



OCS EIS/EA
MMS 85-0092

FINAL ENVIRONMENTAL ASSESSMENT

PIPELINE IMPACTS ON WETLANDS

GULF OF MEXICO
OUTER CONTINENTAL SHELF
REGIONAL OFFICE



U.S. DEPARTMENT OF THE INTERIOR/MINERALS MANAGEMENT SERVICE

Disclaimer

This report has not been edited for conformity with Minerals Management Service's editorial standards. The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PIPELINE IMPACTS ON WETLANDS
FINAL ENVIRONMENTAL ASSESSMENT

by

Daniel K. Tabberer
West Hagg
Mike Coquat
Minerals Management Service
Gulf of Mexico OCS Region
New Orleans, Louisiana 70123-2394

and

Dr. Carroll L. Cordes
National Coastal Ecosystem Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, Louisiana 70458

October 1985

Prepared for

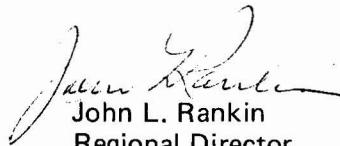
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Environmental Assessment Section

Any comments or questions about this publication or requests for the publication should be directed to the following address:

Minerals Management Service
Gulf of Mexico OCS Region
Public Information Unit (OPS-3-4)
1420 South Clearview Parkway
New Orleans, Louisiana 70123-2394

REGIONAL DIRECTOR'S NOTE

In August 1983, the Minerals Management Service (MMS) published the Regional Environmental Assessment, Gulf of Mexico Pipeline Activities. Since that time, considerable interest has been devoted to the issue of wetlands loss, particularly by the State of Louisiana, MMS, and a number of other Federal and State agencies. In preparation for the award of MMS study G-538 concerning the causes of wetland loss and the respective contributions to wetland loss by these causative factors, the Gulf of Mexico OCS Region commenced this assessment involving field work and ground truthing in the Louisiana wetlands. This document, Pipeline Impacts on Wetlands, Final Environmental Assessment, serves as a supplement to the August 1983 MMS Regional Environmental Assessment, Gulf of Mexico Pipeline Activities, particularly supplementing Section VI.A.4., pages 120-122. This environmental assessment also increases the information base in the Appendix to the Final Environmental Impact Statement for Sales 94/98/102, Appendix IX.D., Wetland Loss: Preliminary Summary Statement, pages 729-748, which was published in December 1984 by MMS's Gulf of Mexico OCS Region.



John L. Rankin
Regional Director
Gulf of Mexico OCS Region
Minerals Management Service

Acknowledgments

Special thanks are extended to the following agencies, companies, and individuals for their work on this report:

Minerals Management Service

Jerry Brashier, Environmental Assessment Section (EAS), Metairie, Louisiana
Heino Beckert, EAS, Vienna, Virginia
R. Mark Rouse, EAS, Metairie, Louisiana
Lawrence R. Handley, EAS, Metairie, Louisiana
Deborah H. Miller, EAS, Metairie, Louisiana
Rosemarie Falcone, EAS, Metairie, Louisiana

U.S. Fish and Wildlife Service

Rebecca Howard, National Coastal Ecosystems Team (NCET), Slidell, Louisiana
Dave Morais, NCET, Slidell, Louisiana
Chris Onuf, NCET, Slidell, Louisiana
Dave Fruge, Division of Ecological Services, Lafayette, Louisiana

Industry

ARCO Oil and Gas Company, Lafayette, Louisiana
Exxon Company, USA, New Orleans, Louisiana
Hawthorne Oil and Gas Corporation, Lafayette, Louisiana
Pumpkin Air Inc.
Tenneco LaTerre, Houma, Louisiana

Landowners and/or Representatives

Lonny Lege, Abbeville, Louisiana
John Plaisance and Son Inc., Golden Meadow, Louisiana
Hugh M. Wilkinson Jr., New Orleans, Louisiana

CONTENTS

I.	Introduction	Page 1
II.	Materials and Methods	9
III.	Statistical Analysis	19
IV.	Results	23
V.	Discussion	35
	Literature Cited	39
Tables		
1	Production of Oil and Gas in Federal and State Waters during the Period 1954-1982	4
2	Variables Measured in the Field for Computation of Habitat Suitability Indices (HSI) for Three Target Species	17
3	Comparisons of Mean Percentage of Canopy Cover for Five Distances from the Pipelines with Their Respective Control Areas	24
4	Habitat Suitability Indices for Three Wetland Species	33
Figures		
1	Pipeline transects in coastal Louisiana	10
2	Pipeline field study sampling schematic	11
3	Field crew determining percent canopy cover and plant identification along Texas Gas Transmission Co. 20" pipeline in Vermilion Parish. The pipeline was installed in 1978.	12
4	Field crew sampling along Texas Gas Exploration Co. 8" pipeline in Lafourche Parish. The pipeline was installed in 1984.	13
5	Apparatus for measuring percent canopy cover in one square meter at each sampling site.	14
6	Field crew taking temperature and salinity measurements from helicopter every 100 meters along each transect	15
7	Percent frequency vs. percent canopy cover	20
8	Percent pipeline canopy cover vs. distance	21
9	Tennessee Gas Pipeline Co. 20" pipeline right-of-way in Lafourche Parish. The pipeline was installed in 1978.	25
10	Percent canopy cover vs. distance	26
11	Surface water salinities	29
12	Texas Gas Exploration Co. 8" pipeline right-of-way in Lafourche Parish. The pipeline was installed in 1984.	30
13	Tennessee Gas Pipeline Co. 20" pipeline right-of-way in Lafourche Parish. The pipeline was installed in 1978.	31
14	Atlantic Richfield Co. 6" pipeline right-of-way in Plaquemines Parish. The pipeline was installed in 1984.	32

Pipeline Impacts on Wetlands

I. INTRODUCTION

The marshes of the Louisiana coastal region compose the most extensive expanse of estuarine wetlands (4.3 million acres) in the contiguous 48 states. They are of national importance because they produce fish and wildlife, oil and gas, and support an indigenous way of life. These marshes support the largest volume of estuarine-dependent fish and shellfish landings in the United States (Fruge 1982); produce the largest fur harvest in North America; and provide winter habitat for about one-fourth of the North America dabbling duck population and over 400,000 geese. Fish- and wildlife-related recreation is extensive with over 5 million man-days of saltwater fishing in 1975 and 676,000 man-days of waterfowl hunting during the 1977-1978 season.

During recent years, Louisiana marshes have been disappearing due to natural and man-induced causes. Gagliano and van Beek (1970) reported a net loss of $16.5 \text{ mi}^2/\text{yr}$ in the Louisiana coastal region during the 1960's. U.S. Fish and Wildlife Service (FWS) studies in 1979-1980 reported a loss of $7 \text{ mi}^2/\text{yr}$ in the Chenier Plain region of southwestern Louisiana between 1952 and 1974 and $32 \text{ mi}^2/\text{yr}$ in the deltaic plain of southeastern Louisiana between 1955-1956 and 1978 (Boesch 1982). Gagliano et al., (1981) estimated the rate of loss in the Mississippi Deltaic Plain in 1980 to be $39.4 \text{ mi}^2/\text{yr}$. The present statewide rate of loss is estimated at $50 \text{ mi}^2/\text{yr}$ (Wicker 1980).

Marsh loss in the Louisiana coastal region is caused by both natural processes and human activities. The extent of loss attributable to each has not been fully quantified. Natural processes causing marsh loss include eustacy, wind and wave action, and subsidence. Principal human-induced causes are sediment starvation due to leveeing and channelization, canalization for oil and gas exploration, construction of oil and gas transmission pipelines and other infrastructure, and urban development. These human-induced factors, when coupled with natural processes, act to accelerate the rate of marsh loss.

Studies to date lend some insight into the relative importance of natural processes. Rates of apparent sea level rise were 0.47 and 0.51 in/yr from 1954 to the present in the Barataria and Calcasieu basins, respectively (Baumann and DeLaune 1982). Sedimentation rates through the same period were approximately 0.30 in/yr in inland marshes, while streamside marshes aggraded at the rate of 0.53 in/yr. Swanson and Thurlow (1973) found that sea level and tide level rose at several locations along the Louisiana and Texas coast during the period 1959-1970. Rates ranged from as little as 0.2 in/yr at Port Isabel, Texas, to a maximum of 1.7 in/yr at South Pass, Louisiana. No quantitative estimates of marsh loss due to wind and wave erosion alone have been completed.

Decreased sedimentation on Mississippi River Delta marshes is due to natural abandonment of the present river course, leveeing and channelization of other river systems, and trapping of sediments by reservoirs upstream. The U.S. Army Corps of Engineers has planned two freshwater diversion structures to arrest the rate of marsh loss. The Davis Pond structure has a capacity of 11,000 cubic feet per second and is expected to reduce marsh erosion by 83,000

acres over the 50-year project life. The structure would introduce Mississippi River water and sediment into the Barataria Basin.

The Big Mar structure would introduce water into the Breton Sound basin. Loss of an estimated 16,000 acres of marsh would be arrested with a structure capable of passing 6,600 cubic feet per second (Sue Hawes and John Weber, USCE, telephone conversation, 1985). A canvassing of knowledgeable persons by Minerals Management Service (MMS) employees indicates that sediment starvation due to channelization and leveeing of the Mississippi River is the major cause of wetlands loss in southeastern Louisiana.

Recent studies have focused on human-induced factors that affect wetlands such as sediment starvation, canalization, and development in general. One of the primary factors identified is development related to the oil and gas industry. Oil was discovered in Louisiana in 1902. In the mid-1930's the first submersible drilling barge was developed which facilitated exploration of oil and gas in the coastal marshes. Initiation of the OCS oil and gas leasing program in 1954 added impetus to development in the marshes, particularly the construction of pipelines for the transport of petroleum products inland. During the period 1947-1983 more than 20,000 wells were drilled offshore from Louisiana. It was reported that more than 25,000 wells were in operation in the Louisiana coastal zone in 1971, and by 1981 that number was over 28,000. An indication of the relative production of oil and gas from Federal offshore areas in comparison to areas under State regulations is presented in Table 1.

Table 1

Production of Oil and Gas in Federal and State Waters
during the Period 1954-1982

<u>Production</u>	<u>Oil (barrels)</u>	<u>Gas (thousand cubic feet)</u>
Federal	5,710,908,960	53,715,586,185
State	9,872,634,066	80,408,977,933

Oil- and gas-related impacts to coastal marshes are extensive, mainly in the form of exploration access canals, well sites, navigation canals that service the onshore and offshore industry, and pipelines that transport oil and gas produced in Federal and State waters. Boesch et al. (1982) estimated that at least half of the rapid loss of coastal wetlands in Louisiana is a direct or indirect result of channelization. Most of the channelization is attributed to oil and gas development in the marshes; however, some is attributable to activities related to offshore development. Estimates of the proportion of land loss that can be attributed to canals, which includes pipelines, range from 20% (Johnson and Gosselink 1982) to 90% (Turner et al. 1981). The impact results from direct replacement of marsh by open water and dredged material and from alteration of the hydrologic regime which induces saltwater intrusion and subsequent erosion of marsh vegetation.

The oil and gas industry has used two major construction methods to place pipelines through the coastal marshes: the "push" method and the "flotation" method. The push method requires excavation of a relatively narrow and shallow ditch with a dragline or marsh buggy-mounted backhoe. The ditch ranges from 4 feet to 6 feet deep by 8 feet to 10 feet wide. Because of the high water table in coastal marshes, the ditch remains filled with water.

Pipe sections are joined together at the beginning of the ditch and given temporary buoyancy by floats strapped to the pipe. The buoyant pipe is floated along the ditch. Up to 15 miles of pipeline can be installed from one push location using this method. Pipelines as large as 42 inches inside diameter have been installed in the Louisiana marshes using this method. Once floated into place, floats are removed and the line is submerged to the bottom of the ditch. The ditch may be left open or backfilled. When backfilled, the soil will not completely fill the flotation canal; however, Willingham et al. (1975) showed that backfilling promoted re-establishment of original conditions. Other studies (Turner et al. 1983) indicated that undrained Louisiana muck (greater than 75% organic matter) shrinks about 60% in volume when completely dry, and "it will retain only 70% of its original volume when saturated for a long time." Smith (1970) stated that "if the soil is turned or plowed or otherwise cultivated, this process (disintegration of the root mass) is increased rapidly, and what was a high spongy turf will reduce to one inch of soil. As the water drains out of the layers, the soil becomes more compact." The push method is preferred where possible because it results in less damage from the smaller ditch size and is less costly.

The flotation method requires excavation of a flotation canal to provide access for the pipe and pipe-laying equipment. The canal may range in size from 40 feet to 50 feet wide by 6 feet to 8 feet deep and may have an additional trench in the bottom to provide 10 feet to 12 feet clearance above the top of the pipeline. The flotation method was the first one developed and is now used for extremely large pipe, in shallow open water, and where marshes will not support equipment. A standard 40-foot section of 36-inch diameter pipe weighs approximately 8,000 lbs. After anti-corrosion coating

and 3 inches to 4 inches of concrete are applied for negative buoyancy, a 40-foot section weighs approximately 34,000 lbs. Equipment to handle pipe of this weight cannot be supported by some marshes. The flotation method is not preferred because it is time consuming, costly, and highly destructive to the marsh.

The following is a generic summary description of pipeline impacts contained in the Regional Environmental Assessment/Gulf of Mexico OCS Regional Office. It is based on field study and literature review of pipeline impacts in the coastal marshes.

"A pipeline traversing coastal marsh can cause serious and long lasting adverse environmental impacts. Regardless of the emplacement technique employed, an approximately 200-foot wide strip of marsh vegetation will be destroyed. This amounts to about 25 acres per mile. Excavation by a barge-mounted clam shell bucket dredge and use of other support equipment accounts for the loss of soil and vegetation. If the pipeline is installed by the flotation canal method, an open canal, about 40 feet to 50 feet wide and 6 feet to 8 feet deep, will remain after the dredging work is completed. The excavated spoil is left on the canal bank, with openings in the spoil bank to allow for drainage into and out of the canal. This type of construction activity usually has the following impacts on coastal marsh habitat. The open-ended (unplugged) flotation canal facilitates saltwater intrusion by allowing a faster rate of flushing freshwater out of the marshes, thereby lowering the water level and at the same time providing a direct avenue for saline waters to move further

inland at high tide. The effects of this very gradual process are usually not immediately apparent. Plant and animal species unable to adapt to higher salinity die and/or immigrate and are replaced by more salt tolerant flora and fauna. As fresh marsh vegetation is killed by increased salinity, erosion of the soil, typically rich in organic matter occurs. This erosion process is facilitated by a lack of plant roots normally helping to consolidate the substrate. Tidal flushing, often amplified by channelization of coastal streams, tends to remove loosened marsh soil particles. Before new, more salt tolerant species can establish themselves, enough soil is usually lost so that marsh soil elevation may drop 4 inches to 8 inches. In this manner, highly productive marsh is lost, and shallow ponds and lakes develop. Thousands of acres of marsh have thus been lost and converted to open water."

The degree to which OCS production impacts the amount of pipeline construction through the coastal marshes is unknown because of several factors. Pipelines are constructed to transport both State- and/or OCS-produced products, and the amount of State- or OCS-produced products varies with time and economic factors. Most pipelines transport both State- and OCS-produced products. However, during the period 1951-1982, MMS approved 72,870 miles of pipeline rights-of-way on the OCS in the Gulf of Mexico. Approximately 90% of the pipelines are found in the Central Gulf Coast, from the Texas-Louisiana boundary to the Florida-Alabama boundary. Approximately 130 of these pipelines make landfall on the Louisiana coast.

This study was designed with the following objectives: (1) to determine and quantify the effects of pipeline installation on fish and wildlife habitat in the brackish and saline marsh zones of coastal Louisiana; and (2) to determine if the habitat is recovering after construction.

II. MATERIALS AND METHODS

Five pipelines constructed using the push method were selected for study in the brackish or saline marsh zones. Records detailing the date of construction, pipeline size, excavation plans, and pipeline company were obtained from the Louisiana Department of Natural Resources. Three pipelines were studied in the Mississippi Deltaic Plain; one pipeline was constructed in 1978, and two were constructed in 1984. Two pipelines were studied in the Chenier Plain; both were constructed in 1978. Pipelines were inspected by MMS personnel prior to collecting field data to verify the location and extent of construction. The locations and names of the pipeline operators are shown in Figure 1. The five pipelines were plotted on 1:62,500 scale quadrangle maps and partitioned into consecutive study sections one kilometer long. Each study section was assigned a number, and a study section was randomly selected. Habitat was sampled at the pipeline and at a control site in a systematic manner as illustrated on Figures 2 and 3. The control was located to one side or the other of the pipeline, randomly determined at each location, parallel to and 100 meters from the pipeline. This location was assumed to be outside the impact zone of the pipeline. A rope 100 meters long, with a knot every 5 meters for the first 40 meters, was used to measure distances and establish plot locations (Figure 4).

Two methods were selected for evaluating the effect of pipeline corridors on marsh habitat. The first method was a comparison of habitat quality measurements between each pipeline and its control. Comparisons were also made between different age pipelines. Variables measured for the comparisons were percentage canopy and salinity (Figures 5 and 6). The second method for evaluating pipeline impacts involved application of the Habitat Evaluation

PIPELINE TRANSECTS IN COASTAL LOUISIANA

①	Tennessee Gas Pipeline Co.	20"	1978
②	Atlantic Richfield Co.	6"	1984
③	Texas Gas Exploration Co.	8"	1984
④	Texas Gas Transmission Co.	20"	1978
⑤	Tennessee Gas Pipeline Co.	16"	1978

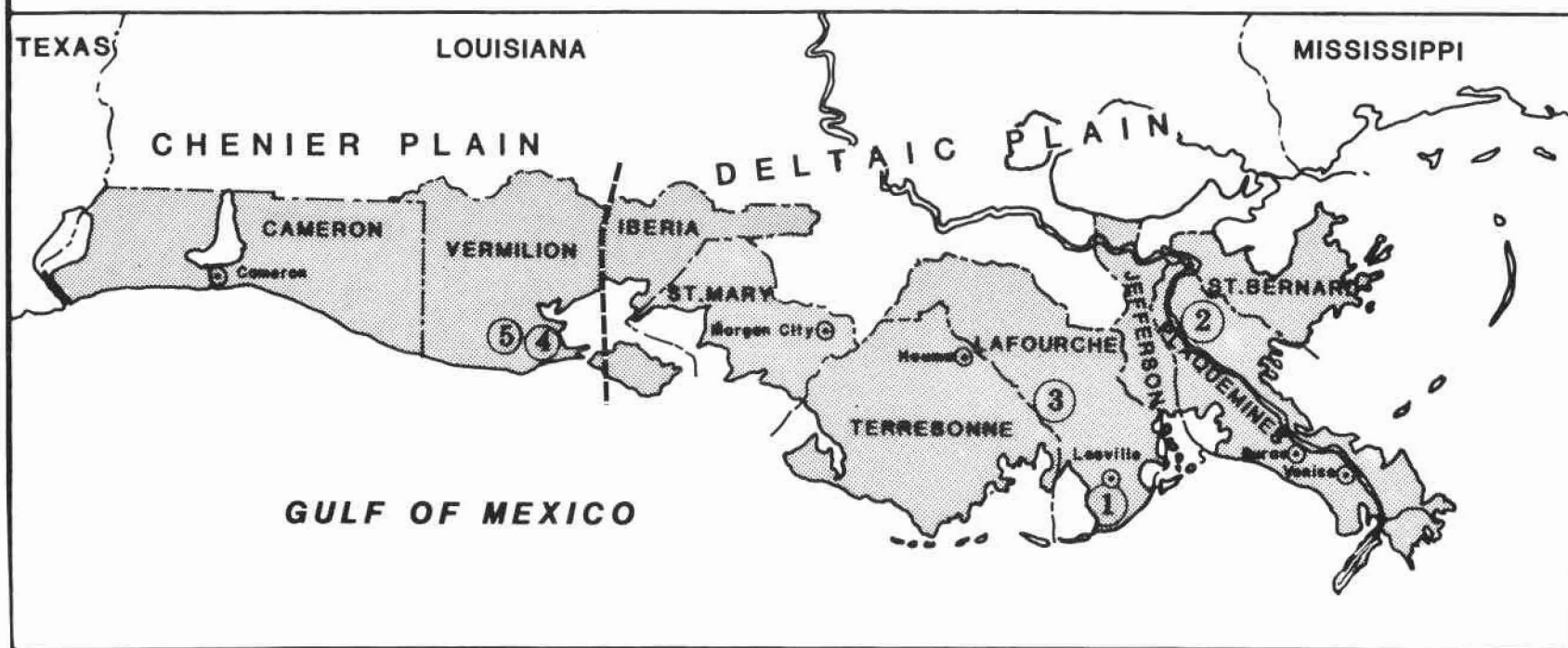


Figure 1. Pipeline transects in coastal Louisiana.

PIPELINE FIELD STUDY SAMPLING SCHEMATIC

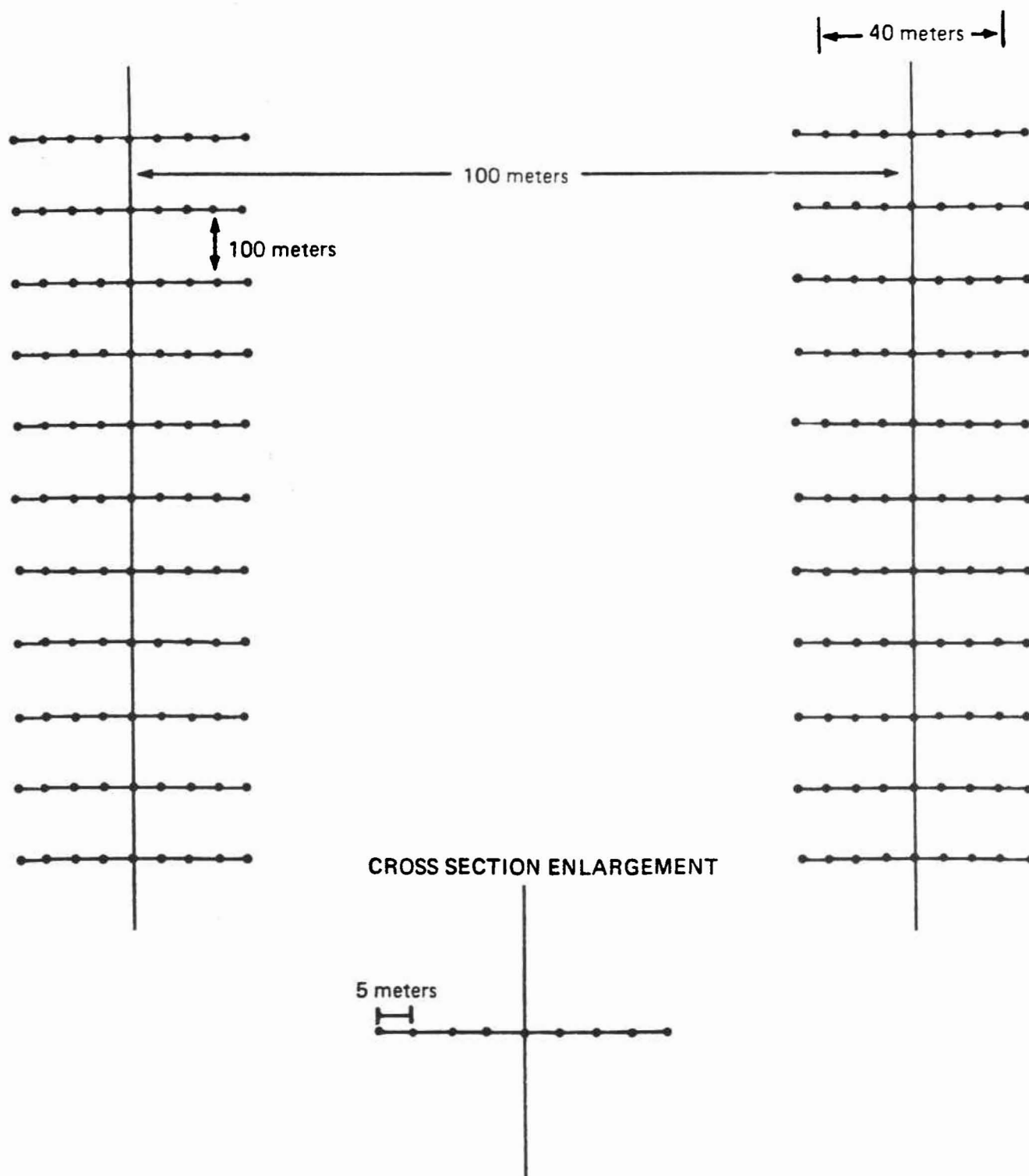


Figure 2. Pipeline field study sampling schematic.



Figure 3. Field crew determining percent canopy cover and plant identification along Texas Gas Transmission Co. 20" pipeline in Vermilion Parish. The pipeline was installed in 1978.



Figure 4. Field crew sampling along Texas Gas Exploration Co. 8" pipeline in Lafourche Parish. The pipeline was installed in 1984.



Figure 5. Apparatus for measuring percent canopy cover in 1 square meter at each sample site.



Figure 6. Field crew taking temperature and salinity measurements from helicopter every 100 meters along each transect.

Procedure (HEP) developed by the U.S. Fish and Wildlife Service (FWS 1980). HEP is a method used to measure habitat quality change based on the requirements of fish and wildlife species. Habitat suitability index (HSI) models for use in HEP are developed for individual species. The models allow assignment of an index to an area that reflects the potential habitat quality for each species being evaluated. Habitat impact is assessed in HEP through changes in habitat units, which are determined by multiplying the HSI (a measure of quality) by the area of available habitat (a measure of quantity). Species selected for the pipeline impact study are dependent on and utilize the brackish and saline marshes. The muskrat (Ondatra zibethicus) (Allen and Hoffman 1984), mottled duck (Anas fulvigula maculosa) (Rorabaugh and Zwank 1983), and white shrimp (Penaeus setiferus) (Turner and Brody 1983) HSI models were used.

For each species a set of variables are used in the model to determine the HSI. The variables are measurable parameters that, based on review of life history and habitat requirements, could affect the suitability of the habitat for the species being evaluated. A list of variables, methods of measurement, and the HSI model used appear in Table 2. Water salinity and temperature were measured at 100-meter intervals along the pipeline and the midpoints of control transects only at stations where open water was present.

Table 2

Variables Measured in the Field for Computation of Habitat
Suitability Indices (HSI) for Three Target Species

<u>Variable</u>	<u>Target Species</u>	<u>Variable Measured</u>	<u>Method of Measurement</u>
1	Mottled Duck White Shrimp	Percent canopy cover of emergent herbaceous vegetation	Meter square quadrat- ocular estimate
2	White Shrimp	Substrate: (1) soft bottom, (2) sand, and (3) coarse or hard bottom	Ocular inspection of soil
3	White Shrimp	Salinity	Yellow Springs Instruments (YSI) temperature, salinity meter, model 33s-C-T
4	White Shrimp	Temperature	YSI temperature, salin- ity meter, model 33s-C-T
5	Mottled Duck	Percent of submerged substrate with woody or herbaceous vegetation	Meter square-ocular estimate
6	Mottled Duck	Vegetation structure in submerged substrate (1) less than 0.3 m tall and too dense for passage of ducklings; (2) greater than or equal to 0.3 m tall growing in mats or stands; (3) 0.3 to 1 m tall and difficult passage for a large predator; and (4) greater than 1 m tall and impenetrable to a large predator, but with openings for escape of ducklings	Meter square-ocular estimate

Table 2. Variables Measured in the Field for Computation of Habitat Suitability Indices (HSI) for Three Target Species (continued)

<u>Variable</u>	<u>Target Species</u>	<u>Variable Measured</u>	<u>Method of Measurement</u>
7	Mottled Duck	Percent land; upland such as spoil levees or natural ridges was defined as land	Meter square-measured estimate
8	Mottled Duck	Water depth-less than 0.3 m yes or no; parameter measured only if more than 50% of the meter square plot was open water	Meter square-measured with meter stick
9	Mottled Duck	Disturbance level such as boat traffic, mechanical noises, or human activity: (1) extreme, (2) moderate, (3) minimal, and (4) none	Ocular estimate of surroundings
10	Muskrat	Percent of persistent species (<u>Scirpus spp.</u> , and <u>Typha spp.</u>)	Meter square-ocular estimate
11	Muskrat	Percent coverage of <u>Scirpus olneyi</u> , <u>S. americanus</u> , or <u>Typha spp.</u> ; all species carry same weight.	Meter square-ocular estimate
12*	Muskrat	Percent of area in water*	Meter square-ocular estimate
13	Muskrat	Percent of open water with submerged or floating vegetation.	Meter square-ocular estimate

* Variable measured only if meter square plot was greater than 10% open water.

III. STATISTICAL ANALYSIS

In our analysis we examined the change in percentage of canopy cover as it varied with lateral distance from the pipeline and water salinity as it varied over the pipeline. Percentage of canopy cover and salinity were selected as measures of the two main postulated effects of pipeline activities on wetlands: wetland loss and salinity intrusion. Wetland loss reduces the acreage of marsh habitat and production of fish and wildlife. Salinity intrusion is a major secondary negative factor that accelerates wetland loss. In addition, these variables and others were used in calculations of habitat suitability indices for white shrimp, mottled duck, and muskrat for all five sites.

Percentage of canopy cover was not normally distributed (Figure 7); therefore, nonparametric tests were applied to the data (Conover 1971). The Mann-Whitney test (a non-parametric equivalent of the t-test) was used to detect significant differences in percentage of canopy cover on the pipeline as compared to the control. Mean percentage of canopy cover was calculated from all sample sites measured the same distance from the pipeline and was compared to the mean percentage of canopy cover of the entire control site (Table 3). The pattern is illustrated in Figure 8. The randomization test for matched pairs was used to test for differences in percentage of canopy cover between adjacent sites on the same transects to determine whether reductions in canopy cover were more severe closer to pipelines or farther away. The Spearman rank correlation coefficient was used to test for trends in salinity directly over the pipeline and on the central transect of the control.

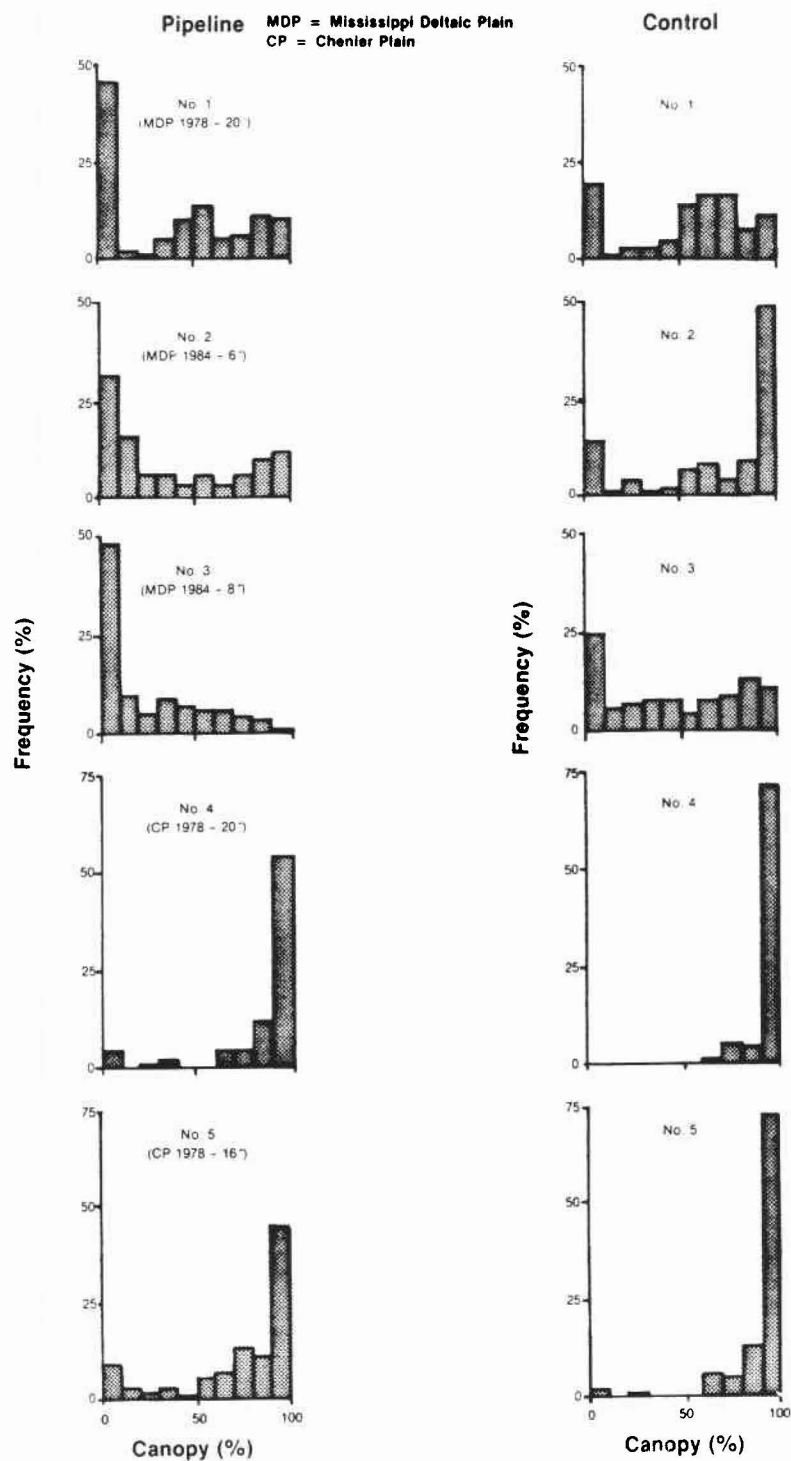
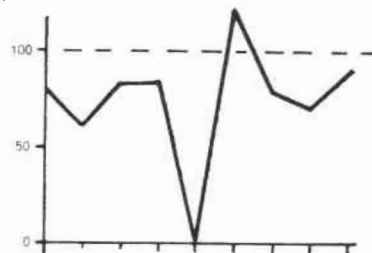


Figure 7. Percent frequency vs. percent canopy cover. Percent frequency distribution of observations of percentage canopy cover for pipelines and adjacent control areas. Location, date of installation, and size of pipeline are indicated in parentheses.

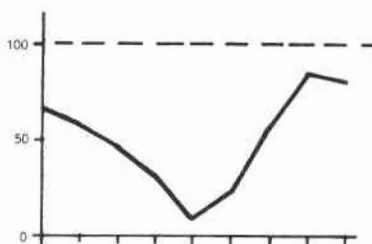
Pipeline

MDP = Mississippi Deltaic Plain
CP = Chenier Plain

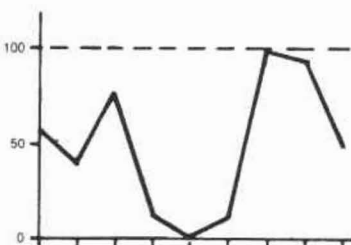
No. 1
(MDP 1978 - 20')



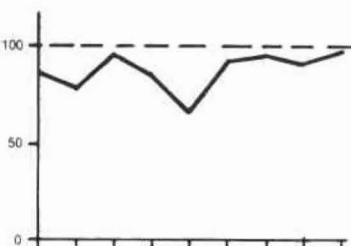
No. 2
(MDP 1984 - 6')



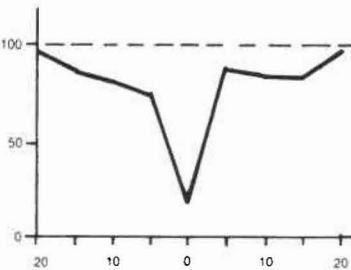
No. 3
(MDP 1984 - 8')



No. 4
(CP 1978 - 20')



No. 5
(CP 1978 - 16')



Pipeline canopy cover expressed as a percentage of mean canopy cover on control transects

Distance from pipeline (m)

Mean of
all pipelines

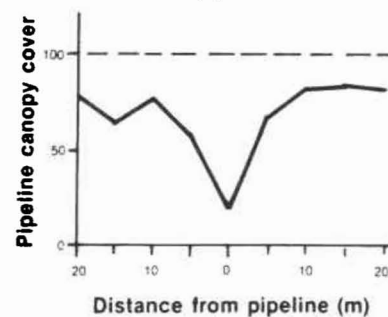


Figure 8. Percent pipeline canopy cover vs. distance. Canopy cover of different distances from pipelines expressed as a percentage of the mean canopy cover along the adjacent control transect. Location, date of installation, and size of the pipeline are indicated in parentheses.

IV. RESULTS

To statistically ascertain whether the construction of pipelines affects marsh vegetation and the distance from the pipeline that vegetation is affected, the comparison of canopy cover observations at sample sites equidistant from the pipeline to the respective controls is presented (Table 3). The level of significance is 0.05, which corresponds to a level of confidence of 95%. Mean canopy cover was higher at only one of five distances (5 meters) from one pipeline (pipeline 1) in comparison to overall mean canopy cover on the corresponding control (Figure 9) but this difference was not significant. In 18 of 25 cases, the Mann-Whitney Test revealed that the percentage of canopy cover at 0 to 20 meters from pipelines were significantly lower than that found along transects 100 meters away from the pipelines. One difference not statistically significant occurred at 5 meters (pipeline 1), three at 10 meters (pipelines 1, 3, and 4), and three at 20 meters (pipelines 1, 4, and 5) from their respective pipelines.

The test between adjacent sites to determine whether reductions in cover were more severe closer or farther away from pipelines is illustrated in Figure 10. As there were nine sets of observations at differing distances from the pipeline (including the pipe itself), there were eight comparisons to be made between a set and the set 5 meters more distant from the pipe. There were five pipelines; therefore, there are 40 comparisons in all on the pipeline samples, and another 40 on the controls. The null hypothesis for the pipeline areas was that canopy cover nearer the pipe was greater than or equal to canopy cover 5 meters farther out. The alternative hypothesis was that canopy cover nearer the pipe was less than canopy cover 5 meters farther out. For the controls, there was no disturbance involved and no expected change in canopy cover in

Table 3

Comparisons of Mean Percentage of Canopy Cover for Five Distances from the Pipelines with Their Respective Control Areas

Distance from Pipeline (m)	Location Number	Observed Significance Level	Mean/(standard error)	
			Pipelines n = 22, except n = 11 for zero meter from pipeline	Control n = 99
0	1	< 0.000005	0 (0.0)	50.9(3.1)
	2	< 0.000005	6.0(2.0)	68.6(3.5)
	3	< 0.000005	0.5(0.5)	42.8(3.4)
	4	0.000008	61.6(12.1)	93.8(0.9)
	5	< 0.000005	17.4(7.4)	88.3(1.8)
5	1	*	53.2(8.0)	50.9(3.1)
	2	< 0.000005	18.2(4.0)	68.6(3.5)
	3	< 0.000005	5.1(2.4)	42.8(3.4)
	4	0.021	83.9(5.6)	93.8(0.9)
	5	0.001	72.3(6.4)	88.3(1.8)
10	1	0.09	40.9(7.4)	50.9(3.1)
	2	0.0001	36.0(6.2)	68.6(3.5)
	3	0.26	37.3(6.0)	42.8(3.4)
	4	0.14	90.3(2.5)	93.8(0.9)
	5	0.006	73.4(6.0)	88.3(1.8)
15	1	0.0034	33.6(6.3)	50.9(3.1)
	2	0.013	49.0(8.3)	68.6(3.5)
	3	0.049	28.9(5.7)	42.8(3.4)
	4	0.0068	80.0(6.4)	93.8(0.9)
	5	0.0031	75.2(5.5)	88.3(1.8)
20	1	0.13	43.6(6.4)	50.9(3.1)
	2	0.027	50.5(9.2)	68.6(3.5)
	3	0.0073	23.0(5.4)	42.8(3.4)
	4	0.068	87.2(5.4)	93.8(8.9)
	5	0.17	85.9(3.3)	88.3(1.8)

* Pipeline canopy greater than control canopy; all others are less.



Figure 9. Tennessee Gas Pipeline Co. 20" pipeline right-of-way in Lafourche Parish.
The pipeline was installed in 1978.

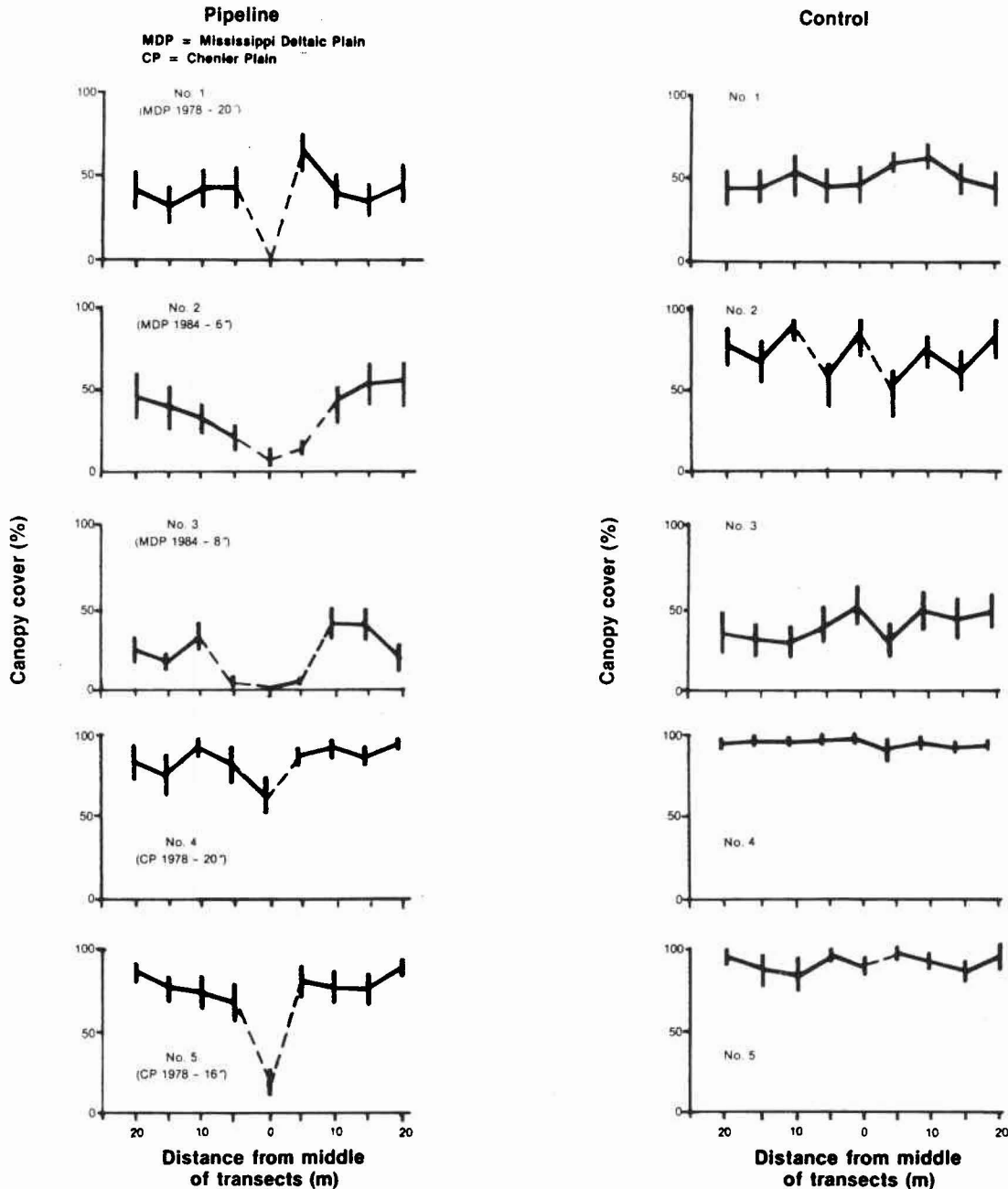


Figure 10. Percent canopy cover vs. distance. Means of percent canopy cover for the five pipelines by distance from the pipeline and their controls. Vertical lines extend one standard error on either side of the means. Dashed lines connecting the means indicate significant differences between the means. Location, date of installation, and size of pipelines are indicated in parentheses.

relation to the middle set of data. The null hypothesis was, therefore, that there would be no difference in either direction.

The 0.05 probability level was chosen as significant. At this level, 2 comparisons out of the 40, on the average, would be significant by chance alone and would not be indicative of lower canopy cover close to the pipeline. For the pipelines, 11 out of 40 reached or surpassed this level of significance. The probability that this many or more could occur at random is given by the cumulative binomial distribution with $n = 40$, $p = 0.05$, and $y = 11$ (Conover 1971), and is calculated to be 0.000004. All 11 significant differences between adjacent sites were within 10 meters of the pipeline. Therefore, although significant differences between pipeline sites and control areas extended as far out from the pipelines as sampling was conducted (Table 3 and Figure 8), the effects were greatest close to the pipelines. Corresponding tests between sites in the control areas gave only three significant differences, not different from the expected 2 of 40 significant differences for a probability level of 0.05 under the null hypothesis of no difference in either direction.

The patterns of distribution of plant cover in the vicinity of pipelines and their relation to the mean cover of control sites are illustrated in Figures 7, 8, and 10. Consistent with the statistical analyses, reductions in canopy cover were greatest at the pipeline itself, were variable farther from the pipeline but extended to the farthest distance samples, and tended to be less at greater distances from the pipelines. Nevertheless, even at 20 meters from pipelines, canopy cover was 80% of what it was in the control areas for all study areas combined. Reductions were most pronounced along the two pipelines installed the same year as the sampling was conducted, even though they were

the smallest pipes. Among the three large pipelines, all installed in 1978, there is an indication of a greater residual effect of pipeline laying activities in the Mississippi Deltaic Plain than in the Chenier Plain. Overall, canopy cover was 75% of control cover along the Mississippi Deltaic Plain pipelines versus 88% and 79% along the Chenier Plain pipelines.

There were significant correlations between salinity and distance in some study areas (Figure 11). Pipeline 3 (Figure 12) and control 2 showed an increase in salinity toward the south end, while the reverse was apparent for pipelines 1 (Figure 13) and 2 (Figure 14). In the Chenier Plain, pipeline 5 increased from both ends toward the middle, and pipeline 4 and controls 4 and 5 were too dry to measure. Too few sites with standing water occurred in control areas 1 and 3 to test for trends. There was no consistent difference in salinity between pipelines and their associated control areas (Figure 11).

As an indicator of the potential effects of pipelines on fish and wildlife resources, HSI's were calculated for three wetland-dependent species: White shrimp, muskrat, and brood-rearing mottled duck. White shrimp had higher HSI's in three control areas than in the corresponding pipeline study areas (pipelines 1-3), a lower HSI in one case (pipeline 5), and both pipeline and control areas were unsuitable because surface water was absent in one case (pipeline 4) (Table 4). Brood-rearing mottled ducks had higher HSI's in control than pipeline areas in three cases (pipelines 1-3) (Table 4). Adverse effects on fish and wildlife resources were more strongly expressed in the Mississippi Deltaic Plain than in the Chenier Plain (Table 4). Considering the average of all pipelines, the mean HSI value for all species was lower than the HSI value for the average of corresponding controls. The magnitude of change

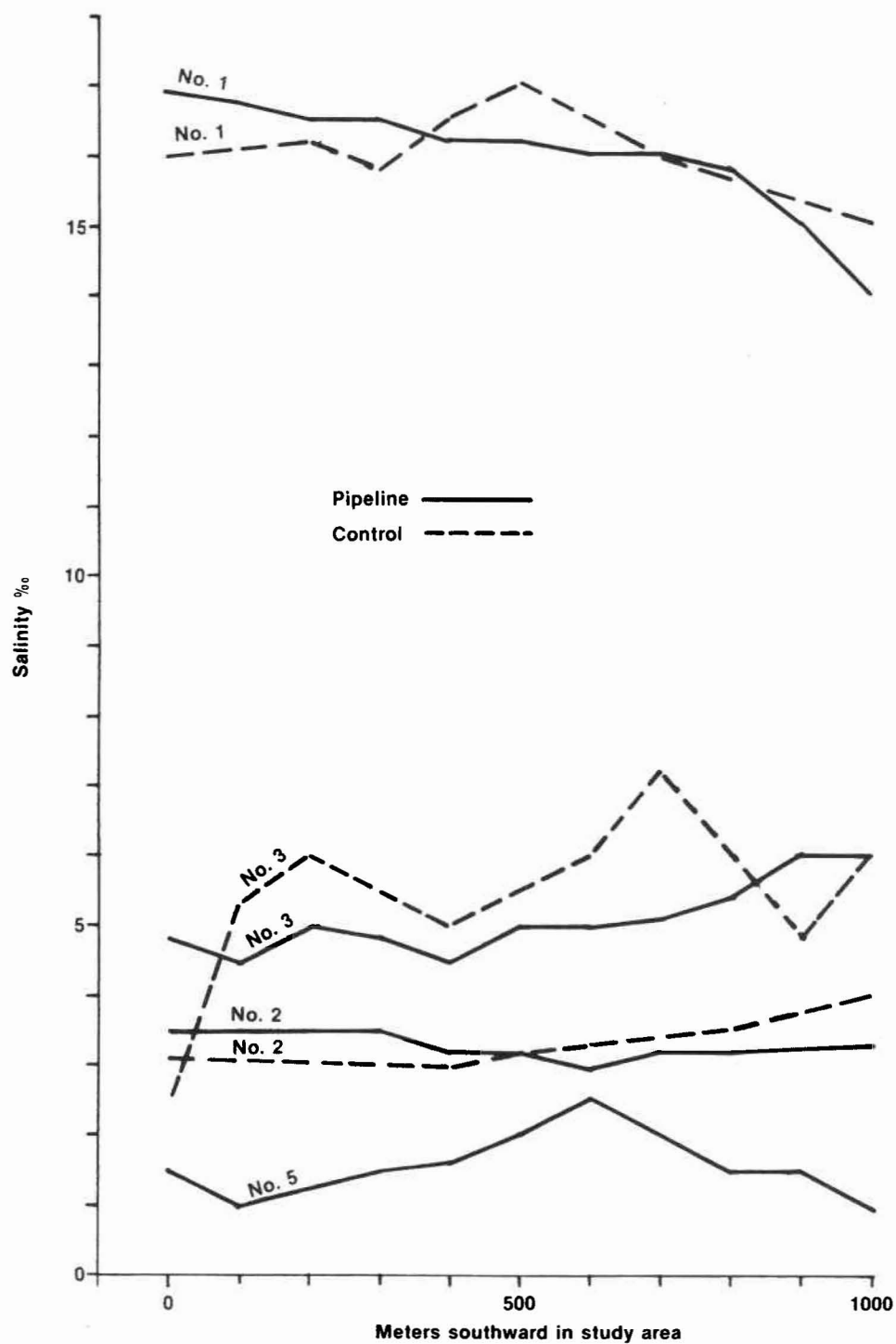


Figure 11. Surface water salinities. Sampled at 100 m intervals southward along pipelines and in their corresponding control areas.



Figure 12. Texas Gas Exploration Co. 8" pipeline right-of-way in Lafourche Parish.
The pipeline was installed in 1984.



Figure 13. Tennessee Gas Pipeline Co. 20" pipeline right-of-way in Lafourche Parish.
The pipeline was installed in 1978.



Figure 14. Atlantic Richfield Co. 6" pipeline right-of-way in Plaquemines Parish. The pipeline was installed in 1984.

ranged from +0.46 in the Chenier Plain on pipeline 5 for white shrimp to -0.53 in the Mississippi Deltaic Plain for the mottled duck. One "no change" was reflected on Chenier Plain pipeline 4, and one change of +0.21 for brood-rearing mottled duck on Chenier Plain pipeline 4 was recorded. The remaining 12 out of 15 HSI measurements indicated a reduction in HSI on the pipeline as compared to the control.

Table 4

Habitat Suitability Indices for Three Wetland Species

<u>Location</u>	<u>White Shrimp</u>		<u>Muskrat</u>		<u>Mottled Duck</u>	
	<u>Pipeline</u>	<u>Control</u>	<u>Pipeline</u>	<u>Control</u>	<u>Pipeline</u>	<u>Control</u>
Mississippi Deltaic Plain						
#1	0.52	0.63	0.18	0.26	0.16	0.69
#2	0.35	0.55	0.15	0.23	0.58	0.67
#3	0.49	0.77	0.19	0.22	0.49	0.76
Chenier Plain						
#4	0.00	0.00	0.32	0.43	0.21	0.00
#5	0.46	0.00	0.25	0.28	0.72	0.32
Mean	0.37	0.39	0.22	0.28	0.43	0.53

V. DISCUSSIONS

Based on field inspection, analysis of canopy cover, and determination of HSI for these wetland species, the most apparent impacts of pipeline construction are marsh loss and the reduction in habitat value for fish and wildlife. The most evident impact is removal of marsh vegetation by excavation of the trench used in the push method. The impact was most severe in the Mississippi Deltaic Plain where highly organic soils are present and the marsh is rapidly being lost. All three pipelines sampled had a significant level of canopy reduction 5 meters on each side of the pipe. Pipelines 2 and 3 also had a significant level of canopy reduction 10 meters from the pipe.

Marsh loss is, based on field inspection, directly related to construction impacts. Pipelines 2 and 3 were constructed in 1984 and the zone of impact corresponded directly with marsh buggy trails, the trench, and spoil areas. The exact width of the construction corridor could not be determined for Pipeline 1, and it was constructed in 1978. It is noteworthy, however, that canopy cover along the corridor remains significantly reduced compared to its control area.

Analysis of canopy cover within 20 meters of pipelines, as a percentage of the mean canopy cover along the adjacent control transects, illustrates the overall initial construction impact. Figure 8 indicates that on the average the pipeline corridor had a canopy cover less than 70% of that recorded for controls. The reduction in canopy cover was most severe (up to 90%) directly over the pipe. On the average, reduction in canopy cover from the pipe 5 meters in either direction was approximately 50%.

The fact that the increase in HSI values on pipelines occurred where no water was present in the corresponding control is noteworthy. Habitat requirements of the brood-rearing mottled duck and white shrimp include some open water interlaced with emergent vegetation. Construction of pipelines results in open water areas for these species.

The reduction in HSI values on pipeline sites for white shrimp, muskrat, and mottled duck was due largely to removal of emergent vegetation used for food and cover. In most cases the vegetation was removed by physical construction. Reduction ranged from 0.03 for muskrat on Mississippi Deltaic Plain pipeline 3 and Chenier Plain pipeline 4 to a high of 0.53 for mottled duck on Mississippi Deltaic Plain pipeline 1. The overall impact of pipeline construction based on mean HSI values for all pipelines in the Mississippi Deltaic Plain and Chenier Plain was a reduction in HSI for all species due to reduction in canopy cover of emergent vegetation. On pipeline 1 extremely high salinities (> 15 ppt) measured at the time of the inventory indicated that the conditions are not conducive to revegetation.

The overall impact of pipeline construction, as evidenced from this and previous studies, is a reduction in both quantity and quality of fish and wildlife habitat. Quantity is, in most cases, more severely reduced than quality, based on the limited number of pipelines in this study.

This pilot study, with a very small sample size of five pipelines, indicates that pipeline impacts to the coastal marshes are negative. The primary impacts are physical removal of a strip of marsh vegetation along the pipeline right-of-way. Secondary impacts are marsh loss due to saltwater intrusion

along the pipeline ditch. The impact of reduction in quantity of coastal marsh is more important than reduction in the quality of wildlife habitat in the total marsh loss problem. This study documents the destruction of coastal marshes by pipelines.

Marsh restoration technology is available and in practice in Louisiana. The rate of marsh deterioration from saltwater intrusion can be slowed by the introduction of freshwater into the marshes. This is currently being practiced in St. Bernard Parish. A siphon is in operation at Violet, Louisiana, transferring water from the Mississippi River into the marshes east of Violet. The freshwater has had a beneficial effect on the marsh vegetation in an area of serious marsh loss.

Introduction of sediments with Mississippi River water reverses marsh loss and will cause delta accretion that supports marsh vegetation. Marsh creation by crevassing natural distributaries in the Mississippi River's natural delta is being practiced as a mitigating measure on the Delta National Wildlife Refuge in Plaquemines Parish. In December 1983, the right descending bank of Octave Pass was breached 10 feet deep by 100 feet wide by 1,200 feet long to provide natural delta accretion. To date approximately 20 acres of marsh have accreted.

Throughout coastal Louisiana, freshwater introduction is recognized as a management tool to manipulate salinities, to distribute plant species and to elevate the marsh floor. Institutional arrangements for the right to divert water over privately-owned marshlands can be made through acquisition of conservation easements or fee title ownership.

This study indicates that pipelines contribute to loss of vegetation and salinity changes. Technology exists to mitigate the damages, and the Federal planning process is available to prepare and implement mitigation plans. Therefore, it is recommended to the Department of the Interior--Fish and Wildlife Service, Department of the Army Corps of Engineers, and the State of Louisiana that:

- (1) all pipelines crossing the Louisiana marshes be identified;
- (2) these pipelines be inventoried to determine the acreage of marsh destruction from primary and secondary impacts and the extent of reduction in value of fish and wildlife habitat; and
- (3) a cooperative mitigation plan be designed and implemented by said agencies to arrest and reverse the marsh loss caused by pipelines.

Literature Cited

- Allen, A.W. and R.P. Hoffman. 1984. Habitat Suitability Index Models: Muskrat. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.46.
- Baumann, R.H. and R.D. DeLaune. 1982. "Sedimentation and apparent sea level rise as factors affecting land loss in coastal Louisiana." Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences and Options, D.F. Boesch, ed. Washington, D.C.: U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59. pp. 2-13.
- Boesch, D.F., ed. 1982. Proceedings of the conference on coastal erosion and wetland modification in Louisiana: causes, consequences, and options. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-82/59. 256 pp.
- Conover, W.J. 1971. Practical non-parametric statistics. New York, NY: John Wiley and Sons.
- Fruge, D.W. 1982. "Effects of wetland deterioration on the fish and wildlife resources of coastal Louisiana." Proceedings of the Conference on Coastal Erosion, and Wetland Modification in Louisiana: Causes, Consequences and Options, D.F. Boesch, ed. Washington, D.C.: U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59. pp. 99-107.

- Gagliano, S.M. and J.L. van Beek. 1970. Geological and geomorphic aspects of deltaic processes, Mississippi delta system: Louisiana State University, Center for Wetland Resources, Baton Rouge. Hydrologic and Geologic Studies of Coastal Louisiana, Report 1. 140 pp.
- Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Land loss in the Mississippi River Deltaic Plain. Trans. Gulf Coast Assoc. of Geol. Soc. 31:295-300.
- Johnson, W.B. and J.G. Gosselink. 1982. "Wetland loss directly associated with canal dredging in the Louisiana coastal zone." Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes Consequences and Options, D.F. Boesch, ed. Washington, D.C.: U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59. pp. 60-72.
- McGinnis, J.T., R.A. Ewing, C.A. Willingham, S.E. Rogers, D.H. Douglas, and D.L. Morrision. 1972. Environmental Aspects of Gas Pipeline Operations in the Louisiana Coastal Marshes. Columbus, OH: Battelle Laboratories.
- Rorabaugh, J.C. and P.J. Zwank. 1983. Habitat Suitability Index Models: Mottled Duck. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.52.
- Swanson, R.L. and C.I. Thurlow. 1973. "Recent subsidence rates along the Texas and Louisiana coasts as determined from tide measurements." Journal of Geophysical Research 78, pp. 2665-2671.

- Smith, E. 1970. "Evaluation of a leveed Louisiana marsh." N. Am. Wildl. Conf. 35:265-275.
- Turner, R.E. and M.S. Brody. 1983. Habitat Suitability Index Models: Northern Gulf of Mexico Brown Shrimp and White Shrimp. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS 82/10.54.
- Turner, R.E., R. Costanza, and W. Scaife. 1981. "Canals and wetlands erosion rates in coastal Louisiana." Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options, D.F. Boesch, ed. Washington, D.C.: U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59. pp. 73-84.
- Wicker, K.M. 1980. Mississippi deltaic plain region ecological characterization: a habitat mapping study. A user's guide to the habitat map. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79/07.
- Willingham, C., B. Carnaby, and D. Engstorm. 1975. Final report on a study of selected coastal zone ecosystems in the Gulf of Mexico in relation to gas pipelining activities. Columbus, OH: Battelle-Columbus Laboratories. p. 230.



As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE