NOAA Technical Memorandum NMFS-SEFC-35

NOAA/NMFS ANNUAL REPORT TO EPA

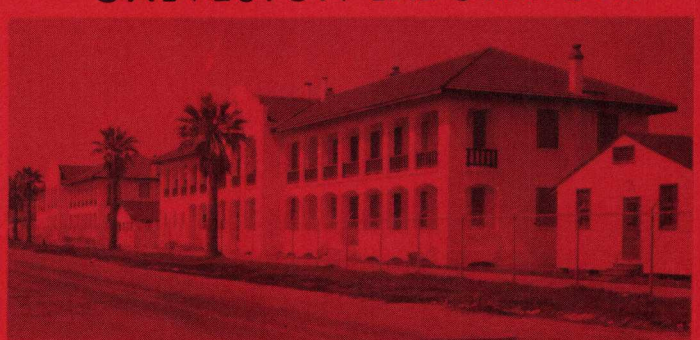
Environmental Assessment of Buccaneer Gas and Oil Field in the Northwestern Gulf of Mexico, 1978 - 1979

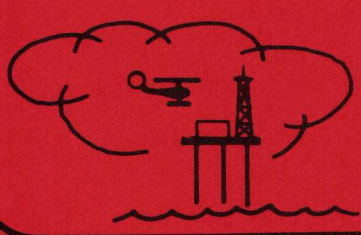
A report to the Environmental Protection Agency on work conducted under provisions of Interagency Agreement EPA-IAG-D5-E693-EO during 1978 - 1979.

Volume I

SOUTHEAST FISHERIES CENTER
GALVESTON LABORATORY

SYNOPSIS/ DATA MANAGEMENT





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-35

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

VOL. I PART A - SYNOPSIS BY Principal Investigators

PART B - IMPLEMENT, MONITOR AND MODIFY DATA MANAGEMENT SYSTEM

BY K. Savastano and H. Holley
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A report to the Environmental Protection Agency on work conducted under provisions of Interagency Agreement EPA-IAG-D5-E693-EO 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 cooporation 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
Chief, Environmental Research Division
and
William B. Jackson and E. Peter Wilkens
Editors

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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:

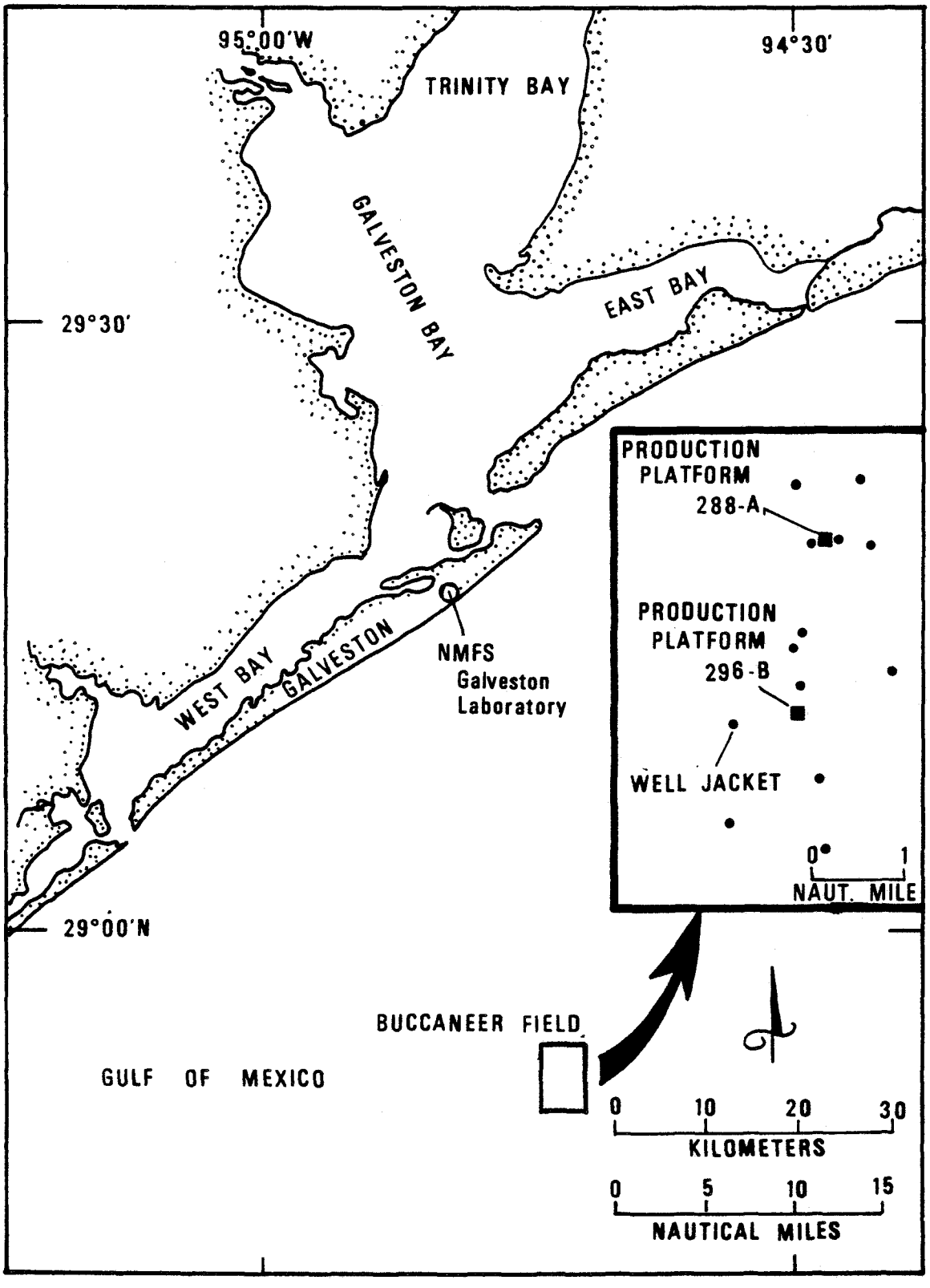

FIGURE 1. LOCATION OF BUCCANEER FIELD

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.

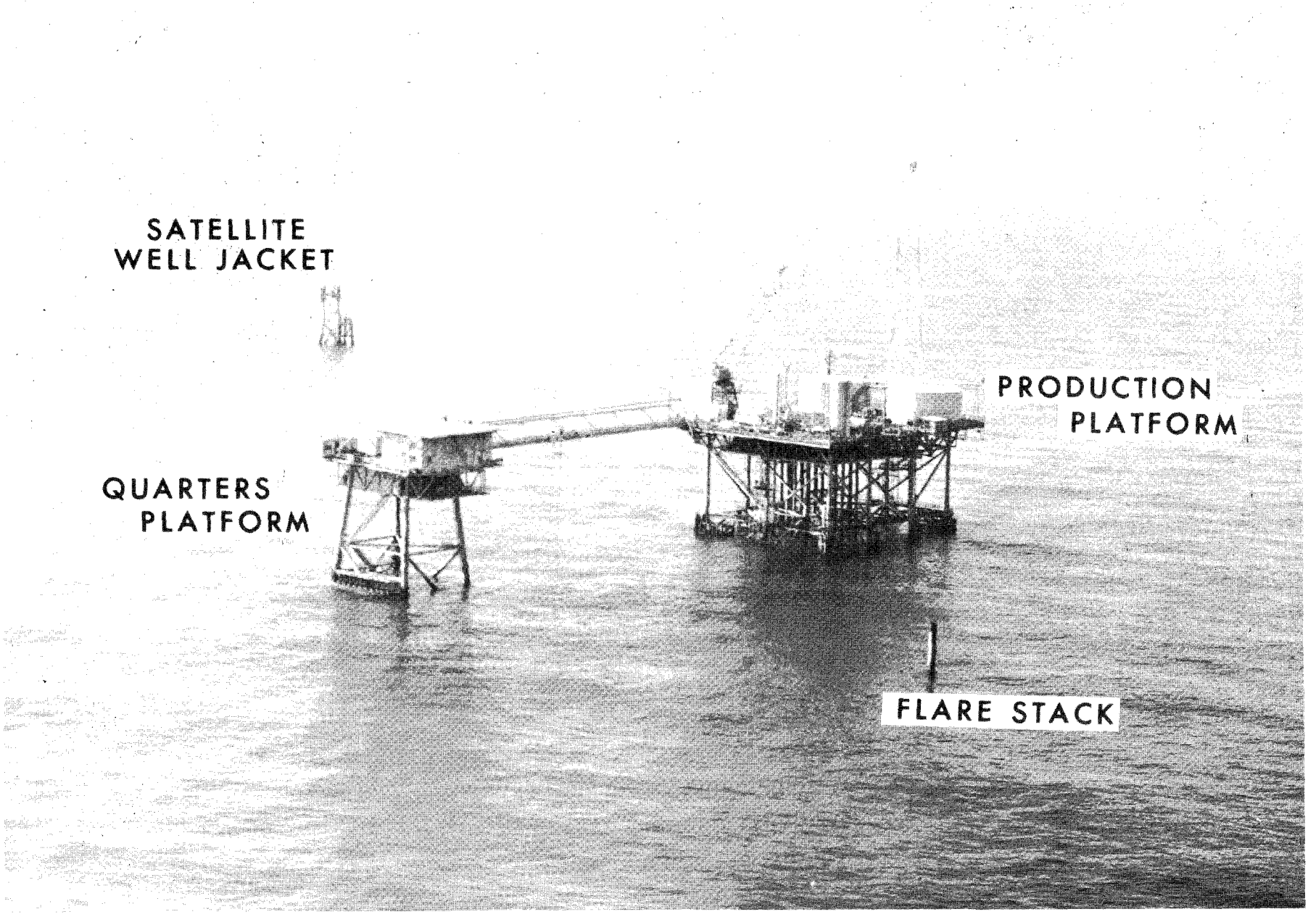

FIGURE 2. BUCCANEER FIELD STRUCTURES

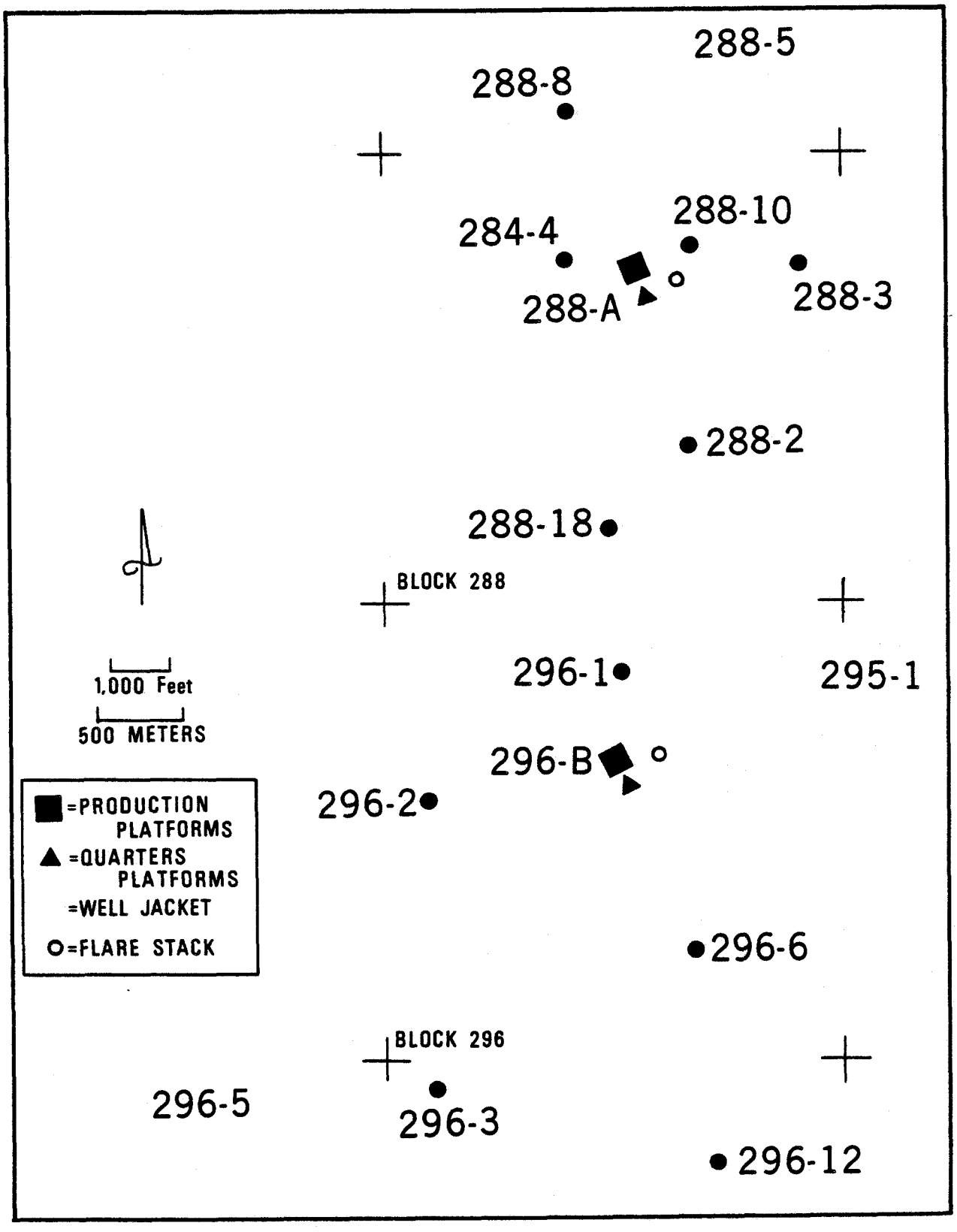

FIGURE 3. SHELL OIL COMPANY'S ALPHANUMERICAL IDENTIFICATION OF BUCCANEER GAS AND OIL FIELD STRUCTURES

PART A

WORK UNIT 2.6.1 - SYNOPSIS

National Marine Fisheries Service
Southeast Fisheries Center
Galveston Laboratory

W. Jackson
E. Wilkens

WORK UNIT 2.3.2 - INVESTIGATION OF SURFICIAL SEDIMENTS AND SUSPENDED PARTICULATES AT BUCCANEER FIELD

Texas A&M University

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E. Estes, Ph.D.
W. Huang, Ph.D.

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R. Shokes, Ph.D. (SAI)
C. Schwab (TAMU)
D. Wiesenburg, Ph.D. (TAMU)
F. Weber (TAMU)
H. Abdel-Reheim (TAMU)
C. Coleman (TAMU)

OBJECTIVES

1. Sample surficial sediments to determine particle size distribution, clay mineralogy, carbonate content, organic carbon content, and sedimentaiton rates by Pb-210 dating;

2. Estimate phytoplankton standing crop via chlorophyll *a*;

3. Estimate living biomass via ATP measurements;

4. Characterize suspended load of the water column through determination of total suspended matter, transmissometry, clay mineralogy, particle size, organic carbon, carbonate, and nutrients.

MATERIALS AND METHODS

1. Water column and surficial sediment samples were taken at stations around two production platforms and near a well jacket and flare stack in the Buccaneer Field during summer, fall, winter and spring periods (1978-1979).

2. Suspended particulates were characterized through analyses of total suspended matter (TSM), particulate organic carbon (POC), chlorophyll *a*, adnesoine-triphosphate (ATP), calcium carbonate ($CaCO_3$), silicate, carbon isotopes, particle size and clay mineralogy and transmissometry.

3. Water samples were analyzed for nutrients (phosphate, nitrate, nitrite) and dissovled organic carbon (DOC).

4. Surficial sediment samples were analyzed for organic carbon, $CaCO_3$, clay mineralogy, particulate size and carbon isotopes.

5. Pb-210 dating was performed on six cores to provide an estimate of the sedimentation rate.

RESULTS AND CONCLUSIONS

1. Large seasonal variations in the suspended load of the water column were observed, however, the winter total suspended matter (TSM) concentration were significantly higher than in other seasons.

2. Although the TSM load was uniform throughout the water column during the winter sampling period, nepheloid layer(s) were present during all other sampling periods.

3. Clay was the dominate particulate material in the water column, and accounted for more than 50% of the TSM during all seasons.

4. The organic fraction of the TSM consisted almost exclusively of cellular material (phytoplankton, zooplankton, and bacteria).

5. The Buccaneer Field production platforms do not measurably alter the bulk composition of suspended particulates or biological activity (as measured by chlorophyll a and ATP) in their immediate vicinity.

6. Pollutants introduced into the water column from the platforms could be rapidly transported out of the system either because of hydrographic conditions or perhaps by attachment to suspended particulates.

7. Suspended particulate data indicates that the water column was stratified during all samplings except winter. The stratification of the water column during the majority of the year, no doubt, acts as a barrier against introduction of platform contaminants to the sediments near the platforms.

8. The sedimentation rate in the field, based on Pb-210 dating, varies from 1.5 to 2.1 mm/yr in the northern part of the field, and from 3.5 to 3.7 mm/yr in the southern portion.

9. Both the organic and inorganic carbon content of the sediments decreased with distance from the platform.

10. Sediment grain size decreased with increased distance from the platform, however, sorting increased with distance from the platform.

11. Surficial sediment data indicate that there is considerable movement of fine grain material in the area, therefore, contaminants

introduced to the sediments in the Buccaneer field may be rapidly removed from the platform vicinity by suspension and redeposition. Only contaminants associated with very coarse grained material would be expected to remain permanently in the field.

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

LGL Ecological Research Associates, Inc.

B. Gallaway, Ph.D.
L. Martin

OBJECTIVES

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 (Atlantic spadefish, Chaetodipterus faber and blue fish, Pomatomus saltrix);

   - 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, Hypleurochelus geminatus; sheepshead, Archosargus probatocephalus and red snapper, Lutjanus campechanus).

   - 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.

MATERIALS AND METHODS

1. Field investigations were performed on a quarterly basis.

2. 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, and expanded to include Satellite structure 296-12 and Production-Quarters structure 288A during the remainder of the study.

3. Samples were preserved in a 10% buffered formalin and seawater solution and returned to the laboratory for analysis.

4. 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.

5. 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.

6. Population estimates were made on five species of fish (Atlantic spadefish, bluefish, red snapper, sheepshead, crested blenny), using mark recapture and/or diver census techniques.

RESULTS AND CONCLUSIONS

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

2. 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.

3. Within the same sediment type, sugar shrimp were more abundant at the production platforms (particularly 288A) than at control structures.

4. Chevron shrimp were more abundant at production platforms (particularly 288A) than at control structures over the same bottom type.

5. Rock shrimp were abundant in spring, and collections indicated an even distribution among stations.

6. Mantis shrimp were significantly more abundant at Production Platform 288A than at 296B.

7. Brown shrimp were abundant in the BGOF only in fall (migration period); other commercial penaeid shrimp were even more scarce.

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

9. Density of Atlantic spadefish around BGOF 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.

10. 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.

11. Bluefish were abundant during all seasons except summer.

12. Most of the red snapper recruited to BGOF structures appear to be harvested by sportfishermen.

13. The BGOF 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 eventually returned to normal levels.

14. Sheepshead abundance appeared atypically low at Production Platform 296B in summer.

15. The crested blenny was more abundant at sites near the discharges on production platforms than at any other location in the field.

WORK UNIT 2.3.7 - BACTERIAL COMMUNITIES

University of Houston

R. Sizemore, Ph.D.
K. Olsen

OBJECTIVES

1. To observe subtle effects of the production platform on bacterial numbers in the water, sediment and suspended particulate material.

2. To examine the taxonomic composition of the bacteria found in sediment samples from the field and from the control area.

3. To investigate the bacteria associated with diseased fish in the study area.

4. To determine the capacity of the bacteria from the field to utilize oil and its potential for oxidizing sulfur; and

5. To observe any detrimental effects that Buccaneer field brine discharge might have on bacteria.

MATERIALS AND METHODS

1. Samples of water for this study were collected with Niskin sterile bag samplers. Sterile glass bottles were used to collect surface water samples. Surface sediment samples were collected with a Petite Ponar Grab. Water and sediment were always subjected to bacteriological analysis immediately after collection. (Suspended particulate material was collected in the water samples by the Niskin sampler).

2. The sewage effluent samples were collected as close as feasible to the effluent pipe of the living quarters platform and examined carefully for traces of dilute sewage effluent.

3. Brine discharge was studied by examining samples collected on rigs and returned to the laboratory.

4. Samples from 10 sites were routinely collected including areas as near as possible to platform 288-A, platform 296-B, flare stack 288-10, well jacket 288-8 and the living quarters of platform 296-B. Multiple samples (3) were collected at platforms 288-A and 296-B in an attempt to identify a gradient around these two platforms. A control station five miles north of the study area was also sampled.

5. Initial bacterial enumerations (colony forming units - CFU) were made on MSWYE medium which is composed of 1 g proteose peptone and 1 g yeast extract in 1000 ml of 3 salt solutions (0.4M NaCl, 0.028 M $MgSO_4 \cdot 7H_2O$, 0.01 M KCl). The medium was brought to pH of 7.2.-7.4 with 1N NaOH.

6. Shipboard analyses included inoculation of broth tubes for the determination of the number of hydrocarbon-utilizing and autotrophic sulfur-oxidizing bacteria.

7. Hydrocarbon degradation was tested in a two step procedure. Initially the samples and dilutions of the samples were placed in an inorganic salts plus a crude oil medium. The crude oil used was from the Buccaneer field. Confirmation of hydrocarbon utilization was made by transferring some of the presumptive positive strains from oil medium to silica gel oil media or to a second passage in the oil media. Salt-requiring bacteria were enumerated by plating water samples on MSWYE-like medium made with distilled water instead of the salt solution.

8. The water around the sewage discharge was examined for the presence of fecal coliforms.

9. Laboratory based analysis included bacterial numbers and biomass estimates determined by epiflourescent microscopy (Hobie, et al, 1977). Water samples were fixed with formalin on board ship immediately after collection. The fixed cells were stained with Acridine Orange and counted with an Olympus BH-B epiflourescent microscope equipped with oil immersion optics.

10. Bacterial cell volumes were estimated to determine bacterial biomass. Water samples were returned to the laboratory for determination of bacterial numbers attached to suspended particulate material. Sterile Millipore filters of different port sizes were used to remove different fractions of the suspended materials. Bacterial counts using MSWYE agar were performed on each filter fraction and the number of bacteria remaining was compared to the initial total viable count.

11. The makeup of the bacterial community was determined by taxonomic analysis of 511 isolates collected from MSWYE plates. Taxonomic tests which were run on the strains included: gram stain, Kovac's oxidase test, M.O.F. reactions, flagella stain, catalase reaction, spore stain, 0/129 sensitivity and arginine dihydrolyase.

12. The strains were also tested for oil degrading, sulfur oxidizing and sulfur producing potential. A simple taxonomic key designed specifically for marine bacteria was used to identify the strains (Holloway, et al., 1980).

13. One hundred and nine bacterial strains were collected from diseased fish and bioassay samples (from Work Unit 2.3.4 and 2.3.5). The isolates which appeared to be the predominant colony type of swab plates derived from the samples were chosen for testing on A.P.I. diagnosis strips. The key provided with the strips was not utilized since it is biased toward human pathogens. Instead the large number of taxonomic tests provided by the strips were used in keys (e.g. Bergey's Manual of Determinative Bacteriology).

14. Bacterial biodegradation experiments used mixed and pure culture collected in the field. Mixed culture inocula were freshly collected water samples or were prepared by diluting sediment in sterile sea water, centrifuging to pellet the sediment, and using the supernatant as a mixed culture inoculum. Mixed culture experiments were used to give an indication of the turnover rates of petroleum in the environment.

15. The pure culture experiments used strains identified during the taxonomic portion of the study. Some of the strains which

appeared to degrade petroleum upon initial isolation were examined in detail. All degradation experiments used the same initial pH, salinity, and approximate temperature as the sampling sites. Experiments were run for time periods ranging from 3 to 30 days with some subsampling at intermediate times. The bacterial numbers in the inoculum were manipulated to resemble water column total viable counts. The degradation experiments were run in sterile artificial sea water which had been enriched with PO_4 and NO_3. Hydrocarbons were introduced by adding either filter sterilized Buccaneer condensate or filter sterilized brine discharge (either at full strength or diluted). The degradation rates of various hydrocarbon components were calulated by careful measurement of the hydrocarbon components of the degradion experiment and comparing them with a sterile control prepared and incubated the same time as the experimental flask. Estimates were made of the total portion of the hydrocarbons utilized as well as measurements of the loss of some of the specific components of the hydrocarbon mixture.

16. Qualitative and quantitative measurements of the hydrocarbons were made using an Antek 300 dual column temperature programmable gas chromatograph equipped with glass packed and capillary columns. The extraction, fractionation and concentration techniques used were essentially those proposed by Dr. Brian Middleditch in his study of the hydrocarbons of Buccaneer field. This procedure calls for extraction of an acidified sample using equal volumes of cyclohexane. The sample is then fractionated into "alkane", "aromatic", and "asphaltene" components using various solvents on a silica gel column. The resulting fractions were concentrated under nitrogen and stored in the dark until gas chromatographic analysis. Deuterated hydrocarbon standards of known concentration are added to the sample before extraction for use as an internal standard in quantitation. The emphasis in the degradation experiments was on the degradation of the aliphatic alkane components since we were more confident in our identification of these components.

17. The effect of Buccaneer field discharge was tested by growing pure and mixed cultures of Buccaneer field isolates as well as laboratory isolates in the presence of various concentrations of brine. Either 1% or 90% solutions of refrigerated filter sterilized brine discharge in sterile 3 salts solution were used. Pure cultures included isolates taken from the taxonomic analysis or laboratory control isolates. Mixed cultures were aliquots of freshly collected Buccaneer field water samples. At varying time intervals the growth flasks were sampled and the bacterial numbers determined by plating on MSWYE agar. A few experiments were monitored for sulfur loss and pH shift in the growth flask.

RESULTS AND CONCLUSIONS

1. The bacterial numbers and taxonomic types in the oil field are the same as the control area.

2. Epiflourescent microscopy is a superior enumeration technique for bacterial populations.

3. Ninety percent of the bacteria (CFU) in the water column are attached to particles greater than 3 u in diameter.

4. More oil degrading and sulfur oxidizing bacteria are present in the oil field than the control area.

5. Sulfate reducing bacteria are much more common in the sediment at the oil field compared to the control site.

6. The most common taxonomic type in the sediment of the platform and control site were Vibrio, Pseudomonas, Aeromonas, and Acinetobacter.

7. Bacterial diversity was the same for the control and platform area but changes with the season, being the lowest in the spring.

8. Aeromonas hydrophila was the only potential bacterial pathogen found associated with diseased fish from the study area.

9. Presumptive coliform microorganisms were more common near the crew's quarters than the control site but no fecal coliform were found at either site.

10. Bacterial biomass estimates made from epiflourescent counts were much higher than previous estimates being in the range of 6.2 - 44.0 x 10^{-6} gC/l.

11. Ninety-four percent of the bacteria enumerated show a requirement for salt to grow. This indicates the marine origin of the strains.

12. Bacterial population from Cruise I & II were different than Cruise III & IV at both the control and platform site.

13. Brine discharge from the oil field inhibited or retarded growth of laboratory culture but appear to have either no effect or a stimulatory effect on isolates from the oil field.

14. Both mixed and pure culture from the Buccaneer oil field show the ability to degrade significant portions of the n-alkanes in Buccaneer crude oil.

WORK UNIT 2.3.8 - EFFECTS OF GAS AND OIL FIELD STRUCTURES AND EFFLUENTS ON FOULING COMMUNITY PRODUCTION AND FUNCTION

LGL Ecological Research Associates, Inc.

R. Howard
G. Boland
B. Gallaway, Ph.D.
G. Dennis

OBJECTIVES

Biofouling Comunity

1. Estimate the amount of produced water being discharged.

2. Define the spatial exponent of direct effects of the produced water on the biofouling community that can be detected.

3. Gather information contributing to an understanding of the functionings of the biofouling community.

Overall Program

1. Concentrations and effects of contaminants on major ecosystem components.

2. Effects of circulation dynamics and hydrography on contaminant distribution in the environment.

3. Use mathematical modeling to describe and predict sources, fate and effects of pollutants.

MATERIALS AND METHODS

A. Sampling was specifically designed to measure direct effects:

1. Seasonal measurement of produced water discharge rates at production platform 296B with samples of the effluent and receiving environment taken synoptically for chemical characterization;

2. Seasonal respirometry experiments designed to evaluate the effects of the produced water on oxygen-demand characteristics of the biofouling community;

3. Spatial extent of measurable effects of the produced water on biofouling community and biomass and abundance;

4. Confirmation of the effects of produced water on recolonization of platform substrate by the biofouling community;

5. Effects of seasons and the produced water on the condition of the primary habitat former, Balanus tintinnabulum.

B. Additional experiments were performed to describe other aspects of community function as follows:

1. Obtaining indices of feeding and assimilation capabilities of B. tintinnabulum;

2. The production and fate of small barnacles (why does B. tintinnabulum dominate?);

3. Production aspects of certain hydroids and branching bryozoans.

C. Effluent Discharge

1. Samples were collected summer, fall, winter and spring seasons taken at 4-h intervals over a 24-h period, 3 replicates each 4-h period.

2. Seawater and surficial sediment samples were taken on a "bullseye" sampling array.

D. Respirometry

1. Were performed in situ using specially constructed chambers which were temporarily attached to the platform support members.

2. A battey-operated stirrer was used to provide water circulation.

3. Oxygen changes were measured with a YSI dissovled oxygen meter.

4. Measured variables included time of day and the concentration of produced water which was introduced.

5. Produced water was added to the enclosed system so as to provide a measure of its effects on the biolouling community.

E. Biofouling Community Harvest Sampling

1. A total of 28 stations were harvested during summer 1978 and 10 were harvested during winter 1979. Sampling at each station consisted of collecting all of the attached fouling growth contained within three or four 25- x 25-cm quadrats.

2. Diver's using putty knives and hatchets collected the fouling growth, placed each sample into labled plastic bags, transferred each to plastic jars at the surface, labeled and preserved each in 7% buffered formalin.

3. In the laboratory, faunal samples were analyzed for total wet weight, shell wet weight, number of live and dead barnacles (B. tintinnabulum, Balanus spp.), and number and weights of macrocryptic fauna. Carapace length and width data, respectively, were obtained for the cryptic crustaceans, pistol shrimp (Synalpheus fritzmuelleri) and stone crab (Menippe mercenaria).

4. Floral samples were subsampled by weight.

5. Analyses were designed to be performed within season and to address (1) effects of discharges based upon the 3- and 8-m deep stations, and (2) compare fouling biomass on an exposed pipeline to that on a 21-m deep station on a platform support.

6. Analyses were performed on both transformed and untransformed data for comparative purposes. Significant differences among

stations sampled during summer were evaluated using orthogonal contrasts. Comparisons of pipeline biomass to that on the platform leg at a 21-m depth were made each season (summer and winter) using a standard t-test. Comparisons of floral data were of a qualitative nature due to the lack of sample replicates.

F. Biofouling Community Recolonization Sampling

1. Small 25- x 25-cm areas were cleared of existing fouling growth at nine locations and allowed to recolonize for either 90- or 180-d periods.

2. Ninety-day samples were collected four times from 10 stations.

3. Three stations were collected twice to obtain the 180-d samples.

4. Samples consisted of triplicate glass jar (4.8-cm opening) samples.

5. Samples were analyzed for total wet weight and total wet weight of each barnacle species in the sample.

6. Means were compared using either a Duncan's Multiple Range test or an appropriate orthogonal contrast. Where significant interaction differences were evident, means were compared graphically.

RESULTS AND CONCLUSIONS

1. Production Platform 296B was estimated to have discharged 5.08 x 10^5 bbl of produced water during 1978-1979.

2. Results from respirometry experiments indicated that biofouling primary production rates were low and that produced water generally increased the oxygen demand of the systems under study, particularly the biofouling components.

3. A well casing on Production Platform 296B had lower biomass than other platform supports, measurable effects on total biomass from produced water were limited to near the area of the discharge point.

4. Pistol shrimp were significantly more abundant at 8-m depths than at 3-m depths during both summer and winter, and were slightly more abundant in summer than winter.

5. Stone crabs were significantly more abundant at 3-m depths than at 8-m depths and were more abundant in summer than in winter.

6. Brittle stars were patchily distributed and were most abundant at Satellite 288-5. Maximum densities were at 3-m depths.

7. Biomass of macroalgae was higher in summer (28 g/m^2 at 3 m; 6 g/m^2 at 8 m) than in winter (6 g/m^2 at 3 m; 1.0 g/m^2 at 8 m) and higher at 3-m depths than at 8-m depths.

8. The macroalgae were dominated by greens and reds, distribution by species was patchy during both seasons and exhibited few definite trends.

9. During winter, structures without discharges had higher macroalgae biomass at 3-m depths than structure with discharges.

10. Recolonization samples taken for summer and fall seasons were dominated by Balanus amphitrite. Beneath the discharge, numbers and biomass increased with depth, whereas abundance and biomass decreased with depth at control structures.

11. Recolonization rates were low for winter and spring seasons.

12. Long-term recolonization experiments performed at the surface for summer to winter and winter to summer periods gave results similar

to the short-term seasonal xperiments. In general, lowest biomass was obtained at production platforms and highest biomass at control structures.

13. B. tintinnabulum condition was intermediate in summer, lowest in fall and increased from the fall low to a spring high. The differences were mostly associated with reproduction stages.

14. Barnacles at 1-m depths were characterized by significantly better condition than those living at 8-m depths.

15. Comparisons of the production discharge leg to a quarters platform leg using condition of barnacles from 1-m deep collections as the response variable showed no significant differences.

16. A 10% solution of produced water-seawater killed 100% of the amphipod J. falcata in 48 h; a 1% solution killed 12.5% in 48 h.

17. The large barnacle, Balanus tintinnabulum, feeds during the night with feeding rates apparently higher in summer than in winter.

18. Barnacle production experiments indicated production rates for a single recruitment of B. amphitrite was 9.3 $g/m^2/d$ and that adult size is attained in 1 year.

19. Production experiments using the hydroid Tubularia crocea as a test animal indicated that winter production rates for an average stalk was 0.00016 g/d for areas undergoing regrowth after clipping, and 0.00042 g/d for undamaged areas of the colony.

20. Based upon the above results and those from time-lapse photography, hydroid production is high during winter and the colonies decline markedly during spring.

21. Production rate of the bryozoan Bugula neritina during a winter to spring period was estimated to have been 0.24 $mg/cm^2/d$.

WORK UNIT 2.3.9 - CURRENTS AND HYDROGRAPHY OF THE BUCCANEER GAS AND OIL FIELD AND ADJACENT WATERS

Hazleton Environmental Sciences Corporation

L. Danek, Ph.D.
M. Tomlinson

OBJECTIVES

1. Describe the hydrography and seasonal variations in and adjacent to the Buccaneer Gas and Oil Field (BGOF).

2. Describe the current and forces affecting the currents in the oil field.

3. Estimate the amount and flux of suspended particulate matter in the vicinity of the oil field.

4. Measure and document wave activity near the oil field and estimate the relative importance of wave energy in sediment resuspension and transport.

5. Provide the above information to all other investigators to aid them in their respective tasks.

MATERIALS AND METHODS

1. In situ hydrographic measurments of conductivity, salinity, temperature, dissolved oxygen, pH, and transmissivity versus depth were made with an InterOceans 513D CSTD system.

2. The hydrographic data were tabulated and contours were plotted to aid in the interpretation and presentation of the data.

3. Total suspended solids samples were taken from selected depths and bottled for analysis according to the procedures specified in "Standard Methods for the Examination of Water and Wastewater " (Taras 1975).

4. Vertical profiles of current speed and direction were made during the ebb and flood stages of the tide with a Marsh-McBirney Model 727 Electromagnetic Current Meter and computer plotted for interpretation and presentation.

5. Continuous current measurements were made at depths (4.5, 10.5, and 18.0 m) for 35 days during the summer and winter with ENDECO type 105 Current Meters.

6. The continuous current measurements were entered onto Hazleton's computer system and current speeds and directions were computer tabulated and plotted and progressive vector plots for each depth were made.

7. Wind speed and direction were measured for 30 days during summer and winter with a Meteorology Research Incorporated Model 1071 Mechanical Weather Station located on Platform B 30 m above the sea surface.

8. Continuous wind speed and direction were tabulated and plotted and progressive vector plots were made.

9. Wave measurements were made during two recording intervals, one each during the summer and winter, with a Bass Engineering Model WG/100M Wave Gauge.

10. The data collected with the wave gauge were used to determine significant wave height, significant wave period, and estimated maximum orbital velocities at the bottom using linear wave theory.

RESULTS AND CONCLUSIONS

1. The BGOF is located in a mixing zone between the fresher coastal water and the offshore waters which resulted in large salinity gradients in the area.

2. The salinity generally increased from north to south except in July when northeast currents reversed the salinity gradients.

3. The currents were usually to the southwest; however, in July the currents were variable with periods of easterly flow.

4. The current directon was uniform with depth; however, there was about a 50% reduction in current speed from surface to the bottom.

5. The currents were of sufficient magnitude to readily resuspend unconsolidated sediments as the currents near the bottom exceeded 26 cm/sec more than 3.5% of the time. The maximum speed recorded was 66 cm/sec.

6. Increases and decreases in curent speed were closely related to changes in the wind with approximately a 12-hr lag time for the current to respond to wind changes.

7. Tidal fluctuations (both diurnal and semi-diurnal) were the dominant periodic components in the velocity field.

8. Wave heights were usually less than 1 m; the maximum measured significant wave height was 2.1 m which occurred as the wind speed peaked at 15.2 m/sec.

9. The computed amplitude of the wave orbital velocities at the water sediment interface was greater than 20 cm/sec about 7.5% of the time. The maximum computed value was nearly 40 cm/sec.

10. The total suspended solids values were typically between 1 and 2 mg/l. The average flux of suspended material through the study area was about 2 gm/sec per meter of water surface, however, this value can increase greatly during storm conditions.

11. Surface temperatures exhibited the normal seasonal variation with a low in February of 13.7°C and a high in July of 29.5°C.

12. Temperature values usually decreased with depth, however, some temperature inversions were noted during the surveys.

13. Dissolved oxygen values loosely followed temperature distribution with increasing DO and decreasing temperature. An oxygen depleted nepheloid layer was noted near the bottom in May 1979.

14. The pH values remained relatively uniform between 8.0 and 8.3 with no apparent seasonal trends.

15. The transmissivity values indicated very clear water except for the intermittent existence of a nepheloid layer near the bottom.

WORK UNIT 2.4.1 - HYDROCARBONS, BIOCIDES AND SULFUR

University of Houston

B. Middleditch, Ph.D.
D. West

OBJECTIVES

Determine levels, pathways, and bioaccumulation of hydrocarbons, biocides and sulfur in the marine ecosystem of the gas and oil field.

MATERIALS AND METHODS

MATERIALS

All organic solvents (cyclohexane, benzene, methanol, and chloroform) were Mallinckrodt (St. Louis, Mo.) "Nanograde" quality, meaning distilled in glass. Alumina gel (chromatographic, neutral) for column chromatography was from Sigma (St. Louis, Mo.). Hydrocarbon standards were purchased from Applied Science Labs. (State College, Pa.) and deuterated hydrocarbons were from Merck (Elmsford, N.Y.). Bicyclohexyl was obtained from Aldrich (Milwaukee, Wis.).

SAMPLE COLLECTION AND STORAGE

1. Discharged Brine

Samples of discharged brine were collected from the sampling spigot of the 296-B discharge pipe in 1 liter narrow-mouth glass bottles with Teflon-lined screw caps and frozen immediately after collection. Brines collected on some monthly visits were drawn into 15 ml conical centrifuge tubes for volatiles analysis. The latter samples were frozen on return to the laboratory and maintained at -20°C to minimize bacterial growth as well as loss of volatile components.

2. Seawater

Water samples were collected by divers using 1 liter screw cap bottles. Surface samples were collected at less than 1 m from the air-sea interface. All samples were frozen in glass bottles and were maintained at -20°C until analysis.

3. Sediments

Sediments were collected by divers in 1 liter or 250 ml wide-mouth glass bottles fitted with ground glass stoppers. Being surficial sediments they were scooped directly from the bottom by the divers, then stoppered and later frozen and maintained at -20°C to minimize microbial activity.

4. Sediment Traps

A sediment trap is a device for collecting suspended particulate matter over a period of weeks. The traps employed consisted of acrylic tubes about 5 cm x 30 cm with a screened opening at one

end to which a funnel was attached. The traps were placed at certain depths off the side of one of the structures. Collection was simply a matter of hoisting the traps up and capping the trap tubes, followed by refrigeration at -20°C.

5. Fish

Samples were obtained either by trawling with a 12 m nylon mesh semiballoon shrimp trawl, by casting line, or by spear gun. Samples were wrapped in aluminum foil and then frozen and maintained at -20°C.

6. Shrimp

Shrimp samples were collected using a 12 m nylon mesh semiballon shrimp trawl. Shrimp were sorted by species and were wrapped in aluminum foil. Samples were maintained at -20°C to minimize contamination.

7. Barnacles and Fouling Mat

Barnacles were removed from the structures by divers. The fouling community was left attached to the barnacle shells, and both were wrapped in aluminum foil and maintained at -20°C until analysis.

8. Other Platform Samples

Sewage was collected at the outfall in 1 liter wide-mouth glass bottles with ground glass stoppers. Fire-fighting water was collected from quarters platform 296-B after purging the hose for 2 minutes. Separator tank water and separator tank oil were collected from their respective sampling spigots. Seawater was collected either from the lower deck of the quarters platform 296-B or next to brine discharge outfall on the production platform by lowering a 1 liter wide-mouth glass bottle into the water followed by capping with a ground glass stopper. All of the above samples were frozen upon return to the laboratory and maintained at -20°C until analysis.

EXTRACTION PROCEDURES

1. Discharged Brine

Samples were acidified to pH 2 and n-[$^2H_{42}$]eicosane, [$^2H_{10}$]-2-methylnapthalene and [$^2H_{12}$]benzo[a]pyrene (internal standards) were added to the discharged brines. One hundred ml of cyclohexane was added to the sample and then tumbled on a modified

rock polisher for at least 6 hr. The cyclohexane was concentrated using a Buchi/Brinkmann Rotavapor R rotating evaporator before column chromatography. Following extraction, sulfur in the brine sample was vacuum filtered and weighed after drying.

2. Seawater

Water samples were extracted using the same procedure as the discharged brine samples (see above).

3. Sediments

Approximately 100 g of sediment was transferred to a 300 ml lyophilization flask (Virtis F-121), standards were added, and the sample was freeze-dried (Labconco Freeze Dryer). The dried sample was then placed in a 500 ml Erlenmeyer flask. The lyophilization flask was rinsed with 150 ml of cyclohexane and the rinse was added to the sample. The sample flask was then capped with aluminum foil and shaken (Burrell Wrist-Action Shaker) for at least 6 hr. Cyclohexane was then decanted and reduced in volume before column chromatography.

4. Sediment Traps

The total solid content of the sediment trap (30-150 g) was transferred to a 1 liter narrow-mouth screw cap bottle. Standards and cyclohexane (100 ml) were added, and this was followed by tumbling for 24 hr on a modified rock polisher.

5. Other Platform Samples

Sewage, separator tank water, and fire-fighting water were extracted using the same procedure outlined for the discharged brine (No. 1). Separator tank oil was dissolved in cyclohexane, standards added, and the mixture was applied directly to the liquid chromatography column. Seawater was prepared as stated in No. 2.

6. Fish

In the laboratory, a sample of dorsal flesh (including subcutaneous fat) was removed from each specimen using a degreased scalpel and forceps. With the exception of the very small specimens, livers were also removed and analyzed. Whole animal analysis was performed on Hypleurochilus geminatus, Stenotomus caprinus, and specimens too small to obtain a liver sample. Muscle (5-10 g) and liver (1-5 g) were homogenized using a

Brinkman PT1035 Polytron power unit equipped with a PT20ST generator. The homogenate was transferred to a 50 ml centrifuge tube spiked with the internal standard. A sodium hydroxide solution (4 ml, 4M) was added and the homogenate saponified for 2 hr at 110°. Saponified material was allowed to cool and was extracted with 2 x 15 ml of cyclohexane. Each time, the organic layer was drawn off after centrifugation at 2000 r.p.m. for 10 min. The combined extracts were then reduced in volume and fractionated by column chromatography.

7. Shrimp

Entire shrimp (including shell) were analyzed using the same extraction procedure as used for fish (see above).

8. Barnacles and Fouling Mat

Scutum, tergum, and outer shell were removed from the barnacle flesh using degreased pliers and forceps. Approximately 7 g was extracted in the same manner as the fish (No. 6). Fouling mat was scraped from barnacle shells using a degreased scoopula and forceps. Fouling material was also homogenized and extracted the same as for fish (see No. 6 above).

LIQUID COLUMN CHROMATOGRAPHY

Tissue samples (fish, shrimp, barnacles, and fouling mat) were fractionated on a 1 x 10 cm column of alumina. Alumina was washed with cyclohexane (20 ml), and the sample applied. "Alkanes" and "aromatics" were eluted in cyclohexane (40 ml). All other samples (sediment, discharged brine, sediment traps, and platform samples) were fractionated on a 1 x 10 cm alumina column but were eluted with 20 ml of cyclohexane. Eluates were reduced to 100 µl, first by the rotating evaporator and then under a stream of nitrogen on a hot plate, before gas chromatography or combined gas chromatography - mass spectrometry.

GAS CHROMATOGRAPHY

1. Use of Internal Standards

Deuterated hydrocarbons were added to all samples prior to analysis so that variations in sample recovery, GC injection volume, and instrument parameters would not impair the accuracy of the quantitative data. In general, differentiation between labelled and unlabelled species requires the use of a mass spectrometer as

the gas chromatographic detector (Sweeley *et al.*, 1966). Fortunately, this situation is obviated by the use of per-deuterated eicosane (*n*-$C_{20}D_{42}$). The deuterated analog is sufficiently resolved from the unlabelled C_{20} such that the flame ionization detector suffices for detection.

The various compounds used for quantitation were *n*-[$^2H_{42}$]eicosane, [$^2H_{10}$]-2-methylnapthalene, and [$^2H_{12}$]benzo[*a*]pyrene. An appropriate quantity of the deuterated hydrocarbons was added to the sample before analysis. For example, 10 µl of a 1.0% solution added to 1 liter of seawater afforded a concentration 10 ppb.

2. Instrument Conditions

Gas chromatography was performed on a Hewlett-Packard 5840A instrument equipped with flame ionization detectors, a temperature programmer, and a peak integrator. Samples were examined using a 10 m glass capillary column coated with OV-101, programmed from 90° to 270°C at 4° per minute. The injector and detector temperatures were 250° and 300°C, respectively, for all analyses.

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

1. Identification and confirmation

Representative samples were examined with a Hewlett-Packard 5992A GC-MS instrument to verify the identities of compounds characterized by GC. The interface for this system is a single stage glass jet separator, while columns used were: a 1 m x 2 mm I.D. silanized glass column containing 3% OV-1 on GasChrom Q (100-120 mesh) programmed from 100-270°C at 4° per minute, and a 30 m glass capillary column coated with OV-101 programmed from 80-270°C at 4° per minute. Spectra were acquired every 2 seconds, but only those from the apices of the total ion current peaks were stored on floppy disks (Hewlett-Packard 9885M disk drive). Total ion as well as selected ion chromatograms were obtained in real time and spectra were available for a full range of data manipulation procedures.

Unknown spectra were compared to spectra of known compounds via telecommunication link with facilities at Cornell University.

2. Volatile Analysis

Volatile organic compounds in discharged brine were examined using a purge-and-trap sampler (Hewlett-Packard 7675A). Volatile organics were purged from the sample for 15 minutes with nitrogen and simultaneously concentrated on a cooled adsorbent (Tenax-GC). The

adsorbent was then heated and the volatiles were thermally desorbed and back-flushed into the GC column of the GC-MS instrument. The 2 m x 2 mm I.D. stainless steel column containing 0.2% Carbowax 1500 on Carbopak C (80-100 mesh) was programmed from 30-150°C at 4° per minute. Spectra were acquired every two seconds, but only those from the apices of the GC peaks were stored on the floppy disk. Total ion as well as selected ion chromatograms were obtained in real time, and programs were available for a full range of data manipulation procedures.

RESULTS AND CONCLUSIONS

1. Alkane profiles in discharged brine are similar (with respect to alkane/isoprenoid ratios, OEP and concentration maxima) to profiles obtained from crude oil, but total alkane concentrations in oil may be as much as four orders of magnitude greater than in the brine.

2. An average of 13.3 ppm of total oil is being discharged into the sea daily, of which total alkanes account for 2.4 ppm or approximately 18%. Sixty-eight different light aromatic compounds (104.2 ppb) have been identified in discharged brine and 25 (0.4%) in separator tank oil. The greater number of aromatics in discharged brine is attributed to an enrichment phenomenon associated with increased water solubility of these compounds.

3. Twelve normal, branched, and cyclic alkanes were characterized in the analysis of volatiles in discharged brines. Three aromatics, comprising 64% of the volatile components measured, were identified as benzene, toluene and ethylbenzene. 2-Butanone and 2-pentanone were also identified.

4. Approximately 207 kg of sulfur is discharged daily compared to 382 g of alkanes. Sulfur may serve as an essential nutrient for bacteria, thus enhancing biomass at the base of the marine food web.

5. The acrolein biocide used to control microbialy aggravated corrosion of pipes and vessels has yet to be detected in discharged brines. It is not expected that such a toxic yet labile compound will pose any threat to the environment as long as proper application and disposal procedures are followed.

6. Sewage appears to be contributing an insignificant amount of alkanes (less than 10 ppb) to the marine environment. Alkanes in sewage are probably biogenic as opposed to being derived from petroleum.

7. Winds and currents obviously play an important role in the distribution and dispersion of pollutants in the water column. All samples collected on summer transets showed a "weathered" alkane profile and no discernible concentration gradient horizontally or vertically. The predominance of alkanes (2/3) were found within 3 m of the brine discharge point with a large minority (1/3) being measured in samples 8 m and beyond. By contrast, fall samples collected along the east transect displayed a definite gradient

with respect to concentration (decreasing with distance) and degree of "weathering" which increased with distance from brine outfall. A similar trend, although less pronounced, was observed for the winter samples. During the spring, appreciable amounts of petroleum alkanes were again found only in close proximity to the discharge point.

8. The greatest concentration of petroleum alkanes was usually encountered at the air/sea interface either directly below the discharge pipe or within 3 m of that location. On the days when samples were collected, our data did not indicate any clearly-defined "plume" of contaminants in the region of the mixing zone. Such a plume would be predicted if there were a steady discharge of contaminants into receiving water which were either static (affording a circular plume) or moving with a constant speed (so that the plume would extend away from the platform in the direction of current flow). However, the discharge is not continuous, but intermittent. Also, the vertical movement of the water (wave action) is comparable to the horizontal extent of the mixing zone. Moreover, samples were collected over a period of several hours and do not reflect the instantaneous concentrations of contaminants at the various locations at any particular point in time.

9. It was consistently found that the lighter contaminants were present only within a few meters of the discharge pipe, and that they had been dissipated (presumably by evaporation) by the time that the heavier contaminants had travelled as little as 8 m from the discharge point.

10. Hydrographic information indicated that, under normal conditions, there was sufficient wave energy to readily penetrate to the bottom, thereby resuspending bottom, surficial sediments (Danek, 1979). This information, in connection with past observations of a "scouring" of sediments (Anderson et al., 1979; Machemehl and Abad, 1975) indicated that sediments may be in a high flux condition at any given time.

11. This situation was demonstrated in summer transects. On September 1 a total of 64.6 ppm total alkanes were measured in sediments from stations on north, south, east, and west transects (excluding sediments under platform 296-B). The next day, sediments from stations on the diagonal transects showed a total alkane content of 7.08 ppm, or an overnight reduction of 89% in the amount of alkanes in area sediments.

12. Distribution of oil in sediments seems to follow prevailing currents with generally higher concentrations in sectors 10 to 25 m down-current from the discharge pipe.

13. Resuspension of oiled sediments is of some importance to biota in the area since this increases the oil concentration in the water column. An increase of this type would result in greater availability of petroleum hydrocarbons to free-swimming marine animals which may be ingested and accumulated by them. This would be particularly true for such fish as spadefish (Chaetodipterus faber) which are primarily zooplankton-particulate feeders (Gallaway and Martin, 1980).

14. Oil concentrations in sediments collected below structures varied considerably for platforms 296-B and 288-A, with 288-A showing the greatest variation in mean concentration, from 9.78 to 60.8 ppm. Change in concentrations below flare stack 296-F and well jacket 288-5 was not as radical, but may have been influenced by deposition of oiled sediments from highly contaminated areas such as platforms 288-A and 296-B.

15. Sediment trap contents, being rich in organic and presumably inorganic nutrients (from feces), are a hotbed of microbial activity. This explains the significant input of biogenic alkanes, sometimes obscuring petroleum alkanes. Sediment traps may also be representative of processes occurring in surficial sediments, whereby even-carbon alkanes are preferentially degraded and metabolized by bacteria.

16. Crested blennies were generally the most highly contaminated fish, and the petroleum alkanes that they contained were always fresh and relatively unweathered. The alkane profiles to these fish were very similar to those of the fouling mat which provides a major component of their diet.

17. Of the larger fish, sheepshead were usually the most heavily contaminated and spadefish the least contaminated, with red snapper and longspine porgy intermediate in degree of contamination.

18. It appears that livers serve as a repository for alkanes, as evidenced by the higher concentrations of these compounds in livers than in muscle samples. This is not unexpected since the liver has a high lipid content and serves as a center for metabolism of many compounds, including chemical pollutants.

19. Concentrations of petroleum alkanes in fish tissues were generally higher in the summer than in the winter.

20. Alkane concentrations in red snaper (L. campechanus) were measured over a range of 4 orders of magnitude for liver and muscle samples. Mean alkane concentrations, however, fell within the same order of magnitude as sheepshead. Many liver and muscle alkanes were of biogenic origin as evidenced by disproportionate amounts of C_{15}, C_{17} and C_{21}.

21. Mean alkane concentrations in longspine porgy (S. caprinus) were close to those for red snapper and sheepshead, but profiles showed evidence for petroleum contamination in most of the animals.

22. Alkane levels in crested blenny (H. geminatus) were generally higher than those in other fish with a mean alkane concentration 2 to 3 ppm above sheepshead and longspine porgy, and more than 4 ppm higher than spadefish. Blennies generally showed an accumulation of fresh oil evidenced by maximum concentrations of light alkanes in most samples.

23. It appears that livers may in fact serve as a repository for alkanes as evidenced by higher mean alkane concentrations than in muscle. This is reasonable since the liver serves as a center for metabolism of many compounds, including chemical pollutants, and is high in lipid content.

24. While shrimp are of great commercial importance, especially on the upper Texas Gulf Coast, past studies, as well as this one, have not indicated significant contamination by hydrocarbons from offshore facilities. Shrimp are normally highly mobile in shelf waters affording them ample opportunity for depuration of ingested hydrocarbons (Neff et al., 1976). Since they are only found occasionally in the area under study, it would be difficult to attribute hydrocarbon contamination (if any) to Buccaneer oil.

25. The barnacles from all four structures, with few exceptions, did not contain measurable amounts of petroleum alkanes. They did contain the biogenic alkanes C_{15}, C_{17}, C_{21}, and C_{27}, as well as large amounts of pristane, typical of animals filter-feeding on phytoplankton and detritus. Even animals from the discharge leg of the brine-discharging platform 296-B showed little petroleum contamination.

26. Fouling mat samples scraped from barnacle shells attached to the discharge leg and east leg (about 10 m from discharge) of production platform 296-B typically showed smooth alkane profiles with occasional odd-carbon alkanes C_{15}, C_{17}, C_{19}, and C_{21} interrupting continuity. The highest concentration of alkanes was observed in mat samples from the discharge leg but at a depth of 3 m. The

mean concentration for these samples was a very high 122 ppm. Obviously, these samples were contaminated with oil directly and all showed signs of fresh oiling with profiles having concentration maxima at C_{15}. These samples did not show the biogenic odd-carbon preference since the petroleum alkanes predominated.

27. At the surface, mat samples on the discharge leg showed some amount of petroleum alkanes but quantities of odd-carbon alkanes were prominent in the profile. The mean was 1.1 ppm compared to 220 ppm at a depth of 3 m.

28. On the east leg, mat samples collected at the surface and at a depth of 3 m were similar, with the exception of a sample from the 3 m depth showing background petroleum alkanes. Again, matters were confused by the presence of prominent odd-carbon alkanes. The mean alkane concentration for the east leg at the surface was 6.8 ppm, and at 3 m depth was 12 ppm.

29. Since some fouling mat samples were contaminated with large quantities of petroleum alkanes and sheepshead feed on fouling community, it is highly probable that the higher levels of alkanes found in these fish are due to ingestion of contaminated mat. Also it is probable that, since mat at a depth of 3 m is not exposed to the same wave "scrubbing" experienced by intertidal mat at the surface, this could account for the much higher concentrations at the 3 m depth.

WORK UNIT 2.4.2 - TRACE METALS

Southwest Research Institute

J. Tillery

OBJECTIVES

1. Quantitate "bioavailable" and total trace metal concentrations in surficial sediments, both temporally and spacially at platforms A and B and compare with concentrations from a control structure (well jacket). Determine if metal concentrations can be associated with platform structures and or discharges.

2. Determine the trace metal concentrations in suspended particulate matter and sea water temporally and spacially at platforms A and B and compare with concentrations from a control structure (well jacket).

3. Analyze the produced brine discharge for its trace metal burden and estimate its annual input of trace metal pollution to the Gulf.

4. Determine the trace metal burden of select marine biota samples from the area of platforms A and B and the control structure. Compare concentrations with trace metal data into biota from other Gulf studies and literature values. Determine if bioaccumulation of trace metals has occurred.

5. Analyze marine fouling community samples for trace metal concentration and determine if concentrations are related to produced brine discharge.

6. Determine the trace metal concentration of selected bioassay solutions and determine if toxic levels of any metals exist for the species being tested.

7. Estimate possible inputs and outputs of trace metals to the study area and their effect on the marine ecosystems operating in the area.

MATERIALS AND METHODS

1. Sediments, sea water, suspended particulates, produced brine and biota samples were collected by other work units (2.3.2, 2.3.4, 2.3.5 and 2.3.8) and stored in acid-washed polyethylene containers.

2. Sediments were leached with 5N HNO_3 to extract the "bioavailable" trace metals.

3. Sea water and produced brine samples were extracted with APDC-DDC/$CHCl_3$ system for all metals except Ba, Sr and Hg. Aliquots of the raw samples were used for Ba, Sr and Hg analysis (see below).

4. Biota samples were freeze-dried and 1 to 5 grams of tissue were ashed in a low temperature asher using an O_2 plasma. The ash was further digested in a Teflon bomb with HNO_3.

5. All glassware and plastic ware were acid-washed prior to use and biota sample preparations and SPM preparations were performed on a clean bench.

6. Quality assurance was provided by analyses of NBS River Sediments, NBS Bovine Liver samples, and a homogeneous shrimp muscle tissue sample.

7. All metal analyses were performed by atomic absorption spectrophotometry (AAS) using the following Perkin-Elmer instruments:

    a. Models 5000, 560, 403 and 306
    b. HGA 2000 or HGA 500
    c. AS-1 or AS-40 auto samplers for graphite furnace analyses
    d. AS-3 auto sampler for flame analysis

8. All AAS instruments were equipped with D_2 arc background correction (Model 5000 also has background correction) which were routinely used on all sample analyses.

9. Ba and Sr were analyzed with a nitrous oxide-acetylene flame. Other metals were analyzed with an air-acetylene flame.

10. Hg analysis was performed by the cold-vapor atomic absorption technique using a Mercury Monitor Model 1235 system.

RESULTS AND CONCLUSIONS

1. Concentration gradients of Ba, Cd, Cr, Cu, Mn, Pb, Sr, and Zn in surficial sediments at platform structures 288-A and 296-B are not related to the hydrated iron fraction of the sediments or the sediment grain size. This suggests these metals have an input that is related to the platform structures or petroleum production activities.

2. There are seasonal variations in the concentration and distribution of these metals in the sediments near the platform structures. Generally, the summer and fall seasons have higher and more variable concentrations while the winter and spring are lower and less variable.

3. There is an increase in sediment concentrations of Cr, Hg, Pb, Sr and Zn above ambient levels at the platform structures.

4. There are seasonal variations in all metals, except Cd, in Archosargus probatocephalus (sheepshead) and Ba, Fe, Hg, Mn, Pb, Sr and Zn in Chaetodipterus faber (spadefish) tissues. No evidence of bioaccumulation of Cd, Cr, Cu, Fe, Ni, and Zn was observed in either sheepshead or spadefish. Seasonal variations in heavy metal concentrations in sheepshead and spadefish are not necessarily related to the platform structures.

5. Comparison of the heavy metal concentrations from Stenostomus caprinus (longspine porgy) with data from other studies indicate an increase in Cd, Cr, Cu, Fe, Ni, Pb, and Zn. Lack of sensitivity in testing for Cr and Ni may cause a bias towards higher mean concentrations for these metals.

6. The higher metal concentrations in the longspine porgy may be related to the higher (and more variable) metal concentration in the surficial sediments and SPM near the platforms during the summer. More data is needed to determine if this is a seasonal variation or irreversible bioaccumulatiom.

7. There are higher concentrations of Cd in Trachypenaeus similis (broken neck shrimp) than what other investigators have found in this species. Higher Ni concentrations were found in the fall and winter but had returned to normal by spring.

8. No significant trends or increases were noted for heavy metal concentrations in fouling mat or barnacles in any season.

9. Suspended particulate matter trace metal concentrations are highly variable and the highest concentrations occurred in the summer. There is an input of Pb from resuspended sediments during the summer, fall and winter. Also, Sr input from resuspended sediments occurred in the spring.

10. Sea water samples from the platforms and well jacket do not show any accumulation of trace metals. Concentrations are low and no seasonal differences were observed.

11. Produced brine samples have high concentrations of Ba, Cr, Fe, Mn and Sr, but other trace metals are in low concentrations. The average Ba concentration is 4X higher and the Sr concentration is 2X higher than the concentrations reported in the second year of this study.

WORK UNIT 2.5.1 - SOURCES, FATE AND EFFECTS MODELING

Science Applications, Inc.

F. Fucik, Ph.D.
I. Show, Ph.D.

OBJECTIVE

Evaluate existing data and mathematical models to adapt and develop a model to describe and predict sources, fate and effects of gas and oil field contaminants.

MATERIALS AND METHODS

1. Reviewed, evaluated and summarized the findings of the disciplinary studies conducted in the Buccaneer gas and oil field for the three research years of 1976 -1977, 1977-1978 and 1978-1979.

2. Incorporated the summarized research data into the ecosystem model.

3. Developed an ecosystem model that is comprised of a physical hydrodynamics component, a chemical component, and a biological system component.

4. Developed the hydrodynamic model so as to describe the current and water movement dynamics in the field and to relate these movements to chemical and biological distributions.

5. Developed the chemical model so as to describe the fate of oil that is introduced into the system as it is affected by various physical and biological factors.

6. Developed the biological systems model so as to describe the trophic dynamic relationships that exists in the field.

RESULTS AND CONCLUSIONS

1. Major flow pathways in the Buccaneer system originate in two sources, the phytoplankton and the fouling flora. The major flows of materials through the zooplankton, plankton feeders, particulates (particulate organic matter), benthos, benthic feeders, and large predators originates in the phytoplankton compartment. Biomass for these compartments is highest in the spring with a secondary maximum in the fall. Major input to the fouling fauna and fouling feeders compartments originate from the fouling flora. These compartments show a biomass maximum in the spring with reduced populations the remainder of the year.

2. Particulates derived from the fouling communities do not provide a significant input to the pelagic and benthic communities around the platform. However, the paticulates may be internally cycled within the platform communities providing an important food source.

3. Advection into and out of the system is orders of magnitude greater than flows between compartments.

4. Because of the large amount of advection, hydrocarbons released from the platforms are rapidly dispersed and are carried out of the BOF. However, it would appear that the released hydrocarbons can persist and be carried long distances before degradation is complete.

5. Transport of hydrocarbons into the sediments around the platforms is accomplished either through adsorption onto fecal material or attachment to sulfur particles.

6. Trace metal contaminants around the platform appear to be derived from the platforms themselves and not the discharged brine.

WORK UNIT 2.5.2 - HYDRODYNAMIC MODELING

Environmental Research and Technology, Inc.

G. Smedes, Ph.D.
J. Calman
J. Beebe

OBJECTIVES

1. To describe and characterize the horizontal and vertical circulation in the gas and oil field and surrounding area.

2. To describe turbulent effects associated with the presence of gas and oil field structures.

3. To describe and characterize other physical aspects of water masses in and around the gas and oil field.

4. To predict circulation, turbulence and other physical effects governing dispersion, transport, and recycling of gas and oil field contaminants.

MATERIALS AND METHODS

1. The hydrodynamic model is used to describe the area which might be affected by floating and sinking pollutants, and to predict the concentration of pollutants which are vertically distributed in the water column.

2. For vertically distributed pollutants, separate analytical procedures are used for near-field (<1km) and far-field (>4km) distances from the platform, with conservative estimations for pollutant concentrations at intermediate distances.

3. The model is designed to operate in a time sequential mode, using input wind and subsurface current data at each time step.

4. Other parameters which describe the geometry and the nature of the discharge are as follows:

   a. Initial Mixing
   b. Dispersion in the Near Field
   c. Mixing Downstream from the Platform
   d. Matching Conditions
   e. Trajectory
   f. Floating Pollutants
   g. Settling Particles

5. Description of the model output is as follows:

   a. Printed Output
   b. Graphical Output
   c. User's Manual

RESULTS AND CONCLUSIONS

1. The disperison model was run using data for six two-day periods -- three each in winter (February) and summer (August).

2. Data graphs indicate that the pollutant wake can spread to approximately 1 km in width within 48 hours. No appreciable differences in the rate or extent of wake spreading are indicated between seasons.

3. Pollutant concentration (non-dimensional) decreases over time, for vertically distributed pollutants.

4. Concentrations decrease by a factor of approximately 10^{-6} in 48 hours, as pollutants are dispersed downstream. Initial turbulant mixing reduces concentrations by 10^{-2} in the immediate vicinity of the platform, and the remainder of the dispersion occurs as currents carry the pollutants downstream.

5. Overall patterns are similar for all cases examined.

6. Data showing reduction of concentration over range also indicate a regular rate of reduction, but the total distance transported varies more among the specific cases examined.

7. Trajectories of subsurface pollutants demonstrate an expected variability in discrete trajectories for each sample date. However, it is also clearly evident that vertically mixed pollutants are transported over greater distances in the winter season than in the summer. The winter trajectories generally paralleled the coastline, and no short-term impact on the Texas coast was indicated.

8. Floating pollutant trajectories showed seasonal differences in trajectories even more pronounced than those for vertically distributed pollutants. The floating pollutants are carried much greater distances by wind drift currents in February than in August.

9. Results also indicate that the coast southwest of Galveston could be affected by floating pollutants within about two days in winter.

PART B

WORK UNIT 2.2.3 - IMPLEMENT, MONITOR AND MODIFY DATA MANAGEMENT SYSTEM

National Marine Fisheries Service
National Fisheries Engineering Laboratory

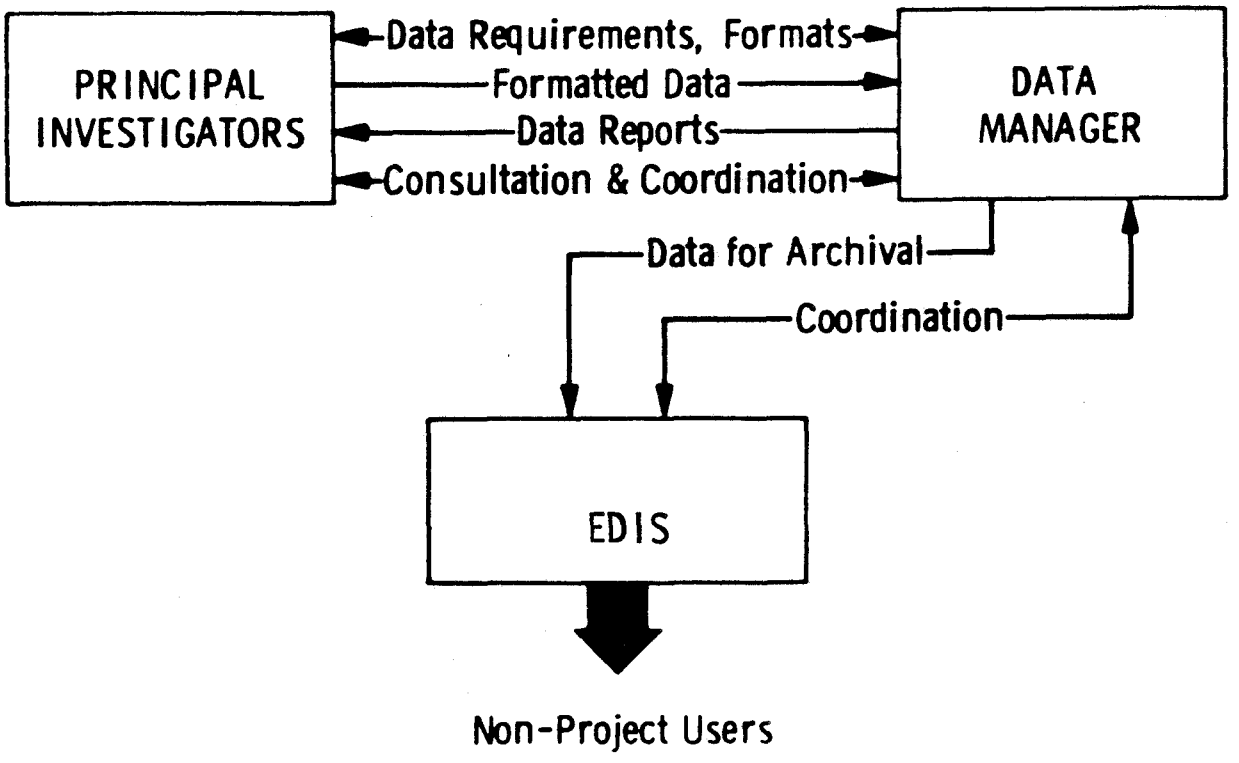
K. Savastano
H. Holley

OBJECTIVES

1. Provide a smooth flow of data products from the field collectors to the analyst to the ultimate users.

2. Provide EDIS and TIMS with project data for archival.

DATA MANAGEMENT OVERVIEW



Information concerning the following data files may be obtained by writing to:

National Oceanic and Atmospheric Administration
Environmental Data and Information Service
National Oceanographic Data Center
Page 1 Building
2001 Wisconsin Avenue, N.W.
Washington, D.C. 20235

ATTN: Dr. Francis J. Mitchell

BUCCANEER OIL FIELD DATA

Year I (1976-77)

NODC ACCESSION NO. 7800501

- Demersal Fish
- Sediment
- Birds
- Ichthyoplankton
- Pelagic Fish
- Plankton
- Sessile Fauna
- Total Organics
- Hydrocarbons
- Fish Determination
- Ocean Serial Stations
- Trace Metals
- Benthos
- Drift Bottle Releases

BUCCANEER OIL FIELD ARCHIVE DATA

1976/1977

FILE #	WORK UNIT	TITLE	NUMBERS OF RECORDS
1	4.1	Hydrocarbons	4225
2	3.8	Fish Determination	25
3	3.2	Sediments	300
4	3.9	Hydrography	975
5	4.3	Total Organics	250
6	3.8	Plankton	350
7	3.8	Sensile Fauna Quadrat	850
8	3.4	Demersal Fish	2875
9	3.8	Bird Data	325
10	3.9	Drift Bottles Release/Recovery	975
11	3.5	Pelagic Fish	200
12	4.2	Trace Metals	350
13	3.3	Benthos	2575
14	3.6	Ichthyoplankton	600

BUCCANEER OIL FIELD DATA

Year II (1977-78), Part 1

NODC ACCESSION NO. 8000423

- Brine Dye Release
- Fish Bioassay
- Ichthyoplankton
- Food Habits-Station
- Food Habits-Stomach
- Reef Fish Census
- Biofouling
- Transponding Buoy (2 Files)
- Drift Bottle Release/Recovery
- Dye Study-Station
- Ocean Serial Stations
- Current Meter/Wind Records
- Non-Metal Analysis (Hydrocarbons)
- Bacteria - Behavior
- Bacteria - Degradation Rates
- Bacteria - Enumeration
- Bacteria - Taxonomy/Physiological Diversity
- Respirometry Experiment
- Trace Metals - Sediment (Diver Core)
- Sediment Size Analysis
- Stomach Contents
- Demersal Fish
- Shrimp Bioassay
- Trace Metals
- Trapped Suspended Sediment

BUCCANEER OIL FIELD DATA

Year II (1977-78), Part 2

NODC ACCESSION NO. 8000461

- Non-metal Analysis (hydrocarbons)
- Bacteria - Behavior
- Bacteria - Degradation Rates
- Bacteria - Enumeration
- Bacteria - Taxonomy/Physiological Diversity
- Respirometry Experiment
- Tract Metals - Sediment (Diver Core)
- Sediment - Size Analysis
- Stomach Contents
- Demersal Fish
- Shrimp Bioassay
- Trace Metals
- Trapped Suspended Sediment

BUCCANEER OIL FIELD ARCHIVE DATA

1977/1978

FILE #	WORK UNIT	TITLE	NUMBERS OF RECORDS
1	3.5	Brine Dye Release	25
2	3.5	Fish Bioassay	175
3	3.6	Ichthyoplankton	1450
4	3.5	Food Habits	25
5	3.5	Reef Fish Census	350
6	3.5	Pelagic Fish Census	2075
7	3.5	Food Habits-Stomach Contents	100
8	3.5	Biofouling	975
9	3.9	Transponding Buoy	200
10	3.9	Drift Bottle Release/Recovery	225
11	3.9	Hydrography	50
12	3.9	Dye Study	50
13	3.9	Current Meter and Wind	9050
14	4.1	Hydrocarbons	4025
15	3.7	Bacteria-Behavior	150
16	3.7	Bacteria-Degradation Rates	150
17	3.7	Bacteria-Enumeration	175
18	3.7	Bacteria-Taxonomy/Physiological Diversity	425
19	3.8	Respirometry Experiment	25
20	4.2	Trace Metals (Diver Core)	100
21	3.2	Sediment	50
22	3.8	Stomach Contents	1600
23	3.8	Demersal Fish	600
24	3.4	Shrimp Bioassay	875
25	4.2	Trace Metals	450
26	3.2	Trapped Suspended Sediment	50

BUCCANEER OIL FIELD DATA

Year III (1978-79)

NODC ACCESSION NO. 8000416

- Stomach Contents
- Clay Mineralogy
- Bioassay (Toxicity)
- Algae
- Tagging
- Histopathology and Bacteriology
- Morphometric
- Blenny Census
- Biomass Samples - Weight and Barnacles
- Pistol Shrimp and Stone Crab
- Biomass - Large Cryptic Samples
- Surficial Sediments
- Suspended Particulates
- Sediments
- Water Column (Water Chemistry)
- Pb - 210
- Bacteria - Enumeration
- Bacteria - Degradation Rates
- Bacteria - Taxomony
- Bacteria - Growth Characteristics
- Trace Metals
- Trace Metals - Organism, Sediment, Water
- Hydrography
- Electromagnetic Current Meter
- Total Suspended Solids
- Continuous Current Meter
- Meteorological Data
- Wave Data
- Hydrocarbons, Biocides and Sulfur
- Respirometry

BUCCANEER OIL FIELD ARCHIVE DATA

1978/1979

FILE #	WORK UNIT	TITLE	NUMBERS OF RECORDS
1	3.5	Stomach Contents	900
2	3.2	Clay Mineralogy	75
3	3.4	Bioassay	1700
4	3.8	Algae	175
5	3.5	Tagging	1050
6	3.5	Histopathology and Bacteriology	250
7	3.5	Morphometric	15550
8	3.5	Blenny Census	100
9	3.8	Biomass Samples-Weights and Barnacles	150
10	3.8	Pistol Shrimp and Stone Crab	425
11	3.8	Biomass-Large Cryptic Samples	150
12	3.2	Surficial Sediments	1125
13	3.2	Suspended Particulates	1225
14	3.2	Sediments	100
15	3.2	Water Column	275
16	3.2	Pb-210	150
17	3.7	Bacteria-Enumeration	200
18	3.7	Bacteria-Degradation Rates	275
19	3.7	Bacteria-Taxonomy	725
20	3.7	Bacteria-Growth Characteristics	225
21	4.2	Trace Metals	1100
22	4.2	Trace Metals-Organism, Sediment, Water	4825
23	3.9	Hydrography	850
24	3.9	Electromagnetic Current Meter	200
25	3.9	Total Suspended Solids	50
26	3.9	Continuous Current Meter	5000
27	3.9	Meterological Data	1500
28	3.9	Wave Data	225
29	4.1	Hydrocarbons, Biocides and Sulfur	9225
30	3.8	Respirometry Experiment	100

BUCCANEER OIL FIELD DATA

Year IV (1979-80)

NODC ACCESSION NO. 8000576

- Transmissiometry
- Suspended Particulates
- Bacteria - Enumeration #2
- Bacteria - Taxonomy #2
- Bacteria - Degradation Rates #2
- Bacteria - Degradation Rates
- Stomach Contents
- Bacteria - Growth Charactristics
- Bacteria - Enumeration
- Red Snapper Census
- Large Barnacle Production
- Trace Metals
- Bacteria - Growth Characteristics #2
- Gaseous Hydrocarbons
- Surficial Sediments
- Sediments
- Time Lapse Photography
- Tagging
- C5 - C14
- Water Column
- Hydrocarbons, Biocides and Sulfur

BUCCANEER OIL FIELD ARCHIVE DATA

1979/1980

FILE #	WORK UNIT	TITLE	NUMBERS OF RECORDS
1	3.2	Transmissometry	4200
2	3.2	Suspended Particulates	775
3	3.7	Bacteria-Enumeration #2	75
4	3.7	Bacteria-Taxonomy #2	200
5	3.7	Bacteria-Taxonomy	550
6	3.7	Bacteria-Degradation Rates #2	100
7	3.7	Bacteria-Degradation Rates	175
8	3.5	Stomach Contents	325
9	3.7	Bacteria-Growth Characteristics	100
10	3.7	Bacteria-Enumeration	100
11	3.5	Red Snapper Census	125
12	3.8	Large Barnacle Production	200
13	4.2	Trace Metals	4850
14	3.7	Bacteria-Growth Characteristics #2	75
15	3.2	Gaseous Hydrocarbons	200
16	3.2	Surficial Sediments	500
17	3.2	Sediments	75
18	3.8	Time Lapse Photography	50
19	3.5	Tagging	325
20	3.2	C5-C14	475
21	3.2	Water Column	150
22	4.1	Hydrocarbons, Biocides and Sulfur	2700

ADDENDUM TO:

Jackson, W. B. (Editor). 1979. Environmental assessment of an active oil field in the northwestern Gulf of Mexico, 1977-1978. Volume III: Chemical and physical investigations. NOAA Annual Report to EPA, Project Number EPA-IAG-D5-E693-EO. 722 pp.

SEE: Anderson, J. B. and R. R. Schwarzer. Work Unit 2.3.2/2.4.2- Describe the fine sediments and nepheloid layer of the oil field, focusing upon the relationship of the heavy metal adsorption/ determine levels, pathways, and bioaccumulation of heavy metals in the marine ecosystem in the oil field.

The following synopsis of research was acomplished under the above referenced programs and should be cited as follows:

Wheeler, R. B. 1979. Environmental trace metal geochemistry of the Buccaneer oil and gas field. M.S. Thesis, Rice University, Houston, Texas. 176 pp.

OBJECTIVE

1. To develop a conceptual model relating possible sources of trace metal contaminants to potential sinks for these contaminants, and to test this model using bottom sediment, suspended sediment and biological samples obtained from the Buccaneer Oil/Gas Field.

MATERIALS AND METHODS

1. Bottom samples were obtained by gravity corer.

2. Suspended sediments were collected using sediment traps placed at 4.5, 12.0 and 18.5 m depth beneath platform 288-B and satellite platform 288-3.

3. Routine turbidity meter measurements were made under different oceanographic and meterologic conditions.

4. Sediment size analyses were conducted using an automated settling tube system for particles coarser than 16 mm (6.0 ϕ) and a hydrophotometer for particles smaller than 16 mm.

5. Trace metal analyses were conducted using a Perkin-Elmer Model 360 atomic absorption spectrophotometer, with a nitrous oxide-acetylene flame used for Ba analysis, and flameless atomic absorption for Hg analysis.

6. Trace element extractions were prepared by partial digestion of a dried sample with sodium hypochlorite and nitric acid, used to dissolve the organic and carbonate fractions and, in the case of sediment samples, to leach detrital material.

7. Ba, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr and Zn were analyzed for sediment and biological samples.

RESULTS AND CONCLUSIONS

1. The conceptual model developed for the Buccaneer Field is illustrated in flow chart form in figure 14 of Anderson et al., 1978 (p. 105, v. 3).

THE MODEL

1. Potential sources for trace metal contaminants in the Buccaneer Field include:

    a. Corrosion of structures
    b. Drilling mud from drilling operations
    c. Brine discharged into the sea during production operations
    d. Accidental oil spills
    e. Remote sources, particularly contaminants introduced into the field from nearby Galveston Bay via suspended sediments

2. Intermediate receptors of trace metal contaminants include fouling organisms, seawater and shelled invertebrates. The latter two are contaminated only by dissolved constituants, the former (fouling organisms) may incorporate trace metals from structures directly into their bodies.

3. Important sinks for trace metals include bottom sediments, suspended sediments and filter feeders, infauna and predators.

CONCLUSIONS

1. There are no permanent sinks in the Buccaneer Field, even bottom sediments are continuously resuspended. Contaminants released into the sediment through decomposition of organisms are dispersed through continued resuspension of fine organic detritus.

2. The seafloor in the Buccaneer Field is characterized as erosive and/or passive with regard to modern sediments; that is, no fine sediments are settling from suspension to rest permanently on the seafloor. This includes sediments derived from remote areas (i.e. Galveston Bay). Silts and clays on the seafloor are derived from the Pleistocene Beaumont Formation which is exposed in the northeastern portion of the field. Thus, the Buccaneer Field is

a sufficiently dynamic sedimentary environment to mitigate most sources of contamination, with perhaps the exception of severe accidental spills, through continuous resuspension of bottom sediments. It does not represent a closed system as depicted in our conceptual model.