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A STUDY OF FISH POPULATIONS IN THE
ESPIRITU SANTO RIVER ESTUARY

IRIS 8. CORUJO FLORES

?TERRESTRIAL ECOLOGY DIVISION

SUBMITTED AS A DISSERTATION TO

?THE FACULTY OF NATURAL SCIENCES

of the

UNIVERSITY OF PUERTO RICO, RIO PIEDRAS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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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* (Eck 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. The:

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.

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DEDICATORY

TO MY MOTHER

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TABLE OF CONTENTS

INTRODUCTION ..

General concepts .

1

Objectives of the Project (see page 5)

Study Area (see page 5)

MATERIALS AND METHODS (see page 10)

RESULTS AND DISCUSSION (see page 14)

Fishes of the Espiritu Santo River Estuary (see page 16)

Species Accounts . setseeeeeee mu

?trophic Levels . . 48

Number of Species 48

Number of Individuals . 58

Species Diversity Index . 6

Community Similarity Index . 70

SUMMARY AND CONCLUSIONS . se see 6

LITERATURE CITED cesteeeeeseseesesees 80

?APPENDIX a 84

---Page Break---

Table

2

10.

List of Tables and Figures

Mean and range of surface and bottom salinity and range
of temperature at each station »

Mean and range of bottom and surface salinity (0/00)

at each stationseceeseeee

Monthly distribution and abundance of fish species in
the Espiritu Santo River estuary (1977-1978) »

Spatial distributions and number of individuals of fish
species in the Espiritu Santo River estuary »

Fish stomach contents:

Number of species per station per month .

Occurrence and relative abundance rank of fishes
species in different localities in the Espiritu Santo
River based on sample frequency of occurrence (n= 12)

Pooled species diversity by stations .

Matrix of Bray and Curtis (1957) index of similarity .

Matrix of the Jaccard coefficient of community similarity

ve

v

8

2

ay

49

33

n

2

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---Page Break---

Figure

Rio Espiritu Santo River Drainage Basin .

Rio Espiritu Santo River estuary showing sampling

SALONS seeeessseesseeetes

Nusber of species (5) caught per collection .

Number of individuals (a) caught per collection

Number of individuals per aoath .

Species diversity per sampling date

Species composition similarity based on Bray and
Curtis (1957) index seeere.+

Appendix Table:

Le

2

List of scientific and comon nanes of fish species in
the Rio Espiritu Santo River estuary .

Values of species diversity expres

individuals

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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 periodic 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 hypersaline. 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 themselves 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.

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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, 1965; Maedrich and Hall, 1976). The large quantity of nutrients trapped and recirculated in the estuary provides suitable conditions for 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 subsistence. 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 (McEwan et al., 1973; Frane, 1973)

Livingston, 1976). Organisms 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, *Sicydiun plunieri*

which changes its habitat preference with its life stage. *Sicydiun*

plunieri (Fa. Gobiidae) lives as an adult in freshwater, but in its post-

Jarvis phase has been caught in the Miasco 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 (Erdaan, 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 from 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 those 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 of a mathematical expression that deals with the relationship between species and the number of individuals (Withm, 1968). The analysis of natural communities based on the distribution of organisms within a species can reveal information about the community (argalef, 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 @ particular events 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

Diversity indices have been used as a measure of environmental

quality and as indicators of pollution, where lower diversity values are

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indicative of stress (Bechtel and Copeland, 1970; McErlean et al., 1973; Teai, 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 way occur because pollution intolerant organisms undergo @ 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

envisonnent in two ways: they evolve a high plasticity and/or migrate

at critical times of their Life cycle to # suitable area. It is known

that migrations to various areas for spawning frequently help 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 construction:

in, 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

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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.

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

To assess the relative abundance and species diversity

of fish populations.

To evaluate the effects of selected physical, chemical

and biological factors on fish distribution.

The study areas

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 Jincez. 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 km². (Cuevas and Clements, 1975).

The estuary extends landward approximately 7 Km. with Highway PR 3

?a8 the southern limit, The coastal plain provides four additional fresh=

water inputs; Rio Grande, Calo Castaién, Quebrada Juan Gonsflez and Caio

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Figure 2.

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Sento River

Drainage Basin.

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San Luis. Caio Castafén 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 700 m inland to its mouth

(Cuenca

and Clenets, 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; Godnan, 1978 unpublished). The geological substrate consists mostly of swamp deposits, but also terrace alluvial 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 (63 inches) in the coastal plain. Under normal flow conditions, the estuary is stratified with surface freshwater overlain by a salt-water wedge and the halocline found at depth of approximately one meter (Godnan, 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

penetrate 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).

1

?Stati

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

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Figure 2. Rio Espirita

Santo Estuary showing six sampling stations

or

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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 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 width of 32 meters. The substrates consist of gravel, very fine sand and clay. Adjacent lands are dedicated to

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.

ion &

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 grass

and mangroves. Quebrada Castaién, which transports secondary sewage

plant effluents, drains into this area. Adjacent land area is largely

undeveloped, overgrown tropical old-field or flood plain.

Station

Station 5 was located approximately 18.0 to 18.1 km. from the river origin, at the confluence with Quebrada Juan Consilez. The bordering vegetation consists 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.

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Station 6

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

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Station 7.

Station 7 was located approximately 19.6 to 19.7 Km. from the origin, above the Caio 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 mouth, and is approximately 20.4 to 20.5 Ka. 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.

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Methods and Materials

?The fish populations study was done in conjunction with other

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

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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, exen-

tion 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

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determined by standard Hob titration with silver nitrate (AgNO_3).

Water temperature was recorded in situ with a Keane-Riveter 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 determine the volumetric displacement, after which the water displacement for all tanks 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:

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Immature or inactive: gona:

small and undeveloped ovaries or

Mature: eggs visible to the naked eye or enlarged gonads; the

gonads from small fishes showed small eggs attached to the ovarian 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 pressures

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

#

$H' = -\sum_{j=1}^C \frac{n_j}{N} \log_{10} \frac{n_j}{N}$

where N is the total number of individuals in the collection, n_j is the number of individuals in the j 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 with

in 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

sea 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

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8 and freshwater at atation 1. Salinity concentration values varied with

tidal position (Table 2). Tov 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.

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Mean and range of bot

Table 2:

SURFACE

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High tide

Low tide

High tige

STATION

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

STATION

sepectes 1 2 3 4 5 6 7 8

Aetobatus narinaci 1 3

Elops sourus 1 1 1

fega tons atlantica 2 4

Angitia Fostrat 5 14 who

Harengula hunerali

Opisthonens ogli trum 3028 Bohn

Rachos hepsetus 5

Anchovia clupeatdes 2 B

Getenoraulis edentulus = § & OG

Stronylura tinea =

Poscitia vivipara 1 6

Dostethus TTneatus 2% 2h 262310

PseudophaITus sindit 2

Eentroponus ensiFerus 306 4 1 8

Eentropanus pectinatus

Centropows undecimal?s 1 4 3 ob 5

?rachicotus goodet

Totjonse apodus

Cot jaar riseds

Tatienay tece 12 1

Diapteris?oTTSthostomus 3

?Diageerus rhawbens m5 bo 3 3 3

HetaSsroane TeFPoy | i

?Eigerte pluntert

?Gerres cinereus

Fomsdazys crocro

Boiraiet ta ronchis

?Eynoseton jana teensis

Larinus brevleeps

Siero en Furnes 1

cthostodiprerts Tater

?Tilapia sossanbiea? 38

os tonus ?pont Te woo

?AgrT Sareea

RagrT cure 7 3% 7 5

nyraena barracuda 1

TSphyraena Suachanch 1

6m

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Table 4, (Cont.)

STATION

species 4 2 03 4 5 6 7 28

Scarus sp. 1

Polyeaceyive virginicus 2

Luoinoblenr ius dispar 4

Dormitator maculatus yoy as 5 oat

Eleotris sisonts 2 30 17 BO

Gabionorus dormitor 3508S

7

4

ogous tajacica 2

Bathyeb ius seporator

GobloneT Tus Beleovon 1

Gobionelius oceanicus, ?

Gobiosona spes 4a

Trichiurus Tepturus 110

Sconberonorus regaTis 1 2

Cithariehtnys spi loprerus 1 1

?*Achirus Tineatus* 2

Synshuruis plagiusa 1

Lagoceghalus lacvigatus Bo 1

Spmoeroides testudinevs 10

TovaLs 142207155 2311721529602.

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Species Accounts

Class chondrichthyes

order Lanniforses

None collected, but several small ones observed at station 4 and

fone larger individual w

observed during dawa sampling on July 22, 1977.

Fisherman reported sharks up to station 2.

Order Rajifornes

Family Myliobetidae

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 em SL

Erdman (1972) reports that Ladyfish occurs in fresh and saltwater.

In the Espiritu Santo Rivér 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

2b

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fish and crustaceans (Cervigén, 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 *leptecephalus* enter rivers in September (Erdman, 1972).

Family Megalopidae

Megalope atlantica Valenciennes 9: 285-628 mm SL

Tarpons were not common throughout the year, but fishermen report a 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 (26.932); shrimps (16.402), exos (13.082), and on fish (33.60%). The tarpon spawning occurs in the sea, moving to open waters to spawn from late April to August (Erdean, 1960).

Family Anguillidae

Anguilla rostrata (Le Sueur) 35:62-195 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

strassipes) 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. Odus 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

25

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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

Marengula humeralis Cuvier 1134-152 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. Erdaan

(1976) states that females with ripe ova can be found from March to May.

Opisthonema optinua (Le Sueur) 137:86-226

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,

invertebrates, small crustaceans and fish larvae (Table 5). The thread herring

reproduction took

place in March (Martin, 1974) although not al

individuals collected in the Espiritu Santo were sexually mature.

Family Engraulidse

Anchos hepsetus (Linnaeus) 5:89-199 um SL.

?This species was collected only once at station 7 during May. ALL

specimens had stomachs full of unidentifiable fish renaine and all vere

26

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ripe fenales, This species {s preyed upon by *Sphyraena guschancho*,

Anchovia clupeoides (Svainson) 35:79-170 um SL

A

clupeoides (*Anchoa producta* Pocy) 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
(5.522) ostracods (6.392) copepods (8.892) and amphipods (12.70%).

Specimens with enlarged gonads were found on May and July.

Cotengraulis edentulus (Gunther) 42:87-116 am St

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 organisms (Fisher, 1978). It feeds mainly on decapod larvae
in the estuary. Gonzalez and Vite11a (1976) found whalebone anchovy

with developed ovas from April to June in Pifones lagoon.

Family Belontiidae

Strongylura timseu (Walbaum) 3:335-350 am SL

Only three individuals were collected, but none were seen suit

between station 5 and 7. - Some individuals were soon jumping from the

water; this activity is considered to be feeding behavior. Stomach

analysis revealed insects such as Hemiptera and ymonoptera. One specimen

27

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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 gonad:

Family Poeciliidae

Poecilia vivipara (Bloch & Schneider) 7:11-30 em St

?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

Sostethus lineatus (Kaup) 114:14-155 a St

Giimore (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

Bisonis to lower sections of the estuary. *O. lineatus* was more common

along shore at the above mentioned stations. It seems to avoid predation

by 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

-28-

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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 other species. Spawning population were very much in

evidence, Various brooding males were captured with eggs attached 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 (Giimore, 1977). Some juveniles were collected in plankton samples

(Bhajan, personal communication, 1977) in October.

Paedophallus nindii (Meck & 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. aindii* occurred in the same habitat as *O. lineatus* in Trinidad. Other 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 Centroponidae

Centroponus ensiferus Poey 30:97-234 am 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 *Libinia* sp.). Other food items encountered were fish remains

(22.312), molluscs (8.702), crabs (13.742) and plant leaves (3.002). Vascular

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last leaves found in the stomachs which also contained chrimpe 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

Sune.

Gontropomus pectinatus Poey 2:104-148 um SL

This speci

15 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).

cont ropomss uméecimslis (Bloch) 28:24-318 um SL

?This snook occurred in the estuary as both juveniles and young

adults {rom stations 1 through 6, Four individuals vere caught during the

night sampling at station 5. Stomach analyses of 16 stomachs revealed

thie species fed chiefly on shrimps (64.532). Other food items encountered

vere fish reunins (19.692), vascular plant leaves (5.982) crab (9.113) and

molluscs (0.692). Kone of the speciens collected had nature gonads.

justin (1972), Exdoan (2976), Fisher (1978) reported that spawning takes

place from April through September. One individual of 206 gns. and 295

ua SI, was captured while it was winning on the surface. Its viscera

were full of a yellow Liquid (probably derived from fats), its stonach

vas empty and # silvery plastic hand vas found attached to ite gill,

which no doubt interfered with the regular feeding of this fish.

7304

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Family Carangidae

caranx hippos (Linnaeus) 3:145-325 em SL

Crevalle jack were caught at stations 6 to 8. Cervigén (1966)

cites them as coastal pelagic, but juveniles can be found in mangrove

areas. This species is

44 to feed chiefly on fish, crabs, squid,

shrimp and smaller invertebrates (O'Neil 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 col

lected from the Espiritu Santo River estuary had developed gonads.

Caranx latus Agassiz 15:58-163 am St.

?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 *Xiphosura*

5p.) and on fish, The stomach analysis

of one individual revealed anchovy remains. The anchovy had fed on small neritimid 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).

es

Microstomus chrysurus (Linnaeus) 12:104-156 wn St

cervigén (1966) described the buaper as a coastal pelagic, but

small individuals can be found in areas surrounded by mangroves. The
duper 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 (Cervig6a, 1966). Specimens from the Espiritu Santo @iver

oe

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estuary had empty stomachs. Martin (1971) found fish remains in speci~

mens collected from Jobos Bay, Puerto Rico. No reproductive data for

this species was available from this study, but Fisher (1978) reported

spawning probably occurred in spring and summer for the Caribbean area.

Selene voner (Linnaeus) 2:69-160 mm St

Lockdown were collected in April and May at stations 7 and 8,

amis

cies is said to feed chiefly on small crabs, shriaps, 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.

Teachinotus 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 oyster 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) 3:129-154 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

said to

feed on crabs, fish, shrimps and octupuses (Randall, 1967; Cervigén, 1966),

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but juvenii

feed on anhipods and copepods (Austin and Austin, 1972).

?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. The stomach contained only shrimps used as bait. Randall (1967) stated that juvenile specimens in seagrass beds feed on small crustaceans while large individuals feed on

shrimps, crabs and fishé

Sexually mature specimens were reported as

occurring May through September (Erdnan, 1976).

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

Four individuals of this

species were collected during this study

?but more were seen between mangrove roots when ater was clear. Two stomachs examined revealed shrimp and crab remains (*Callinectes* sp-)

There was no evidence of sexual maturity in the specimens collected.

Fantly Gerreidac

Diapterue olisthostonus (Goode and Bean) 3:90-113 me SL

Specimens of Irish poupano 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, PLR.

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Diapterus rhombeus Cuvier 43:51-142 mm SL.

?The rhomboid mojarra was found to be more prevalent during 6

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 (9.712), small crustaceans (40,662), oysters (21.432), 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 hefroyi (Goode) 2271-76 ea 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 area sampling at station 7 in July. The stomachs of the two specimens examined revealed it fed on pelecypods (44.52), small crustaceans (50.002) and other unidentified material (5.502). No information on spawning period was available from this study.

Fucinostonus gelanopterus (Bleeker) 2:67-74 ms SL

Erdsan (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.

Eugerses pluniceus (Cuvier) 23:960280 sm SL

The striped mojarra occurred in all localities sampled in the

estuary, but it seemed to prefer fresh to brackish waters, hence the

water was clear, it was possible to see striped mojarra feeding on the

mangrove root oyster communities, where fisherman caught them with

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harpoons. Large quantities of oysters were found in stonach 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 gus.,
280 wn SL) was caught at station 5 during night sampling on May showed

full ripe ova,

Gerres cinereus (Salpaua) 9:58-134 mm SL.

The yellow fin nojarra w:

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 nojarra feeds on erabs, pelecypods and gastropods

as main food items

Five stomachs examined during this study revealed

the following food items:

amphipods (43.462), pelecypods (45.072),

polychaetes (6.252) and insect larvae (5.232). No specimens with mature

gonads were collected. Kimmel (1979) reported sub-ripe gonad conditions

occurring between March and September for *Gusyanilla Ray* specimens.

Yanily Ponadacyidae

Bomadasyaie 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.

35

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Fa

ily Sciaenidae

Bairdietta ronchus (Cuvier) 1:62-192 mp SL

?The ground drumer is the most common Sciaenid in the estuary,

cervigén (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 (8:

7-87 mm SL) fed on Amphipods and insect larva

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

Gmoseion janaicensis (Vaillant and Bocourt) 9:205-242 mm SL

This species was collected only during May and July at the lower port 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.

Larinus breviceps Cuvier 5:146-168 = SL.

This species was found only during May and July at the lower part

of the estuary. As with *G. jamaicae*, 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.

36

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Micropogon furnieri (Desmarest) 19: 155-355 mm St.

The croaker was found only from 91

seins 4 to B. 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.

soother one (644 gus., 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 (72.992), crab (9.382), fish remains (6.902) and plant materials (7.292). The spawning period probably

occurs from June to November (Martin, 1972; Erdman, 1976).

Family Ehippidae

Ghaetodipterus faber (Brossonet) 1:206 um 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 grt

variety of food items such as sponges, soantherians,

worms and algac (Randall, 1967; Martin, 1972). Reproductivity activit 

occur from May to October (Er san, 1976).

Family Cichlidae

Tilapia ossaubica (Peter) 17:212-342 um SL

?The tilapia vas imported to the island in 1958 from Alabasa for fish culture purposes (Erdman, 1972), and subsequently spread to open

waters. Gonz lez and Vilella (1876) reported that the tilapia occurred

37

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in the Piones lagoon. Various mature males and a spent fenale (222 am SL) were caught, but young individuals were not collected. Probably this species cane into the estuary fron adjacent channels that drain into

the estuary. Tilapi

are bottom feeders. Stomachs analyses reveals

Large quantities of diatoms, filamentous algae and detritus. Erdman

(1976) reported this species as a year-round spammer.

Family Mugilidae

Agonostonus aoticola (Bancroft) 15:32-234 mm SL

The mountain mullet develops eggs in sunser and the eggs or young larvae are washed to the sea (Erénan, 1972). The first specinen collected was in June, # ripe female of 234 mm SL, In August # small one (52 mx SL) was collected at station 2. Erdaan (personal communication, 1977) entfoned that this specinen had recently returned from the sea. The mountain mullet becoues abundant in Septenber after the heavy rains when they try to return to upper areas. This suggest that probably they were displaced from their prefered areas to lover areas by the large snount of freshwater runoff or they were returning to their habitat after reprodue~ sion, Males from 83-96 ms SL caught in Septenber shoved runoing ganetes

?and a female of 216 mm SL was spent. The sountain mullet feed on shrimps

(93.33%), adult insects (50.00%) and on plant material (seeds, 16.672),

Mugil curema Valenciennes 103:98-280 em SL

?The white mullet is more abundant than the data suggest. Schools

of white mullet has been se

moving along the estuary. The white mullet

have a muscular stonach that grinds the food itens obtained from the

benthic layer. These food items consist primarily of benthic diatoms,

- 38

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blue green and filamentous algae, plant detritus and inorganic eedinent

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particles. Stomachs and vicer of mullet taken from the estuary exhibited

large quantities empty diatoms 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 fishermen reported that

they are more common in the adjacent channels such as Quebrada Juan

Gonzalez. Just as *M. curema*, *Liza* also fed on algae and other organic

Liza spawning occurs in January (Erdman, 1976).

Family Sphyraenidae

12 mm SL

Sphyracna barracuda (Walbaum)

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.

Sphyræna 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

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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 *Anchon hepsetus*. Martin (1972) reported a female with enlarged ovaries in

December.

Family Searidae

Scarus sp.

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

Family Polyneniidae

Polydactylus virginicus (Linnaeus) 11:96-193 =m SL

The threadfin occurred in the mangrove ar

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 (57.162) 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 Blenniidae

Lupnoblennius dispar Herre 21:9-24 um SL

?This blenny occurred in the oyster communities associated with mangrove roots. It was found with *Gobiosoma* species in most catches. Blenny presence in the estuary seen highly dependant on the oyster community

since when the oyster community becomes scarce in January, no blennies

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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* (Kissel, personal communication, 1979). Mature Females were Found from August to November. Sexual dimorphisms

present in this species is described by Dawson (1970).

Family Eleotridae

gmitator 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 gaudes. 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.

jeotris pisonie (Gmelin) 145:13-132 mm SL

The spinycheek steper 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

mae

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and 6, Its presence in the latter stations was due mainly to the

movement of water hyacinth into th

tions. The spinycheck 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.

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 bignouth steeper 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).

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3468 am SL

Bathygobius soporator (Valenciennes) 2

?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 Diatoms and to a lesser degree on filamentous algae and other food

ites (Table 5). A ripe females (68 mm SL) was collected in August.

Gobionellus boleosoma (Jordan and Gilbert)

8-39 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 Erdaan

a7).

Gobionellus ocesnicus (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 fine-

mentous green algae. No information on reproductive activities w

available for this species.

Gobi

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

?This goby occurred in the same habitat as *L. dispar*. 6. spes
feeds on amphipods and isopods which were abundant in the mangrove

oyster communities. Various mature females were found in October.

Family Trichiuridae

Teichurus lepturus Linnaeus 12:403-787 mm SL

This species occurred in the lower part of the estuary. Of twelve

he

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stomachs examined, only three were empty. The food items consisted mainly of fish remains (88.86%), but shrimps remains (11.112) were also found. A male caught during the night sampling at station 5

nearly ripe gonad and eight of nine #1

specimens captured in July at

station 7 showed ripe gonads.

Family Scombridae

Scomberomorus rogalis (Bloch) 9:226-526 mm SL

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

All fishes collected showed isopods attached to the gills.

Family Bothidae

Cicharichthys spinepterus Gunther 2:103-106 se 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 (23.692), crab fragments (34.212) and fish (28.952). Austin and Austin (1971) found 100% £{sh in one specimen. No information for reproductive condition was available from specinens collected.

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Fasily Soleidse

Achirus Lineatus (Linnaeus) 2:111-113 sm St

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 stonach exasined was eopty. Odun and Heald (1972) found amphipods, nysids, diptera larvae, voras and foraninifera in specinens from North

available for

River estuary in Florida, No reproductive data w

specimens collected but Erdman (1976) reports reproduction occurring in

July.

Family Cynoglossic

Syephorus plagiuea (Linnaeus) 1:109 n 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 (197) stated that this species lives with muddy bottoms, and high salinities. The tongue fish has been described as a nocturnal feeder, feeding mainly on polychaetes and crustaceans.

Family Tetradontid

Lagocephalus laevis (Linnaeus) 5:121-150 um SL

?The smooth puffer was collected in the lower part of the estuary.

?Three stomachs examined contained Pelecypods (96.672) and vascular plant wood (3.332). 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 Nay at station 5,

aus

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Sphacroides 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 crustaceans and gastropods 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 Silyva, 1975).

The primary consumers are organisms which feed on plant material and/or detritus and they can obtain additional nourishment from micro-organisms ingested 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 curena*, *Tilapia*

soseanbic

and others. Some species were found to be partially primary

testudis

consumers such as *Sphaeroides su*

According to stomach contents analyses, most species collected

feed

belong to the group of the secondary consumers. These organi

on insects, crustaceans, molluscs, and also on herbivorous fish, These

46

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Table 5, Stomach contents of some fishes examined.

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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 types of estuarine food webs (Odum and Heald,

1975) one based on vascular plant detritus, and the other on phyto~ plankton. The results of the stomach content analyses indicated that both types of food webs are present in the Rio Espiritu Santo River estuary.

?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 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

48

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Table 6, Number of species per station per month

Station

February 2 6 3 8 5 4s

March 3 ? Cr

April ? 8 6 2 8 4 2 7

May 2 8 5 2 nm on wm o3

June 2 5 es 5 8 1 8 6

July 6 on 302 & 3 6 2

August 2 5 5 6 7 8 5

September 6 5 er

October ? 6 2 6 5 2 2 2

November 10 5 4m 8 5 4 4

December 5 ? 208 2 2 3 6

January 6 7 5s 8 6 5 2 2

49

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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, hence, after heavy rains, this station exhibited its natural tidal fluctuations. Species like *Avaous tajasica* appeared in samples at station 1 after heavy rains.

Station 4 was located in the zone near the exit of Caño Castaño,

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 *Domitator*

maculatus released its spores 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 cao Castafén 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

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heavy during periods of low flow that it literally clogged the mesh of

the gill net

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 jannicensis* 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 deter

mine 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 heavily populated due to the recruitment of juveniles of the species

Anguilla rostrata

Demmator maculatus (16-39 mm SL) and *Eleotris plsonis* (13-71 mm SL).

(42-62 mm SL), *Gobsonorus*

dormitor (16-46 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.

ogltinun re:

appeared in the sample from January. This species

52

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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 eight (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.

5

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+ This symbol was assigned to those species represented by only one individual. The low frequency in the samples (annual occurrence of 1.04) gives no 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

hole 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. plagivsa*, *L. laevigatus* and *A. ro!* (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

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

She

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Table 7. Occurrence and relative abundance rank of fishes species in

Different localities of the Espiritu Santo River estuary

based on frequency (= 12). (A= abundant, C = common,

= occasional, += species represent by only one individual)

species stations 25 of annual

ty 2 3 8 5 6 7 8! occurrence

As narinor! ? ° ° "3.2

saurus "0 ° oa

atlantl nr) + 2.08

Ap rostrata = 1 0 0 0 oo + 6.25

-humeratis Oo 10%

gals = © 0 0 fC 0 Oc Of 3125

heosetus ° 108

cluscoides ' 0 0 0 0 + 729

G edentuus 1 0 0 0 0 0 0 0 * 43.54

ho ° 32

' 2 0 + 2.08

linatus 1 © A A C0 0 "37.50

indi so + 2.08

10 0 0 0 0 0 0 0 ' 4B75

Gs poctinatus ?' oo + 2,08

"0 0 0 0 0 o + 15.62

' oo ot an

+0 0 0 0 0 0 o * 12,50

fe chrysurus ° 0 0 0 ! 625

Ss voner ? 0 0 + 2.08

55

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Table 7 (Cont.)

species stations 5 of annual

t12 4 6 7 8 | occurrence

Te soodei ' ° ° * 2,08

?Le apodus | ' ° "104

griseus , + + 1,04

Jocu ' 0 0 ot a7

D, olisthostoms ° "2.08

hombeus * 0 0 © 0 © 8 oO * 19,79

Es lefroyi, : ° 1,08

E, melanopterus ' 0 ° + 2,08

prom "0 © © 0 0 0 0 oO th58

eres \$0 0 0 ° + 6.25

erocro, ?0 0 "3.2

ronchus "0 0 0 0 0 0 0 oO * 18,75

Jamaicensis ' ° ° yaa

breviceps ° ° "32

furniert ' 0 0 0 0 0 * 9,38

Faber ' + "1.08

mossambica o co 0 0 * 13,54

ronticola =! 00 "5.20

curena ?oA ct 0 0 0 cf 35.41

tk ' oo 2.08

barracuda 4 + "1,08

+ guachancho ° "108

---Page Break---

Table 7 (Cont.)

species stations, 1 of annual

hy 2 3 4 5 6 7 8! occurrence

Searus sp. ' + 8 tom

Virginicus ?¢ 0 0 0 0 + 625

Ls dispar ' 0 0 © 8.33

D. maculatus | 0 0 0 0 0 0 + 14,58

pisonis a a) * 37.50

G dormitor = © 6 0 0 * 29.17

tajesia ho + 2,08

soporator oc 0 0 * 13.54

boleosona oo ° + 6.25

cceanicus | + "1,08

spe, ? oo + 6.25

eptures oo "3a

Se regalis ? 00 0! 5.20

©. spilopterus ! ° ° + 2,08

Ay Vineatus ° + 2.08

S. plagives + 1,08

L, Jnevigatus ?* oo 0 kay

8. testudineus cot 625

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particular area, and the fishes cat\ move from one place to another with

out chowing a particular preference for a particular area.

tiunber of individuals

?The nusber of individuals dsring the year of sampling varied widely (Figure 4). The number of fishes caught per sampling date varied from zero to 84 individuais with the highest munber of individuals per sample being caught at station 4. This occurred during August vhen *Dormitator saculatus* became abundant.

The estuary is subject to seasonal influxes of many species. Some

of the species observed used the estuary for spawning, spending @ short

time period in the estuary, while others species such

Anguilla rostrata

used the estuary as juveniles but mature elsewhere. The munber of individuals of resident species also varied depending on their spasming

and migrations within the estuary. The recruitment of juveniles of

Gobionorus dormitor, *Dormitator matulatus* and *Eleotris pisonie* 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)

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Figure 5.

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lumber of individuals per month.

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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 *Megalope atlanti*

Anchovia clupeioides, *Cetengravis edentul*

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 optinum*

(n= 126), *Dorvivato*:

culatus (n = 115), *Oostethus Lineatus* (a = 114),

ups

the maximum weight of the individuals taken was 36 grams.

gurena (n= 100). While the most abundant in number was *E. pisonis*,

Fish bel

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*,

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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 for 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 Brillouin'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

a

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, 2 tri-

@imensional graphic presentation in which date, etation-number snd species

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

?The February catch consisted of 117 individuals representing 22 species. The highest species diversity occurred at station 3, vhere 70% of the species collected were marine species. Species diversity for March ranged frox 1.9264 (station 3) to 0.6856 (station 5) while the range for Aprit was 2.0935 (station 2) to 0.4010 (station 7). The

yxinun 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 *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. atlanti*

(2), *A. elupeoides* (10), *O. lineatus* (3), *C. ensiferus* (3), *ϕ. undecinalis*

(2), *Dezhombeus* (1), *G. cinereus* (2), *Be rhonchus* (3), *M. curema* (1),

E. pisonis (1) and *G. dormitor* (2). The August catch consisted of 136 individuals representing 22 species, with the maximum species diversity

occurring at station 6 (1.8533 bit/individuals). The September maximum species diversity occurred at station 1 (1.6759 bit/individuals) and decreased to station 5 where three *B. saporator* 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 (21,6130 bit/individuals) when surface and bottom salinities were 12 ppa

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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 *Q. curena*, *Q. oplinum* became

abundant during this period. From May to June, the diversity was reduced to @ 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 3.

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 62.507 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,

65-

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The peak value of species diversity at station 3 occurred in February when 70% of the species collected were marine species. The decrease 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 *Q. ogtinuz*, which constituted 48.15% of the catch, and significantly the reproductive period of this species has been established 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. paculatus 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. saculatus*, 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/individual. Indices

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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 *As narinari*, *O. optinum*, *Ø. 2*, *virginicus* and *A. Lineatus*.

Species diversity increased in May due to the additional species collected such as *C. jansicensis*, *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

species were collected. The species collected in October were *C.*

edentulus (4), *C. ensiferus* (1),

undatus (1), *G. datus* (2), *Le*

gobius (1), while in December only two species, *O. ophiurus* and *E. pisonis* were caught. In January, most species were collected among shore vegetation and under water hyacinth, 24 specimens of *A. zostrata* 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

G. hippos, *S. regalis*, *B. ronchus*, *P. {aber* and *P. spilopterus*. In May

the diversity index reached its maximum value when eleven species were collected. Five of 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 *P.*

Aepturus was caught at station 6 and it was a gravid female. Significantly,

during July nine individuals collected showed ripe gonads. Species

diversity gradually increased from July to August. Three species, *B.*

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soporator, *G. spes* and *L. dispar* were common in the mangrove oyster com

munities during August to October. These three species constituted 89.76% of the catch for that period. The species *Gobiososa spes* and

Lypinoblennius dispar seen to be highly dependent on the oyst

munities 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 stre

flow in watershed at this time and the hyacinth root system appears to have conveyed species such as *E. pisonis* and *O. Jineatus*, which were previously uncollected at station 6,

?*Opisthonema oglinum* constitute 76.00% of the catch for the first

three months of sampling at station 7. The species 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.*

S., *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 of anchovy remains, The

contents analysis revealed large quantity

Carangidae collected included *C. latus*, *C.*

cheysurus, *S. voner* and *T.*

collected in May were limited to this period and the

goodel. Most spec:

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 lower index. In August, fishing in this station was totally unsuccessful. Indeed, only scyphozoans (Jelly-fish) were

captured in the nets,

-68-

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The diversity value for station 8 was more variable temporally, with peaks occurring in April (maximum diversity), June, August and

December. *Mugil curena* comprised 70.58% of the February collection, but

the number of *M. curena* decreased in subsequent samples. Three *S. regalis*

collected in June had stomachs full of fish remains and the gonads were

inactive. Other species collected were *C. hippos*, *P. virginicus*, 0.

Opsanus, *D. rhosbeus* and *M. eur*

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 hanelalis* appeared in the sample for

First time.

hue

and 2, 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 root

one characteristic of the Rio Espiritu Santo River estuary fish

populations is that many species are not permanent residents but only

ind 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 @ marine

695

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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

downstream 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 of 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

10

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Table 8, Pooled Species Diversity by Stations

Number Species Diversity

Station species (bit/individual)

a » az 3.2147

2 23 207 3.2966

3 2 ass 3.3797

? 2 231 2.9733

5 33 im 4.3410

? 28 152 3.7919

7 26 96 3.5384

8 2 102 3.2864

?ne

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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 $2u/(a + b)$, where a is sum of all values for the first station, b is the same as a but for the station with which comparison is sought, and y 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 0 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 4 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 curem* and *Qpisthonems oglinu* found at both stations but if faunal similarity is re-calculated without taking these two species into consideration, the

similarity between stations decreases gradually (Table 9).

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Table 9.

Matrix of the Bray & Curtis (1957) index of similarity.

(see text for explanation)

1 2 ee ee a

a 15824529460 403.950.260.117

2 661.512 459.362.301.422 /(.160)*

3 eS 488 376.361 .422/ (.155)*

4 sel .328 202 181

5 1550-350 .280

6 271.280

7 408

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1 .syng puv foug vo peoeg Ayjauryays woraTeeduc0 soyoods ?g ountrE

AyautTaS

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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 *Electris pisonis* and *Oostethus Lineatus*.

Unexpected similarity between stations 3 and 8 was due to the high number

of individuals of *M. curena* and *O. oglinus* 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

mis si

ilarity can not be explained in terms of bordering vegetation,
put the occurrence of species such as *setbatus narinari* (Spotted Eagle

Ray) at station 3 would appear to de

and 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 dec:

ve 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 a

10 characterized using Jaccard

Coefficients (Srover and Zar, 1977). This index is defined by the

equation: $C_{0y} = C / (S_1 + S_2 - C)$; where S_1 and S_2 are the number of

species in each community under comparison, respectively and C , is the number of

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species common to both stations. This index is predicated on the pr

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. From 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

60 contribute heavily to these differences.

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Table 10.

Matrix of the Jaccard coefficient of community

(see text for explanation)

1 2 3 4 5 6 7

1 s615 519.367.368.343 284

2 4-800 500.400.342.225

3 S17 447.389 263,

4 410.282 333

s 2566 405

6 2385

an

-250/ (.206)#

+294) (250)

2333

cet

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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* Lint

Eleotris pisonis, and *Gobiomorus dormitor*.

Yost species collected were occasional visitors to the estuary,

since they ve

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 on insects, crustaceans, molluscs, and other fish. The secondary consumers feed on only one prey item or can include 2 or 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.

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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 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 characteristics 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 selectivity (Martin, 1972). The fish

fare 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 continuously changing nature of the ichthyofauna components in the Espiritu Santo River estuary during an annual cycle.

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APPENDIX

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Appendix Table I, List of scientific and common nanes of fish species

in the Espiritu Santo River estuary.

Scientific Common name

English name Spanish nane

Myliobatidae spotted Eagle ray chucho, mariposa

?Aetobatue garin

us ladyfish piojo, sacabi

Megalopidae

Megalops atlantic Tarpon sabato

anguillidae

?Anguilla rostrata ?Averican eel anguila

chupeidae

Harengula huseralis Redear herring sachvelo

Qpisthonena optinus Thread herring arenque

Engravlidae

?anchoa hepsetus Striped anchovy bocua

dnchovin clupeoides boeua

Eetengravis edentulue whalebone anchovy bocua

Betonidae

?Seronylura timucu Atlantic needlefish agujéo

Poeciliidae

Poscilia vivipara top minnow auppy

Syngnathidae

(*Oosterhus lineatus* _Opossum piperfish trompetero

Pseudophallus windii short nose piperfish?

centroponidae

Centroponus ensiferus Svordfin snock robalo machuelo

Gentroponus pectinatus Tarpon snook robalo aachvelo

?*Centroposus undecinadie* Snook robalo nachuelo

carangidae

?*caranx hippos crevaie* juret

Horse eye jack Jurel of6n

Bumper casabe

Lockdown jerobado

Teachinotus goodei -Paloneta Patoneea

Bie

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Appendix Table 1. (cont.)

Lutjanidae

?ut janus apodus

Eutjanas griseus

Eurjanus jocu

Gerridae

Dispterus olisthostomus

Diapterus Tomb

cous lefroyi

Eucinostosus golenopterus

fuentes plialect

Gerres cinereus

Ponadayidae

Ponadasys crocro

Seianidae

réiella ronchus

Gmoneion jauaicensis

Lgrilus, breviceps

Wieropogon. furaieri

Ephippidae

Shastodiprerus

cichtidade

?Tilapia poseambica

Mugilidae

?Agnostonus, sonticola

Mogsl curema

Mueat Th

Shyraenidae

?Sphyraena barracuda

Sphyraens guachancho

Scaridae

Searus sp.

Polynenidae

Polydactylus virginicus

Bleniid

Lupinoblennius dispar

Schoolmaater snapper

Gray snapper

Dog snapper

Irish pompano

Rhonboid nojarra

Mottled mojarra

Blackfin mojarra

Striped nojarra

yellow fin mojarra

freshwater grunt.

Ground drummer

Mongolar drummer

Drumer, Creaker

Spadefish

Tapia

nountain millet

White mullet

Liza mullet

barracuda

?guachanche

ehreadfin

blenny

-85-

Pargo amarillo

Pargo prieto

Pargo colorado

wojarra

Morarreta

Muniana

Espuela, mojarra

Miniana

viejo

dentin, dientén

coving cabexén

Pagualla

ritapia

dajao

Javea

Lita

picua

picuilla

loro, cotorro

barb

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?Appendix Table I. (cont.)

Eleotridae

Gobionorus dorsitor

cobiidae

Barnygobtous soporator

Gobioneiius voleosean

Gobionelius oceanicus,

Gobiosona spes

Trichivridse

Trichiurus lepeuros

Sconbridae

?Scouberonorus repalic

Bothidae

Citharichthys spilopterue

Soleidae

?Achirus

cynoglossidae

Symphurus. plagivea

Tetraodontidae

Lagocephalus laevigatus

Shaeroides cestudineus

Fat sleeper

Spinycheek sleeper

Bigmouth sleeper

River goby

Frillfin goby

Darter goby

Hightin goby

cutlasefieh

coro

bay white

Lined sole

Blackcheek tonguefish

Snooth puffer

checkered puffer

86

moroneillo

Morn

Sage

moroneillo

Sable, machete

Sierra

Lenguado

lenguado

Lenguado

tanbor, ratén

tanborin

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curt ecoe'r wees" t6O"Y BCT EvaH sexo ?BOY
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