STRUCTURE OF THE INTERTIDAL FAUNA ON A GALVESTON GROIN

A Thesis

by

JOSE ENRIQUE BARRAZA SANDOVAL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 1993

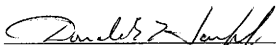Major Subject: Marine Invetebrate Zoology

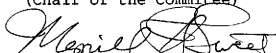# STRUCTURE OF THE INTERTIDAL FAUNA ON A GALVESTON GROIN

A Thesis
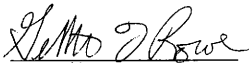
by

JOSE ENRIQUE BARRAZA SANDOVAL

Approved as to style and content by:

_____
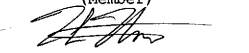Donald E. Harper, Jr.
(Chair of the Commitee)

_____
Gilbert T. Rowe
(Member)

_____
Merrill H. Sweet
(Member)

_____
Terry L. Thomas
(Head of the Deparment)

May 1993

ABSTRACT

Structure of the Intertidal Fauna on a Galveston Groin.

(May 1993)

José Enrique Barraza Sandoval, B. Sc., in Biology,

Universidad de El Salvador;

Chair of Advisory Committee: Dr. Donald E. Harper, Jr.

A Galveston groin was surveyed bimonthly from July 1991 through May 1992. Four transects were established along one side of the groin. Four contiguous quadrats (QI-QIV), each 100 wide x 50 cm height, extended from the top of the groin to the water line, constituted each transect. Paired random numbers were used to locate the sampling points where counting or scraping was performed. Persistence of species was assumed when random ANOVA and Kulczynski's Similarity Index established no differences among the six different periods. Similarity Index detected some similarity when transects were compared. Stratification indicated that species abundance changed along the four vertical quadrats. This was confirmed by randomized block ANOVA. Quadrat I (QI) was characterized by the presence of *Nodilittorina lineolata* (Order Mesogastropoda) in some seasons. QII was populated by the above species and *Chthalamus fragilis* (Subclass Cirripedia). Densities of these two species increased in the QIII zone; other common biota in QIII included *Neanthes succinea* (Order Phyllodocida), *Balanus eburneus* (Subclass Cirripedia), *Corophium acherusicum* (Order Amphipoda), and algae. QIV showed enhancement in diversity and abundance of some species, but abundances of others decreased. *C. acherusicum* was the overall numerically dominant species. Some physical and biological features may have increased diversity, and probably contributed to the huge densities observed. The two most important physical factors found in

lower zones were the deposition of sediment and refuge provided by crevices. Biological factors included barnacles, oysters, and algal colonies, which created sheltered areas for many invertebrates. Other important members on the QIV area were *Balanus amphitrite* (Cirripedia), *Caprella equilibra* (Amphipoda), and *Dynamenella dianae* (Isopoda). Detritivores and suspension feeders were the most abundant trophic categories, resembling, in part, communities on natural rocky shores. Experimental bricks were set in December. In January, they were colonized only by cirripeds. In later months diversity and live coverage increased during spring. In summer those parameters decreased. Distribution of intertidal fauna may be controlled by the interactions of exposure periods, temperature, radiation, sedimentation, shelter, substratum microtopography, predation and dispersion-persistance strategies.

THIS THESIS IS DEDICATED WITH LOVE

TO MY WIFE OLGA ELVIRA

MY MOTHER AMELIA EUGENIA

MY FATHER JOSE MAURICIO (EL CHELE)

MY BROTHERS RICARDO, MAURICIO AND IVO

MY SISTER OLGA

AND ALL THE PEOPLE WHO CARE

ABOUT LIFE IN THE OCEANS.

ACKNOWLEDGMENTS

I am grateful to all the people who helped me sampling or with suggestions.

I thank my academic advisor Dr. Donald Ernest Harper, Jr., who provided accurate and excellent advice for my degree plan and research. Also, for the patience and kindness he had with me trying to correct my mispellings and bad pronunciations in English. I enjoyed his classes, particularly the marine Annelida course, where he introduced me into the wonderful world of polychaetes, although I had hard times!

I appreciate very much the comments and suggestions of the other members of my committee, Dr. Gilbert T. Rowe and Dr. Merrill H. Sweet, which improved the quality of this thesis.

I am thankful to Dr. James H. Matis (TAMU) for helping me to choose the adequate statistical design for this research.

I am indebted to those colleagues who collaborated in the samplings, particularly to Tsui-Hui Wu and Wang Ding, and my wife Olga who also suffered collecting the critters.

Tsui-Hui Wu kindly took for me excellent slides of the different zones of the jetty.

Dr. Mark Benfield (TAMUG) donated much time explaining different tricks of the Macintosh computers, statistical design and advice for the graduation process. Liang-Saw Wen ("cat"), kindly taught many aspects of computers. Thanks, also for their sincere friendship.

I thank Dr. William Wardle (TAMUG), who helped me in the identification of some bivalves.

Thanks to all the graduate students at Texas A&M University at Galveston, who showed me ways to survive better in U.S. universities.

Finally, I want to thank the support and love given by my wife Olga, who deserves special mention, since she was my permanent assistant in the different stages of my research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Rocky shores represent very dynamic ecosytems which have de-
veloped particular communities. In the United States, natural
rocky shores are very common along the west coast. However,
in the east coast, rocky shores are scarce, occurring at
scattered locations in north and central Florida and North
Carolina (Stephenson & Stepheson, 1952), and commonly along
the New England coast. Rocky beaches have been the subject of
many ecological experiments, primarily due to the easy manip-
ulation of organisms for experimental purposes. These works
have investigated algae-herbivore relationships (Sousa, 1979;
Lubchenco & Menge, 1978; Lubchenco & Gaines, 1981; Branch,
1985); competition and predator-prey interactions (Connell,
1961; Lubchencho & Menge, 1978; Hughes, 1985; Wethey, 1985).

The intertidal fauna of hard substrata of Texas shores has
been poorly studied, probably because hard substrata are un-
common. Hard intertidal habitats (jetties and groins) along
the Gulf of Mexico were introduced by humans in the late 19th
century (Whitten et al., 1950; Britton & Morton, 1989).

Jetties were designed to protect boat traffic, and groins to
trap sand. Galveston groins, rebuilt in the late 1960's by
the U.S. Army Corps of Engineers, created new habitats for
hard-bottom organisms and estuarine associates from oyster
reefs. Also, the crevices between rocks provide shelter to
some species. (Whitten et al., 1950; Hedgpeth, 1953;
Fotheringham, 1980; Britton & Morton; 1989).

As on natural rocky shores, the groin community is primarily
influenced by fluctuations in salinity and temperature, air
exposure, shock force of waves, substratum microtopography,
competition and predation (Whitten et al., 1950; Kronberg
1988; Fuji & Nomura, 1990). The gradual changes in these
factors creates a gradient which causes a vertical zonation
of organisms in intertidal rocky communities.

This Thesis follows the format and style of *Marine Ecology Progress Series*.

That gradient has been observed in different hard shores, including natural and artificial rocky shores along the east coast of the United States. Stephenson & Stephenson (1952) observed such zonation on natural and artificial rocky substrata in Florida and the Carolinas. This has been found along Texas jetties, also (Whitten et al., 1950; Hedgpeth, 1953; Britton & Morton, 1989).

Some jetties, groins and breakwaters on the warm temperate east coast may be influenced by the great amounts of sus- pended sediments, which tend to be deposited along the rock flanks. In fact, Fotheringham (1980) reported the ocurrence of mud in the lower intertidal on Texas jetties. Also, species distribution can be influenced by the scouring action of sand. Therefore, the jetty biota can be considered as mix- tures of representatives of rocky, sandy and muddy communi- ties (Whitten et al., 1950; Stephenson & Stephenson, 1952).

Britton & Morton (1989), based on studies pertaining to Port Aransas jetties, mentioned that *Ligia exotica* (Isopoda) and *Nodilittorina lineolata* (Mesogastropoda) inhabited the upper intertidal. The splash zone caused by waves creates "wet" ar- eas on the upper areas of the jetties, increasing the inhab- itable area for heat-resistant species such as barnacles and littorinids.

In the midlittoral, some common organisms are *Chthalamus fragilis*, *Balanus eburneus* (Thoracica); *Menippe adina* (Decapoda); *Siphonaria pectinata* (Basommatophora); *Stramonita* (=*Thais*) *haemostoma* (Neogastropoda); *Brachidontes exustus* (Mytiloida). Connell (1961) mentioned that the *Chthalamus* zone is above the *Balanus* layer on intertidal rocky shores. He explained that abiotic factors may control the upper dis- tribution of *Chthalamus*, while the distribution below may be controlled by the presence of *Balanus* and predators. Britton & Morton (1989) observed the same pattern, but questioned the role of *Balanus* in this zonation. Zonation of different

species of intertidal barnacles along the Florida Keys has been studied by Bierbaum & Zischke (1979).

Macroalgae are characteristic of the lower intertidal. They have been surveyed at Galveston (Lowe & Coxe, 1978) and Port Aransas (Kapraun, 1980). Some mobile and sesile fauna have been mentioned in the lower intertidal of Port Aransas jetties, e.g. different hydroids; the warty anemone *Bunodosoma cavernata*; the sea hare *Aplysia* sp. and other gastropods from the midlittoral; the oyster *Crassostrea virginica*, the sea urchin *Arbacia punctulata*, some poly- chaetes and amphipods (Whitten et al. 1950; Hedgpeth, 1953; Britton & Morton, 1989).

Many of the fauna mentioned above were recorded by Stephenson & Stephenson (1952) in the Carolinas and nothern Florida, although the abundance patterns for some species differ from those on Texas jetties. One case is the abundant mussel *Brachidontes exustus* (=*Mytilus exustus*) in some areas of Charleston, South Carolina, whereas in Texas it is not a dominant species. Whitten et al. (1950) and Hedgpeth (1953) mentioned that in the Gulf of Mexico, species composition of jetties changes according to latitude. Thus, more tropical species have been found in the southern shores of Texas.

The geographical distribution of species along the Gulf of Mexico as well as the east coast may be influenced by physi- cal factors. Voss (1959) described the world wide distribu- tion of the false limpet *Siphonaria pectinata*, which ranges within the 55° C isocrymes in some areas of the American Atlantic and Pacific. However its absence in areas of the Gulf of Mexico is not discussed. Another zoogeographical study in the same area is that of Dando & Southward (1980), who established latitudinal ranges for different species of barnacles, including *Chthalamus fragilis*. Some other studies about barnacles of the east coast mentioned their geographic and climatic ranges (Zullo, 1979; Ruppert & Fox, 1988; Britton & Morton, 1989).

I did not find records concerning the trophic hierarchy on the hard shores of Texas. However, MacQuaid & Branch (1985), in a study of trophic levels in some rocky beaches of South Africa, observed that in exposed areas the presence of filter feeders was dominant and they were replaced by algae and grazers in sheltered places. Fuji & Nomura (1990) detected great dominance of suspension feeders (probably the same as filter feeders) in Japan.

Objectives

The objectives of my research were to determine qualitative and quantitative seasonal changes in the structure of the biota; detect the distribution of the different species along a vertical gradient; attempt to relate the biotic-abiotic variations and the changes in species composition of this community; compare the different trophic categories observed; and determine settlements, succession and survival rates of invertebrate fauna on experimental substrata.

Hypothesis

The null hypothesis for this research proposed that faunistic diversity and abundance are constant along the vertical gradient and among transects. The alternative hypothesis proposes that faunistic diversity and abundance are different within the vertical gradient and among the different transects.

Justification

Many surveys have reported general distributional patterns of the jetty fauna, but none has studied population variations through different seasons. Moreover, benthic inhabitants of jetty sediments have not been very well documented. And the lack of research on the ecology of hard substrata of the Galveston area, are reasons requiring studies which can evaluate the diversity of species and its changes along seasons.

MATERIALS AND METHODS

Study site

The groin chosen for this research is located along Seawall Blvd. at 53rd street on Galveston Island. It is 160 m long, and varies in width from 6.8 m nearshore to 20 m at the terminus. According to Whitten et al. (1950) Texas jetties are made up of granite rocks weighing from six to ten tons each.

Sampling procedure

Four one-meter-wide vertical transects were established (Fig. 1). Each transect was separated about 32 m from other transects and was divided into four 100 cm x 50 cm rectangular quadrats, each one having an area of 5000 cm^2 (Fig. 2). In these quadrats, organisms were counted or collected in almost all cases from the exposed surfaces of rocks, because crevices between rocks were difficult to sample. I used paired random numbers to determine the sampling points. Harper (1972) performed this sampling methodology on the Hueneme jetty, California.

Seven random samples were taken within each quadrat, using a small frame (2.5 x 10 cm). Using Kulczynski's index averages (Weinberg, 1978; Kronberg, 1987) I determined that seven samples comprised the minimun representative sample size. Usually in quadrats I, II, and sometimes III, organisms within the sample frame were counted. In quadrats III and IV, which contained dense algal mats and sediments, scraping was necessary. This required a small wood spatula or a wood scraper. For the motile species *Ligia exotica*, only presence was recorded. Generally *Bunodosoma cavernata*, *Thais haemostoma* and *Crassostrea virginica* were observed in crevices and cracks, which made sampling difficult with the described method. For this reason larger sampling frames were not utilized. Pictures were not taken because in some areas sediment and algae covered barnacles. Moreover, empty shells
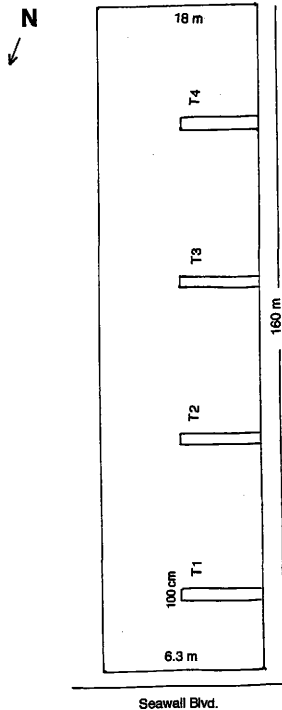
Fig. 1. Location of the transects on the groin in study (not to scale).
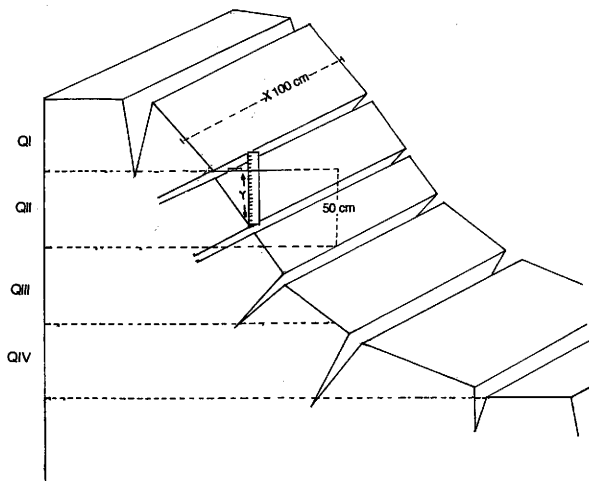
Fig. 2. Illustration of the sampling method.

of barnacles were good sheltered places for many inverte-
brates.

Notes on weather conditions, algal coverage, and presence of
sediment were recorded. Air and water temperature were
measured with a Celsius thermometer, and salinity with a
Reichert refractometer. Samplings were performed every two
months, during lowest tides, from July 1991 to May 1992.

Also, in December 1991 experimental concrete bricks of
different sizes were placed within low-intertidal crevices
around transects area. I did this to observe the settlement
of organisms and their successions from winter to summer. It
was impossible to set bricks on exposed rocks because people
tended to manipulate them.

Data analysis

To confirm significant differences among the total of organ-
isms collected during the sampling periods (700 cm^2 of sam-
pling area), a random Analysis of Variance was used (Reyes,
1980; Ott, 1988). Different sampling periods were considered
treatments, and transects 2, 3 and 4 were considered repeti-
tions (Table 2). Logarithmic transformations (Log #ind + 1)
were required due to the heterogeneity of the raw data vari-
ances (Ott, 1988). The same procedure was done to detect sig-
nificative differences of number of species among the differ-
ent sampling periods. Transects were considered repetitions.
In this case logarithmic transformation was not used.
Unbalanced random ANOVA was necessary due to the lack of data
from T-2, QIV in September 1991 (Table 4).

To compare density values, i.e. total ind./25 cm^2 (the sam-
pling frame size) among the different vertical quadrats, ran-
domized block ANOVA was chosen (Ott, 1988). In this design
the four different quadrats were considered treatments and
the three transects, blocks (Tables 6 and 7). I decided to
perform one randomized block ANOVA per sampling period, try-
ing to reduce error probabilities and to observe spatial
variations within each sampling, comprising a total of 6

RESULTS AND DISCUSSION

The following section describes the intertidal fauna inhab-
iting artificial hard bottoms of the Galveston Island shore.

Physical parameters

Fig. 3 shows that highest temperatures and salinities were
attained during July 1991. Lowest values for the same
physical factors were recorded in January 1992.
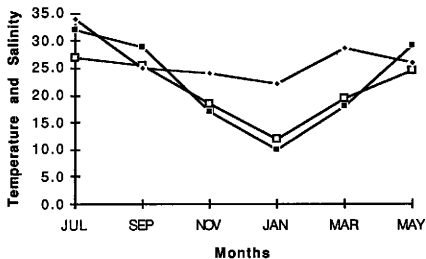
Fig. 3. Water temperature (^{o}C) (black square), air
temperature (^{o}C) (white square) and salinity (ppt)
(black diamond) recorded during sampling periods.

These environmental trends resemble the seasonal peaks men-
tioned by Whitten et al. (1950) and Britton & Morton (1989)
for the Gulf coast. As reported by the same authors, precipi-
tation usually is higher during September and May. I observed
similar rainfall patterns during this research.

Deposition of sediment on the exposed surfaces of rocks
generally occurred on quadrat IV (QIV) areas on all transects
(Fig. 2). Sediment generally accumulated on the horizontal
surfaces of the granite blocks. This unusual characteristic
for rocky sea shores supported mud-dwellers. However, cold
winds dried the sediment and swept away part of it, particu-
larly in the long periods of low tides during winter time.

This could limit habitat availability and therefore faunal composition.

Faunal composition

Table 1 and Appendices 1 to 6, list the abundances of the different 50 invertebrate species found during the different sampling periods. *Corophium acherusicum* was the numerically dominant organism in all the samples, comprising 32,122 individuals (53.18%) of a total of 64,213 individuals collected (Appendix 7). The second most abundant was the fragile barnacle *Chathalamus fragilis*, which comprised 16.47% of all organisms (Appendix 7). These two species occurred in different locations. The former inhabits the lower intertidal, the latter the upper intertidal, which is more exposed to the air.

Other numerically dominant fauna and their respective percentages of the sum of all data were *Balanus eburneus*, 14.6%; *Nodilittorina lineolata*, 4.36%; *Caprella equilibra*, 1.86%; *Dynamenella dianae*, 1.81%; *Neanthes succinea*, 1.25%; *Balanus amphitrite*, 1.12%; *Petricola pholadiformis*, 1.03% (Appendix 7). Zonation and abundance changes of these species are discussed further. Minor fauna included the annelid *Polydora websteri* and the amphipod *Orchestia grillus*.

Three major phyla formed the groin intertidal community: Annelida with 16 species of polychaetes and 1 of oligochaetes, Arthropoda with 15 species of crustaceans and 1 of insects, and Mollusca represented by 4 species of gastropods and 6 of bivalves (Table 1).

N. succinea and *P. websteri* were the most common polychaetes in the samples. Also, *Lumbrineris parvapedata* was collected in almost all samplings. Generally, it was found associated with sandy sediment within empty plates of *B. eburneus*. Other annelids were rare to common.

As mentioned above, two amphipods, three species of barnacles and one isopod attained high abundances. Other important crustaceans were *Jassa falcata*, *O. grillus*, *Sphaeroma quadridentata*, and *Ligia exotica*. *L. exotica* was

Table 1. List of species with their respective trophic category (TC), phylum (PH), abundances (No.) and percentages (%).

ORGANISMS	TC	PH	J No.	J %	S No.	S %	N No.	N %	J No.	J %	M No.	M %	M No.	M %
Algae (%)		P	-	71.70	-	58.60	-	46.40	-	29.1	-	27.40	-	36.70
Obelia dichotoma	S	C	-	6.20	-	3.97	-	12.50	-	4.5	-	4.5	-	29.70
Bunodosoma cavernata	P	C	21	0.37	7	0.05	19	0.19	8	0.10	5	0.05	5	0.03
Stylochus sp.	P	P	14	0.25	6	0.05	48	0.47	19	0.24	142	1.43	42	0.24
Nemertean	P	N	-	-	1	0.01	9	0.09	2	0.02	-	-	6	0.03
Polydora aggregata	S	A	-	-	-	-	-	-	-	-	17	0.17	2	0.01
Polydora socialis	S	A	-	-	-	-	1	0.01	1	0.01	-	-	3	0.02
Polydora websteri	S	A	391	6.96	137	1.07	21	0.20	4	0.05	4	0.04	17	0.10
Capitella capitata	D	A	-	-	-	-	-	-	-	-	1	0.01	-	-
Mediomastus sp.	D	A	-	-	-	-	-	-	1	0.01	-	-	-	-
Peresiella sp.	D	A	-	-	-	-	-	-	2	0.02	-	-	-	-
Young phyllodocid	P	A	-	-	-	-	-	-	-	-	1	0.01	-	-
Neanthes succinea	T	A	28	0.50	31	0.24	183	1.78	80	0.99	157	1.58	326	1.87
Autolytus sp.	P	A	-	-	-	-	2	0.02	-	-	1	0.01	3	0.02
Exogone dispar	P	A	-	-	-	-	2	0.02	2	0.02	1	0.01	-	-
Sylis sp.	P	A	-	-	2	0.02	-	-	2	0.02	-	-	-	-
Syllis cf. gracilis	P	A	-	-	-	-	1	0.01	1	0.01	-	-	-	-
Syllis (Ehlersia) sp.	P	A	-	-	-	-	1	0.01	1	0.01	-	-	-	-
Lumbrineris parvapedsta	?	A	-	-	27	0.21	-	-	15	0.19	22	0.22	5	0.03
Hydroides dianthus	S	A	-	-	-	-	1	0.01	-	-	-	-	-	-
Young polychaete	?	A	-	-	-	-	-	-	-	-	-	-	1	0.01
Oligochaete	D	A	-	-	-	-	-	-	-	-	-	-	1	0.01
Nodilittorina lineolata	G	M	543	9.67	332	2.59	485	4.72	448	5.55	498	5.01	489	2.80
Epitonium sp.	P	M	-	-	-	-	-	-	-	-	3	0.03	-	-
Thais haemastoma	P	M	-	-	4	0.03	1	0.01	-	-	-	-	-	-
Siphonaria pectinata	G	M	-	-	-	-	1	0.01	-	-	-	-	1	0.01
Anadara transversa	S	M	-	-	1	0.01	1	0.01	1	0.01	-	-	-	-
Brachidontes exustus	S	M	8	0.14	10	0.08	8	0.08	7	0.09	8	0.08	2	0.01
Crassostrea virginica	S	M	17	0.3	13	0.10	31	0.30	15	0.19	23	0.23	2	0.01
Donax variabilis	S	M	4	0.07	-	-	-	-	-	-	-	-	-	-
Petricola pholadiformis	S	M	193	3.44	86	0.67	204	1.99	68	0.84	19	0.19	94	0.54
Sphenia antillensis	S	M	11	0.20	17	0.13	48	0.47	15	0.19	7	0.07	4	0.02
Chthalamus fragilis	S	Ar	1174	20.90	1886	14.69	2087	20.33	1601	19.85	2010	20.24	1810	10.38
Balanus amphitrite	S	Ar	263	4.68	195	1.52	123	1.20	71	0.88	62	0.62	6	0.03
Balanus eburneus	S	Ar	477	8.49	350	2.73	272	2.65	2293	28.42	3828	38.55	2148	12.31
Ligia exotica	G	Ar	Ob	-	Ob	-	Ob	-	Ob	-	Ob	-	P	0.00
Dynamenella dianae	O	Ar	9	0.16	17	0.13	493	4.80	3	0.04	226	2.30	413	2.37
Sphaeroma quadridentata	O	Ar	27	0.48	-	-	8	0.08	-	-	-	-	21	0.12
Caprella equilibra	O	Ar	-	-	-	-	96	0.93	188	2.33	335	3.37	572	3.28
Paracaprella tenuis	O	Ar	18	0.32	164	1.28	19	0.19	-	-	1	0.01	-	-
Amphitoe valida	T	Ar	18	0.32	-	-	-	-	-	-	2	0.02	2	0.01
Corophium acherusicum	T	Ar	1916	34.12	9393	73.15	6198	60.36	3204	39.72	2537	25.55	10874	62.34
Jassa falcata	T	Ar	14	0.25	-	-	-	-	-	-	1	0.01	230	1.32
Stenothoe minuta	T	Ar	-	-	-	-	10	0.10	10	0.12	12	0.12	324	1.86
Orchestia grillus	T	Ar	362	6.45	111	0.86	15	0.15	1	0.01	9	0.09	25	0.14
Podocerus sp.	T	Ar	-	-	-	-	17	0.17	2	0.02	-	-	-	-
Menippe edina	P	Ar	10	0.18	50	0.39	3	0.03	-	-	-	-	2	0.01
Chironomid	G	Ar	-	-	-	-	-	-	7	0.09	-	-	-	-
Hippoporina sp.(%)	S	B	-	-	-	-	-	0.06	-	-	-	-	-	-
Membranipora tenuis	S	B	-	12.40	0	0.00	-	1.58	-	0.90	-	0.23	-	0.73
Hemipholis elongata	D	E	4	0.07	4	0.03	-	-	-	-	-	-	4	0.02
Σ			5522		12844		10407		8072		9934		17434	

Trophic categories: D: deposit feeders; G: grazers; O: omnivores; P: predators; S: suspension feeders; T: detritivores. Phyla: P: Porifera; C: Cnidaria; N: Nemertean; A: Annelida; M: Mollusca; Ar: Arthropoda; B: Bryozoa; E: Echinodermata. (%): coverage of colonial organisms; Ob: Observed. Important percentages in bold numbers.

not collected, rather it was observed in large quantities crawling on the rocks, especially at late afternoon when they feed, primarily upon epiphytes (Britton & Morton, 1989).

N. lineolata was the numerically dominant gastropod. *S. pectinata* has been considered common in southern Texas hard shores (Whitten et al., 1950; Fotheringham, 1980; Britton & Morton, 1989). It has been collected in different areas of Florida along rocky outcrops in Marineland (Stephenson & Stephenson, 1952) and jetties (Borkowski, 1974). In my research however, it was not as abundant as reported elsewhere (Table 1).

Seasonal changes

Data from September and May indicate a greater abundance of organisms than in the other months. This is more evident in transect 4 than the other two transects (Table 1, and Fig. 4). Probably, the numerical dominance of *C. acherusicum* has played a major role on this seasonal tendency, since abundance peaks coincide with those of this amphipod (Table 1). A possible explanation could be an increase in feeding resources during these periods. Culpepper (1969) in a survey of amphipods from the northeastern Gulf of Mexico obtained population increases in spring and fall, and also related food resources with the abundance peaks.

A decrease in energetic resources may be associated with the abundances observed in July. Also, many fishes were observed around the groin in summer. This could have increased predation on the community studied. Another possibility could be the decrease of sediment deposition on the rocks, probably caused by continuous long periods of low tides in July and January, when populations decreased. Moreover, high temperatures (Fig. 3) combined with the above mentioned long periods of exposure registered in this period, may have a severe impact on survival rates of intertidal fauna (Britton & Morton, 1989). These assumptions need further investigation to be confirmed.
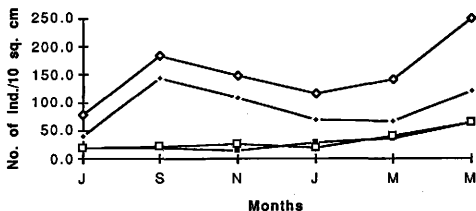
Fig. 4. Seasonal abundances of observed and collected individuals. T2: black square; T3: white square; T4: black diamond; Σ of three transects: white diamond.

A random ANOVA among the total of individuals collected in the different sampling months showed no significant differences (Table 2). This means that the number of organisms apparently experienced few variations in abundances.

Table 2. Random ANOVA among the different sampling periods comparing No. of individuals.

Total of individuals per transect and sampling period

	JUL	SEPT	NOV	JAN	MAR	MAY
T2 (r1)*	1293	1298	952	1982	2518	4423
T3 (r2)	1343	1498	1909	1278	2781	4512
T4 (r3)	2886	10048	7546	4812	4635	8499

* QIV not sampled in Sept.

Log (No. individuals + 1)

	JUL	SEPT	NOV	JAN	MAR	MAY
T2 (r1)	3.112	3.114	2.979	3.297	3.401	3.646
T3 (r2)	3.128	3.176	3.281	3.107	3.444	3.654
T4 (r3)	3.460	4.002	3.878	3.682	3.666	3.929

Randomized ANOVA Table

Sources	df	SQ	MS	F	Resolution
Months	5	0.445781	0.08916	0.854	ns
Error	12	1.25214	0.10434		
Total	17	1.6979			

ns= No significance (p>0.05)

Kulczynski's Similarity Index corroborated ANOVA's results: it revealed some periods similar to each other (Table 3). High similarities occurred when September and May were compared, probably caused by the increases in population sizes mentioned before (Fig. 4). Also, other two pairs may be alike due to their continuity in time, September–November and January–March. Moreover, July and May I_k values was 0.37. It seems that summer weather has a major impact on diversity and abundance trends.

Table 3. Quantitative similarity (I_k) of the faunistic communities among the different sampling periods. *= similarity between 0.37 and 0.69; +=similarity of 0.70 or above.

	JUL	SEP	NOV	JAN	MAR	MAY
JUL	-	*	*	*	*	*
SEP	-	-	+	*	*	+
NOV	-	-	-	*	*	+
JAN	-	-	-	-	+	*
MAR	-	-	-	-	-	*

Diversity varied little among the different surveys. An unbalanced random ANOVA (Table 4) exhibited no significant differences among the number of species collected in the six surveys.

Table 4. Unbalanced random ANOVA for number of species among the different sampling periods.

Total of different species per transect and sampling period

	JUL	SEP	NOV	JAN	MAR	MAY
T2 (r1)*	11	-	22	14	21	25
T3 (r2)	22	19	22	15	18	26
T4 (r3)	22	25	27	27	25	22

*QIV not sampled

Unbalanced random ANOVA table

Sources	df	SC	MS	FC	Resolution
Months	5	92.55	18.51	0.804	ns
Error	11	235.33	23.03		
Total	16				

ns= No significance ($p > 0.05$)

Zonation

Seasonal variations seem to affect the vertical and horizontal distribution of species. To obtain a clear idea of such distributions I divided the biota distribution into vertical and horizontal zonation.

Horizontal. Variations in abundance and diversity were expected among the different transects assuming that at the seaward end of the groin, diversity and populations would be higher due to an increase in wave action, protecting this zone from prolonged periods of exposure.

Kulczinski's index corroborated this assumption, since the result of the comparison T2-T3 (0.64) was higher than T2-T4 (0.46) and T3-T4 (0.49). These results indicated that T4 was different from T2 and T3 and these two were more alike each other. Moreover, large abundances on T4 (Fig. 4) could be evidence for an increase in abundance seaward.

Based on that analysis, part of the null hypothesis which stated that abundance was constant along the transects, was rejected. Therefore the idea that this intertidal community changes relative to distance from the shore was supported.

Bierbaum & Zischke (1979), in a study to determine the relationship between distance from shore and community stability, found a decreasing gradient for the barnacle *Chthalamlus stellatus* on pilings from shore to the sea. They considered that current flow and sedimentation influenced its distribution. In my study *C. acherusicum* was more abundant on the seaward end of the groin, causing the community abundance values to increase seawards (Table 1, Fig. 2).

Another section of the proposed null hypothesis is related to diversity fluctuations relative to the distance to shore. Fig. 5 describes the number of species (considered as diversity) detected at the different transects during the entire sampling period. Generally diversity was higher on transect 4 than the other two transects. The opposite occurred in May, when T2 and T3 obtained higher diversity than T4. Probably

bias in the sampling method caused this variation, since di-
versity tends to increase seaward.
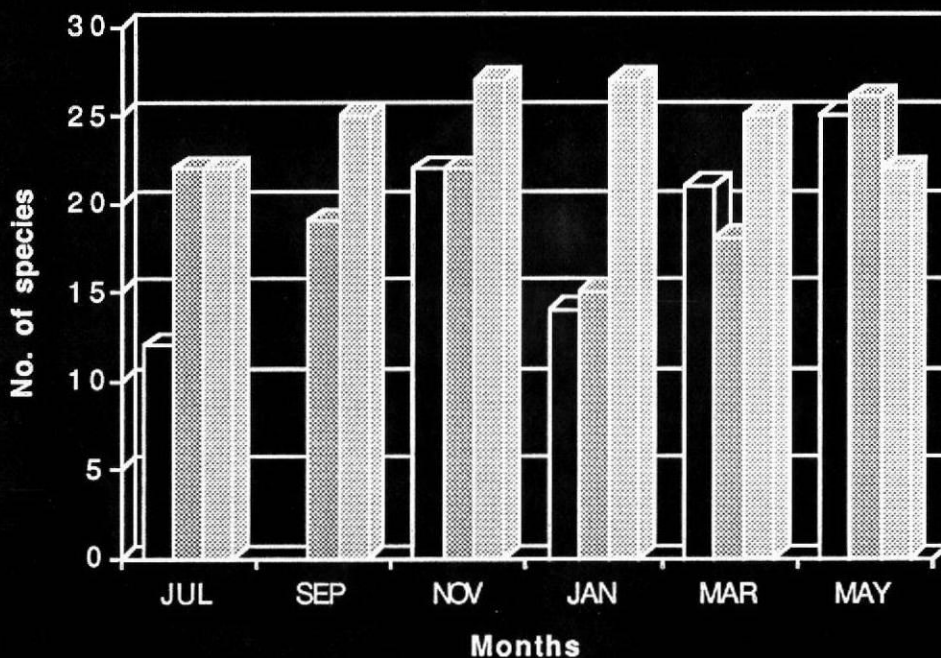
Fig. 5. Representation of the number of species per
transect. T2: white; T3: gray; T4: black. Incomplete data
for September.

Lowest abundance values occurred in July/91 and January/92,
particularly in transect 2. This transect was subjected to
more environmental stress than the other transects in those
months. Because it was closer to land than the others, the
rocks were completely exposed at low tide. Both months were
characterized by long periods of very low tides providing
less protection to adverse conditions which may have reduced
diversity and abundance in this area of the groin.

Vertical. Besides horizontal changes, vertical variation
in abundance and variety of species was found among the four
quadrats of each transect (Table 5). Large standard devia-
tions revealed the patchy distributions of these organisms.
Similar variations were obtained by Southward & Crisp (1956)
in a study of the distribution of intertidal barnacles at the
British coast.

Patchy distributions on the groin, as on rocky shores, probably are influenced by a variety of microhabitats such as small crevices (Raffaelli & Hughes, 1978; Mori et al., 1985), dead and living barnacles (Reimer, 1976a,b; Kudenov, 1979; Bross, 1987). Other typical estuarine features that may create microhabitats can be dead and living oysters (Whitten et al., 1950; Fotheringham, 1980; Ruppert & Fox, 1988) and sediment deposition (Fotheringham, 1980). These factors varied among transects and quadrats.

The only animal with a distribution from QI to QIV was *N. lineolata*. It was found in uppermost areas (QI) of T2 and T3 in March. But in T4-QI, it was recorded from November to May. Increased "splash zone" may be a key factor in the presence of this gastropod in this area.

In QII, *N. lineolata* was slightly more abundant than in QI. The fragile barnacle *Chthalamus fragilis* was observed in QII. These two species seem to withstand the high temperatures typical of this zone during low tides.

About six permanent invertebrates and seasonal algae inhabited QIII. A wider splash zone, microhabitat diversification, and nutrients may have facilitated this increase in diversity.

Table 5. Vertical and seasonal densities (No. individuals/ 25 cm^2) with their specific standard deviations for the most abundant biota.

T2	J	S	N	J	M	M
QI						
N. lineolata	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.6 ± 1.1	0.0 ± 0.0
QII						
N. lineolata	4.0 ± 0.6	0.0 ± 0.0	1.0 ± 1.0	1.0 ± 1.8	1.3 ± 1.7	2.0 ± 0.3
C. fragilis	1.0 ± 1.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
QIII						
Algae (%)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.2	0.0 ± 0.0
N. succinea	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.8	0.0 ± 0.0
N. lineolata	21.1 ± 10.5	21.4 ± 26.6	19.9 ± 26.6	21.3 ± 20.9	44.9 ± 32.8	29.0 ± 18.4
C.fragilis	78.7 ± 37.1	164.0 ± 94.0	63.7 ± 81.3	112.4 ± 96.9	102.9 ± 75.2	64.0 ± 40.4
B. eburneus	7.6 ± 10.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.0 ± 2.6	0.0 ± 0.0
C. acherusicum	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
D. dianae	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
QIV						
Algae (%)	15.7 ± 20.7	N.D	15.0 ± 17.5	5.0 ± 9.6	12.1 ± 29.9	25.7 ± 37.7
N. succinea	0.4 ± 0.8	N.D	1.7 ± 1.6	0.9 ± 1.1	2.1 ± 2.0	11.9 ± 8.9
N. lineolata	19.0 ± 9.2	N.D	2.5 ± 4.2	0.6 ± 0.8	2.1 ± 4.5	6.9 ± 10.9
P. pholadiformis	1.1 ± 1.5	N.D	3.7 ± 4.2	1.1 ± 1.2	0.7 ± 1.5	1.9 ± 2.0
C. fragilis	12.7 ± 6.8	N.D	38.0 ± 40.3	3.4 ± 4.5	37.1 ± 43.6	66.1 ± 55.5
B. amphitrite	3.9 ± 3.4	N.D	7.2 ± 4.0	4.1 ± 4.1	3.7 ± 3.9	0.7 ± 1.0
B. eburneus	16.4 ± 7.7	N.D	20.8 ± 19.1	130.0 ± 46.7	62.9 ± 59.0	81.0 ± 61.3
D. dianae	0.0 ± 0.0	N.D	0.7 ± 0.8	0.6 ± 0.8	17.9 ± 19.9	2.7 ± 6.3
C. equilibra	0.0 ± 0.0	N.D	0.0 ± 0.0	1.0 ± 1.4	0.1 ± 0.2	19.1 ± 20.3
C. acherusicum	3.9 ± 5.0	N.D	5.2 ± 4.0	6.7 ± 7.3	72.9 ± 150.4	375.1 ± 302.4

T3	J	S	N	J	M	M
QI						
N. lineolata	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	2.1 ± 3.3	0.0 ± 0.0
QII						
N. lineolata	0.4 ± 0.5	0.3 ± 0.5	3.1 ± 2.3	0.6 ± 0.8	2.7 ± 5.9	0.3 ± 0.8
C. fragilis	0.3 ± 0.5	1.9 ± 3.3	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
QIII						
Algae (%)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.7 ± 15.1	0.0 ± 0.0
N. succinea	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
N. lineolata	4.4 ± 10.9	1.9 ± 2.5	8.1 ± 3.1	1.0 ± 1.7	9.0 ± 14.0	1.3 ± 2.6
C.fragilis	34.6 ± 24.3	12.3 ± 17.4	15.0 ± 37.5	17.1 ± 18.7	16.7 ± 18.7	7.6 ± 8.0
B. eburneus	4.7 ± 7.7	1.1 ± 1.7	0.0 ± 0.0	0.0 ± 0.0	2.1 ± 5.7	0.0 ± 0.0
C. acherusicum	0.3 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
D. dianae	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
QIV						
Algae (%)	9.3 ± 1.9	24.3 ± 30.5	63.3 ± 43.8	6.1 ± 10.8	10.7 ± 17.9	18.6 ± 13.5
N. succinea	1.3 ± 0.5	1.7 ± 3.3	7.6 ± 8.6	0.7 ± 0.8	6.3 ± 5.9	10.0 ± 7.6
N. lineolata	6.9 ± 8.6	3.1 ± 5.1	0.0 ± 0.0	1.4 ± 1.6	1.7 ± 4.5	6.7 ± 12.7
P. pholadiformis	3.1 ± 2.9	2.1 ± 2.8	16.3 ± 27.3	0.9 ± 0.9	0.7 ± 1.5	1.9 ± 3.7
C. fragilis	13.9 ± 5.8	4.4 ± 6.7	1.4 ± 1.5	10.6 ± 9.3	64.1 ± 83.5	45.1 ± 50.8
B. amphitrite	17.0 ± 5.6	13.9 ± 12.3	4.9 ± 3.2	9.4 ± 5.8	3.1 ± 3.1	0.1 ± 0.4
B. eburneus	19.4 ± 7.2	19.4 ± 15.8	15.4 ± 11.2	137.4 ± 56.5	216.9 ± 205.3	141.7 ± 119.7
D. dianae	0.9 ± 1.9	1.3 ± 2.0	82.1 ± 75.0	0.4 ± 1.0	6.3 ± 8.5	39.1 ± 33.8
C. equilibra	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 2.5	0.3 ± 0.8	20.6 ± 38.2
C. acherusicum	62.1 ± 29.6	124.3 ± 181.1	139.7 ± 144.0	5.0 ± 3.9	50.1 ± 74.7	372.3 ± 308.0

Table 5. Continued.

τ4	J	8	N	J	M	N
QI						
N. lineolata	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.5	0.3 ± 0.5	1.4 ± 2.1	0.0 ± 0.0
QII						
N. lineolata	0.1 ± 0.4	0.4 ± 0.5	0.4 ± 0.8	0.6 ± 0.8	1.9 ± 1.8	0.8 ± 0.8
C. fragilis	0.7 ± 1.3	0.0 ± 0.0	0.7 ± 1.5	0.4 ± 0.8	0.0 ± 0.0	0.0 ± 0.0
QIII						
Algae (%)	0.0 ± 0.0	2.9 ± 4.5	14.3 ± 35.6	0.9 ± 1.9	52.0 ± 44.7	19.4 ± 18.4
N. succinea	0.0 ± 0.0	0.3 ± 0.8	4.6 ± 7.1	0.0 ± 0.0	3.0 ± 5.1	16.4 ± 25.2
N. lineolata	10.7 ± 16.8	19.0 ± 20.2	33.0 ± 48.3	39.0 ± 42.8	3.4 ± 5.2	27.1 ± 22.6
C.fragilis	10.3 ± 11.9	65.9 ± 48.2	104.6 ± 126.8	86.1 ± 101.4	66.3 ± 76.9	104.9 ± 50.8
B. eburneus	4.6 ± 4.7	16.0 ± 27.5	2.0 ± 3.1	5.0 ± 9.1	34.3 ± 59.7	74.7 ± 80.1
C. acherusicum	0.4 ± 0.8	37.6 ± 73.6	64.6 ± 128.8	0.7 ± 1.2	6.7 ± 10.5	48.7 ± 57.0
D. dianae	0.0 ± 0.0	0.4 ± 0.8	0.3 ± 0.8	0.0 ± 0.0	2.0 ± 3.6	38.4 ± 35.6
QIV						
Algae (%)	100.0 ± 0.0	98.9 ± 2.7	61.0 ± 32.8	77.5 ± 24.3	59.3 ± 38.8	65.7 ± 23.0
N. succinea	2.1 ± 0.9	2.4 ± 1.1	12.6 ± 9.9	9.9 ± 6.8	10.7 ± 5.2	8.3 ± 3.6
N. lineolata	14.3 ± 5.1	0.1 ± 1.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
P. pholadiformis	23.3 ± 20.6	9.9 ± 7.2	8.7 ± 7.5	7.6 ± 9.9	0.6 ± 1.0	4.0 ± 1.8
C. fragilis	15.6 ± 6.0	21.0 ± 21.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 0.8
B. amphitrite	16.1 ± 6.5	94.0 ± 4.7	2.0 ± 2.2	0.6 ± 0.8	0.9 ± 0.2	0.0 ± 0.0
B. eburneus	15.4 ± 7.7	13.4 ± 9.5	3.6 ± 4.2	95.0 ± 43.3	229.7 ± 132.7	9.4 ± 6.6
D. dianae	0.3 ± 0.5	0.7 ± 1.0	7.5 ± 14.9	0.4 ± 0.5	6.4 ± 7.2	1.4 ± 2.1
C. equilibra	0.0 ± 0.0	0.0 ± 0.0	13.7 ± 15.9	23.7 ± 10.8	46.4 ± 33.2	54.1 ± 30.4
C. acherusicum	207.0 ± 33.7	1180.0 ± 318.3	676.7 ± 404.4	445.3 ± 101.9	232.7 ± 182.9	760.3 ± 209.3

Finally, 9 important animal species (including the numerically dominant *C. acherusicum*) and several algal species were found at the·lowest zone, i.e. QIV. This zone was exposed only during very low tides. There, environmental harshness is reduced, allowing more species to establish (Britton & Morton, 1989). Many organisms seek refuge from ecological stress in protected zones provided by microtopographical varieties such as crevices, holes and sessile biota.

Vertical distributions of intertidal fauna along hard substrata have been very well documented all over the world (Stephenson & Stephenson, 1950, 1952; and Whitten et al., 1950; Southward & Crisp, 1956; Connell, 1961; Harper, 1972; Lubchenco & Menge 1978; Bierbaum & Zischke, 1979; McQuaid & Branch, 1985; Kronberg, 1988; Britton & Morton, 1989). However, few authors have considered microtopography an important factor influencing population distributions (Raffaelli & Hughes, 1978; Mori et al., 1985; Fuji & Nomura, 1990).

Based on Table 1, nine species were classified as the most abundant, and grouped in Table 3. Large standard deviations reflected the patchy distribution of the groin inhabitants. Similar tendencies were reported by Bierbaum & Zischke (1979) in a study of intertidal barnacles in the Florida Keys.

The dispersion of the dominant species within the four vertical quadrats along the sampled areas of the groin are described below.

Fig. 6 shows vertical distribution of the common gastropod *Nodilittorina lineolata* (=*Littorina ziczac* of some authors) (=*Littorina lineolata*). It seems that it has a strong preference for QIII, a zone neither as dry as above, nor with the presence of sediment, algae and the greater diversity typical of QIV. Probably competition for space and resources with other species is less severe in this area. However, in July and May this gastropod was very common in the low areas

of QIV, representing the settling of juvenile snails from
plankton. In Florida the spawning season of this species is
from April to early November, but this gastropod experienced
a break in spawning season, from mid-May to mid-August
(Borkowski, 1974). This is the same period of high abundances
found in QIV, what suggests that the reproduction period may
occur in the summer period.
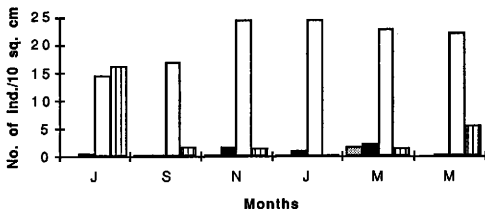
Fig. 6. Representation of the vertical stratification and sea-
sonal abundance fluctuations of *Nodilittorina lineolata*. QI:
stippled; QII: black; QIII: white; QIV: vertical lines.

Moreover it was the only species found in QI in March,
indicating that conditions are favorable in this area. The
other invertebrate which visits this zone is *L. exotica*.
Their presence in uppermost positions has been documented by
Whitten et al. (1950), Hedgpeth (1953), Fotheringham (1980),
Bandel & Kaldosky (1982), and Britton & Morton (1989).

Vertical zonation of *Chthalamus fragilis* is illustrated in
Fig. 7. As the above species, it prefers the middle
intertidal (QIII), indicating its capability to resist some
desiccation (Ruppert & Fox, 1988). However, it seems that it
cannot survive well above that region or perhaps larvae
cannot reach higher zones. But the relative abundance in
March and May may indicate recruitment of juveniles (Fig. 7).

Fig. 7. Representation of the vertical stratification and
seasonal abundance fluctuations of *Chthalamus fragilis*.
QII: black; QIII: white; QIV: vertical lines.

According to Connell (1961), physical factors such as
freezing and desiccation may restrict its upwards dispersion.
Below, interspecific competition for space with other
species, in this case *B. eburneus*, appears to be a limit.
Moreover, he mentioned that *Balanus* grows faster than
Chthalamus, reducing the presence of the latter (Connell,
1961). Britton & Morton (1989) discussed this theory, and
concluded that it described in part the interaction between
C. fragilis and *B. eburneus* because the latter was not
considered a strong competitor due to its relative paucity
along Texas shores.

Moreover, sediment should be considered as another physical
inhibitor of *C. fragilis*, because it might reduce the
existence of firm substrata on which to settle, or might
cover the barnacles. This species is rare in the warm blue
waters of the Florida Keys, and seems to be more common in
nothern areas (Dando & Southward, 1980), including the Texas
coast (Whitten et al., 1950; Hedgpeth, 1953; Gittings et al.,
1986; Britton & Morton, 1989). This may indicate that *C.
fragilis* is a strong competitor in turbid waters. However, it

appears that at certain level, sediment can act as a
inhibiting factor.

  Balanus eburneus grows better in low intertidal areas (QIV).
In a study of intertidal fauna of the British coast, Connell
(1961) determined that *Balanus balanoides* occurs below
Chthalamus stellatus. This resembles the zonation of their
counterpart in Texas shores.

  B. eburneus was relatively scarce from July to November, but
became abundant from January to May, attaining a peak in
March (Fig. 8). This probably indicates a recruitment period
for this species. This is partially similar to the
investigations of Moore and Frue (1959), who found three
peaks of cypris settlement for this species during March,
July and October in the Miami area. The relative low
frequencies of *B. eburneus* on the groin could be explained by
the preference of this species for estuarine habitats (Moore
& Frue, 1959; Gordon, 1969; Zullo, 1979; Gittings et al.,
1986; Britton & Morton, 1989). Fig. 1 confirmed this because
a low salinity trend was recorded during the high abundance
periods of this barnacle.

Fig. 8. Representation of the vertical stratification and
seasonal abundance fluctuations of *Balanus eburneus*. QIII:
white; QIV: vertical lines.

  B. eburneus appears to have a greater tendency to attach to
different surfaces, e.g. other barnacles, oysters, aluminum
cans, tires, glass, algae, and even on the dorsal area of D.
dianae, probably influenced by the presence of arthropodin in
this isopod (Crisp, 1990).

  The other barnacle species, B. amphitrite, was found fre-
quently in the low-intertidal (QIV) and a few in the middle
intertidal (QIII) but in small numbers relatively to all of
the three species mentioned previously. B. amphitrite
attained an abundance peak in summer (Fig. 9). Moore and Frue
(1959) reported similar results of cypris production in the
Miami area. The difference in abundances between seasons
might be explained due to the marine salinity preferences of
this cirriped (Zullo, 1979; Britton & Morton, 1989). Also,
it grows faster in warmer months (Moore & Frue, 1959). Both,
temperature and salinity tendencies increased with the
increase of this population (Fig. 3).

Fig. 9. Representation of the vertical stratification and
seasonal abundance fluctuations of Balanus amphitrite. QIII:
white; QIV: vertical lines.

  Living and dead B. eburneus and B. amphitrite were found to
shelter Stylochus sp., Polydora aggregata, Polydora socialis,
Polydora websteri, various syllids, Neanthes succinea,
Lumbrineris cf. parvapedata, N. lineolata, B. exustus, P.

pholadiformis, *S. antillensis*, *C. acherusicum*. They also
provided firm substratum for *O. dichotoma* and *Membranipora*
cf. *tenuis*. Based on this information, I suggest that
barnacles play an important ecological role as potential
habitat for motile fauna on the groins. Similar associations
with barnacles have been reported in Panama (Reimer, 1976a,
b), Baja California (Kudenov, 1979), and Tampa Bay (Bross,
1987).

Another important member of this community is *Neanthes
succinea* (=*Nereis succinea*). It was scarce in July, September
and January (Fig. 10). Extreme salinities, high temperatures,
and predation rates could be a major cause for this paucity
in summer.

N. succinea, has been considered an emigrant from estuaries
onto the jetties (Whitten et al., 1950; Fotheringham, 1980).
Juveniles of *Menippe adina* (=*M. mercenaria*) and transient
fishes appeared in summer, and might have impacted *N.
succinea* population as well as other resident fauna.
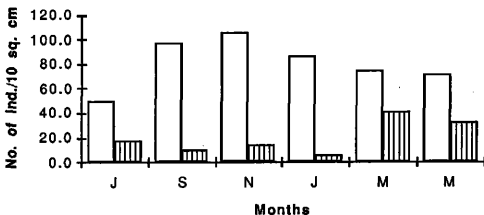

Fig. 10. Representation of the vertical stratification and
seasonal abundance fluctuations of *Neanthes succinea*.
QIII: white; QIV: vertical lines.

Many young specimens of *N. succinea* were found in spring
(March-May). Ruppert and Fox (1988) said that this polychaete

spawns in spring and late summer, which is partially similar to the abundances that I found in March and May samples.

  N. succinea was found mostly in the low-intertidal under sediment, within empty barnacle plates, underneath dead oysters and sometimes in oyster valves within the empty burrows of the spionid P. websteri.

  The skeleton shrimp Caprella equilibra occurred from fall to spring (Fig. 11). It has been described as common, especially in winter time along the east coast of the United States (Ruppert & Fox, 1988). Many caprellids, including C. equilibra, associate with algae, bryozoans and hydrozoans (Edmonson & Mansfield, 1948; McCain, 1965; Keith, 1969; Caine, 1974; Britton & Morton, 1989). In my study, C. equilibra was commonly associated with algae and the hydrozoan O. dichotoma from the lower intertidal. During the surveys made by Whitten et al. (1950) on Texas jetties uncertain caprellid species were reported, Caprella acutifrons and Caprella sp. No comparisons could be made due to the lack of descriptions in Whitten et al. study.
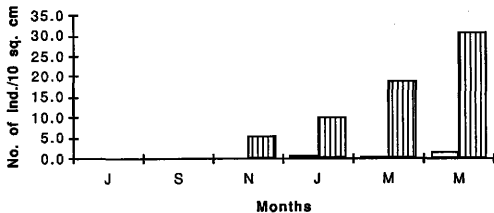
Fig. 11. Representation of the vertical stratification and seasonal abundance fluctuations of Caprella equilibra. QIII: white; QIV: vertical lines.

  From July to November another smaller caprellid, Paracaprella tenuis (=Deutella abracadabra), was discovered.

Although abundance was low (Table 1), it did show the same habitat preferences of its winter counterpart. This was confirmed by Steinberg & Dougherty (1957) who found it associated with bryozoans.

  The only bivalve quantitatively dominant in the lower intertidal was *Petricola pholadiformis*. Although rare in March (Fig. 12), it was very common in July and November. Young specimens were observed in May, indicating a possible larval recruitment after the winter decrease. Ruppert & Fox (1988) explained that in the southeast coast the juveniles of this bivalve live on rocks and pilings associated with mussels. Investigations conducted by Whitten et al. (1950) and Hedgpeth (1953) did not include it as part of the jetty fauna. Andrews (1971) considered clay its typical substratum, and Britton & Morton (1989) mentioned that *P. pholadiformis* was a boring clam in the mud banks of Sargent Beach, Texas.
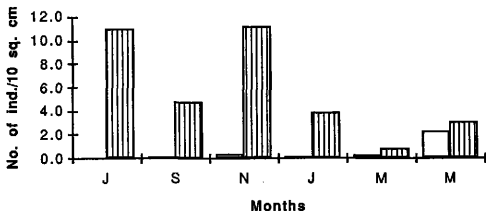
Fig. 12. Representation of the vertical stratification and seasonal abundance fluctuations of *Petricola pholadiformis*. QIII: white; QIV: vertical lines.

  Many specimens of *Dynamenella dianae* were collected in November, March and May (Fig. 13), coinciding in part with the peak values of the community (Fig. 4). Very few specimens were observed in the other months. It was an inhabitant of the lower intertidal (QIV), but in May it also was in the QIII region.
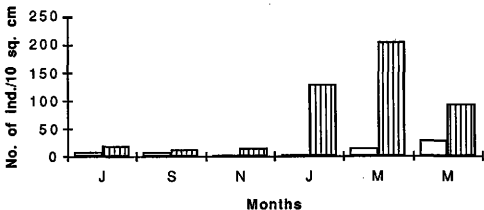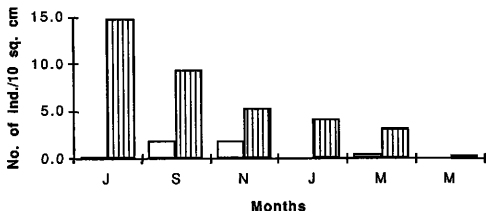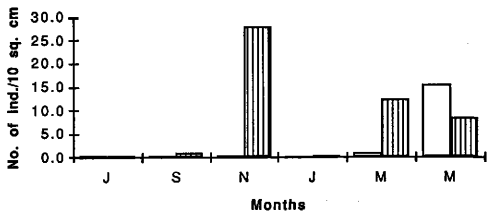
Fig. 13. Representation of the vertical stratification and seasonal abundance fluctuations of *Dynamenella dianae*. QIII: white; QIV: vertical lines.

Its presence along Texas jetties has been probably over-looked or confused with a similar isopod *Sphaeroma quadridentatum* (Whitten et al., 1950; Britton & Morton, 1989). Clark (1978), and Clark & Robertson (1982), reported that *S. quadridentatum* was dominant on the nothern jetties and it was replaced by *D. dianae* in southern jetties. However, I found the opposite on the groin studied: *D. dianae* was dominant and *S. quadridentatum* was found occasionally (Table 1). This change in geographical distribution could be temporary, since large numbers of *S. quadridentatum* have been collected on Galveston groins previously (Harper, personal communication).

The last and most important member of the groin faunal com-munity was *Corophium acherusicum* (Table 1, Fig. 14). Characteristic of the lower intertidal, it attained very high densities (Table 2). Fotheringham (1980) stated that *C. louisianum* was the dominant amphipod jetties and groins along the Gulf of Mexico coast, but *C. lousianum* is a common organism in low salinity areas of the Gulf of Mexico (Thomas, 1976; McKinney, 1977).

When the community seasonal abundance trend (Fig. 4) and *C. acherusicum* tendency (Fig. 14) are compared, it can be

observed that this species definitely governed the seasonal
abundance trends of the entire community. Fotheringham (1980)
explained that *C. acherusicum* and other infaunal crustaceans
experience spring blooms in offshore bottoms. This coincided
with the peak observed in May (Fig. 4), but nothing was said
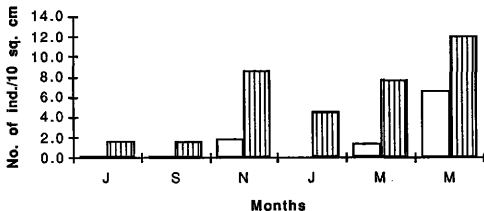about fall blooms.
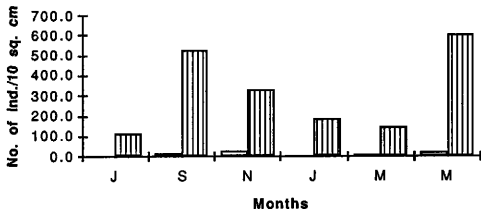
Fig. 14. Representation of the vertical stratification and sea-
sonal abundance fluctuations of *Corophium acherusicum*. QIII:
white; QIV: vertical lines.

The successful settlement could be facilitated by some phys-
ical factors, e.g. much sediment on the rocks, salinity
ranges, the existence of sheltered areas provided by barna-
cles, oysters and algae. Also, biological features such as
small size, reproduction strategies, feeding habits may have
collaborated to the dispersion of this species along the
groin.

Sediment probably is rich is detritus, facilitating the nu-
trition and adequate habitat for *C. acherusicum*. But not only
sediment is required for its success. Generally it also re-
quires hard substratum to attain large colonies (McKinney,
1977; Ruppert & Fox, 1988). Probably this is the most impor-
tant physical factor responsible for its numerical dominance.

McKinney (1977) determined the species ubiquity along the
Texas coast in salinities above 15 ppt. The salinities
recorded along the groin were always above 15 ppt (Fig. 1).

Many individuals were observed to build their tubes in areas populated with larger sessile biota. Many ovigerous females were found within dead barnacles. Its low-salinity counterpart, *C. louisianum* exhibits the same behavior (Fotheringham, 1980).

Reproduction and life cycles probably are very important. Females carrying eggs, and juveniles, were common in samples from all periods. Bousfield (1973) stated that ovigerous females of this species appear from March to September. That continuity in reproduction might keep this population with large and constant numbers.

Based on Barnes (1985), I considered *C. acherusicum* to have detritivorous feeding habits. Therefore, its surrounding environment with plenty of organic matter is favorable.

In addition to the important invertebrate members of the community, algal coverage (%) was included because of the shelter, substratum and nourishment they might provide. Present throughout the year, they seemed to be very abundant in summer, and scarce in November, March and May (Fig. 15). Temperature regimes may be considered a regulatory factor in these populations (Britton & Morton, 1989). They are conspicuous along the lower intertidal. However, there were differences among the three transects: low coverage characterized T2 and sometimes T3, high coverage occurred in T4 and occasionally T3. Exposure was more severe at T2, which probably inhibited the development of algal colonies in this zone. Exposure was reduced seaward, facilitating the establishment of algae on T3 and T4.

Its possible role as shelter for fauna is mentioned above, particularly for motile organisms, but they also represent strong competition for space with sessile fauna (McQuaid & Branch, 1985). They attached to the scuta and terga of barnacles, causing damage to part of the community. Also, young *B. eburneus* were observed to adhere to different kinds of algae, contrasting the effect of algae over barnacles.

Larger sizes of barnacles were not discovered. Probably they dislodge the algae due to the heavy weight of their plates.
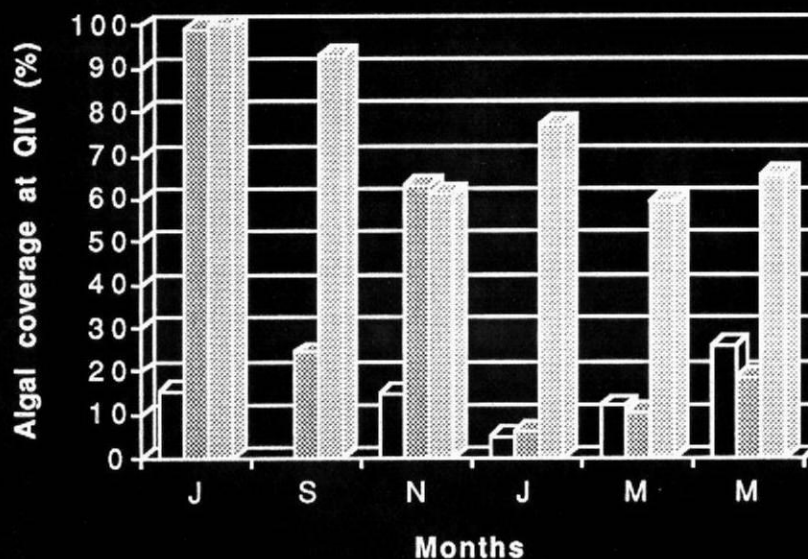
Fig. 15. Seasonal fluctuations of algal coverage (%) along the transects, based on the 7 replicates taken at QIV. T2: white; T3: light gray; T4: dark gray. Incomplete data for September.

Surprisingly, herbivore action was not obvious, except for the epiphyte grazer *N. lineolata*. However, herbivore diversity increases at Port Aransas jetties and some herbivore species are *Aplysia* spp., *S. pectinata*, and *A. punctulata* (Whitten et al., 1950; Britton & Morton, 1989). Reasons for their absence in nothern areas are not mentioned, but this could be an interaction of salinity, turbidity, temperature ranges and types of algae.

The low representation of primary consumers make Galveston groins differ much from natural rocky shores, where herbivore action is important in the population dynamics of communities (Lubchenco & Menge, 1978; Lubchenco & Gaines, 1981; Branch, 1985; Jones & Baxter, 1985).

Four less abundant species, *Polydora websteri*, *Orchestia grillus* and the colonial organisms *Obelia dichotoma* and *Membranipora tenuis*, were common at least in one collection.

P. websteri was common only in summer (Table 1). Salinity might have some influence on its presence, since this population attained important densities in July. It was found in QIV, generally within dead and alive oyster valves. Also, two or three specimens were living within the plates of large, dead *B. amphitrite*. Blake (1971), and Britton & Morton (1989) have considered this annelid as a pest of oysters due to its burrowing behavior within the valves, which are dissolved by chemical action (Zottoli & Carriker, 1974). It has been reported in oyster reefs of Galveston Bay (Zimmermann et al., 1989), where larvae might be carried by currents toward the seashore.

O. grillus was common in summer. It has been considered a semi-terrestrial amphipod, which crawls around salt marshes and sea shores of the Atlantic coast and the Gulf of Mexico (Bousfield, 1973; McKinney, 1977; Fotheringham, 1980). Perhaps the bait left by fishermen in summer may create greater dispersion due to its detritivorous habits (Table 1).

The two colonial organisms *O. dichotoma* and *M. tenuis* were not very abundant, their coverage in QIV varied from 0.0% to 12.5% depending on the season. The former species seemed the most common of the two. Defenbaugh (1970) and Fotheringham (1980) considered it common on Texas jetties and groins. Large colonies were observed on barnacles, oysters, mussels and rocks with a low degree of sedimentation.

Some fauna not included in quadrats during samplings, but observed, were sponges, the coral *Astrangia* cf. *astraeiformis*, the hermit crab *Clibanarius vittatus*, the crabs *Callinectes sapidus*, *Menippe adina*, and *Petrolisthes armatus*.

To determine statistically significant differences in the number of individuals and number of species present among the different four quadrats, six randomized block ANOVA, one per sampling month, were performed. Example for the month of July is illustrated in Table 6.

Table 6. Example of logarithmic transformation (Log(A+1))
and randomized block ANOVA for the comparison of the
averages of No. of individuals/ 25 cm^2 (A) observed in
the different quadrats during July 1991.

Total of individuals average (A)

	QI	QII	QIII	QIV
T2 (block 1)	0.00	1.57	107.43	74.43
T3 (block 2)	0.00	0.71	47.43	142.71
T4 (block 3)	0.11	0.86	26.28	363.43

A= total of individuals/7 repetitions

Logarithmic transformation Log (A+1)

T2 (block 1)	0.000	0.410	2.035	1.878
T3 (block 2)	0.000	0.233	1.685	2.157
T4 (block 3)	0.046	0.270	1.436	2.585

Randomized Block ANOVA Table

	df	SS	MS	F	Resolution
TRT	3	10.33	3.443	46.6	**
BLK	2	0.009	0.00045	0.0061	ns
Error	6	0.443	0.074		

** = Highly significant (p<0.01)
ns= no significant (p>0.05)

Highly significant differences (p < 0.01) were established among the four quadrats (treatments) in the six ANOVA. This rejected the hypothesis that the number of individuals is equal along the different vertical zones of the lateral areas of the groin, and supports the alternative hypothesis, e.g. variations occur among the quadrats. In contrast, transects (blocks) did not present significant differences, supporting horizontal equality along the groin.

Another six similar ANOVA were carried out, using number of species instead of the average of number of individuals (Table 7).

Table 7. Example of logarithmic transformation (Log (No. species + 1)) and randomized block ANOVA for the comparisons of the number of species observed in the different quadrats during July 1991.

Number of species (Z)

	QI	QII	QIII	QIV
T2 (block 1)	0	2	3	12
T3 (block 2)	0	2	13	22
T4 (block 3)	0	2	6	22

Logarithmic transformation   Log (No. species+1)

T2 (block 1)	0.000	0.477	0.602	1.114
T3 (block 2)	0.000	0.477	1.146	1.362
T4 (block 3)	0.046	0.477	0.845	1.362

Randomized Block ANOVA Table

	df	SS	MS	F	Resolution
TRT	3	2.683	0.894	49.7	**
BLK	2	0.08	0.0400	2.22	ns
Error	6	0.11	0.018		

** = Highly significant (p<0.01)
ns= no significant (p>0.05)

 Results indicated that diversity changed along a vertical gradient. This rejected the null hypothesis, which denied variations from the upper intertidal to the lower intertidal. Moreover, in comparisons of transects (blocks) pertaining to September and January, significant differences were produced $p < 0.05$ and $p < 0.01$ respectively. These partial results confirmed that at least in September and January diversity changes horizontally along the groin.

Trophic categories

 An attempt to display the presence of different trophic levels is included in Table 1 and Fig. 16. The categories were suspension feeders, predators, deposit feeders, grazers, detritivores, and omnivores.
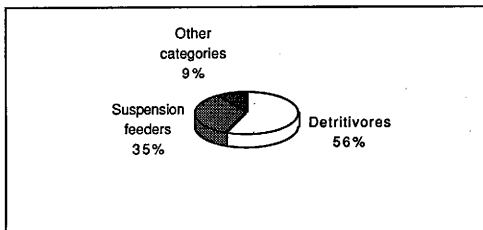
Fig. 16. Representation in percentages of the abundance of
the different trophic categories. Other categories: preda-
tors (0.67%), deposit feeders (0.03%), grazers (4.4%),
omnivores (4.0%).

Detritivores were dominant (56.3%; 36092 individuals),
influenced completely by *C. acherusicum*. Suspension feeders,
mostly barnacles, were the second dominant (34.6%; 22172
individuals). Low representation characterized the other four
classes which comprised a combined 9.1% (5876 individuals).

These results contrast with the results of McQuaid & Branch
(1985), who determined that filter feeder biomass was
dominant on protected rocky shores of South Africa, whereas
herbivores and algal biomass was higher on exposed shores.
Also, Fuji & Nomura (1990) referred to similar conclusions in
an apparent exposed rocky shore of Japan, where presence of
filter feeders, particularly barnacles was relevant.

In this survey the most important trophic group was
detritivores, included as a minor group in the above studies.
Besides, zoogeographical and climatological causes, probably
three major reasons could explain these differences: strong
influence from adjacent estuarine areas, type of substratum
and age of the communities on those shores.

Estuaries may have a major effect on jetties and groins.
Those studies mentioned above were performed in natural rocky
areas, where muddy estuarine influence probably is limited.

Sediments from large estuaries influence the Gulf of Mexico, especially in the shore (Britton & Morton, 1989). Sediments deposited along the rocks create ideal environment for *C. acherusicum* (Fotheringham, 1980). Salinity ranges nearshore, influenced by estuaries, facilitates the establishment of this amphipod colony (McKinney, 1977).

Whitten et al. (1950) mentioned that Texas jetties and groins are artificial substrata introduced by men on sandy-muddy shores at the end of the last century. Therefore, fauna inhabiting that firm substrata have migrated recently from estuaries, Caribbean or northwestern-Atlantic areas (Whitten et al., 1950; Hedgpeth 1953; Fotheringam, 1980). Natural rocky shores communities have evolved throughout different geological periods and adapted in many ways to this environment (Thurman & Webber, 1984).

Surprisingly, herbivore action was not obvious, except for the epiphyte grazer *N. lineolata* (Table 1 and Figs. 6). This feature made Galveston groins differ from natural rocky shores, where herbivore action is important for the population dynamics of the communities (Lubchenco & Menge, 1978; Lubchenco & Gaines, 1981; Branch, 1985; Jones & Baxter, 1985).

This brief discussion about the groin's trophic categories is a preliminary effort to explain energetic flow in these community, but intense research is required to better under-stand the ecological relationships on artificial substrata.

Succession on experimental substrata

In early December, six small bricks of different materials were placed within crevices in the lower intertidal of the transect areas. Twenty invertebrate species were recruited from January to July, of which the first were *B. eburneus*, *N. lineolata*, *C. fragilis* and *D. dianae* (Table 8).

Table 8. Qualitative representation of fouling organisms observed on the experimental bricks from January to July 1992. -: scarce (1-10 individuals/25 cm², 1-10%); +: common (11-100 individuals/25 cm², 11-49%); *: abundant (>100 individuals/25 cm², 50-100%) . [1] Coverage for colonial organisms.

	Jan	Feb	Mar	May	Jun	Jul
SEDIMENT		+	+	+	+	-
ORGANIMS						
B. eburneus	*	*	*	+	+	-
C. fragilis	+					-
N. lineolata	+	-	+	+	-	-
D. dianae	-	-	-	-	-	-
Algae[1]		+	+	-		
M. cf.tenuis[1]		+	+	-	-	
P. armatus		-				
C. acherusicum		-	+	+	+	
C. equilibra		-	+	-	-	
B. cavernata		-	-	-	-	-
Stylochus sp.		-				
O. dichotoma[1]			+	*	*	-
S. haemostoma			+			
N. succinea			-	+	-	
O. grillus			-	-	-	-
C. virginica			-	-	-	-
H. dianthus			-	-	-	
A. transversa				-	-	-
M. adina				-	-	
B. amphitrite					-	-
S. antillensis					-	

Diversity and density increased in March and May (Fig. 17), this increase probably was associated with the presence of algae in that period. By July those parameters decreased and so did the coverage of sediment and algae. These two components probably were scarce due to long periods of low tides typical of summer, and with them the development of a new community was affected. These preliminary results evidenced in part the effects of low tides in summer.
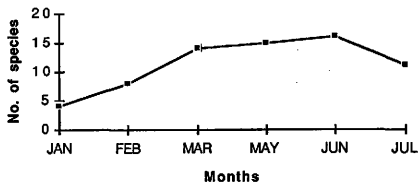
Fig. 17. Representation of the seasonal variations
of the diversity trend observed on the experimental
bricks. Data of April missing.

Some other organisms recorded on the bricks were *C.
acherusicum*, *S. haemastoma*, *N. succinea*, *C. virginica* and *B.
cavernata*. *C. acherusicum* took advantage of sediment, or
perhaps it built tubes on the bricks taking mud particles
from the water and surrounding areas. But all those biota de-
clined in July.

The reduced experimental period limited the implications
that could be drawn from this experiment. However, a
preliminary set of succession of data from winter to summer
has been provided.

All analyses made indicated that the nature of the communi-
ties was not regulated by one major physical or biological
factor, but by the interactions of all of them. For the groin
studied such factors are probably tide level, temperature,
salinity, sediment deposition, type of substratum, microto-
pography, predation, reproductive cycles, competence for
space, and shelter provided by sessile organisms.

Based on conclusions made by Whitten et al. (1950), and
Fotheringham (1980) and the assumptions of this work, I
consider the groin community to be introduced inhabitants on
sandy-muddy shores, with a mixture of representatives from
oyster reefs, marshes, continental shelf, Caribbean Sea,
Carolinian province, and cosmopolitan species.

An analysis on the faunal community of the groin community of Galveston has been performed. This study gathered information mainly on faunal composition, community zonation, and possible effects of physical and biological factors. This research provided a better understanding of the ecology of the intertidal fauna on jetties and groins. However, investigations on population dynamics, species life history, dispersion-persistence strategies and feeding ecology, could enhance the knowledge of the ecology of the jetties and groins of Gulf of Mexico.

CONCLUSIONS

 The groin faunistic community consisted of fifty species,
within nine phyla. The numerically dominant species in this
community was *Corophium acherusicum,* comprising 53.18% of all
specimens. Other numerically important organisms were
*Chthalamus fragilis, Nodolittorina lineolata, Balanus
eburneus, B. amphitrite, Dynamenella dianae* and *Caprella
equilibra.* These species except for the latter, were
persistent throughout the seasons. Different algae were
observed during samplings. They were abundant in July, but
their presence decreased in cooler months.

 Random ANOVA detected non-significant differences detected
among the different sampling periods. Moreover, Kulczynski's
similarity index demonstrated that some periods were more
alike to others, generally due to continuity, i.e. September-
November, September-May, November-May and January-March.
July-May were very different from each other. These seasonal
trends were dominated by *C. acherusicum* abundances, but the
community seasonal trends, excluding this amphipod, were
opposite when comparing data with abundance values including
C. acherusicum, except for the faunistic increase during
spring bloom.

 Similarity index and randomized block ANOVA applied to the
three different transects proved that abundances do not
fluctuate seaward or landward. Although, the same ANOVA
design detected fluctuations among horizontal diversity
gradient during September and January.

 The most dispersed animal through the vertical community
gradient was *N. lineolata. C. fragilis* also withstood dry and
hot substratum but not as effectively the former species did.
The others, including *C. acherusicum,* were considered mid-low
intertidal species, which were incapable of surviving above
this area. Randomized Block ANOVA proved that abundance and

diversity were different along the vertical quadrats during the six sampling periods.

The biota zonation might be in part controlled by the interaction of physical factors such as periods of exposure, temperature, salinity, nutrients, intensity of radiation, sedimentation, slope of substratum and hardness of substratum. Algae, barnacles, oysters and sediment produce microhabitats for various species.

The groin assemblage was dominated by detritivores and suspension feeders; herbivores were poorly represented. This was different from natural rocky shores where herbivores are common and detritivores rare. The existence of sediment could be related to this variation.

B. eburneus recruited rapidly on the experimental substrata, and 19 more animal species settled, reaching coverage peaks in March and May. Probably that development was enhanced by the presence of algae and sediments. However, representation declined in summer.

Texas groins and jetties are inhabited by biota of different geographical areas including estuaries, Carolinian and Caribbean provinces, offshore grounds and cosmopolitan species.

LITERATURE CITED

Andrews, J. (1971). Shells and Shores of Texas. University of
   Texas Press. Austin

Bandel, K., Kaldosky, D. 1982. Western Atlantic species of
   Nodilittorina (Gastropoda: Prosobranchia): comparative
   morphology and its functional, ecological, phylogenetic
   and tasonomic implications. Velig. 25: 1-42

Barnes, R. D. (1985). Zoología de los Invertebrados. 4a.
   Edición. Nueva Editorial Interamericana, S. A. de C. V.,
   México, D. F.

Bierbaum, T. J., Zischke, J. A. (1979). Changes in barnacle
   population structure along an intertidal community
   gradient in the Florida Keys. Mar. Biol. 53: 345-351

Blake, J. A. (1971). Revision of the genus *Polydora* from the
   east coast of North America (Polychaeta: Spionidae).
   Smithsonian Cont. Zool. No. 75

Bousfield, E. L. (1973). Shallow-Water Gammaridean Amphipoda
   of New England. Cornell Univ. Press, New York

Branch, M. (1985). Limpets: their rôle in littoral and
   sublittoral community dyanmics. In: Moore, P.G., Seed, R.
   (ed.) The Ecology of Rocky Coasts. Hodder and Stoughton
   Ltd., Kent, United Kingdom, p. 97-116

Britton, J. C., Morton, B. (1989). Shore Ecology of the Gulf
   of Mexico. University of Texas Press, Austin

Borkowski, T. V. (1974). Growth, mortality, and productivity
   of south Floridian Littorinidae (Gastropoda:
   Prosobranchia). Bull. Mar. Sci. 24: 408-437

Bross, W. E. (1987). Effect of removing or addding structure
   (barnacle shells) on recruitment to a fouling community
   in Tampa Bay, Florida. J. exp. mar. Biol. Ecol. 105: 275-
   296

Caine, E. A. (1974). Comparative functional morphology of
   feeding in three species of caprellids (Crustacea,

Amphipoda) from the northwestern Florida Gulf coast. J. exp. mar. Biol. Ecol. 15: 81-96

Clark, S. T. (1978). The shallow water marine isopods of Texas. M.S. Thesis, Lamar University, Beaumont, Texas

Clark, S. T., Robertson, P. B. (1982). Shallow marine isopods of Texas, Contr. Mar. Sci. 25: 45-59

Connell, J. H. (1961). The influence of interspecific competition and other factors on the distribution of the barnacle *Chthalamus stellatus*. Ecology 42: 710-723

Crisp, D.J. (1990). Gregariousness and systematic affinity in some North Carolinian barnacles. Bull. Mar. Sci. 47: 516-525

Culpepper, T. J. (1969). A taxonomic study of selected benthonic gammarid crustaceans from the northeastern Gulf of Mexico. Dissertation, Texas A&M Universtiy

Dando, R. P., Southward, A. J. (1980). A new species of *Chthalamus* (Crustacea: Cirripedia) characterized by enzime electrophoresis and shell morphology: with a revision of other species of *Chthalamus* from the western shores of the Atlantic Ocean. J. mar. biol. Ass. U. K. 60: 787-831

Defenbaugh, R. E. (1970). The ocurrence and distribution of the Hydroida of the Galveston Bay, Texas, area. M.S. Thesis, Texas A&M Univ.

Emondson, C. H., Mansfield, G. S. (1948). Hawaiian Caprellidae. Occ. Pap. Berenice P. Bishop Mus. 19: 201-208

Fotheringham, N. (1980). Beachcomber's Guide to Gulf Coast Marine Life. Gulf Publishing Company, Houston

Fuji, A., Nomura, H. (1990). Community structure of the rocky shore macrobenthos in southern Hokkaido, Japan. Mar. Biol. 107: 471-477

Gittings, S. R., Dennis, G.D., Harry, H. W. (1986). Annotated guide to the barnacles of the northern Gulf of Mexico. Texas A&M University Sea Grant Program, TAMU-S6-86-402

Gordon, C. M. (1969). The apparent influence of salinity on
    the distribution of barnacle species in Chesapeake Bay
    (Cirripedia). Crustaceana. 16: 139-142
Harper, D. E., Jr. (1972). Rocky Intertidal Biota. In:
    Biological, Geological and Oceanographic Studies of the
    Hueneme Continental Shelf, California. Ronald L. Kolpak
    and Dale Straughan, Principal Investigators. Report to
    Southern California, Edison.
Hedgpeth, J. W. (1953). An introduction to the zoogeography
    of the northwestern Gulf of Mexico with reference to the
    invertebrate fauna. Publs. Inst. Mar. Sci., Univ. Texas.
    3: 111-224
Hughes, R. N. (1985). Rocky shore communities: catalysts to
    understanding predation. In: Moore, P.G., Seed, R. (ed.)
    The Ecology of Rocky Coasts. Hodder and Stoughton, Ltd.,
    Kent, United Kingdom, p. 223-234
Jones, A. M., Baxter, J. M. (1985). The use of *Patella
    vulgata* L. in rocky shore surveillance. In: Moore, P.G.,
    Seed, R. (ed.) The ecology of rocky coasts. Hodder and
    Stoughton, Ltd., Kent, United Kingdom, p. 265-273
Kapraun, D.F. (1980). Summer aspect of algal zonation on a
    Texas jetty in relation to wave exposure. Contr. Mar.
    Sci. 23: 101-109
Keith, D. E. (1969). Aspects of feeding in *Caprella
    californica* and *Caprella equilibra* Say (Amphipoda).
    Crustaceana. 16: 119-124
Kronberg, I. (1987). Accuracy of species and abundances
    minimal areas determined by similarity area curves. Mar.
    Biol. 96: 555-561
_____. (1988). Structure and adaptation of the fauna
    in the black zone (littoral fringe) along rocky shores in
    northern Europe. Mar. Ecol. Prog. Ser. 49: 95-106
Kudenov, J. D. (1979). New species and records of poly-
    chaetous annelids from the *Tetraclita* (Cirripedia:

Crustacea) zone of the nothern Gulf of California, Mexico. Bull. So. Calif. Acad. Sci. 78: 116-121

Lowe, G. C., Cox, E. R. (1981). Species composition and seasonal periodicity of marine benthic algae of Galveston Island, Texas. Contr. Mar. Sci. 21: 9-24

Lubchenco, J., Menge, B. A. (1978). Community development and persistence in a low rocky intertidal zone. Ecol. Monogr. 59: 67-94

Lubchenco, J., Gaines, S.D. (1981). A unified approach to marine plant-herbivore interactions. I. Populations and communities. Ann. Rev. Ecol. Syst. 12: 405-437

McCain, C. (1965). The Caprellidae (Crustacea: Amphipoda) of Virginia. Chesapeake Sci. 6: 190-196

McKinney, L. D. (1977). The origin and distribution of shallow water gammaridean Amphipoda in the Gulf of Mexico and Caribbean Sea with notes on their ecology. Ph.D. Dissertation, Texas A&M University. 401 pp

McQuaid, C. D., Branch, G. M. (1985). Trophic structure of rocky intertidal communities: response to wave action and implications for energy flow. Mar. Ecol. Prog. Ser. 22: 153-161

Mori, K., Nishihama, S., Tanaka, M. (1985). Community structure of a rocky shore in Tsuji-shima Island, Amakusa. III. The analysis of relationships between distribution of organisms and micro-topographical conditions using small quadrat. Publ. Amakusa Mar. Biol. Lab. 8: 43-63

Moore, H. B., Frue, A. C. (1959). The settlement and growth of *Balanus improvisus*, *B. eburneus* and *B. amphitrite* in the Miami area. Bull. Mar. Sci. 9: 421-440

Ott, L. (1988). An Introduction to Statistical Methods and Data Analysis. 3rd. Ed. PWS-KENT Publishing Company, Boston

Raffaelli, D. G., Hughes, R. N. (1978). The effects of crevice size and availabililty on populations of

   Littorina rudis and *Littorina neritoides*. J. Anim. Ecol.
   47: 71-83

Reimer, A. A. (1976a). Description of a *Tetraclita
   stalactifera panamensis* community on a rocky intertidal
   Pacific shore of Panama. Mar. Biol. 35: 225-238

_____. (1976b). Succession of invertebrates in
   vacant tests of *Tetraclita stalactifera panamensis*. Mar.
   Biol. 35: 239-251

Reyes, P. (1980). Bioestadística Aplicada. 2nd. Ed. Editorial
   Trillas, México, D.F.

Ruppert, E. E., Fox, R. S. (1988). Seashore Animals of the
   Southeast. University of South Carolina Press, Columbia,
   South Carolina

Sousa, W. P. (1979). Experimental investigations of distur-
   bance and ecological succession in a rocky intertidal al-
   gal community. Ecol. Monog. 49: 227-254

Southward A.J., Crisp, D.J. (1956). Fluctuations in the
   distribution and abundance of intertidal barnacles. J.
   mar. biol. Ass. U.K. 35: 211-229

Steinberg, J. E., Dougherty, E. C. (1957). The skeleton
   shrimps (Crustacea: Caprellidae) of the Gulf of Mexico.
   Tulane Stud. Zool. 5: 267-288

Stephenson, T. A., Stephenson, A. (1950). Life between tide-
   marks in North America. I. The Florida Keys. J. Ecol. 38:
   354-402

Stephenson, T. A., Stephenson, A. (1952). Life between tide-
   marks in North America. II. Nothern Florida and the
   Carolinas. J. Ecol. 40: 1-49

Thomas, J.D. (1976). A survey of gammarid amphipods of the
   Barataria Bay, Louisiana region. Cont. Mar. Sci. 20: 87-
   100.

Thurmann, H. V., Webber, H. H. (1984). Marine Biology. Bell
   and Howell Company, Columbus, Ohio

Voss, N. A. (1959). Studies on the pulmonate gastropod *Siphonaria pectinata* (Linnaeus) from the southeast coast of Florida. Bull. Mar. Sci. 9: 84-99

Weinberg, S. (1978). The minimal area problem in invertebrate communities of mediterranean rocky substrata. Mar. Biol. 49: 33-40

Wethey, D. S. (1985). Local and regional variation in settlement and survival in the littoral barnacle *Semibalanus balanoides* (L.): patterns and consequences. In: Moore, P.G., Seed, R. (ed.) The Ecology of Rocky Coasts. Hodder and Stoughton Ltd., Kent, United Kingdom, p. 194-202

Whitten, H. L., Rosene, H. F., Hedgpeth, J. W. (1950). The invertebrate fauna of the Texas coast jetties: a preliminary survey. Publs. Inst. Mar. Sci., Univ. Texas. 1: 53-87

Zimmerman, R. J., Minello, T. J., Baumer, T. J., Castiglione, M. C. (1989) Oyster reef as habitat for estuarine macrofauna. NOAA Technical Memorandum, NMFS-SECF-249

Zottoli, R. A., Carriker, M. R. (1974). Burrow morphology, tube transformation, and microarchitecture of shell dissolution by the spionid polychaete *Polydora websteri*. Mar. Biol. 27: 307-316

Zullo, V. A. (1979). Marine flora and fauna of the northeastern United States. Arthropoda: Cirripedia. NOAA Technical Report. NMFS Circular 425

APPENDIX 1

LIST OF SPECIES COLLECTED IN JULY 1991

SPECIES	T 2				T 3				T 4				Σ
	QI	QII	QIII	QIV	QI	QII	QIII	QIV	QI	QII	QIII	QIV	
B. cavernata	-	-	-	13	-	-	-	-	-	-	8	-	21
Stylochus sp.	-	-	-	-	-	-	-	5	-	-	-	9	14
Nemertinean	-	-	-	-	-	-	-	-	-	-	-	-	-
P. aggregata	-	-	-	-	-	-	-	-	-	-	-	-	-
P. socialis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. websteri	-	-	79	-	-	-	6	74	-	-	1	231	391
C. capitata	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	-	-
N. succinea	-	-	3	-	-	-	1	9	-	-	-	15	28
Autolytus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
E. dispar	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. cf. *gracilis*	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
L. parvapedata	-	-	-	-	-	-	-	-	-	-	-	-	-
H. dianthus	-	-	-	-	-	-	-	-	-	-	-	-	-
Young polychaete	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	-	-	-	-	-	-	-	-	-
N. lineolata	-	4	148	133	-	3	31	48	-	1	75	100	543
Epitonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. haemastoma	-	-	-	-	-	-	-	-	-	-	-	-	-
S. pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-
A. transversa	-	-	-	-	-	-	-	-	-	-	-	-	-
B. exustus	-	-	-	-	-	-	-	2	-	-	-	6	8
C. virginica	-	-	5	-	-	-	1	5	-	-	-	6	17
D. variabilis	-	-	-	-	-	-	-	4	-	-	-	-	4
P. pholadiformis	-	-	-	8	-	-	-	22	-	-	-	163	193
S. antillensis	-	-	-	-	-	-	-	4	-	-	-	7	11
C. fragilis	-	7	551	89	-	2	242	97	-	5	72	109	1174
B. amphitrite	-	-	-	27	-	-	4	119	-	-	-	113	263
B. eburneus	-	-	53	115	-	-	33	136	-	-	32	108	477
D. dianae	-	-	-	-	-	-	1	6	-	-	-	2	9
S. quadridentatum	-	-	-	-	-	-	5	8	-	-	-	14	27
C. equilibra	-	-	-	-	-	-	-	-	-	-	-	-	-
P. tenuis	-	-	-	-	-	-	1	9	-	-	-	8	18
A. valida	-	-	6	-	-	-	-	7	-	-	-	5	18
C. acherusicum	-	-	-	27	-	-	2	435	-	-	3	1449	1916
J. falcata	-	-	3	-	-	-	-	2	-	-	-	9	14
S. minuta	-	-	-	-	-	-	-	-	-	-	-	-	-
O. grillus	-	-	21	-	-	-	4	11	-	-	1	325	362
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
M. adina	-	-	1	-	-	-	-	2	-	-	-	7	10
Chironomid	-	-	-	-	-	-	-	-	-	-	-	-	-
H. elongata	-	-	-	-	-	-	1	1	-	-	-	2	4
Σ	-	11	752	530	-	5	332	1006	-	6	192	2688	5522

APPENDIX 2
LIST OF SPECIES COLLECTED IN SEPTEMBER 1991

SPECIES	T2				T3				T4				
	QI	QII	QIII	QIV	QI	QII	QIII	QIV	QI	QII	QIII	QIV	Σ
B. cavernata	-	-	-	-	-	-	-	-	-	-	-	7	7
Stylochus sp.	-	-	-	-	-	-	-	2	-	-	1	3	6
Nemertinean	-	-	-	-	-	-	-	-	-	-	-	1	1
P. aggregata	-	-	-	-	-	-	-	-	-	-	-	-	-
P. socialis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. websteri	-	-	-	-	-	-	-	64	-	-	27	46	137
C. capitata	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	-	-
N. succinea	-	-	-	-	-	-	-	12	-	-	2	17	31
Autolytus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
E. dispar	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis sp.	-	-	-	-	-	-	-	-	-	-	-	2	2
S. cf. *gracilis*	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
L. parvapedata	-	-	-	-	-	-	-	18	-	-	-	9	27
H. dianthus	-	-	-	-	-	-	-	-	-	-	-	-	-
Young polychaete	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	-	-	-	-	-	-	-	-	-
N. lineolata	-	-	150	-	-	2	13	22	1	3	133	8	332
Epitonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. haemastoma	-	-	-	-	-	-	-	-	-	-	2	2	4
S. pectinata	-	-	-	-	-	-	-	-	-	-	-	1	1
A. transversa	-	-	-	-	-	-	-	-	-	-	-	1	1
B. exustus	-	-	-	-	-	-	-	1	-	-	1	8	10
C. virginica	-	-	-	-	-	-	-	2	-	-	3	8	13
D. variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. pholadiformis	-	-	-	-	-	-	-	15	-	-	2	69	86
S. antillensis	-	-	-	-	-	-	-	5	-	-	1	11	17
C. fragilis	-	-	1148	-	-	13	86	31	-	-	461	147	1886
B. amphitrite	-	-	-	-	-	-	-	97	-	-	32	66	195
B. eburneus	-	-	-	-	-	-	8	136	-	-	112	94	350
D. dianae	-	-	-	-	-	-	-	9	-	-	3	5	17
S. quadridentatum	-	-	-	-	-	-	-	-	-	-	-	-	-
C. equilibra	-	-	-	-	-	-	-	-	-	-	-	-	-
P. tenuis	-	-	-	-	-	-	-	81	-	-	3	80	164
A. valida	-	-	-	-	-	-	-	-	-	-	-	-	-
C. acherusicum	-	-	-	-	-	-	-	870	-	-	263	8260	9393
J. falcata	-	-	-	-	-	-	-	-	-	-	-	-	-
S. minuta	-	-	-	-	-	-	-	-	-	-	-	-	-
O. grillus	-	-	-	-	-	-	-	-	-	-	65	46	111
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
M. adina	-	-	-	-	-	-	-	9	-	-	17	24	50
Chironomid	-	-	-	-	-	-	-	-	-	-	-	-	-
H. elongata	-	-	-	-	-	-	-	2	-	-	-	2	4
Σ	-	-	1298	-	-	15	107	1376	1	3	1128	8916	12844

APPENDIX 3
LIST OF SPECIES COLLECTED IN NOVEMBER 1991

SPECIES	T 2				T 3				T 4				Σ
	QI	QII	QIII	QIV	QI	QII	QIII	QIV	QI	QII	QIII	QIV	
B. cavernata	-	-	-	2	-	-	-	1	-	-	2	14	19
Stylochus sp.	-	-	-	2	-	-	-	34	-	-	-	12	48
Nemertinean	-	-	-	-	-	-	-	6	-	-	1	2	9
P. aggregata	-	-	-	-	-	-	-	-	-	-	-	-	-
P. socialis	-	-	-	-	-	-	-	1	-	-	-	-	1
P. websteri	-	-	-	2	-	-	-	-	-	-	2	17	21
C. capitata	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	-	-
N. succinea	-	-	-	10	-	-	-	53	-	-	32	88	183
Autolytus sp.	-	-	-	1	-	-	-	1	-	-	-	-	2
E. dispar	-	-	-	1	-	-	-	-	-	-	1	-	2
Syliis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. cf. gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	1	-	1
L. parvapedata	-	-	-	-	-	-	-	-	-	-	-	-	-
H. dianthus	-	-	-	-	-	-	-	1	-	-	-	-	1
Young polychaete	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	-	-	-	-	-	-	-	-	-
N. lineolata	-	7	139	24	-	22	57	-	2	3	231	-	485
Epitonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. haemastoma	-	-	-	1	-	-	-	-	-	-	-	-	1
S. pectinata	-	-	-	-	-	-	-	-	-	-	1	-	1
A. transversa	-	-	-	1	-	-	-	-	-	-	-	-	1
B. exustus	-	-	-	4	-	-	-	2	-	-	2	-	8
C. virginica	-	-	-	15	-	-	-	10	-	-	3	3	31
D. variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. pholadiformis	-	-	-	22	-	-	-	114	-	-	7	61	204
S. antillensis	-	-	-	9	-	-	-	32	-	-	2	5	48
C. fragilis	-	-	446	228	-	1	105	10	-	5	1292	-	2087
B. amphitrite	-	-	-	43	-	-	-	34	-	-	32	14	123
B. eburneus	-	-	-	125	-	-	-	108	-	-	14	25	272
D. dianae	-	-	1	4	-	-	-	435	-	-	2	51	493
S. quadridentatum	-	-	-	2	-	-	-	1	-	-	5	-	8
C. equilibra	-	-	-	-	-	-	-	-	-	-	-	96	96
P. tenuis	-	-	-	2	-	-	-	8	-	-	-	9	19
A. valida	-	-	-	-	-	-	-	-	-	-	-	-	-
C. acherusicum	-	-	-	31	-	-	-	978	-	-	452	4737	6198
J. falcata	-	-	-	-	-	-	-	-	-	-	-	-	-
S. minuta	-	-	-	-	-	-	-	-	-	-	-	10	10
O. grillus	-	-	-	-	-	-	-	-	-	-	10	5	15
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	17	17
M. adina	-	-	-	-	-	-	-	1	-	-	-	2	3
Chironomid	-	-	-	-	-	-	-	-	-	-	-	-	-
H. elongata	-	-	-	-	-	-	-	-	-	-	-	-	-
Σ	-	7	586	529	-	23	162	1830	2	8	2092	5168	10407

APPENDIX 4
LIST OF SPECIES COLLECTED IN JANUARY 1992

SPECIES	T2 QI	QII	QIII	QIV	T3 QI	QII	QIII	QIV	T4 QI	QII	QIII	QIV	Σ
B. cavernata	-	-	-	5	-	-	-	-	-	-	-	3	8
Stylochus sp.	-	-	-	-	-	-	-	1	-	-	-	18	19
Nemertinean	-	-	-	-	-	-	-	-	-	-	1	1	2
P. aggregata	-	-	-	-	-	-	-	-	-	-	-	-	-
P. socialis	-	-	-	-	-	-	-	-	-	-	-	1	1
P. websteri	-	-	-	-	-	-	-	4	-	-	-	-	4
C. capitata	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	1	1
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	2	2
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	-	-
N. succinea	-	-	-	6	-	-	-	5	-	-	-	69	80
Autolytus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
E. dispar	-	-	-	-	-	-	-	-	-	-	-	2	2
Syllis sp.	-	-	-	1	-	-	-	-	-	-	-	1	2
S. cf. gracilis	-	-	-	-	-	-	-	-	-	-	-	1	1
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	-	1	1
L. parvapedata	-	-	-	-	-	-	-	-	-	-	-	-	-
H. dianthus	-	-	-	-	-	-	-	-	-	-	-	15	15
Young polychaete	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	-	-	-	-	-	-	-	-	-
N. lineolata	-	7	149	1	-	4	7	1	2	4	273	-	448
Epitonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. haemastoma	-	-	-	-	-	-	-	-	-	-	-	-	-
S. pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-
A. transversa	-	-	-	-	-	-	-	-	-	-	-	1	1
B. exustus	-	-	-	-	-	-	-	4	-	-	-	3	7
C. virginica	-	-	-	4	-	-	-	5	-	-	1	5	15
D. variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. pholadiformis	-	-	-	8	-	-	-	6	-	-	1	53	68
S. antillensis	-	-	-	4	-	-	-	1	-	-	-	10	15
C. fragilis	-	-	780	24	-	-	120	74	-	-	603	-	1601
B. amphitrite	-	-	-	29	-	-	-	38	-	-	-	4	71
B. eburneus	-	-	-	910	-	-	-	963	-	-	35	385	2293
D. dianae	-	-	-	-	-	-	-	-	-	-	-	3	3
S. quadridentatum	-	-	-	-	-	-	-	-	-	-	-	-	-
C. equilibra	-	-	-	7	-	-	-	10	-	-	5	166	188
P. tenuis	-	-	-	-	-	-	-	-	-	-	-	-	-
A. valida	-	-	-	-	-	-	-	-	-	-	-	-	-
C. acherusicum	-	-	-	47	-	-	-	35	-	-	5	3117	3204
J. falcata	-	-	-	-	-	-	-	-	-	-	-	-	-
S. minuta	-	-	-	-	-	-	-	-	-	-	-	10	10
O. grillus	-	-	-	-	-	-	-	-	-	-	-	1	1
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	2	2
M. adina	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomid	-	-	-	-	-	-	-	-	-	-	-	7	7
H. elongata	-	-	-	-	-	-	-	-	-	-	-	-	-
Σ	-	7	929	1046	-	4	127	1147	2	4	924	3882	8072

APPENDIX 5
LIST OF SPECIES OBSERVED IN MARCH 1992

SPECIES	T 2				T 3				T 4			Σ
	QI	QII	QIII	QIV	QI	QII	QIII	QIV	QI	QII	QIII	QIV	
B. cavernata	-	-	-	4	-	-	-	-	-	-	-	1	5
Stylochus sp.	-	-	-	17	-	-	-	84	-	-	8	33	142
Nemertinean	-	-	-	-	-	-	-	-	-	-	-	-	-
P. aggregata	-	-	-	-	-	-	-	7	-	-	4	6	17
P. socialis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. websteri	-	-	-	1	-	-	-	1	-	-	-	2	4
C. capitata	-	-	-	1	-	-	-	-	-	-	-	-	1
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	1	1
N. succinea	-	-	2	15	-	-	-	44	-	-	21	75	157
Autolytus sp.	-	-	-	1	-	-	-	-	-	-	-	-	1
E. dispar	-	-	-	-	-	-	-	-	-	-	1	-	1
Syllis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. cf. gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
L. parvapedata	-	-	-	13	-	-	-	-	-	-	1	8	22
H. dianthus	-	-	-	-	-	-	-	-	-	-	-	-	-
Young polychaete	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	-	-	-	-	-	-	-	-	-
N. lineolata	4	9	314	15	15	19	63	12	10	13	24	-	498
Epitonium sp.	-	-	-	3	-	-	-	-	-	-	-	-	3
S. haemastoma	-	-	-	-	-	-	-	-	-	-	-	-	-
S. pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-
A. transversa	-	-	-	-	-	-	-	-	-	-	-	-	-
B. exustus	-	-	-	-	-	-	-	2	-	-	6	-	8
C. virginica	-	-	10	6	-	-	-	5	-	-	1	1	23
D. variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. pholadiformis	-	-	-	5	-	-	-	5	-	-	5	4	19
S. antillensis	-	-	-	3	-	-	-	3	-	-	1	-	7
C. fragilis	-	-	720	260	-	-	117	449	-	-	464	-	2010
B. amphitrite	-	-	4	26	-	-	-	22	-	-	4	6	62
B. eburneus	-	-	7	440	-	-	15	1518	-	-	240	1608	3828
D. dianae	-	-	-	125	-	-	-	44	-	-	14	45	228
S. quadridentatum	-	-	-	-	-	-	-	-	-	-	-	-	-
C. equilibra	-	-	-	1	-	-	-	2	-	-	7	325	335
P. tenuis	-	-	-	-	-	-	-	-	-	-	-	1	1
A. valida	-	-	-	-	-	-	-	-	-	-	-	2	2
C. acherusicum	-	-	-	510	-	-	-	351	-	-	47	1629	2537
J. falcata	-	-	-	-	-	-	-	-	-	-	-	1	1
S. minuta	-	-	-	1	-	-	-	-	-	-	-	11	12
O. grillus	-	-	-	1	-	-	-	3	-	-	3	2	9
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
M. adina	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomid	-	-	-	-	-	-	-	-	-	-	-	-	-
H. elongata	-	-	-	-	-	-	-	-	-	-	-	-	-
Σ	4	9	1057	1448	15	19	195	2552	10	13	851	3761	9934

APPENDIX 6
LIST OF SPECIES COLLECTED IN MAY 1992

SPECIES	T 2 QI	QII	QIII	QIV	T 3 QI	QII	QIII	QIV	T 4 QI	QII	QIII	QIV	Σ
B. cavernata	-	-	-	4	-	-	-	1	-	-	-	-	5
Stylochus sp.	-	-	-	11	-	-	-	8	-	-	22	1	42
Nemertinean	-	-	-	-	-	-	-	4	-	-	-	2	6
P. aggregata	-	-	-	-	-	-	-	1	-	-	-	1	2
P. socialis	-	-	-	3	-	-	-	-	-	-	-	-	3
P. websteri	-	-	-	5	-	-	-	5	-	-	-	7	17
C. capitata	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Peresiella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Young phyllodocid	-	-	-	-	-	-	-	-	-	-	-	-	-
N. succinea	-	-	-	83	-	-	-	70	-	-	115	58	326
Autolytus sp.	-	-	-	1	-	-	-	2	-	-	-	-	3
E. dispar	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. cf. gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis (Ehlersia) sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
L. parvapedata	-	-	-	3	-	-	-	1	-	-	-	1	5
H. dianthus	-	-	-	-	-	-	-	-	-	-	-	-	-
Young polychaete	-	-	-	1	-	-	-	-	-	-	-	-	1
Oligochaete	-	-	-	-	-	-	-	1	-	-	-	-	1
N. lineolata	-	2	189	48	-	2	9	47	-	2	190	-	489
Epitonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
S. haemastoma	-	-	-	-	-	-	-	-	-	-	-	-	-
S. pectinata	-	-	-	-	-	-	-	-	-	-	1	-	1
A. transversa	-	-	-	-	-	-	-	-	-	-	-	-	-
B. exustus	-	-	-	-	-	-	-	2	-	-	-	-	2
C. virginica	-	-	-	1	-	-	-	1	-	-	-	-	2
D. variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-
P. pholadiformis	-	-	-	13	-	-	-	13	-	-	40	28	94
S. antillensis	-	-	-	1	-	-	-	2	-	-	-	1	4
C. fragilis	-	-	451	253	-	-	53	316	-	-	734	3	1810
B. amphitrite	-	-	-	5	-	-	-	1	-	-	-	-	6
B. eburneus	-	-	-	567	-	-	-	992	-	-	523	66	2148
D. dianae	-	-	-	134	-	-	-	-	-	-	269	10	413
S. quadridentatum	-	-	-	3	-	-	-	6	-	-	12	-	21
C. equilibra	-	-	-	19	-	-	-	144	-	-	30	379	572
P. tenuis	-	-	-	-	-	-	-	-	-	-	-	-	-
A. valida	-	-	-	2	-	-	-	-	-	-	-	-	2
C. acherusicum	-	-	-	2605	-	-	-	2606	-	-	341	5322	10874
J. falcata	-	-	-	10	-	-	-	10	-	-	34	176	230
S. minuta	-	-	-	-	-	-	-	212	-	-	5	107	324
O. grillus	-	-	-	8	-	-	-	-	-	-	16	1	25
Podocerus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
M. adina	-	-	-	-	-	-	-	2	-	-	-	-	2
Chironomid	-	-	-	-	-	-	-	-	-	-	-	-	-
H. elongata	-	-	-	1	-	-	-	1	-	-	1	1	4
Σ	-	2	640	3781	-	2	62	4448	-	2	2333	6164	17434

APPENDIX 7

ANNUAL ABUNDANCES AND PERCENTAGES FOR EACH MEMBER OF THE GROIN COMMUNITY. (%)* Colonial organisms coverage

ORGANISMS	Σ	%
Algae (%)*	-	44.98
O. dichotoma (%)*	-	10.96
B. cavernata	65	-.10
Stylochus sp.	271	-.42
Nemertinean	18	-.03
P. aggregata	19	-.03
P. socialis	5	-.01
P. websteri	574	-.89
C. capitata	1	-.00
Mediomastus sp.	1	-.00
Paresiella sp.	2	-.00
Young phyllodocid	1	-.00
N. succinea	805	1.25
Autolytus sp.	6	-.01
E. dispar	5	-.01
Syllis sp.	4	-.01
S. cf. *gracilis*	1	-.00
Syllis (Ehlersia) sp.	2	-.00
L. parvapedata	69	-.11
H. dianthus	1	-.00
Young polychaete	1	-.00
Oligochaete	1	-.00
N. lineolata	2795	4.36
Epitonium sp.	3	-.00
S. haemastoma	5	-.01
S. pectinata	2	-.00
A. transversa	3	-.00
B. exustus	43	-.07
C. virginica	101	-.16
D. variabilis	4	-.01
P. pholadiformis	6664	1.03
S. antillensis	102	-.16
C. fragilis	10568	16.47
B. amphitrite	720	1.12
B. eburneus	9368	14.60
L. exotica	P	
D. dianae	1163	1.81
S. quadridentata	56	-.09
C. equilibra	1191	1.86
P. tenuis	202	-.31
A. valida	22	-.03
C. acherusicum	34122	53.18
J. falcata	245	-.38
S. minuta	356	-.55
O. grillus	523	-.82
Podocerus sp.	19	-.03
M. adina	65	-.10
Chironomid	7	-.01
Hippoporina sp. (%)*	-	-.01
M. cf. *tenuis* (%)*	-	2.64
H. elongata	12	-.02
Σ	64123	100.1

VITA

NAME
José Enrique Barraza Sandoval.

EDUCATION
High school Colegio "García Flamenco", San Salvador, El Salvador, 1982.
B.Sc. Universidad de El Salvador (Biology), San Salvador, El Salvador, December 1988.
M.Sc. Texas A&M University (Zoology), May 1993.

EMPLOYMENT
Biology and ecology teacher.
Colegio "Salvadoreño-Español". El Salvador, 1988-1990.

Volunteer research associate
Natural History Museum of El Salvador-El Salvador, 1988-1990.

Teaching Assistant
Texas A&M University-Galveston, fall/1992.

PERMANENT ADDRESS
Department of Marine Biology, Texas A&M University at Galveston, 5007 Avenue U, Galveston, TX 77551, USA.

Alameda Juan Pablo II, Residencial Juan Pablo II # 39, San Salvador, El Salvador, Central America.