OBSERVATIONS ON THE EFFECTS OF OIL FIELD STRUCTURES ON THEIR BIOTIC ENVIRONMENT: PLATFORM FOULING COMMUNITY

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ABSTRACT

The fouling community, its planktonic larvae and its predators were studied at Buccanneer Field, Texas from May, 1976 to April, 1977. Sixteen algae and 101 invertebrate species were identified from the structures. The existing fouling community was dominated by the large barnacle *Balanus tintinnabulum*, which provided a matrix of crevices in which other invertebrates were found. Unoccupied space was rare in the natural community but persisted for several months in disturbed quadrats, especially in winter. The erect bryozoan *Savignyella lafonti* and the urchin *Arbacia punctulata* were seasonally common on the well jacket but absent or rare on the production platform. On the other hand, the erect bryozoans *Bugula neritina* and *Bugula rylandi* and the hydroid *Tubularia crocea* were

seasonally common on the platform but rare on the well jacket. Predator exclusion cages on experimental quadrats seemed to encourage the development of <u>Savignyella lafonti</u> and tubes of the corophiid amphipod <u>Erichthonius brasiliensis</u>. Scraped quadrats were recolonized primarily by hydroids, green algae and sponges. Several fouling species were found on shells on the bottom directly beneath the structures which did not occur on the structures themselves. Growth rates of several mollusks (<u>Pteria colymbus</u>, <u>Musculus lateralis</u>, <u>Anadara transversa</u>, <u>Aequipecten gibbus</u>, and <u>Ostrea equestris</u>) were sufficiently rapid to permit adult size to be attained in less than one year.

INTRODUCTION

Fouling organisms include nearly 2,000 species of sessile algae and invertebrates (WHOI, 1952) that have great economic importance to owners and operators of ships and fixed offshore structures. They increase the fuel consumption of ships and affect the design of offshore oil platforms. The fouling community has been described in many parts of the world and on many substrates (McDougall, 1943; Scheer, 1945; Fuller, 1946; WHOI, 1952; Daniel, 1954; Raja, 1959, 1963; Skerman, 1959; Kawahara, 1962; Nair, 1962; Stubbings & Houghton, 1964; Haderlie, 1969; Pearse & Chess, 1971; Lee & Trott, 1973), including Texas coast oil field structures (Gunter & Geyer, 1955). However, the variation in this community is large, even over relatively short distances (Weiss, 1948), and alternative stable communities may be established at the same site on structures added at different times of the year (Sutherland, 1974).

The fouling community, its planktonic larvae and its predators were investigated at Buccaneer Field from May, 1976 to April, 1977 in an effort to determine the structure and the factors regulating the structure of the fouling community. Offshore structures increase the availability of a limiting resource by providing a substrate for numerous sessile species and associated motile species. This substrate may represent a refuge for undesirable fouling organisms and so may enhance the fouling of shipping in the region. The structures may also provide an invasion route ("stepping stones," in the sense of MacArthur and Wilson, 1967) for undesirable species, such as may enter the Gulf of Mexico if a sea-level canal were constructed across Central America.

MATERIALS AND METHODS

Buccaneer Field is located approximately 50 km (30 mi) south of the lighthouse on Galveston's south jetty. Shell Oil Company has constructed 16 structures on the field: two production platforms and 14 well jackets. Two structures, Platform A and Jacket C (Figure 1), were selected for study. Platform A was selected for its proximity to several of the well jackets, which are potential sources of colonists and predators. For contrast Jacket C was selected for its relative isolation. Both structures are located in approximately 21.5 m (70 ft) of water overlying a silty sand substrate with sporadic clay outcrops.

Most of the field work was conducted with SCUBA, using 2- and 3-man dive teams to collect samples and carry out field experiments on the structures. The field experiments were designed to examine the dynamic properties of the fouling community. The macroscopic component of the community was scraped away from selected portions of the structures. This component was removed with a rock hammer or chisel and sledge from zones 0.5 m (1.6 ft) wide around each of three legs on each structure at the 3 m (10 ft), 8 m (25 ft) and 15 m (45 ft) depths.

The legs selected were from the eastern sides of the structures. A portion of each zone approximately 20 x 30 cm was cleaned thoroughly with a wire brush, and a stainless steel mesh cage measuring 16 x 12 x 2 cm (similar to that of Connell, 1970) was placed over the upper half of this area and fastened with stainless steel or plastic bands around the leg. A wire cloth with 3.15 meshes to the centimeter was used for the cages.

Each cage enclosed two 8 x 12 cm quadrats and protected them from fish grazing. Two matching quadrats below the cage were thus exposed to fish predation. Each quadrat was sampled photogrammetrically using a Nikonos II underwater camera and strobe.

Photographs of good quality were obtained even when the water was very turbid (visability of less than 2 m). Photographs of identical format were taken of undisturbed quadrats for comparison.

Large qualitative (10 - 20 liter) samples were collected from the littoral zone, 8 m and 15 m depths on each structure to provide a taxonomic base for the photogrammetric surveys. These samples were supplemented by smaller qualitative samples from 5, 11, 18 and 21 m depths and by miscellaneous collections of species not previously encountered.

Color transparencies of the 8 x 12 cm quadrats were projected onto a wall from a distance calibrated to produce an image 16 x 24 cm in size. Identifiable organisms and colonies or clusters (eg. hydroids) were traced onto a piece of white paper, and the area of each object was measured with a compensating polar planimeter to the nearest 0.4 cm^2 (i.e. to the nearest 0.1 cm^2 on the original scale). Areas occupied by each species were summed and converted to a proportion of the total area..

Samples of fouling organisms were sorted and the specimens identified to the lowest practical taxon. Presence of ovigerous females or juveniles was noted. Spicules were isolated, mounted and measured as an aid in identifying the sponges.

RESULTS AND INTERPRETATION

A list of the algae, sessile invertebrates and associated motile invertebrates identified from the Buccaneer Field samples is presented in Table 1. Sixteen algal species and 101 invertebrates have been identified from the structures. Among taxa common to both habitats, the species composition of the biota on the structures differed markedly from that associated with adjacent soft bottom habitats, as described by Harper (1977).

The depths and structures at which each of the identified species were found are presented with their relative abundances in Table 2. Since the largest samples were collected in the littoral zone and at 8 m and 15 m, these depths are disproportionately represented in the vertical profiles. These large samples were taken in June-July, 1976 and January, 1977; hence Table 2 is subdivided into summer and winter seasons.

A more quantitative view of the natural community was derived from the interpretation of photographs of undisturbed quadrats. Four photographic transects were run, each consisting of six quadrats at each of six depths (3, 6, 9, 12, 15 and 18 m). A starting point was selected haphazardly and the quadrats at each depth were adjacent to one another to avoid unnecessary bias on the part of the photographer. Transects were run at Platform A on November 1, 1976 and January 21, 1977; transects were run at Jacket C on January 22, 1977. Results are shown in Tables 3 through 6. This technique has the limitation that only sessile species recognizable in photographs were included; however, these collectively represented most of the biomass on the structures.

Perhaps the most conspicuous structural feature of the Buccaneer Field fouling community is the abundance of the large barnacle Balanus tintinnabulum. This barnacle is often 3-4 cm in diameter and, when crowded, may be twice that high. Moreover, individuals were often found growing on top of one another, especially near the sea surface, yielding a three dimensional microhabitat which may be 10-15 cm thick. This undoubtedly contributed to the abundance of snapping shrimp, xanthid crabs, ophiuroids, etc. on the upper portions of the structures and may affect colonization rates on new structures (Schoener, 1974). Twenty years ago B. tintinnbulum was an incidental species on Texas offshore oil field structures (Gunter and Geyer, 1955), and it has remained so on similar structures in Louisiana which are older than those at Buccaneer Field (Thomas, 1975). However, it occupied as much as 77% of the original substrate on Buccaneer Field structures (Table 6).

Unoccupied habitat was extremely rare in natural quadrats and consisted almost entirely of scars left by dislodged barnacles or oysters. Occupied habitat was typically exploited by several layers of organisms. Barnacles appear to be the most perennial inhabitants. A variety of sponges, hydroids and algae appear to be among the earliest colonizers. The species richness on Buccaneer Field structures was apparently intermediate between Louisiana platforms of similiar age (Thomas, 1975) and the fouled floats studied off the Florida Gulf coast by Pequegnat and Pequegnat (1968). However, sampling as extensive as that of the latter study may yield a longer species list for Buccaneer Field.

Recolonization patterns were studied through the use of denuded quadrats and denuded and caged quadrats. Results from nine quadrats representing summer colonization at 15 m on Jacket C (Table 7) indicate that sponges, hydroids and the erect bryozoan *Savignyella lafonti* were the major colonists at this time. The hydroids and bryozoans were typically found growing over the sponges.

Two series of experiments were completed during the winter. Sets of experimental quadrats were established on both structures on September 30 - October 1, 1976. Those on Jacket C were monitored on December 29, 1976 and March 8, 1977; those on Platform A were monitored on January 21 and March 8, 1977. These quadrats were established only at the 8 m and 15 m depths. A second set of quadrats was established at the 3 m, 8 m and 15 m depths on both structures on January 21-22, 1977. Results are presented in Tables 8 through 13.

Initial colonists on uncaged quadrats on Jacket C were green algae, hydroids and sponges, all of which were less abundant in caged quadrats, presumably due to reduced light and planktonic food levels with the cages. Only *Savignyella lafonti* was noticeably more abundant in the cages, where it may have been encouraged by reduced fish predation. Savignyella lafonti was found in the gut contents of Chaetodipterus faber, one of the most abundant resident fishes.

The major barnacle colonists observed during the study were Balanus improvisus and Balanus (amphitrite complex). Juveniles of Balanus tintinnabulum were rarely observed. In general, barnacle colonists were rare, as were barnacle larvae in the plankton samples. Since these observations encompass nearly a year, they suggest that successful sets by the dominant barnacle may not occur annually. Studies of fouling communities (Osman, 1977) and coral reefs (Jackson, 1977) suggest that colonial animals may be better competitors for space than solitary species. In light of this observation, it is surprising that solitary species were not more prominant as opportunistic early exploiters of denuded space.

Subsequent (March 8) observations of the first set of Jacket C quadrats indicated an increased abundance of red algae on the uncaged quadrats and of the encrusting bryozoan Parasmittina trispinosa at the 15 m depth in both caged and uncaged quadrats. Relatively little colonization occurred on the second set of quadrats, that which occurred being primarily hydroids and green algae.

The first set of experimental quadrats on Platform A were also colonized by hydroids, sponges and green algae, with Parasmittina trispinosa and the erect bryozoan Bugula neritina becoming more abundant with time. The second set of quadrats indicated a similar pattern at lower intensity, except without Bugula rylandi and with a greater abundance of Tubularia crocea.

Several interesting differences between the two structures were observed. Savignyella lafonti was seasonally common on Jacket C but rare on Platform A. Similarly, Bugula neritina and Bugula rylandi were seasonally abundant on Platform A but very rare on Jacket C. During the winter a large bloom of the large hydroid Tubularia crocea occurred on Platform A but not on Jacket C. Similarly, the urchin Arbacia punctulata appeared and became moderately common on Jacket C during the winter but was not observed on Platform A. Such spatial variation is often observed and may be attributed to stochastic processes (Fager, 1971).

Among the motile invertebrates, Pachygrapsus transversus and the isopod Dynamene perforata were distinctly littoral, and the tanaids and pycnogonids were predominantly so. Neanthes succinea, Trypanosyllis gemmipara, Turritopisis nutricula, Anadara transversa, Ostrea equestris, Leucothoe spinicarpa, Caprella equilibra, Balanus tintinnabulum, Synalpheus fritzmeulleri, Menippe mercenaria, Bugula neritina, and Aetea anguina had rather broad vertical distributions. Hermit crabs, associated shell-inhabiting species, most gastropods, and Octopus sp. were largely limited to the bottom. Erichthonius brasiliensis was the dominant tube-building amphipod observed, and it appeared to fare better under the protection of the cages than in the open (Tables 9 and 11).

Another relevant feature of this bottom fauna is that most of the gastropod shells, many of which contain hermit crabs, were heavily encrusted by fouling organisms. One Thais haemastoma shell occupied by Dardanus fucosus contained over 20 commensal or fouling species. These included some which have not been found on the structures, such as Chelonibia patula, Lepidonotus sublevis and Porcellana sayana. These shells are a potential source of immigrants to the structures, but some species apparently have not yet made the transition.

Very few organisms (e.g. barnacles) whose growth could be followed in the photographs settled on the experimental quadrats. The mean area covered by 11 Balanus (amphitrite complex) individuals measured 159 days after the quadrat was scraped was 0.134 $\pm$ 0.014 cm^2, suggesting a minimum growth rate of 0.026 cm^2 per month.

The cages on Jacket C were changed on December 29, 1976, and those on Platform A were changed on January 21, 1977. Several species had fouled the cages, and thus their minimum growth rates could be estimated from measurements of individuals returned to the laboratory. The sizes and estimated minimum growth rates of several mollusks and one bryozoan are presented in Table 14. These data are

are compared in the table to the size of the largest individual collected at Buccaneer Field and to the adult size reported in the literature (Andrews, 1977) to determine what proportion of the adult size had been attained.

The presence of ovigerous amphipods, isopods and decapods in the samples was noted in an effort to determine breeding seasons. Ovigerous Jassa falcata were observed in October and January, Leucothoe spinicarpa in June, Erichthonius brasiliensis in July, December and January, Caprella equilibra in June and January, and Stenothoe gallensis in January. Ovigerous Tanais sp. were observed in July, October and January. Ovigerous Synalpheus fritzmeulleri were observed in May, July, September and October, and numerous juveniles were observed in January. Ovigerous Hexapanopeus paulensis were observed in September, Pilumnus dasypodus in September, Porcellana sayana in September, Pachygrapsus transversus in June and July, Menippe mercenaria included numerous juveniles throughout the year but was never observed with eggs, Pseudomedaeus agassizi in September, November and January, Stenorhynchus seticornis in October, and Panopeus turgidus in January. Thus a large portion of these taxa breed during the winter months.

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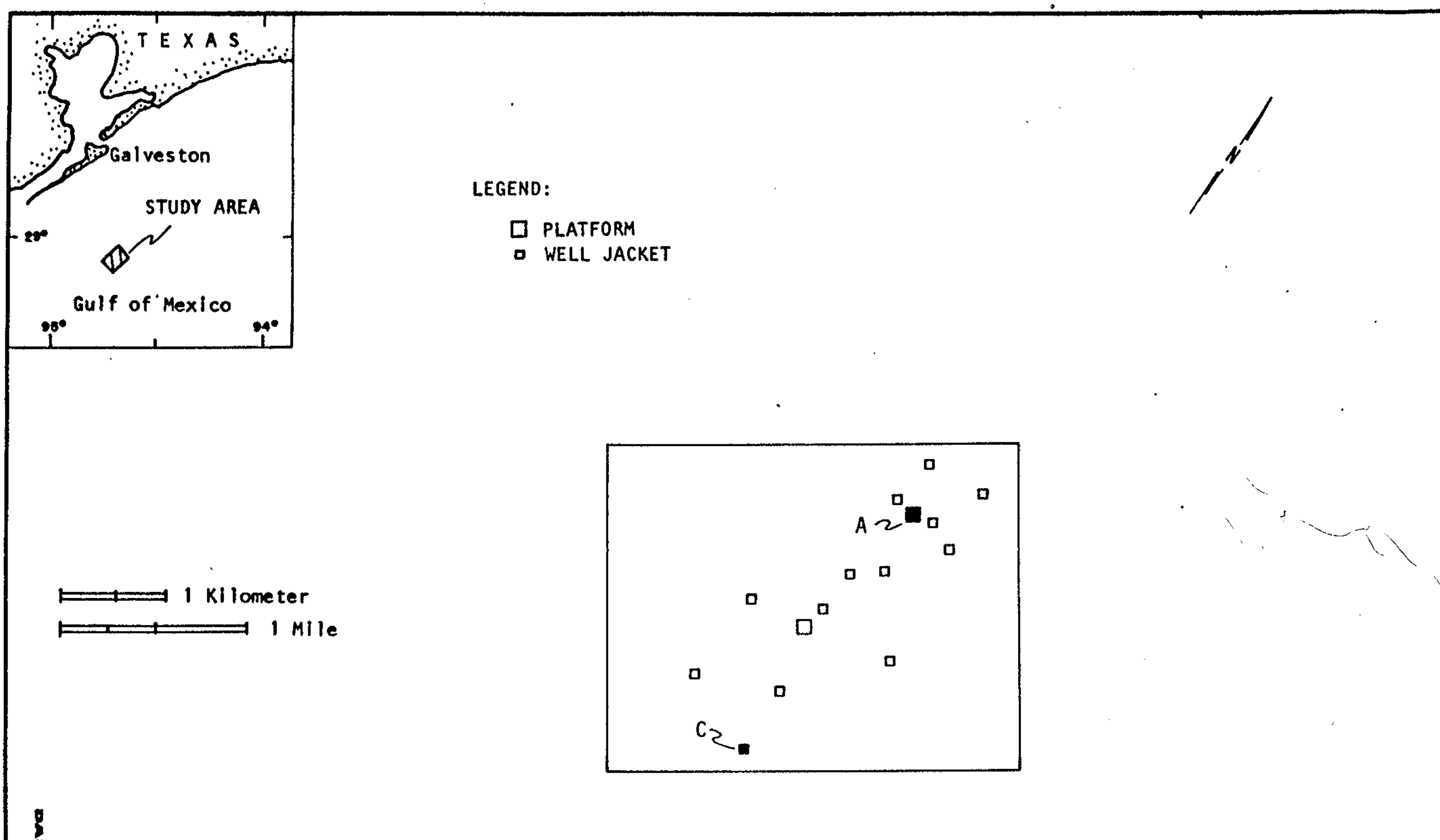

FIGURE 1 - LOCATION OF BUCCANEER FIELD SAMPLING STATIONS
(A = PLATFORM A, C = JACKET C)

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TABLE 1

LIST OF ALGAE AND BENTHIC INVERTEBRATES COLLECTED AT BUCCANEER FIELD

- Chlorophyceae
  - Cladophoraceae
    - *Cladophora delicatula*
    - *Cladophora vagabunda*
    - *Cladophora catenifera*
    - *Chaetomorpha media*
  - Ulvaceae
    - *Enteromorpha lingulata*
    - *Enteromorpha flexuosa*
  - Derbesiaceae
    - *Derbesia vaucheriaeformis*
  - Bryopsidaceae
    - *Bryopsis plumosa*

- Phaeophyceae
  - Ectocarpaceae
    - *Giffordia mitchelliae*

- Rhodophyceae
  - Gelidiaceae
    - *Gelidium pusillum*
  - Rhodomelaceae
    - *Polysiphonia denudata*
    - *Polysiphonia subtilissima*
    - *Centrocerus clavulatum*
    - *Bangia fuscopurpurea*
  - Ceramiaceae
    - *Callithamnion byssoides*
    - *Ceramium byssoideum*

- Porifera
  - Calcerea
    - Homocoelidae
      - *Clathrina* sp.
      - *Leucosolenia botryoides*
    - Heterocoelidae
      - *Scypha* sp.
      - *Leuconia* sp.
  - Demospongiaria
    - Spongiidae
    - Haliclonidae
      - *Haliclona permollis*
      - *Haliclona viridis*
      - *Haliclona loosanoffi*
      - *Haliclona* sp.
    - Renieridae
    - Halichondriidae
      - *Halichondria bowerbanki*
    - Hymeniacidonidae
      - *Hymeniacidon heliophila*
    - Suberitidae
      - *Prosuberites microsclerus*
    - Clionidae
      - *Cliona celata*
      - *Cliona vastifica*

- Hydrozoa
  - Clavidae
    - *Turritopsis nutricula*
  - Campanularidae
    - *Obelia dichtoma*
    - *Obelia hyalina*
    - *Clytia cylindrica*
  - Hydractinidae
    - *Stylactis* sp.
  - Corynidae
    - *Syncoryne eximia*
  - Eudendridae
    - *Eudendrium eximium*
  - Plumularidae
    - *Plumularia diaphana*
  - Tubularidae
    - *Tubularia crocea*

- Anthozoa
  - Ceriantharia
  - Actiniaria
    - Actiniidae
    - Aiptasiidae
    - Aiptasiomorphidae
  - Gorgonacea
    - *Leptogorgia virgulata*
  - Madreporaria
    - *Astrangia* sp.

- Rhynchocoela

- Turbellaria

Polychaeta
- Nereidae
  - *Neanthes succinea*
- Polynoidae
  - *Lepidonotus sublevis*
  - *Lepidonotus variabilis*
- Syllidae
  - *Trypanosyllis gemmipara*
  - *Haplosyllis spongicola*
- Eunicidae
  - *Eunice* sp.
- Lumbrineridae
  - *Lumbrineris* sp.
- Serpulidae
  - *Eupomatus dianthus*
  - *Eupomatus protulicola*
  - *Spirobranchus giganteus*
- Terebellidae
  - *Thelepus setosus*
- Sabellidae
  - *Sabella microphthalma*

Gastropoda
- Dotoidae
  - *Doto* sp.
- Calyptraeidae
  - *Crepidula plana*
  - *Crepidula fornicata*
- Columbellidae
  - *Mitrella lunata*
- Olividae
  - *Oliva sayana*
- Fasciolariidae
  - *Pleuroploca gigantea*
- Buccinidae
  - *Cantharus cancellarius*
- Muricidae
  - *Thais haemastoma*
  - *Murex fulvescens*
- Cerithiopsidae
  - *Seila adamsi*
- Cypraeidae
  - *Cypraea spurca acicularis*
- Ovulidae
  - *Neosimnia acicularis*
- Epitoniidae
  - *Epitonium albidum*
- Turridae
  - *Mangelia* cf. *M. oxytata*

Pelecypoda
- Mytilidae
  - *Lithophaga bisulcata*
  - *Lithophaga aristata*
  - *Brachidontes exustus*
  - *Musculus lateralis*
- Arcidae
  - *Anadara transversa*
  - *Arca imbricata*
- Chamidae
  - *Chama macerophylla*
- Pteridae
  - *Pteria colymbus*
- Ostreidae
  - *Ostrea equestris*
  - *Crassostrea virginica*
- Pectinidae
  - *Aequipecten gibbus*
- Isognomonidae
  - *Isognomon bicolor*
- Veneridae
  - *Chione grus*
- Limidae
  - *Lima pellucida*
- Pinnidae
  - *Atrina seminuda*
- Pholadidae
  - *Diplothyra smythi*

Cephalopoda
- Octopodidae
  - *Octopus* sp.

Pycnogonida
- Tanystylidae
  - *Tanystylum orbiculare*

Amphipoda
- Ischyroceridae
  - *Jassa falcata*
- Leucothoidae
  - *Leucothoe spinicarpa*
- Corophiidae
  - *Erichthonius brasiliensis*
  - *Corophium* sp.
- Caprellidae
  - *Caprella equilibra*
- Gammaridae
  - *Elasmopus* sp.
- Stenothoidae
  - *Stenothoe gallensis*

TABLE 1 (continued)

Isopoda
- Tanaidae
  - *Tanais* sp.
- Sphaeromidae
  - *Dynamene perforata*

Cirripedia
- Chthamalidae
  - *Chthamalus fragilis*
- Balanidae
  - *Balanus tintinnabulum*
  - *Balanus improvisus*
  - *Balanus* (*amphitrite* complex)
  - *Chelonibia patula*

Decapoda
- Alpheidae
  - *Synalpheus fritzmeulleri*
- Diogenidae
  - *Petrochirus diogenes*
  - *Dardanus fucosus*
  - *Paguristes puncticeps*
- Paguridae
  - *Pagurus impressus*
  - *Pylopagurus holthuisi*
- Majidae
  - *Stenorhynchus seticornis*
- Porcellanidae
  - *Porcellana sayana*
- Dromiidae
  - *Dromidia antillensis*
- Grapsidae
  - *Pachygrapsus transversus*
- Portunidae
  - *Portunus gibbesii*
  - *Callinectes similis*
  - *Cronius ruber*
- Xanthidae
  - *Menippe mercenaria*
  - *Hexapanopeus paulensis*
  - *Pilumnus dasypodus*
  - *Pilumnus pannosus*
  - *Pseudomedaeus agassizi*
  - *Panopeus turgidus*

Bryozoa
- Bugulidae
  - *Bugula neritina*
  - *Bugula rylandi*
- Savignyellidae
  - *Savignyella lafonti*
- Schizoporellidae
  - *Schizoporella errata*
- Scrupariidae
  - *Eucratea loricata*
- Smittinidae
  - *Parasmittina trispinosa*
- Membraniporidae
  - *Membranipora tenuis*
  - *Membranipora savartii*
- Aeteidae
  - *Aetea anguina*

Ophiuroidea
- Ophiothricidae
  - *Ophiothrix angulata*
- Ophiactidae
  - *Ophiactis savignyi*

Echinoidea
- Arbaciidae
  - *Arbacia punctulata*

Ascidiacea
- Enterogona

Table 2

SEASONAL AND VERTICAL DISTRIBUTION OF ALGAE AND INVERTEBRATES

Depth interval[1]	lit				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure[2]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Cladophora delicatula	P	P	P	P							P																					
Cladophora vagabunda		P	P																													
Cladophora catenifera			P																													
Chaetomorpha media	P																															
Enteromorpha lingulata	P		P																													
Enteromorpha flexuosa	P																															
Derbesia vaucheriaeformis	P		P								P						P															
Bryopsis plumosa	P																															
Giffordia mitchelliae	P																															
Gelidium pusillum	P	P																														
Polysiphonia denudata	P		P								P	P																				
Polysiphonia subtilissima	P								P		P	P											P									
Centrocerus clavulatum			P	P																												
Bangia fuscopurpurea		P		P																												
Callithamnion byssoides		P	P						P		P	P					P				P											
Ceramium byssoideum	P		P																													
Clathrina sp.	P																															
Leucosolenia botryoides	P		P						P																							
Scypha sp.	P		P						P												P											
Leuconia sp.	P		P																													
Haliclona sp.											P																					
Haliclona permollis									P												P											
Haliclona viridis					P				P																							
Haliclona loosanoffi	P				P				P								P				P		P		P							
Halichondria bowerbanki	P								P								P				P											
Hymeniacidon heliophila											P																					
Prosuberites microsclerus											P																					
Cliona celata									P																							
Cliona vastifica									P																							
Turritopsis nutricula			C		C				C	U	A	U									C	U	C		R							
Obelia dichtoma				C								C					U				R											

Table 2 (continued)

Depth interval[1]	lit				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure[2]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Obelia hyalina			C																													
Clytia cylindrica																	A															
Stylactis sp.	R		U																													
Syncoryne eximia		A		A																												
Eudendrium eximium																					U					R						
Plumularia diaphana																					R				R		R					
Tubularia crocea		C								A							C															
Leptogorgia virgulata									R						R												R					
Astrangia sp.																									R	R	U	U				
Neanthes succinea	C	C	C	U	C				A	C	A	A					U				A	A	C	U	R							
Lepidonotus sublevis																															R	
Lepidonotus variabilis									R												R		R									
Trypanosyllis gemmipara	C	R	U	U	A				A	U	A	U					U				C	R	C	U	U							
Haplosyllis spongicola	A		A		A				A	R	A	C					A					R	C	U	U							
Eunice sp.	R										R												C	R								
Lumbrineris sp.											R												R									
Eupomatus dianthus									R														U								C	
Eupomatus protulicola	U								R		R												R									
Spirobranchus giganteus																											R					
Thelepus setosus																					R											
Sabella microphthalma																																
Doto sp.			C								C												R									
Crepidula plana									R																						C	
Crepidula fornicata																													C	R	C	
Mitrella lunata																							R						R	R		
Oliva sayana																															U	
Pleuroploca gigantea																							R							R		
Cantharus cancellarius																															U	
Thais haemastoma																						R							R	U		
Murex fulvescens																													R		R	

Table 2 (continued)

Depth interval[1]	lit				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure[2]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Stenothoe gallensis		C	C	R						U	C	R														R		R				
Tanais sp.	A	A	A	U	C						A																					
Dynamene perforata	A	C	A	C																												
Chthamalus fragilis			R																													
Balanus tintinnabulum	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	U	U	U	U				
Balanus improvisus											R																					
Balanus (amphitrite complex)			C						U				R												U						R	
Chelonibia patula																															U	
Synalpheus fritzmeulleri			U	C	A				A	A	A		U				R				A	A	A	C	U							
Petrochirus diogenes																															C	
Dardanus fucosus																															C	
Paguristes puncticeps																															U	
Pagurus impressus																															C	
Pylopagurus holthuisi																															U	
Stenorynchus seticornis																							R	R								
Porcellana sayana																															C	
Dromidia antillensis											C										C		U									
Pachygrapsus transversus	U	U	U	C																												
Portunus gibbesii			U																													
Callinectes similis			U																													
Cronius ruber											R	R																				
Menippe mercenaria	R	U	C	R	A				C	R	C	R	U				C				R	R			C							
Hexapanopeus paulensis	R								C		C										C		A							R	C	
Pilumnus dasypodus	R								R				R								R	R	R								U	
Pilumnus pannosus													R																			
Pseudomedaeus agassizi													A								C	A	A	C	C					R	C	
Panopeus turgidus											R																			R		

Table 2 (continued)

Depth interval[1]	lit				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure[2]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Bugula neritina		R		U	R				A	C			A								A	C			R							
Bugula rylandi									U	U			C								U	U										
Savignyella lafonti		R											C								A	R	A				R					
Schizoporella errata									C		C	U	U												U							
Eucratea loricata																											U					
Parasmittina trispinosa										R												U					R					
Membranipora tenuis	U																															
Membranipora savartii									R			R																				
Aetea anguina	A	C			U				C				C								C	U			C							
Ophiothrix angulata									R		R	R																				
Ophiactis savignyi	A	U		C					A	A	R		C								A	C		R								
Arbacia punctulata												U												U								

[1]lit. = littoral;btm. = bottom

[2]1 = Platform A in summer; 2 = Platform A in winter; 3= Jacket C in summer; 4 = Jacket C in winter

P = present; A = abundant; C = common; U = uncommon; R = rare

Table 3

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN UNDISTURBED PHOTOGRAMMETRIC QUADRATS ON NOVEMBER 1, 1976 ON PLATFORM A

	Depth									
	6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.079	.050	.233	.083	.592	.073	.293	.098	.004	.004
Bugula neritina	.023	.020	.015	.010	.040	.028	.014	.009	0	
Savignyella lafonti	0		0		.974	.017	.982	.008	0	
Ostrea equestris	.318	.162	0		0		0		0	
Astrangia sp.	0		0		0		0		.002	.002
Haliclona permollis	.015	.015	.015	.015	.014	.014	0		0	
Haliclona loosanoffi	.160	.160	.245	.245	.473	.213	.991	.006	0	
Haliclona sp.	.797	.161	.595	.595	.155	.155	0		.824	
hydroids	.932	.031	.984	.984	0		0		0	
green algae	.932	.031	.958	.958	.974	.017	.982	.008	0	
serpulids	0		.017	.017	0		0		0	
sponge (red)	0		0	0	0		0		.172	.069
bare substrate	.006	.006	0	0	0		0		.002	.002

[1]mean of six replicates; [2]standard error

Table 4

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN UNDISTURBED PHOTOGRAMMETRIC QUADRATS ON JANUARY 1, 1977 ON PLATFORM A

	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.389	.115	.324	.072	.145	.052	.208	.040	.121	.047	.033	.023
Bugula neritina	..028	.021	.119	.038	.147	.059	.094	.050	.071	.028	.037	.037
Bugula rylandi	0		.001	.001	.076	.055	.185	.130	.020	.015	.015	.015
Savignyella lafonti	0		0		.003	.003	0		0		0	
Parasmittina trispinosa	0		.001	.001	.004	.004	0		0		0	
Ostrea equestris	0		0		0		.001	.001	0		0	
Astrangia sp.	0		0		0		0		0		.002	.002
Tubularia crocea	.090	.035	.187	.048	.025	.021	0		0		0	
Haliclona permollis	.662	.151	0		0		0		0		0	
Haliclona loosanoffi	.0		0		0		0		.731	.151	.800	.163
Haliclona sp.	.128	.128	.637	.039	.721	.063	.428	.186	.167	.167	.167	.167
hydroids	.759	.072	.663	.061	.696	.074	.645	.126	.731	.151	.856	.068
red algae	.014	.009	0		0		0		.012	.012	0	
green algae	.022	.022	0		0		0		0		0	
compound ascidian (transparent)	0		.013	.013	0		0		0		0	
compound ascidian (orange)	0		.003	.013	0		.407	.189	0		0	
sponge (red)	0		0		0		0		0		.031	.027

[1]mean of six replicates; [2]standard error

Table 5

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN UNDISTURBED PHOTOGRAMMETRIC QUADRATS ON JANUARY 22, 1977 ON LEG B1 OF JACKET C

	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.485	.130	.583	.111	.190	.103	.433	.142	.175	.066	.105	.048
Parasmittina trispinosa	.003	.033	.011	.011	.027	.027	0		0		.006	.006
Ostrea equestris	.030	.019	0		.015	.015	0		.006	.006	0	
Haliclona permollis	0		0		.027	.027	0		.125	.125	0	
Haliclona loosanoffi	.0		.582	.160	.392	.164	.498	.167	.709	.171	.762	.194
Haliclona sp.	.839	.095	.381	.156	.404	.163	.385	.198	.100	.100	.181	.181
hydroids	.949	.051	.908	.042	.741	.151	.691	.114	.932	.027	.908	.092
red algae	.063	.039	.006	.006	0		0		0		0	
green algae	.059	.034	0		0		0		0		0	
compound ascidian (transparent)	0		0		0		0		.025	.025	.032	.032
sponge (orange)	0		.007	.006	0		.117	.063	0		0	

[1]mean of six replicates; [2]standard error

Table 6

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN UNDISTURBED PHOTOGRAMMETRIC QUADRATS ON JANUARY 22, 1977 ON LEG B2 OF JACKET C

	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$ [1]	s.e. [2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.392	.151	.682	.112	.529	.083	.771	.098	.386	.072	.255	.161
Bugula neritina	0		0		0		0		.052	.052	.144	.119
Parasmittina trispinosa	0		.007	.004	.006	.006	0		0		0	
Ostrea equestris	0		0		0		.006	.006	.013	.013	0	
Haliclona permollis	.318	.318	.694	.188	.332	.210	0		0		0	
Haliclona loosanoffi	.156	.156	0		.055	.052	.029	.018	.651	.186	.405	.167
Haliclona sp.	.456	.259	0		.491	.220	.904	.030	.124	.124	.257	.170
hydroids	.930	.017	.948	.033	.941	.047	.942	.030	.646	.191	.765	.119
red algae	.076	.013	.010	.006	.051	.048	.005	.004	.002	.002	0	
compound ascidian (transparent)	0		0		0		0		.170	.098	.193	.113
sponge (orange)	.007	.007	0		0		.057	.031	.002	.002	0	

[1]mean of six replicates; [2]standard error

Table 8

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS ON JACKET C ON DECEMBER 29, 1976
(90 Days After Start of the Treatment)

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus (*amphitrite* complex)	.049	.002	.007	.004	.065	.023	.002	.002
Balanus tintinnabulum	0		0		.002	.002	0	
Savignyella lafonti	.003	.003	.002	.002	.159	.054	.185	.089
Parasmittina trispinosa	.005	.004	.088	.048	.100	.045	.095	.049
Ostrea equestris	.004	.004	0		0		0	
Astrangia sp.	0		.001	.001	0		0	
Haliclona permollis	.052	.052	0		0		.004	.004
Haliclona loosanoffi	0		.036	.022	0		.025	.020
Haliclona sp.	.225	.109	.063	.052	.016	.016	0	
Leuconia sp.	0		0		.003	.002	0	
serpulids	0		.001	.001	.001	.001	.004	.002
hydroids	.661	.149	.303	.189	.018	.018	.186	.124
red algae	.001	.001	0		0		0	
green algae	.694	.145	.303	.189	.012	.012	.186	.124
sponge (orange)	0		0		0		.002	.002
compound ascidian (transparent)	0		0		.401	.190	.008	.005
bare substrate	.041	.041	.466	.148	.384	.062	.331	.136

[1]mean of six replicates; [2]standard error

Table 9

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS
ON JACKET C ON MARCH 8, 1977
(159) Days After Start of the Treatment)

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus (*amphitrite* complex)	0		.002	.001	.026	.015	.001	.001
Parasmittina trispinosa	.001	.001	.272	.101	.058	.053	.240	.090
Aetea anguina	0		0		.189	.147	0	
Haliclona permollis	0		0		0		.006	.006
Haliclona viridis	0		0		.010	.006	.056	.036
Haliclona loosanoffi	0		.013	.013	0		.128	.070
Haliclona sp.	.336	.208	.103	.062	0		.017	.017
hydroids	.509	.196	.296	.144	.067	.067	.281	.130
red algae	.341	.221	.134	.058	0		.020	.013
green algae	.696	.118	.049	.045	.009	.009	0	
serpulids	0		.002	.002	0		.002	.002
corophiid tubes	0		0		.067	.067	.153	.059
compound ascidian (transparent)	.036	.022	.227	.102	.481	.273	0	
bare substrate	.003	.003	.132	.084	.161	.066	.115	.048

[1]mean of six replicates; [2]standard error

Table 10

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS
ON JACKET C ON MARCH 8, 1977
(46 Days After Start of the Treatment)

Treatment	Scraped						Scraped and Caged					
Depth	3 m		6 m		9 m		12 m		15 m		18 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus improvisus	0		0		0		0		0		.001	.001
Balanus sp.	0		0		0		0		.001	.001	0	
Parasmittina trispinosa	0		.023	.023	.024	.020	0		0		.050	.039
Haliclona permollis	.022	022	0		0		0		0		0	
Haliclona loosanoffi	0		0		.185	.128	0		0		0	
hydroids	.525	.201	0		.493	.150	063	.050	.189	.144	.132	.084
red algae	.001	.001	.020	.020	.151	.066	0		.063	.043	.002	.002
green algae	.080	.044	.619	.068	0		.008	.007	.236	.133	0	
bare substrate	.444	.205	.338	.110	.423	.136	.926	.047	.675	.111	.815	.083

[1]mean of six replicates; [2]standard error

Table 11

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS
ON PLATFROM A ON JANUARY 21, 1977
(113 Days After Start of the Treatment)

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus (*amphitrite* complex)	0		.002	.001	.026	.015	.001	.001
Parasmittina trispinosa	.001	.001	.272	.101	.058	.053	.240	.090
Aetea anguina	0		0		.189	.147	0	
Haliclona permollis	0		0		0		.006	.006
Haliclona viridis	0		0		.010	.006	.056	.036
Haliclona loosanoffi	0		.013	.013	0		.128	.070
Haliclona sp.	.336	.208	.103	.062	0		.017	.017
hydroids	.509	.196	.296	.144	.067	.067	.281	.130
red algae	.341	.221	.134	.058	0		.020	.013
green algae	.696	.118	.049	.045	.009	.009	0	
serpulids	0		.002	.002	0		.002	.002
corophiid tubes	0		0		.067	.067	.153	.059
compound ascidian (transparent)	.036	.022	.227	.102	.481	.273	0	
bare substrate	.003	.003	.132	.084	.161	.066	.115	.048

[1]mean of six replicates; [2]standard error

Table 12

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS
ON PLATFROM A ON MARCH 8, 1977
(159 Days After Start of the Treatment)

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus (*amphitrite* complex)	.005	.002	0		.006	.006	0	
Balanus improvisus	0		0		.001	.001	0	
Bugula neritina	.296	.065	.483	.125	.252	.094	.434	.056
Bugula rylandi	.001	.001	.031	.025	.041	.013	.122	.059
Parasmittina trispinosa	.246	.078	0		.074	.060	.010	.010
Ostrea equestris	.005	.002	0		.002	.002	0	
Chama macerophylla	0		0		.001	.001	0	
Tubularia crocea	.019	.006	0		.001	.001	.003	.002
Haliclona loosanoffi	.019	.019	.412	.127	0		0	
Haliclona viridis	0		0		.002	.002	0	
Haliclona sp.	0		.043	.030	.061	.050	0	
hydroids	.411	.070	.444	.013	.541	.066	.435	.032
red algae	.032	.016	0		0		0	
green algae	.174	.102	0		0		0	
corophiid tubes	0		0		.108	.065	0	
bare substrate	.006	.005	0		0		0	

[1]mean of six replicates; [2]standard error

Table 13

PROPORATION OF SPACE OCCUPIED BY VARIOUS FOULING SPECIES
IN EXPERIMENTAL PHOTOGRAMMETRIC QUADRATS
ON PLATFORM A ON MARCH 8, 1977
(46 Days After Start of the Treatment)

Treatment	Scraped						Scraped and Caged					
Depth	3 m		8 m		15 m		3 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus improvisus	0		0		0		0		.004	.002	0	
Balanus sp.	.001	.001	0		0		.002	.001	0		0	
Bugula neritina	0		.031	.026	.030	.008	.002	.002	.011	.007	.038	.013
Parasmittina trispinosa	0		.016	.011	0		0		0		.004	.004
Tubularia crocea	.002	.002	.003	.003	0		.079	.033	.038	.020	.009	.009
Haliclona sp.	0		0		.013	.008	0		0		0	
hydroids	0		.087	.058	0		.137	.050	.066	.047	0	
red algae	.021	.021	.006	.006	0		.054	.033	.010	.010	0	
green algae	.172	.056	.011	.006	0		.174	.046	.002	.002	0	
corophiid tubes	.005	.005	0		0		0		0		0	
bare substrate	.801	.059	.847	.084	.957	.007	.742	.044	.870	.038	.949	.018

[1]mean of six replicates; [2]standard error

Table 14

MEASUREMENTS AND ESTIMATED MINIMUM GROWTH RATES
OF SELECTED INVERTEBRATES FOULING CAGES AT BUCCANEER FIELD

Species	Structure	Date	n	$\bar{x}$[1]	s.e.	Maximum Size	Maximum Growth Rate[2]	Maximum Size Observed	Reported Size (Andrews, 1977)
Pteria colymbus	A	1/21	23	1.69	.09	2.56	.69	8.92	3.8 - 7.6
Pteria colymbus	C	12/29	12	1.59	.15	2.48	.83	8.92	3.8 - 7.6
Musculus lateralis	A	1/21	22	.65	.02	.82	.22	.76	1.00
Musculus lateralis	C	12/29	10	.59	.03	.69	.23	.76	1.00
Anadara transversa	A	1/21	1	.52	-	.52	.14	.97	1.2 - 3.6
Aequipecten gibbus	A	1/21	2	1.60	.09	1.69	.46	-	2.5 - 5.2
Ostrea equestris	A	1/21	1	1.60	-	1.60	.43	7.12	2.5 - 5.2
Ostrea equistris	C	12/29	1	.78	-	.78	.26	7.12	2.5 - 5.2
Parasmittina trispinosa	C	12/29	7	7.11	1.76	13.45	4.50	-	-

[1]mean length in cm for mollusks; mean area in cm^2 for *Parasmittina trispinosa*.
[2]in cm $month^{-1}$ for mollusks; in cm^2 $month^{-1}$ for *Parasmittina trispinosa*.

Environmental Effects of Offshore Oil Production: The Buccaneer Oil Field Study, EXPOCHEM '80, October 6-9, 1980, Houston, TX.

ENVIRONMENTAL EFFECTS OF OFFSHORE OIL PRODUCTION: THE BUCCANEER OIL FIELD STUDY

WEDNESDAY MORNING........................Room 201

8:30 Introduction. B. S. Middleditch, University of Houston, Houston, Texas

ORGANIC POLLUTANTS

B. J. Gallaway, Presiding

8:40 (79) Discharge, Fates, and Effects of Hydrocarbons, Biocides, and Sulfur. B. S. Middleditch, University of Houston, Houston, Texas.

9:10 (80) Gaseous and Volatile Hydrocarbons. D. A. Wiesenburg, G. Bodennec, R. A. Burke, Jr., and J. M. Brooks, Texas A & M University, College Station, Texas.

9:30 INTERMISSION

INORGANIC POLLUTANTS AND SEDIMENTS

D. E. Harper, Jr., Presiding

10:30 (81) Total Organic Carbon and Carbon Isotopes of Sediments. E. W. Behrens, University of Texas, Galveston, Texas.

10:50 (82) Trace Metals. J. B. Tillery, Southwest Research Institute, San Antonio, Texas.

11:10 (83) Sedimentology and Geochemistry. J. B. Anderson, R. R. Schwarzer and R. B. Wheeler, Rice University, Houston, Texas.

11:30 (84) Surficial Sediments and Suspended Particulates. J. M. Brooks, E. L. Estes, C. R. Schwab, D. A. Wiesenburg and R. Shokes, Texas A&M University, College Station, Texas.

ENVIRONMENTAL EFFECTS OF OFFSHORE OIL PRODUCTION: THE BUCCANEER OIL FIELD STUDY

WEDNESDAY AFTERNOON....................Room 201

BIOTA I

R. K. Sizemore, Presiding

2:00 (96) Effects of Offshore Oil Field Structures on Their Biotic Environment: Platform Fouling Community. N. Fotheringham, University of Houston, Houston, Texas.

2:20 (97) The Effect of Structures on Migratory and Local Marine Birds. G. D. Aumann, University of Houston, Houston, Texas.

2:40 (98) Distribution and Abundance of Macrobenthic and Meiobenthic Organisms. D. E. Harper, Jr., D. L. Potts, R. R. Salzer, R. J. Case, R. B. Jaschek, and C. M. Walker, Texas A & M University Marine Laboratory, Galveston, Texas.

3:00 INTERMISSION

BIOTA II

J. M. Brooks, Presiding

4:00 (99) Bacterial Community Composition and Activity. R. K. Sizemore, C-S. Hsu and K. D. Olsen, University of Houston, Houston, Texas.

4:30 (100) Effects Upon Platform Fouling Community. B. J. Gallaway, LGL Ecological Research Associates, Bryan, Texas.

5:00 (101) Effects Upon Platform Fish Communities. B. J. Gallaway, LGL Ecological Research Associates, Bryan, Texas.

ENVIRONMENTAL EFFECTS OF OFFSHORE OIL PRODUCTION: THE BUCCANEER OIL FIELD STUDY

BIOASSAYS

THURSDAY MORNING.............................Room 201

R. S. Armstrong, Presiding

8:30 (107) Penaeid Shrimp Bioassays. Z. P. Zein-Eldin, National Marine Fisheries Service, Galveston, Texas.

9:00 (108) Acute Toxicity and Aquatic Hazard Associated with Discharged Formation Water. C. Rose, Energy Resources Co., Cambridge, Massachusetts.

9:30 INTERMISSION

HYDROGRAPHY AND MODELING

B. J. Gallaway, Presiding

10:30 (109) Water Currents and Hydrography. L. J. Danek, Hazleton Environmental Sciences Corporation, Inc., Northbrook, Illinois.

10:50 (110) Hydrodynamic Modeling. G. Smedes, Environmental Research and Technology, Inc., Seattle, Washington.

11:10 (111) The Use of Mathematical Models for Environmental Synthesis. K. W. Fucik, Science Applications, Inc., Boulder, Colorado.

11:30 (112) Transport and Dispersion of Potential Contaminants. R. S. Armstrong, National Marine Fisheries Service, Narragansett, Rhode Island.

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