow that it literally clogged the mesh of the gill nets. This clogging tendency of particulate material could be expected to interfere with fish oxygen exchange systems as well as the efficiency of the nets. With the beginning of the rainy season and periodic large freshwater inputs, the estuary was flushed more often, thus creating a more favorable habitat in this zone.

Station 7 showed the highest number of species per sampling during the month of May. Some species captured, such as Cynoscion jamaicensis and Anchoa hepsetus showed ripe or near ripe gonads. Presence of other species such as Sphyraena guachancho could be attributed to feeding migrations.

For each month, the data for all stations were combined to determine the total number of species present. The highest number of species was observed during the month of May where 31 species were collected (Table 3). Most species collected showed ripe or near ripe gonads. This evidence reflects the recruitment of migratory species that use the estuary as a spawning ground. The lowest number of species per month was observed in January, when the shore zones were found to be the most heavy populated due to the recruitment of juveniles of the species Anguilla rostrata (42-62 mm SL), Gobiomorus dormitor (16-46 mm SL), Dormitator maculatus (16-39 mm SL) and Eleotris pisonis (13-71 mm SL). Oostethus lineatus also appeared to be abundant along the shore. These five species constituted 86.97% of the total catch for January. Stomach analyses of these species revealed large quantities of diptera larvae. Opisthonema oglinum re-appeared in the sample from January. This species probably was just beginning to arrive in the estuary since most of the individuals netted were captured in station 8.

The number of species and the species composition varied considerably at each station as can be seen in Table 4. The highest number of species for the twelve months was observed at station 5 where a total of 33 species were collected. This station is characterized by a fairly high diversity of habitats (such as open shore, mangrove and intertidal marsh grass), where the different requirements for food and space of many different species can be satisfied. The lowest number of species was observed at station 1, where 19 species were collected. Although station 1 showed a higher number of individuals than station 7, 26 species were taken at the latter. Some species caught at station 1 were represented by a large number of individuals.

Fish species collected were recorded in terms of their frequency of occurrence in the samples for each station, and classified into various categories with regard to their occurrence. The following relative terms were used to express population status:

Abundant: The species was collected in nine (9) to twelve (12) samples for that station. Juveniles and adults were captured.

Common: The species was collected in five (5) to eigth (8) samples for that station.

Occasional: The species was collected in one (1) to four (4) samples for that station. Occurrence of the species is usually due to migration into the station.

+ This symbol was assigned to those species represented by only one individual. The low frequency in the samples (annual occurrence of 1.04) gives a more realistic categorical evaluation.

These data are summarized in Table 7.

The fish populations collected from the Espiritu Santo River estuary consist mainly of occasional visitors (Table 7). Most of these occasional visitors into the estuary were migratory species and dominated the samples in which they occurred. A high number of these species showed ripe or near ripe gonads, supporting the hypothesized function of the estuary as a spawning ground. Species occurring only once in the whole year of sampling were probably found present at this level due to the sampling and/or the environmental conditions existent at that station at a particular time. Sampling technique could explain the low frequency of occurrence for species like S. plagiusa, L. laevigatus and A. rostrata (adults) since gill nets had low efficiency in capturing these fishes (Martin, 1972). Variations in salinity or the amount of freshwater at a particular time in a station will determine the presence of a species in a station.

Another aspect which should be considered as influencing the observed distribution is location preference. A high number of individuals caught in one locality established the preference of that species for that locality in the estuary. The high mobility exhibited by most fishes enable them to move to more suitable areas in a short time. The existing estuarine conditions may well dictate which species may inhabit a

Table 7. Occurrence and relative abundance rank of fishes species in different localities of the Espiritu Santo River estuary based on frequency (n = 12). (A = abundant, C = common, 0 = occasional, + = species represent by only one individual)

species	stations								% of annual
	1	2	3	4	5	6	7	8	occurrence
A. narinari			0		0				3.12
E. saurus		0		0				0	3.12
M. atlantica		0		0					2.08
A. rostrata	0	0	0		0				6.25
H. humeralis								0	1.04
O. oglinum	0	0	0	C	0	0	C	0	31.25
A. hepsetus							0		1.04
A. clupeoides		0			0	0	0		7.29
C. edentulus	0	0	0	0	0	0		0	13.54
S. timucu	0					0			3.12
P. vivipara				0	0				2.08
O. lineatus	C	A	A	C	0	0			37.50
P. mindii	0								2.08
C. ensiferus	0	0	0	0	0	0	0	0	18.75
C. pectinatus			0	0					2.08
C. undecimalis	0	0	0	0	0	0			15.62
C. hippos						0	0	0	3.12
C. latus	0	0	0		0	0	0	0	12.50
C. chrysurus			0			0	0	0	6.25
S. vomer							0	0	2.08

Table 7 (Cont.)

species	stations								% of annual
	1	2	3	4	5	6	7	8	occurrence
T. goodei				0			0		2.08
L. apodus							0		1.04
L. griseus							+		1.04
L. jocu						0	0	0	4.17
D. olisthostomus			0						2.08
D. rhombeus		0	0	0	0	0	0	0	19.79
E. lefroyi			0						1.04
E. melanopterus		0		0					2.08
E. plumieri	0	0	C	0	0	0	0	0	14.58
G. cinereus	0	0	0		0				6.25
P. crocro	0	0							3.12
B. ronchus	0	0	0	0	0	0	0	0	18.75
C. jamaicensis					0		0		3.12
L. breviceps					0		0		3.12
M. furnieri				0	0	0	0	0	9.38
C. faber						+			1.04
T. mossambica			0	C	0		0	0	13.54
A. monticola	0	0							5.20
M. curema	0	A	C	0	0		0	C	35.41
M. liza					0	0			2.08
S. barracuda		+							1.04
S. guachancho							0		1.04

Table 7 (Cont.)

species	stations								% of annual
	1	2	3	4	5	6	7	8	occurrence
Scarus sp.								+	1.04
P. virginicus					0	0	0	0	6.25
L. dispar					0	0	0		8.33
D. maculatus	0	0	0	0	0	0	0		14.58
E. pisonis	C	A	C	C	0	0			37.50
G. dormitor	C	C	0	0	0				29.17
A. tajasica	0								2.08
B. soporator					0	C	0	0	13.54
G. boleosoma				0	0		0		6.25
G. oceanicus		+							1.04
G. spes					0	0			6.25
T. lepturus						0	0		3.12
S. regalis					0	0		0	5.20
C. spilopterus			0			0			2.08
A. lineatus					0				2.08
S. plagiusa					+				1.04
L. laevigatus					0	0		0	4.17
S. testudineus								C	6.25

particular area, and the fishes can move from one place to another without showing a particular preference for a particular area.

Number of individuals

The number of individuals during the year of sampling varied widely (Figure 4). The number of fishes caught per sampling date varied from zero to 84 individuals with the highest number of individuals per sample being caught at station 4. This occurred during August when Dormitator maculatus became abundant.

The estuary is subject to seasonal influxes of many species. Some of the species observed used the estuary for spawning, spending a short time period in the estuary, while others species such as Anguilla rostrata used the estuary as juveniles but mature elsewhere. The number of individuals of resident species also varied depending on their spawning and migrations within the estuary. The recruitment of juveniles of Gobiomorus dormitor, Dormitator maculatus and Eleotris pisonis resulted in a larger catch of individuals of those species.

For each month, the data for all stations were combined to determine the total number of individuals (Figure 5). The number of individuals fluctuates every three months but more sampling would be required to determine if this cycle of fluctuation is a natural phenomenon or an artifact of this particular study. If the effect is general, one possible explanation may be associated with the increase and decrease of zooplankton throughout the year (Canals, personal communication). Stomach content analyses data could possibly be related to these fluctuations since food availability (especially decapod larvae and juveniles)

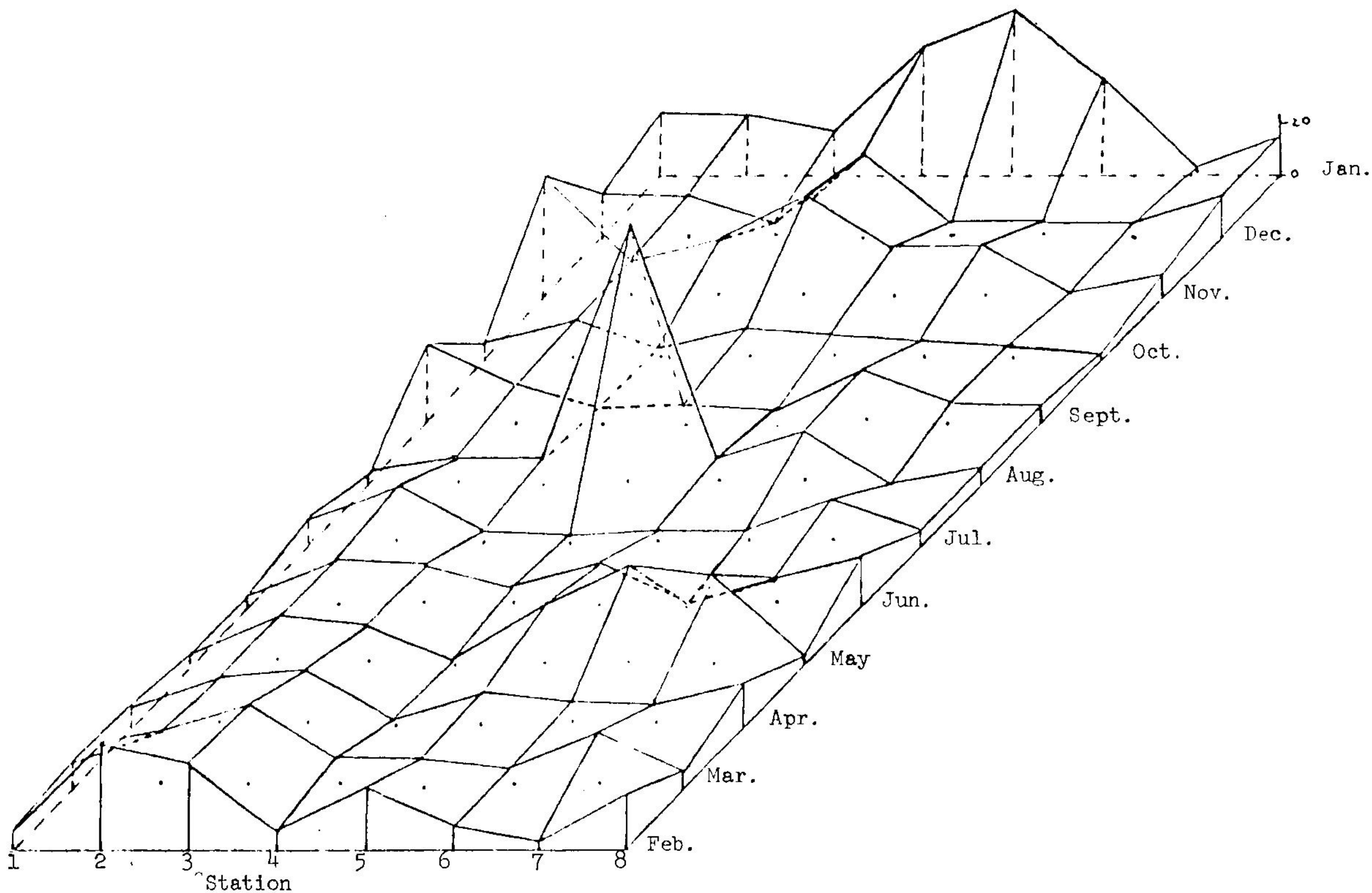

Figure 4. Number of individuals per sampling date.

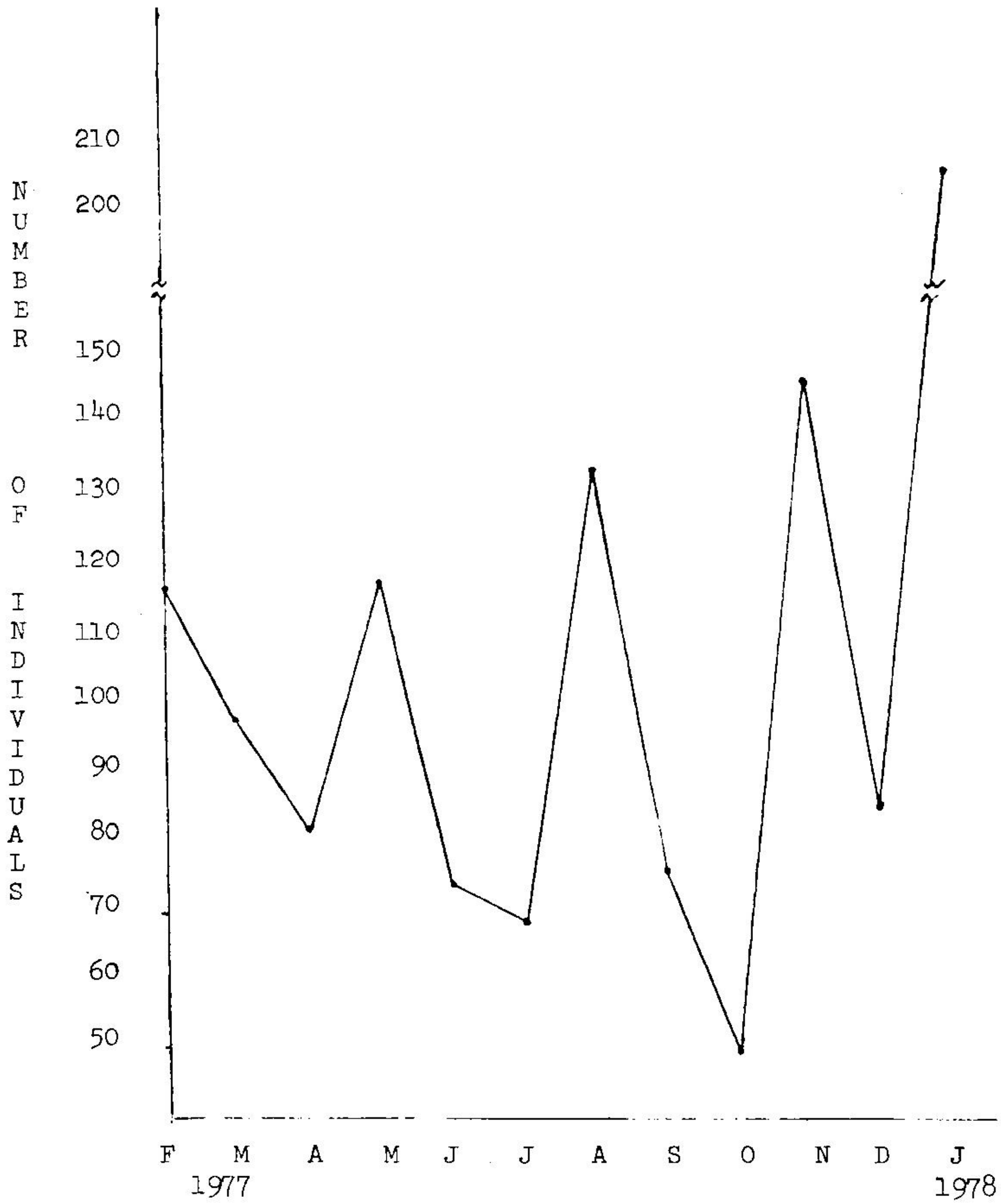

Figure 5. Number of individuals per month.

appear to be important for the presence of some species in a particular location. For example, at station 2 in July, all individuals captured (such as *Megalops atlantica*, *Anchovia clupeoides*, *Cetengraulis edentulus*) contained stomachs full of amphipods and shrimp larvae. The number of individuals peaks occurred in February, May, August, November and January (the latter month of sampling extended to the first week of February, 1978 due to scheduling problems).

The number of individuals can be used as an index of the relative abundance of fishes found in the estuary. On the other hand it does not take into account the relationships among the number, distribution, size and/or weight within or among species. The most numerically abundant species were found to be *Eleotris pisonis* (n = 145), *Opisthonema oglinum* (n = 126), *Dormitator maculatus* (n = 115), *Oostethus lineatus* (n = 114), *Mugil curema* (n = 100). While the most abundant in number was *E. pisonis*, the maximum weight of the individuals taken was 36 grams.

Fish behavior affects the number of individuals caught since sedentary species like *E. pisonis* and *O. lineatus* escape predation by seeking refuge in the aquatic vegetation of the shore line. As a result, the number of individuals of these species was more abundant in the catch. Also, a higher number of individuals caught could be anticipated for those species which exhibit schooling behavior such as *Mugil curema* and *Opisthonema oglinum*.

Species Diversity Index

Species diversity as measured by the formula from Information Theory (Brillouin, 1962) allows one to obtain the degree of uncertainty of occurrence of a particular symbol at a certain point in a message, and ultimately, the amount of information conveyed by its occurrence (Lloyd et al., 1968, Pielou, 1966). The concept of diversity, when it is used in an ecological context is an expression fo a particular distribution of individuals as a species. The factors influencing the species diversity are: (1) the number of individuals (2) the number of species, and (3) the distribution of individuals among the species. Both, number of species and number of individuals, formerly presented as separate entities, do not account for how the number of individuals are allocated into species categories. This latter consideration can be gauged by means of the Brilloun's species diversity formula (Lloyd et. al., 1968).

The species diversity index used in this study summarizes the distribution of the individuals among the species for each sampling date at a particular station. All individuals obtained using different sampling gear in the various different habitats within stations are included in the analysis. Comparative studies of habitats should take this difference in sampling methodology into account to avoid misapplication or misinterpretation of the conclusions derived. Thus the effect of pollution on species diversity, for example, can be mis-estimated unless the methodology used in sampling is identical at each station.

Species diversity information is summarized in Figure 6, a tri-dimensional graphic presentation in which date, station-number and species

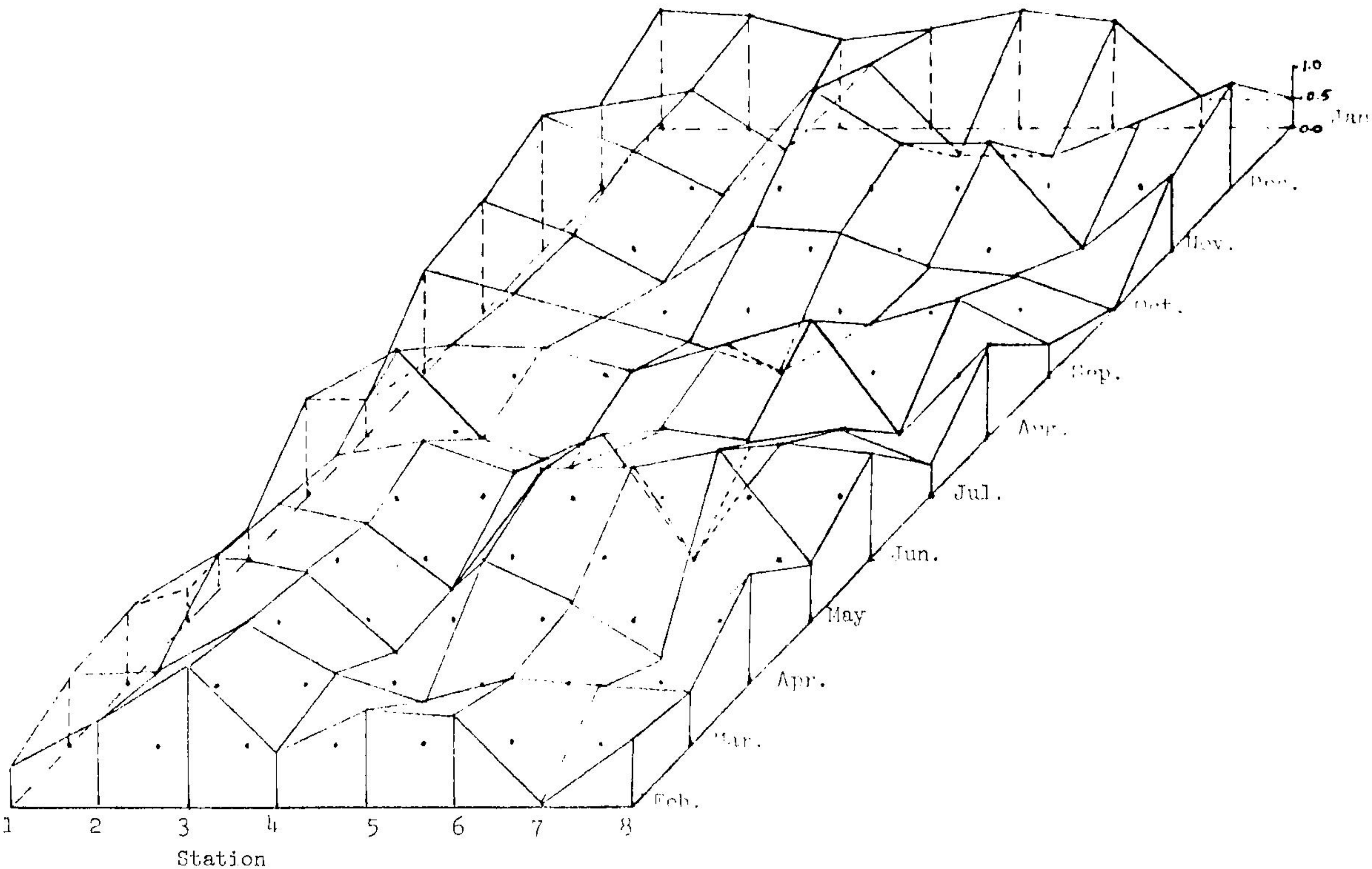

Figure 6. Species diversity per sampling date.

diversity are plotted in the conventional cartesian co-ordinates X, Y and Z respectively. The graph is based upon numerical values given in Appendix Table 2.

The February catch consisted of 117 individuals representing 21 species. The highest species diversity occurred at station 3, where 70% of the species collected were marine species. Species diversity for March ranged from 1.9264 (station 3) to 0.6856 (station 5) while the range for April was 2.0935 (station 2) to 0.4010 (station 7). The maximum species diversity for May was obtained at station 7 (SD 2.7778 bit/individuals) and the minimum at station 4 where only two individuals were caught. The June species diversity ranged from 2.0280 (at station 5) to zero at station 6 when only one specimen of T. lepturus was collected, while in July the maximum species diversity was 2.4227 (at station 2) and the minimum was 0.5000 at stations 4 and 8. The maximum species diversity in July was attributable to observations of M. atlantica (2), A. clupeoides (10), O. lineatus (3), C. ensiferus (3), C. undecimalis (1), D. rhombeus (1), G. cinereus (2), B. rhonchus (3), M. curema (1), E. pisonis (1) and G. dormitor (2). The August catch consisted of 134 individuals representing 22 species, with the maximum species diversity occurring at station 6 (1.8633 bit/individuals). The September maximum species diversity occurred at station 1(1.6759 bit/individuals) and decreased to station 5 where three B. soporator were collected along the shore. The number of fish collected in October was considerably less than previous sampling periods, with only 50 individuals representing 18 species caught. The maximum species diversity was obtained at station 1 (1.8130 bit/individuals) when surface and bottom salinities were 12 ppm and 64 ppm respectively. During November, a total of 147 individuals representing 25 species were collected, with a maximum diversity of 2.6373 bit/individuals at station 4. At station 7 only one B. ronchus was collected. December species diversity ranged from 1.9656 (station 4) to 0.5000 at stations 5 and 6. The January maximum species diversity occurred at station 5, with an index of 1.9028 bit/individuals. The minimum species diversity was at station 4, where O. oglinum comprised 84.62% of the catch.

Station 1 showed a gradual increase in species diversity from February to April. Marine species such as M. curema, O.oglinum became abundant during this period. From May to June, the diversity was reduced to a minimum at station 1, while stations 5 and 6 reached their maximum values. Diversity indices increased from September to November in station 1. The migrations of A. monticola, and the presence of B. ronchus, C. latus and A. tajasica contributed to this increase.

Species diversity for station 2 ranged from 1.0859 to 2.4227 bit/individuals. During the February to March sampling period, M. curema and O. oglinum constituted 84.91% of the catch. Samples for April and May had the same number of species and individuals, but the diversity index differed due to the frequency distribution of the individuals among species. In May, two species accounted for 62.50% of the catch. From April to June, the species diversity decreased, but rose abruptly in July when it reached its maximum value. Stomach contents of the different species collected indicated large number of decapod larvae at this time. During the August to September sampling period, the diversity decreased, but from October to January the index fluctuated from 1.5773 to 1.7556 bit/individuals.

The peak value of species diversity at station 3 occurred in February when 70% of the species collected were marine species. The decreased noted in the diversity for March is due not only to the decrease in the number of species, but also to an increase in the number of O. oglinum, which constituted 48.15 % of the catch, and significantly the reproductive period of this species has been establish as occurring in March (Martin, 1974). A decline in diversity continued during following months with the exception of June and October, in which several species collected were represented by only one individual. In November, D. maculatus constituted 73.68% of the catch

Species diversity for station 4 range from 0.5000 to 2.6373 bit/ individuals. Low diversity values were obtained from February to July. During these months, this area was covered by water hyacinth, which in turn was washed away by heavy rains in the upper watershed during the month of August. After this, the number of species increased from 2 to 6. accounting for an increase in the species diversity from 0.5000 to 1.0939 bit/individuals. A higher value was expected due to the gain in species number, but the large number of D. maculatus, which constituted 76.19% of the catch tended to maintain a lower index. The maximum species diversity for this station occurred in November, when eleven species contained 34 individuals were collected. The reduction in the number of species and the recruitment of E. pisonis juveniles are responsible for the lower diversity for December and January.

Species diversity for station 5 ranged from zero (all individuals collected belonging to one species) to 2.4828 bit/individuals. Indices for February and March were 1.5620 and 0.6856 respectively, and an increase in April was noted when eleven individuals representing eight species were collected. Most species collected in April were marine species such as A. narinari, O. oglinum, C. latus, P. virginicus and A. lineatus. Species diversity increased in May due to the additional species collected such as C. jamaicensis, L. breviceps. A decline in species diversity was noted during June when many species collected previously were not found in catches from that period. In August most species collected were Gobiidae. The same situation persisted in September when only three B. soporator were collected. The species collected in October were C. edentulus (4), C. ensiferus (1), C. undecimalis (1), C. latus (2), L. jocus (1), while in December only two species, O. oglinum and E. pisonis were caught. In January, most species were collected among shore vegetation and under water hyacinth, 24 specimens of A.rostrata were collected in one sample.

Species diversity for station 6 fluctuated from 1.1510 to 1.4713 bit/individuals from February to April. Some species collected were C. hippos, S. regalis, B. ronchus, C. faber and C. spilopterus. In May the diversity index reached its maximum value when eleven species were collected. Five these 11 species were represented by only one individual. Stomach contents of C. undecimalis, M. furnieri, B. ronchus and P. virginicus revealed decapod and fish remains. In June only one T. lepturus was caught at station 6 and it was a gravid female. Significanly, during July nine individuals collected showed ripe gonads. Species diversity gradually increased from July to August. Three species, B.

soporator, G. spes and L. dispar were common in the mangrove oyster communities during August to October. These three species constituted 89.74% of the catch for that period. The species Gobiosoma spes and Lupinoblennius dispar seem to be highly dependent on the oyster communities since it was observed that in December, when oyster communities became scarce, the number of G. spes was reduced and no L. dispar was collected. Also, a mat of water hyacinth moved into this station from higher stream flow in watershed at this time and the hyacinth root system appears to have conveyed species such as E. pisonis and O. lineatus, which were previously uncommon at station 6.

Opisthonema oglinum constitute 76.00% of the catch for the first three months of sampling at station 7. The maximum diversity for this station occurred in May. This increase in species diversity was due to the presence of many species that evidenced spawning conditions such as A. hepsetus, C. jamaicensis, L. breviceps, T. lepturus. Species A. hepsetus appeared for first time in the collections and it may have been even more abundant than the collection data showed since S. guachancho stomach contents analysis revealed large quantities of anchory remains. The Carangidae collected included C. latus, C. chrysurus, S. vomer and T. goodei. Most species collected in May were limited to this period and the loss of these species from the other sampling dates caused a reduction in number of species and consequently a reduction in diversity. Also, the increase in numerical abundance of T. lepturus related to reproduction activities resulted in a lower index. In August, fishing in this station was totally unsuccessfull. Indeed, only scyphozoans (jelly-fish) were captured in the nets.

The diversity value for station 8 was more variable temporally, with peaks occurring in April (maximum diversity), June, August and December. *Mugil curema* comprised 70.58% of the February collection, but the number of *M. curema* decreased in subsequent samples. Three *S. regalis* collected in June had stomachs full fo fish remains and the gonads were inactive. Other species collected were *C. hippos*, *P. virginicus*, *O. oglinum*, *D. rhombeus* and *M. curema*. In July, *C. chrysurus* constituted 75.00% of the catch. One *Scarus* species was collected in October, but blue-crab (*Callinectes sp.*) fed on it. The blue-crab eliminated much of the catch and it is not known if there had been more than one *Scarus sp.* present. In December, *Harengula humeralis* appeared in the sample for first time. *H. humeralis* and *P. virginicus* stomachs were full of fish remains. *O. oglinum* constituted 84.62% for the January catch at station 8. The numerical abundance of this species probably was due to migration into the estuary. The shore fish populations consisted of *S. testudineus* which can be found along open shore or hidden in the mangrove roots.

One characteristic of the Rio Espiritu Santo River estuary fish populations is that many species are not permanent residents but only spend part of their life cycle in the estuary. For most samples, fluctuations in species diversity was indicative of the changing composition of the ichthyofauna of the estuary, but in some collections the fluctuations of diversity index resulted the same or nearly the same values. This would suggest that the collections are equivalent. However, the determination of the species diversity for a collection does not take into account the nature of the individuals. One individual of a marine species can be substituted by one individual of a freshwater species as a result of abiotic or biotic factors, thus species diversity may be seasonally compensating. Since all stations were affected by migration, it was necessary to determine the annual species diversity for the station to eliminate the seasonal compensation. Species diversity indices were calculated for each of the eight stations by considering each station as one sample. Pooled samples contain all species found at a station during the year and the results are presented in Table 8. Species index gradually increased from station 1 to station 3. At station 4, the minimum value for the index was obtained while station 5 showed the highest value. The difference in depth, salinity and water quality may act as barriers to upstream migration of the fish and additional investigation is required to determine if any of these factors contribute to station from station differences in diversity. The heavy growth of water hyacinth (generally indicative or organic enrichment) at station 4 during the first months of sampling can contribute to the difference in species diversity. Thus, although stations 4 and 5 are close together, the bloom of water hyacinth present at station 4 did not extend to station 5. While salinity increased from stations 6 to 8 the number of species decreased resulting in lower diversity values, although fish collected were, in general, larger.

Community Similarity Indices

Similarity between stations was characterized using calculated Community Similarity indices. The species composition of individual stations were compared using a modified coefficient of community or

Table 8. Pooled Species Diversity by Stations

Station	Number species	Number Individuals	Species Diversity (bit/individuals
1	19	142	3.2147
2	23	207	3.2966
3	22	155	3.3797
4	22	231	2.9733
5	33	172	4.3410
6	28	152	3.7919
7	26	96	3.5384
8	22	102	3.2864

index of similarity, (Bray and Curtis, 1957) which takes into consideration the relative abundance of the individuals among the species. The Similarity index is defined as 2w/(a + b), where a is sum of all value for the first station, b is the same as a but for the station with which comparison is sought, and w is the sum of the lower of the two quantitative values for those species shared by the station compared (Bray and Curtis, 1957). The index is 1 when sample stations have identical populations and a value of 0 when they are totally dissimilar. The numerical measure of fauna similarity within stations derived from the Bray and Curtis' index is given in Table 9 and depicted graphically in Figure 7.

Station 1 gives the best indication of the similarity between this location (upper part) with other stations closer to the sea (Figure 7). There is a gradual decrease of species shared by stations as habitats change due to salinity and/or bordering vegetation type. The similarity between stations compared with station 1 is inversely proportional to their distance from one another.

Station 2 showed greatest similarity with station 3 with a Community Similarity index of 0.661 (Table 9). The faunal similarity of station 2 with other stations decreases from station 5 through station 7 and then increases at station 8, an unexpected result. A detailed examination of the data show that this similarity between station 2 and station 8 was due to the relatively high number of individuals of species *Mugil curema* and *Opisthonema oglinum* found at both stations but if faunal similarity is re-computed without taking these two species into consideration, the similarity between stations decreases gradually (Table 9).

Table 9. Matrix of the Bray & Curtis (1957) index of similarity. (*see text for explanation)

	1	2	3	4	5	6	7	8
1		.582	.529	.460	.403	.350	.160	.117
2			.661	.512	.459	.362	.301	.412/(.160)*
3				.541	.488	.376	.361	.422/(.155)*
4					.441	.328	.202	.181
5						.550	.350	.280
6							.271	.280
7								.408

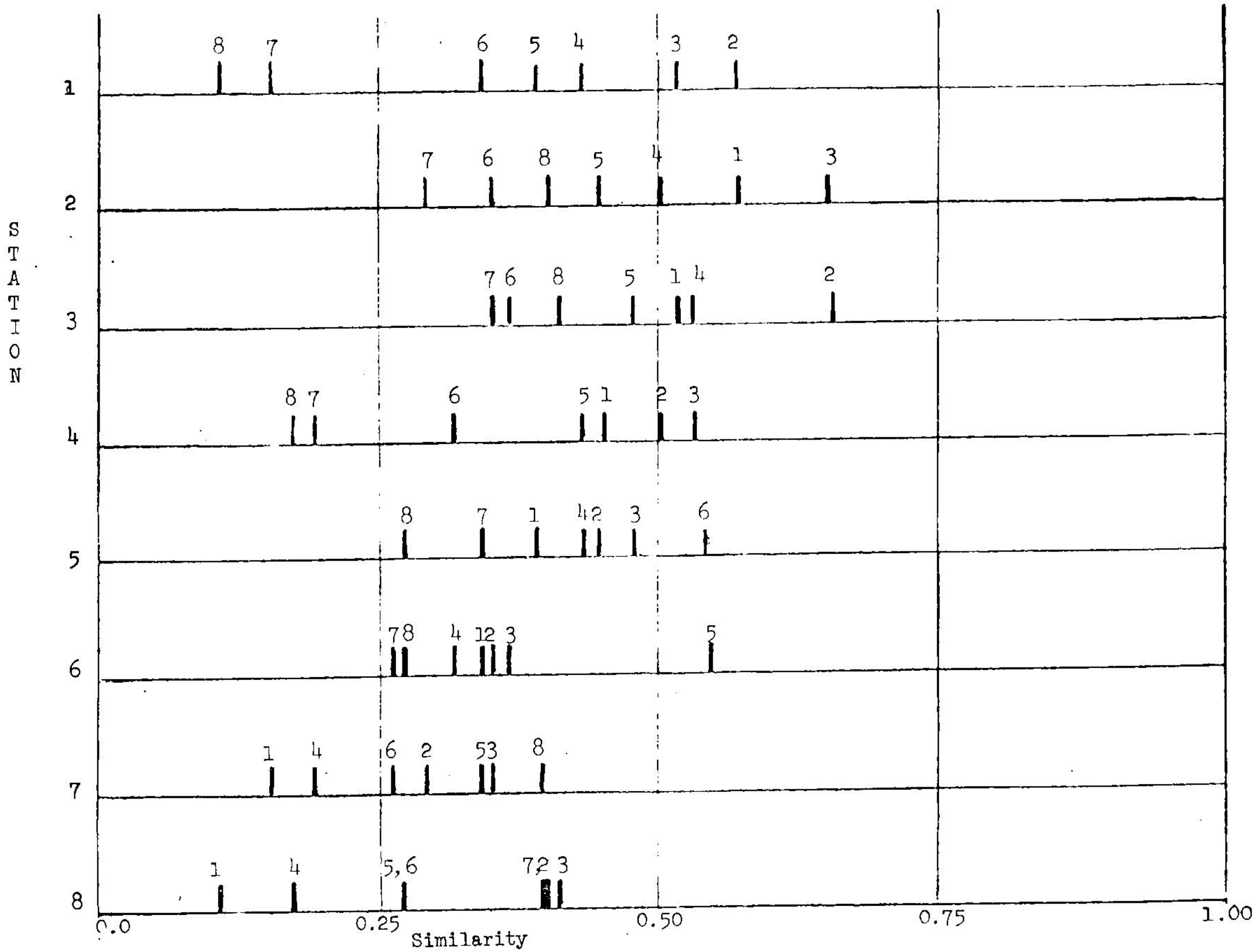

Figure 8. Species composition similarity based on Bray and Curtis' index.

Station 3 has more similarity with neighboring stations than with stations further away. Bordering vegetation common to the station allows the presence of species such as Eleotris pisonis and Oostethus lineatus. Unexpected similarity between stations 3 and 8 was due to the high number of individuals of M. curema and O. oglinum as was the case at station 2. Re-computed data shows less similarity (Table 9).

Station 5 showed more similarity with station 3 than with station 4. This similarity can not be explained in terms of bordering vegetation, but the occurrence of species such as Aetobatus narinari (Spotted Eagle Ray) at station 3 would appear to depend upon the salinity gradient found at particular times.

Station 6 showed less similarity with station 7 than expected, and a high similarity with station 5. Differences between stations 6 and 7 may be due to salinity difference found during high and low tides (Table 2) and the proximity of station 7 to the sea may be decisive in explaining why the index for stations 6 and 7 is not higher.

As expected, station 8 shows a great dissimilarity with station 1, but more similarity than expected with stations 2 and 3. Station 8 is located at the river mouth where marine species enter the estuary. The number of marine species shared with other localities contributed to their similarity, although there was a very pronounced difference in salinity and bordering vegetation.

The community similarity was also characterized using Jaccard Coefficients (Brower and Zar, 1977). This index is defined by the equation: $CC_j = C / (S_1 + S_2 - C)$; where S_1 and S_2 are the number of species in each community under comparison, respectively and C, is the number of species common to both stations. This index is predicated on the presence or absence of species at the stations under comparison and not on the distribution of individuals among the species as with the Bray and Curtis index of similarity. These data are presented in Table 10. When comparing stations based only on the presence and absence of species without taking into consideration their relative abundance, rare species contribute heavily to the similarity, since their contribution to similarity is the same as the contribution of numerically important species. On the other hand, when numerical abundance is considered, the effect of rare species is reduced.

Both community similarity indices have shown that the areas into which the estuary was arbitrarily divided during station designation are different in their species composition. Food availability and salinity concentrations also contribute heavily to these differences.

Table 10. Matrix of the Jaccard coefficient of community (*see text for explanation)

	1	2	3	4	5	6	7	8
1		.615	.519	.367	.368	.343	.184	.171
2			.500	.500	.400	.342	.225	.250/(.206)*
3				.517	.447	.389	.263	.294/(.250)*
4					.410	.282	.333	.333
5						.564	.405	.341
6							.385	.429
7								.371

Summary and conclusions

A twelve months survey was carried out to collect, identify and describe the ichthyofauna components of the Rio Espiritu Santo River estuary. Comparative analyses were conducted between the type and number of fish collected on a spatial and temporal basis. Sixty species were encountered at eight localities in the estuary. Only a few species were captured throughout the year, but their presence was restricted to the upper zone of the estuary. These species were *Oosthetus lineatus*, *Eleotris pisonis*, and *Gobiomorus dormitor*.

Most species collected were occasional visitors to the estuary, since they were only captured during a maximum of 4 sampling periods at any given station. The migration of most of the species was found to be in response not only to abiotic factors, but also to species specific reproductive cycles. Trophic relations appeared to greatly influence the movement of these species in the estuary.

Migratory patterns were related to the reproductive cycle in which the spawning migrations of the adults and the recruitment of juveniles resulted in variations in species composition and in the number of components of each sample.

Stomach contents analyses revealed that the majority of fish could be considered as secondary consumers feeding of insects, crustaceans, molluscs, and other fish. The secondary consumers feed on only one prey item or can include a more variable diet depending on several factors such as prey abundance. Future studies should examine the relationship between food abundance changes along the estuary and the pattern of prey utilization by fish.

The fluctuations in species diversity values of collections were due to the temporal and spatial separation of the fish populations. These spatial and temporal separations combined with trophic variability allowed more species to utilize the estuary than if they were in a constant direct competition. However, over a long period of time species diversity may be high.

The similarity indices show that each sampling location in the estuary supports different fish populations. The temporal change in environmental conditions at each locality and the biological characteristic of the species operate in such a way as to permit the best utilization of the estuarine resources. Any modification of the estuarine environment could affect the fish populations and their trophic relationship. This is especially true of the coastal commercial and sport related fish species.

Censuses of fish populations as performed in this study presented various difficulties. The chief limitation to obtaining substantial data on fish populations was in gear selectively (Martin, 1972). The fish are too mobile and too clever to be captured in most sampling gear and they may avoid the nets by moving to areas which lie outside the sampling stations. Also, all habitats can not be sampled with specific gear. For this reason, any generalizations predicated on censuses of fish populations as performed in this study will always be relative. Despite the weaknesses in the collection procedures, the results presented here illustrate the continously changing nature of the ichthyofauna components in the Espiritu Santo River estuary during an annual cycle.

Literature Cited

Austin, H. (1971) A Survey of the Ichthyofauna of the Mangroves of Western Puerto Rico during December 1967-August 1968. Carib J. Sci. II (1-2): 27-39.

Austin, H. and S. Austin (1971). The Feeding Habits of Some Juvenile Marine Fishes from the Mangrove in Western Puerto Rico. Carib. J. Sci. II (3-4): 171-178.

Bechtel, T. and B. J. Copeland (1970). Fish Species Diversity Indices as Indicators of Pollution in Galveston Bay, Texas. Marine Sc. XV: 103-132.

Beebe, W. and J. T. Van (1933). Field Book of the Shore Fishes of Bahamas and Adjacent Tropical Waters. Livington Publ. New York, U.S.A.

Boeseman M. (1960). The Freshwater fishes of the Island of Trinidad. Studies on the Fauna Curacao. Vol. 10 (48): 72-153.

Bohlke, J.W. and C.C.G Chaplin. (1968). Fishes of the Bahamas and Adjacent Tropical Waters. Livingston Publ. Comp. Wynnewood, P.A. 771 pp.

Bray, J.R. and J.T. Curtis (1957). An Ordination of the Upland Forest Communities of Southern Wisconsin. Ecolog. Monogr. 27:325-349.

Brillouin, L. (1962). Science and Information Theory. Academic Press, New York, U.S.A.

Brower, J. and J. Zar (1977). Fields Laboratories Methods for General Ecology. Brown Co., U.S.A.

Cervigón, F.M. (1966). Los Peces Marinos de Venezuela. Fundación La Salle de Ciencias Naturales, Caracas, Venezuela. Vol. I-II: 951 pp.

Cox, G. (1976). Laboratory Manual of General Ecology. W.C. Brown Co. Dubuque, Iowa. 3th edit. pp 162-165.

Cronin, L.E. and A. Mansueti (1971). The Biology of the Estuary. In a Symposium of the Biology Significance of Estuary. Sport Fishing Institute, Washington, D.C., U.S.A.

Cuevas, E. and R. Clements (1975). Changes in Selected Water Quality Parameters as Influence by Land Use in the Espiritu Santo Drainage Basin. PRNC Report #195 pp. 70.

Dawson, C.E. (1970). The Caribbean Atlantic Blenny Lupinoblennius dispar (Tribe:Blenniini) with observation on a Pacific Population. Biol. Soc. of Wash. 83(26):273-286.

Denoncourt, R.F. and J.W. Stambauch (1974). An Ichthyofauna Survey and Discussion of Fish Species Diversity as an Indicator of Water Quality Codorus Creek Drainage York Country, Pennsylvania. Proc. PA Acad. Sci. 48:71-78.

de Sylva, D.P. (1973). Nektonic food webs in estuaries. In Estuarine Research, ed. LE. Cronin, Vol. I, pp 420-427. New York Academic Press.

Diener, R.A., A. Inglish and G. B. Adams (1974). Stomach Contents of Fishes from Clear Lake and Tributary Waters, a Texas Estuarine Area. Marine Sci. Vol. 18: 7-17.

Erdman, D.S. (1956). Recent Fish Records from Puerto Rico. Bull. Mar. Sci. Gulf Carib. 6 (4): 315-340.

__________ (1960). Larvae of Tarpon, Megalops atlantica, from Añasco River, Puerto Rico, Copeia 2:146.

__________ (1972). Inland Game Fishes of Puerto Rico. Dept. Agric. Commonwealth of Puerto Rico. Vol. IV(2): 1-96.

__________ (1976). Spawning Patterns of Fishes from the Northeastern Caribbean. Agricul. Fish. Contrib. Commonwealth of Puerto Rico. Vol. VIII (2): 1-36.

Evermann, B.W. and M.C. Marsh (1902). The Fishes of Puerto Rico. Bull. U.S.A. Fish. Comm. 20:49-350.

Fisher, W. ed. (1978). FAO Species identification sheets for fishery purposes, Western Central Atlantic (Fishing Area 31). Vol. I-7. UNDP/FAO Inter. Proj. for the Devel. of Fisheries in Western C. Atl. Rome.

Frame, D.W. (1974). Feeding Habits of Young Winter Founder (Pseudopleuronectes americanus): Prey Availability and Diversity. Trans. Amer. Fish Soc. 103 (2):261-269.

Gilmore, G.R. (1977). Notes on the Opossum Piperfish, Oostethus lineatus from the Indian River Lagoon and Vecinity, Florida. Copeia: 781-783.

Goldman, G.C. (1978). Bathymetry and Salinity Measurements of Espiritu Santo River Estuary. Marine Ecology Division, CEER (unpublished).

González, J. and M.R. Vilella (1976). Biología de las Lagunas Costeras. Segundo Simposio del Dept. Recursos Naturales. D.R.N.

Greenwood, P.H. D.E. Rosen, S. H. Weitzman and G.S. Myers (1966). Phyletic studies of teleostean fishes, with a provisional classification of living forms. Bull. Amer. Mus. Nat. Hist. 131(4):389-456.

Haedrich, R.L. and C.A.S. Hall. (1976). Fishes and Estuaries. Oceanus 19 (5):55-63.

Kimmel, J. J. (1979). Thermal effects on fish of Guayanilla Bay. In Proc. Ener. Mar. Env. Guayanilla Bay. Center for Energy and Environment Research.

Livingston, R.J. (1976) Diurnal and Seasonal Fluctuation of Organisms in a North Florida Estuary. Estuarine and Coastal Marine Science 4:373-400.

Lloyd, M.; J.H. Zar and J.R. Karr (1968). On the Calculation of Informational -Theorical measures of Diversity. Amer. Midl. Naturalist 79(2):257-272.

Margalef, R. (1958). Information Theory in Ecology. Gen. Syst. 3:36-71.

Martín, F.D. (1971). Report on investigation in the Biology of Jobos Bay fishes for the fall quarter 1971. IN Aguirre Power Project Environmental Studies. 1971 Annual Report.

Martín, F.D. (1972). The distribution and ecology of the fishes of Jobos Bay IN Aguirre Power Project Environmental Study. 1972 Annual Report PRNC, Rio Piedras (162) 225-251.

Martín, F.D. (1972b). Collecting methods for fish. IN Aguirre Power Project Environmental Study 1972 Annual Report. PRNC 162, Appendix B:391.

__________ (1974). Distribution, Seasonality and Feeding Ecology of Fishes of Jobos Bay. IN Jobos Bay Environmental Report. PRNC I: 90-189.

__________ (1976). Artificial key to the Families of Teleost Fishes of Puerto Rico. CEER (unpublished).

McErlean, A. J.; S.G.O'Connor; J.A. Mihursky and C.I. Gibson (1973). Abundance Diversity and Seasonal Patterns of Estuarine Fish Populations. Estuarine and Coastal Marine Sci. I:19-36.

Munro, J.L., V.C. Gaut, R. Thompson and P.H. Reeson (1973). The spawning seasons of Caribbean reef fishes. J. Fish Biol. 5:69-84.

Nichols, J.T. (1929). The Fishes of Porto Rico and the Virgin Islands. Sci. Surv. Porto Rico and Virgin Island. Acad. Nat. Sci. 10 (2-3).

Odum, W. and E. Heald (1972). Trophic Analyses of an Estuarine Mangrove Community. Bull. Mar. Sci. 22:671-738.

Odum, W. and H. Heald (1975). The Detritus Based Food wed on an Estuarine Mangrove Community. IN Estuarine Research, ed. L.E. Cronin. New York, Acad. Press. Vol. I:265-286.

Pielou, E.C. (1966). The Measurement of Diversity in Different Types of Biological Collections. J. Theoret. Biol. 13:131-144.

Pritchard, D.W. (1967). What is an Estuary:Physical Viewpoint. IN Estuaries, ed. G.H. Lauff. Amer. Ass. Adv. Sci. Publ. No. 83. W. Washington, D. C. pp 3-5.

Randall, J.E. (1967). Food habits of reef Fishes of the West Indies. Stud. Trop. Oceanogr. Miami 5:665-847.

Randall, J.E. (1968). Caribbean Reef Fishes. T.F.H. Publ. Inc., New Jersey, U.S.A.

Schelske, C. and E. Odum (1961). Mechanisms Maintaining High Productivity in Georgia Estuaries. Proc. Gulf and Carib. Fish Inst., 14:75-80.

Tsai, C.F. (1973). Water Quality and Fish Life Below Sewage Outfalls. Trans Amer. Fish Soc. 102 (2):281-292.

Vernberg, W.B. and F.J. Vernberg (1976). Physiological Adaptation of Estuarine Animals. Oceanus 19(5):48-54.

Wilhm, J. L. (1968). The Use of Biomass Unit in Shannon Formula. Ecology 49:153-156.

APPENDIX

Appendix Table I. List of scientific and common names of fish species in the Espiritu Santo River estuary.

Scientific	Common name	
	English name	Spanish name
Myliobatidae		
Aetobatus narinai	spotted Eagle ray	chucho, mariposa
Elopidae		
Elops saurus	ladyfish	piojo, macabi
Megalopidae		
Megalops atlantica	Tarpon	sâbalo
Anguillidae		
Anguilla rostrata	American eel	anguila
Clupeidae		
Harengula humeralis	Redear herring	machuelo
Opisthonema oglinum	Thread herring	arenque
Engraulidae		
Anchoa hepsetus	Striped anchovy	bocua
Anchovia clupeoides		bocua
Cetengraulis edentulus	Whalebone anchovy	bocua
Belonidae		
Strongylura timucu	Atlantic needlefish	agujón
Poeciliidae		
Poecilia vivipara	top minnow	guppy
Syngnathidae		
Oostethus lineatus	Opossum piperfish	trompetero
Pseudophallus mindii	short nose piperfish?	
Centropomidae		
Centropomus ensiferus	Swordfin snook	robalo machuelo
Centropomus pectinatus	Tarpon snook	robalo machuelo
Centropomus undecimalis	Snook	robalo machuelo
Carangidae		
Caranx hippos	Crevalle jack	jurel
Caranx latus	Horse eye jack	jurel ojón
Chloroscombrus chrysurus	Bumper	Casabe
Selene vomer	Lookdown	jorobado
Trachinotus goodei	Palometa	Palometa

Appendix Table I. (cont.)

Lutjanidae		
Lutjanus apodus	Schoolmaster snapper	Pargo amarillo
Lutjanus griseus	Gray snapper	Pargo prieto
Lutjanus jocu	Dog snapper	Pargo colorado
Gerridae		
Diapterus olisthostomus	Irish pompano	mojarra
Diapterus rhombeus	Rhomboid mojarra	Morarreta
Eucinostomus lefroyi	Mottled mojarra	
Eucinostomus melanopterus	Blackfin mojarra	Muniana
Eugerres plumieri	Striped mojarra	Espuela, mojarra
Gerres cinereus	yellow fin mojarra	Miniama
Pomadayidae		
Pomadasys crocro	freshwater grunt	viejo
Scianidae		
Bairdiella ronchus	Ground drummer	ronco
Cynoncion jamaicensis	Mongolar drummer	dentõn, dientõn
Larimus breviceps		corvino cabezõn
Micropogon furnieri	Drummer, Creaker	corvino
Ephippidae		
Chaetodipterus faber	Spadefish	Paguala
Cichlidade		
Tilapia mossambica	Tilapia	Tilapia
Mugilidae		
Agnostomus monticola	mountain mullet	dajao
Mugil curema	White mullet	Jarea
Mugil liza	liza mullet	liza
Shyraenidae		
Sphyraena barracuda	barracuda	picua
Sphyraena guachancho	guachanche	picuilla
Scaridae		
Scarus sp.		loro, cotorro
Polymenidae		
Polydactylus virginicus	threadfin	barbũ
Bleniidae		
Lupinoblennius dispar	blenny	

Appendix Table I. (cont.)

Eleotridae		
Dormitator maculatus	Fat sleeper	moroncillo
Eleotris pisonis	Spinycheek sleeper	Morôn
Gobiomorus dormitor	Bigmouth sleeper	mapiro
Gobiidae		
Awaous tajasica	River goby	Saga
Bathygobious soporator	Frillfin goby	moroncillo
Gobionellus boleosoma	Darter goby	
Gobionellus oceanicus	Highfin goby	
Gobiosoma spes		
Trichiuridae		
Trichiurus lepturus	Cutlassfish	Sable, machete
Scombridae		
Scomberomorus regalis	Cero	Sierra
Bothidae		
Citharichthys spilopterus	bay whiff	lenguado
Soleidae		
Achirus lineatus	lined sole	lenguado
Cynoglossidae		
Symphurus plagiusa	Blackcheek tonguefish	lenguado
Tetraodontidae		
Lagocephalus laevigatus	Smooth puffer	tambor, ratôn
Shaeroides testudineus	checkered puffer	tamborîn

Appendix Table 2 - Values of species diversity expressed in bit/ individuals.

	1	2	3	4	5	6	7	8
Feb.	0.6644	1.3799	2.3337	0.8644	1.5620	1.4713	0.0000	1.0883
Mar.	1.1019	1.0859	1.9264	1.1736	0.6856	1.1510	1.0295	0.8963
Apr.	1.2447	2.0935	1.8068	0.5000	2.0227	1.3394	0.4010	1.8178
May	0.5285	1.8859	1.5766	0.5000	2.4828	2.4622	2.7778	0.8617
Jun.	0.5000	1.6782	1.8942	1.4155	2.0280	0.0000	1.9124	1.6739
Jul.	1.5892	2.4227	0.8617	0.5000	1.1464	0.8963	1.1381	0.5000
Aug.	0.4953	1.4643	1.3876	1.0939	1.5374	1.8633	------	1.4713
Sep.	1.6759	1.2946	0.8963	0.4644	0.0000	0.8385	1.2487	0.4644
Oct.	1.8130	1.7221	0.5285	1.3630	1.4318	0.6511	0.6464	0.0000
Nov.	2.2101	1.5773	0.9381	2.6373	1.6616	1.7111	0.0000	1.2447
Dec.	1.3185	1.6238	0.6644	1.9656	0.5000	0.5000	0.9813	1.7221
Jan.	1.8590	1.7556	1.3577	1.6460	1.9028	1.6580	0.5285	0.4833