OIL PRODUCTION AND ECOLOGY OF THE LITTORAL POLYCHAETA OF TIMBALIER BAY

by Henry Kritzler

ABSTRACT

A seasonal quantitative study was made of the polychaetous annelids from Timbalier Bay in 1973. Collections were analyzed from samples taken near oil drilling and production platforms as well as from two sites located some distance from any oil activities. The species from each sample were identified and the results analyzed according to species diversity, faunal similarities, and biomass. Eighty-two species of polychaetes were identified, raising the total known species from Louisiana to 117. *Spiochaetopterus c. oculatus* accounted for over 80% of the specimen total. The polychaete fauna was diverse with many secondary dominants and many species present in small numbers. Ambient stations always had the highest species and specimen total, biomass, and species diversity, while the lowest values for these parameters were recorded from either the oil drilling station or the production station. The index of similarity showed a close relationship between the oil drilling station and one ambient station, which was probably the result of the high numbers of *Spiochaetopterus* at these two stations. Cluster analysis separated two groups of stations; one group linked the production station with ambient station AB-2; the second group linked the drilling station with ambient station AB-1 and one production station. On the basis of these data, there is no in-

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dication that the long-term oil activities in Timbalier Bay have had any adverse effect on the benthic polychaete communities.

INTRODUCTION

The primary objective of this study was to assess the effects of long-term oil drilling and production on the composition of the benthic polychaetous annelid fauna of estuarine Timbalier Bay. The study was planned in such a way that the results could constitute a scientifically sound baseline against which any possible past or future effects of oil activities could be measured. Since virtually all previous studies on polychaetes from the Gulf of Mexico have been based on qualitative collections, I hoped to contribute to knowledge not only of this group in a bay environment but also of the quantitative occurrences of these organisms.

Prior to this study only 53 species had been reported from Louisiana, the majority from the vicinity of Grand Isle. Warren (1942) recorded three species and later Behre (1950) added 28 species from Grand Isle. Hartman (1951, 1954) summarized the knowledge of the polychaetes from the Gulf of Mexico; she reported 16 species from Louisiana. In the first quantitative study of the marine benthos of Louisiana, Parker (1956) reported 29 species from the eastern Mississippi delta region including a new species, *Cossura delta*, later described by Reish (1958). The number of species of polychaetes known from Louisiana totaled 53 at the outset of this study of Timbalier Bay.

The polychaetes were chosen for study because Timbalier Bay lies within the Mississippi River delta, and its substrate consists exclusively of fine sand, silt, and clay (Barrett 1971). Accordingly, it was expected that the macrobenthos would be dominated numerically and in biomass by deposit-feeding polychaetes. This has generally been found to be the case in fine sediments elsewhere (Blegvad 1928; Sanders 1958; Lie 1968; Rhodes and Young 1970; O'Connor 1972). Since assemblages of polychaete species have been shown to serve as indicators of sewage and industrial pollution (Reish 1955, 1957, 1959), it was thought that the data might also show the effects of long-term oil drilling and production if, indeed, such occur.

MATERIALS AND METHODS

Collection

Sixteen replicate samples were taken from 29 stations for polychaetes in Timbalier Bay over a period of 17 months from September 1972

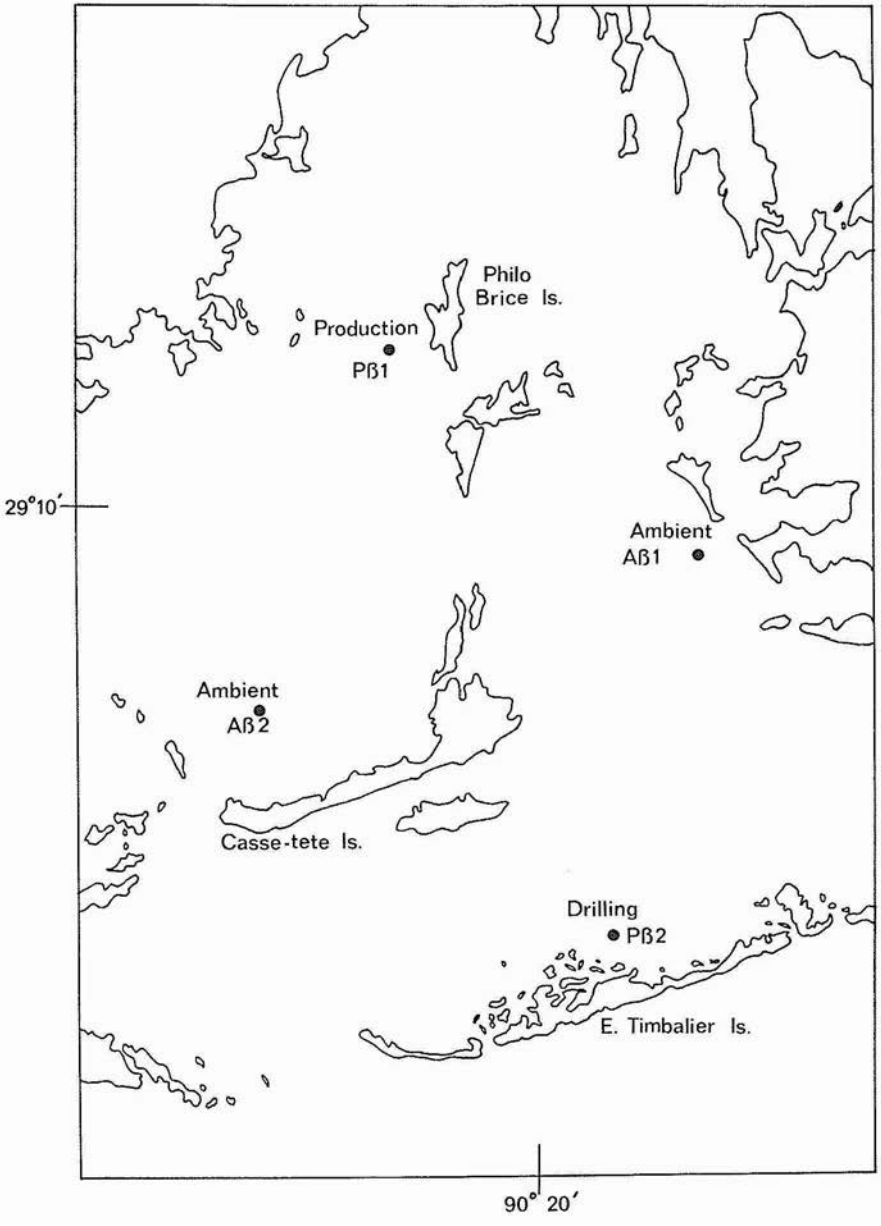

FIG. 1. STATION LOCATIONS.

through January 1974. Samples were taken with a plastic tube, which sampled an area of 625 cm^2 to a depth of 10 cm. The sampler was connected to an air hose that lifted the material into the boat, where it was washed through a 0.5 mm mesh sieve; the material retained on the sieve was preserved (Kritzler et al. 1974). Four stations were completely analyzed, two of which were located near oil operations (producing PB-1 and drilling PB-2) and two of which were used as representative of ambient or natural environmental conditions (AB-1 and AB-2) (figure 1). Data from four stations in winter, spring, and summer 1973 collections were analyzed and two from fall 1973 (PB-1 and AB-2). Since each sample covered a surface area of 625 cm^2, the combined surface area of the 16 replicates was 1.0 m^2.

Data analyses

The polychaetes were identified to species insofar as possible. Biomass was estimated by volumetry and converted to dry weight. The data were analyzed for species diversity and faunal similarities, and were clustered for index of similarities. Species diversity (H′) was calculated according to the method defined by Shannon and Weaver (1963). This index measures both species index and evenness. The numerical value obtained is of particular use in environmental studies in comparing the results of a set of stations. The higher the value, the cleaner, healthier, or more natural the environment; in contrast, a low number indicates a dominance by one or two species with very few others present, which, in turn, may indicate a stressed or polluted environment.

Faunal affinities or similarities (Cλ) between two communities (or stations) were measured by the Morisita-Ono index (Morisita 1959; Ono 1961). The values for Cλ will vary from 0 to 1.0. A numerical value of 1.0 indicates identical communities, and 0 indicates no species in common. A dendrogram was drawn from calculations based on the minimal faunal percentages (Sanders 1958), which were subjected to Mountford's (1962) clustering method.

RESULTS

The quantities of the polychaetes at the four stations analyzed are summarized in tables 1 and 2 according to species, station, date, number of species and specimens, biomass, and species diversity. The results of Morisita-Ono index of faunal similarity for all possible pairs of samples are represented in a trellis diagram in figure 2 (p. 482). A dendrogram showing the similarities and differences of the 14 stations is given in figure 3 (p. 483).

TABLE 1

Polychaetous Annelids in Timbalier Bay, Louisiana, Collected in Winter and Spring 1973

Species	Winter 1973				Spring 1973			
	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2
Spiochaetopterus c. oculatus	113	4210	1872	70	208	4316	3283	56
**Paraeurythoe americana*	14	82	16	5	22	237	58	1
**Myriochele bioculata*	5	23	8	176	50	6		23
**Harmothoe trimaculata*	12	154	8	3	116	3	2	48
Lumbrineris parvapedata	44	45	37	39	68	44	7	8
**Heteromastus filiformis*	24	18	9		6	21	68	19
**Notomastus latericeus*	6	9	3	45	2	1	19	
**Prionospio sexoculata*	21		1		37	22	1	2
Lumbrineris bassi	16	10	13	2	31	32	8	15
**Melinna maculata*					30	10		
**Paraprionospio pinnata*	8	2			24	8		
**Glycinde polygnatha*	12	14	1	2	10	24	15	3
Clymenella t. calida		1	23	3		2	20	
Cossura delta	3	15	1		2	11	1	
**Euclymene* sp.	4	3	1	2	15	14	5	
**Polydora socialis*	1	2	6		2	2	5	13
**Magelona cincta*		4	2	12	12	3	1	2
**Cirriformia tentaculata*		3	4	12				
**Aedicira pallida*		3	5	4			3	10
Cyptis capensis	1	1	9	1	3	3	3	1
**Capitella capitata*		1		9				
**Mystides borealis*	1						9	
Neanthes succinea		2	3	3			9	1
**Asychis urceolata*		8	2		1			
**Harmothoe lunulata*		3		5	2	9		3
**Aricidea fauveli*			8	7				
Pectinaria gouldii					8	2		
**Arabella iricolor*	2	2	7					
**Sigambra tentaculata*	2	3		4	2	6	3	4

TABLE 1 (continued)

Species	Winter 1973				Spring 1973			
	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2
**Neanthes arenaceodentata*			4			1	5	1
**Diopatra c. cuprea*	1		4	2	3		3	
Onuphis e. oculata			4					
**Ancistrosyllis hamata*	1		1	4		3		1
Maldane sarsi		1			3	2	4	1
**Spiophanes bombyx*	3			1				3
**Nereiphylla paretti*		3						1
**Malaceros fuliginosa*			3					
Semiodera roberti		1		3				1
Nerine agilis		1		3		1		
Owenia fusiformis		1			1	1	3	
**Eteone heteropoda*						2	3	
**Nephtys bucera*	1	1			1	2		3
**Bhawaia goodei*	1	1		2	2	1		1
Glycera americana	2		9				6	
**Prionospio cirrifera*		2		1				1
**Eumida sanguinea*		2						
**Tharyx monilaris*		1		2			1	
**Anaitides maculata*				2				
Lumbrineris erecta				2				
Cirratulus cirratus					2			
Glycera rouxi					2	1	1	
**Sabella microphthalma*						2		
**Cabira brevicirrus*								2
**Melinnexis* sp.	1			1				
**Streblospio benedicti*	1	1						
**Dorvillea rudolphi*		1	1					
**Ophiodromus* sp.		1						
**Poecilochaetus* sp.		1						
**Notomastus hemipodus*		1						

TABLE 1 (continued)

Species	Winter 1973				Spring 1973			
	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2
*Armandia polyophthalma		1						
Ninoe n. gracilis		1						
*Megalomma bioculata		1						
*Dasybranchus lumbricoides			1					
*Sthenelais boa			1					
*Pilargis verrucosa				1				
*Scoloplos rubra				1				
*Haploscoloplos robustus				1				
*Drilonereis magna					17	1		
*Magelona longicornis					1			1
Sthenelais articulata							1	
*Pista mirabilis								1
*Aglaophamus verrillii								1
Number of species	26	42	31	33	30	32	28	29
Number of specimens	300	4690	2067	433	692	4940	3544	211
Biomass (g/m^2 dry wt.)	0.29	5.79	2.94	0.86	0.91	5.34	4.57	0.77
Species diversity (H')	4.56	4.85	3.93	5.44	4.74	3.88	3.43	5.60

*denotes previously unreported species

TABLE 2

Polychaetous Annelids in Timbalier Bay, Louisiana, Collected in Summer and Fall 1973

Species	Summer 1973				Fall 1973	
	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2	Production PB-1	Ambient AB-2
Spiochaetopterus c. oculatus	114	2553	1708	79	516	1113
**Harmothoe trimaculata*	48	175		1	61	16
**Paraeurythoe americana*	37	130	1	1	76	1
**Prionospio sexoculata*	120	5	29	11	32	6
Lumbrineris parvapedata	25	48	46	36	45	58
**Melinna maculata*	24	46		2	1	3
**Notomastus latericeus*		2	14	42		42
**Glycinde polygnatha*	15	41	15	1	9	5
Lumbrineris bassi	33	26	40	33	30	25
**Paraprionospio pinnata*	32	2	3	6	7	2
**Eucl*ymene sp.	7	29		4		
Cossura delta	9	8	27			
**Heteromastus filiformis*	8	2	1	5	23	7
**Aedicira pallida*	2	3	2	12	9	20
**Myriochele bioculata*	6			20		6
**Sigambra tentaculata*	6	1	8	4	19	3
**Magelona cincta*	6	5	1	13	3	13
**Harmothoe lunulata*				13		6
**Polydora socialis*		7	2	2		10
Clymenella t. calida		9		10	2	3
**Asychis urceolata*		9				
**Gyptis capensis*	1		6	4	4	1
Owenia fusiformis		2		5		4
Maldane sarsi		5				
Neanthes succinea	4	2	3	3		2
**Nainereis laevigata*						4
**Prionospio cirrifera*				4		
**Magelona longicornis*	1		2	3	1	3
**Diopatra c. cincta*	3	3	1		1	

TABLE 2 (continued)

Species	Summer 1973				Fall 1973	
	Production PB-1	Ambient AB-1	Drilling PB-2	Ambient AB-2	Production PB-1	Ambient AB-2
**Drilonereis magna*		2			3	
**Ancistosyllis hamata*	3	1		1	2	2
**Spiophanes bombyx*				3		1
Glycera americana	1	3			1	
Pectinaria gouldii		3				1
**Aricidea fauveli*		3		1		1
**Ammotrypane aulogaster*						3
**Sthenelais boa*				2		
Cirratulus cirratus	2				1	
**Laonice* sp.				2		
**Nainereis setosa*				2		
**Bhawania goodei*				1	1	
Diopatra c. cuprea		1	1			1
**Tharyx monilaris*		1	1	1		
**Neanthes arenaceodentata*		1		1		
**Loimia viridis*						1
**Myriowenia* sp.				1		1
**Syllidia armata*		1				
**Exogone* sp.		1				1
Cabira brevicirrus						
Glycera rouxi		1				
**Malaceros fuliginosa*				1		
**Cirriformia tentaculata*			1			
**Dorvillea rudolphi*				1		
**Mystides borealis*			1			
Number of species	24	35	22	36	23	32
Number of specimens	508	3132	1918	327	848	1365
Biomass (g/m^2 dry wt.)	0.26	3.30	2.18	0.20	0.70	1.55
Species diversity (H')	3.69	4.22	2.91	6.04	3.26	4.57

*denotes previously unreported species

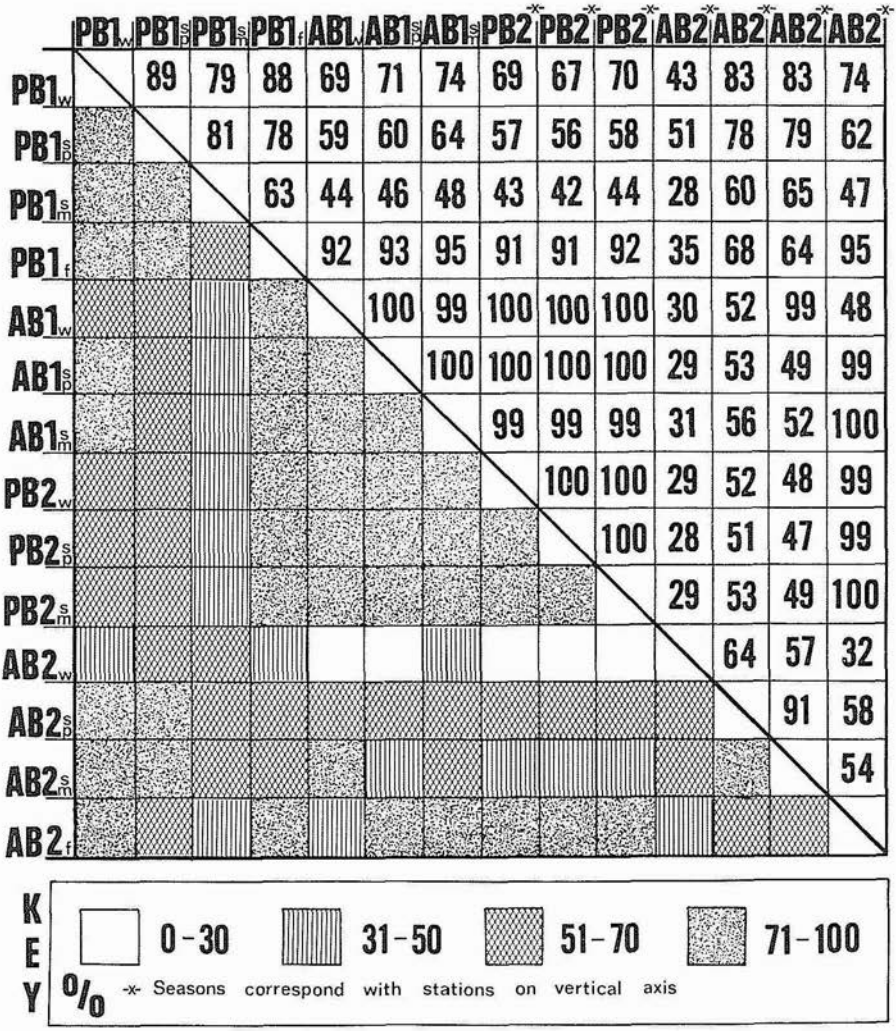

FIG. 2. TRELLIS DIAGRAM SHOWING MORISITA-ONO INDEX OF FAUNAL AFFINITY (×100) for the polychaete data from Timbalier Bay.

A total of 82 species in 33 families of polychaetes was collected in Timbalier Bay (tables 1 and 2). Nearly 25,000 specimens of polychaetes were collected, of which over 80% belong to a single species, *Spiochaetopterus c. oculatus.* Nearly one-half of the species were represented by 5 or fewer specimens; 5 species were encountered at every station and collection period. The more numerous species are listed in table 3 together with the total number of specimens collected.

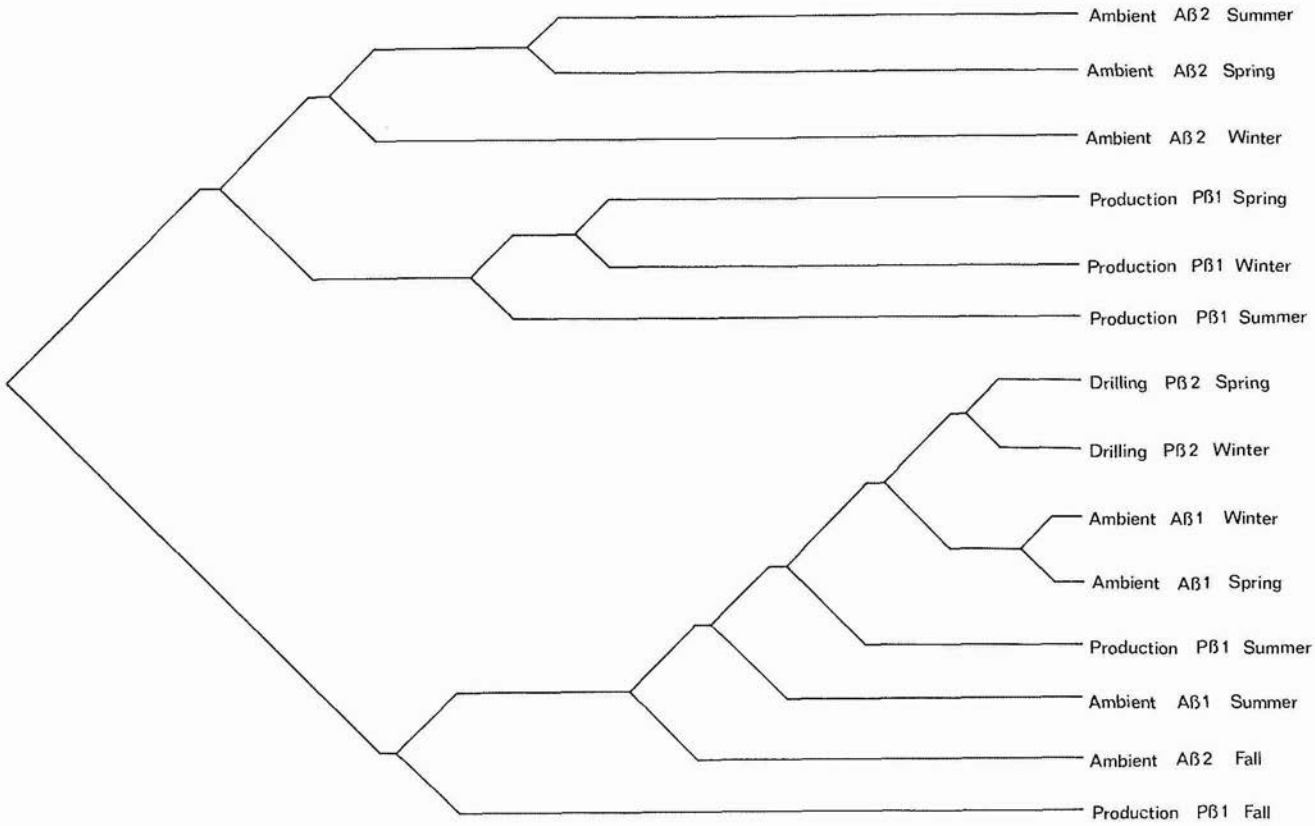

FIG. 3. DENDROGRAM SHOWING THE RESULTS OF A CLUSTER ANALYSIS of the polychaete data from 14 stations.

Spiochaetopterus c. oculatus, *Paraeurythoe americana*, *Lumbrineris parvapedata*, *L. bassi*, and *Glycinde polygnatha* were present at all stations from all collecting periods; these 5 species accounted for over 90% of the specimens collected. The results indicate a rich and diverse polychaete fauna, which is dominated by *Spiochaetopterus* and 4 others plus 14 secondary dominant species (table 3).

The number of species present per station ranged from 22 to 42 with a median of 30. Ambient station AB-1 had the highest average with 36, and production station PB-1 the lowest with 26 species. The number of specimens collected per station ranged from 211 to 4940 with a median of 1783. Ambient station AB-1 had the highest average with 4254 specimens, and production station PB-1 the lowest with 500. Polychaete biomass ranged from 0.2 to 5.79 g/m^2 (dry weight) with a median of 2.12. Ambient station AB-1 had the highest average biomass with 3.81 g/m^2 (dry weight), and production station PB-1 had the lowest with 0.54. Species diversity ranged from 2.91 to 6.04 with a median of 4.04. Ambient station AB-2 had the highest species diversity with 5.41, and drilling station PB-2 had the lowest with 3.42.

Seasonal differences in the various parameters measured were noted, but what occurred at one station during a particular season did not necessarily occur at the others. At the production station PB-1 the highest values were measured during spring for number of species, biomass, and species diversity, but the number of specimens was lowest at this time. The same parameters were highest during the winter collection period at ambient station AB-1. All parameters were more or less similar throughout the four collecting periods at ambient station AB-2. At drilling station PB-2 the number of species and species diversity were low during the summer and the number of specimens increased in the fall. When the various parameters between stations were compared, ambient station AB-1 was highest in biomass at all collecting periods and highest for the number of specimens present for two collections. Ambient station AB-2 was highest in numbers of specimens collected three of the four seasons. Drilling station PB-2 was lowest in species diversity from winter through summer and lowest in number of species present in the spring and summer collections.

When the number of species, specimens, biomass, and species diversity are averaged by collection period, a seasonal pattern is evident. All parameters were highest either during the winter or spring period with a decided drop during the summer period, which generally extended into the fall at the two stations analyzed.

The results of the Morisita-Ono index of affinity ($\times$ 100) are represented by the trellis diagram in figure 2. The polychaete fauna is shown to be very similar in the three collections from ambient station

TABLE 3

Dominant Species of Benthic Polychaetes as Measured by Percent Occurrence

Timbalier Bay, 1973

Species	Station and Collection Period														Total Number of Specimens	Percent Occurrence
	PB-1				AB-1			AB-2				PB-2				
	W	Sp	Sum	F	W	Sp	Sum	W	Sp	Sum	F	W	Sp	Sum		
Spiochaetopterus oculatus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21,211	100
Paraeurythoe americana	X	X	X	X	X	X	X	X	X	X	X	X	X	X	681	100
Lumbrineris parvapedata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	550	100
L. bassi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	314	100
Glycinde polygnatha	X	X	X	X	X	X	X	X	X	X	X	X	X	X	167	100
Harmothoe trimaculata	X	X	X	X	X	X	X	X	X	X	X	X	X		747	93
Heteromastus filiformis	X	X	X	X	X	X	X		X	X	X	X	X	X	211	93
Magelona cincta		X	X	X	X	X	X	X	X	X	X	X	X	X	77	93
Sigambra tentaculata	X	X	X	X	X	X	X	X	X	X	X		X	X	65	93
Gyptis capensis	X	X	X	X	X	X		X	X	X	X	X	X	X	38	93
Notomastus latericeus	X	X			X	X	X	X	X	X	X	X	X	X	187	86
Prionospio sexoculata	X	X	X	X		X	X		X	X	X	X	X	X	281	86
Polydora socialis	X	X			X	X	X	X	X	X	X		X	X	52	79
Aedicira pallida			X	X	X		X	X	X	X	X	X	X	X	73	79
Euclymene sp.	X	X	X		X	X	X	X		X		X	X		84	71
Myriochele bioculata	X	X	X		X	X		X	X	X	X	X			373	71
Neanthes succinea			X		X		X	X	X	X	X	X	X	X	32	71
Paraprionospio pinnata	X	X	X	X	X	X	X			X	X			X	90	71
Ancistrosyllis hamata	X		X	X		X	X	X	X	X	X	X			19	71

AB-1 and drilling station PB-2 as well as in the fall sample from ambient station AB-2. The index of affinity was above .95 in comparisons between these stations, indicating essentially identical polychaete faunas. Close affinity was shown between seasonal samples taken at a station (i.e., production station PB-1). The essential similarity of polychaete faunas at these stations is the result of the overwhelming dominance of *Spiochaetopterus* plus similar populations of *Lumbrineris parvapedata* and *L. bassi*.

The samples taken at ambient station AB-2 had a reduced affinity with samples taken at the same site at different seasons and a very low affinity for the polychaete fauna at other stations. Examination of the raw data included in Kritzler (1974) indicates that the separation of the winter sample at ambient station AB-2 is the result of a shifting in numbers of the dominant species. Ambient station AB-2, winter, was characterized by a large number of *Myriochele bioculata* and *Notomastus latericeus* and by the absence of *Heteromastus filiformis* as well as reduced numbers of *Harmothoe trimaculata* and *Paraeurythoe americana*.

The average index of similarity value for all possible sample pairs (91) was .69, and this figure became .75 when the indices for ambient station AB-2 for winter were excluded from the computation. This high average index value demonstrates a similar polychaete community at these stations in 1973 regardless of the presence or absence of oil production activity.

The results of the polychaete sample clustering based on Sanders's (1960) index of affinity is diagrammed in figure 3. There were two major separations of the station data for polychaetes on the basis of clustering. One group was limited to the winter, spring, and summer collections and was further separated according to location (production station PB-1 and ambient station AB-2). The second major cluster essentially gave a staircase effect after the initial winter and spring separation of drilling station PB-2 from ambient station AB-1. In the latter case, these two stations are dominated by *Spiochaetopterus*, which varied considerably in number of specimens present. *Spiochaetopterus* does not dominate the benthic fauna at production station PB-1 or ambient station AB-2 and the distinct separation, on the basis of location, is related to the presence or absence of secondary dominants at these stations.

DISCUSSION

The number of known polychaetous annelids known from Louisiana marine waters has been increased from 53 to 117 as the result of this

quantitative study. It is reasonable to assume that this number will be increased further by additional quantitative studies especially from offshore waters. The previously unreported species of polychaetes are indicated by an asterisk in tables 1 and 2.

The polychaete assemblage from these four stations sampled in 1973 is basically one association dominated by *Spiochaetopterus* and additional species of polychaetes. This is especially true of ambient station AB-1 and drilling station PB-2 in which *Spiochaetopterus* is present in numbers from 1708 to 4316 per m^2. While *Spiochaetopterus* is not dominant at the other two stations (AB-2 and PB-1), it is still present in considerable numbers. The appearance of other dominants at these stations accounts for the separation of faunal similarities between these two groups of stations as indicated in figures 2 and 3. Since nothing is known concerning the reproduction and settlement of *Spiochaetopterus*, it is impossible to ascertain whether the large populations of this species are continuous in time or represent a single age group following a particularly good larval settlement.

The quantitative occurrence of the polychaetes at these four stations from the 1973 collections was analyzed statistically in three ways; these were species diversity (Shannon-Weaver), faunal similarities (Morisita-Ono), and station clustering. Since *Spiochaetopterus* was so abundant at two of the stations, the species diversities and faunal similarities were calculated with and without this species data. A factor of $\times$ 5 was applied to the crustacean and mollusc data in order to equate the data to 1 m^2 to coincide with the polychaete data; the species diversity and faunal similarities were calculated with and without this factor. Much of the data indicates a close relationship between ambient station AB-1 and drilling station PB-2. As indicated by the faunal similarities, cluster analysis, and biomass data from these two sites, the similarity of these two stations is probably the result of the numerical dominance by *Spiochaetopterus*.

The influence of the record 1973 flood waters of the Mississippi River may account for the differences between the summer collections and the winter-spring collections at all stations as shown by species diversity. Lower values were measured for the summer and fall collections. Since the water is shallow in Timbalier Bay, the higher temperatures during the summer may have also played a role in the reduction of the polychaete population. Whatever the cause of the reduction in the population, however, it was not of sufficient severity as to cause massive mortalities, which, in turn, could lead to a different assemblage of organisms.

The relatively large numbers of polychaete species and specimens found at these four stations in 1973 in Timbalier Bay suggest that the

bay is a healthy one. In the array of species reported herein, we find repeated many of the genera of polychaetes reported by Reish and Winter (1954) in Alamitos Bay, by Barnard and Reish (1959) in Newport Bay, and by Reish (1959) from the unpolluted portions of Los Angeles-Long Beach Harbors, all localities from southern California. This is true also when this species list is compared to that of Sanders (1960) from Buzzard's Bay, Massachusetts. It seems likely that the array of polychaetes in Timbalier Bay is more or less typical of what one may expect to find present in such an area with silts, clays, and sand substrates. No exclusion of species at any one station was noted in Timbalier Bay such as what Reish (1959) found in those portions of Los Angeles-Long Beach Harbors that were heavily polluted with refinery wastes. However, there may be a difference between oil refinery wastes and those resulting from drilling and production of oil. If the ambient stations are representative of an unaffected area, one is led to the conclusion that long-term oil drilling and production in Timbalier Bay have not exerted demonstrated stress on the polychaete assemblages. A more complete answer to this question must wait until the remaining samples taken in this study are analyzed and a parallel study is conducted in a bay of similar characteristics in the Gulf of Mexico but free of oil activities.

CONCLUSIONS

The polychaete fauna in Timbalier Bay consists of about 30 different species per square meter. *Spiochaetopterus* dominates the polychaetes in both number of specimens and biomass at the oil drilling station and one of the ambient ones. Several species, including *Spiochaetopterus*, dominate the benthos at the production platform and at the second ambient station. The polychaete species present within Timbalier Bay seem to be typical of a healthy, unpolluted fine sediment benthic environment. The spatial and temporal variation in species composition, species diversity, faunal similarities, and biomass, which were demonstrated, cannot be correlated with the spatial distribution of oil drilling and production activities, which have occurred in the bay for the past 35 years.

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