NOAA Technical Memorandum
NMFS-SEFC-37

NOAA/NMFS ANNUAL REPORT TO EPA

Environmental Assessment of Buccaneer Gas and Oil Field in the Northwestern Gulf of Mexico, 1978 - 1979

A report to the Environmental Protection Agency on work conducted under provisions of Interagency Agreement EPA-IAG-D5-E693-E0 during 1978 - 1979.

Volume III

FISHES AND MACRO-CRUSTACEANS

SOUTHEAST FISHERIES CENTER
GALVESTON LABORATORY

GALVESTON, TEXAS

DECEMBER 1980

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Galveston Laboratory
Galveston, Texas 77550

NOAA Technical Memorandum NMFS-SEFC- 37

Environmental Assessment of Buccaneer Gas and Oil Field In the Northwestern Gulf of Mexico, 1978-1979

VOL.III - EFFECTS OF GAS AND OIL FIELD STRUCTURES AND EFFLUENTS ON PELAGIC AND REEF FISHES, DEMERSAL FISHES AND MACROCRUSTACEANS

BY

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A report to the Environmental Protection Agency on work conducted under provisions of Interagency Agreement EPA-IAG-D5-E693-E0 during 1978-1979.

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GUIDE TO USERS OF THE ANNUAL REPORT

Volume I (SYNOPSIS/DATA MANAGEMENT) of the Annual Report is designed to be used as a briefing document and as a key to more detailed scientific and technical information contained in Volumes II through X. Objectives, methods and results for each work unit are summarized in greatly abbreviated form within Volume I to facilitate dissemination of information. Thus, Volume I can be used alone or as a reference to companion Volumes II through X. Complete citations for literature cited in Volume I can be found in the Volumes II through X in which the detailed work unit reports are presented.

It is hoped that such an approach to environmental impact information dissemination will make the Annual Report a more useful and widely read document.

FOREWORD

Increased petroleum development of the outer continental shelf (OCS) of the United States is anticipated as the U.S. attempts to reduce its dependency on foreign petroleum supplies. To obtain information concerning the environmental consequences of such development, the Federal Government has supported major research efforts on the OCS to document environmental conditions before, during, and after oil and gas exploration, production, and transmission. Among these efforts is the Environmental Assessment of Buccaneer Gas and Oil Field in the Northwestern Gulf of Mexico, a project funded by the Environmental Protection Agency (EPA) through interagency agreement with the National Oceanic and Atomospheric Administration (NOAA) and managed by the National Marine Fisheries Service (NMFS), Southeast Fisheries Center (SEFC), Galveston Laboratory, in Galveston, Texas. Initiated in the autumn of 1975, the study is now in its last year. Its major products have been annual reports disseminated by the National Technical Information Service, data files archived and disseminated by NOAA's Environmental Data and Information Service, and research papers written by participating investigators and published in scientific or technical journals. Results have also been made available through EPA/NOAA/NMFS project reviews and workshops attended by project participants, and various governmental (Federal and State), private, and public user groups. The final products will be milestone reports summarizing the findings of the major investigative components of the study.

Objectives of the project are (1) to identify and document the types and extent of biological, chemical and physical alterations of the marine ecosystem associated with Buccaneer Gas and Oil Field, (2) to determine specific pollutants, their quantity and effects, and (3) to develop the capability to describe and predict fate and effects of Buccaneer Gas and Oil Field contaminants. The project uses historical and new data and includes investigations both in the field and in the laboratory. A brief Pilot Study was conducted in the autumn and winter of 1975-76, followed by an extensive biological/chemical/physical survey in 1976-77 comparing the Buccaneer Gas and Oil Field area with adjacent undeveloped or control areas. In 1977-78, investigations were intensified within Buccaneer Gas and Oil Field, comparing conditions around production platforms, which release various effluents including produced brine, with those around satellite structures (well jackets) which release no effluents. In 1978-79, studies around Buccaneer Gas and Oil Field structures focused on (1) concentrations and effects of pollutants in major components of the marine ecosystem, including seawater, surficial sediments, suspended particulate matter, fouling community, bacterial community, and fishes and macro-crustaceans, (2) effects of circulation dynamics and hydrography on distribution of pollutants, and (3) mathematical modeling to describe and predict sources, fate and effects of pollutants. The final year, 1979-80, of study is continuing to focus on items (1) and (2) and on preparation of the milestone reports which will represent the final products of this study.

This project has provided a unique opportunity for a multi-year investigation of effects of chronic, low-level contamination of a marine ecosystem associated with gas and oil production in a long-established field. In many respects, it represents a pioneering effort. It has been made possible through the cooperation of government agencies, Shell Oil Company (which owns and operates the field) and various contractors including universities and private companies. It is anticipated that the results of this project will impact in a significant way on future decisions regarding operations of gas and oil fields on the OCS.

Charles W. Caillouet, Project Manager
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INTRODUCTION

Location of Study Area

The area selected for study is the operational Buccaneer Gas and Oil Field located approximately 49.6 kilometers (26.8 nautical miles) south southeast of the Galveston Sea Buoy off Galveston, Texas (Figure 1). This field was selected in 1975 as the study area because: (a) the field had been in production for about 15 years, which time had allowed full development of the associated marine communities; (b) it was isolated from other fields which facilitated the selection of an unaltered area (for comparison) within a reasonable distance of the field; (c) it produced both gas and oil that represented sources of pollutants from marine petroleum extraction; (d) its location simplified logistics and reduced the cost of the research; and (e) the Texas offshore area had not been fully developed for gas and oil production but was expected to experience accelerated exploitation in the future.

Operation History of Buccaneer Field

Buccaneer Field was developed by Shell Oil Company in four offshore blocks leased in 1960 and 1968 as follows:

Year	Lease Number	Block Number	Acreage	Hectares
1960	G0709	288	2,790	1,129
1960	G0713	295	4,770	1,930
1960	G0714	296	4,501	1,821
1968	G1783	289	2,610	1,056

In development of the field, 17 structures were built; two are production platforms, two are quarters platforms, and 13 are satellite structures surrounding well jackets. Initial exploratory drilling began about mid-summer of 1960 with mobile drilling rigs. When (as the result of the exploratory drilling) proper locations for platforms were selected, the permanent production platforms were constructed.

There have been no reports of major oil spills from this field. There have been some reported losses of oil due to occasional mechanical failure of various pieces of equipment. The largest reported spill was three barrels in 1973. The reported oil spill chronology and quantity for Buccaneer Field is as follows:

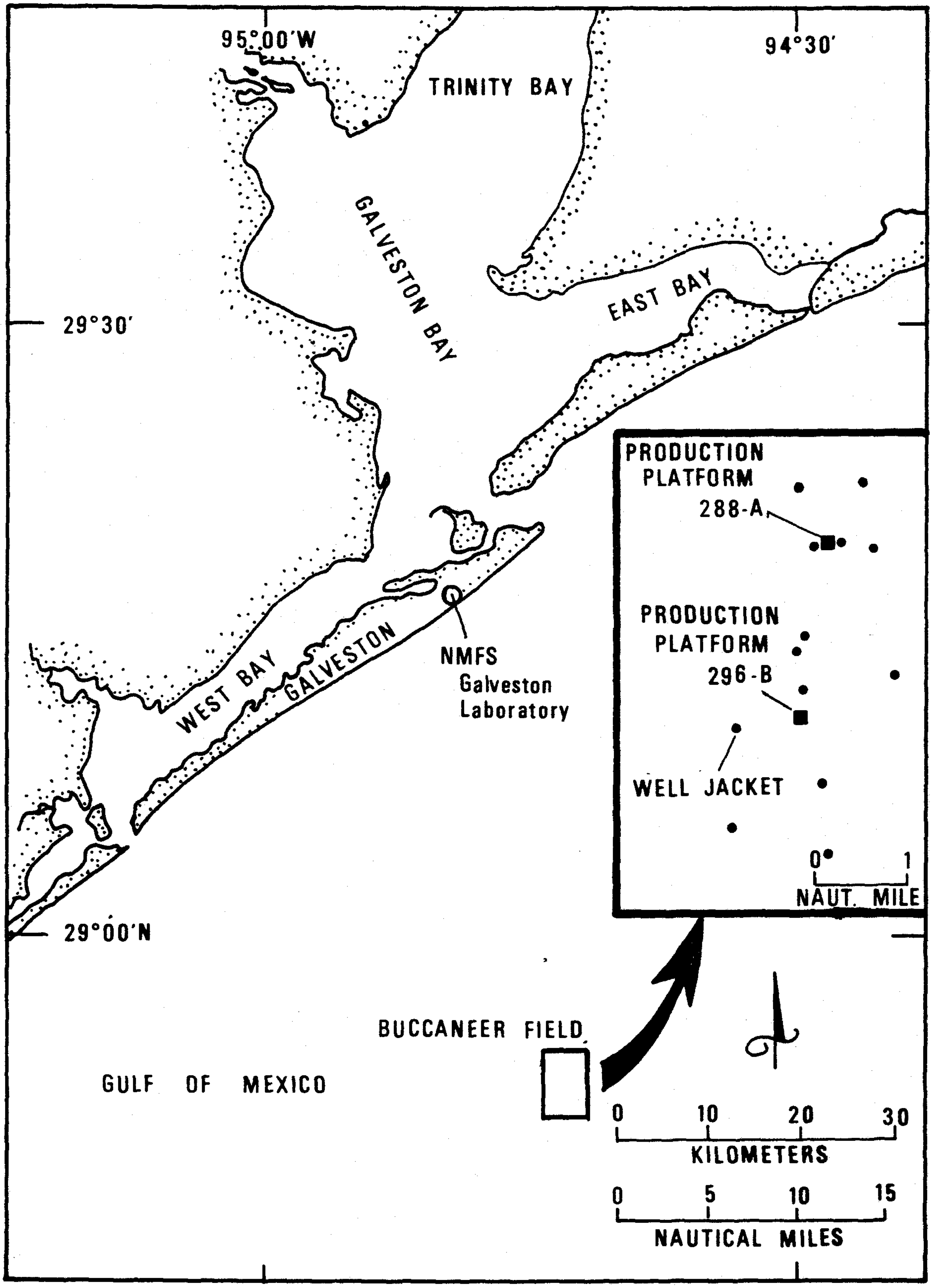

FIGURE 1. LOCATION OF BUCCANEER FIELD

Date	Source	Amount	
		Barrels	Liters
September 1973	Platform 296-B	0.5	79
November 1973	Unknown	3.0	477
July 1974	Platform 296-B	0.5	79
August 1974	Platform 296-B	1.7	265
September 1975	Platform 288-A	0.2-0.4	38-56
Totals		5.9-6.1	938-956

Buccaneer Field first began operations with the production of oil. Later, when significant quantities of gas were found, the field began producing both oil and gas and has continued to do so to date.

The production platforms and satellites (well jackets) are connected by a number of pipelines with a 50.8 centimeters (20-inch) diameter main pipeline connecting the field to shore. All of the pipelines that are 25.4 centimeters (10 inches) or greater in diameter are buried. The Blue Dolphin Pipeline Company was granted a pipeline permit (No. G1381, Blocks 288 and 296) in 1965 and has operated the pipeline since its construction.

Buccaneer Field occupies a limited area (about 59.3 km^2; 22.9 sq. statute miles) leased in the northwestern Gulf of Mexico. Four types of structures are located in Buccaneer Field: production platforms, quarters platforms, satellites (well jackets), and flare stacks. These are shown in Figure 2, which is an oblique aerial photograph of production platform 288-A and vicinity within Buccaneer Field. A map of Buccaneer Field, (Figure 3) depicts the locations of platforms and satellites within the field.

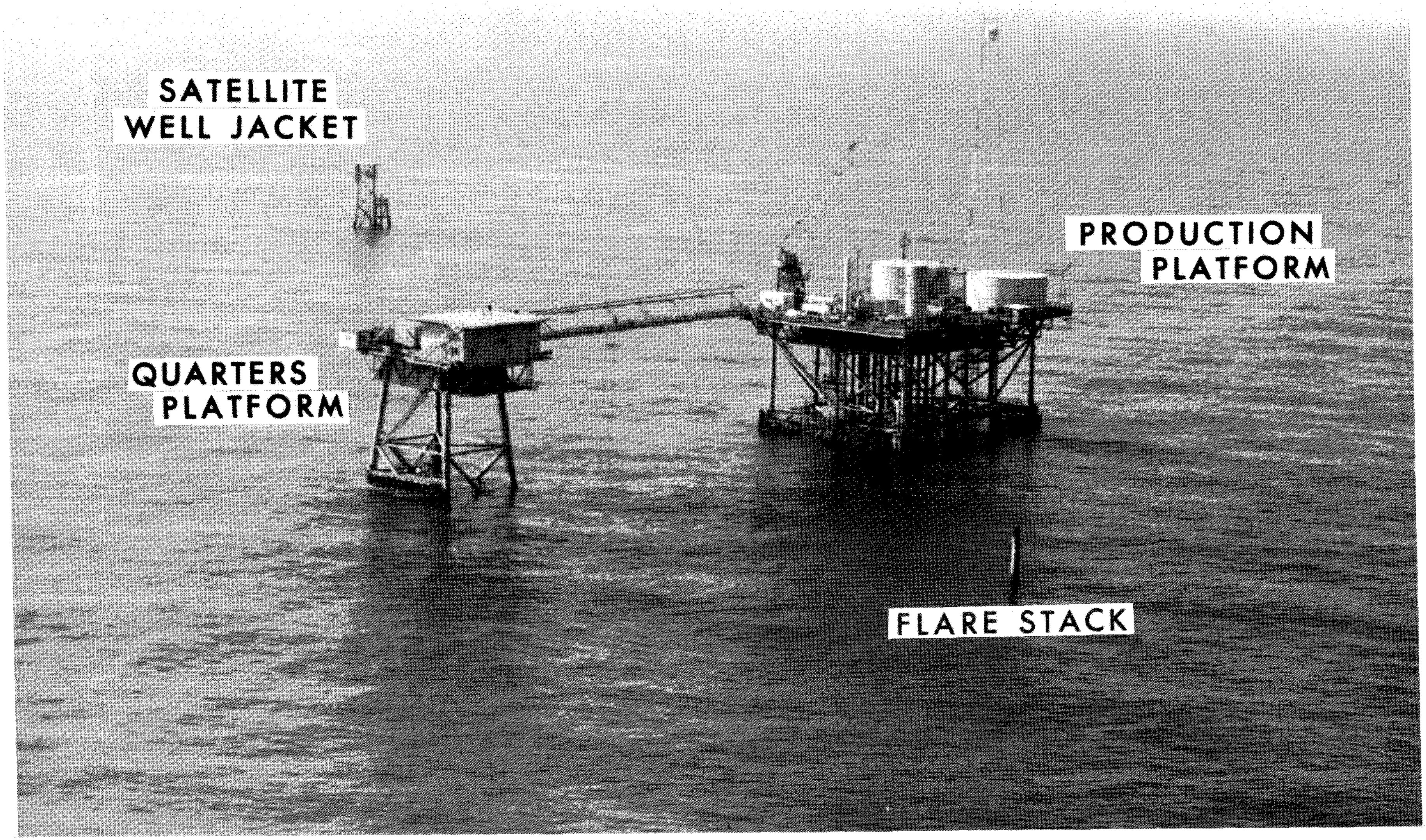

FIGURE 2. BUCCANEER FIELD STRUCTURES

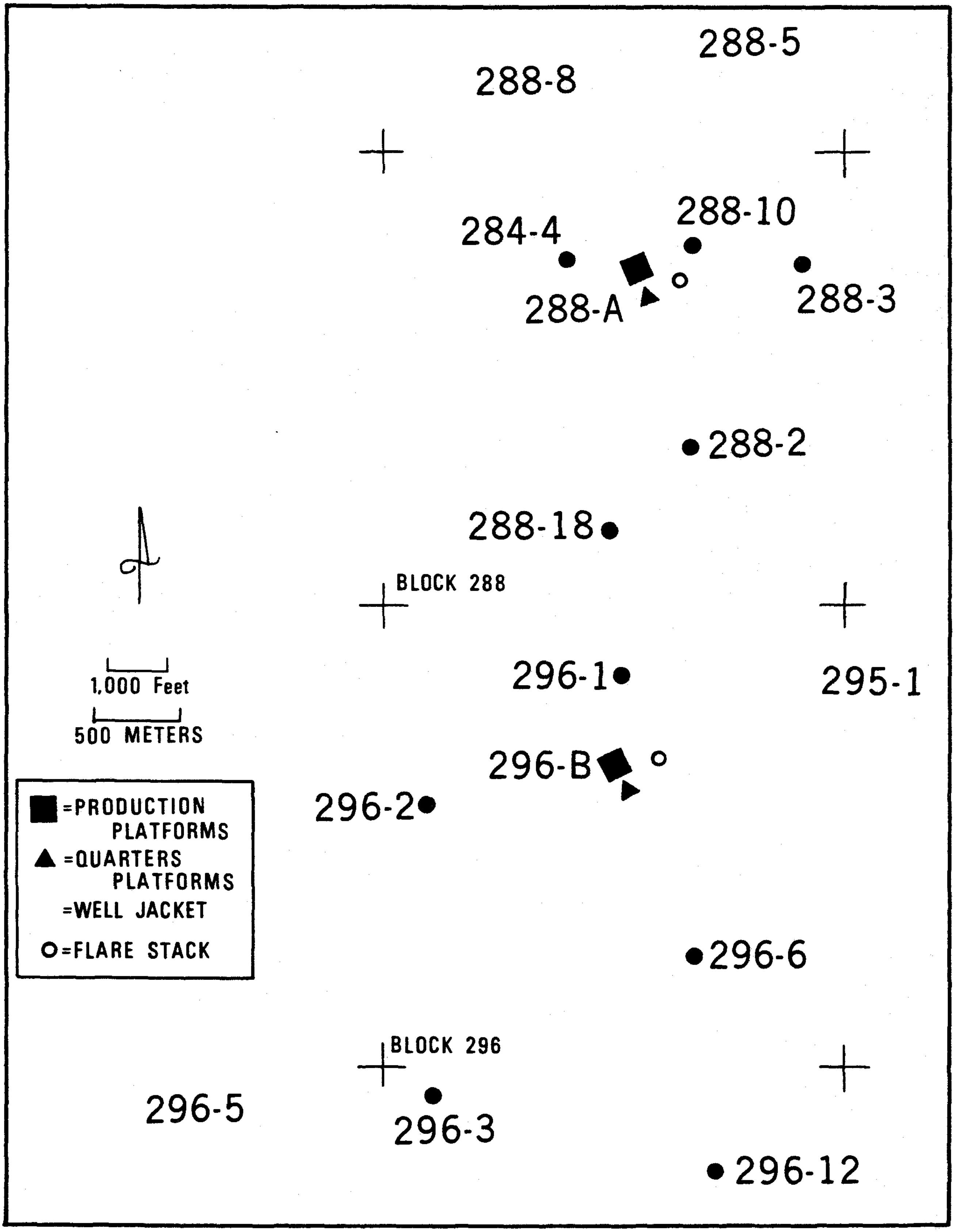

FIGURE 3. SHELL OIL COMPANY'S ALPHANUMERICAL IDENTIFICATION OF BUCCANEER GAS AND OIL FIELD STRUCTURES

WORK UNIT 2.3.5 - EFFECTS OF GAS AND OIL FIELD STRUCTURES AND EFFLUENTS ON PELAGIC AND REEF FISHES, DEMERSAL FISHES AND MACROCRUSTACEANS

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ABSTRACT

Demersal nekton communities in the Buccaneer Oil Field during research year 1978-1979 were dominated by macrocrustaceans, particularly sugar shrimp, *Trachypenaeus similis*. The most abundant fish was the shoal flounder, *Syacium gunteri*. Results of cluster analysis performed on the trawl data indicated three distinct faunal assemblages. Of these, the assemblage grouping all the summer collections was the most dissimilar. The winter collections and the fall collections taken at Production Platform 296 comprised a second distinct cluster whereas the remaining fall collections and all spring collections represented the third major grouping. We interpreted the results to indicate that there were two distinct biological seasons (summer and winter) separated by spring and fall periods of transition.

Based upon analysis of variance performed on the Shannon-Weaver Index (H"), species diversity of the demersal nekton community at control sites was significantly lower than diversity at structures with discharges. Richness of species was generally similar between the two types of structures, but collections taken at control sites were usually strongly dominated by a seasonally abundant form. The resulting lack of evenness of species in collections taken at the control sites contributed towards the significantly lower diversity indices observed there as opposed to that at structures with discharges.

The effects of substrate and platform type on seasonal and areal distributional patterns are provided for dominant, demersal species. Several important species, including sugar shrimp, were indicated more abundant at production platforms than at control structures having the same bottom type. However, within the production platform group, most of the species examined were usually significantly more abundant at P288A (intermittent discharge) than at P296B (continuous discharge).

Atlantic spadefish, *Chaetodipterus faber*, populations were atypically low at Production Platform 296B in summer 1978, and populations at all structures in the Buccaneer Oil Field suffered a disease epidemic during winter. The disease epidemic was believed to have been related to contaminant discharge. This was the second consecutive winter that spadefish disease epidemics have been observed in the field. Bluefish, *Pomatomus saltatrix*, in contrast to the previous year, were scarce or absent in summer 1978. However, as has been observed previously, they were abundant in the study area during other seasons.

Red snapper, *Lutjanus campechanus*, were most abundant during the fall and spring seasons; their low abundance during summer and winter coupled with their non-migratory habitats and the observed heavy fishing pressure in the field, indicate that most of the red snapper recruited to the field were harvested by sportfishermen. We found no evidence of detrimental effects of the discharge on red snapper populations. Based upon the size or age distribution, the oil field population appears overfished, and, we suspect that on a gulf-wide basis, the entire fishery is probably badly in need of regulation or other management.

Sheepshead, *Archosargus probatocephalus*, were found to be a "structure-faithful" species and evidence that resident oil field populations were subject to a higher level of parasitism than were non-resident populations was obtained. The results of this year's program has provided the first indication that sheepshead undergo spawning migrations and/or aggregate at offshore structures for spawning. The Buccaneer Oil Field is a spawning site for this species.

The crested blenny, *Hypleurochelus geminatus*, was more abundant at sites near the discharges on production platforms than at any other location in the field. Such sites offer proportionately more habitat for blennies due to the detrimental effects of the discharge on live barnacles. The blennies utilize empty barnacle shells as habitat. The discharge was not observed to have had any direct detrimental effects on the crested blenny.

EFFECTS OF GAS AND OIL FIELD STRUCTURES AND EFFLUENTS ON PELAGIC AND REEF FISHES AND DEMERSAL FISHES AND MACROCRUSTACEANS

INTRODUCTION

Fisheries investigations have been an integral part of the Buccaneer Oil Field (BOF) studies being performed by the National Marine Fisheries Service (NMFS) Southeast Fisheries Center for the Environmental Protection Agency (EPA). During the 1976-1977 field investigation, studies of demersal fishes and macrocrustaceans (Work Unit 2.3.4) and recreational fisheries of the BOF (Work Unit 2.3.5) were performed by NMFS personnel (Jackson 1977). During 1977-1978, NMFS personnel continued fisheries investigations of pelagic and demersal fishes and macrocrustaceans under Work Unit 2.3.5 and, in addition, studies of spadefish were initiated by representatives of LGL Ecological Research Associates (LGL) as part of Work Unit 2.3.8 dealing with the biofouling community (Jackson 1979).

During the 1978-1979 contract year, all fisheries investigations were combined in a single work unit (2.3.5) and the contract for performance of these studies was awarded to LGL. The general purpose of the 1978-1979 investigations was to further define the effects of BOF gas and oil field structures and effluents on pelagic fish, reef fish and demersal fish and macrocrustacean communities. Oil field fish and macrocrustacean communities had been placed into a regional perspective (oil field *vs* control areas) during 1976-1977 and studies of general effects within the field were described by research performed in 1977-1978. Results of the latter studies formed the basis for more specific experiments which constituted the core of 1978-1979 investigations. The objectives of the third year's research program by fish community category were:

(1) for demersal fishes and macrocrustaceans;

- To describe and compare seasonal abundance and population structure at each of platforms Production 296B and Satellite 288-5 in summer and as later amended at platforms Production 296B, Satellite 288-5, Production 288A and Satellite 296-12 in fall, winter and spring;
- To determine food habits of seasonally dominant fishes,
- To evaluate seasonal health and condition of brown shrimp (*Penaeus aztecus*) based upon histopathological and bacteriological characteristics,

(2) for selected pelagic fishes (spadefish and bluefish);

- To describe seasonal abundance, size and sex distribution, and movements based upon marking and diver census,
- To describe seasonal foods and feeding periodicity,
- To describe seasonal health and condition based upon length-weight regression analysis and bacteriological and histopathological examination; and,

(3) for selected reef fishes (crested blenny, sheepshead and red snapper);

- To describe seasonal abundance, size and sex distribution, and movements based upon marking and diver census,
- To describe seasonal foods and feeding periodicity,
- To describe seasonal health and condition based upon length-weight regression analysis and bacteriological and histopathological examination,
- To determine, for sheepshead and crested blenny, recolonization rates of harvested platforms and areas on platforms, respectively.

In addition to the above objectives, we also collected samples for chemical analyses by other project investigators. All of the 390 planned samples were obtained and transferred.

Field investigations were performed in conjunction with sampling for Work Unit 2.3.8 and on a quarterly basis. Efforts were considered representative of summer 1978, fall 1978, winter 1979 and spring 1979. Summer sampling was initiated 3 August and completed on 7 September 1978; fall sampling extended from 22 November to 18 December; sampling effort for winter suffered the usual disruptions from weather and was performed during the period 21 February-5 April 1978. Spring sampling was performed during the period 3-18 May 1979.

METHODS AND MATERIALS

The diversity of habitats, target species and species groups being investigated required a similar variety of methodologies. In essence. four types of artificial structures were investigated (satellite jackets, production platforms, quarters platforms and flare stacks). Of these satellite jackets were characterized by no discharges and were used as control structures to determine the effects of discharges from other types of structures. Production platforms discharged produced water which has been found to contain low levels of hydrocarbons, biocides and other chemicals and trace elements. During the course of the 1978-1979 studies, Production Platform 296B was actively discharging on a daily basis (1392 bbl/day) and discharges from Production Platform 288A were intermittent. Quarters platforms discharge cooling water and treated sewage; Quarters 296B was occupied during 1978-1979, Quarters 288A was inactive. Similarly, the flare structure 296B was active, Flare 288A was not. The idealized study design (Fig. 1) was intended to allow for comparisons of fish community characteristics in terms of structures with and without discharges taking bottom type into consideration.

Demersal Fishes and Macrocrustaceans

Demersal fishes and macrocrustaceans were sampled using a 12-m otter trawl. Triplicate tows of 10-min duration were taken at night in proximity to structures Satellite 288-5 and the quarters production complex 296B in summer. Based upon differences in collections and the implications of effects of substrate type, the sampling was expanded during the remaining seasons to include Satellite 296-12 and Production-Quarters 288A structures.

Samples were preserved in a 10% buffered formalin and seawater solution and returned to the laboratory for analysis. Collections were sorted by species with each individual weighed (g) using a Mettler top-loading balance and measured (mm). Fishes were measured for fork length, crabs were measured for carapace width and shrimp were measured from the tip of the rostrum to the tip of the telson. For extremely large collections a subsample of 200 individuals were randomly selected for morphometric determinations. During each season, representatives of the dominant trawl fish were selected for stomach analysis by the gravimetric method as described by Gallaway et al. (1979).

Data from the sample analysis were recorded in a computer-ready format, transferred to cards and verified, and were submitted to the NMFS National Fisheries Engineering Laboratory. Collection data were used to calculate species diversity indices and subjected to cluster analysis as described by Gallaway et al. (1979). Length-weight data were used as a basis for analysis of covariance for comparisons of condition, also described in the previous report.

During each season, 5 specimens of brown shrimp were removed from the catch at each of structures Satellite 288-5 and Production Platform 296B for histopathological and bacteriological analyses. The pleopods and gills of each specimen were swabbed and the swab used to inoculate a sterile culture medium. The specimens were then preserved in buffered formalin and returned to the laboratory along with the inoculated media for analyses. Samples were analyzed by representatives of the Texas Veterinary Medical Diagnostic Laboratory in College Station, Texas.

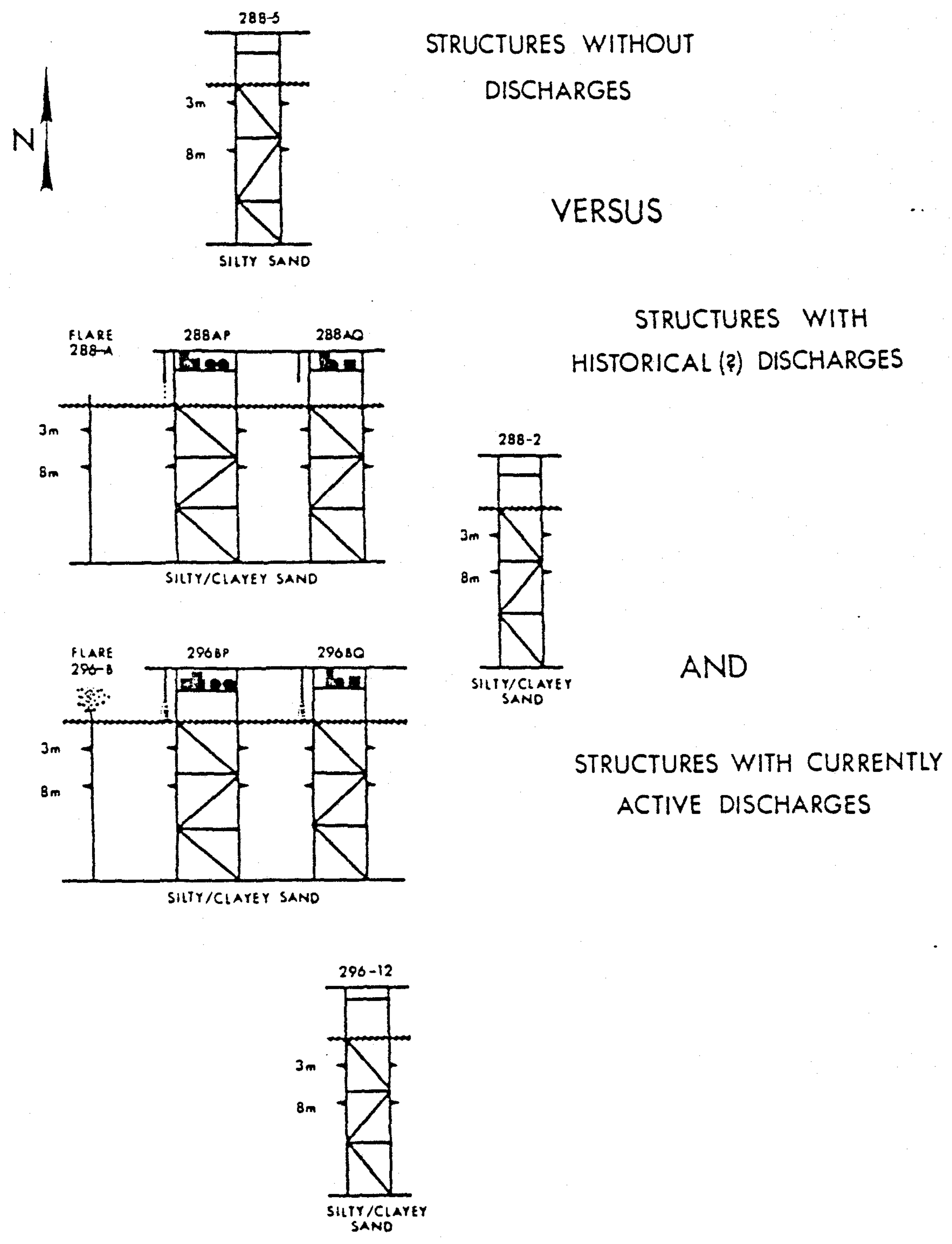

Fig. 1. Idealized experimental design for fish studies in the Buccaneer Oil Field, 1978-1979.

Pelagic Fishes

Spadefish

Population estimates of spadefish at structures Production and Quarters 296B and at Satellite 288-5 were made during summer using a mark-recapture technique (Gallaway et al. 1979). During other seasons, population estimates based upon mark-recapture experiments were made at Production Platform 296B only; the other two platforms were censused for tagged fish during winter.

Specimens of spadefish were collected each season for (1) morphometric determinations, (2) food habits, (3) histopathology and (4) bacterial flora at each of structures Production 296B and Satellite 288-5. Analytical techniques have been previously described (Gallaway et al. 1979).

Bluefish

Mark-recapture experiments for bluefish were performed each season at Production Platform 296B. Bluefish were marked using Floy Tags and guns following capture by hook-and-line. Census sampling was performed by diving scientists. Specimens were collected each season at Production Platform 296B for determinations of morphometrics, food habits, histopathology and bacterial flora.

Reef Fishes

Studies of reef fish populations included a small resident species dependent upon the biofouling community for both habitat and food (crested blenny), and two large species--one an apparent year-round resident (sheepshead), the other an apparent seasonal migrant (red snapper).

Red Snapper

The red snapper investigations were similar to those for other target species. Mark-recapture experiments were performed each season at Production Platform 296B and specimens were collected by trawling, hook-and-line and spear fishing for analysis of morphometric characteristics, food habits, histopathological anomalies and bacterial flora. As for all species for which mark-recapture experiments were performed, the Floy tags were uniquely coded by color and number and contained information requisite for return of the tag to LGL for receipt of reward.

Sheepshead

In addition to specimens being collected each season for morphometric determinations, food habits, histopathological anomalies and determination of bacterial flora, mark-recapture experiments were performed at each of three structures--Production Platform 296B, Quarters 296B and Satellite 288-5. Sheepshead were marked *in situ* using tagging lances and Floy tags and were also censused by diving scientists. A recolonization experiment was performed at Satellite 288-2. At this structure, a near complete spear-fish harvest of sheepshead was performed on 8 August 1978. Following harvest, the platform was censused for recruitment on 12, 16 and 21 August 1978, 5 September 1978, 11 December 1978, 5 April 1979 and 16 May 1979.

Crested Blenny

The number of crested blenny occupying a 0.5 m^2 area at each of 3- and 8-m depths on (1) the discharge and a control leg on Production Platform 296B, (2) the north leg of Quarters Platform 296B, (3) the flare structure 296B, (4) the discharge leg of Production Platform 288A and (5) the west leg of Satellite 288-5 was determined by each of three diving scientists once each season as a basis for determining seasonal abundance and effects of discharges.

As the crested blenny is a small species, we did not expect movement among platforms. However, given the apparent importance of blennies as food to some predators (e.g., almaco jack, *Seriola rivoliana*) we were concerned about rates of recolonization and/or movement of blennies within habitats at a given platform and the effects of produced water on these movements. During summer and winter, 0.5 m^2 areas at 3-m depths on the discharge and a control leg of Production Platform 296B were subjected to a complete blenny harvest. Harvested areas were censused for recolonization two and seven days following harvest in summer and 12 days after harvest in winter.

Specimens of crested blenny were collected each season for determinations of morphometrics, food habits, histopathology and bacterial flora.

RESULTS AND DISCUSSION

Demersal Fishes and Macrocrustaceans

The trawling program resulted in the capture of 103 taxa of nektonic organisms, of which 72 were fishes and 31 were invertebrates. In addition to these, one species of jawfish (2 specimens Opistognathidae) which we suspect is new to the area has yet to be identified and is not included in the total. Of 49,481 specimens trawled, 37,799 were invertebrates and 11,682 were fishes. Invertebrate collections were dominated by sugar shrimp, *Trachypenaeus similis* (25,231); chevron shrimp, *Sicyonia dorsalis* (4,691); rock shrimp, *Sicyonia brevirostris* (4,377); and mantis shrimp, *Squilla empusa* (1,311). Brown (*Penaeus aztecus*), pink (*P. duorarum*) and white (*P. setiferus*) shrimp were represented by 459, 167 and 2 specimens, respectively. The most abundant swimming crab was *Portunus gibbesii* (467 individuals). Collectively the above organisms comprised 97% of the total invertebrate catch.

The 10 most abundant fishes in the trawl collection of 1978-1979 were:

Name	Number Trawled
Shoal flounder (*Syacium gunteri*)	5,825
Dwarf sand perch (*Diplectrum bivitatum*)	1,083
Sea catfish (*Arius felis*)	847
Longspine porgy (*Stenotomus caprinus*)	567
Pancake batfish (*Halieutichthys aculeatus*)	560
Red snapper (*Lutjanus campechanus*)	287
Fringed flounder (*Etropus crossotus*)	285
Atlantic midshipman (*Porichthys porosissimus*)	191
Pigfish (*Orthopristis chrysoptera*)	147
Least puffer (*Sphoeroides parvas*)	137

Collectively these species comprised about 85% of the total fish catch.

Community Aspects

Results of cluster analysis and species diversity indices were used to characterize BOF demersal fish and macrocrustacean communities.

Cluster Analysis. The main objective of the cluster analysis was to determine seasonal patterns among the trawl stations or structures (entities) using species composition and abundance as the attribute upon which comparisons were based. Each replicate or trawl collection was treated as a separate entity allowing for maximum variability. Using this approach, summer collections (Group B, Fig. 2) were greatly dissimilar from all other seasons (Group A, Fig. 2). Within the summer collections, two of the replicates taken at Production Platform 296B comprised

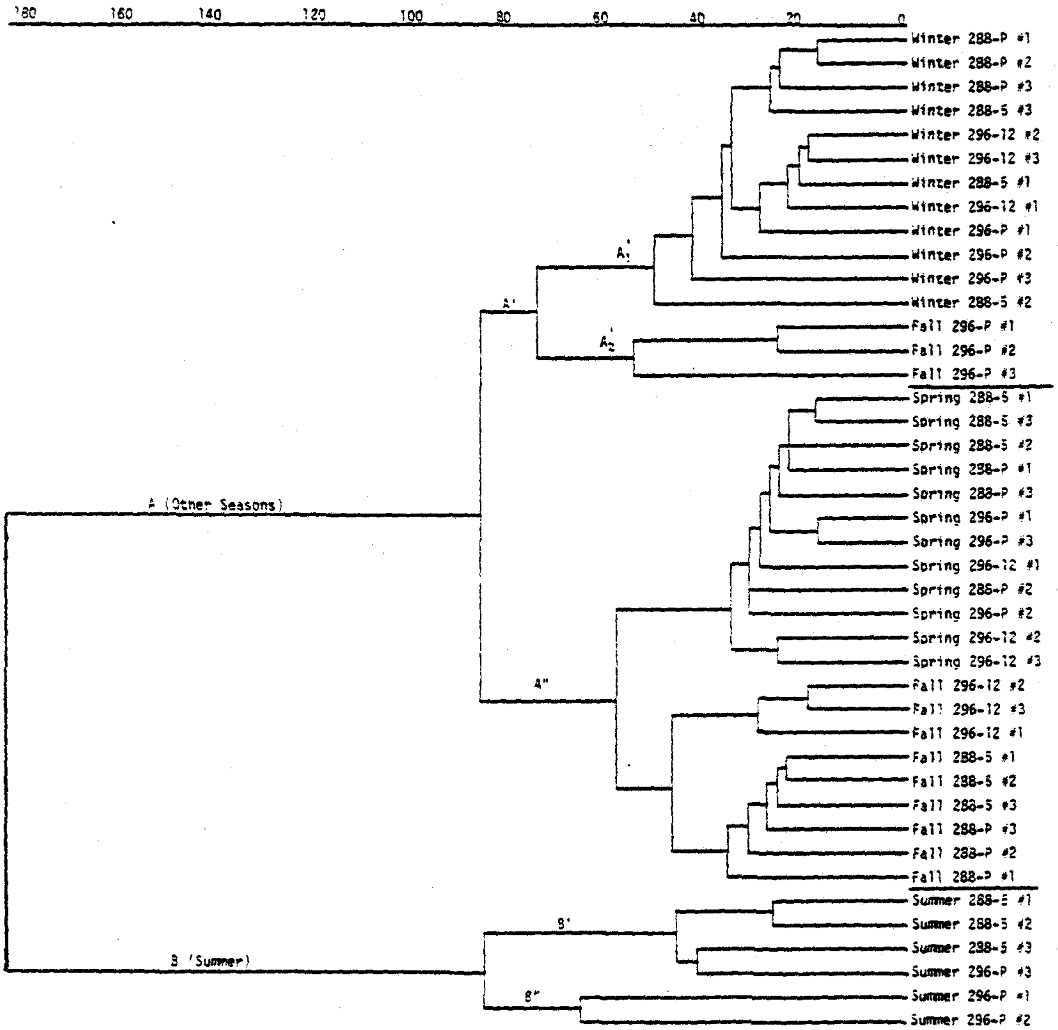

Fig. 2. Normal cluster analysis dendogram for trawl collections made during the 1978-1979 Buccaneer Oil Field study.

a group (B") separate from the other summer collections (B') which included one replicate from Production Platform 296B and the control station collections taken at Satellite 288-5 (Fig. 2).

The "other season" cluster (A, Fig. 2) divided into two major groups which we designate as Winter (A', Fig. 2) and Spring-Fall (A", Fig. 2). Of biological significance, the Fall season collections taken at Production Platform 296B were more similar to winter season collections than to fall samples taken at other stations. Within the Spring-Fall group (A") each season clustered together (Fig. 2).

In general, the summer collections that were taken included fewer species and specimens than were taken during other seasons and were strongly dominated by a single species (longspine porgy) which was abundant during that season alone. Within the summer season, abundance and number of nekton species appeared much higher at the control satellite structure (288-5) than at Production Platform 296B but it was believed that the differences were as likely attributable to substrate differences (Fig. 1) as to contaminant discharge. As described above, the sampling program was expanded after summer to include a satellite (296-12) in the same sediment type as Production Platform 296B for a control, as well as Production Platform 288A which was not only in the same sediment type but was discharging produced water on an intermittent basis. Resulting statistical analysis of nekton species diversity and abundance data using ANOVA were based upon the fall-spring data set and station differences were evaluated using orthogonal contrasts:

1) Satellite 288-5 *vs* Production Platforms 296B and 288A and Satellite 296-12 (sediment type).

2) Satellite 296-12 *vs* Production Platforms (effects of discharge).

3) Production 296B *vs* Production 288A.

Seasonal differences were evaluated using Duncan's Multiple Range Test to rank the seasonal means. When the station by season interaction was significant, differences were evaluated using a graphical format.

Species Diversity. Results of analysis of variance performed on species diversity indices indicated significant differences among stations, seasons and the station by season interaction term:

Source	df	Sum of Squares	Mean Square	F
Total	35	4.74650	0.52478	
Station	3	1.57436	0.52478	17.9*
Season	2	0.41909	0.20955	7.1*
Station x Season	6	2.04918	0.34153	11.7*
Residual	24	0.70339	0.02931	

*Significant at the 1% level

Mean species diversity for Satellite 288-5, Satellite 296-12, Production Platform 296B and Production Platform 288A collections were 1.53, 1.98, 1.78 and 1.45, respectively. Results of the orthogonal contrasts for stations indicated that collections taken at Satellite 288-5 on silty sand substrate had significantly lower diversity than collections taken at structures over silty/clayey sand (F = 10.08 at 1/24 degrees of freedom). Within the silty/clayey sand substrate type, species diversity was significantly higher at the control Satellite 288-12 than at the two production platforms (F = 27.81 at 1/24 degrees of freedom); and diversity of nekton was significantly higher at Production Platform 296B than at 288A (F = 15.93 at 1/24 degrees of freedom).

Seasonal differences in diversity are shown for each station in Fig. 3. At Satellite 288-5, species diversity peaked in fall and declined through spring; the opposite pattern was evident for Production Platform 296B. Species diversity levels for collections made at Production Platform 288A were consistently low and showed little seasonal variation. Species diversity for winter collections taken at Satellite 296-12 were lower than species diversity observed for fall and spring collections.

Species Accounts

The seasonal abundance and distribution of some of the more abundant and/or important species are discussed below. Shrimps and crabs are treated first, followed by analysis for selected fish species in order of abundance. Red snapper trawl data are presented in a later section (Reef Fish).

Sugar Shrimp. This species was the most abundant organism in our trawl collections and comprised over 50% of the catch. Sugar shrimp were absent from summer collections, but were well represented during each of the other seasons--fall abundance was 695 per trawl tow, winter abundance was 268 per tow and, during spring, this species was represented by an average of 1139 specimens per collection. Results of the ANOVA performed on the log-transformed catch values showed significant differences:

Source	df	Sum of Squares	Mean Square	F
Total	35	39.55578		
Station	3	14.17427	4.72476	17.8*
Season	2	10.23284	5.11642	19.2*
Station x Season	6	8.76199	1.46033	5.5*
Residual	24	6.38667	0.26611	

*Significant at the 1% level

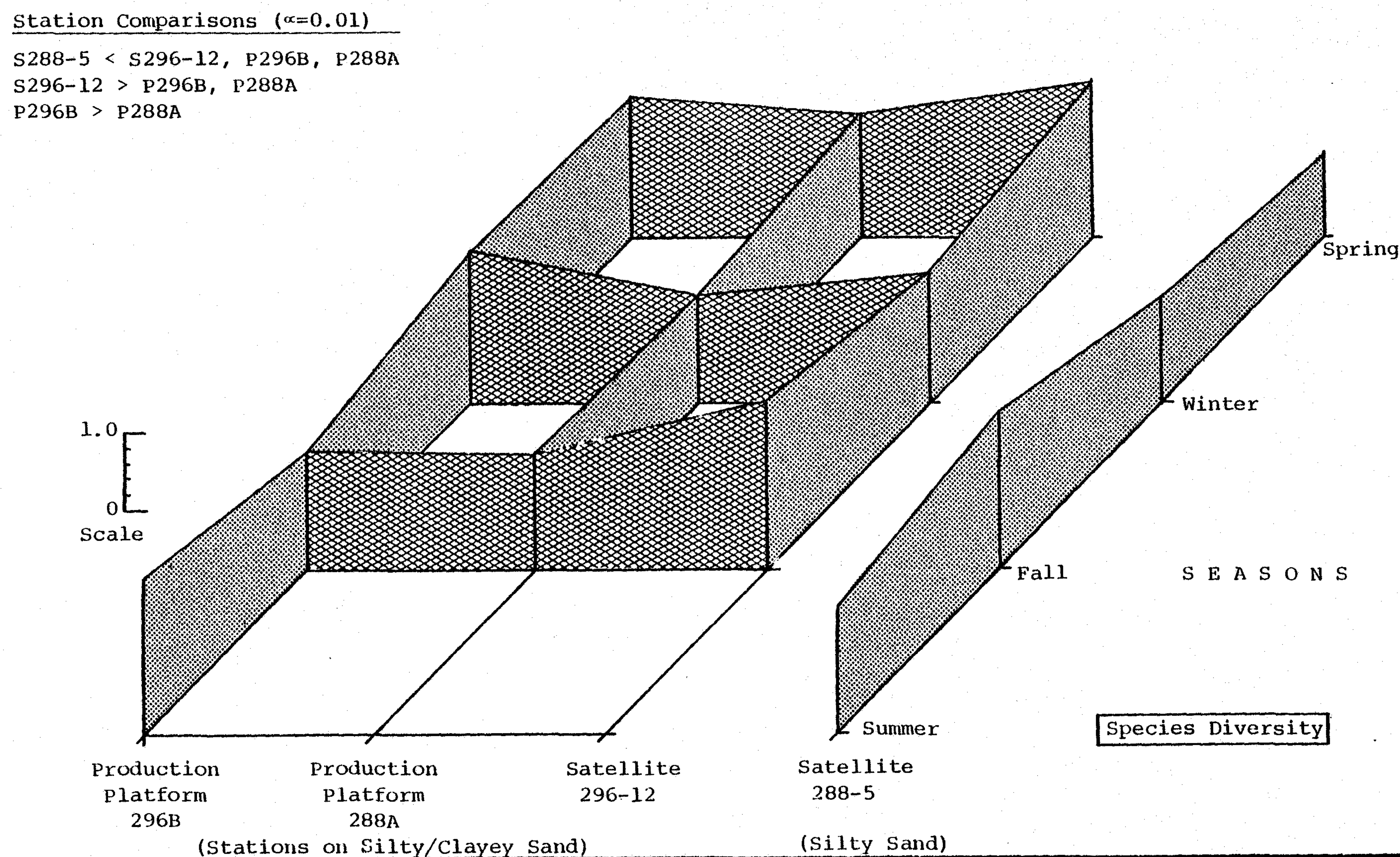

Fig. 3. Comparisons of mean species diversity (H") levels at study area stations or platforms by season.

Each season was significantly different from all others (α=0.01) and, in terms of abundance, ranked from high to low as spring, fall and winter. Station by season differences are shown by Fig. 4. Abundance at Satellite 296-12 gradually increased from fall to spring. At all other stations, abundance levels during winter were lower than those observed during fall, and the winter low was followed by a spring peak.

Sugar shrimp were significantly more abundant (α=0.01) in collections taken on the silty-sand substrate (S288-5) than in collections taken at stations sited on silty/clayey sand (Fig. 4). Within the latter substrate type, sugar shrimp were significantly more abundant (α=0.01) at production platforms than at the control structure. Abundance of sugar shrimp at Production Platform 288A, characterized by intermittent discharge, was significantly higher than that observed for Production Platform 296B (Fig. 4).

Chevron Shrimp. A single specimen of this small rock shrimp was captured in summer; however, in fall, the mean catch was about 113 specimens per trawl tow. Abundance declined to 56 chevron shrimp per tow in winter and peaked in spring at about 222 specimens per tow. Results of ANOVA performed on the $\log_e$ (n+1) catch values were:

Source	df	Sum of Squares	Mean Squares	F
Total	35	41.31996		
Station	3	8.22009	2.74003	4.92*
Season	2	11.92938	5.96469	10.70*
Station x Season	6	7.79194	1.29866	2.33
Residual	24	13.37854	0.55744	

*Significant at the 1% level

Chevron shrimp were significantly more abundant (α=0.01) at the station over the silty-sand substrate than at stations over the silty/clayey sand substrate (Fig. 5). Within the latter, they were significantly more abundant at the production platforms than at the non-discharging platform, but were more abundant at Production Platform 288A than at 296B. Although chevron shrimp were considerably less numerous than sugar shrimp, their patterns of seasonal and spatial abundance were highly similar.

Rock Shrimp. Representatives of the commercially important rock shrimp were not trawled in summer and were represented by an average of only 7 and 12 specimens in fall and winter collections, respectively. However, in spring, each trawl collection averaged about 346 rock shrimp. Results of the ANOVA indicated the seasonal differences were significant (α=0.01) but there were no significant differences in rock shrimp abundance among stations.

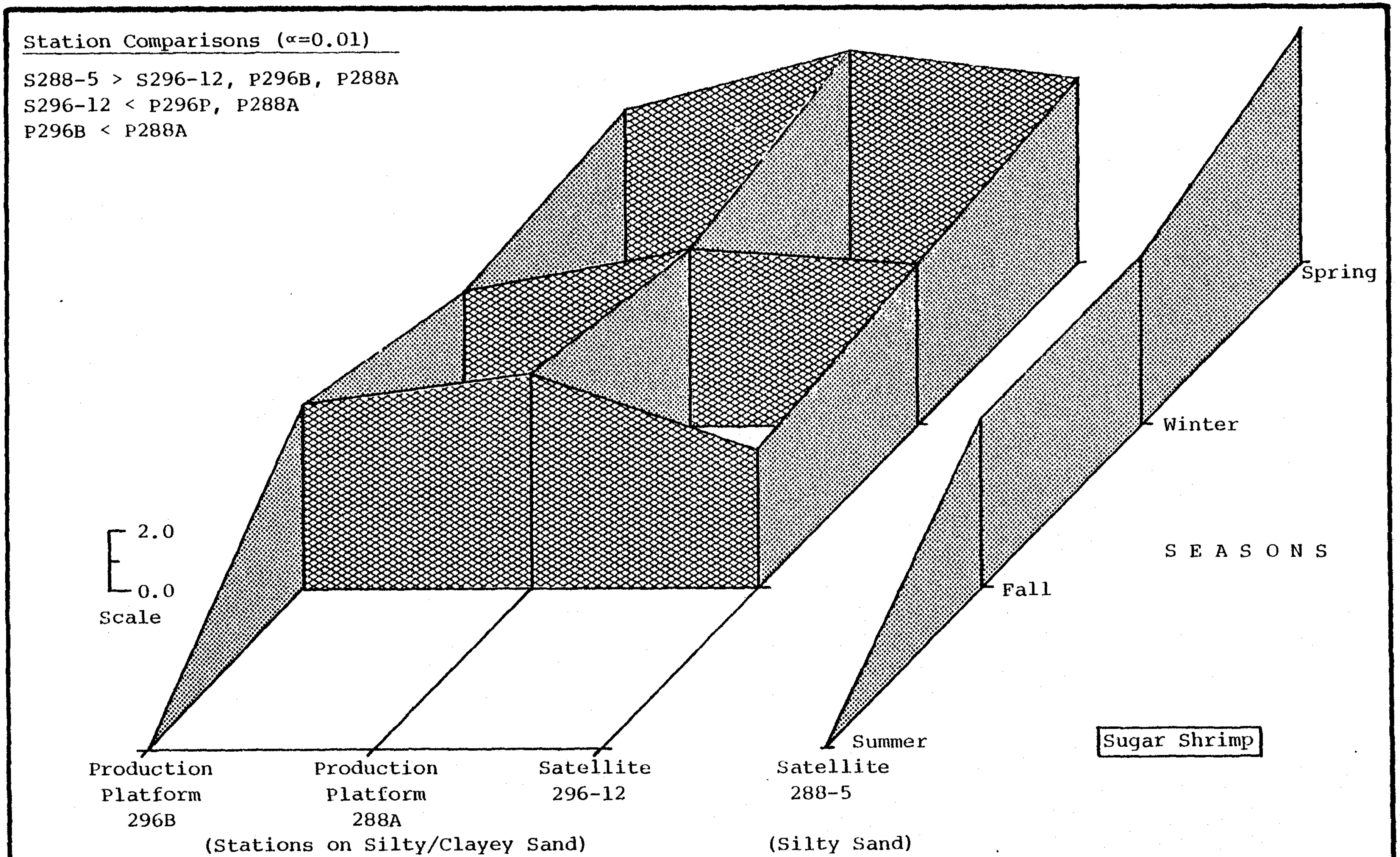

Fig. 4. Comparisons of mean abundance levels [Log_e (n+1)] of sugar shrimp at study area stations or platforms by season.

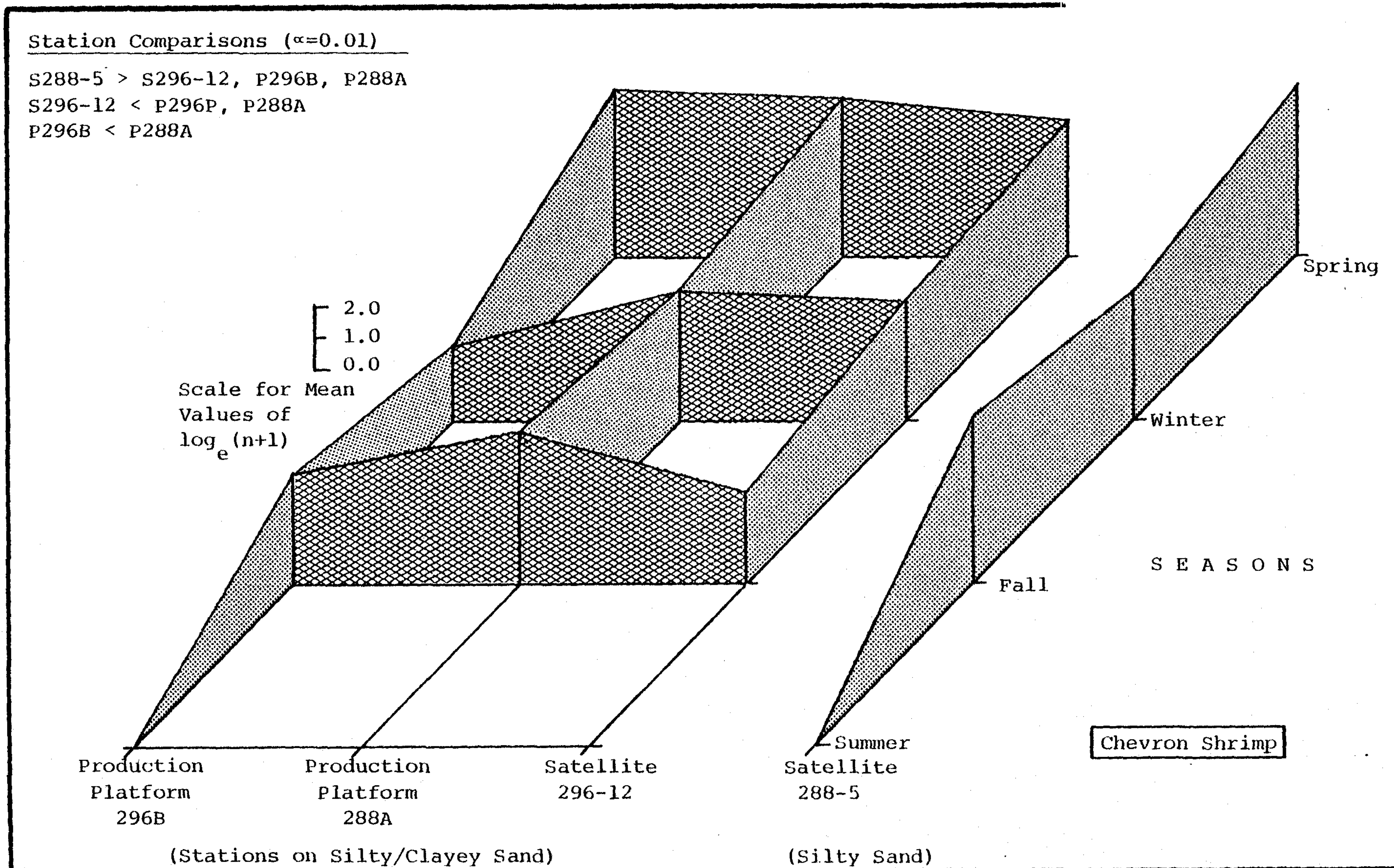

Fig. 5. Comparisons of mean abundance levels [$\log_e$ (n+1)] of chevron shrimp at study area stations or platforms by season.

Mantis Shrimp. An important food of the red snapper, the mantis shrimp was not represented in summer collections but was present in other seasons, being most abundant during spring (Fig. 6). Results of ANOVA, indicated significant differences (α=0.01) in mantis shrimp abundance among stations. Results of the orthogonal contrasts (Fig. 6) indicated no significant differences (α=0.05) in abundance between either substrate types or control versus production platforms in the same substrate type. Mantis shrimp were, however, significantly more abundant at Production Platform 288A than at Production Platform 296B.

Penaeus sp. The commercially important shrimps of the genus *Penaeus* were not abundant in the 1978-1979 trawl collections. Only two white shrimp were trawled, pink shrimp were represented by a total of 167 specimens and brown shrimp by 459 individuals. Pink shrimp were not collected during summer, but 72, 41 and 54 individuals were trawled during fall, winter and spring, respectively. Results of ANOVA performed on the log-transformed catch data for pink shrimp (fall through spring) indicated no significant differences among either stations or seasons.

A total of 95 brown shrimp were trawled during summer, 94 at Satellite 288-5 and 1 at Production Platform 296B. During fall, winter and spring, catches were 258, 56 and 50, respectively. Results of ANOVA performed on these data indicated no significant differences (α=0.05) among stations. Fall catches were significantly higher (α=0.01) than those for winter and spring.

None of the brown shrimp collected each season at either Production Platform 296B or Satellite 288-5 evidenced any histopathological anomalies of significance. The bacterial flora from brown shrimp caught at the two platforms were highly similar; 19 taxa were isolated from brown shrimp trawled at Satellite 288-5 and 15 taxa were isolated from brown shrimp taken at Production Platform 296B. Non-hemolytic *Vibrio* had the highest relative frequency on shrimp from each habitat (P296B=0.21; S288-5=0.24); hemolytic *Vibrio* had a relative frequency of 0.14 for brown shrimp from Production Platform 296B and 0.16 for brown shrimp from Satellite 288-5.

Portunus gibbesii. This species was the most abundant swimming crab represented in our trawl catches. None was trawled in summer, 243 were taken in fall, 19 in winter and, during spring, a total of 205 specimens were collected. Results of the ANOVA performed on the log-transformed catch data indicated no significant differences in abundance among stations. Fall and spring abundance levels were indicated to be equivalent and significantly higher (α=0.01) than abundance of this crab during winter.

Shoal Flounder. This flatfish was the most abundant vertebrate in the trawl collections during each season except summer and was the secondmost abundant of all species taken. During summer 1978, no shoal flounder were collected; but during fall, winter and spring, collection sizes numbered 3,040, 1,063 and 1,722 specimens, respectively. Results of the ANOVA indicated abundance levels among stations were not significantly

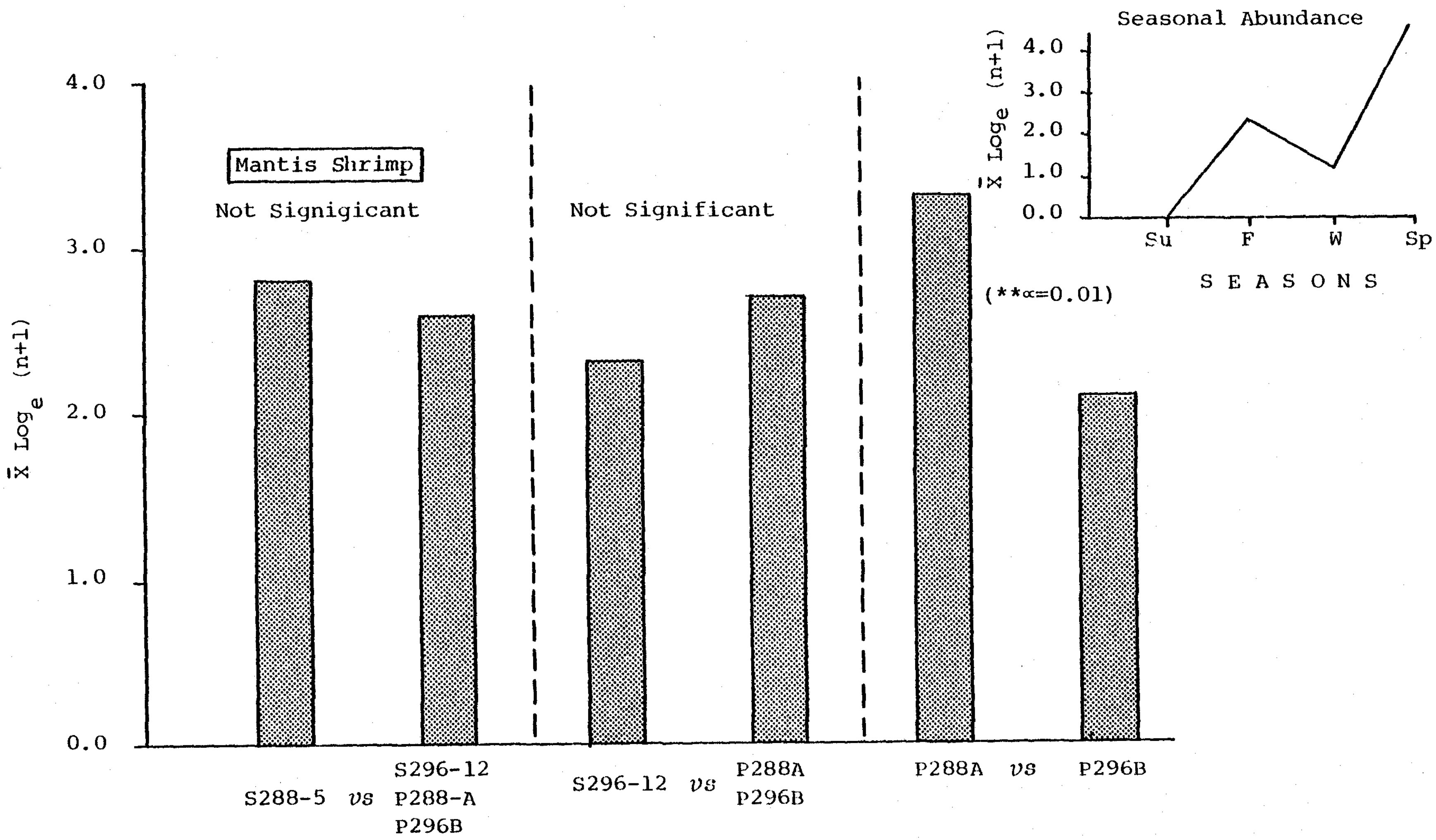

Fig. 6. Results of orthogonal contrasts of mean mantis shrimp abundance [$\log_e$ (n+1)] at study area stations. Insert at upper right shows seasonal abundance.

different. Each season was significantly different (α=0.01) in terms of abundance of shoal flounder.

The food habits of the shoal flounder varied seasonally (Fig. 7). During fall, shrimps (Natantia and/or chevron shrimp, *Sicyonia dorsalis*) dominated the diet. Xanthid crabs and other small crustaceans were the most abundant food organisms during winter. Xanthid crabs (20%) and shrimps (≈21%) were the dominant food items during spring. Rogers (1977) obtained similar results in finding the shoal flounder to feed mainly on shrimp (29%), stomatopods (26%) and crabs (16%).

Dwarf Sand Perch. A total of 1,083 dwarf sand perch were taken with 52, 714, 63 and 254 specimens obtained each respective season from summer 1978 to spring 1979. Results of ANOVA indicated abundance levels among stations were not significantly different.

Sea Catfish. Of the total 847 specimens of this species trawled, 834 were collected during fall and, of these, 822 were taken at Production Platform 296B. Part of this attraction may have been due to the disposal of edible food scraps from Quarters Platform 296B.

Longspine Porgy. All but two of the 569 specimens of this species were trawled during summer with 516 being taken at Satellite 288-5. The longspine porgy was the only species which was considered to have been abundant during summer 1978 and comprised over 48% of the total trawl catch. Polychaetes were the dominant identifiable food item; over 78% of the longspine porgy stomach contents could not be identified.

Condition of longspine porgy contained in collections from Satellite 288-5 was significantly higher (P=0.05) than condition of specimens in collections taken at Production Platform 296B.

Pelagic Fishes

Atlantic Spadefish

Evaluation of tagging data with respect to spadefish distributional patterns in the Buccaneer Oil Field indicated that, even though this species is typically habitat faithful, there is exchange of individuals between quarters and adjacent production platform habitats; i.e., these structures are colonized by a single population. Additionally, the results indicated that during clear water conditions, each of the three diving scientists obtained similar results in terms of number of fish censused and the number of marked fish observed in the sample. However, during periods of restricted underwater visibility, their estimates varied greatly; each diver took a relatively small sample as compared to clear water conditions, and each diver apparently saw different groups of fish. For the above reasons, quarters and production platform samples were combined to form a single census sample.

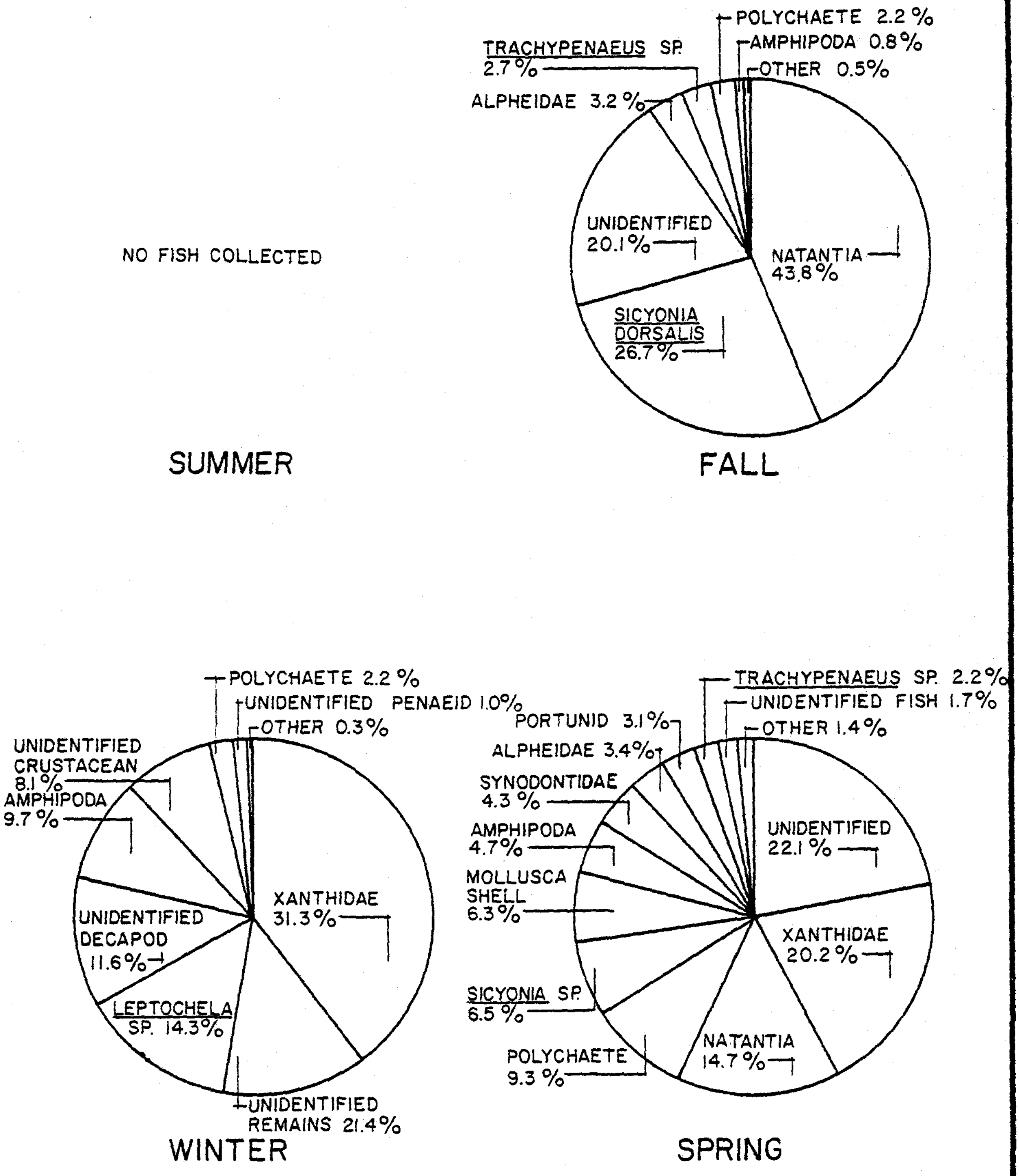

Fig. 7. Seasonal food habits of the shoal flounder, *Syacium gunteri*, in the Buccaneer Oil Field, 1978-1979.

Results of the mark-recapture experiments for spadefish performed each season at the Production/Quarters 296B complex were:

Source	SEASON 1978-1979 Summer	Fall	Winter	Spring
Marked (M)	152	231	182	188
Catch (C)	1939	741	1302	983
Recapture (R)	144	21	26	28
R/C	0.07	0.03	0.02	0.03
$\hat{N}$	2,034	7,791	8,783	6,379
Distribution	Normal Approx.	Poisson Approx.	Poisson Approx.	Poisson Approx.
95% CI	1717-2351	5332-12494	6220-13388	4563-9526
Estimated Density (No/m^3)	0.05	0.20	0.22	0.16

Results of the mark-recapture experiments performed at Satellite 288-5 during summer 1978 indicated the spadefish population numbered 491 individuals (95% confidence interval was 328-653) which equates to a density of about 0.15 fish/m^3. Although a slight increase in population size was indicated, the 1978 summer population of spadefish at S288-5 was not significantly different from that estimated at S288-5 in summer 1977 ($\hat{N}$=366; 95% CI was 229-673; estimated density = 0.11 fish/m^3).

In contrast to the findings at S288-5, summer population estimates for spadefish made at a Production/Quarters habitat complex were significantly different between the two years:

Year:	Summer 1977	Summer 1978
Site:	Production/Quarters 288A	Production/Quarters 296B
$\hat{N}$:	6,554	2,034
95% CI:	4482-10501	1717-2351
Density Estimates:	0.17 fish/m^3	0.05 fish/m^3

We do not have simultaneous population estimates for each of the above habitats during either of the two years; the apparent differences between years may be accounted for by "normal" differences attributable to habitat.

We believe that the best estimates of seasonal densities of spadefish around Buccaneer Oil Field Structures are about 0.11 to 0.15 fish/m^3 in summer, $\approx$0.20 fish/m^3 in fall, $\approx$0.22 fish/m^3 in winter and about 0.16 fish/m^3 in spring. The seasonal size distribution of spadefish populations appears to differ by season. During winter and fall, length of individuals ranges from about 210 to 500 mm with fish greater than 400 mm rather common. These large individuals are scarce or absent around the structures during spring and summer seasons (Fig. 8). In spring, the

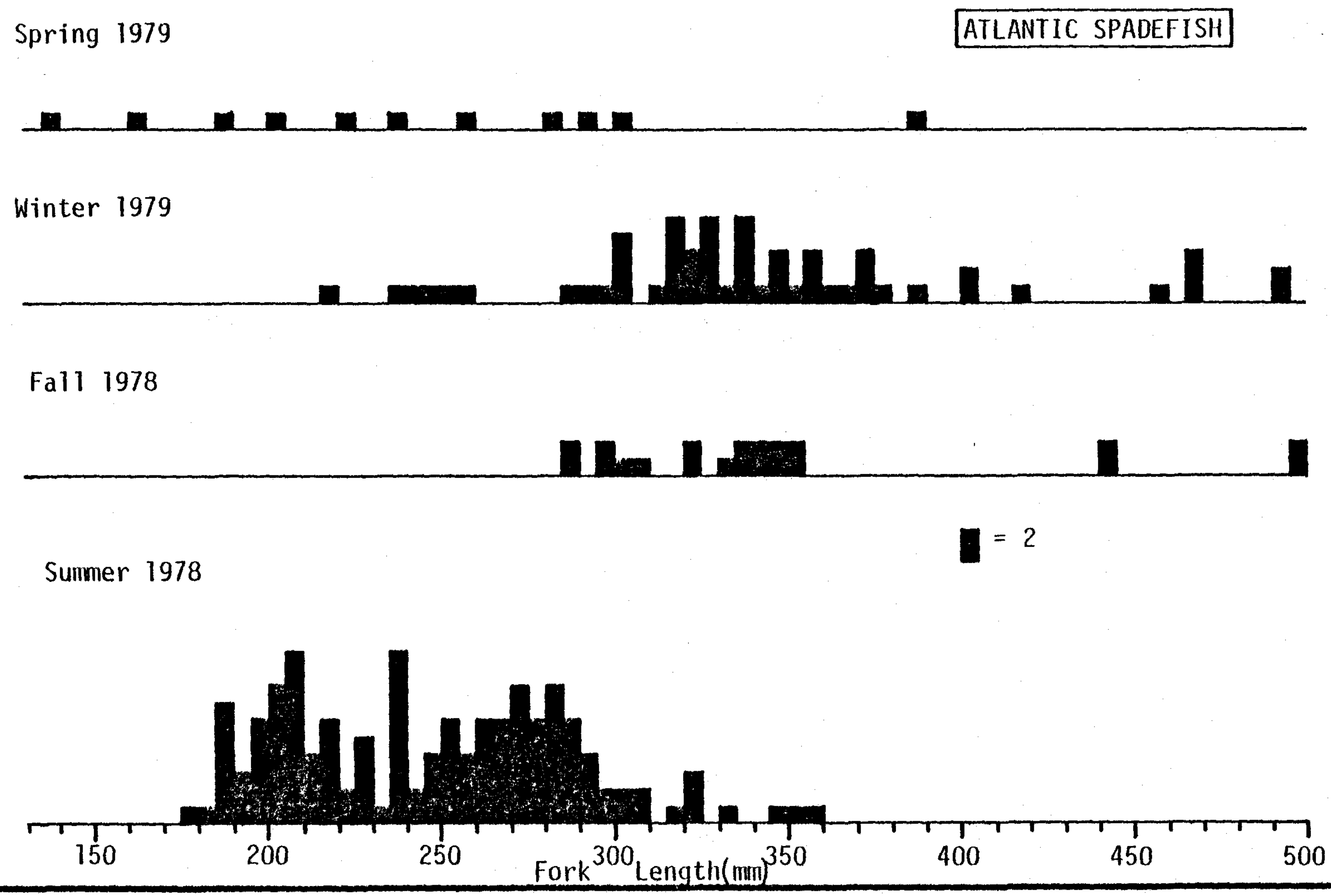

Fig. 8. Size distribution of Atlantic spadefish in the Buccaneer Oil Field, summer 1978-spring 1979.

observed length range of spadefish was from about 135 to 385 mm with no apparent size group dominant. Summer populations ranged in length from 175 to 360 mm with at least two different size groups represented (Fig. 8). We believe that relatively high densities observed during fall and winter are attributable to the influx of large fish which are absent (spawning?) during spring and summer. Spring populations are somewhat higher than summer populations due to recruitment of small individuals.

Recently-spawned spadefish (5-30 mm) have not been observed in the Buccaneer Oil Field by us during any season. Additionally, results from the ichthyoplankton sampling program of 1976-1978 (Jackson 1979), indicated larval spadefish were not abundant during any season. Young spadefish are abundant in the surf zone of Galveston Island in late May and June. We suspect that the absence of large fish during spring and summer and the relatively large size of the smallest recruits indicates that spawning of this species generally occurs elsewhere.

During summer 1978 and winter 1979, 1 and 2 spadefish, respectively, which had been marked during the previous winter were observed at the Production/Quarters complex 296B; the same habitat at which they had been originally marked. Five spadefish tags were returned by sportfishermen, most with incomplete information. One dart tag which had been placed in a spadefish at Production Platform 296B on 30 March 1979 was found washed-up on the beach on Padre Island during the last week of July 1979.

Food habits of Atlantic spadefish varied seasonally (Fig. 9). During summer, the diet of this species was dominated by a planktonic pteropod, *Carolina longirostris*. During each of the fall, winter, and spring seasons, we were unable to identify most of the material in the stomachs, but suspect that it is primarily of biofouling origin. During winter of the previous research year, we were able to obtain a series of stomach contents grading progressively from intact hydroid stalks to an unidentifiable mass. Food habitat data for spadefish indicate that when plankton are unavailable, spadefish will utilize the biofouling community as a food source. This is especially true during periods of the year when biofouling organisms are being sloughed from the substrate and, as suspended particulates, are easily harvested by the plankton-feeding spadefish.

Based upon comparisons of Index of Fullness values (IF, Gallaway et al. 1979) determined from specimens collected by spear, daily feeding periodicity of Atlantic spadefish was not markedly different among seasons. Feeding appeared to have been greatest during the period from mid-morning (≈ 1000 hrs) to early evening (≈ 2000 hrs), particularly during late afternoon (1600-1700 hrs). Although patterns of daily feeding were similar among seasons on a relative basis, the magnitude of the IF values varied greatly among seasons. The respective average IF values for specimens speared during summer, fall, winter and spring were 25.7, 3.3, 1.0 and 20.5. The high summer value was associated with plankton particulate feeding in the upper water column, whereas the low fall and winter levels were believed associated with near-bottom grazing of the biofouling community. As described above, most of the food in the spring

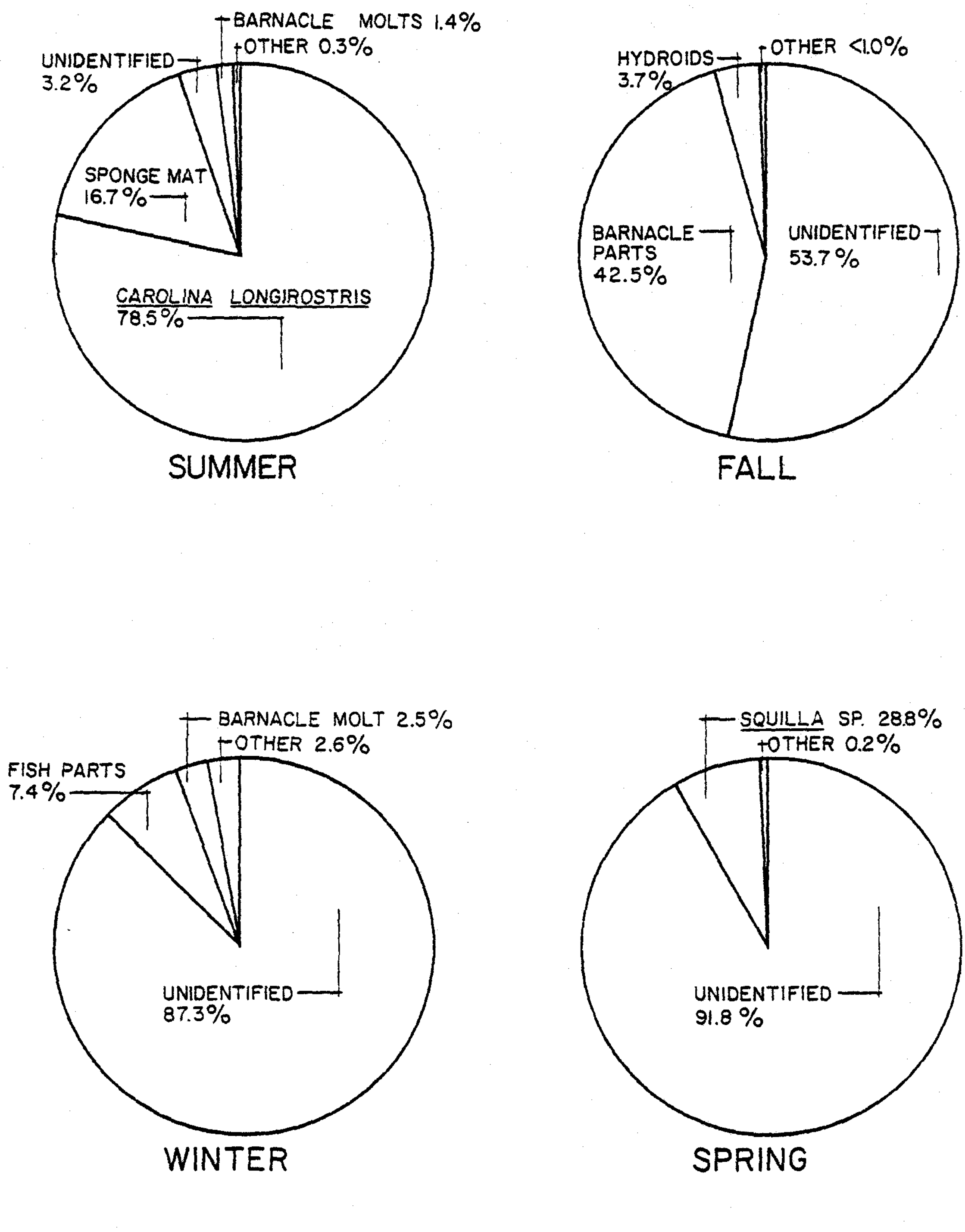

Fig. 9. Seasonal food habits of the Atlantic spadefish, *Chaetodipterus faber*, in the Buccaneer Oil Field, 1978-1979.

samples was also considered to have been of biofouling origin (probably *Tubularia crocea*) but was believed to have been harvested from the water column as opposed to being grazed from the structures.

The food habitat patterns may account for some of the differences in the seasonal population estimates. During summer, when the fish were taking plankton, they may have been foraging further from the platforms than during other seasons, and, because of this, were less susceptible to our diver-census performed at the platforms.

During winter of 1977-1978, we observed that spadefish populations in the Buccaneer Oil Field experienced a disease epidemic characterized by large, external lesions and varying degrees of fin rot. Based upon bacterial isolates cultured from diseased specimens, the fish pathogen *Vibrio* was abundantly represented. Badly diseased fish (those with large lesions and advanced cases of fin rot) were more in evidence at Production Platform 296B (61% of the sample) than at Satellite 288-5 (25%). The spadefish disease epidemic was also in evidence during the winter period of 1978-1979. In contrast to the previous year, there was little difference among structures (73 and 74% of the spadefish at the Production Platform and control satellite structures, respectively, were badly diseased). In early March practically no diseased spadefish were observed at the V.A. Fogg Liberty Ship Reef which was used as a control against which to compare oil field populations.

In addition to gross examination, spadefish tissues were collected each season for microscopic examination. Histopathological anomalies in spadefish tissues (gills, intestine, liver, kidney, skin) determined by microscopic examination varied among seasons and habitats. Although larger sample sizes would be needed to make definitive comparisons, gill hyperplasia was observed to be prevalent during summer, particularly at Production Platform 296B where each of the 5 specimens collected evidenced the anomaly. Fatty infiltration of the liver was pronounced in spadefish at all sites sampled in the winter and fall, less prevalent during summer, and present in only 1 of 10 fish collected during spring. Fatty infiltration of the liver of spadefish colonizing offshore Louisiana platforms during summer was also observed by BLM investigators (C.A. Bedinger, Southwest Research Institute, pers. comm.). Lesions in skin and fin tissues were not common and were only observed for winter samples.

Bacteriological analysis of fish tissues yielded results similar to those of Sizemore (1979) in that *Vibrio* sp. was a predominate genera in all samples, particularly during winter. Potential fish pathogens (*Vibrio* sp., hemolytic; *Seromonas* sp.) were also represented during all seasons. Of these, Sizemore (1979) found only *Aeromonas hydrophila* associated with the four diseased fish he examined.

Spadefish disease epidemics appear the result of the actions of opportunistic pathogens during a period of seasonal stress for the host. Much of the seasonal stress is presumably attributable to the observed reduction in apparent feeding efficiency as well as to the change in food habits from plankton to suspended particulates of biofouling origin. The observed fatty infiltration of the liver may represent results of a nutritional deficiency of this alternate food source utilized during winter. During the 1978 research year Atlantic spadefish were characterized by significantly (α=0.05) better condition in summer than in winter (Gallaway et al. 1979); however, no significant seasonal differences were observed during this year's study.

Although the winter disease epidemic of 1977-1978 appeared more severe at Production Platform 296B than at Satellite 288-5, condition of spadefish at the two habitats during this season was not significantly different. Results of this years investigation allow for a comparison of the oil field population to a control population at the V.A. Fogg Liberty Ship Reef. The length-weight regressions for each population were:

BOF Spadefish

$$\text{Log}_e W = -5.3554 + 2.145\ \text{Log}_e L$$

V.A. Fogg Spadefish

$$\text{Log}_e W = -9.0960 + 2.789\ \text{Log}_e L$$

Although a greater "b" value, or slope, is indicated for fish from the V.A. Fogg Reef, the differences were non-significant at the 5% level (F=4.27 at 1 and 15 d.f.) allowing a comparison of the weights of fish from the two populations at an adjusted mean length. The resulting differences were also non-significant (F=0.007 at 1 and 16 d.f.).

The results of both the 1977-1978 (diseased fish at P296B to fish at S288-5) (Gallaway et al. 1979) and the 1978-1979 (diseased fish from the BOF to fish at V.A. Fogg) comparisons of winter spadefish populations having a high frequency of individuals exhibiting external symptoms (lesions and fin rot) of an epizootic have not differed significantly in terms of overall body condition from populations not showing a high frequency of external symptoms. The seasonal effects apparently overshadow the effects of the disease. However, in each case, diseased populations have been associated with either (1) the oil field as a whole, or (2) a production-quarters platform complex within the oil field.

We believe the external infections of oil field populations are related to contaminant discharge. Minchew and Yarbrough (1977) found that 96% of the mullet, *Mugil cephalus*, held in ponds subjected to a low-level oil spill (4 to 5 ppm) suffered fin rot whereas only 6% in a control pond developed eroded fins. The primary pathogen considered responsible for the fin erosion was a species of *Vibrio*. Subsequent laboratory work by Giles et al. (1978), confirmed the above results and showed that chronic, low-level exposure of mullet to oil significantly altered the bacteria on the fish, allowing for a large population of potentially pathogenic *Vibrio*. They also suggested that the *Vibrio*, through utilization of the oil, may have acquired an enhanced virulence. Our field studies agree with the findings of the above pond and laboratory experiments in that fish exposed to chronic, low-levels of hydrocarbons in discharges developed external lesions and fin rot which may have been attributable to a *Vibrio* sp.

Bluefish

Population studies of the predatory bluefish, a schooling fish, were largely unsuccessful. During summer, they were seldomly seen and we were able to collect only four specimens. This observation was in marked contrast to summer of 1977 when bluefish were one of the most abundant fishes observed around structures in the study area. Bluefish were also observed as not abundant during the summer of 1976, indicating 1977 may have been an atypical year with respect to the summer abundance of this species. We have seen no literature reports concerning seasonal bluefish abundance in the western Gulf.

Bluefish were not well represented in the study area during fall, but appeared abundant during the winter and spring seasons; we were able to mark 6, 50 and 19 individuals during each of the respective seasons. No bluefish, marked or unmarked, were observed in the fall census sampling and no marked fish were seen in 4 and 137 fish censused in winter and spring, respectively. However, in spring, 4 fish tagged in winter were observed from the surface traveling in a school of 45 individuals. The fish were at the same structure at which they had been marked, Production Platform 296B. No bluefish tags were returned by sportfishermen or other persons.

Although seasonal means were not significantly different, bluefish collected during winter averaged smaller than those collected during other seasons (Fig. 10). Bluefish in the study area typically range from about 380 to 600 mm and average about 480 mm in fork length. Fish of this size appear mainly piscivorous during all seasons, but they also take shrimp (Fig. 11). In one instance, food scraps (corn kernel) were found in the stomach. Of interest, benthic species were predominant dietary items in the stomachs of the sampled fish. However, on occasions, we have observed this species predating on pelagic fishes of undetermined species at the surface. We have also had them consume both fish being brought to the surface by rod-and-reel for tagging and just-released, tagged red snapper. They are ferocious feeders.

Based upon angling success and average IF values, bluefish feeding activity was greatest between 1800 and 2100 hrs. During this period, 31 of the 37 total specimens collected were angled, and the mean IF value was 136. This compares to 3 fish caught during each of the 0601- to 1200-hr (IF $\bar{x}$ = 23) and 1200- to 1800-hr (IF $\bar{x}$ = 0) periods. No bluefish were caught between 2400 and 0600 hrs. As indicated above, however, we have observed them feeding during practically all times of the day and night.

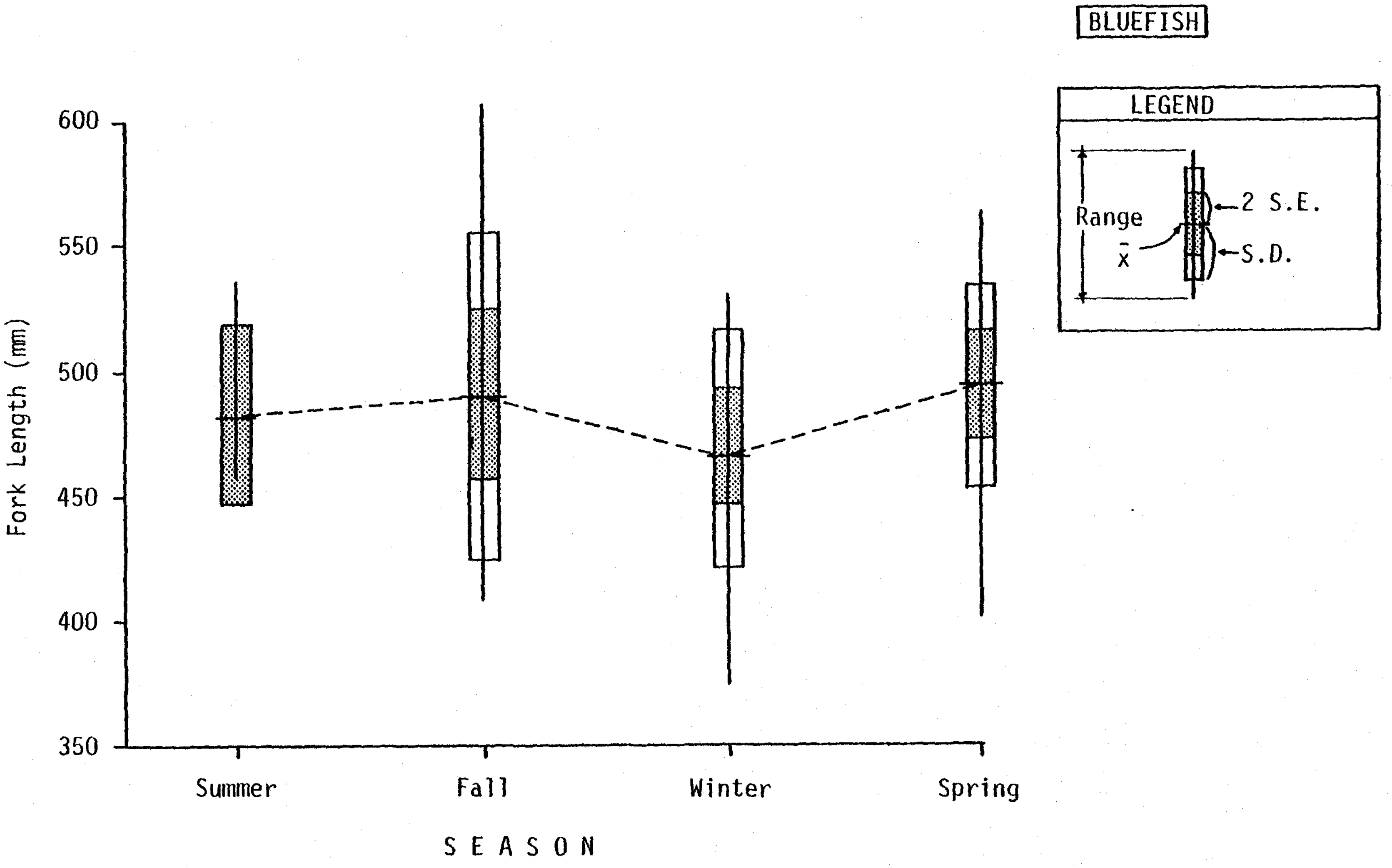

Fig. 10. Size distribution of bluefish collected each season in the Buccaneer Oil Field, 1978-1979.

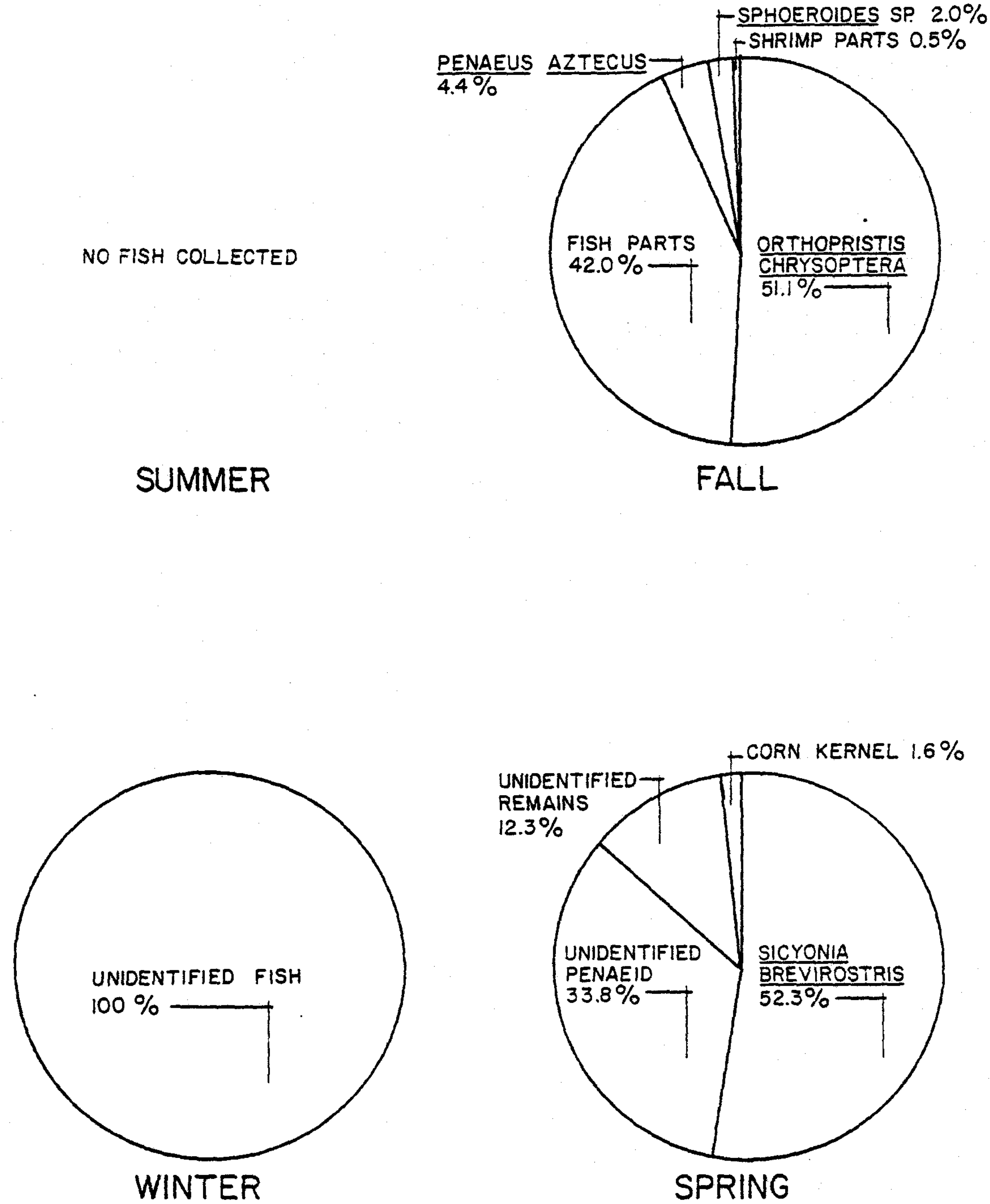

Fig. 11. Seasonal food habits of bluefish, *Pomatomus saltatrix*, in the Buccaneer Oil Field, 1978-1979.

Bluefish populations in the oil field appeared healthy and no evidence of disease was observed. During fall, bacterial flora of bluefish were dominated by *Micrococcus* sp. and, during spring and summer, by *Vibrio* sp. (both hemolytic and non-hemolytic forms). Representatives of *Aeromonas* were among the potential pathogens represented. With the exception of a high frequency of kidney parasites (incidence was 80% each season), bluefish were characterized by few histopathological anomalies. However, each of the five specimens collected in winter exhibited fatty infiltration of the liver. Winter food habits did not appear markedly different from food habits observed for other seasons.

Reef Fishes

Red Snapper

Population levels of red snapper at Production Platform 296B were highest during fall and spring ($\hat{N}$=565 and 441, respectively) but were estimated to have been fewer than 50 individuals at the time of marking during summer and winter (Fig. 12). The seasonal differences in abundance levels based upon population estimates correlated well with the seasonal mean catches of red snapper in trawl collections (Fig. 12). Results of ANOVA performed on the log-transformed catch data for trawled red snapper showed seasonal differences were significant (α=0.01); station differences were not:

Source	d.f.	Sum of Squares	Mean Squares	F
Total	35	62.7383		
Stations	3	3.6114	1.2038	1.03
Seasons	2	22.1547	11.0774	9.47*
Station x Season	6	8.8954	1.4826	1.27
Residual	24	28.0769	1.1699	

*Significant at the 1% level.

Results of the Duncan's Multiple Range Test showed fall and spring abundance levels as indicated from trawled data were equivalent and significantly higher than winter levels. Comparisons of the 95% Confidence Intervals for the seasonal population estimates indicate a similar trend (Fig. 12).

The seasonal size distribution of red snapper in Buccaneer Oil Field is shown by Fig. 13. Within Age Class 0 (after Bradley and Bryan 1976), two size groups were represented in fall, winter and spring--only the larger of these was represented in summer collections. Moseley (1966) stated spawning off the Texas coast extended from early June to mid-September; Bradley and Bryan (1976) provided evidence extending the spawning period from April to as late as November. The latter authors also reported that snapper attain fork lengths of about 200 mm during their first year and grow at a rate of about 75 mm per year after Age or

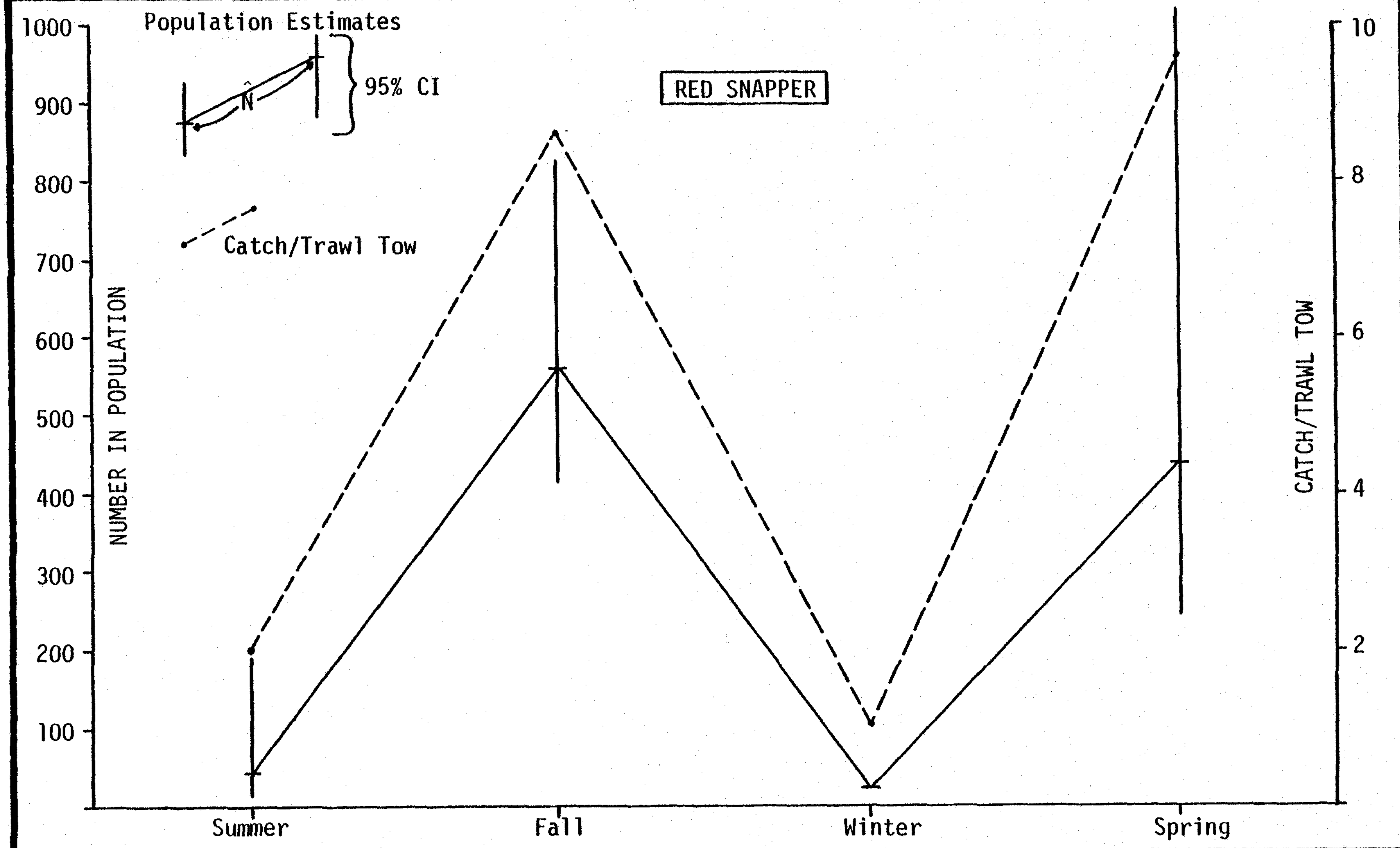

Fig. 12. Seasonal population estimates (solid lines) and catch/trawl tow (dashed line) for red snapper in the Buccaneer Oil Field, 1978-1979. Population estimates were made at Production Platform 296B. Confidence limits cannot be calculated for the winter data (no re-captures).

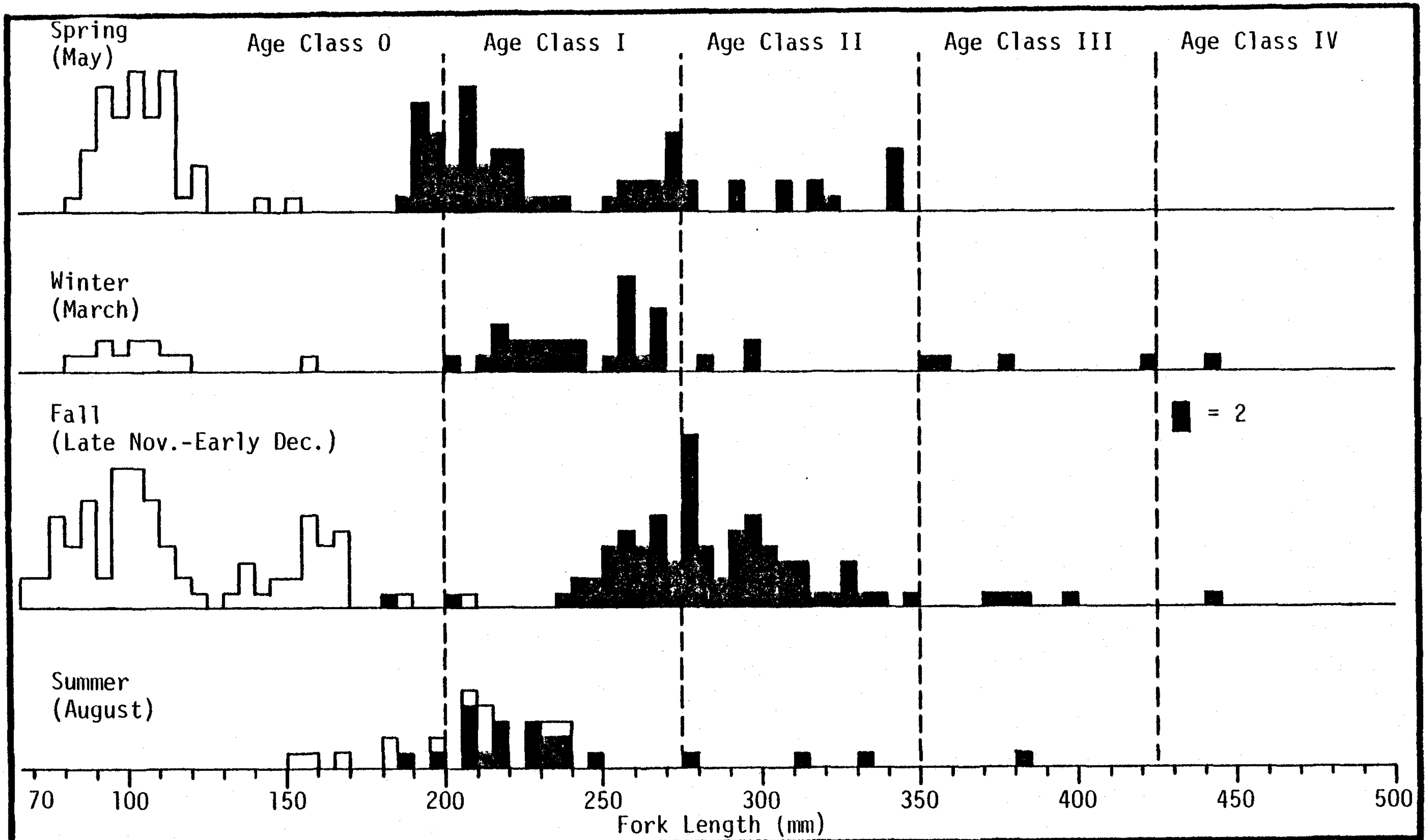

Fig. 13. Seasonal size distribution of red snapper in the Buccaneer Oil Field, 1978-1979. White bar shows trawled specimens, black bars represent specimens collected by angling or spear. Age class designations are based on Bradley and Bryan (1976).

Year Class I. Using the above data as criteria, Age Class 0 fish in the study area during summer of 1978 were probably those of the previous summer's spawn. The small size group of Age 0 fish represented in fall and winter collections were probably spawned in spring of 1978, grew little during the period December 1978-March 1979 and were probably represented by the two specimens between 140 and 155 mm trawled in spring 1979 (Fig. 13). The larger size group of Age 0 fish in fall and winter 1978 collections were probably spawned in early spring of 1978 and were represented by the large Age 0 and small Age I specimens represented in spring 1979 collections. The small size group of Age 0 fish in spring were probably fish spawned the preceding month.

As part of the population experiments, we tagged and released in good condition a total of 108 red snapper; 8, 57, 7 and 36 during each of the respective seasons Summer 1978 to Spring 1979. In addition to these fish, an additional 13 red snapper were tagged and released during the course of an aborted population experiment in fall 1978, raising the total tagged red snapper for the fall season to 70. Sportfishermen returned 21 of the total 121 tagged fish:

Season Tagged (Dates)	No. Tagged	No. Returns	Date of Captures	% Returned
Summer (1 Aug.-4 Sept. 78)	8	0	-	0
Fall (26 Nov.-11 Dec. 78)	70	20	(15-29 Dec. 78	29
Winter (15 March 79)	7	0	-	0
Spring (7 May 79)	36	1	4 Aug. 79	3

All recaptures were made in the Buccaneer Oil Field, and, although data from the sportfishermen were typically incomplete, we believe most, if not all, were recaptured at the structure at which they had been marked. Results of red snapper tagging programs of the previous year also indicated red snapper were structure-faithful with number of days between release and recapture ranging from 19-149 days (Jackson 1979). Fable (1977) tagged 299 red snapper at six reefs off the south Texas coast. Of these, only three tag returns showed movements and these to adjacent banks or structures.

Snapper enter the hook-and-line fishery at about 200 mm (Bradley and Bryan 1976). The red snapper fishery in the Buccaneer Oil Field is dominated by Age Classes I and II, no fish older than Age Class IV was represented in our collections (Fig. 13). The dominance of relatively young red snapper in the Buccaneer Oil Field fishery indicates heavy fishing pressure. Fable (1977) found that heavily fished structures and reefs were characterized by smaller and younger (mostly Age Classes I and II) red snapper than were present at less heavily fished banks (fish up to Age Class V were taken).

The effects of fishing pressure may be well illustrated by our tagging studies. During fall of 1979, the snapper population at Production Platform 296B was relatively high ($\hat{N}$=565 individuals), but fishing pressure was also high (29% of the tags from red snapper marked in fall were returned by sportfishermen). The snapper population at Production Platform 296B during winter was estimated at less than 50 individuals. We believe most of the difference between fall and winter levels was attributable to harvest by sportfishermen, as results of ours and other tagging programs indicate little movement of red snapper once recruited to a habitat. During the spawning season, snapper feed little, but after spawning they feed voraciously. Thus, during fall and early winter, the snapper are "biting", a fact we believe is well known and exploited by sportfishermen.

Spring population levels of red snapper were also high; but, based upon tag returns, fishing success was low. The snapper may have been in a period of low feeding activity related to spawning. In summer 1978 standing stock was exceedingly low, indicating that during the previous spring, recruitment either did not occur, or that new recruits were harvested. Population levels of red snapper at Production Platform 296B in summer of 1979 will be of great interest. Given that we have had only 1 tag returned from the 36 fish that were marked at that structure in May 1979, we suspect that population levels will be high and, further, that high catches of red snapper will be made in the Buccaneer Oil Field during fall of 1978.

The diet of red snapper varied with season with winter appearing to be the most dissimilar in terms of diet (Fig. 14). During winter, red snapper were indicated to feed almost exclusively on squid, although small carangids (probably scad) were also taken. We suspect that the squid was provided by us in the form of bait and that red snapper rely primarily upon other fish as food during the winter season. The mantis shrimp, *Squilla*, was a major component of the diet of red snapper during both the summer and spring seasons with fish also well represented during summer. Shrimp, fish and swimming crabs were the most abundant food items of red snapper collected in the Buccaneer Oil Field during fall. Results of our findings generally agree with those of other investigators (Moseley 1966, Bradley and Bryan 1976).

Average index of fullness values for red snapper captured by angling were 68.7, 29.0 and 18.0 for morning (0600-1200 hrs), afternoon (1201-1800 hrs) and early evening hours (1801-2000 hrs), respectively. No specimens were obtained for the period 2000 to 0600 hrs. These data in combination with the above food habit data could be interpreted to indicate that red snapper feed during the night or early morning over soft bottom away from the platforms. Red snapper exhibited very little, if any, dependence upon the biofouling community as food.

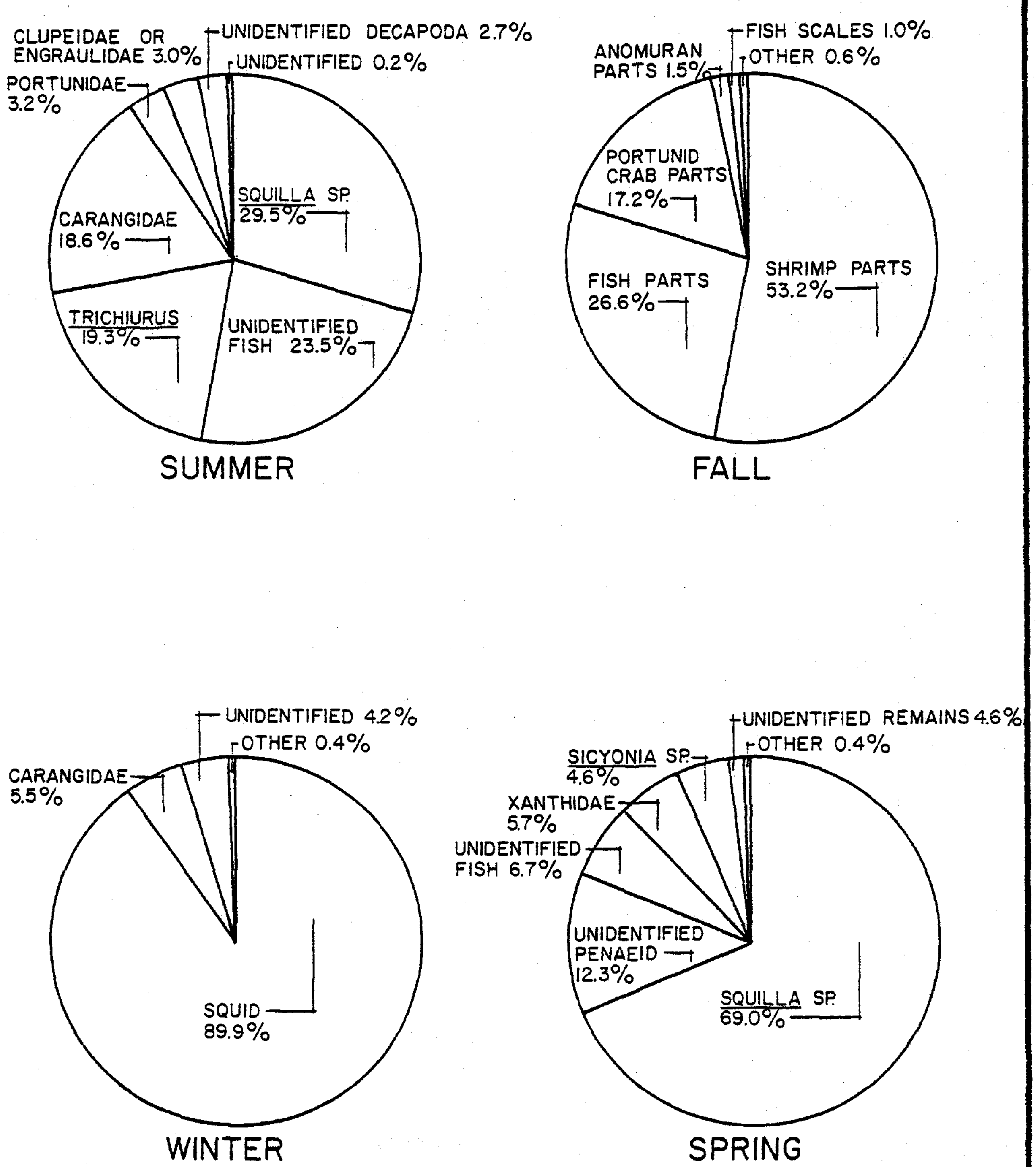

Fig. 14. Seasonal food habits of the red snapper, *Lutjanus campechanus*, in the Buccaneer Oil Field, 1978-1979.

Of the 34 red snapper examined for histopathological anomalies, 62% were characterized by gill hyperplasia and 47% by intestinal parasites, usually accompanied by intestinal inflammation, fibrosis and lesions. Gill parasites were believed largely responsible for the observed hyperplasia. No marked difference in the frequency of the various anomalies was observed for production platform *vs* satellite jacket populations or among seasons. Bacterial flora of red snapper varied seasonally with *Vibrio* sp. usually the dominant form on fish from each of the two habitats sampled. Hemolytic *Vibrio* sp., which include representatives of potential fish pathogens, were well represented on specimens from each structure during each season except fall 1978 when none were isolated from any of the samples. *Aeromonas* sp., which also contains fish pathogens, were isolated from specimens taken at Production Platform 296B in summer 1978 (27% of the total 26 colonies isolated from snapper tissue were *Aeromonas* sp.) and in spring 1979 (15% of the total 47 isolated colonies). *Aeromonas* sp. were not isolated from red snapper specimens taken at Satellite 288-5 during any season.

Seasonal length-weight relationships were determined for Age Class I and older red snapper:

- Summer

  $\mathrm{Log_eW} = -10.5972 + 2.95\ (\mathrm{Log_eL})$

- Fall

  $\mathrm{Log_eW} = -10.7361 + 2.96\ (\mathrm{Log_eL})$

  Winter

  $\mathrm{Log_eW} = -12.6429 + 3.34\ (\mathrm{Log_eL})$

- Spring

  $\mathrm{Log_eW} = -11.1146 + 3.303\ (\mathrm{Log_eL})$

Results of regression analysis indicated that the seasonal relationships did not have significantly different slopes but were characterized by different elevations or intercepts (F=5.25 at 3 and 96 d.f.).

$\mathrm{Log_eW}$ values at an adjusted mean length ranged:

Winter	Summer	Fall	Spring
5.7935	5.7203	5.6511	5.6279

Mean $\mathrm{Log_eW}$ values underlined above by the same line are not significantly different. Seasonal differences in condition appear attributable to life history effects as opposed to effects of structures or discharges.

Sheepshead

With the exception of "winter" (early April 1979), populations of sheepshead at Satellite 288-5 were relatively stable during research year 1978-1979:

	Summer 1978 August-September	Fall 1978 December	Winter 1979 April	Spring 1979 May
$\hat{N}$	151	160	3,055	164
95% C.I.	96-270	100-296	2163-4645	*

*Only 2 fish marked, no recaptures, estimate made: $M \cdot \frac{C+1}{R+1}$

During April, the population of sheepshead at Satellite 288-5 was estimated to have been in excess of 3,000 individuals. A marked increase in population size was also observed at the Production-Quarters Platform 296B complex in April (considered as a single habitat based upon movement of tagged fish between the adjacent structures):

	Summer 1978 August-September	Fall 1978 December	Winter 1979 April	Spring 1979 May
$\hat{N}$	452	1017	16,969	1730
95% C.I.	349-604	602-2049	*	1101-3106

*Recruitment between marking and census sampling.

The observed population levels in April represented 17- to 19-fold increases over the population sizes estimated for each structure the previous quarter. We believe the observed concentrations represented a spawning congregation as the fish were mostly running ripe, and many were exhibiting what we interpreted as courtship behavior. Similar congregations were observed at all the structures examined in the Buccaneer Oil Field during early April 1979. We do not know exactly how long the congregations persisted; populations had returned to the normally observed ranges by mid-May. We believe these observations represent the first evidence of spawning migration and aggregations for this species.

As was observed for Atlantic spadefish, the population of sheepshead at the Production-Quarters 296B structures appeared atypically low during the summer of 1978. The population increased from an estimated 452 individuals in summer to an estimated 1,017 in December. Following the breakup of the April spawning aggregation, the population at this habitat was estimated at 1,730 individuals. The source of the recruitment between summer and fall 1978 is unknown (similar recruitment during this period was not evidenced at either of Satellites 288-5 or 288-2).

Recruitment of sheepshead to Buccaneer Oil Field structures appears to be an annual event related to spring spawning aggregations at this habitat (Fig. 15). During August 1978, we were able to harvest all but about 10 of the sheepshead observed at Satellite 288-2. The observable population remained at about 10 fish until April 1979; after which the observable population was estimated at about 36 individuals (69% of the pre-harvest level, insert B, Fig. 15). Density of sheepshead at the two censused habitats (Production-Quarters 196B, S288-5) were remarkably stable during each season with the obvious exceptions of April at both structures and summer at the Production-Quarters 296B habitat (Fig. 15). With the exception of movement between the adjacent production-quarters structures, sheepshead appeared habitat-faithful. No marked fish were seen at a structure other than where they had been marked. As indicated by Fig. 15, density of sheepshead was typically slightly higher at the satellites than at production-quarters structures.

Sheepshead in the Buccaneer Oil Field during 1978-1979 ranged from about 22- to 50-cm fork length (Fig. 16). Fish between 22 and 35 cm usually dominated the collections, particularly during summer. In the latter case, nearly all the specimens at Satellite 288-2 were harvested and comprised a rather complete sample of the resident population.

The seasonal length-weight relationships for sheepshead were characterized by equal slopes and significant differences (5% level) were indicated among the seasonal levels of condition (F=2.99 at 3 and 90 d.f.). Sheepshead collected in winter and summer were significantly heavier at an adjusted mean length than fish at the same length in fall and spring. Fall fish were not significantly different from summer and spring fish. The greatest difference in condition was observed between winter (April) and spring (May) sheepshead; the former group were in spawning condition, and, at a given length, averaged 6.3% heavier than fish collected after the spawning activity.

The food habits of sheepshead varied with season (Fig. 17). During summer 1978, portunid crabs comprised 67% (by weight) to the diet and were supplemented by biofouling organisms. During each of the fall, winter and spring seasons, the biofouling community comprised the majority of the diet. Most of the material in the "unidentified" category is believed to have been of biofouling origin. The presence of sargassum in stomachs of spring specimens supports visual observations of sheepshead grazing on rafts of this material as well as on the organisms utilizing the sargassum as habitat.

Sheepshead were characterized by higher IF values in winter (26.0) and spring (24.0) than in summer (19.0) and fall (14.0), but the data showed an almost uniform feeding periodicity over the 24-hr cycle during each of the four seasons. Index of fullness values for the periods 2401-0600, 0601-1200, 1201-1800, and 1801-2400 hrs were 19.0, 19.3, 19.0, and 12.6, respectively. This species was heavily dependent upon the biofouling community for food; but, as described above, also obtained food from other sources.

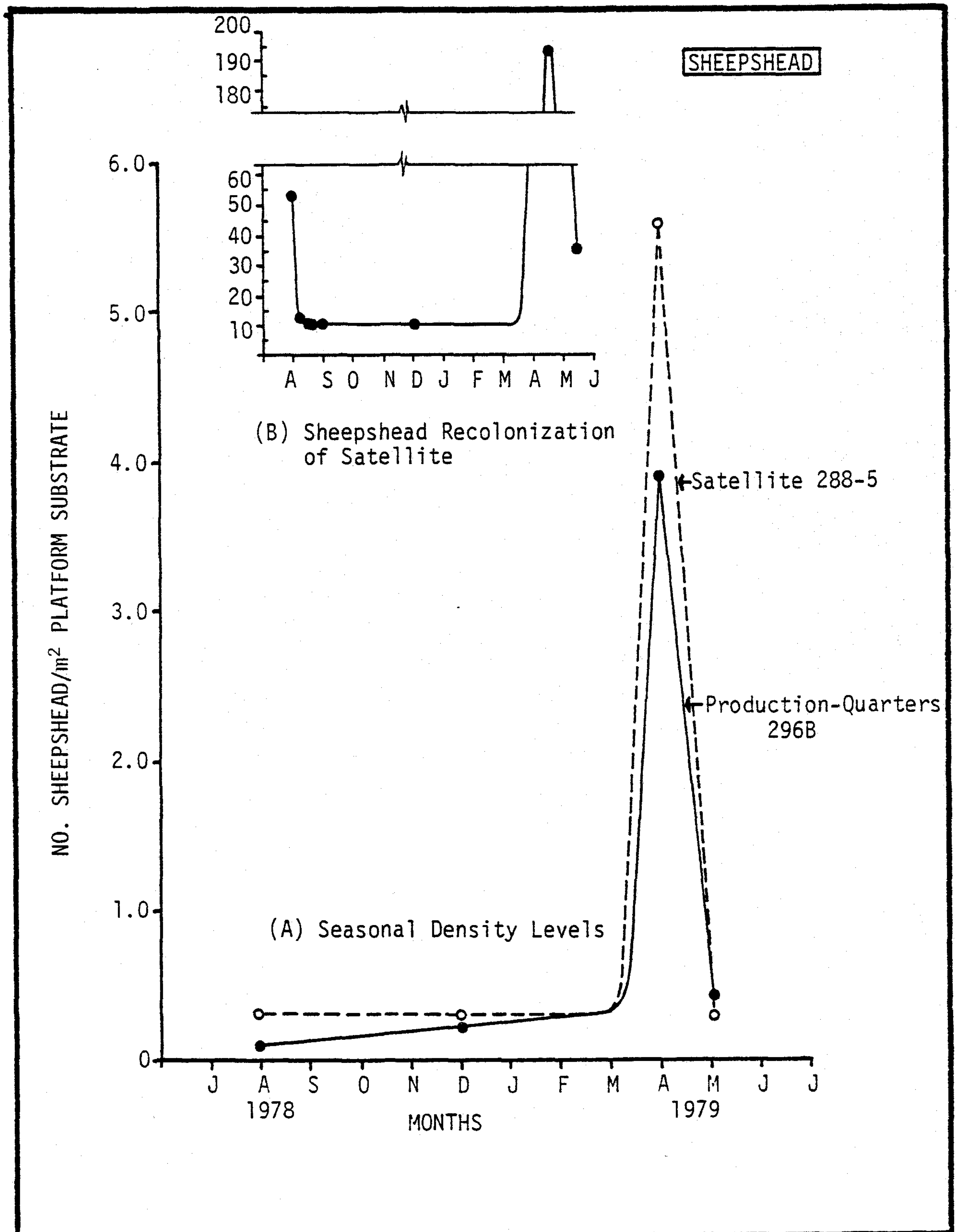

Fig.15. Seasonal densities of sheepshead at Buccaneer Oil Field structures, 1978-1979 (A) and population levels (number seen) following harvest of specimens at Satellite 288-2 (B).

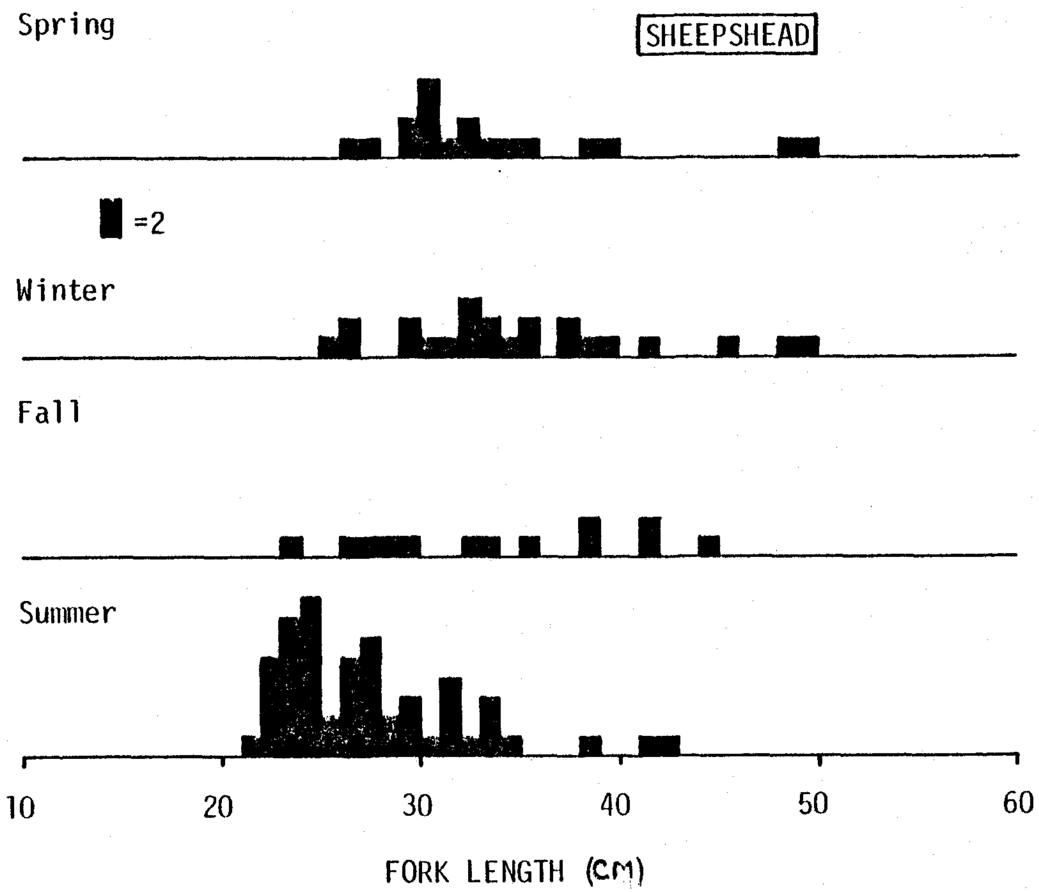

Fig. 16. Size distribution of sheepshead in the Buccaneer Oil Field, summer 1978-spring 1979.

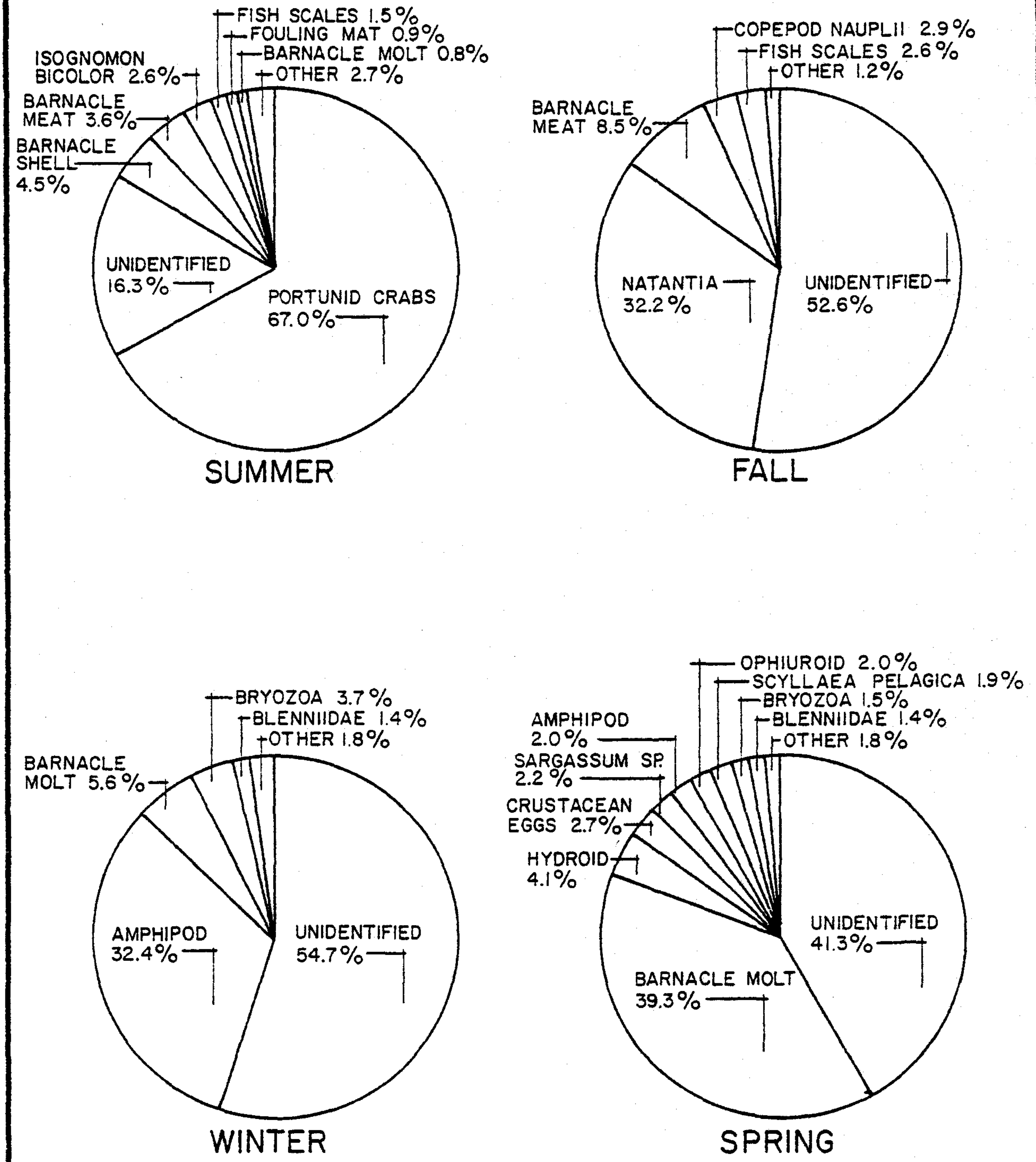

Fig. 17. Seasonal food habits of sheepshead, *Archosargus probatocephalus*, in the Buccaneer Oil Field, 1978-1979.

The bacterial flora of sheepshead was similar to that observed for other fish species collected from the Buccaneer Oil Field. Species of *Vibrio* were represented each season and were usually the dominant form. Of interest, hemolytic *Vibrio* sp., typically abundant, were not isolated from sheepshead collected during fall 1979. *Aeromonas* sp. were one of the dominant taxa on sheepshead collected at each of the two sampled habitats in summer, and were also represented on fish taken at each structure in fall. This potential fish pathogen was not isolated from winter specimens and was represented only on Production Platform 296B specimens in spring. The two categories of structure types (discharging and non-discharging) did not show marked differences in terms of sheepshead bacterial flora.

The most notable histopathological finding with respect to sheepshead was the vertical absence of any anomalous condition in tissue samples taken from specimens collected during the brief period of the spawning aggregation observed in the BOF in late winter-early spring (April). Typically, sheepshead collected during other seasons exhibited five to seven different tissue anomalies, with each condition represented in 20 to 100% of the specimens collected. With the exception of gill hyperplasia which was characteristic of all specimens collected during the summer and four of five specimens collected at Production Platform 296B in fall, most of the anomalies in the tissues examined were lesions in association with the presence of, or attributable to, a parasite (e.g. nematodes). If the fish collected during April were indeed representative of a migrant population, it would appear from these data that resident sheepshead are characterized by a higher degree of histopathological anomalies (or parasitism) than are sheepshead which migrate in and out of the study area for spawning purposes.

Comparisons of condition of sheepshead at the treatment and control structures were based upon specimens subsequently submitted for histopathological and bacterial flora analysis. The data set was reduced to the fall 1978 and spring 1979 collections, as the sheepshead represented during winter were not considered resident fish, and weights were not obtained for the specimens analyzed from the summer season. The length-weight regressions for fish from the two habitats had equal slopes ($F=1.75$ at 1 and 16 d.f.); and, although fish from Production Platform 296B were 10.6% heavier than fish from Satellite 288-5, the differences were non-significant ($F=3.79$ at 1 and 17 d.f.).

Crested Blenny

The crested blenny was abundantly represented at each station on various Buccaneer Oil Field structures during each season of 1978-1979 (Fig. 18). Significant differences (1% level) were indicated for the

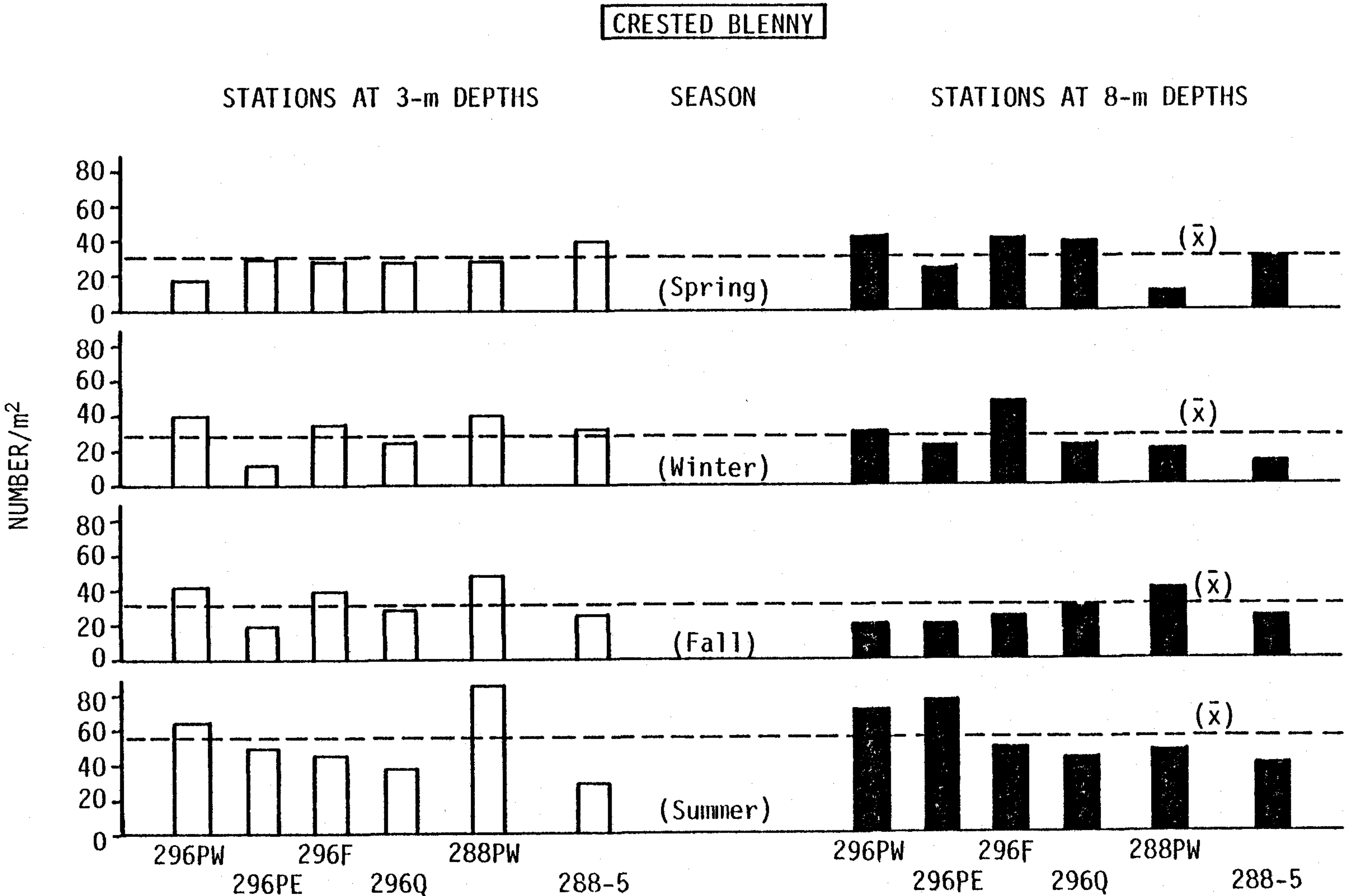

Fig. 18. Seasonal abundance of crested blenny at Buccaneer Oil Field sampling stations, summer 1978-spring 1979.

observed seasonal and areal abundance levels (no/m^2):

Source	d.f.	Sum of Squares	Mean Squares	F
Total	144	8816.93		
Station	11	1650.35	150.0318	16.37*
Season	3	3736.74	1245.5800	135.88*
Station x Season	33	3429.84	103.9345	11.34*
Residual	96	880.00	9.16667	

*Significant at 1% level.

The mean density of crested blenny was significantly higher in summer than during the other seasons, none of which were significantly different from each other. Based upon the presence of the small fish (<50 mm total length, Fig. 19), spawning of this species probably extends from spring into at least August. Thus, the summer samples, taken near the presumed end of the spawning season, benefited more in terms of recruitment from reproduction than did the samples taken in other seasons.

Results of regression analysis performed on the log-transformed length-weight relationships for crested blenny (Fig. 20) indicated significant differences in the seasonal slope values, disallowing for comparisons of condition. The slope values indicated that small fish in May samples were proportionately heavier than small fish in the other seasonal samples. These differences were probably also related to changes in state of maturity.

Most of the orthogonal contrasts of stations proved significant:

Contrast	F	PR>F
Control S288-5 ($\bar{x}$ = 14.801) *vs* Others ($\bar{x}$ = 18.67)	32.76	0.0001*
S288-5 - 3 m ($\bar{x}$ = 17.17) *vs* S288-5 - 8 m ($\bar{x}$ = 12.42)	14.77	0.0002*
Production Platforms ($\bar{x}$ = 19.29) *vs* Quarters and Flares ($\bar{x}$ = 17.73)	7.67	0.0067*
P296B ($\bar{x}$ = 18.79) *vs* P288A ($\bar{x}$ = 20.29)	3.93	0.0504
P296B W ($\bar{x}$ = 21.09) *vs* P296BE ($\bar{x}$ = 16.50)	27.50	0.0001*
P296B W - 3 m ($\bar{x}$ = 21.50) *vs* P296B W - 8 m ($\bar{x}$ = 20.67)	0.45	0.5018
P296B E - 3 m ($\bar{x}$ = 14.58) *vs* P296B E - 8 m ($\bar{x}$ = 18.42)	9.62	0.0025*
P288A - 3 m ($\bar{x}$ = 25.08) *vs* P288A - 8 m ($\bar{x}$ = 15.50)	60.11	0.0001*
Flares ($\bar{x}$ = 19.67) *vs* Quarters ($\bar{x}$ = 15.79)	19.66	0.0001*
Flares - 3 m ($\bar{x}$ = 19.00) *vs* Flares --8 m ($\bar{x}$ = 20.33)	1.16	0.2834
Quarters - 3 m ($\bar{x}$ = 14.83) *vs* Quarters - 8 m ($\bar{x}$ = 16.75)	2.40	0.1243

*Significant at the 0.01 level.

The crested blenny was more abundant on "affected" structures than on the control satellite, and more abundant on production platforms than on

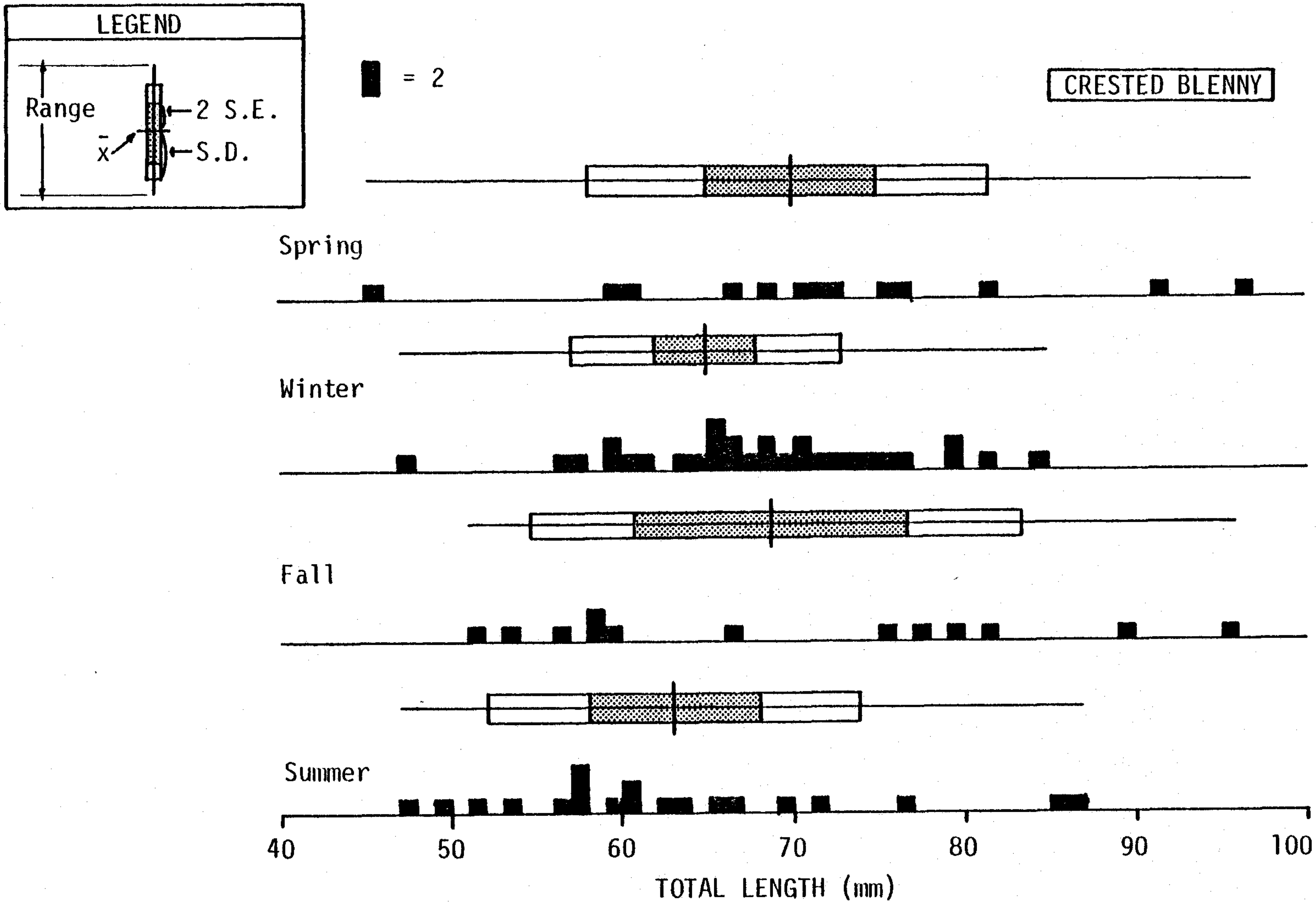

Fig. 19. Seasonal size distribution of crested blenny in the Buccaneer Oil Field, 1978-1979.

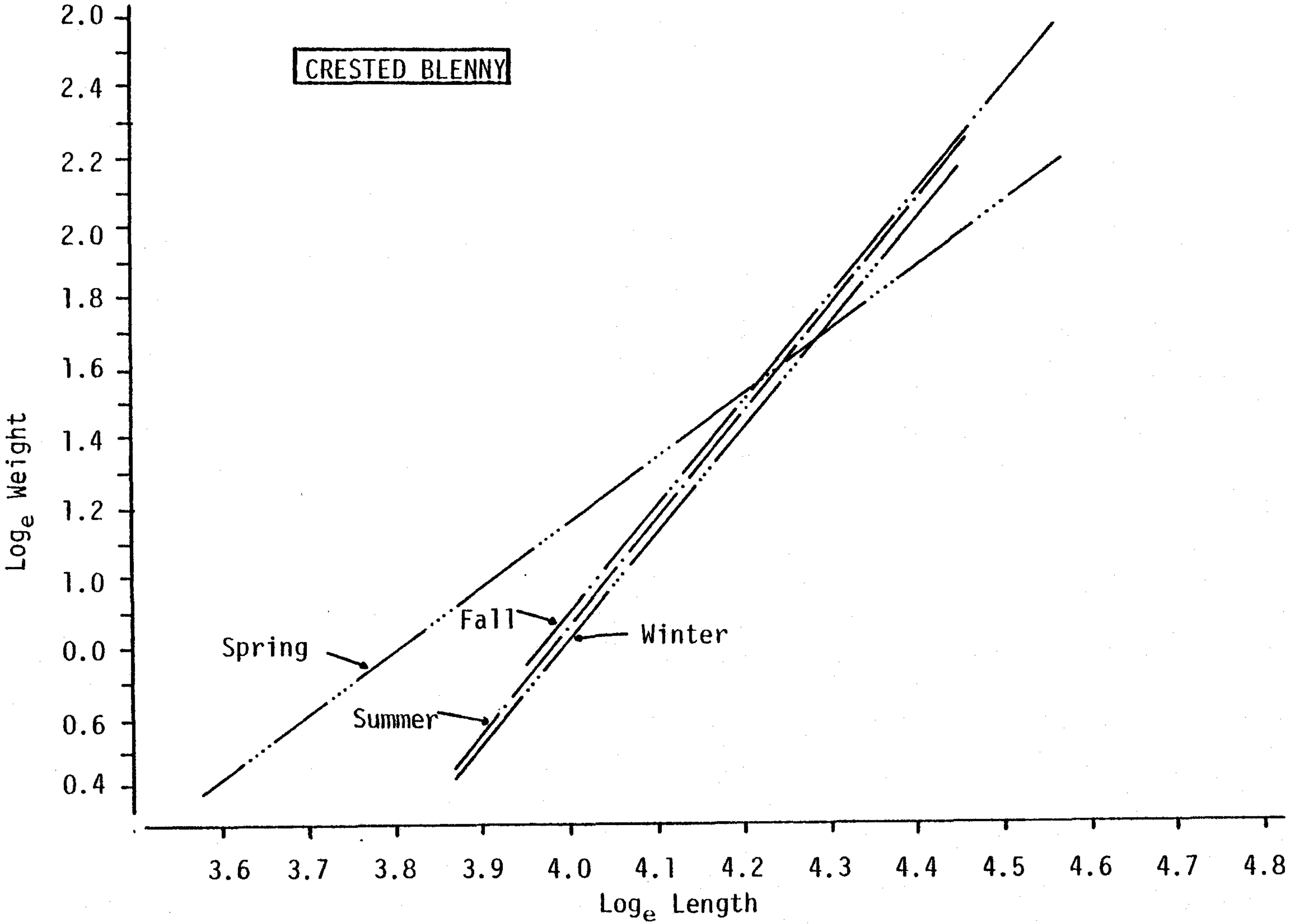

Fig. 20. Seasonal length-weight relationships for crested blenny in the Buccaneer Oil Field, 1978-1979.

quarters and flare structures. Abundance levels between the two production platforms were not significantly different. In contrast to Production Platform 296B, abundance at the 3-m deep station on the discharge or west leg of Production Platform 288A was greater than abundance at 8-m depths. Density of crested blenny on the discharge leg of Production Platform 296B was higher than abundance on the opposite leg on the other side of the platform (P296B E). The flare structure contained a higher density of crested blenny than quarters platform substrates. The apparent enhancement of the discharge on blenny density levels probably relates to the detrimental effects the discharge has on barnacles. The higher percentage of dead barnacles beneath the discharge as compared to other areas furnishes increased habitat or cover for the discharge-resistant crested blenny.

The produced water had no observable effects on recolonization rates of 0.5 m^2 areas totally harvested for blennies during each of the summer and winter seasons. In summer, the area harvested beneath the discharge appeared to recolonize at a faster rate than the control area; but, even after 12 elapsed days, neither site had attained pre-harvest density levels (80% beneath the discharge as opposed to 65% at the control station). We suspected the differences might have been due to the habitat damage that occurred as we installed and removed the quadrat template. In the winter survey, more caution was exercised with respect to altering the habitat during the course of the surveys and damage was minimal. Both sites attained pre-harvest density levels within seven days.

The crested blenny relied almost entirely on the biofouling community as food (Fig. 21). Hydroids, bryozoans and algae were commonly ingested and small, cryptic species (e.g., amphipods, polychaetes, etc.) were also important food items. During summer 1979, sponge spicules represented 5.1% of the diet. Much of the above "fouling mat" material is probably ingested as the blennies take discrete, cryptic organisms. Barnacles provide not only critical habitat for blennies, but also food.

Based upon the identifiable food contents in the stomachs, hydroids and barnacle molts were the dominant food items of blennies during summer and fall; amphipods and algae were important during winter, and, during spring, amphipods, hydroids and algae were the dominant foods. The unidentified category is believed to have been primarily of biofouling origin.

Index of fullness values for the crested blenny were highest in winter (52.5) intermediate in spring (36.0) and lowest in summer and fall (29.6 and 28.2, respectively). On a daily basis, stomach contents of specimens collected between 0601 and 1200 hrs were lower (IF $\bar{x}$ = 27.0) than contents from specimens collected during other periods (IF $\bar{x}$ = 49.0 for period of 1201-1800 hrs; 49.5 for 1801-2400 hrs; and 42.0 for 1201-0600 hrs).

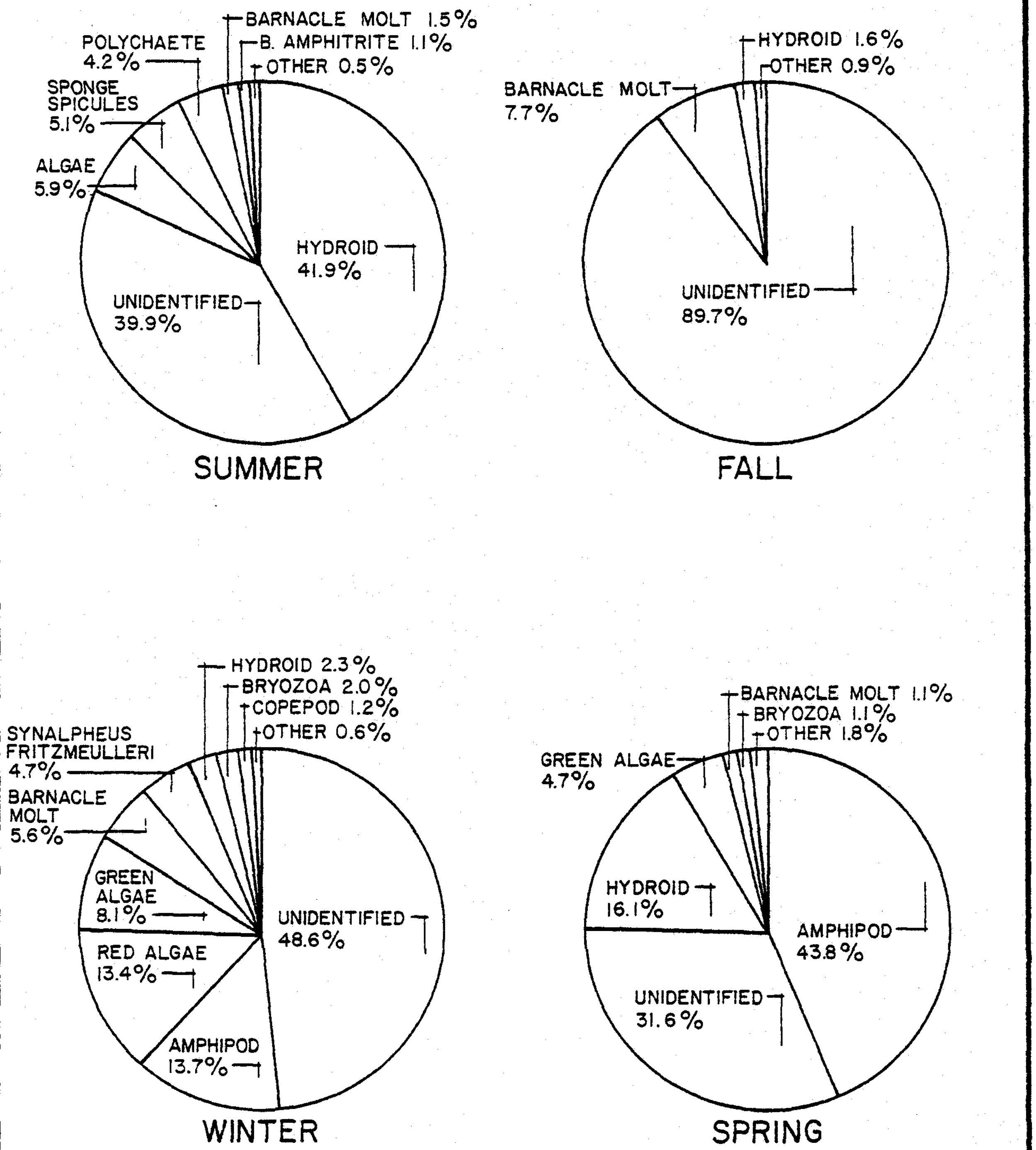

Fig. 21. Seasonal food habits of the crested blenny, *Hypleurochelus geminatus*, in the Buccaneer Oil Field, 1978-1979.

The crested blenny differed little from other Buccaneer Oil Field fishes in terms of bacterial flora. Species of *Vibrio* were the most common taxa during each season; hemolytic *Vibrio* were not isolated from fall specimens. *Moraxella* sp. was apparently a co-dominant with *Vibrio* sp. during spring. There was no marked difference in the bacterial flora of blennies taken from the production platform as compared to those collected at satellite jacket habitats. No diseased blennies were noted in any of the areas sampled.

The crested blenny was a "clean" fish in terms of histopathological anomalies. Other than a light infestation of microsporidean parasites, no significant histopathological anomalies were detected in the specimens which were examined.

SUMMARY OF SIGNIFICANT FINDINGS

The following provides a précis of the significant findings of the 1978-1979 field program:

Trawl collections were dominated by macrocrustaceans (particularly sugar shrimp), and results of cluster analysis showed three biological seasons: summer, winter, and fall-spring.

Production platforms were characterized by a significantly higher species diversity of demersal nekton than were control structures; primarily due to the greater evenness of collections from the former habitats.

- Within the same sediment type, sugar shrimp were more abundant at the production platforms (particularly P288A) than at control structures.
- Chevron shrimp were more abundant at production platforms (particularly P288A) than at control structures over the same bottom type.
- Rock shrimp were abundant in spring, and collections indicated an even distribution among stations.
- Mantis shrimp were significantly more abundant at Production Platform 288A than at P296B.
- Brown shrimp were abundant in the BOF only in Fall (migration period); other commercial penaeid shrimp were even more scarce.

Brown shrimp were "clean" from a histopathological and bacterial flora standpoint.

- Density of Atlantic spadefish around BOF structures was estimated to range between 0.11 and 0.22 fish/m^3; abundance of this species at Production Platform 296B was atypically low (0.05 fish/m^3) in summer 1978.

- Atlantic spadefish again suffered a disease epidemic in winter; comparisons to populations in the control area indicate the seasonal epidemics may be related to contaminant discharge.
- Bluefish were abundant during all seasons except summer.
- Most of the red snapper recruited to BOF structures appear to be harvested by sportfishermen.

  The BOF was a spawning site for sheepshead. Tremendous numbers of running ripe fish migrated into the study area in April and were gone by early May. Resident populations were about the same size following the spawning period as they were before the event, except for areas which had been harvested for sheepshead. Populations at these structures returned to normal levels.

  Sheepshead abundance appeared atypically low at Production Platform 296B in summer.
- The crested blenny was more abundant at sites near the discharges on production platforms than at any other location in the field.

One of the major, and completely unexpected, findings of this year's research program was the spawning aggregation of sheepshead in the Buccaneer Oil Field. This event had been missed in the previous two research years and points out a major problem with any quarterly sampling regime--that of incomplete temporal coverage. Although several major findings describing the effects of oil field operations in the marine environment have resulted from the NMFS/EPA research program, it is difficult to ascertain whether or not all, or even most of the significant effects have been determined.

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