Outer Continental Shelf Pipeline and Navigation Canal Impacts and Mitigation Effects on Wetland Habitats of Coastal Western and Central Gulf of Mexico

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U.S. Geological Survey

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Estimates of total wetland loss attributed to oil and gas activities in the coastal zone of the northern Gulf of Mexico

Overall (%)	Direct (%)	Indirect (%)	Source	Notes
36.06	11.14	24.92	Penland 2001	Delta Plain only (1930–1990)
~9.2-50	9.2-18.4	~0-40	Day et al. 2000	1930–1990, varies by basin
	6.6 (OCS 4-4.7)		Baumann & Turner 1990	1955/6–1978
30-59 (OCS 8-17)*	14-16 (OCS 4-4.7)	20-60(OCS 4-13)	Turner & Cahoon 1987	Consensus
Majority of losses			Turner 1997	1932–1990 maps
12			Britsch & Dunbar 1993	
	9		Boesch et al. 1994	Consensus
	10	48-97	Scaife et al. 1983	

* (OCS = percent loss from outer continental shelf activity)

Indirect impacts of pipelines, pipeline canals and navigation canals: underlying mechanisms related to habitat modification and wetland loss

Indirect Impacts	Citations	
Hydrodynamic Alterations		
Impoundment	Swenson & Turner 1987 Reed et al. 1997 Cahoon 1994	Reed 1992 Boumans & Day 1994 Cahoon et al. 1995
Saltwater intrusion	Wang 1987	Wiseman et al. 1990
Flooding (runoff and storage)	Sikora & Wang 1993 Gagliano 1973 Stone et al. 1978	Reed & Nyman 1995 Craig & Day 1977
Sedimentation and Erosion		
Accretion	Neill & Turner 1987 Polasek & Griffin 1997	Cahoon & Turner 1989
Soil compaction	Polasek & Griffin 1997	
Wake erosion	Baumann & Turner 1990 Polasek & Griffin 1997	Boesch & Robilliard 1987 Monte 1978
Beach erosion/sedimentation patterns	Wicker et al. 1989	
Other erosion (water flow/ponding)	Suhayda 1987 Turner & Rao 1990	Nyman et al. 1993
Vegetation and Habitat		
Vegetation cover	Polasek & Griffin 1997 Tabberer et al. 1985	Belaire Consulting 1993 Krone et al. 1987
Habitat change	Tabberer et al. 1985 T. Baker Smith & Son 2002	Reed & Rozas 1994

MMS Information Needs for EIS

A more comprehensive and accurate understanding of the size of the OCS-pipeline system and its impacts

- Size of the on-shore OCS-pipeline system (Texas, Louisiana, Mississippi, Alabama)
- Extent of direct and indirect wetland impacts of the OCS-pipeline system
- Should standard mitigation efforts be continued or modified? New efforts?

Expand Knowledge & Database

Turner & Cahoon (1987), OCS Study MMS 87-0119

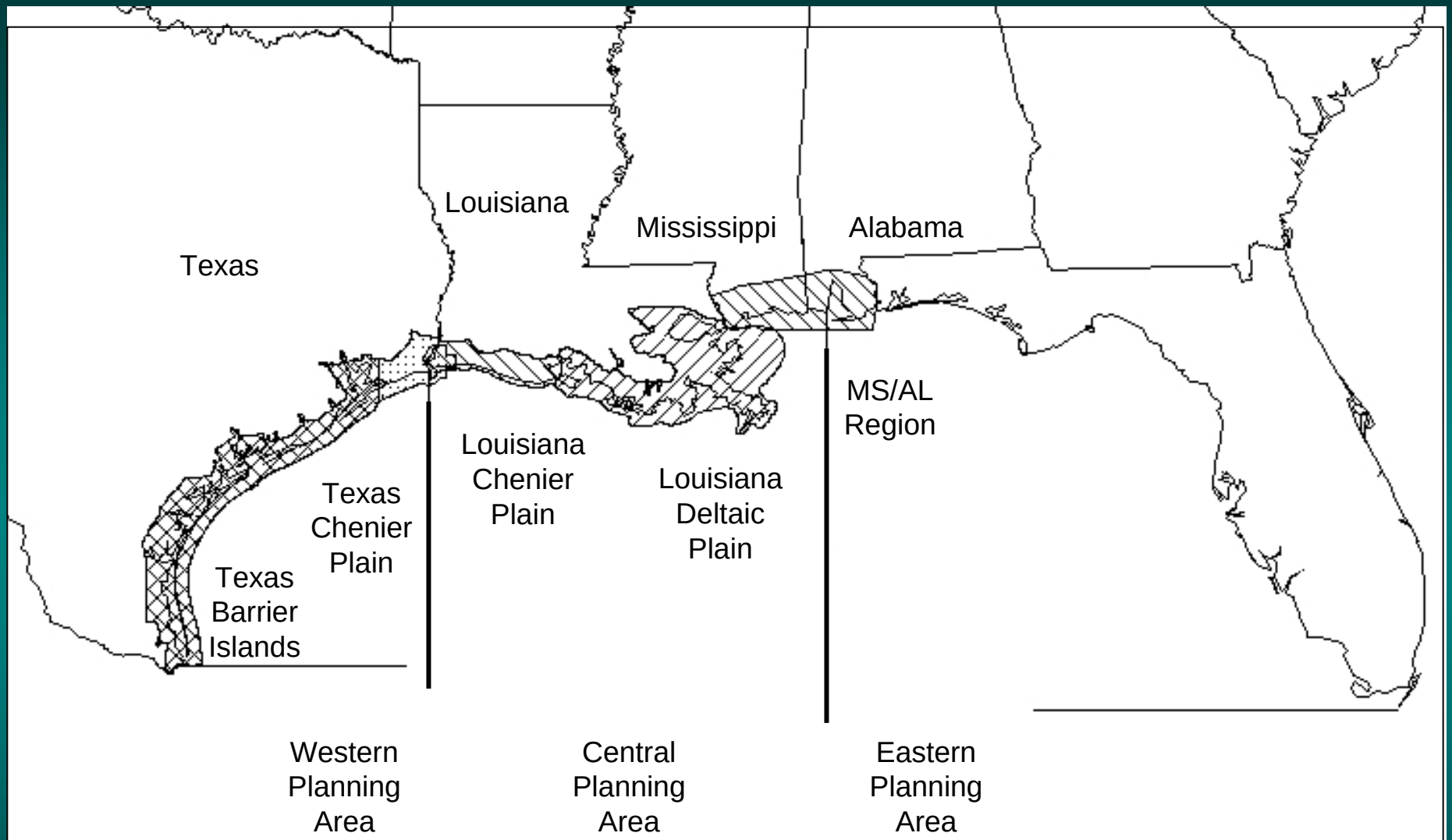
- 1956 to 1978
- Louisiana
- 157/225 OCS pipelines

New study:

- 1956 – 1978 & 1978/9 – 1990s [pre- & post construction]
- LA, TX, MS, AL
- All OCS pipelines from all subareas

GIS OCS Pipeline Database

- Texas 28
- Louisiana 225
- Mississippi/Alabama 10


Texas
Louisiana
Mississippi
Alabama
Texas Chenier Plain
Texas Barrier Islands
Louisiana Chenier Plain
Louisiana Deltaic Plain
MS/AL Region
Western Planning Area
Central Planning Area
Eastern Planning Area

Study Area

Project Goal

Prepare a factual array of data and data analyses in order to quantitatively determine the direct and indirect effects, or lack thereof, of OCS pipelines and navigation canals on land loss and wetland habitat change in the western and central planning areas of the Gulf of Mexico.

Specific Goals

- Estimate changes in land area (land versus open water) and extent of fresh and non-fresh marsh in relation to OCS pipelines and navigation canals

- Evaluate construction and mitigation techniques used to minimize OCS pipeline and navigation canal effects on land loss through the use of a literature review and qualitative analyses of selected case studies

Questions

- Are the rates and patterns of land loss within the immediate vicinity of OCS pipelines and navigation canals similar to regional rates and patterns of land loss? (Louisiana only)

- Do the rates and patterns of land loss, wetland loss, and habitat change within the immediate vicinity of OCS pipelines and navigation canals differ over time and among the five subareas of the western and central planning areas?

Questions

- What is the impact of OCS pipelines and navigation canals on wetland habitats within their immediate vicinity?

- Are the dominant mitigation and construction techniques used for OCS pipelines and navigation canals effective in minimizing the influence of OCS pipelines and navigation canals on land loss, wetland loss, and habitat change?

Project Tasks

- Literature Review: OCS pipeline and navigation canal activities, impacts, and mitigation practices
- GIS Analyses: collection and collation of spatial data; generation of land loss and habitat change data sets within the immediate vicinity of pipelines and navigation canals
- Analysis of Land Loss and Habitat Change: land loss and habitat change trends, OCS activity impacts on trends
- Mitigation Analysis: mitigation effectiveness at ameliorating pipeline and navigation canal impacts

Scales of Analyses

- Regional Analysis: A spatially extensive, quantitative evaluation
- Intensive Impact Analysis: A spatially intensive, quantitative evaluation
- Case Studies: a qualitative (semi-quantitative) evaluation

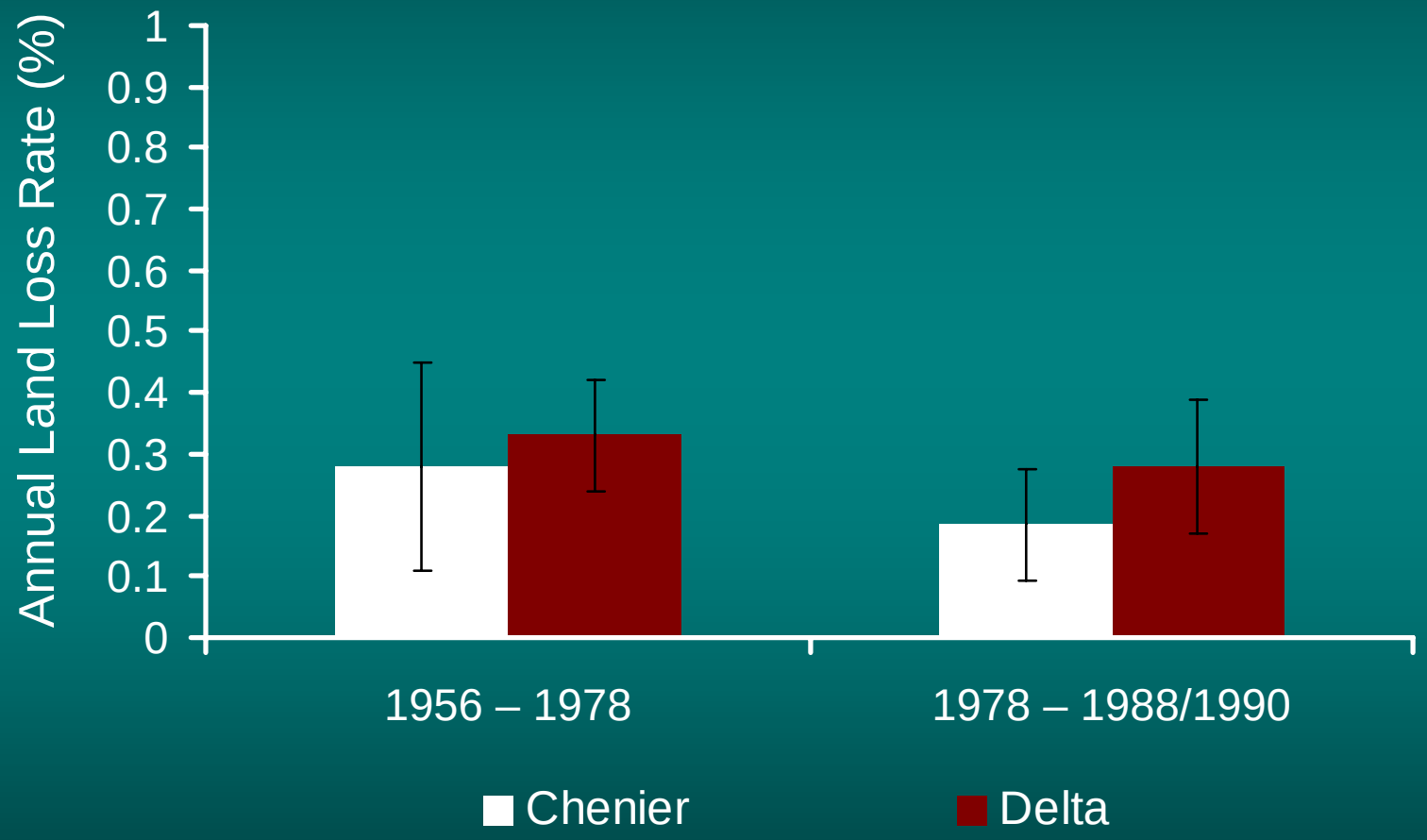
Scales of Analyses

Regional Analysis: A spatially extensive, quantitative evaluation of GIS-derived land loss, wetland loss, and habitat change data within the immediate vicinity of the *entire population* of OCS pipelines and navigation canals compared to regional trends of loss and change in Louisiana.

Question 1

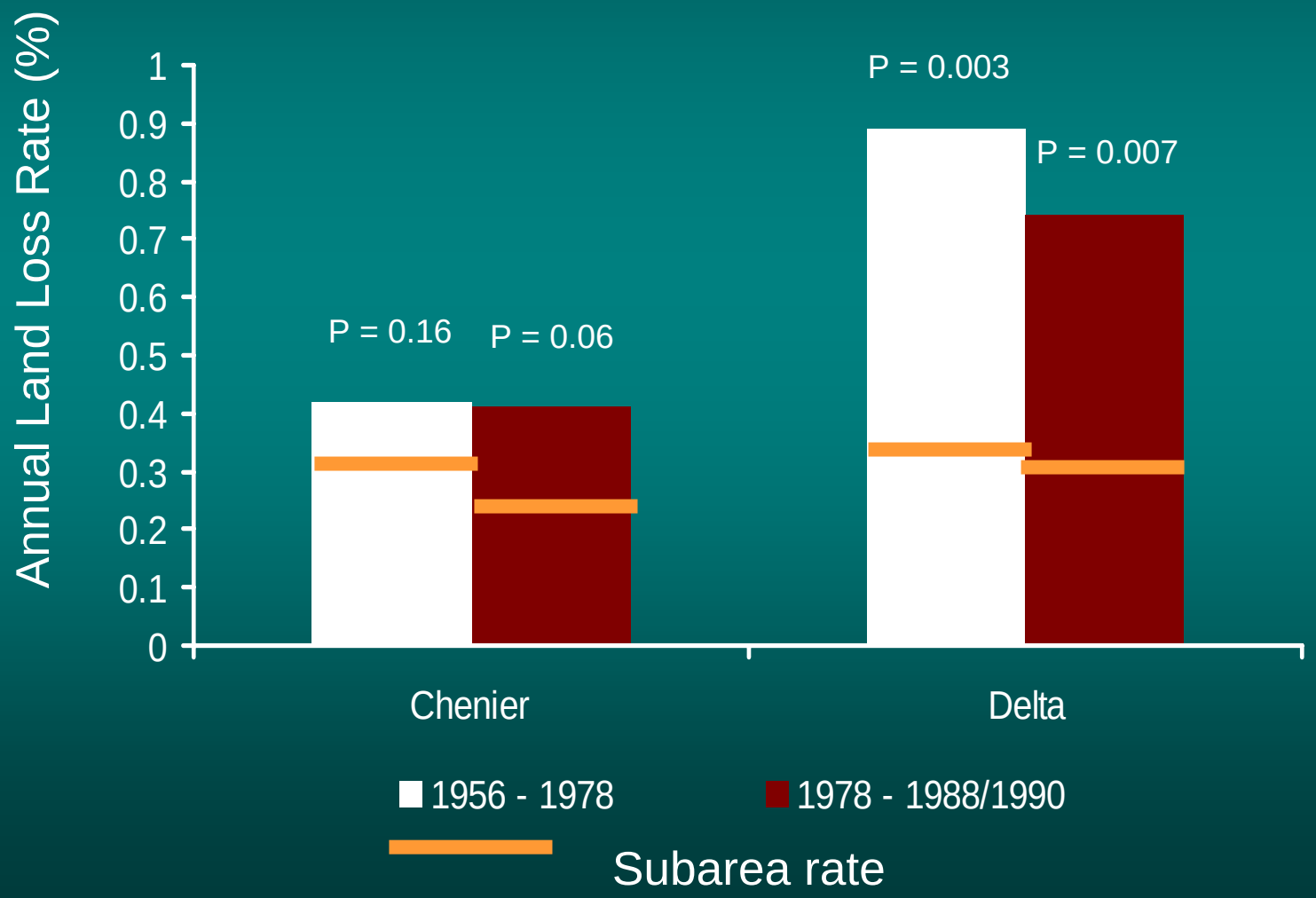
Are the rates and patterns of land loss within the immediate vicinity of OCS pipelines and navigation canals similar to regional rates and patterns of land loss? (Louisiana only)

Subarea Trends of Land Loss in Louisiana

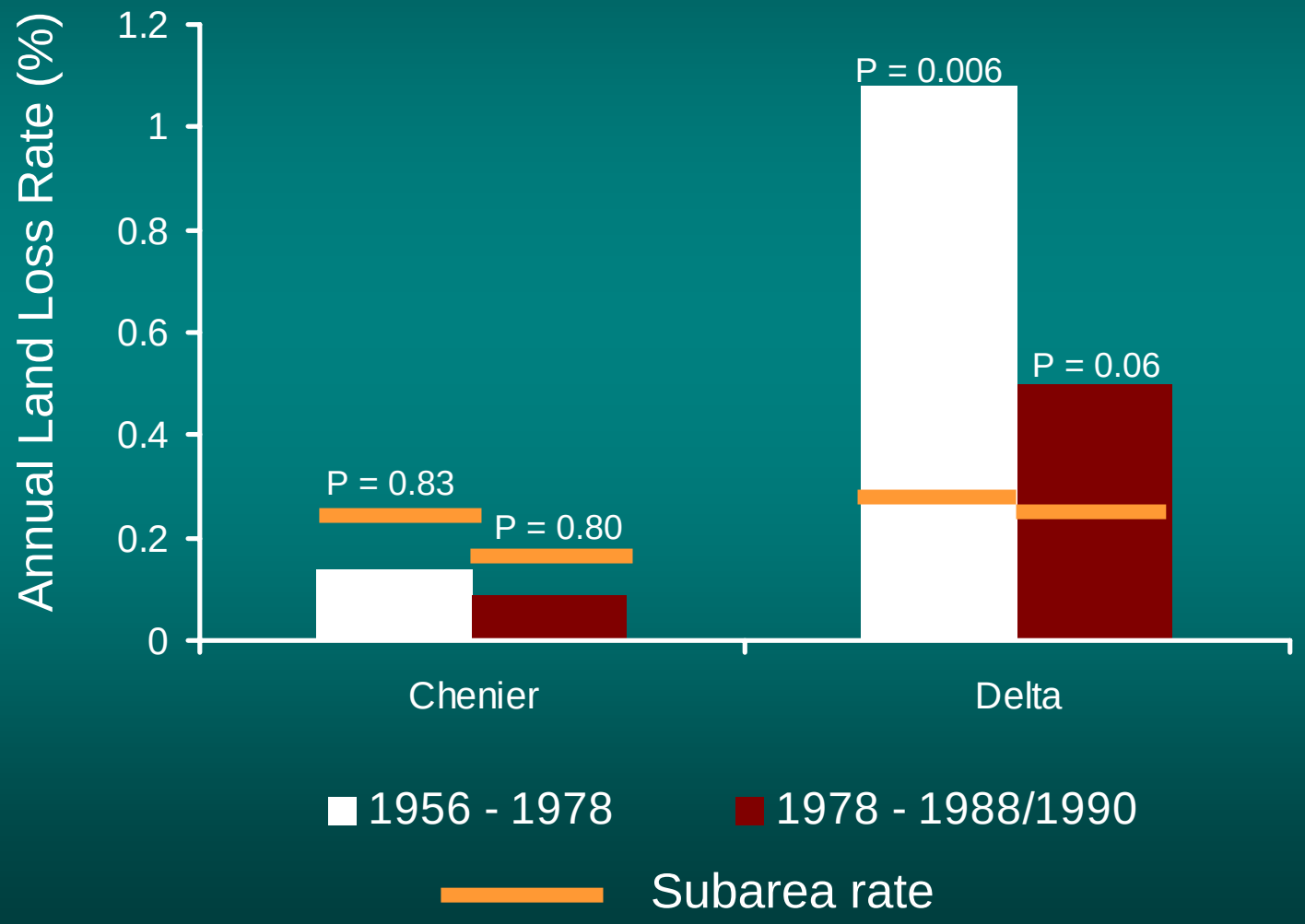


Source: Barras et al. 1994

Trends of Land Loss within 300 m (150 m either side) of Entire Population of Pipelines in Louisiana



Trends of Land Loss within 1000 m (500 m either side) of Entire Population of Navigation Canals in Louisiana



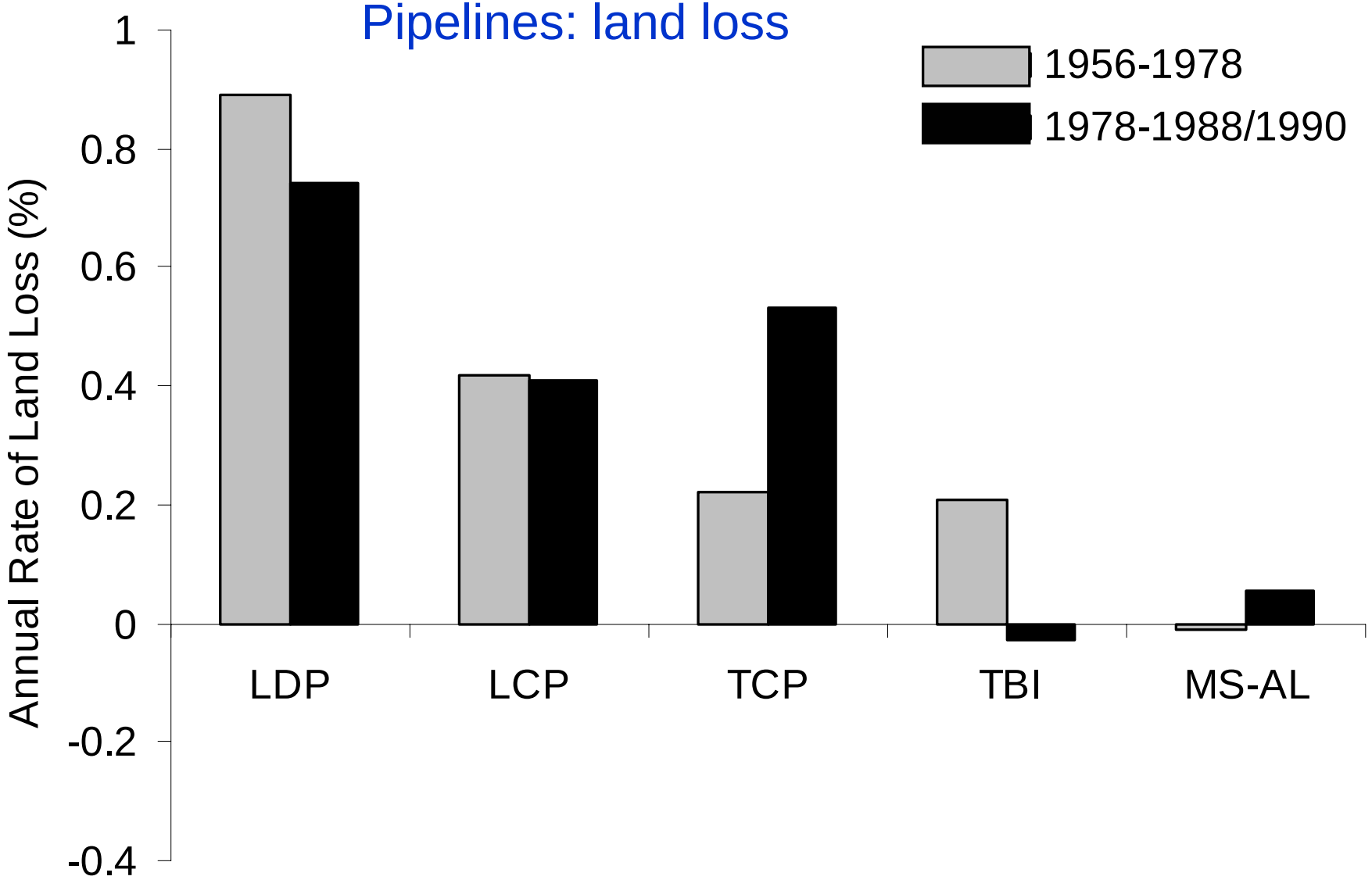
Question 1 Response

OCS pipeline and navigation canal construction in Louisiana from the 1950s to the 1990s was associated with enhanced land loss, and the rate of land loss decreased over time.

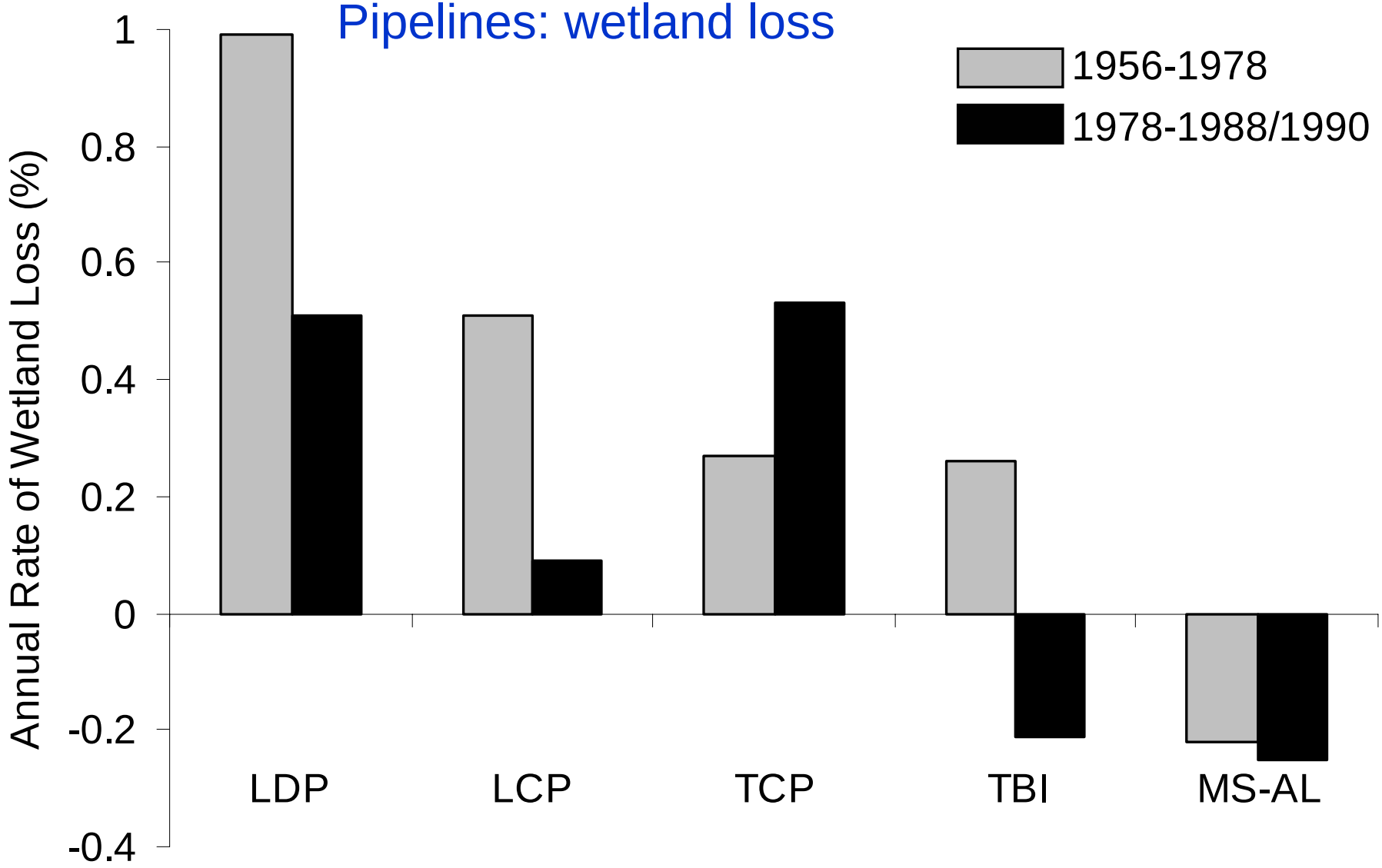
Question 2

Do the rates and patterns of land loss, wetland loss, and habitat change within the immediate vicinity of OCS pipelines and navigation canals differ over time and among the five subareas of the western and central planning areas?

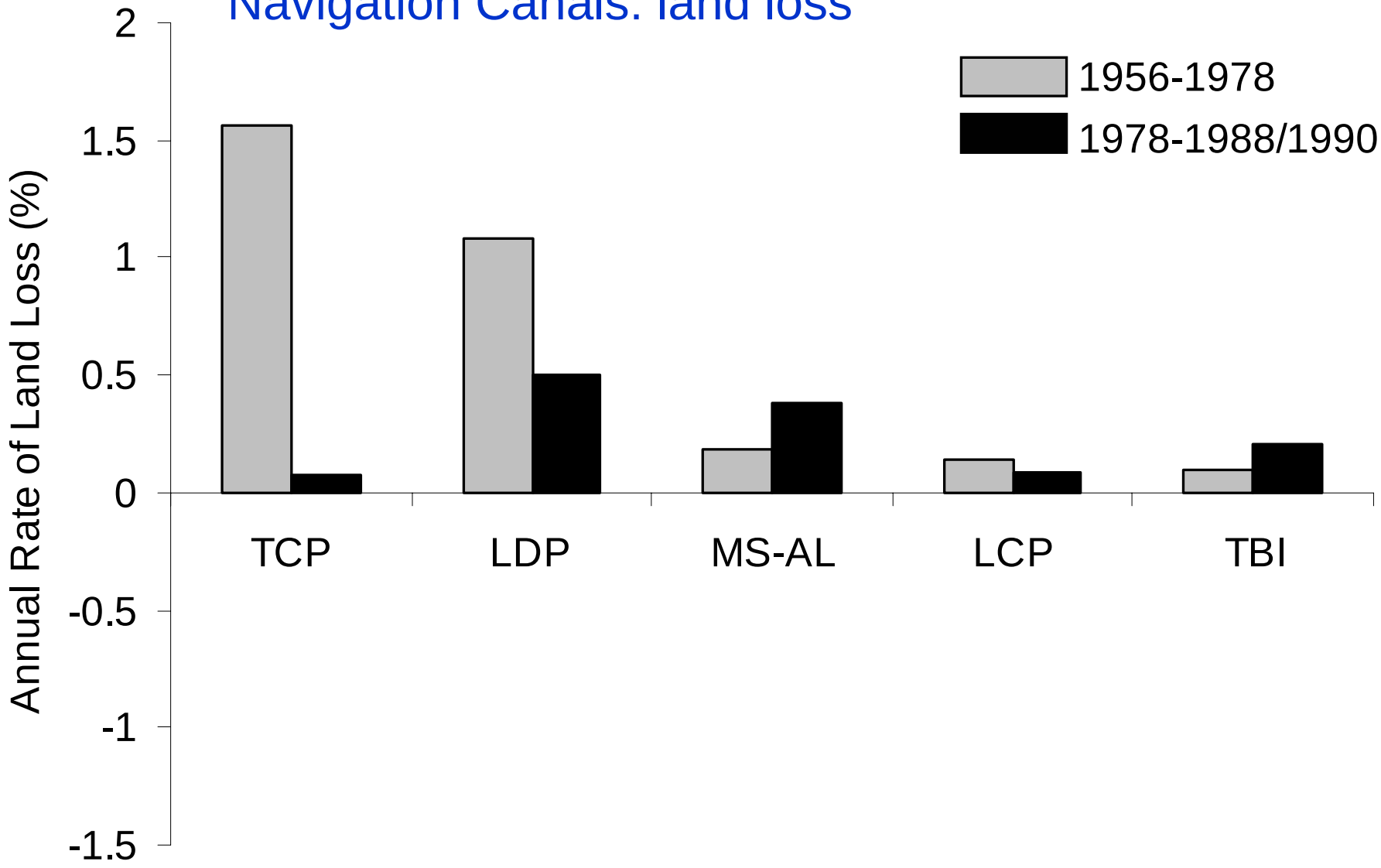
Pipelines: land loss

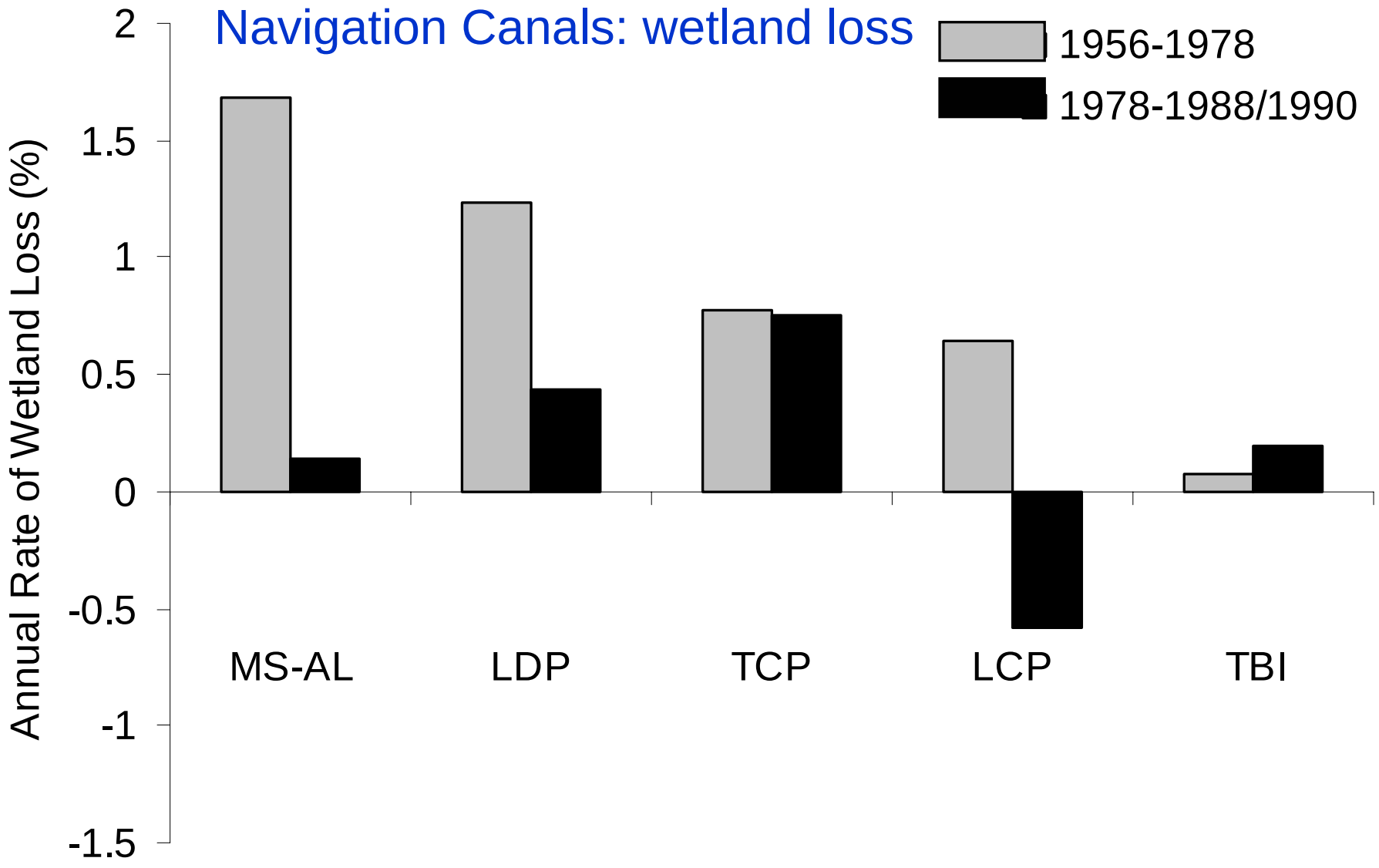


Pipelines: wetland loss

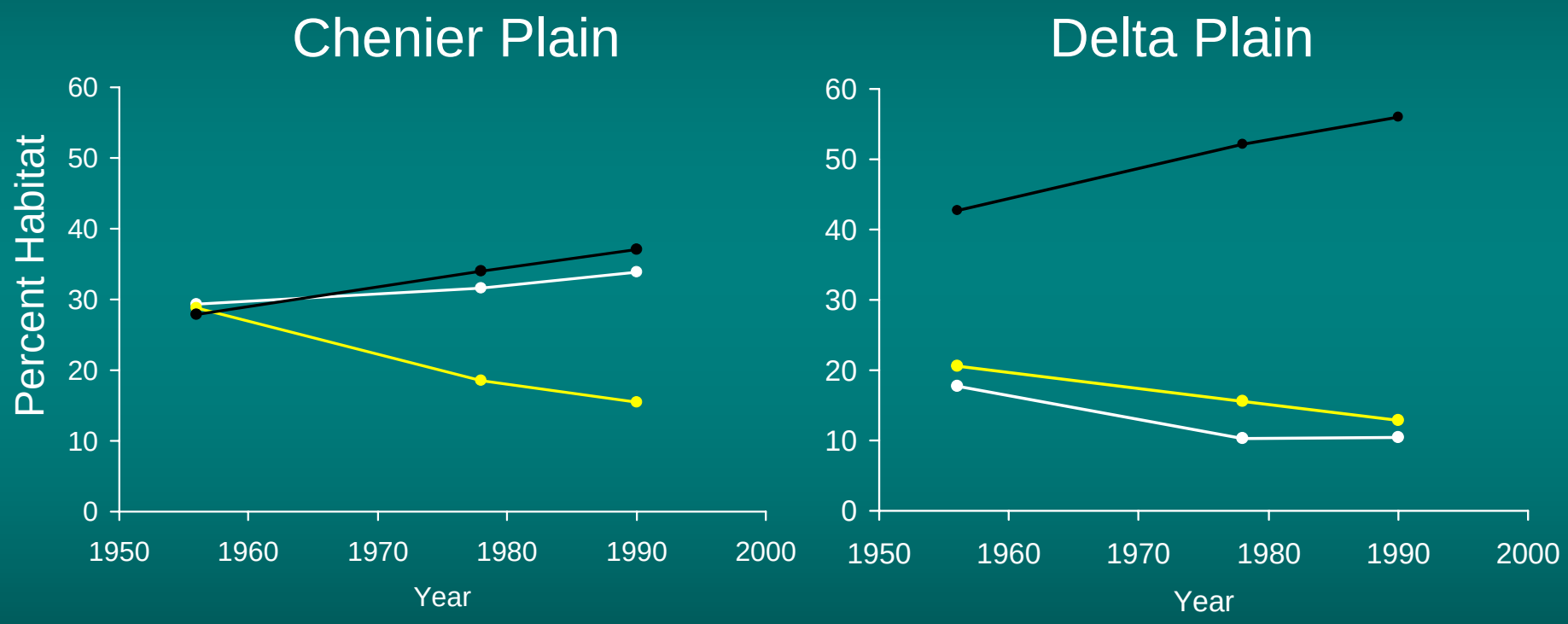


Navigation Canals: land loss



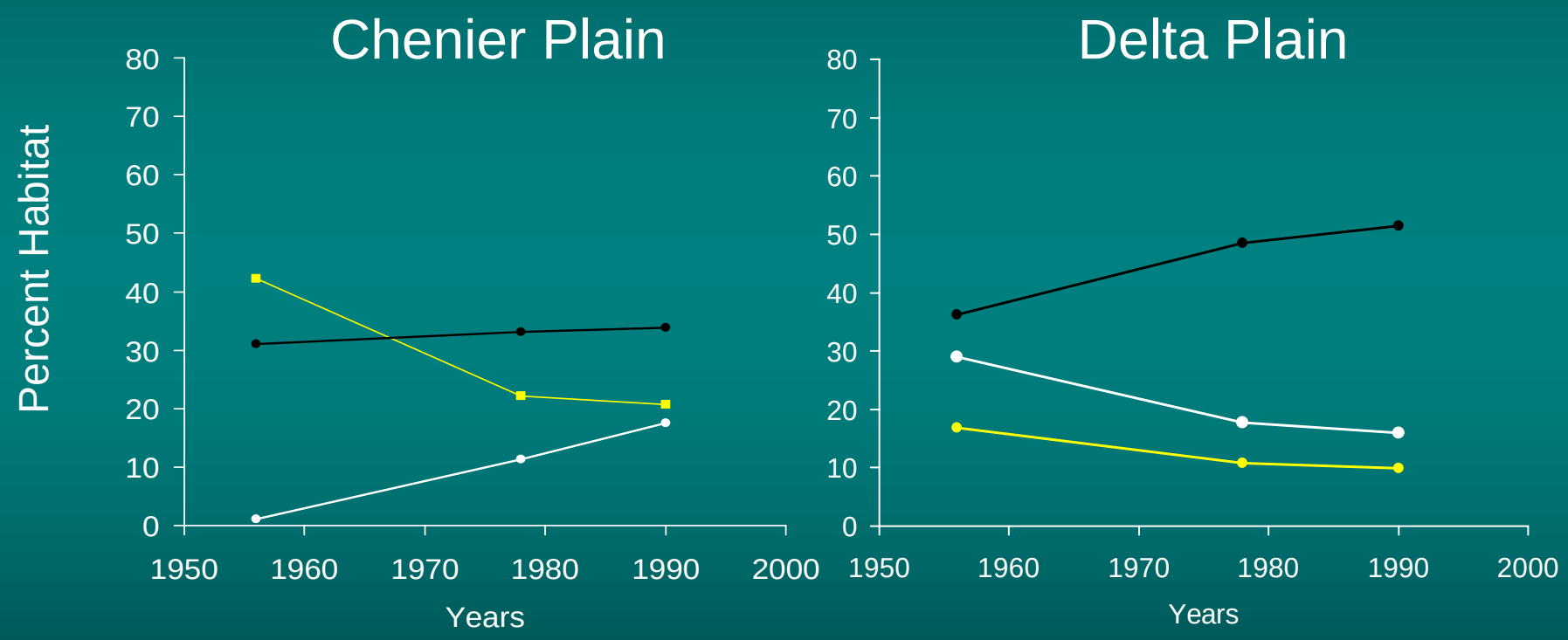

Navigation Canals: wetland loss
1956-1978
1978-1988/1990
Annual Rate of Wetland Loss (%)
2
1.5
1
0.5
0
-0.5
-1
-1.5
MS-AL
LDP
TCP
LCP
TBI

Trends of Habitat Change within 300 m (150 m either side) of Entire Population of Pipelines in Louisiana



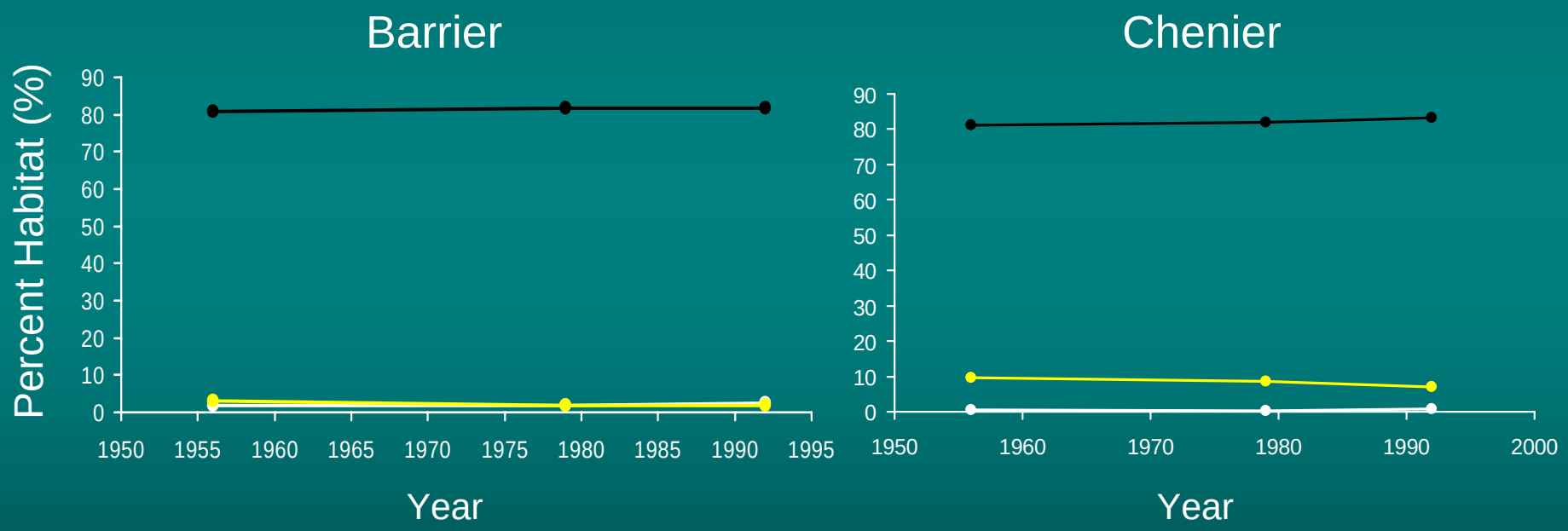
Fresh Marsh Non-Fresh Marsh Water

Trends of Habitat Change within 1000 m (500 m either side) of Entire Population of Navigation Canals in Louisiana



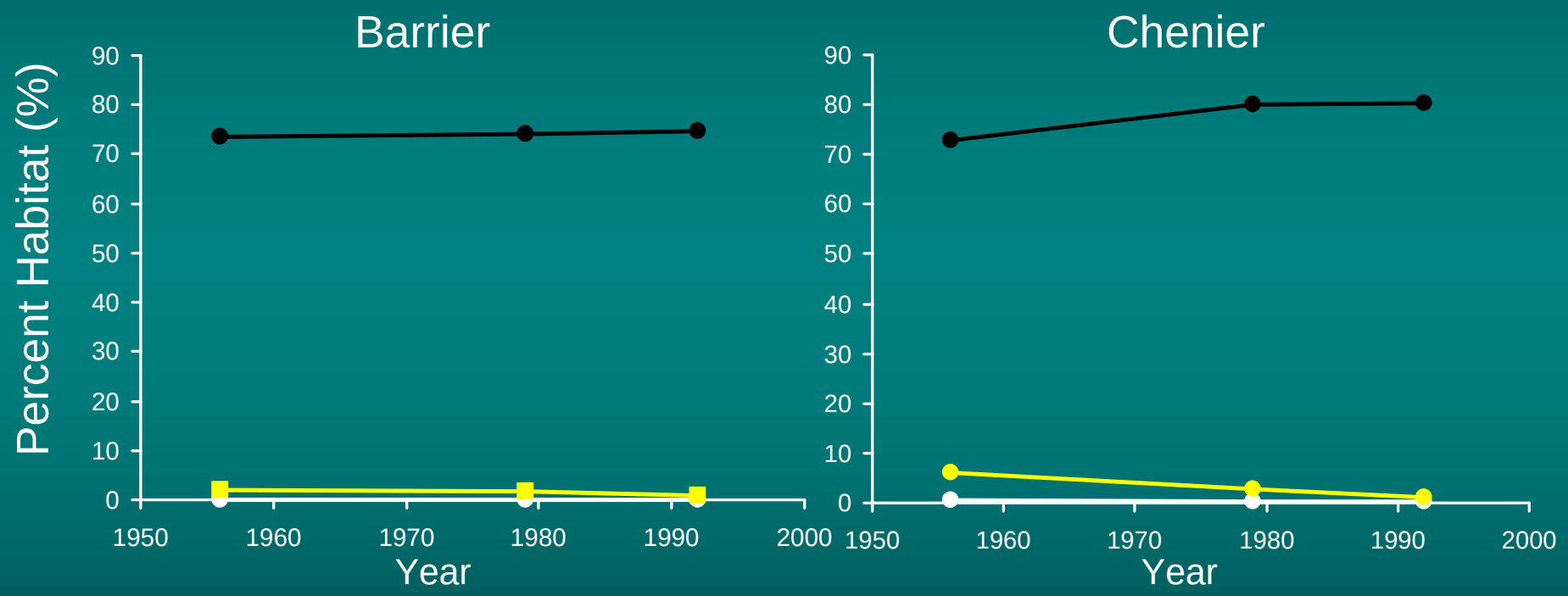
Fresh Marsh Non-Fresh Marsh Water

Trends of Habitat Change within 300 m (150 m either side) of Entire Population of Pipelines in Texas



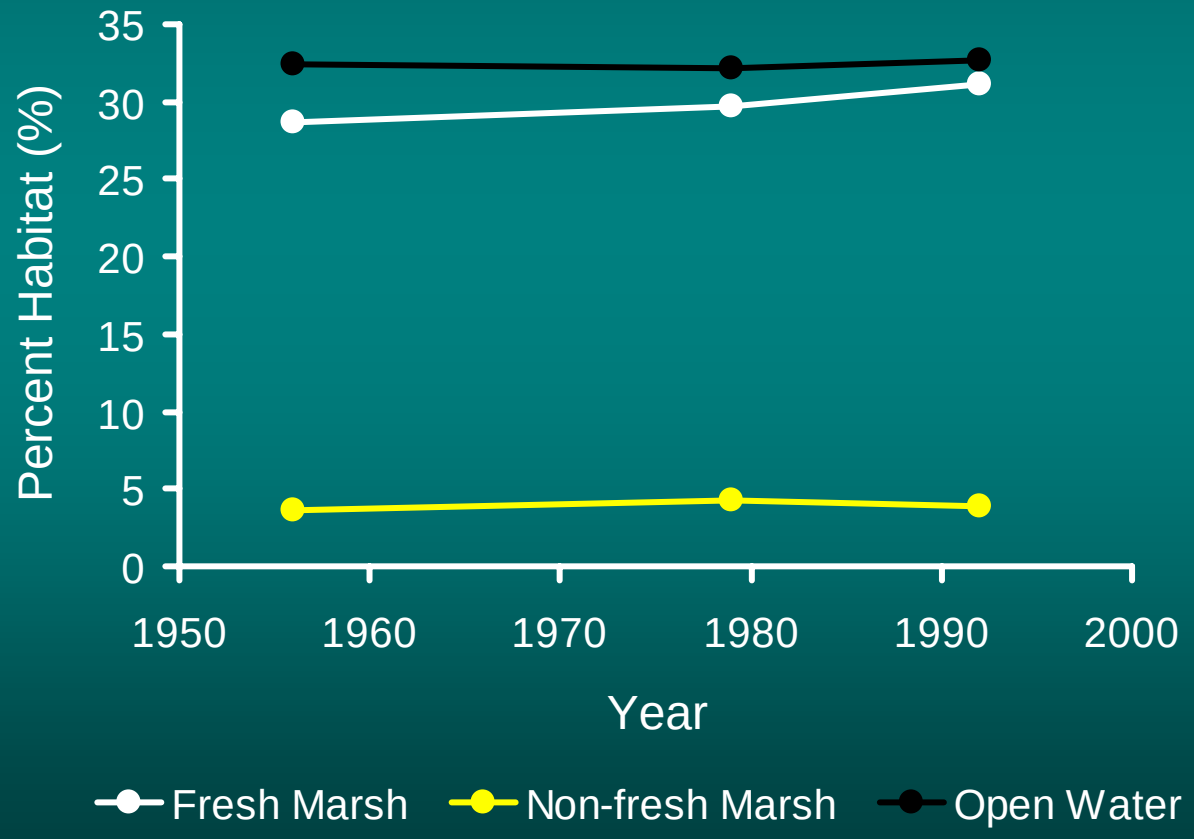
Fresh Marsh Non-Fresh Marsh Water

Trends of Habitat Change within 1000 m (500 m either side) of Entire Population of Navigation Canals in Texas

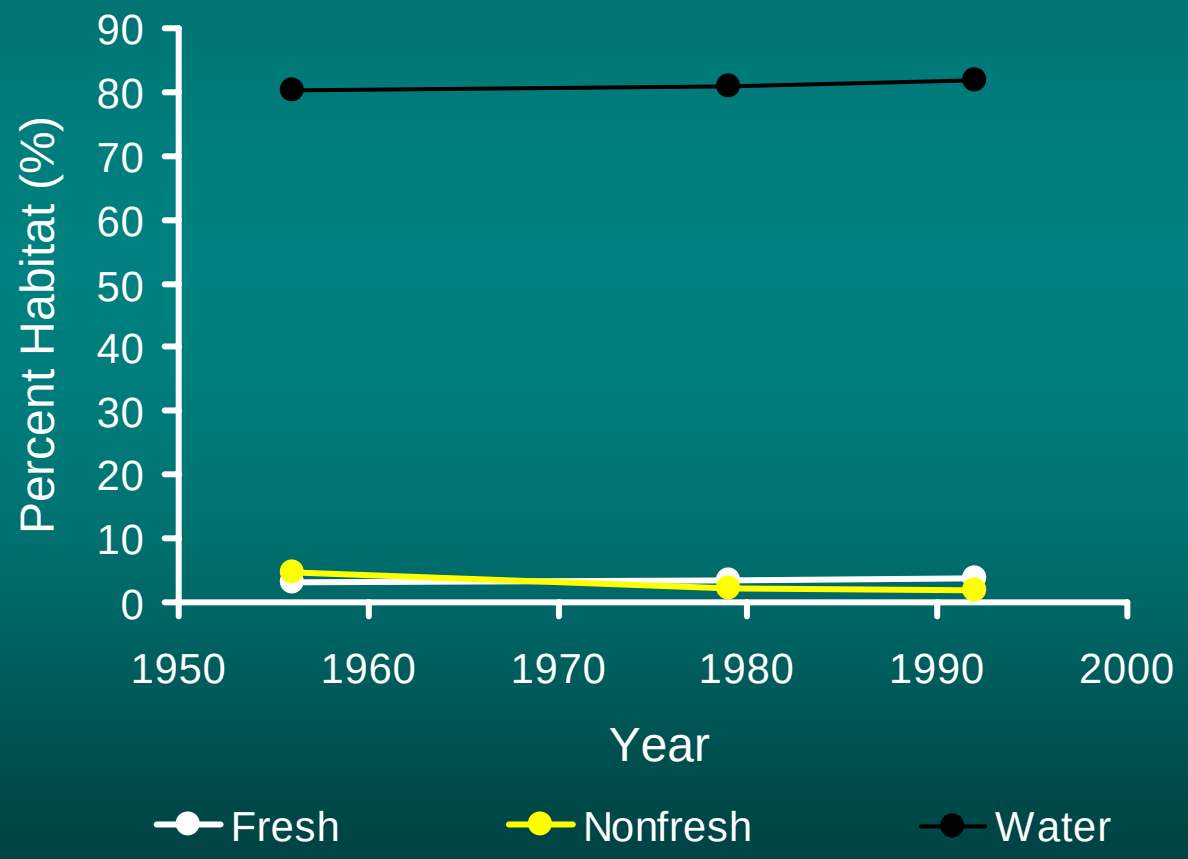


Fresh Marsh Non-Fresh Marsh Water

Trends of Habitat Change within 300 m (150 m either side) of Entire Pipeline Population in Mississippi and Alabama



Trends of Habitat Change within 1000 m (500 m either side) of Entire Population of Navigation Canals in Mississippi and Alabama



Question 2 Response

- Strong temporal and spatial trends in land loss, wetland loss, and habitat change existed within the immediate vicinity of OCS pipelines and navigation canals from the 1950s to the 1990s across the five subareas.

  Pipelines: LA > TX > MS/AL

Scales of Analyses

Intensive Impact Analysis: A spatially intensive, quantitative evaluation of GIS-derived land loss, wetland loss, and habitat change data within the immediate vicinity of *a select sample* of OCS pipelines and navigation canals compared to reference sites located up to 1.5 km away, and includes pre- and post-construction comparisons

Question 3

What is the impact of OCS pipelines and navigation canals on wetland habitats within their immediate vicinity?

Habitat Change (Sample Analysis)

- Spatial Comparison: sample vs. reference [REFERENCE]
- Temporal Comparison:
  time-dependent processes [YEAR]
  before/after construction [PHASE]

Population Sample

1. Selected 24 pipelines distributed across all five subareas where construction and mitigation data available:

Construction	Mitigation	Date
Push-pull (12)	backfill (14)	pre-56 (0)
Flotation canal (5)	bulkhead/dam (6)	pre-79 (13)
Directional drill (5)	double ditch (2)	post-79 (11)

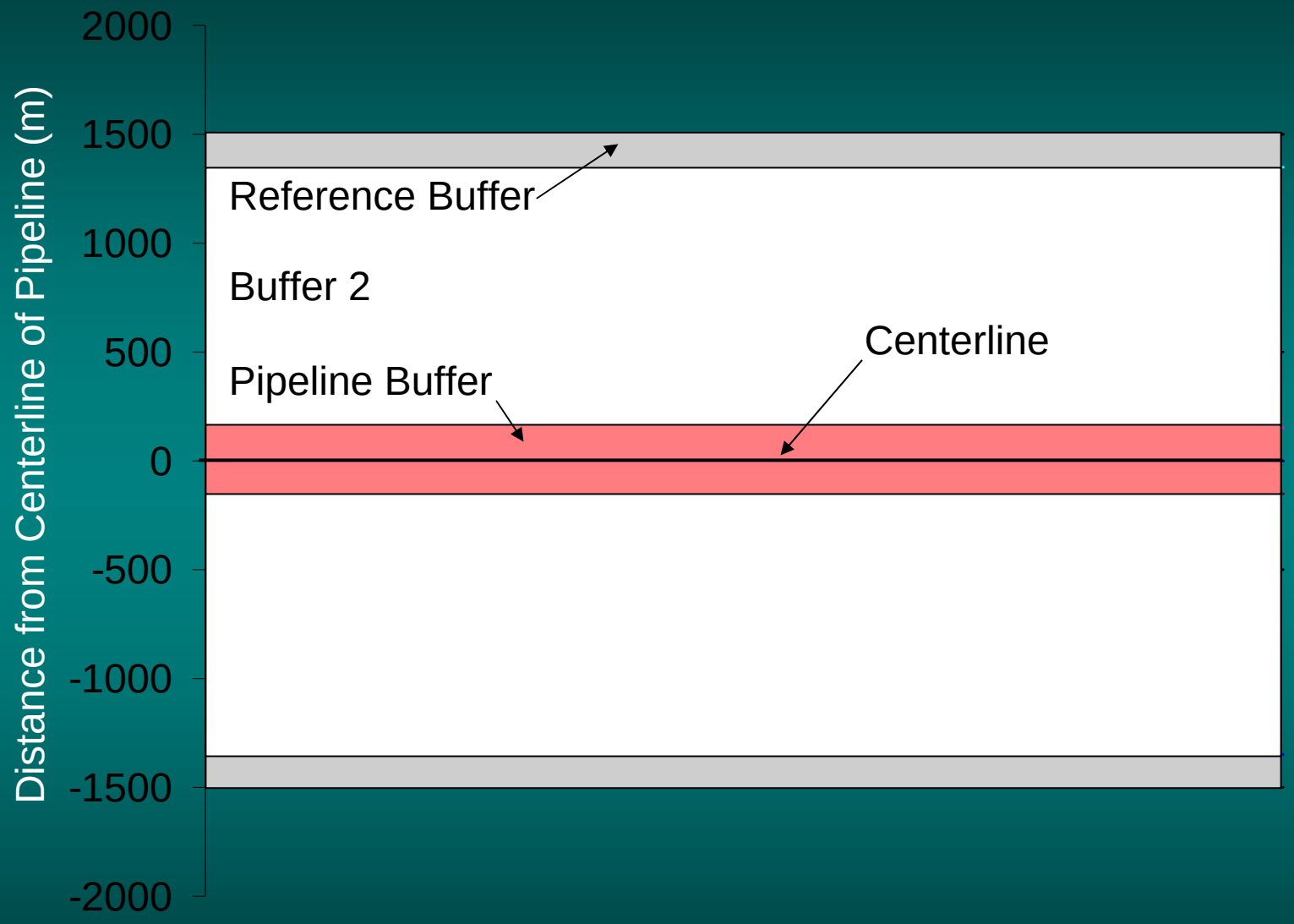
2. Selected a total of 11 navigation canals across all five subareas.

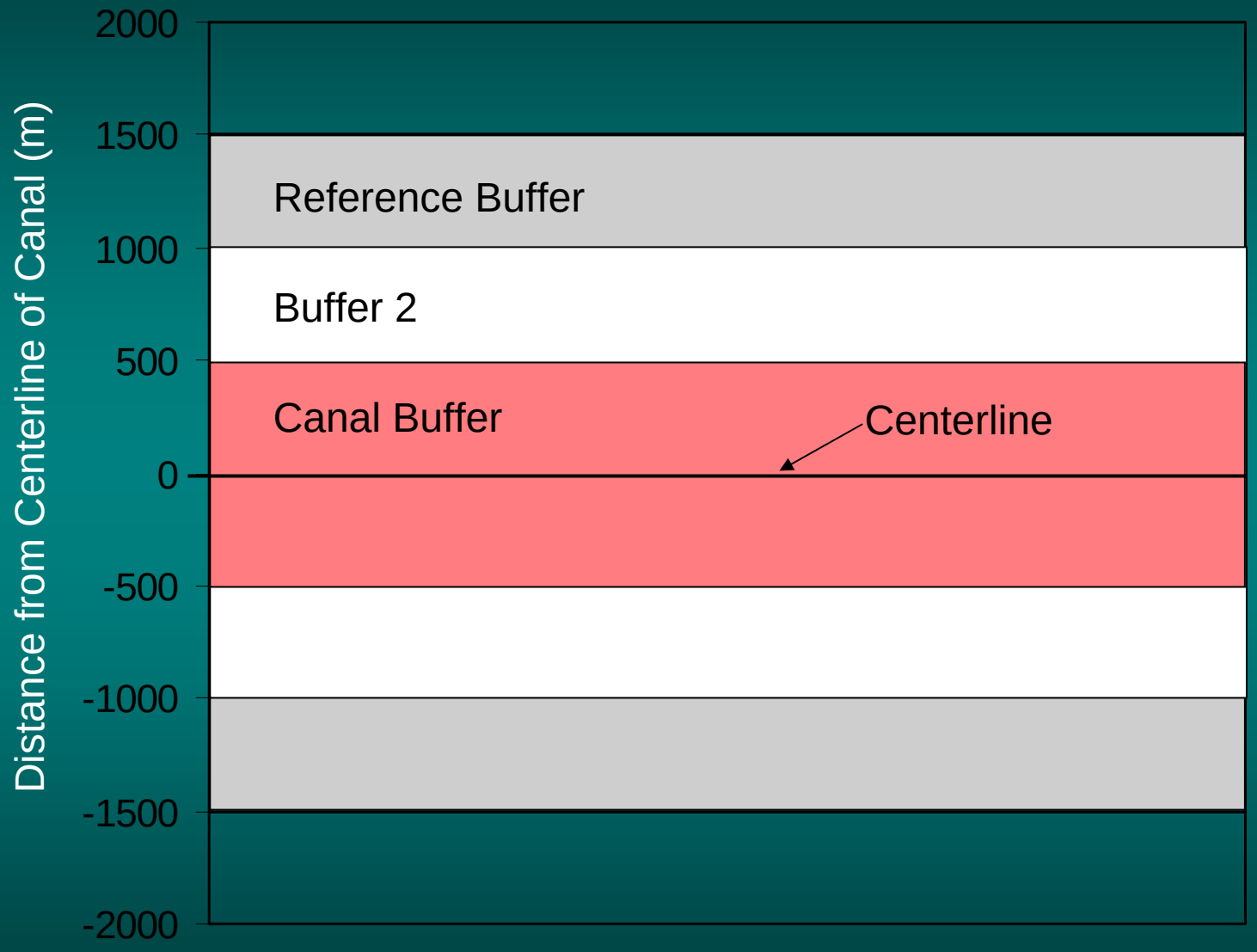
3. Compared habitat changes in 300 m buffer, 300 m control zone and within 3 km buffer zone for these selected lines and canals.

Selection Criteria

- Pipelines: restricted, random design – chosen randomly from a list of all pipelines screened to represent the most common characteristics (e.g., age, construction type, mitigation)

- Navigation Canals: canals along the borders of subareas excluded, if possible


Distance from Centerline of Pipeline (m)
2000
1500
1000
500
0
-500
-1000
-1500
-2000
Reference Buffer
Buffer 2
Centerline
Pipeline Buffer


Distance from Centerline of Canal (m)
2000
1500
1000
500
0
-500
-1000
-1500
-2000
Reference Buffer
Buffer 2
Canal Buffer
Centerline

Analysis of Distance and Time Effects on Habitat Type

Distance:

-Three non-overlapping distance buffers
- Habitat type expressed as % of total buffer area (GIS)

Time & Pre- Post-Construction:

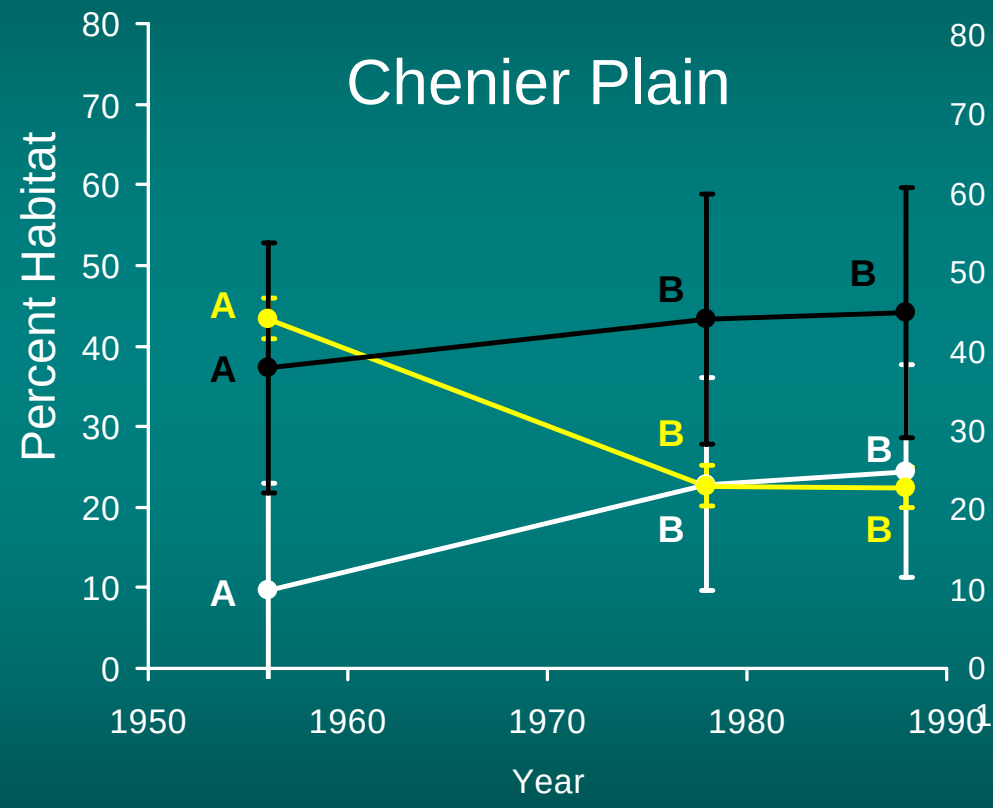
Pre - Pipeline Construction and Post – Pipeline Construction

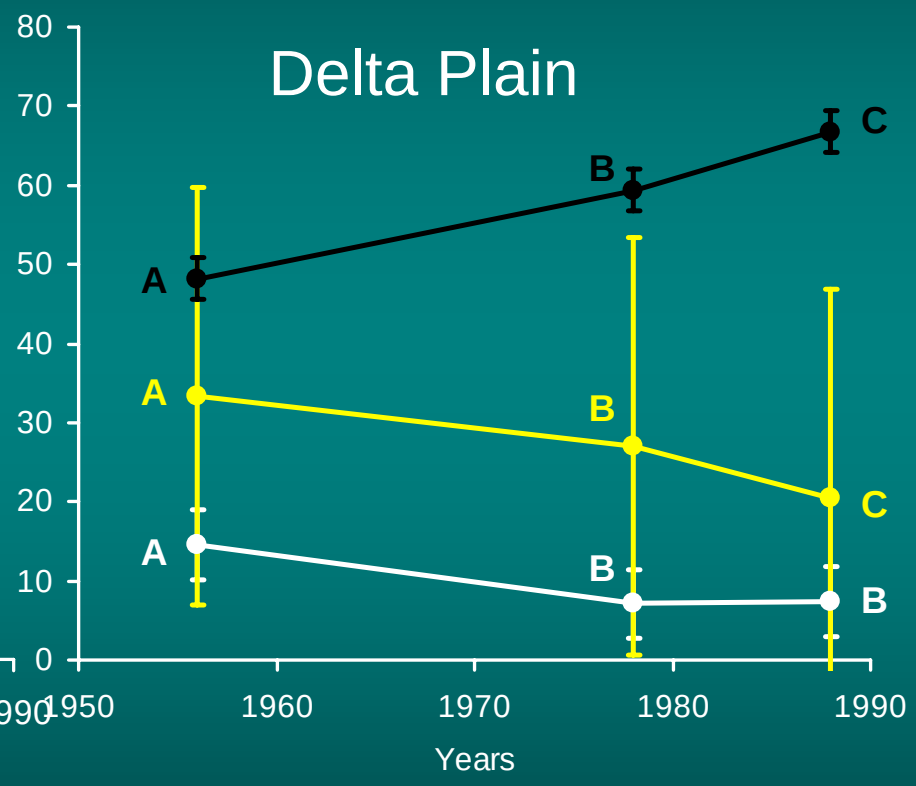
- Split plot, repeated measures design:
- Distance as split plot
- Time or construction phase as main plot (modeled as repeated measures)
- Arcsine square root – transformed % data

Habitat Change (Sample Analysis)

- Spatial Comparison: no distance effect
- Temporal Comparison: significant
  time [YEAR]
  before/after construction [PHASE]

Trends of Habitat Change Within 3 km of Selected Pipelines in Louisiana



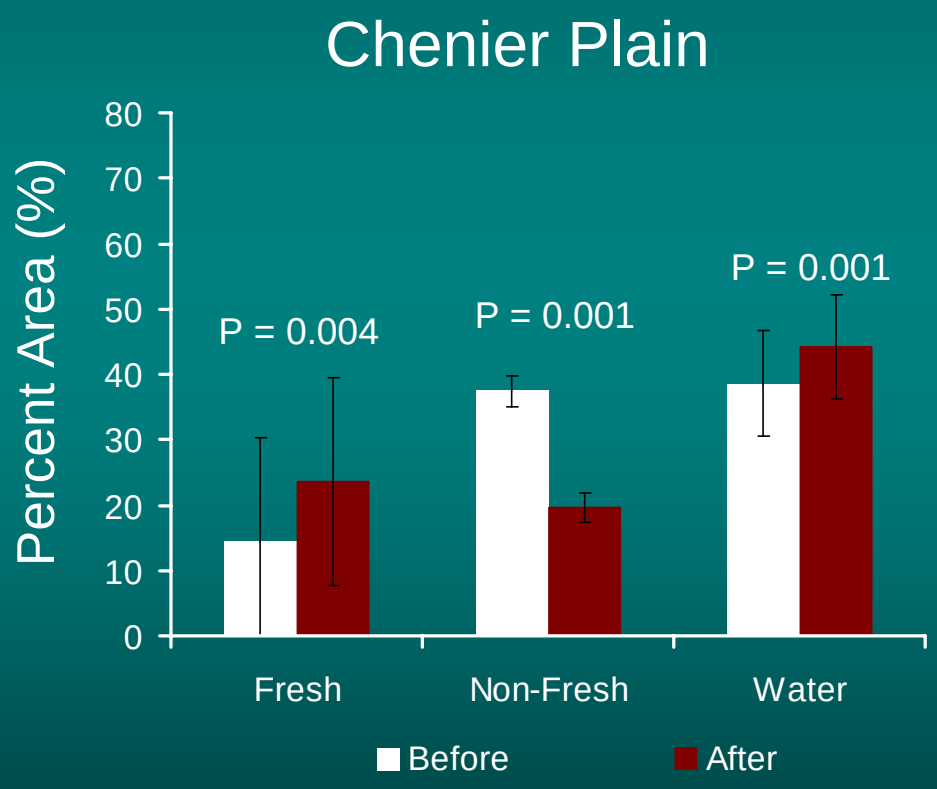


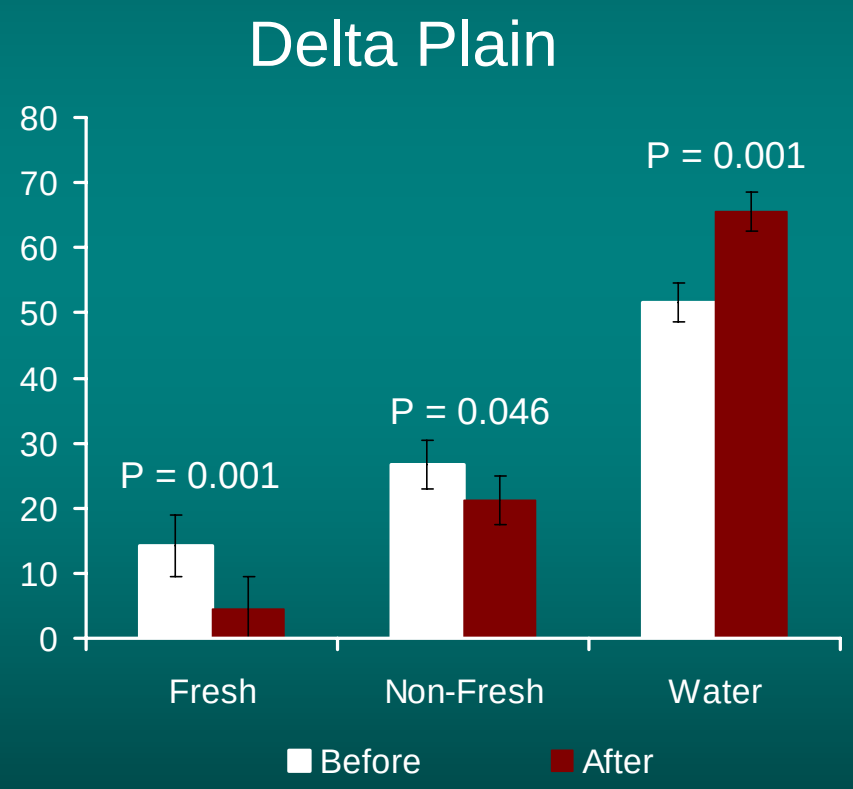
Significance of Time Trend:

Fresh: P = 0.0001
Non-Fresh: P = 0.0001
Water: P = 0.0001

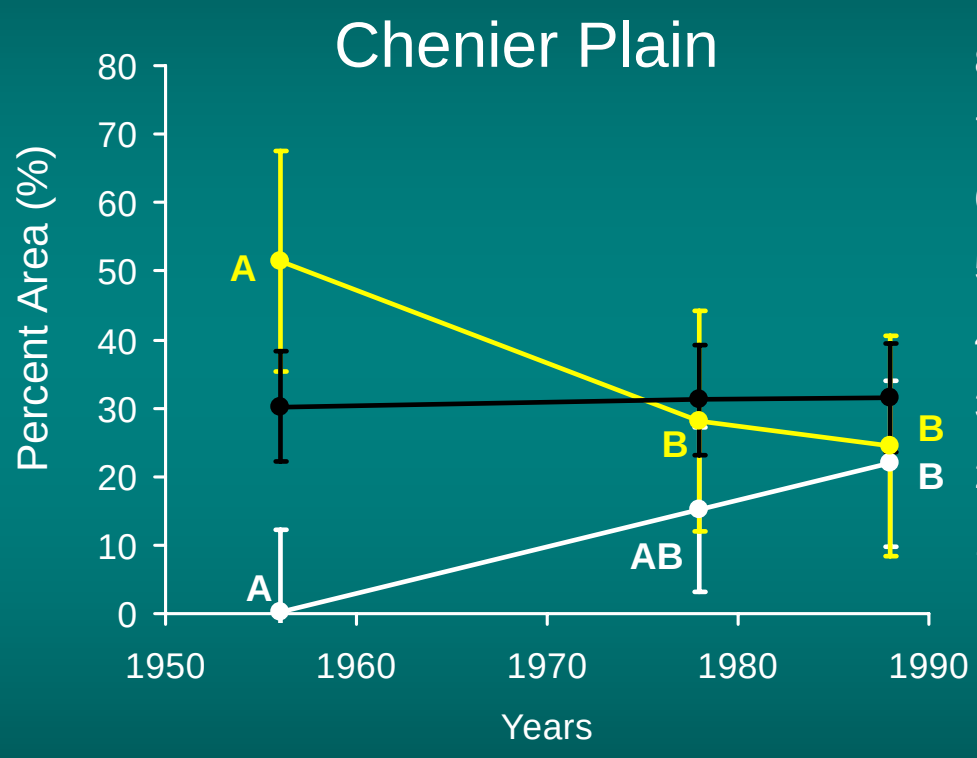
Fresh: P = 0.0007
Non-Fresh: P = 0.0001
Water: P = 0.0001

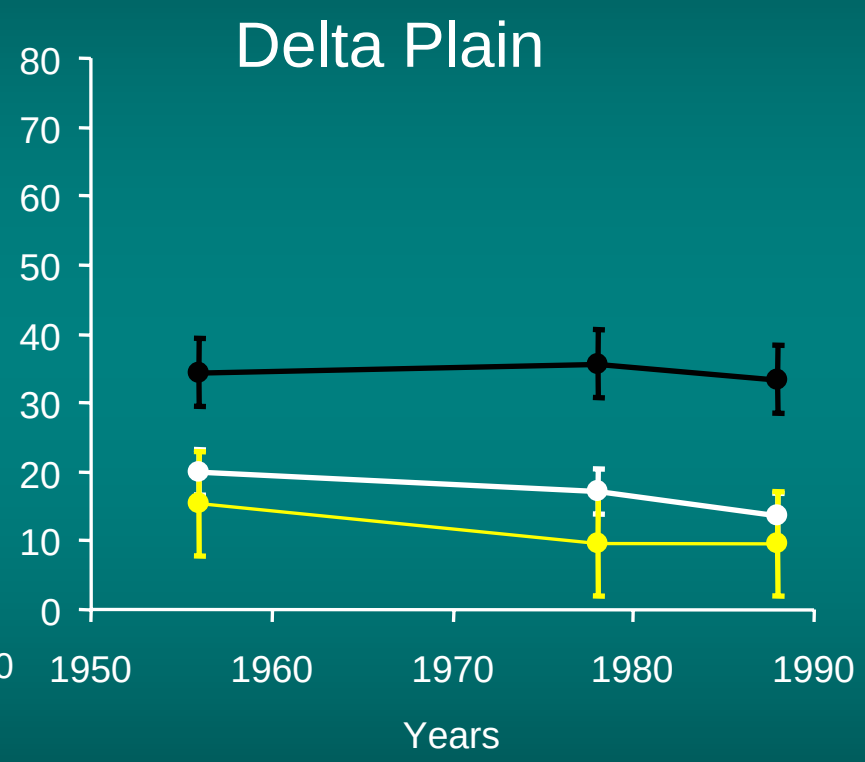
Comparison of Habitat Area Before and After Pipeline Construction for Selected Pipelines in Louisiana





Trends of Habitat Change Within 3 km of Selected Navigation Canals in Louisiana



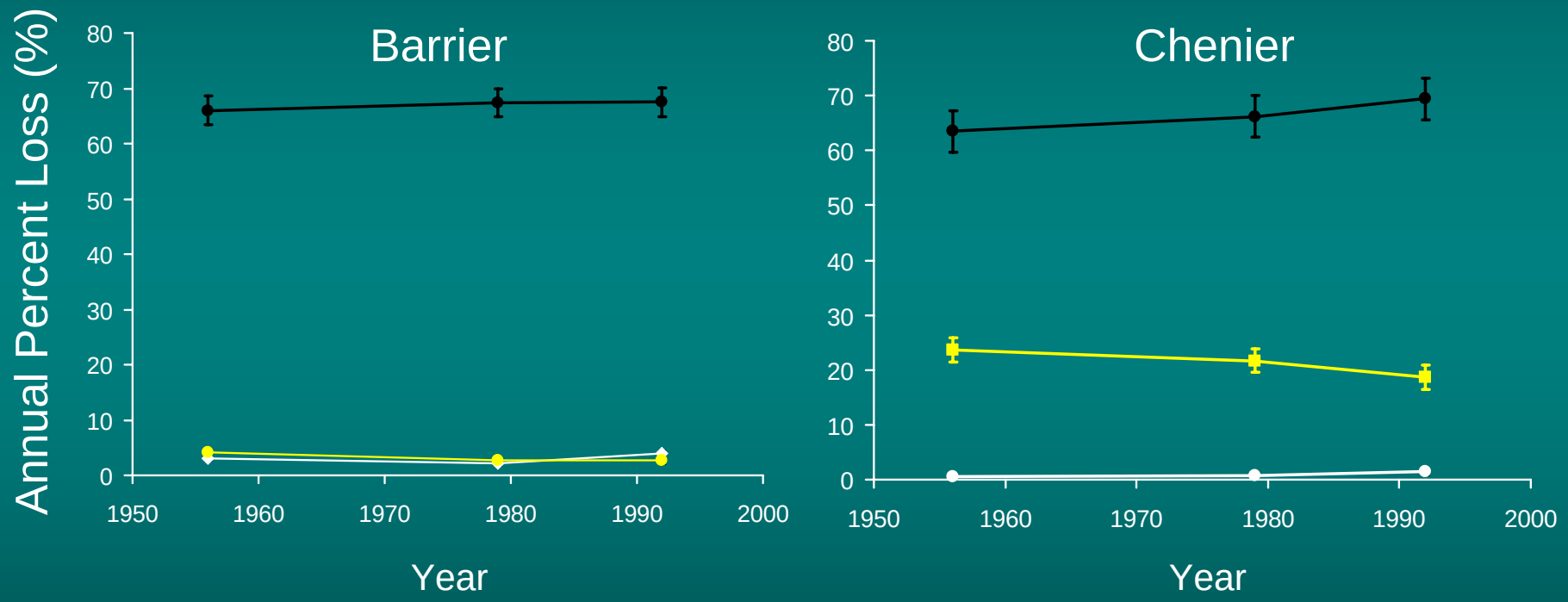


Significance of Time Trend:

Fresh: P = 0.08
Non-Fresh: P = 0.04
Water: P = 0.86

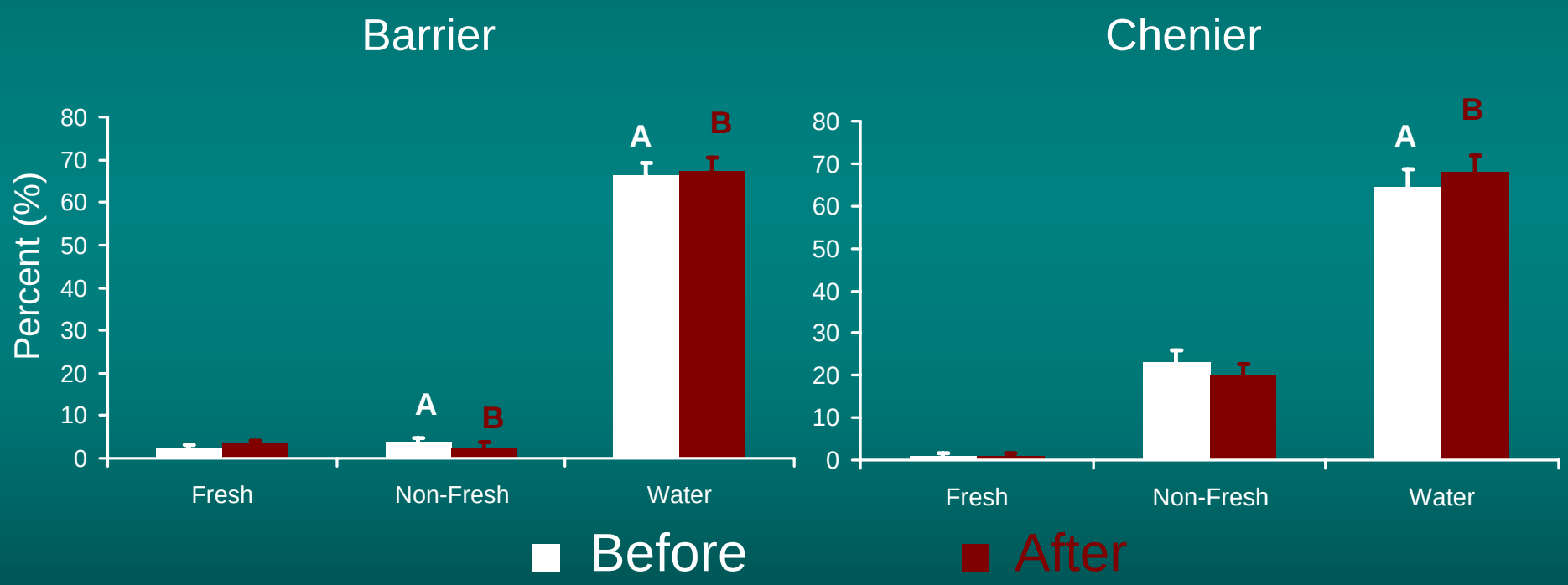
Fresh: P = 0.19
Non-Fresh: P = 0.16
Water: P = 0.95

Trends of Habitat Change Within 3 km of Selected Pipelines in Texas



Fresh Marsh Non-Fresh Marsh Water

Comparison of Habitat Area Before and After Pipeline Construction for Selected Pipelines in Texas

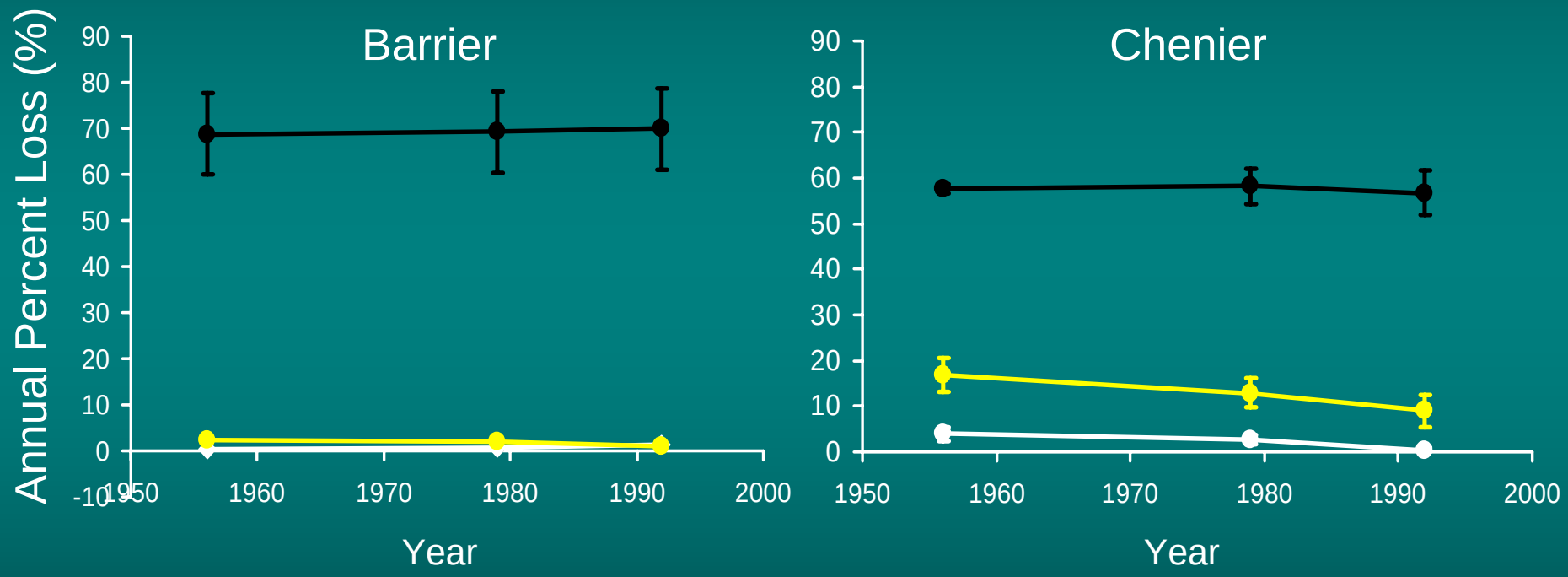


Significance of Phase Trend:

Fresh: P = 0.12
Non-Fresh: P = 0.003
Water: P = 0.002

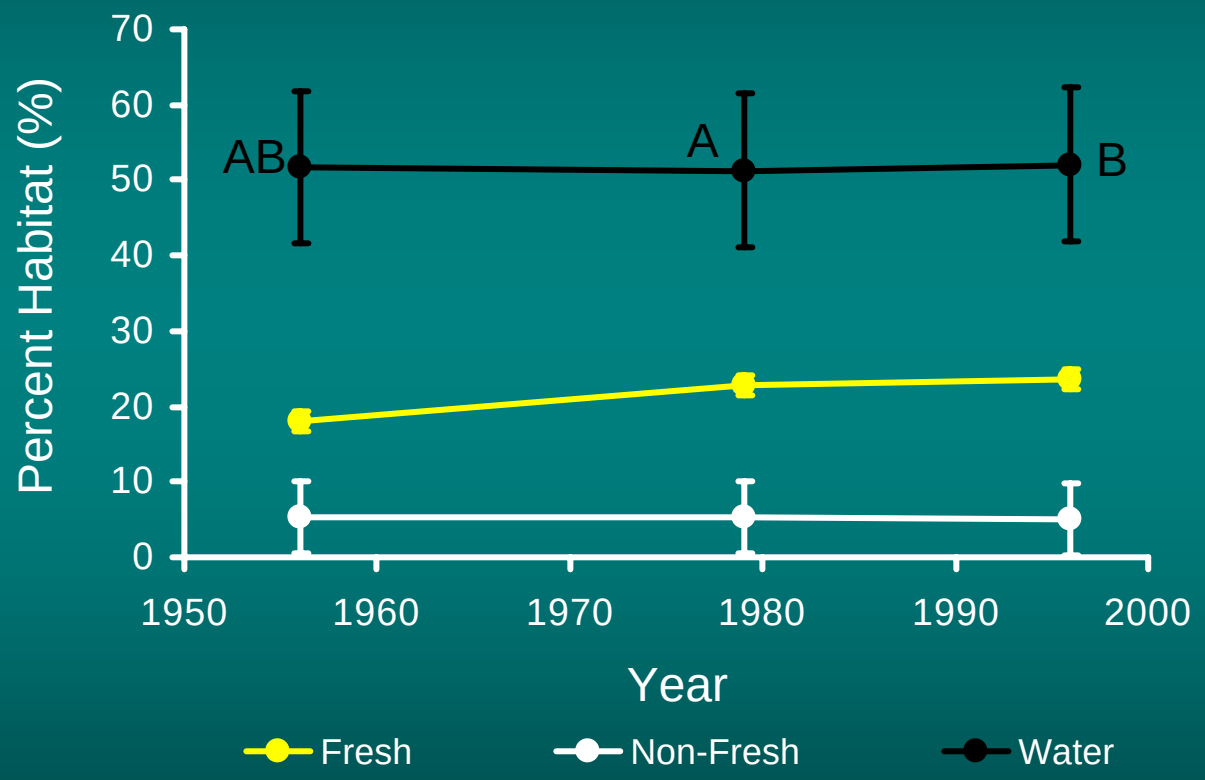
Fresh: P = 0.854
Non-Fresh: P = 0.12
Water: P = 0.04

Trends of Habitat Change Within 3 km of Selected Navigation Canals in Texas



Fresh Marsh Non-Fresh Marsh Water

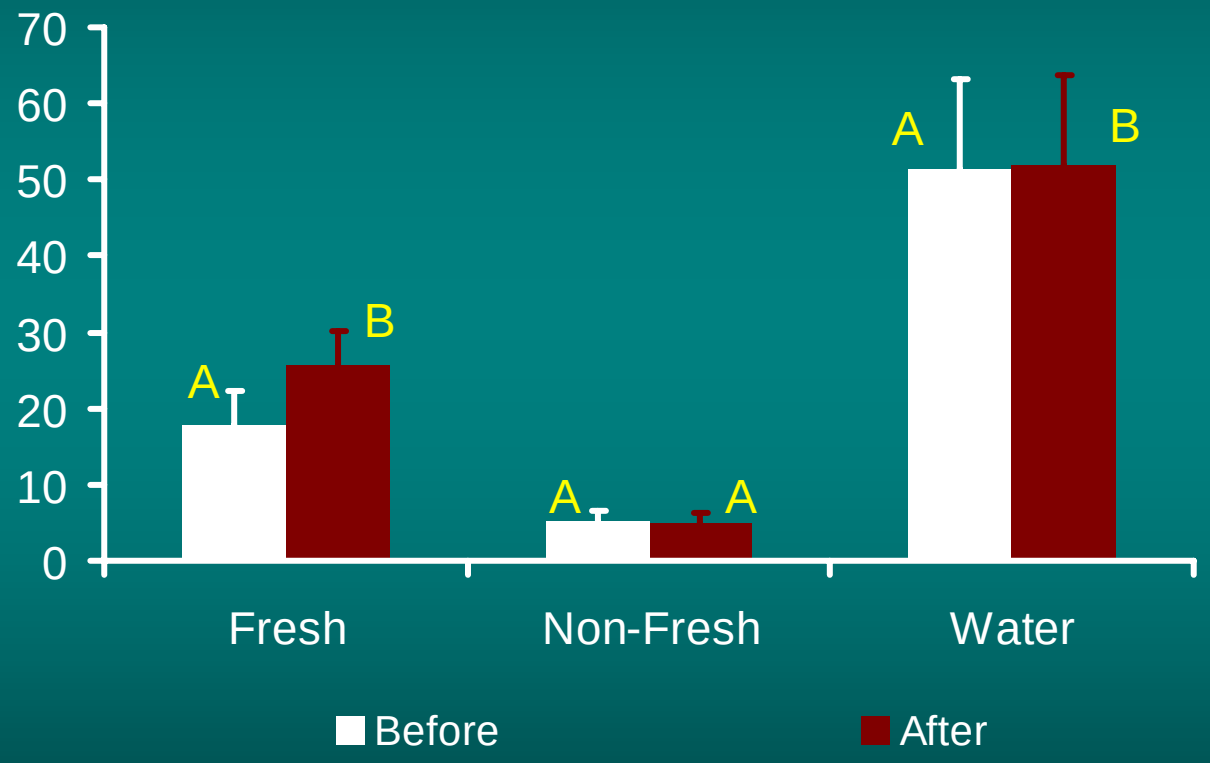
Trends of Habitat Change Within 3 km of Selected Pipelines in Mississippi and Alabama



Significance of Time Trend:

Fresh: P = 0.25
Non-Fresh: P = 0.42
Water: P = 0.004

Comparison of Habitat Area Before and After Pipeline Construction for Selected Pipelines in Mississippi and Alabama



Significance of Phase Trend:

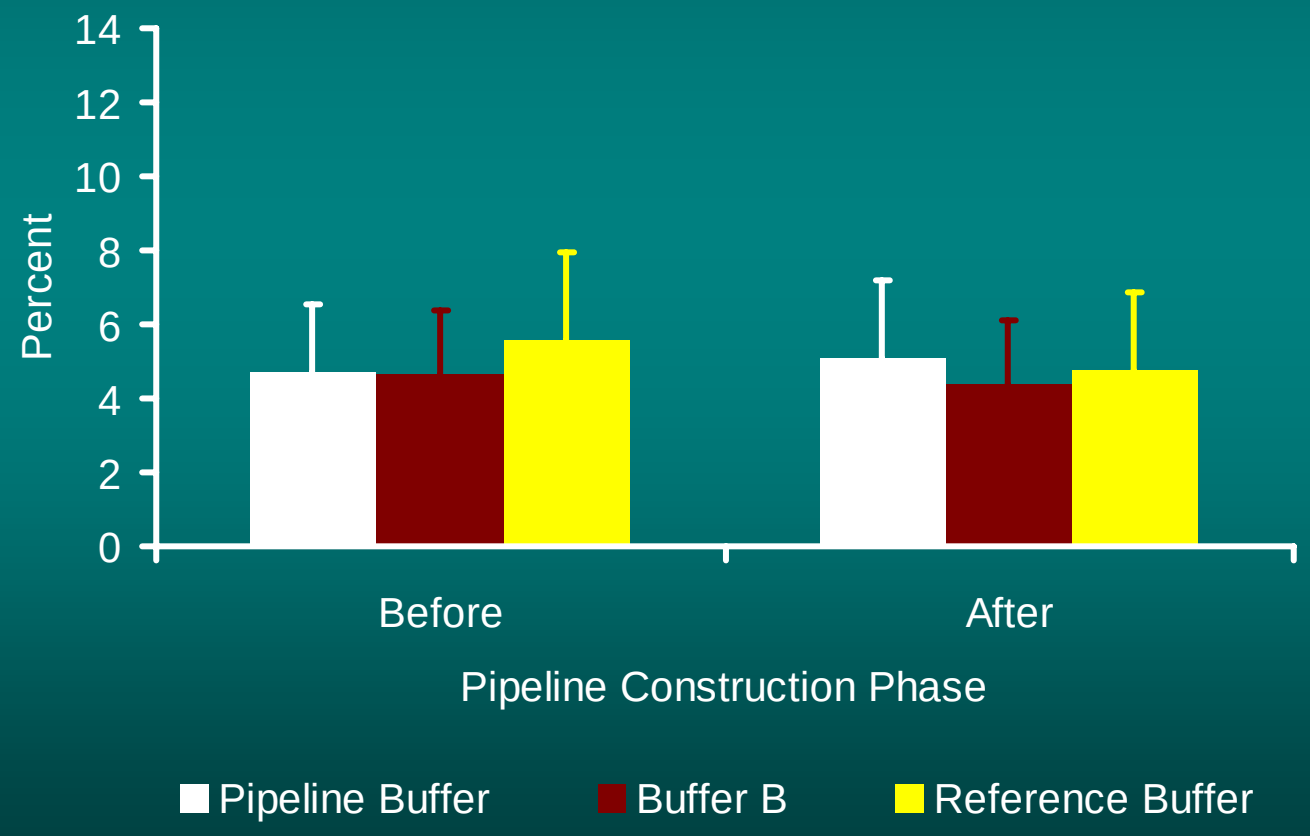
Fresh: P = 0.008

Non-Fresh: P = 0.36*

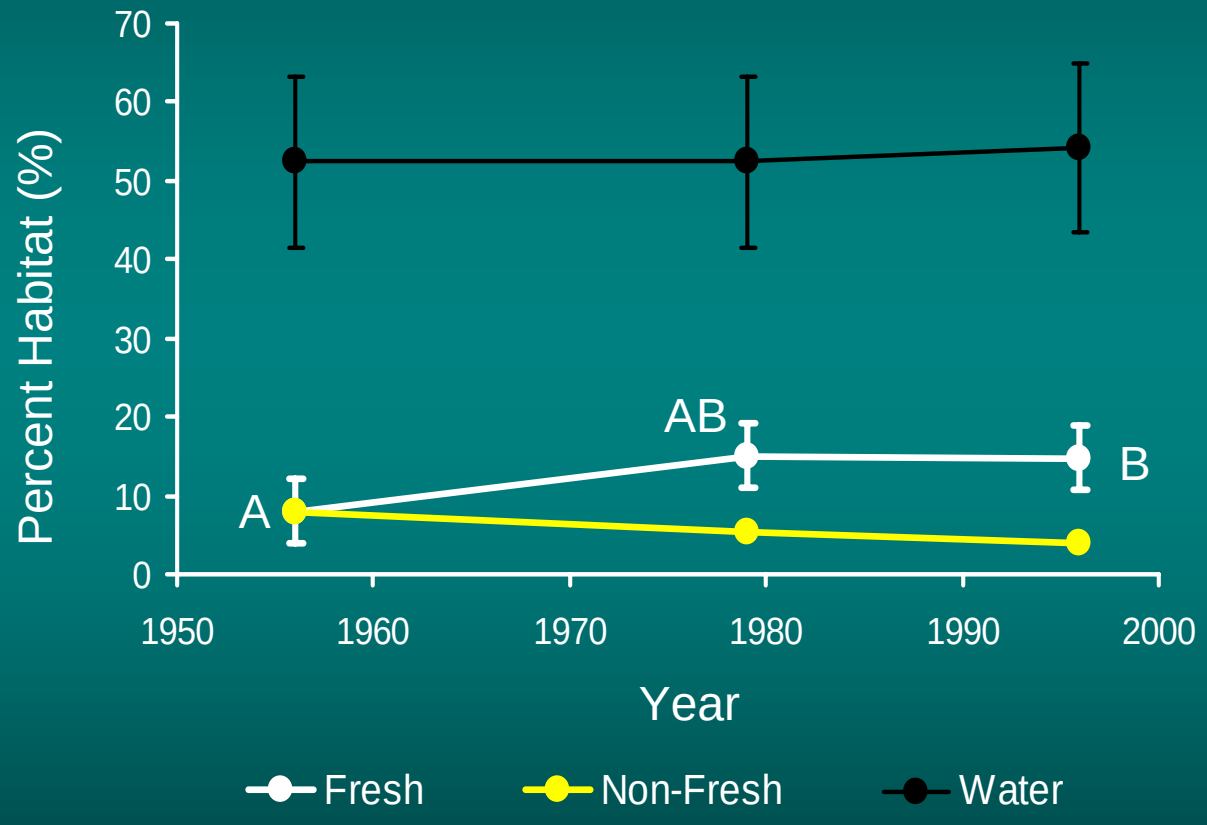
Water: P = 0.054

* Interaction term distance × phase significant at P = 0.03 (see next slide)

Percent Non-Fresh Marsh Within Experimental Buffers Surrounding Selected Pipelines in Mississippi and Alabama



Trends of Habitat Change Within 3 km of Selected Navigation Canals in Mississippi and Alabama



Significance of Time Trend:

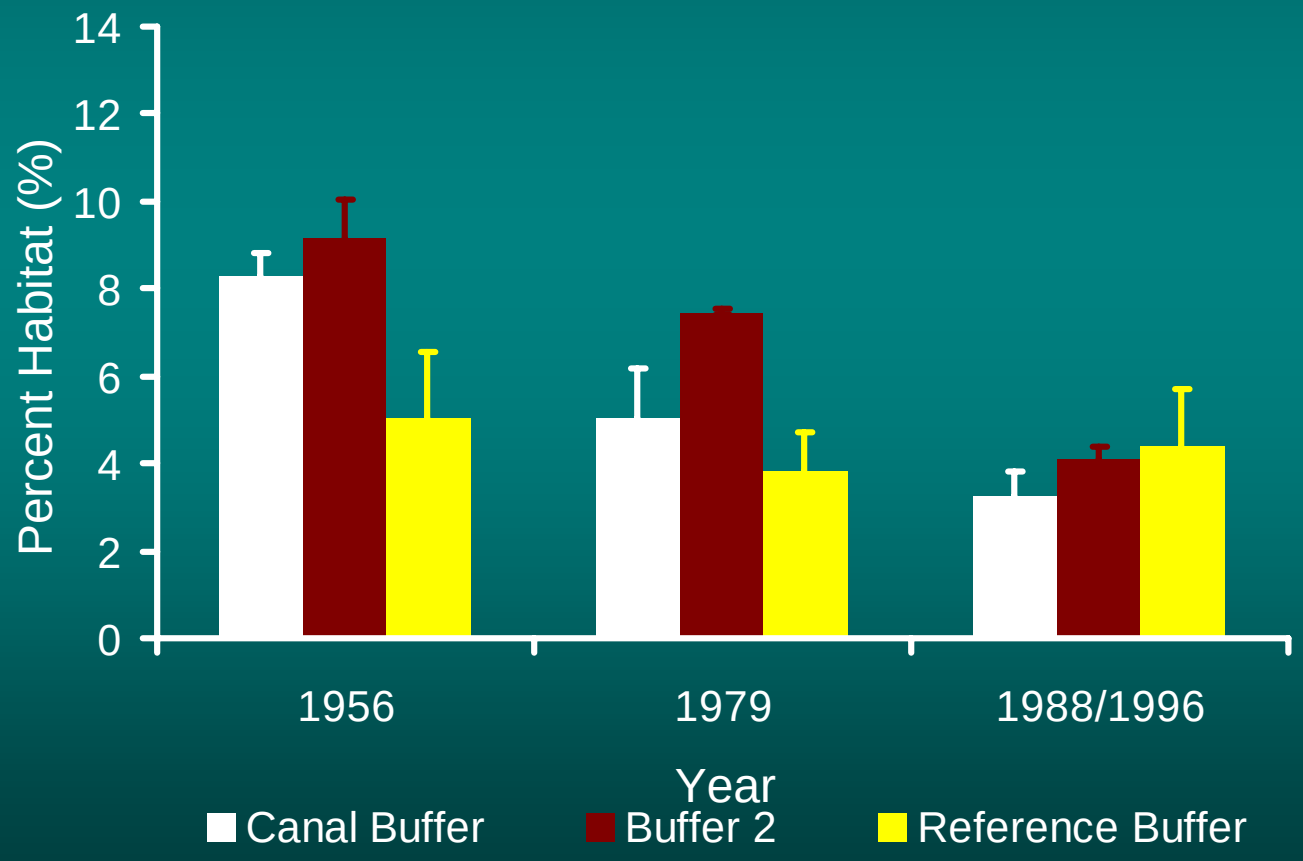
Fresh: P = 0.04

Non-Fresh: P = 0.0002*

Water: P = 0.14

* Interaction term distance × phase significant at P = 0.01 (see next slide)

Percent Non-Fresh Marsh Within Experimental Buffers Surrounding Selected Navigation Canals in Mississippi and Alabama



Question 3 Response

Table: Habitat change trends and OCS pipeline habitat impacts by subarea

Area	REFERENCE	YEAR	PHASE	Model Fit	Probability
LDP	Not significant	Open water ↑ Marsh ↓	Open water ↑ Marsh ↓	PHASE > YEAR	High
LCP	Not significant	Open water ↑ Fresh marsh ↑ Non-fresh marsh↓	Open water ↑ Fresh marsh ↑ Non-fresh ↓	PHASE > YEAR (marsh) PHASE = YEAR (open water)	High
TCP	Not significant	Open water ↑ Non-fresh marsh ↓	Open water ↑ Non-fresh marsh ↓	YEAR ≥ PHASE	Intermediate
TBI	Not significant	Open water ↑ Fresh marsh ↑ Non-fresh marsh↓	Open water ↑ Fresh marsh ↑ Non-fresh marsh↓	YEAR ≥ PHASE	Intermediate
MS/ AL	Not significant	Open water ↑	Open water ↑ Fresh marsh ↑ Non-fresh marsh↓	YEAR > PHASE	Low

Scales of Analyses

Case Studies: a qualitative (semi-quantitative) evaluation of GIS-derived land loss, wetland loss, and habitat change data within the immediate vicinity of *individual pipelines and navigation canals*, supplemented with data from monitoring reports, compared to reference sites, and including pre- and post-construction comparisons

Case Study Approach

1. Selected 24 pipelines distributed across all five subareas where construction and mitigation data available:

Construction	Mitigation	Date
Push-pull (12)	backfill (14)	pre-56 (0)
Flotation canal (5)	bulkhead/dam (6)	pre-79 (13)
Directional drill (5)	double ditch (2)	post-79 (11)

2. Selected a total of 11 navigation canals across all five subareas

3. Compared habitat changes in 300 m buffer, 300 m control zone and within 3 km buffer zone for these selected lines and canals

Pipeline Impacts – Louisiana, TBI

1. Conversion of wetland to open water
   - trenching for canals
   - flank subsidence

2. Conversion of wetland to scrub-shrub
   - creation of spoil embankments
   - overfilling of canals

Navigation Canal Impacts – All Subareas

1. Conversion of wetland to open water
   – trenching for canals
   – canal widening by erosion

2. Conversion of wetland to scrub-shrub
   – creation of spoil embankments

Sub Area	Canal	Year Built	Widening Rate (m/yr)		
			1956-1979	**1979-1992**	**1956-1992**
Texas Barrier Islands	Corpus Christi Ship Canal	1919	9	-0.5	5.6
	Brazos-Santiago Ship Canal	1960*	6.7	0.4	3.5
	Matagorda Ship Canal	1967*	21.3	-1	9.7
	* Rates are from construction date				
Texas Chenier Plain	Sabine Ship Canal	1912	1.5	0.6	1.2
			1956-1979	**1979-1990**	**1956-1990**
Louisiana Chenier Plain	Calcasieu Ship Canal	1949	2.3	5.4	3.1
	Freshwater Bayou Ship Canal	1979		4.1	
Louisiana Delta	Wax Lake	1940s	0.2	-1.7	-0.4
	Houma Navigation Canal	1962		9	
			1956-1979	**1979-1988/96**	**1956-1988/96**
Mississippi / Alabama	Theodore Canal	1960s		2.8-5.2	
	Bayou Cassote of Pascagoula	1955	5.9	0	3.3-14.4

Navigation Canal Impacts – All Subareas

3. Conversion of open water to wetland
   – by deposition of dredged material in open water

4. Conversion of fresh to non-fresh marsh
   – saltwater intrusion

Question 4

Are the dominant mitigation and construction techniques used for OCS pipelines and navigation canals effective in minimizing the influence of OCS pipelines and navigation canals on land loss, wetland loss, and habitat change?

OCS Pipeline Impacts – All Subareas

The magnitude of impacts is inversely proportional to the quantity and quality of mitigation techniques applied. OCS pipelines constructed using extensive mitigation measures appear to have had minimal impact on the landscape.

OCS Pipeline Impacts – All Subareas

Of the pipelines examined, we could attribute significant habitat changes only to those that were not backfilled, and/or had spoil banks that remained after construction (i.e., Sonat 36”, Tennesse Gas 26”, Tennesse Gas 20”, United 12”, Transco 36”)

OCS Pipeline Impacts – All Subareas

In sensitive habitats, OCS pipelines appear to have been constructed in such ways as to effectively minimize damage by using multiple mitigation techniques.

Pipeline Impacts – Across GOM

Although some pipelines had little impact, as pipeline construction, both OCS and non-OCS, is widely distributed across the Gulf coast, leaving few areas unaffected by pipeline construction, it is difficult to say with certainty that pipelines do not result in significant habitat change. Given the large number of pipelines built, it is possible that some of the regional patterns of habitat change may be partly a result of cumulative impacts of pipelines.

Navigation Canal Impacts

All navigation canals had significant habitat impacts on the landscape beyond the direct impact of canal construction as a result of canal widening and salt water intrusion. Canal widening rates diminished over time, suggesting that bank stabilization efforts are helpful. What cannot be addressed currently by mitigation efforts is the impact of saltwater intrusion into previously freshwater areas.

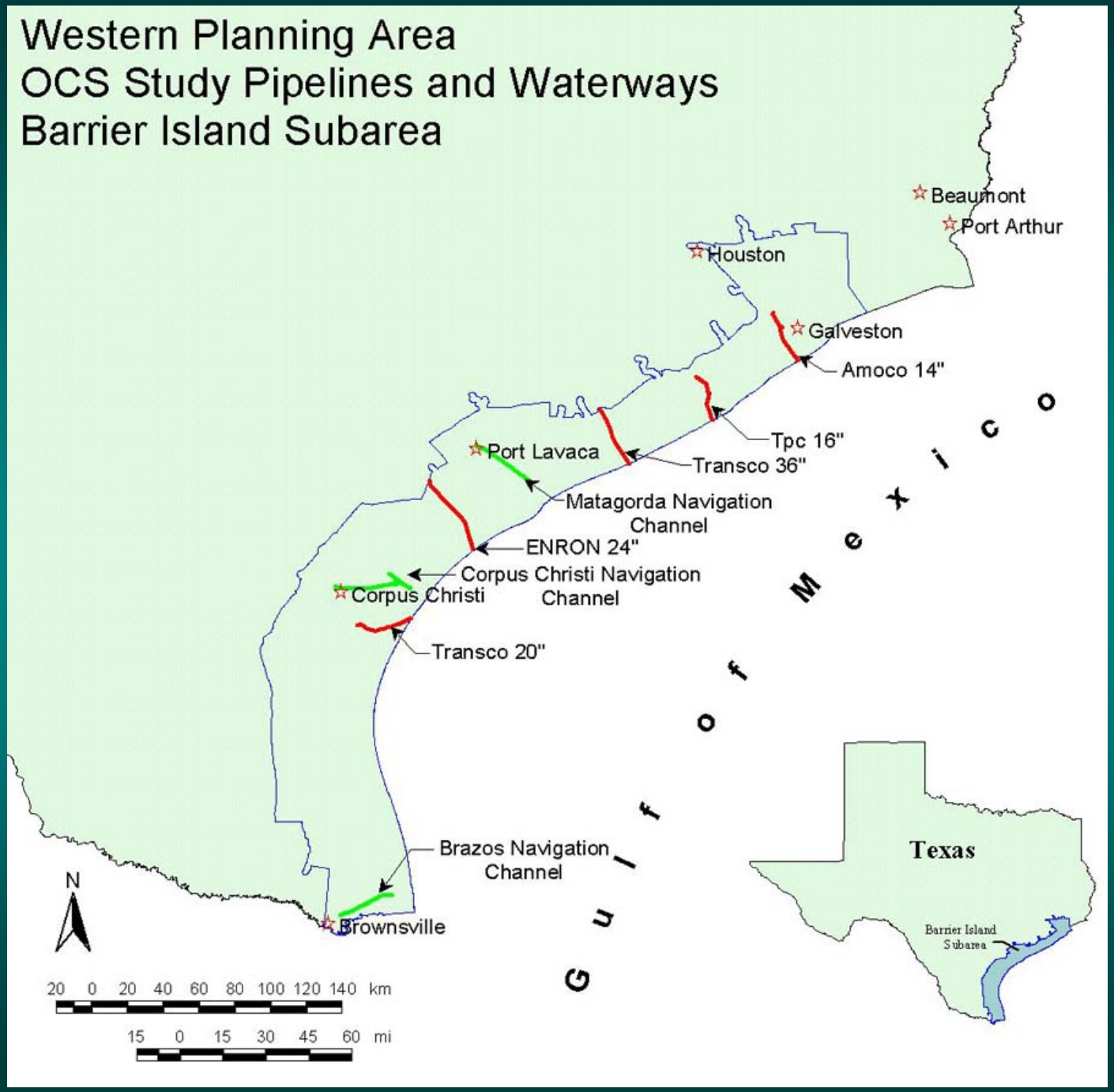
Pipeline Summary

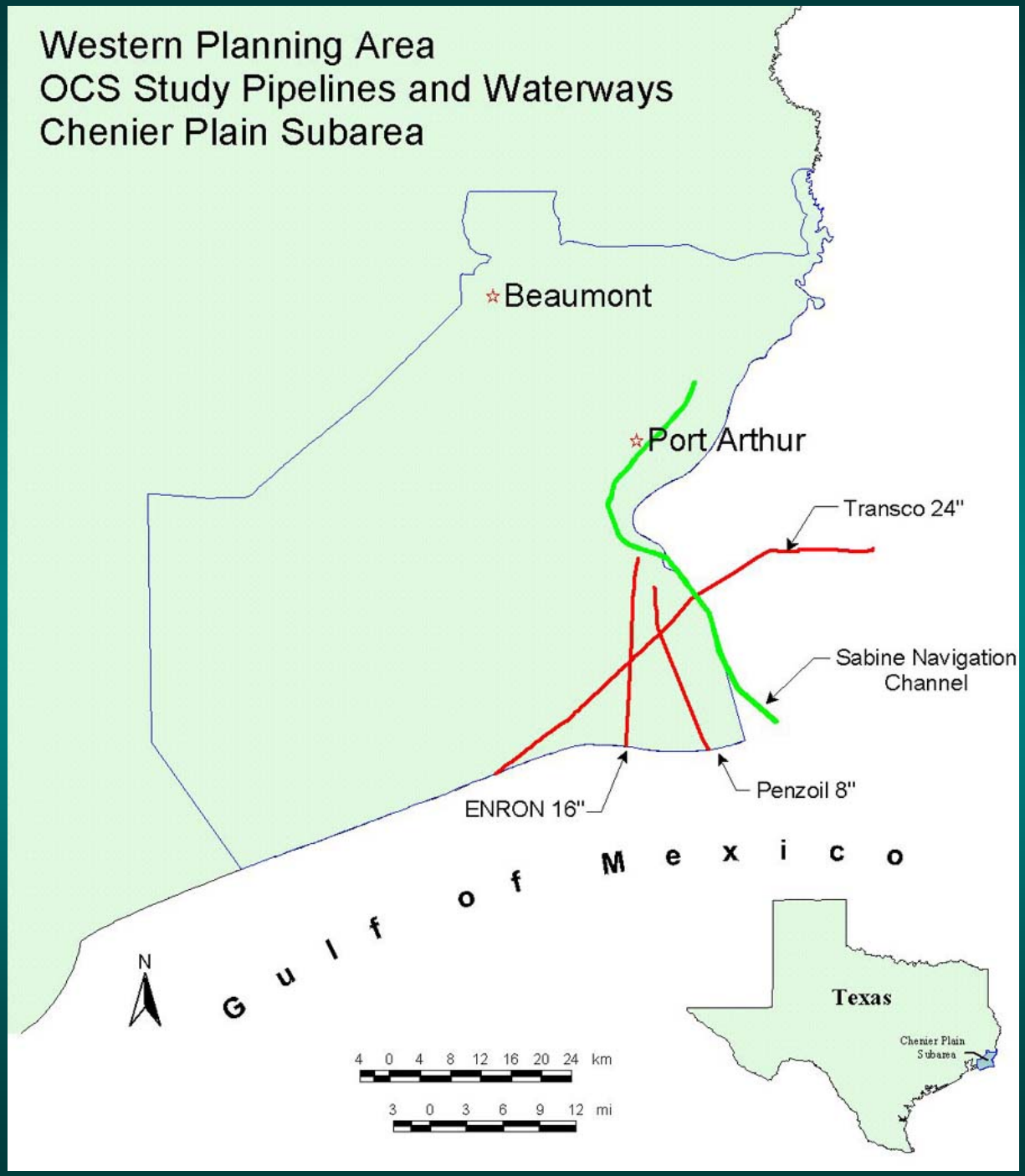
(Louisiana regional, local, individual scale)

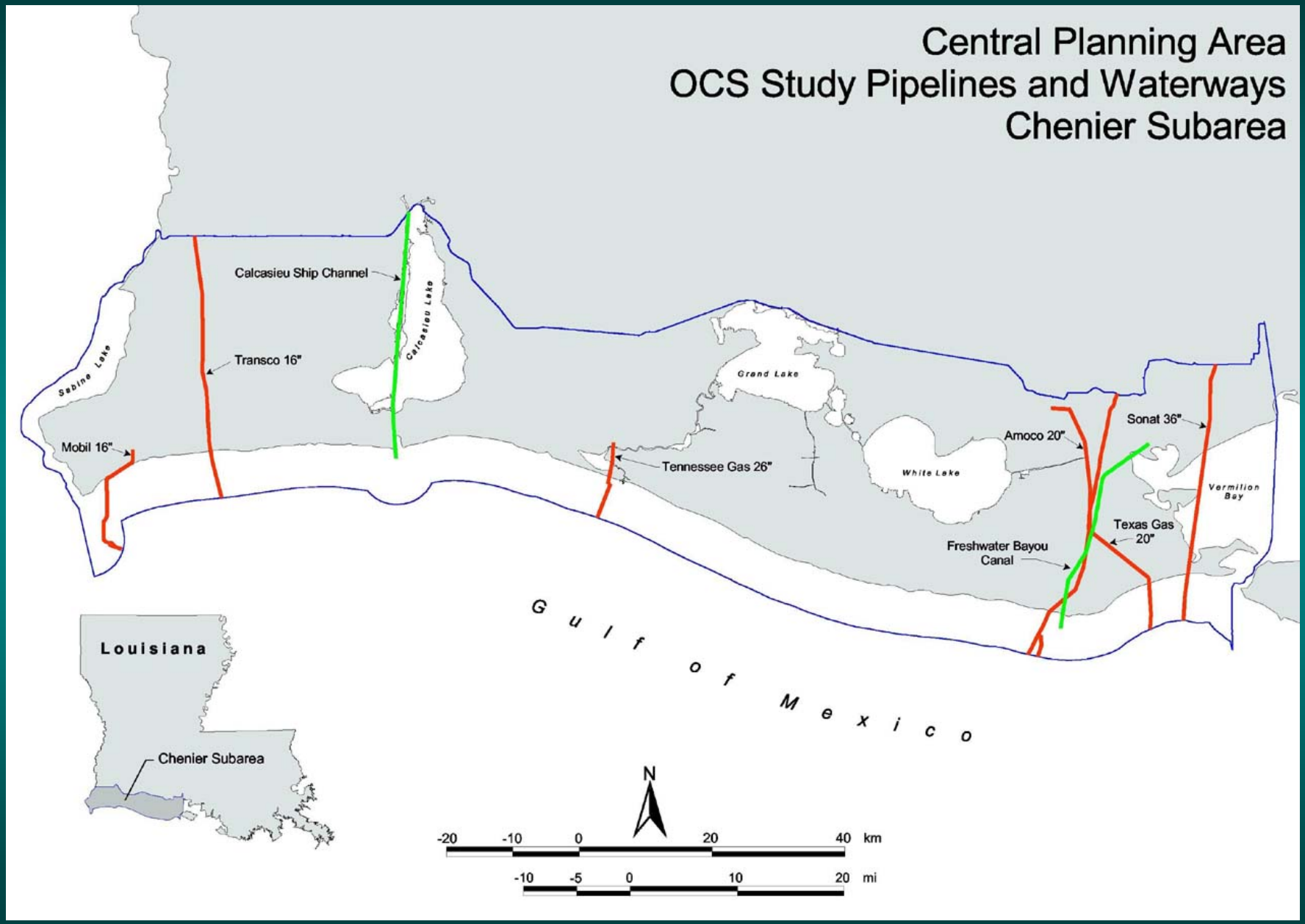
The land loss rate within 150 m either side of the entire OCS pipeline population was significantly higher than the regional land loss rate for both the chenier and delta plain in Louisiana. A comparison of pre- and post-construction habitat change trends from a population sample confirmed that pipeline construction influenced habitat change trends. Yet, our in-depth qualitative analyses of individual pipelines revealed that pipelines not backfilled altered the trajectory of habitat change (e.g., Tennessee 26”) while backfilled pipelines did not (e.g., Amoco 20”). The important factor determining the degree of impact was the type and quality of mitigation techniques applied.

Navigation Canal Summary

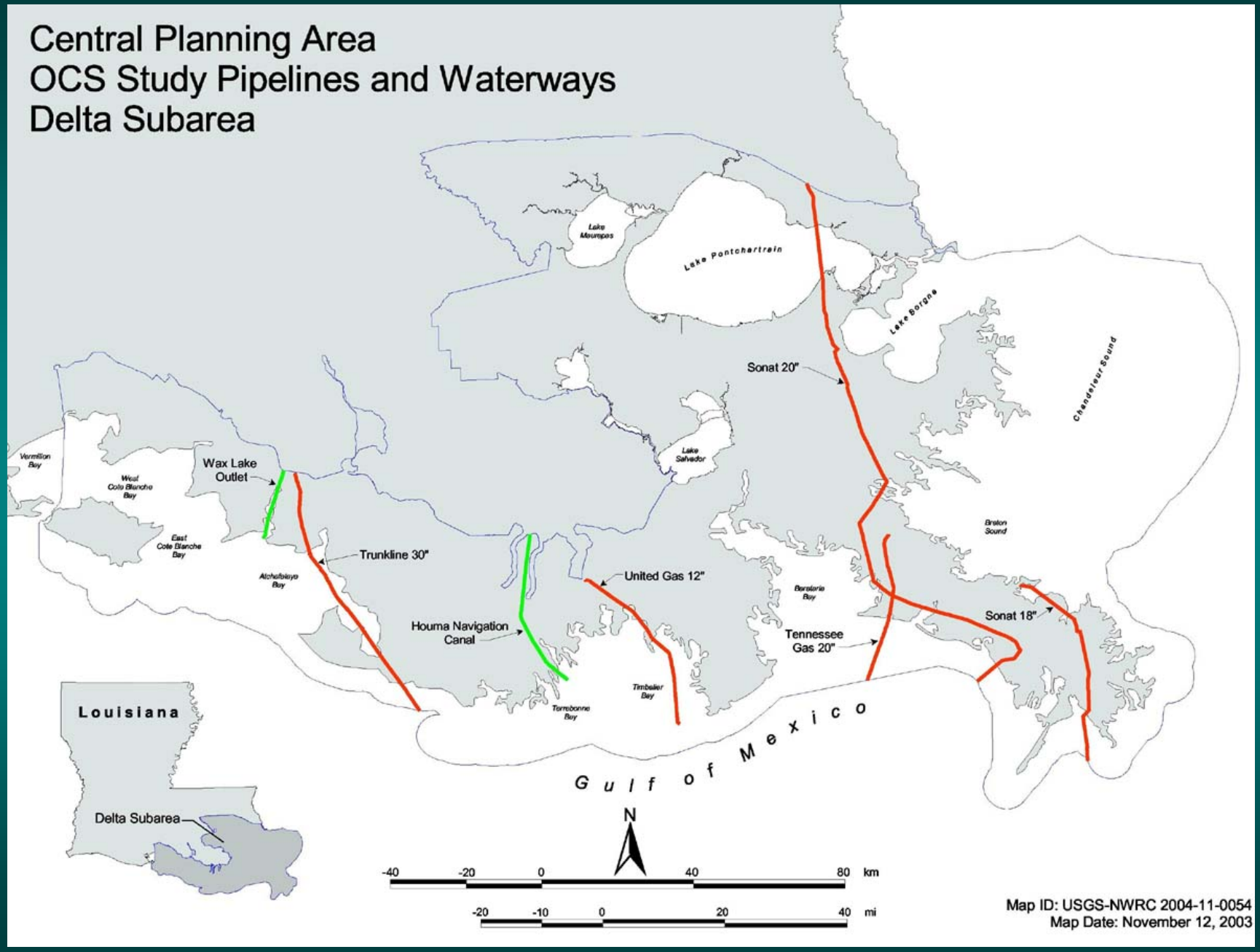
Compared to pipeline impacts, navigation canal impacts are typically larger, more persistent, and more difficult to minimize. Canal widening rates have slowed in recent years, apparently as a result of increased bank stabilization efforts, but saltwater intrusion and other hydrologic effects persist for all navigation canals.

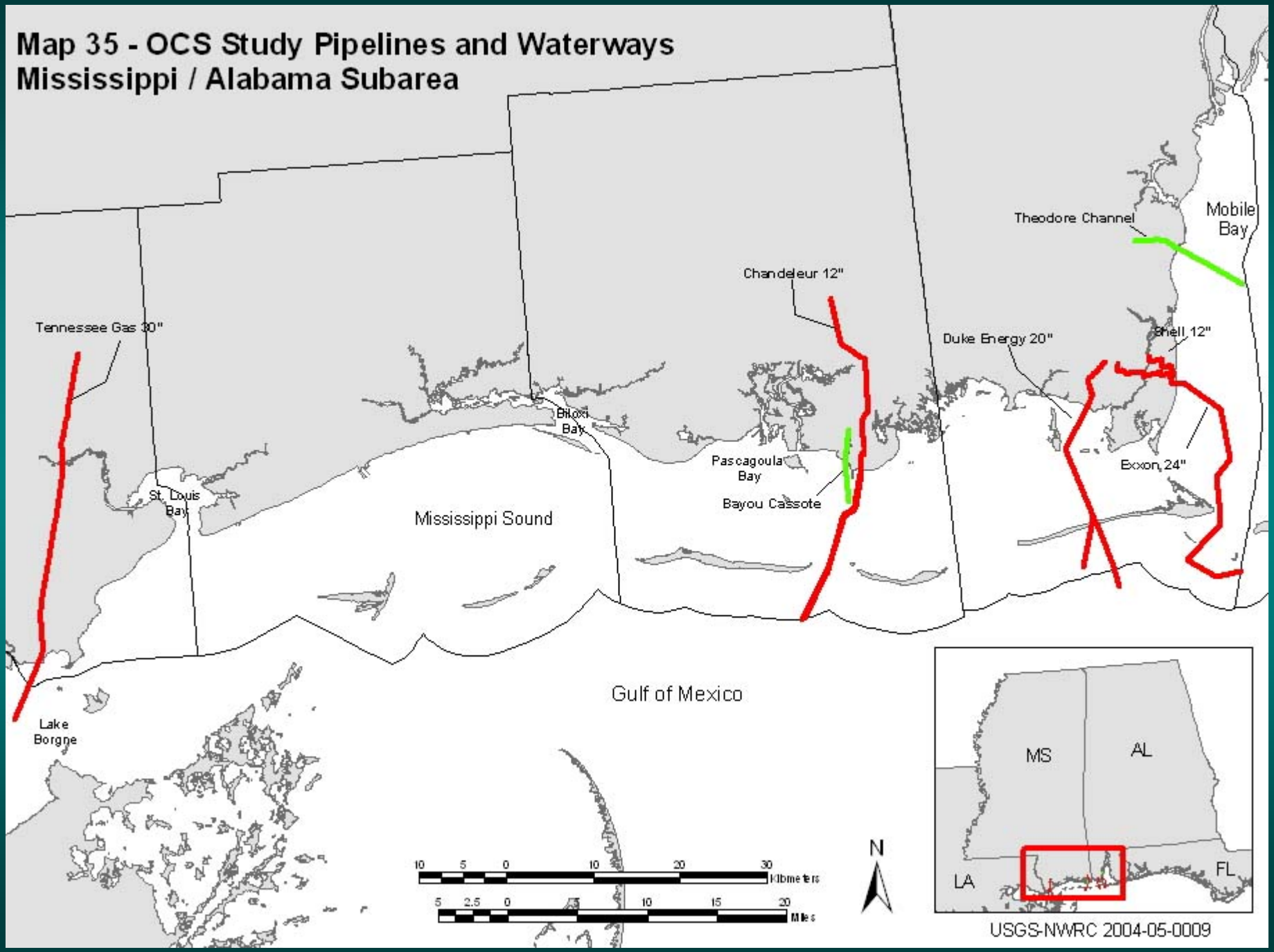

Western Planning Area
OCS Study Pipelines and Waterways
Barrier Island Subarea
Beaumont
Port Arthur
Houston
Galveston
Amoco 14"
Tpc 16"
Transco 36"
Port Lavaca
Matagorda Navigation Channel
ENRON 24"
Corpus Christi Navigation Channel
Corpus Christi
Transco 20"
Brazos Navigation Channel
Brownsville
Gulf of Mexico
Texas
Barrier Island Subarea
N
20 0 20 40 60 80 100 120 140 km
15 0 15 30 45 60 mi


Western Planning Area
OCS Study Pipelines and Waterways
Chenier Plain Subarea
Beaumont
Port Arthur
Transco 24"
Sabine Navigation Channel
Penzoil 8"
ENRON 16"
Gulf of Mexico
N
4 0 4 8 12 16 20 24 km
3 0 3 6 9 12 mi
Texas
Chenier Plain Subarea


Central Planning Area
OCS Study Pipelines and Waterways
Chenier Subarea
Calcasieu Ship Channel
Calcasieu Lake
Sabine Lake
Transco 16"
Mobil 16"
Grand Lake
Tennessee Gas 26"
White Lake
Amoco 20"
Sonat 36"
Vermilion Bay
Texas Gas 20"
Freshwater Bayou Canal
Gulf of Mexico
Louisiana
Chenier Subarea
N
-20 -10 0 20 40 km
-10 -5 0 10 20 mi

Central Planning Area
OCS Study Pipelines and Waterways
Delta Subarea




Map 35 - OCS Study Pipelines and Waterways
Mississippi / Alabama Subarea
Tennessee Gas 30"
Chandeleur 12"
Theodore Channel
Mobile Bay
Duke Energy 20"
Shell 12"
Biloxi Bay
Pascagoula Bay
Bayou Cassote
Exxon 24"
St. Louis Bay
Mississippi Sound
Gulf of Mexico
Lake Borgne
10 5 0 10 20 30 Kilometers
5 2.5 0 5 10 15 20 Miles
N
MS
AL
LA
FL
USGS-NWRC 2004-05-0009

Objective 3. Mitigation

1. Quantify the effectiveness of common construction and mitigation techniques used to minimize impacts of OCS oil and gas pipelines and canals.

2. Determine if effects vary depending on habitat, subarea or construction technique.

Mitigation Study – Conclusions

<u>Pipeline canals</u>

Differences noted by subarea and habitat:

1. MS/AL: minimal effects – most built in pipeline corridors which effectively minimized impacts
2. TX Barrier Island: one instance of wetland loss due to flank subsidence or ponding, otherwise minimal impacts; predominantly directionally drilled
3. TX Chenier Plain: no impacts noted attributed solely to pipelines on all lines where mitigation occurred
4. LCP and LDP: evidence of saltwater intrusion and scars along pipelines in which no evidence documenting mitigation occurred

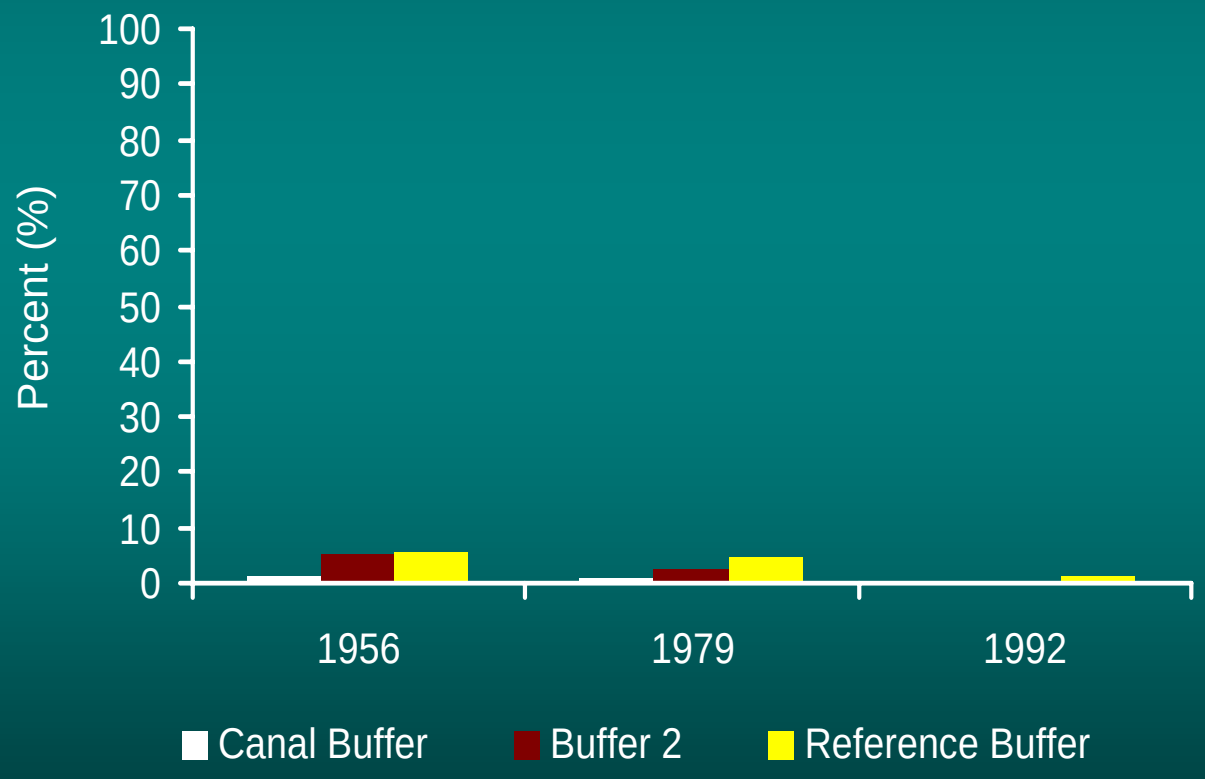
**Where it was clear that mitigation had occurred, there were no significant impacts from the pipeline

Mitigation Study – Conclusions

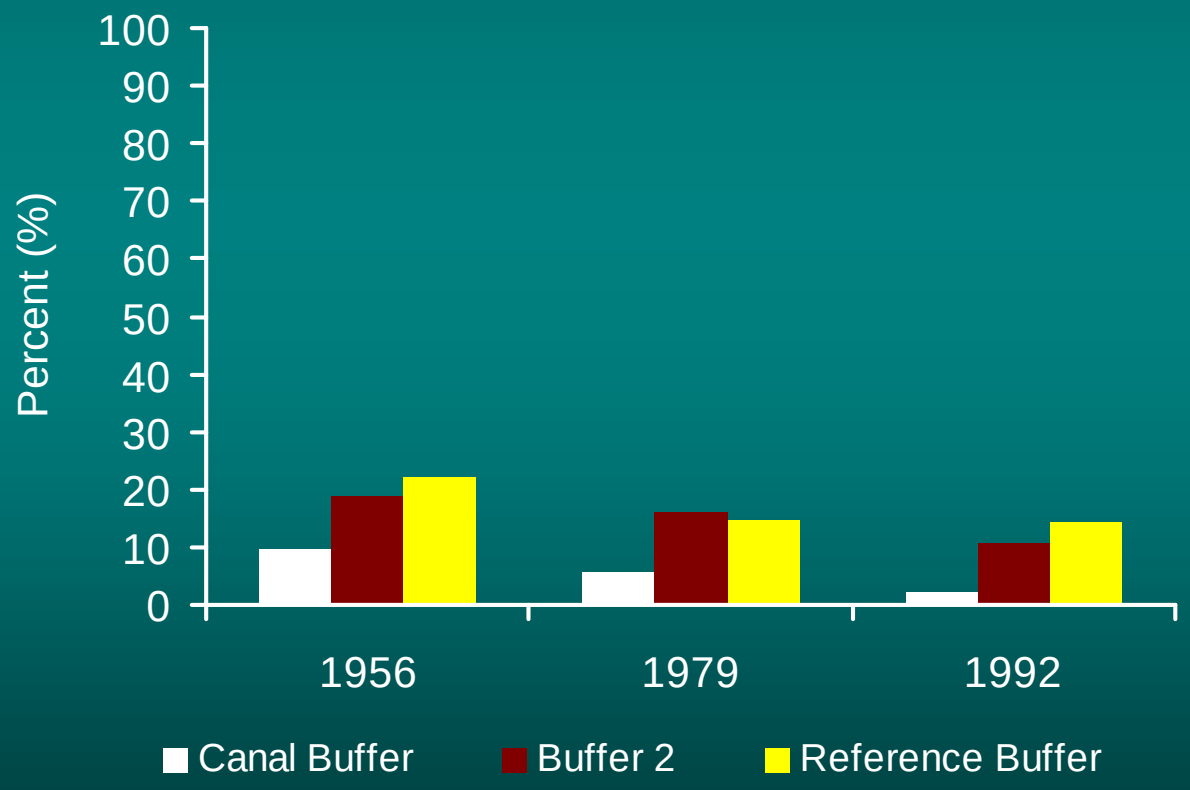
Navigation canals:

1. Navigation canals in all five subareas clearly contributed to land loss through erosion and salt water intrusion.
2. Most significant impacts occurred in the 1950s and 1970s; reduced effects in later decades, either due to age or to increased shoreline stabilization measures enacted.

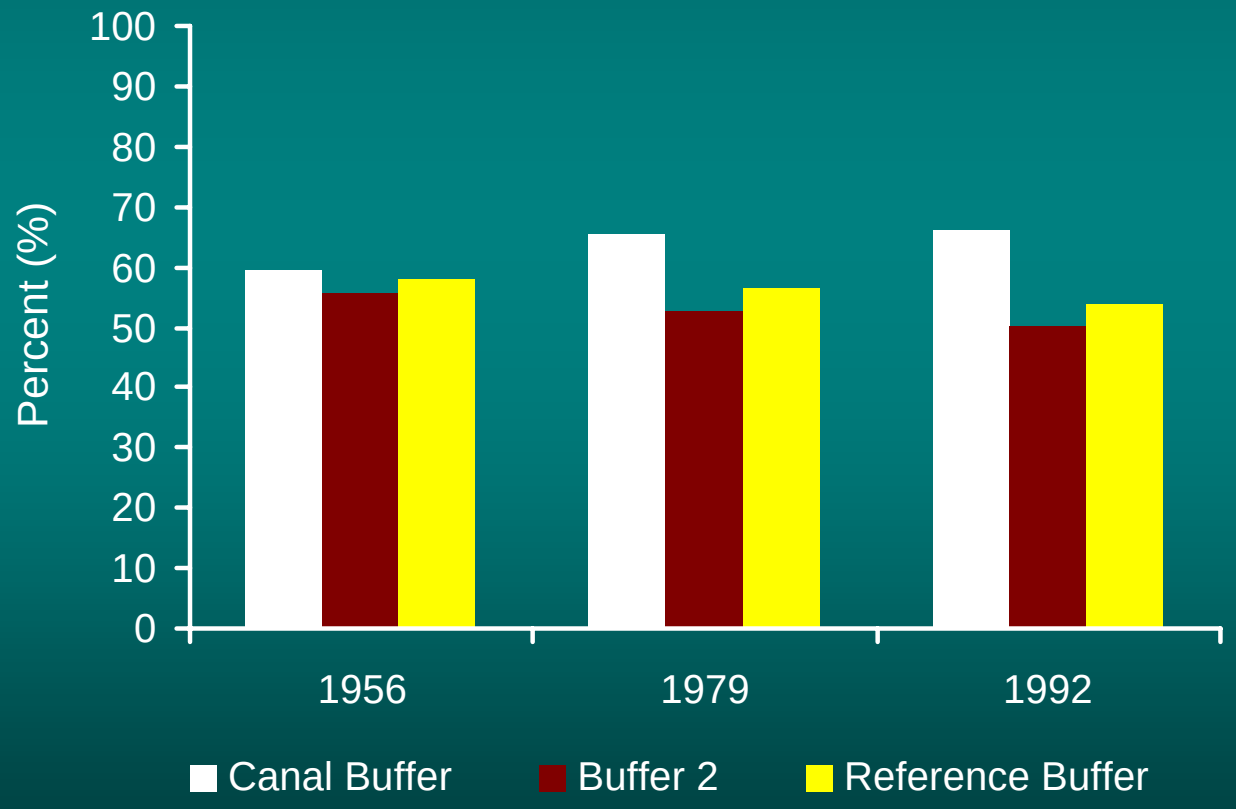
Percent Fresh Marsh within Experimental Buffers Surrounding Selected Navigation Canals in the Texas Chenier Plain



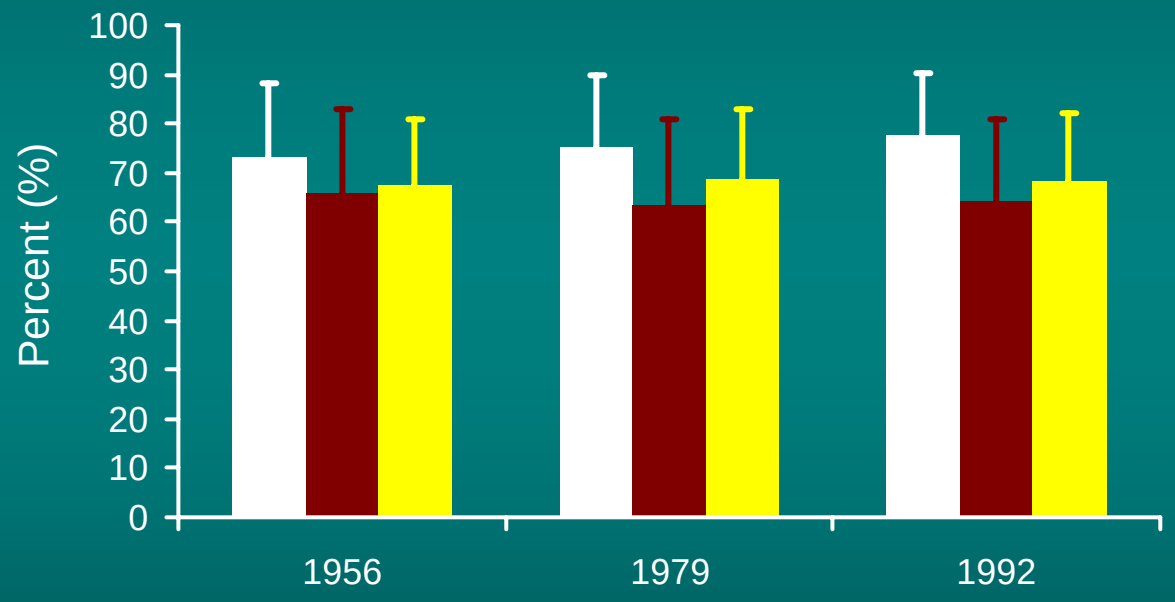
Percent Non-Fresh Marsh within Experimental Buffers Surrounding Selected Navigation Canals in the Texas Chenier Plain



Percent Open Water within Experimental Buffers Surrounding Selected Navigation Canals in the Texas Chenier Plain



Percent Open Water within Experimental Buffers Surrounding Selected Navigation Canals in Texas Barrier Island



Canal Buffer Buffer 2 Reference Buffer

Given the lack of a distance effect, we determined the influence of pipeline and navigation canal construction on these habitat trends by comparing pre- and post-construction habitat areas (% of total buffer area).

Project Goals

- Create a GIS data base of the entire OCS pipeline and navigation canal system for the western and central planning areas (TX, LA, MS, AL).

- Assess the types and severity of adverse impacts caused by OCS pipeline and canal projects.

- Assess construction and mitigation techniques on land loss and habitat change through literature review and analyses of selected case studies.

Impacts	Backfilled Pipeline	Open Pipeline Canal	Navigation canal
Direct			
Conversion to Open Water			
Dredging		B M F	B M F
Insufficient Backfill	M F*		
Soil Compaction			
Spoil Banks	F	M F	M F
Machinery	M F		
Backfill and ROW Volume Deficit	M F		
Conversion to Upland		B M F	B M F
Hydrodynamic Changes			
Sediment Sink	B M	B M	
Longshore Current Disruption		B M	
Hydrodynamic efficiency	B M F	B M F	B M F
Frac-out	Unique to Directional Drilling	Unique to Directional Drilling	Unique to Directional Drilling
Indirect			
Hydrodynamic Changes			
Impoundment		M F	M F
Hydrodynamic efficiency			
Channel Theft	B M F	B M F	B M F
Freshwater Drainage	M F	M F	M F
Saltwater Intrusion	M F	M F	M F
Altered Sedimentation	B M	B M	B M
Altered Erosion	B M	B M	B M
Ponding and Continued Erosion			
Flank subsidence		M F	M F
Canal and channel Erosion		B M F	B M F
Pond Expansion	M F	M F	M F

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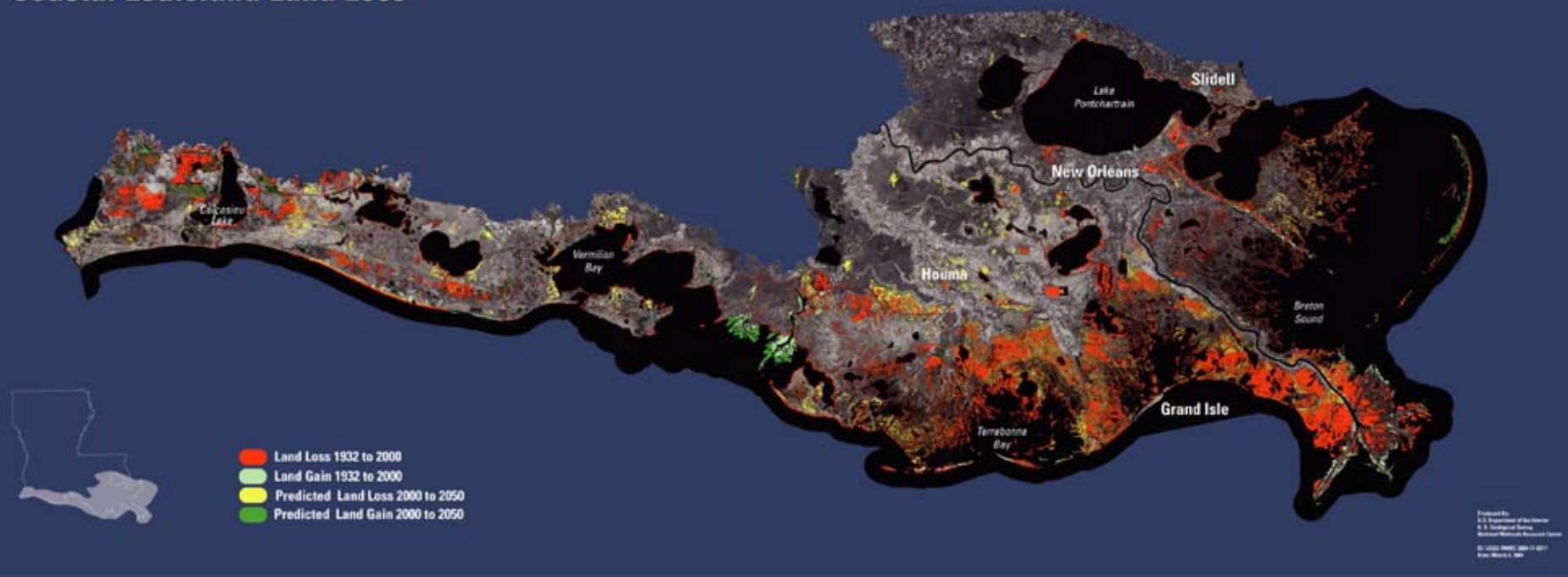
Coastal Louisiana Land Loss



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Objective 1. GIS Network

- Identify OCS-related pipelines, pipeline canals, and navigational canals found inshore of this entire region for the mid-1950s, late 1970s, and early 1990s and designate them in a geographical information system that is compatible with the MMS GIS system.

  GIS Data Sources: Texas General Land Office, The Texas Railroad Commission, MMS, PennWell Maps Search, National Pipeline Mapping System, Louisiana Geological Survey, Louisiana Department of Natural Resources

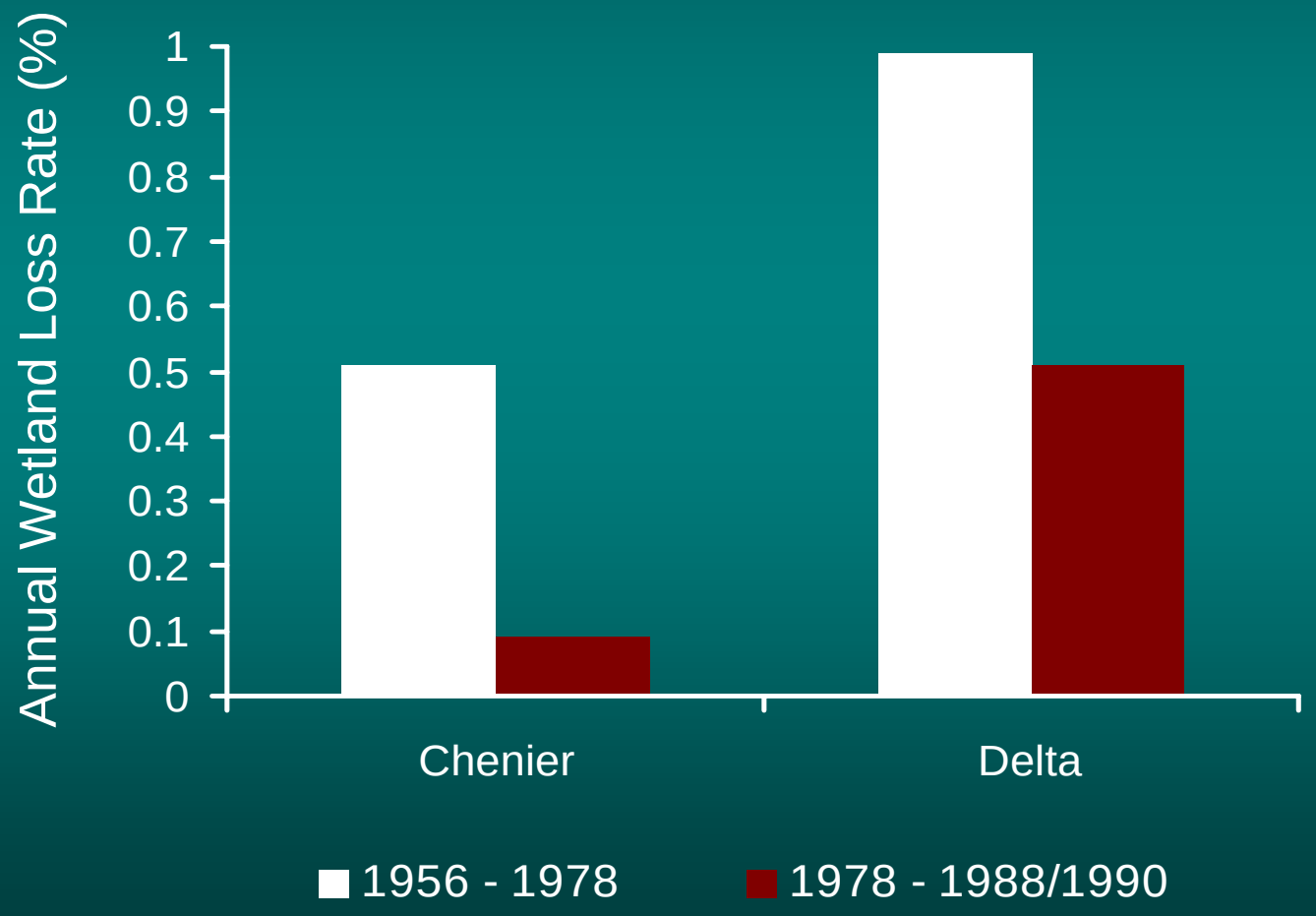
Objective 2. Habitat Impacts

- Using the new GIS network of OCS-pipeline and navigation canals, quantify land loss, wetland loss, and habitat change within the immediate vicinity

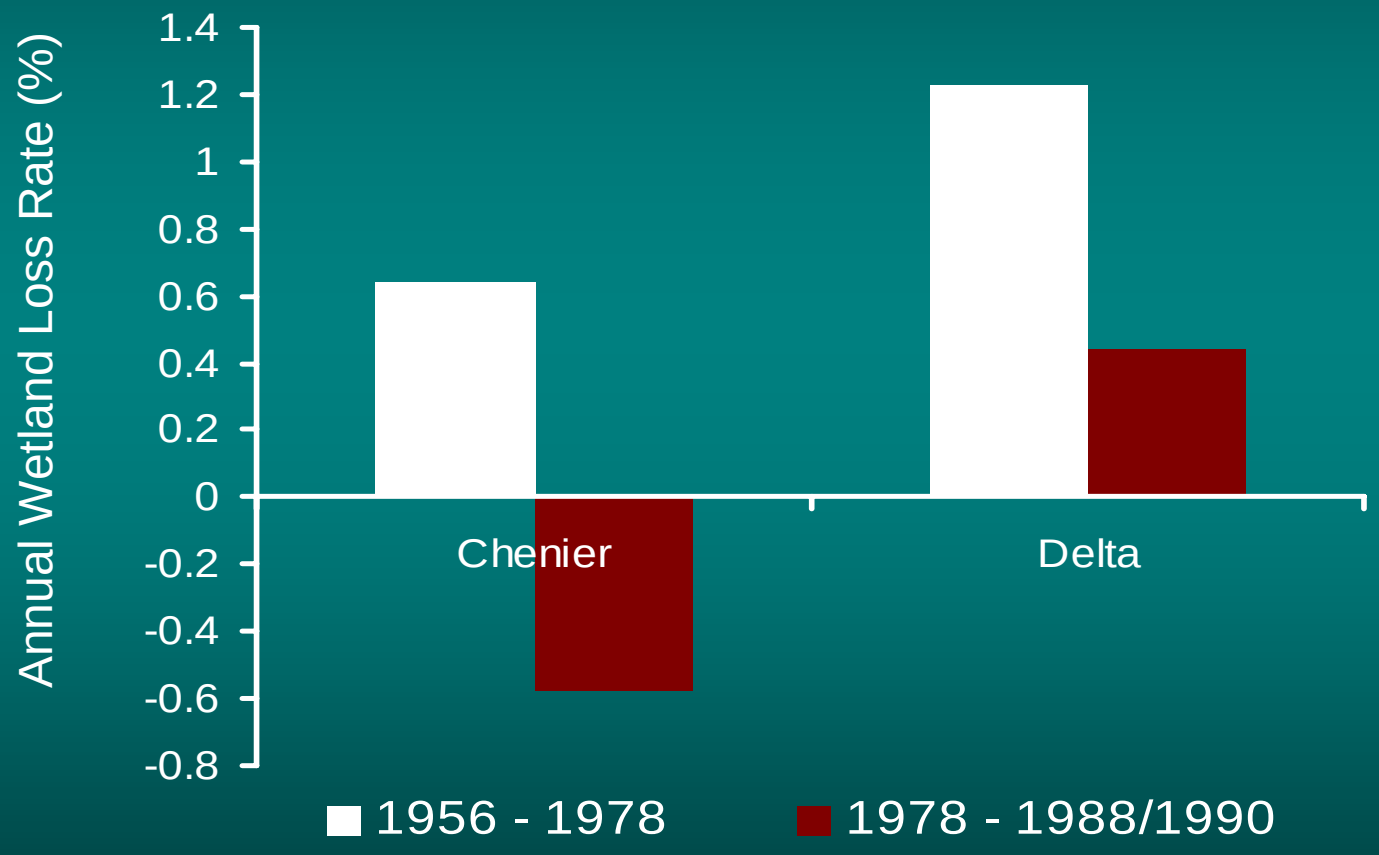
Land Loss and Wetland Loss (Population Analysis)

- Louisiana: Pipeline & Canal Network vs. Subarea Trends
- Texas: Pipeline & Canal Network
- MS/AL: Pipeline & Canal Network

Trends of Wetland Loss Within 300 m (150 m either side) of Entire Network of Pipelines in Louisiana

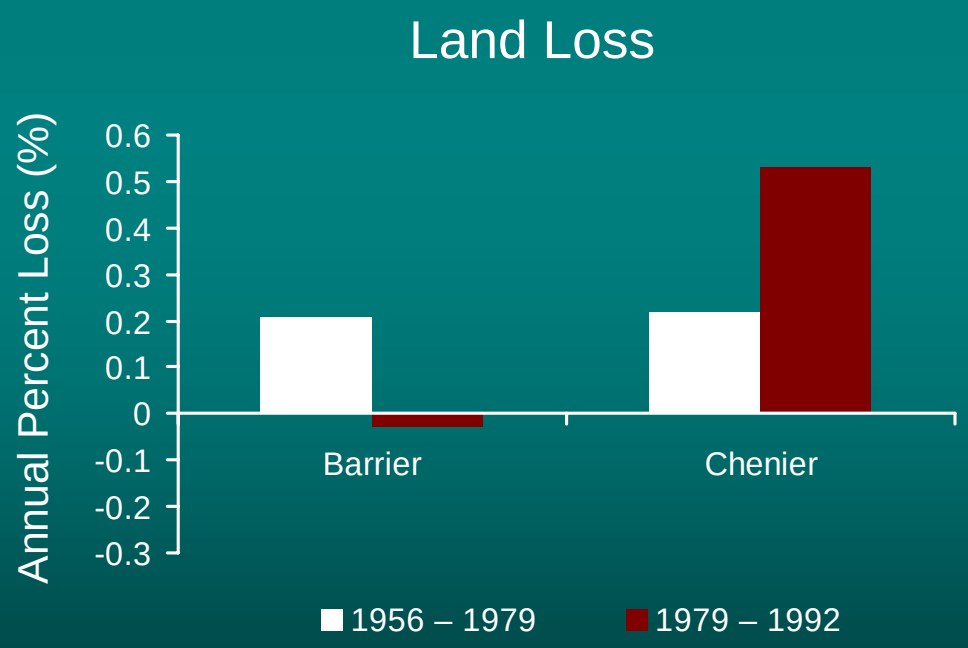


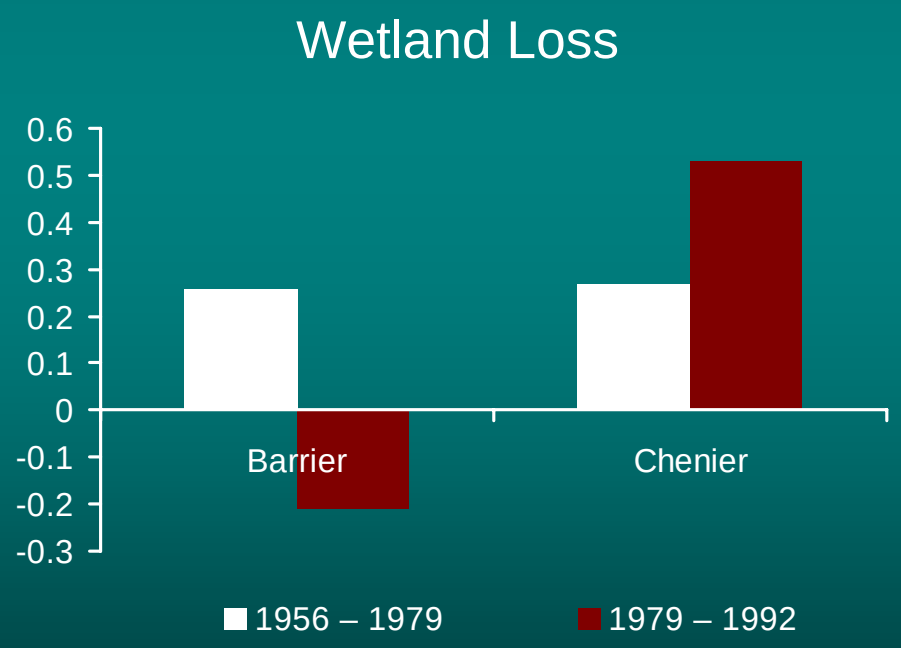
Trends of Wetland Loss Within 1000 m (500 m either side) of Entire Network of Navigation Canals in Louisiana



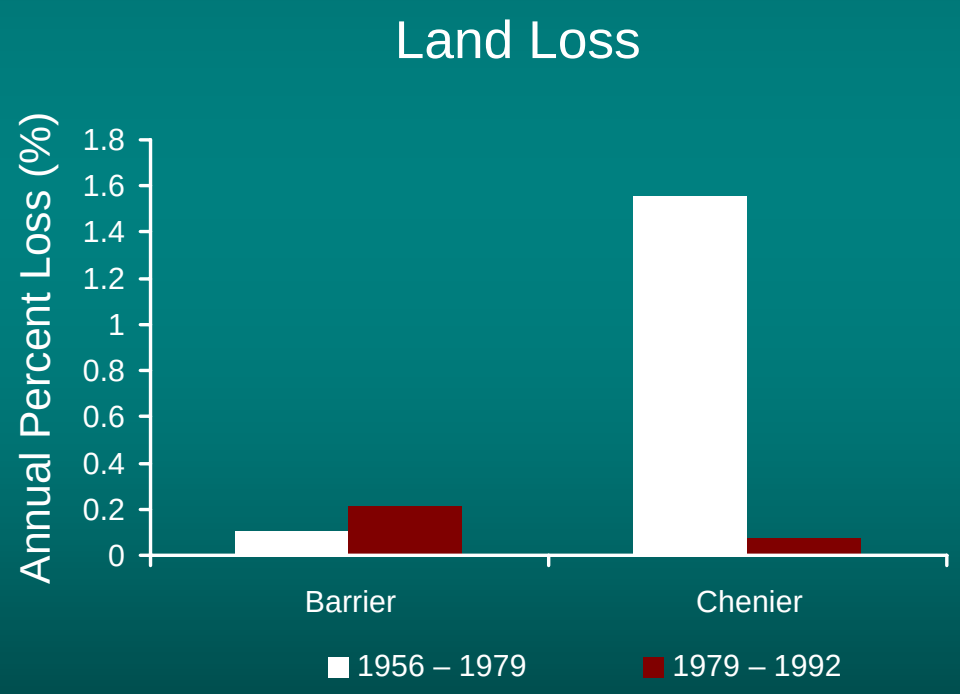
Negative rate = gain in wetland area

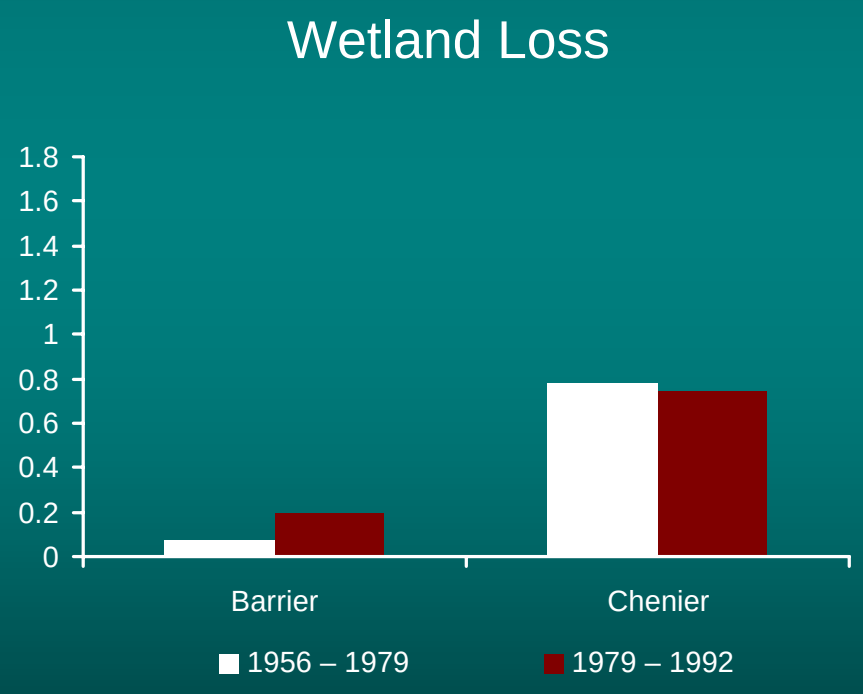
Land and Wetland Loss Within 300 m (150 m either side) of Entire Population of Pipelines in Texas



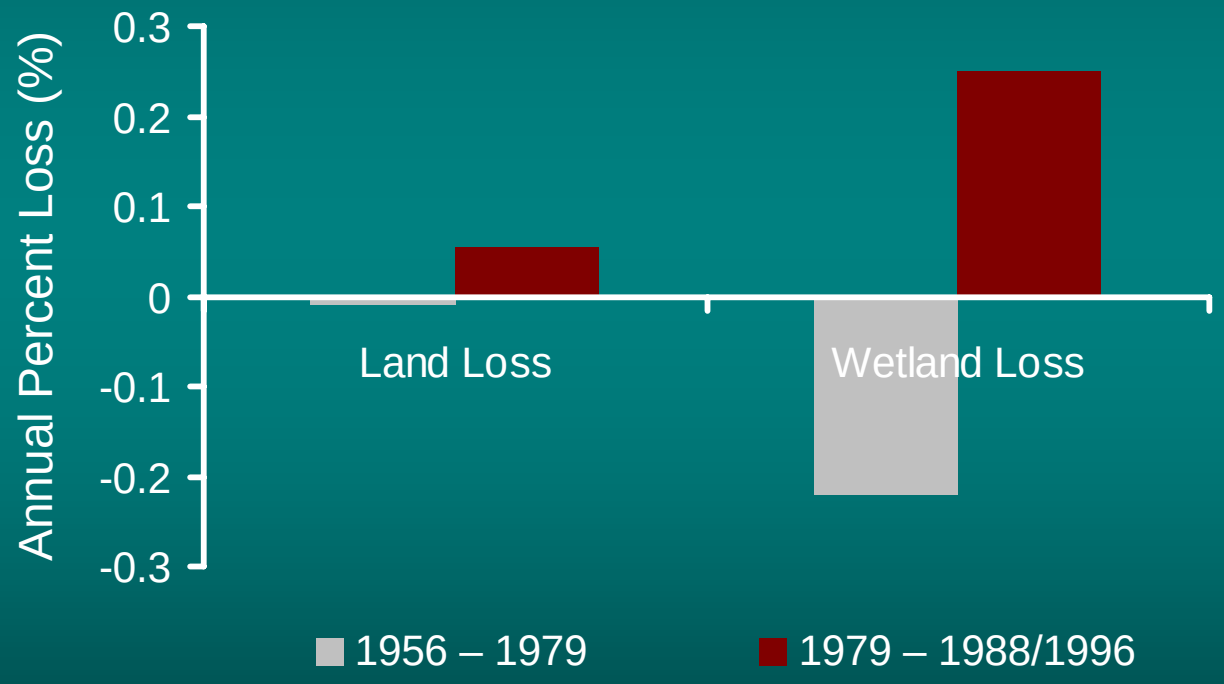


Land and Wetland Loss Within 1000 m (500 m either side) of Entire Population of Navigation Canals in Texas

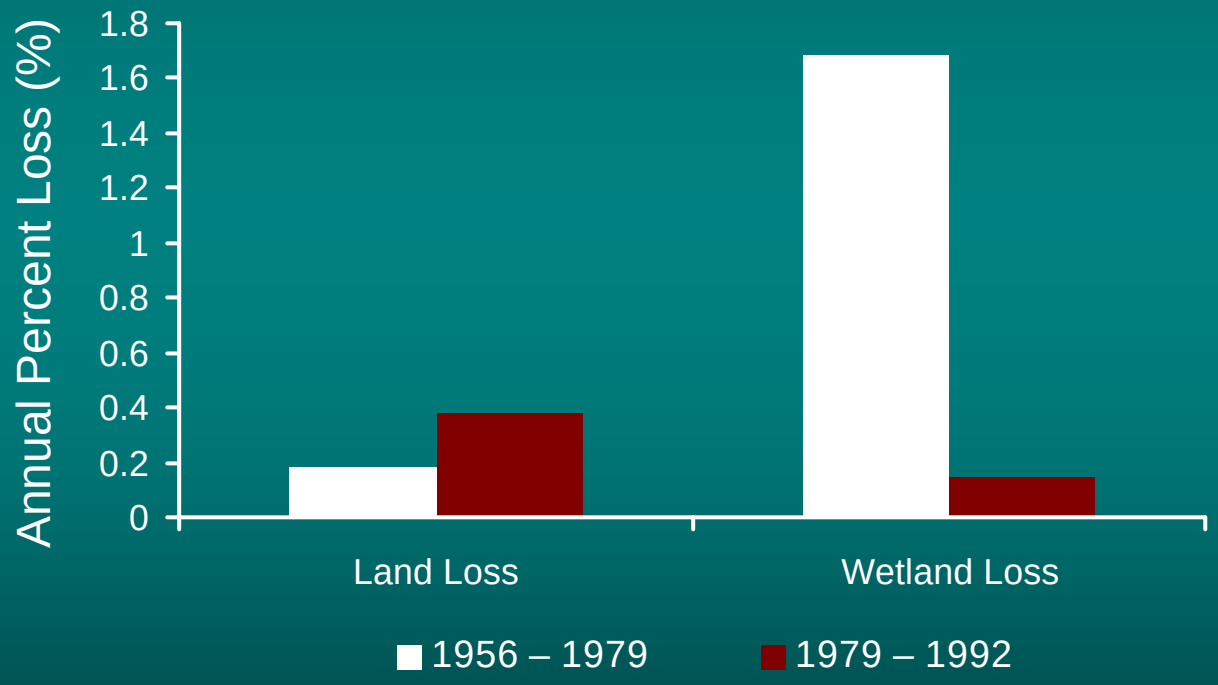




Trends of Land and Wetland Loss Within 300 m (150 m either side) of Entire Population of Pipelines in Mississippi and Alabama



Trends of Land and Wetland Loss Within 1000 m (500 m either side) of Entire Population of Navigation Canals in Mississippi and Alabama



Habitat Change (Population Analysis)

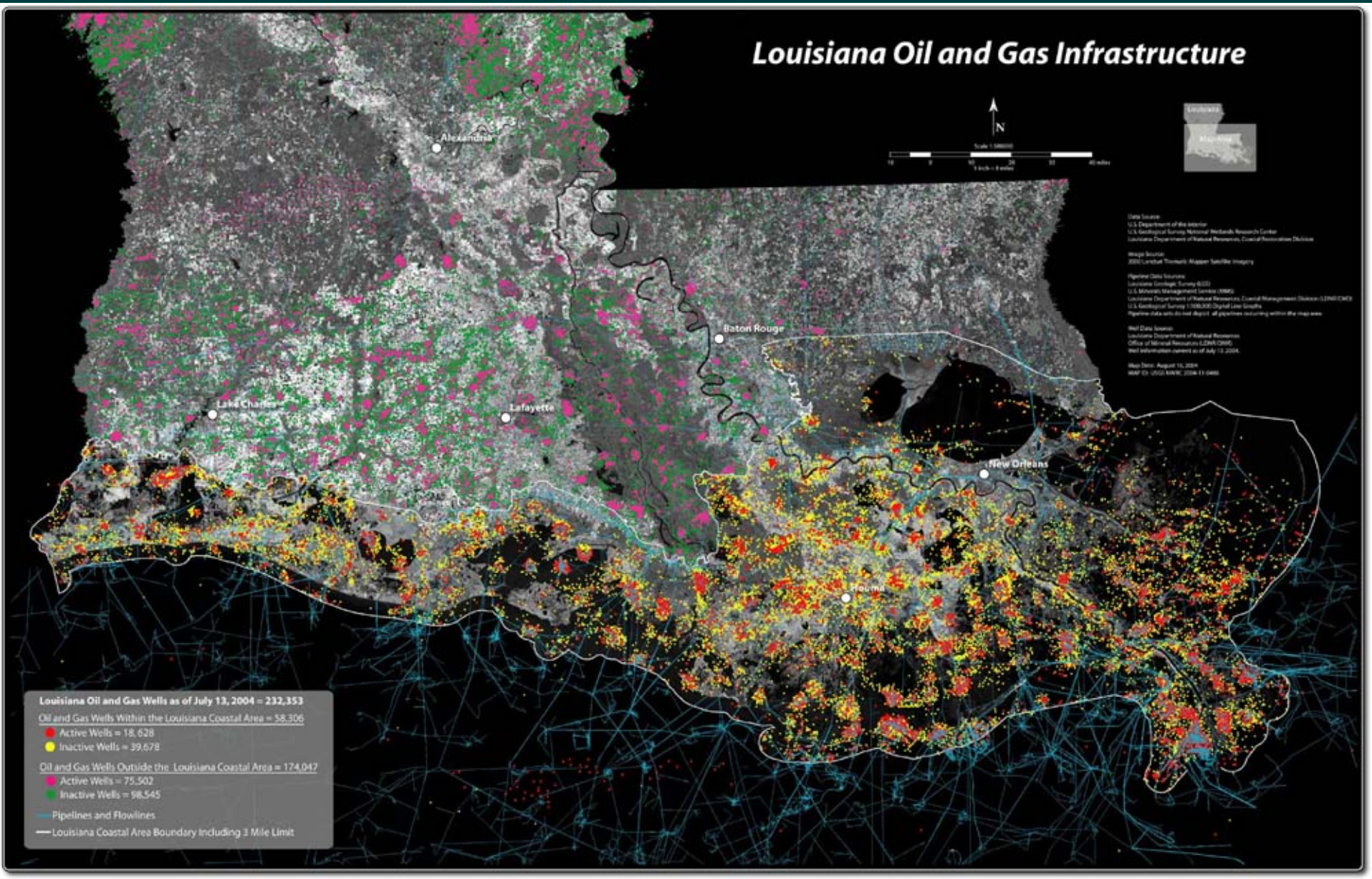
- Fresh Marsh
- Non-Fresh Marsh
- Open Water

Land Loss in Louisiana

- Estimated that over 900,000 acres lost since the 1930s
- In the 1970s, estimated that 25,600 acres/year were lost
- Current loss rate estimated at 16,000 acres/year
- Estimated that a 320,000 acre net loss will occur by 2050

Land Loss in Louisiana

- Estimated that only 30% of losses from natural causes
- Remaining 70% of loss attributed to direct and indirect human effects, including altered hydrology, subsidence, and erosion (all potential effects of canals)
- Estimates of loss attributed to oil and gas activities range from approximately 10 to 25% of all wetland loss



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Other Topics

- Regional Analysis
- Intensive Impact Analysis
- Case Studies of Mitigation Effectiveness

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