The Association of Salinity Pattern and Landscape Configuration with OCS Oil and Gas Navigational Canals in Coastal Louisiana

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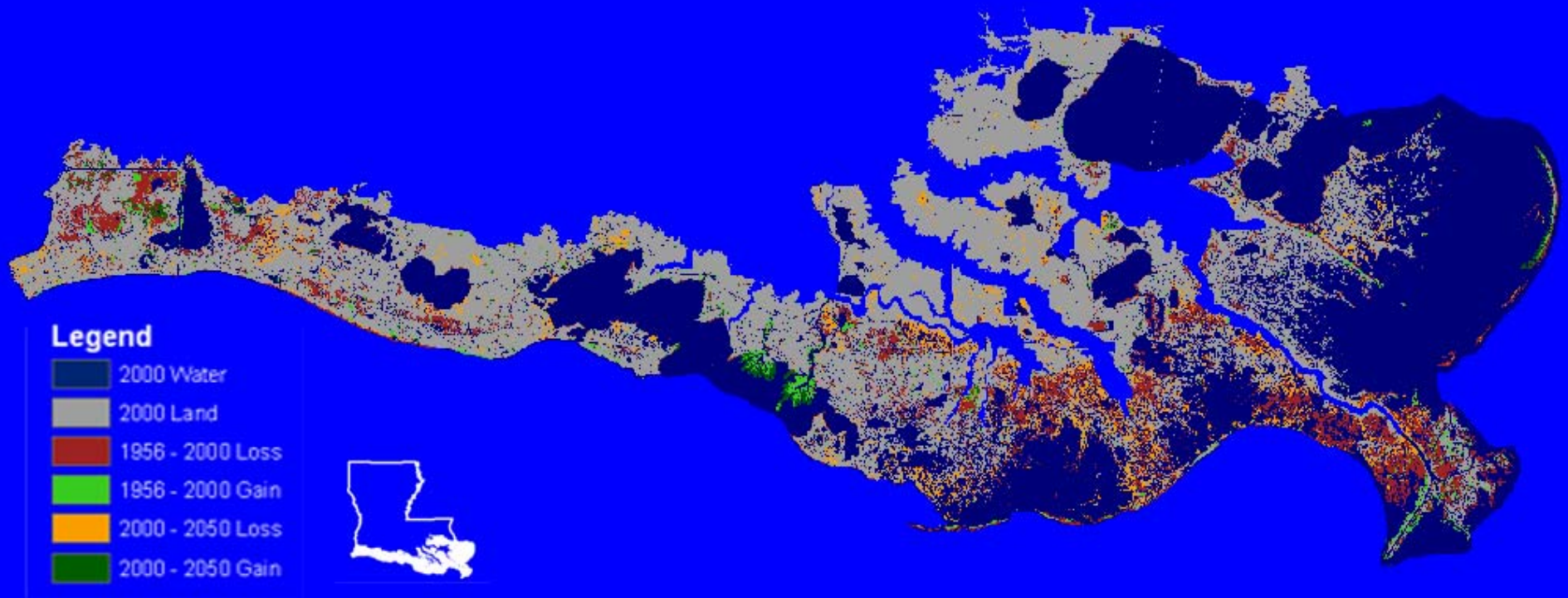
Introduction

- Coastal Louisiana is a dynamic and ever-changing landscape
  - over 310,000 ha of coastal wetlands lost in past 50 years



- Land change occurs over wide range of spatial/temporal scales
- Indirect impacts of those changes are difficult to describe
  - changes are subtle and operate over long time horizons

- These causes affect the connectivity, configuration, and percentage of water in a marsh landscape

- Useful indicators for evaluating marsh conditions

Previous Studies

- Past studies of coastwide salinity
  - focused on broad-scale coastwide patterns and trends
- Detailed analysis of spatial/temporal salinity patterns in Barataria-Terrebonne Basins
  - did not directly address the impacts of waterways or navigation canals
- Few studies have investigated trends in historical salinity records related to navigation canals:
  - limited historical salinity data
  - no comprehensive analysis of existing data assessing impacts of navigation canals on salinity patterns

Objectives

- Examine extent that OCS navigational canals have

  (1) contributed to changes in marsh salinity regimes

  (2) influenced wetland landscape patterns and loss rates

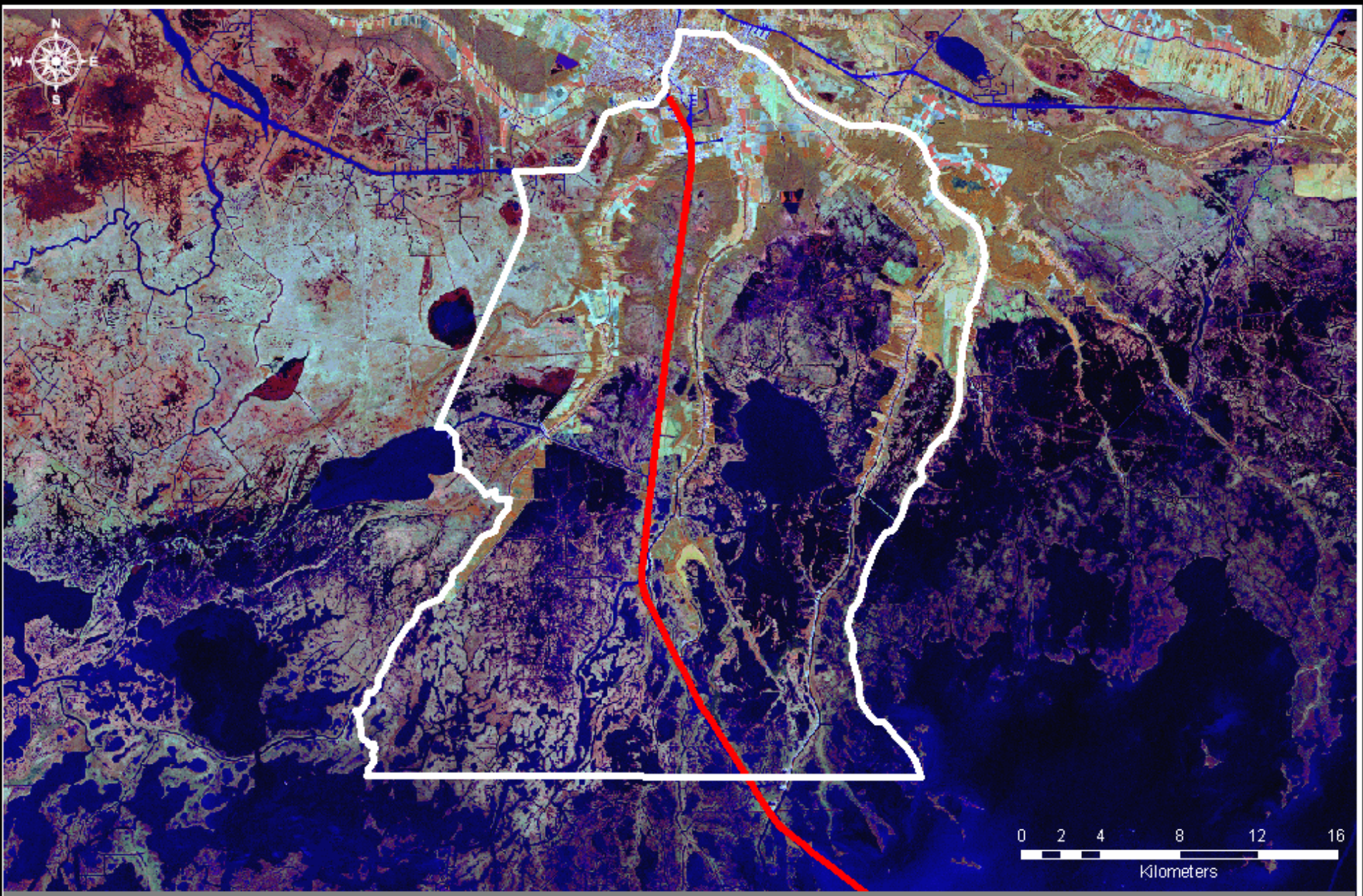
Approach

(1) review salinity literature, salinity management studies, and salinity models

(2) assemble and analyze historic salinity data

(3) salinity pulse and pathway studies

(4) landscape analysis (configurations, fragmentation, and connectivity to canals and other landscape features)



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LEGEND

HNC Boundary

Houma Navigational Channel

Data Source:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Coastal Restoration Field Station
Baton Rouge, Louisiana

Image Source:
2000 Thematic Mapper Imagery

Map Date: September 14, 2004
Map ID: USGS-NWRC 2004-11-DRAFT

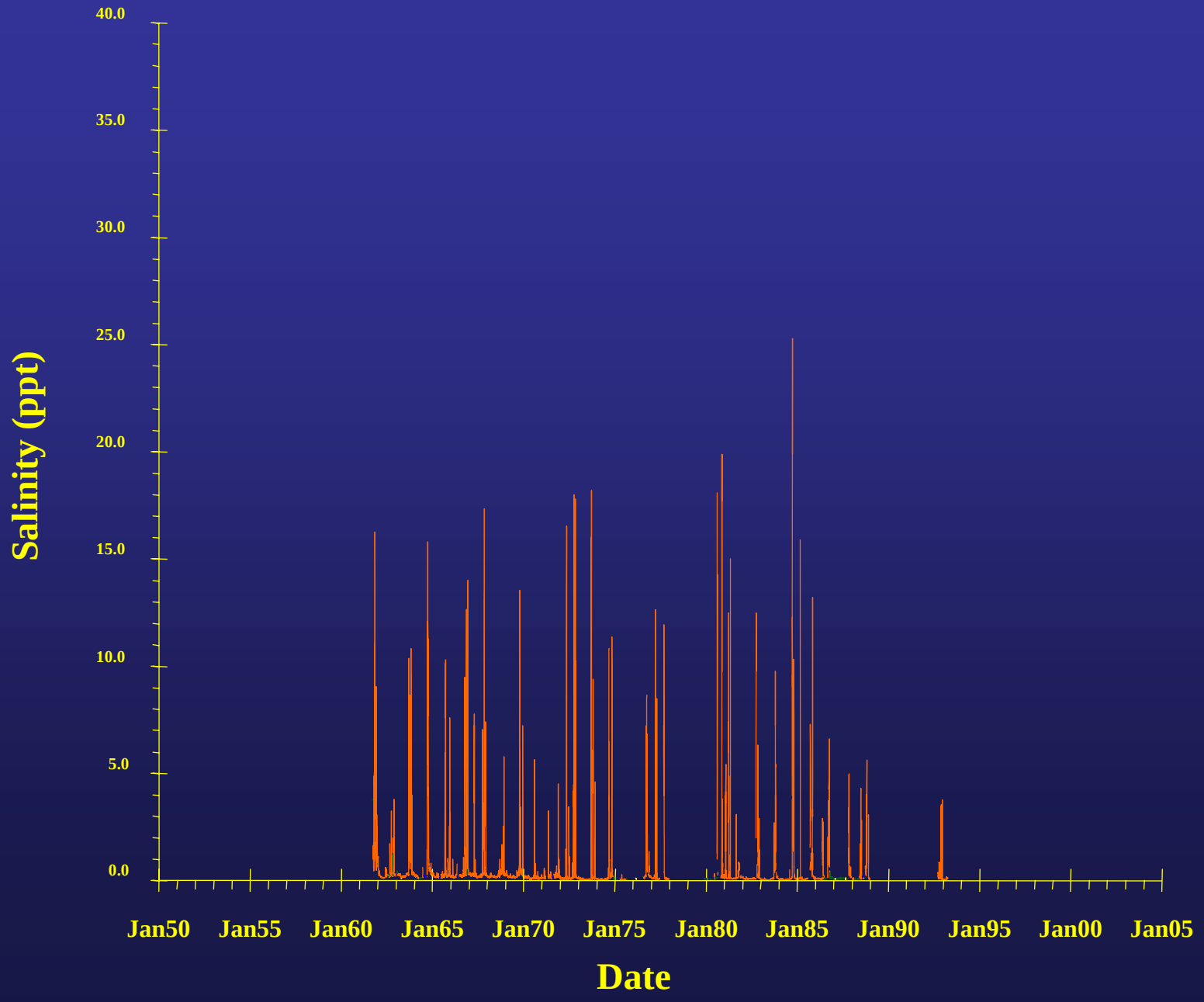
Coastwide Salinity Assessment Results

- 125 coastwide stations evaluated, 42 for long-term trends
- Coastal salinity patterns in brackish/saline marsh:
  - large-scale fluctuations (frontal passage influence)
  - typically remain above 15–20 ppt
  - decrease fairly rapidly as you move inland
  - inter-annual variability
    - inversely related to Mississippi River discharge
- Inland salinity patterns in fresh/intermediate marsh:
  - more pronounced seasonal change
    - low salinities (0–2 ppt) to moderate salinities (2–8 ppt)
    - “pulses” or “spikes” up to 15–20 ppt are also apparent
- A typical inland station on a large channel:
  - low salinities (0–1 ppt) most of the time
  - high salinity (~15 ppt) “spikes” from meteorological forcing
- Inland water bodies in Eastern Louisiana:
  - higher salinity than those found in west

Analysis of Salinity Trends within the Louisiana Coastal Zone 1975–1998

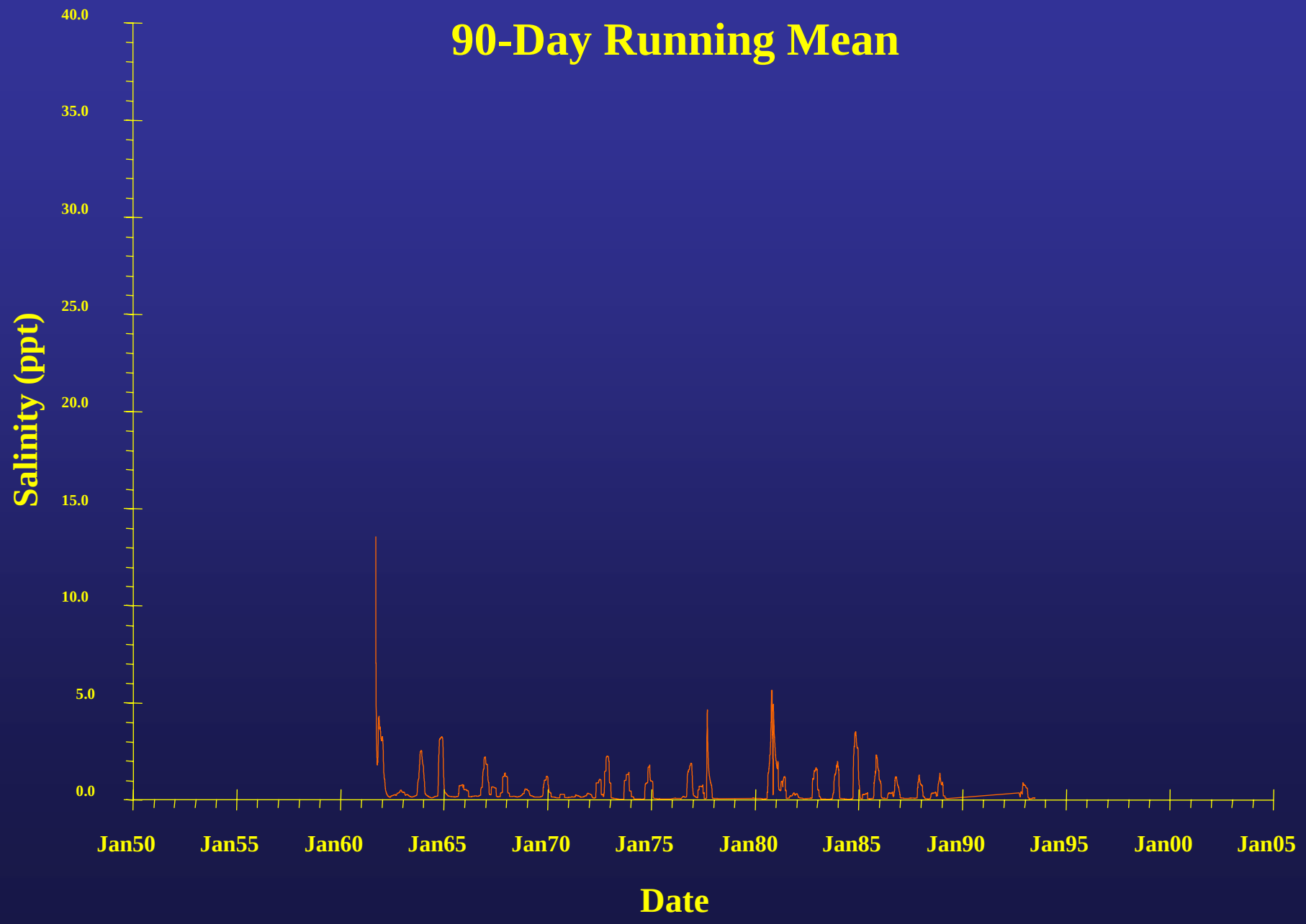
- Salinity changes:
  - increases at 27 (64%) stations
  - decreases at 15 (36%) stations
- Salinity changes were small:
  - 74% of stations showed less than ±2 ppt change
- Long-term salinity trends explain less than 10% of the variance at most (72%) of the stations
- No coherent coast-wide trend of increasing or decreasing salinity
  - is consistent increase for internal basins of Chenier Plai
- There is an indication of salinity increase in the Houma Channel
  - as opposed to stations on either side, which show decreases

USACE Station 76343: Houma Navigation Canal near Crozier



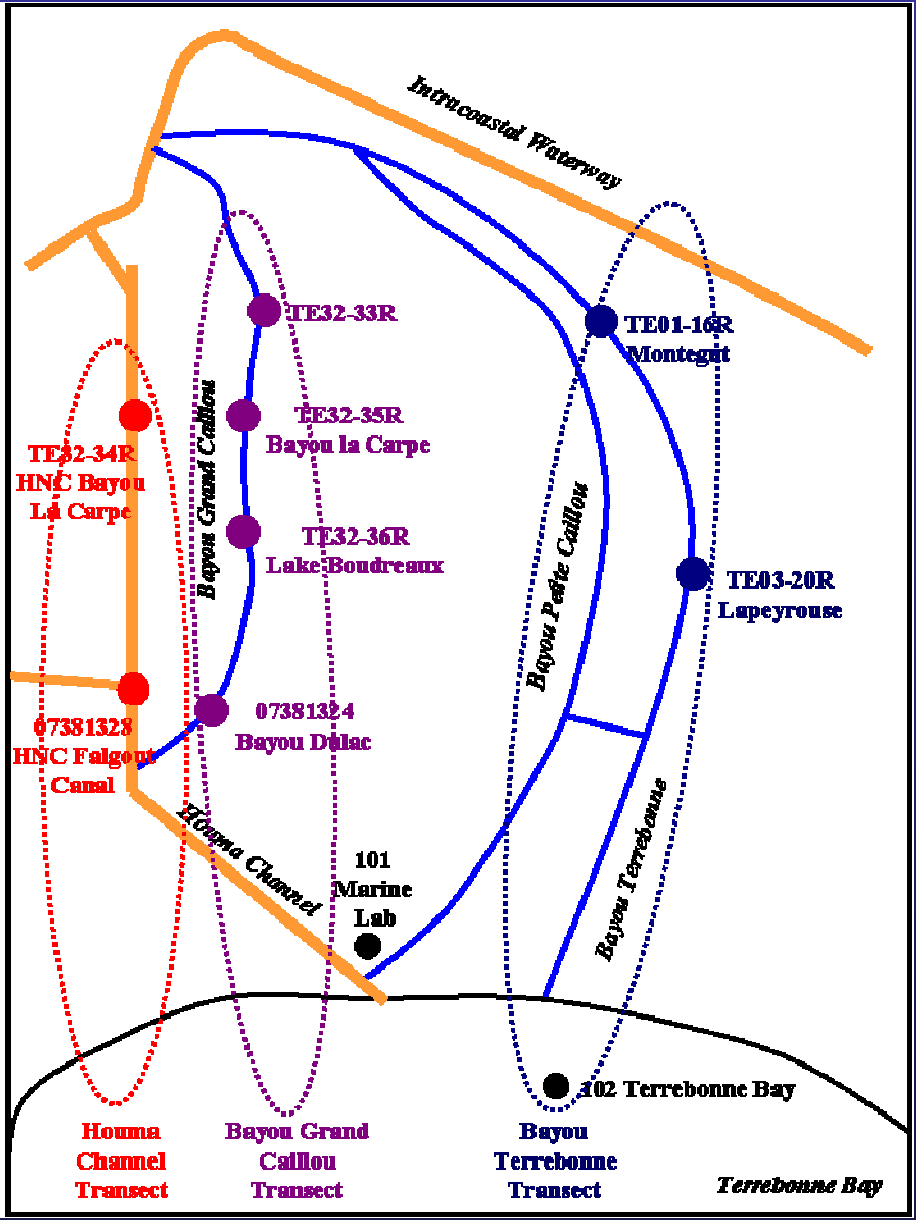
USACE Station 76343: Houma Navigation Canal near Crozier

90-Day Running Mean



2003 Analysis of Salinity Pulses within HNC

- Salinity decrease along a coast-inland gradient was lowest in the HNC.
- Salt water can intrude further inland in the HNC than in natural bayous.
- Regression analysis identified that discharge explains ~50% of observed salinity pulses in the HNC.



FRAGSTATS Overview

- FRAGSTATS: application that computes landscape metrics for categorical map patterns

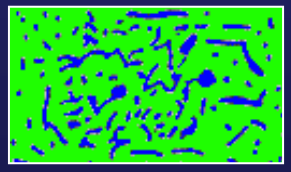
- Use of FRAGSTATS to develop a grid-based method that utilizes land/water classified image and two-part classification system:

  (1) ratio of water to land

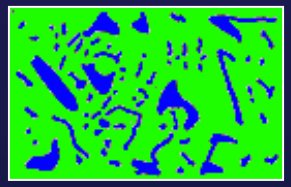
  (2) marsh water configuration & connectivity

Classification	Percentage water
1	<5%
2abc	5%–10%
3abc	10%–25%
4abc	25%–40%
5abc	40%–60%
6	60%–80%
Water	80%–100%
Other	Other non-marsh area

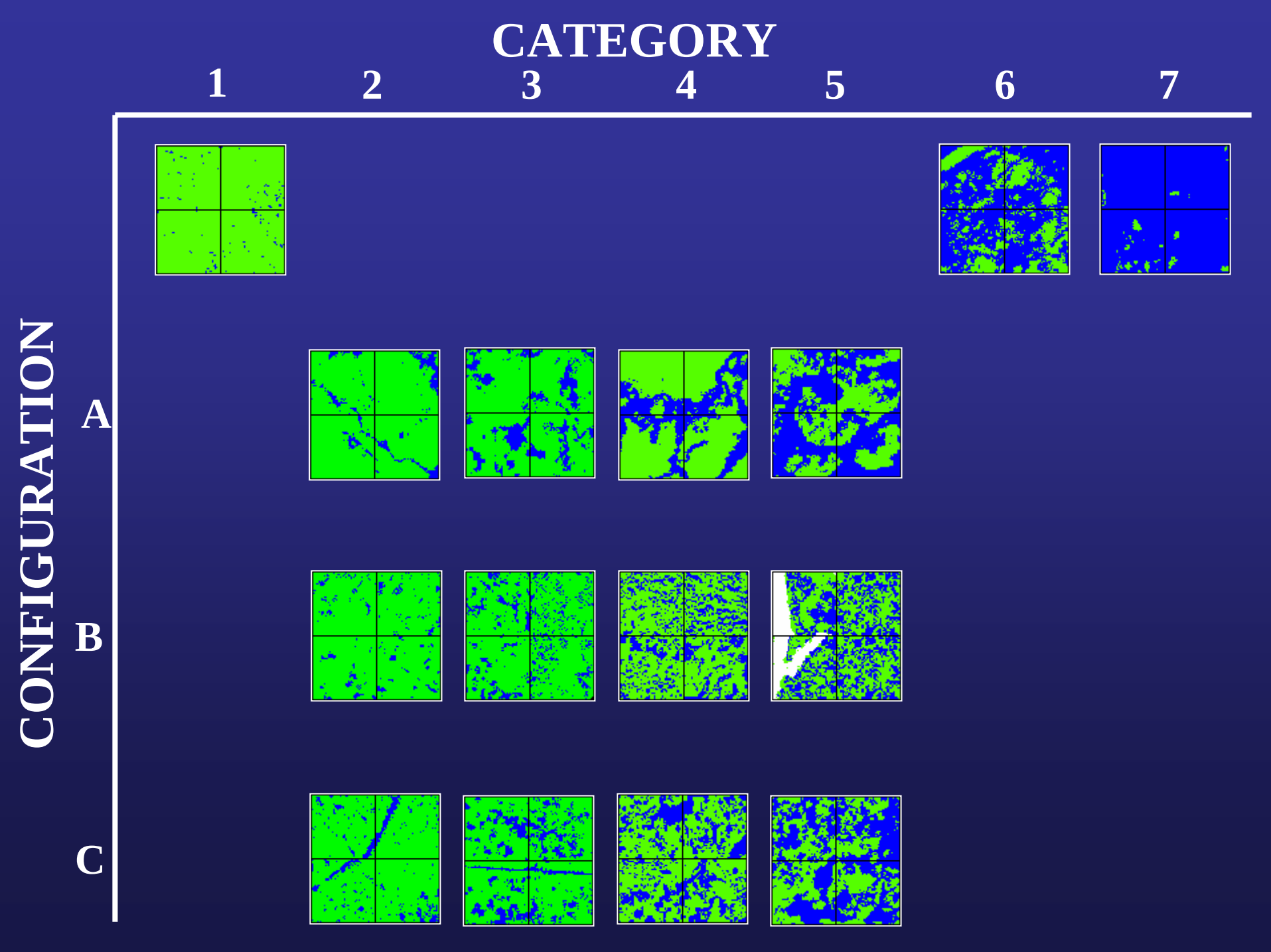
a - larger individual, randomly spaced water bodies identifiable shorelines separated by solid marsh



b - a matrix of small, regularly spaced water bodies

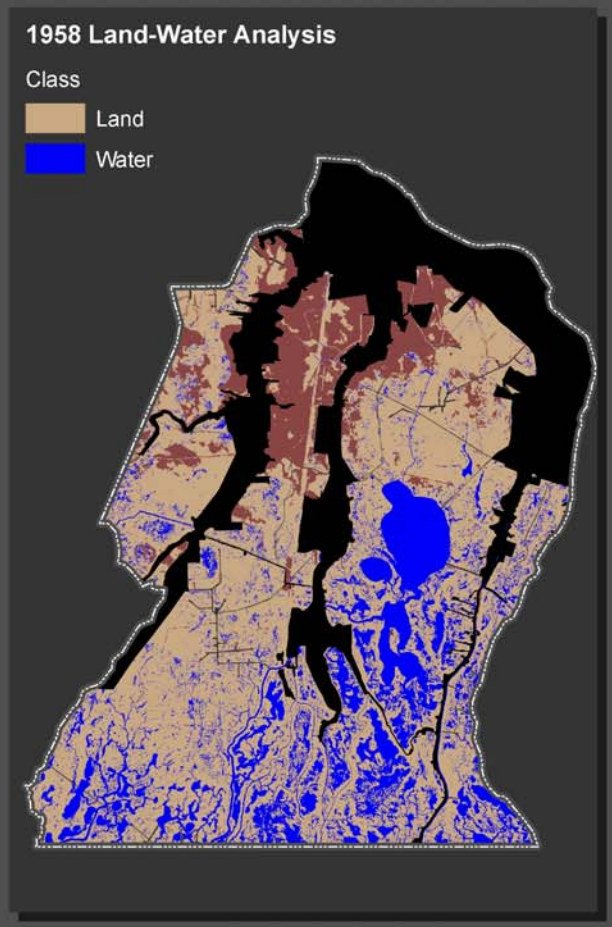


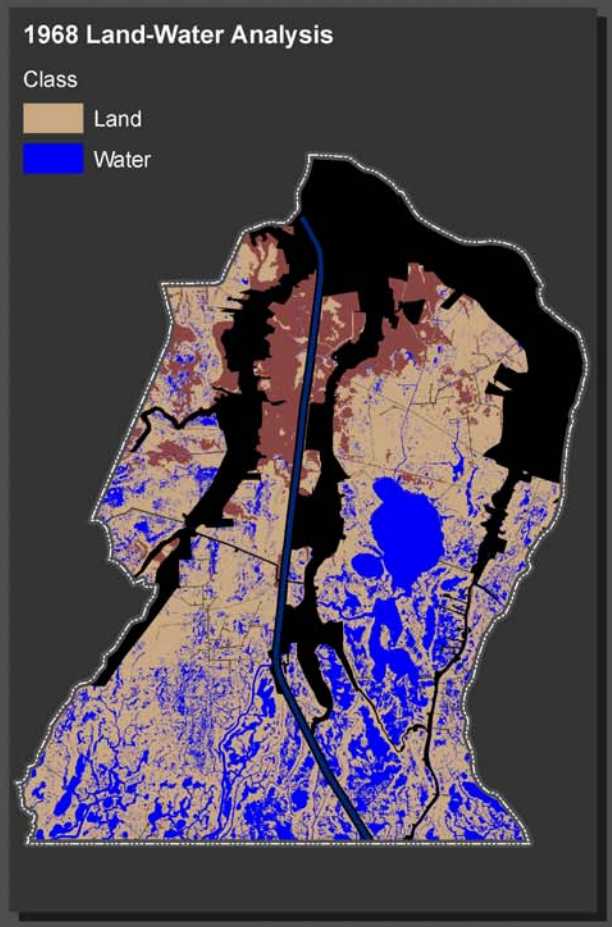
c - a combination of “a” and “b,” consisting of a matrix of small, regularly spaced water bodies within areas of larger, randomly spaced water bodies

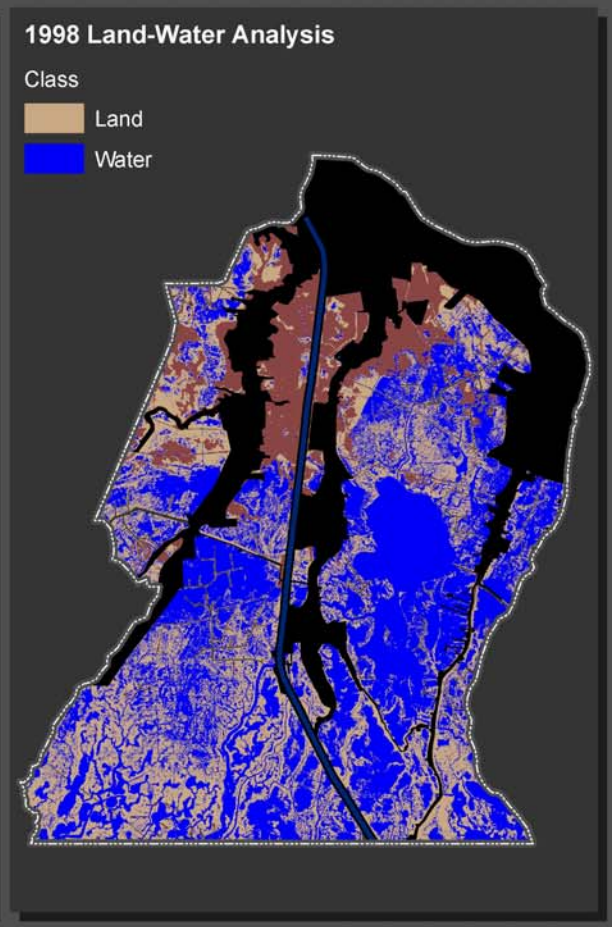

CATEGORY
1
2
3
4
5
6
7
CONFIGURATION
A
B
C

Landscape Analysis

- Three years of photography selected
  - 1958 – Pre-construction
    - » Black and white 1:24k scale
  - 1968/69 – Post-construction
    - » Black and white 1:20k scale
  - 1998 – End point
    - » Color 1:24k scale
- Land and water analysis performed on all photo
  - Landscape analysis required very fine scale land and water interpretation and classification







LEGEND

- Houma Navigation Canal
- Project Boundary
- Developed/Other
- Forest

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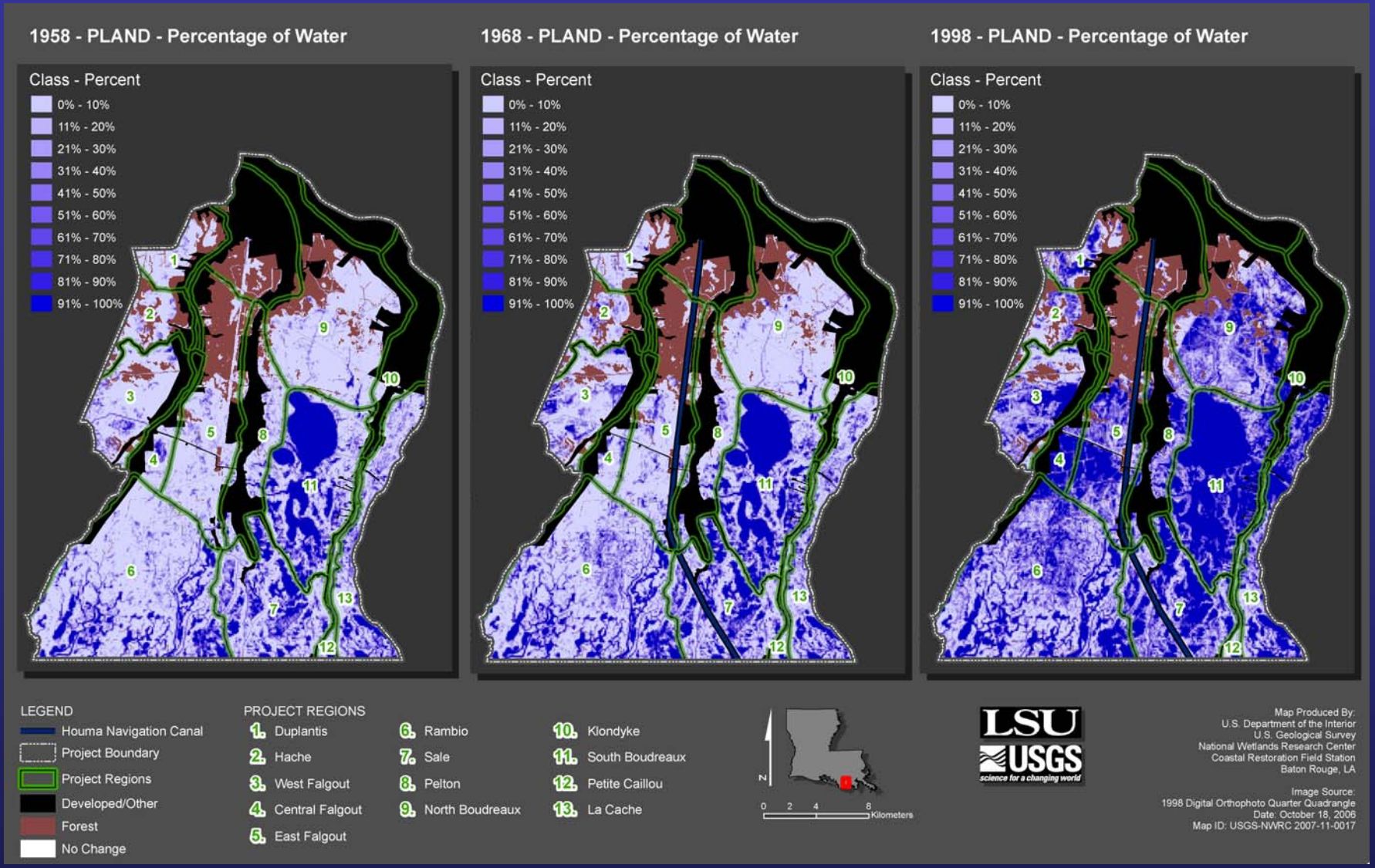
Map Produced By:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Coastal Restoration Field Station
Baton Rouge, LA

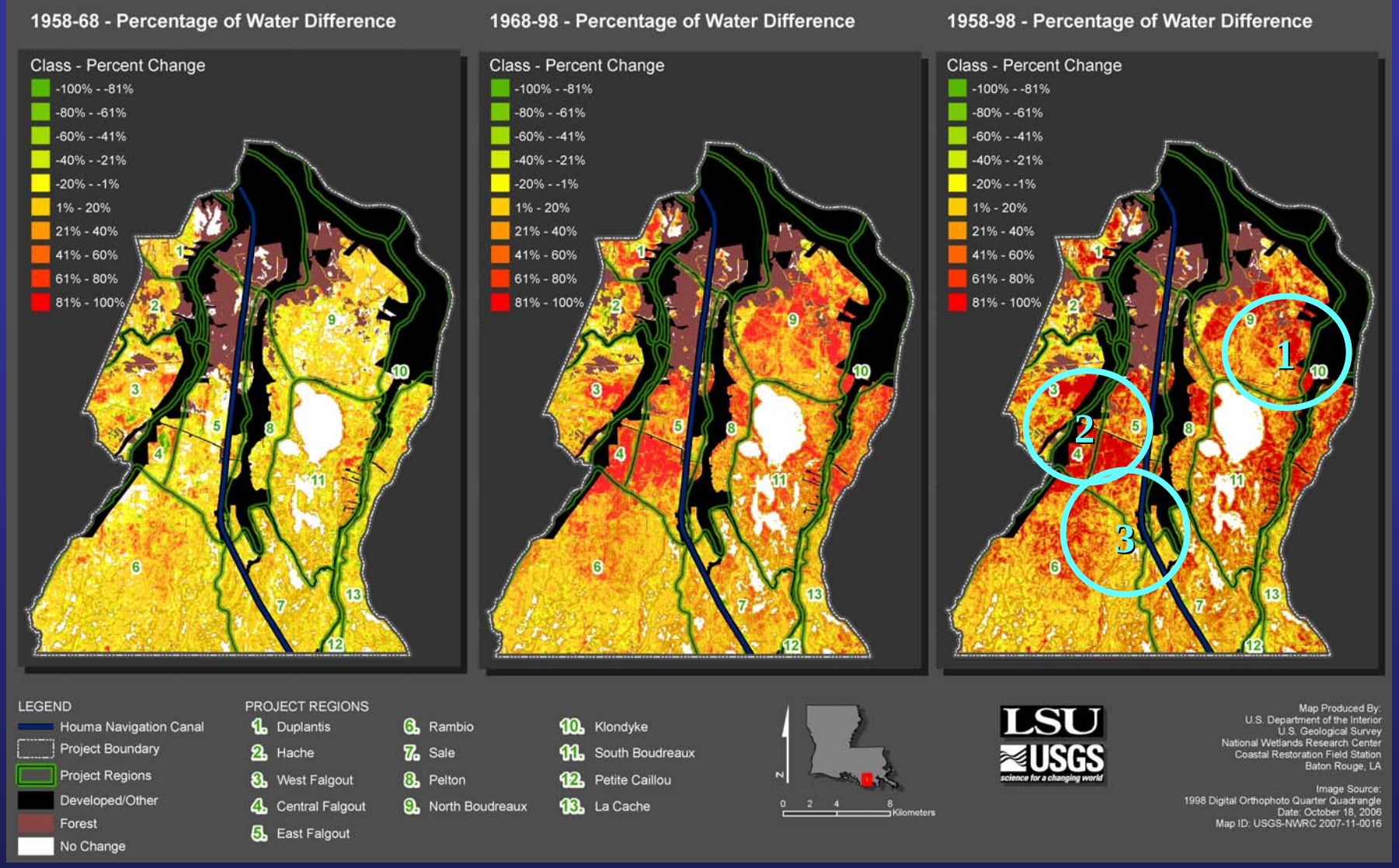
Image Source:
1958 Digital Panchromatic Photography
1968 Digital Panchromatic Photography
1998 Digital Orthophoto Quarter Quadrangle
Date: October 18, 2006
Map ID: USGS-NWRC 2007-11-0015

Landscape Analysis (cont.)

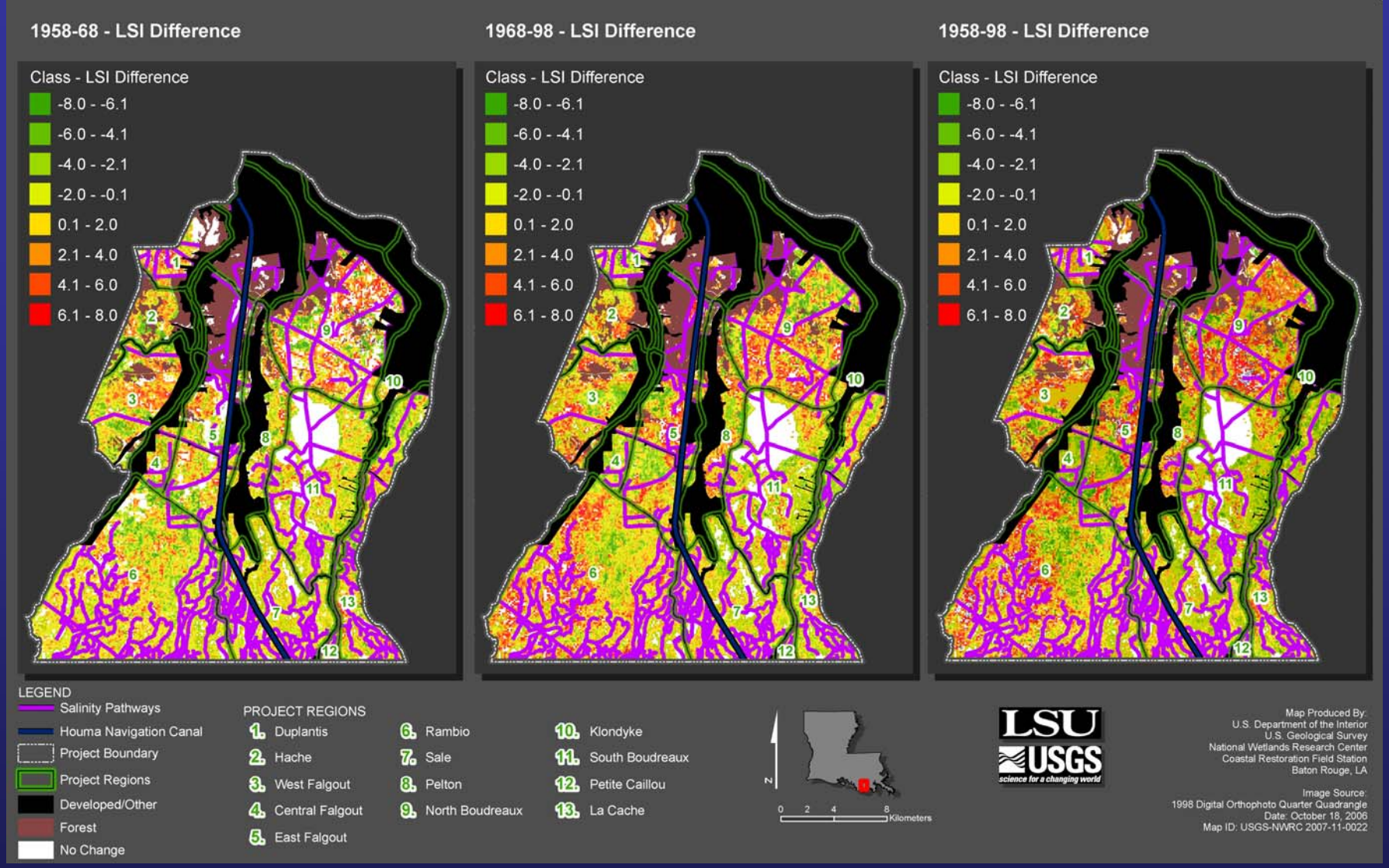
- Land and water image tiled into 1/64 km^2 grids
  - 52,146 individual project grids
- 8 Classification Metrics – Class level
  1. Number of Patches – number of land/water patches per grid
  2. Total Class Area – total area of land/water per grid
  3. Landscape Shape – class perimeter divided to give max aggregation
  4. Clumpiness Index – index of how aggregated water patches are
  5. Percentage of Landscape – proportion of water in each grid
  6. Patch Density – number of water patches divided by total area of grid
  7. Largest Patch – percentage of grid comprised of largest water patch
  8. Patch Cohesion Index – index of physical connectedness of water
- FRAGSTATS – generated class metrics for each grid



Date	TOTAL AREA	Land	Water	Other	**Location Canals**
1958	805.24	474.86	131.98	190.94	**7.46**
1968/69	805.24	448.40	155.44	190.94	**10.46**
1998	805.24	298.30	298.79	190.94	**17.21**



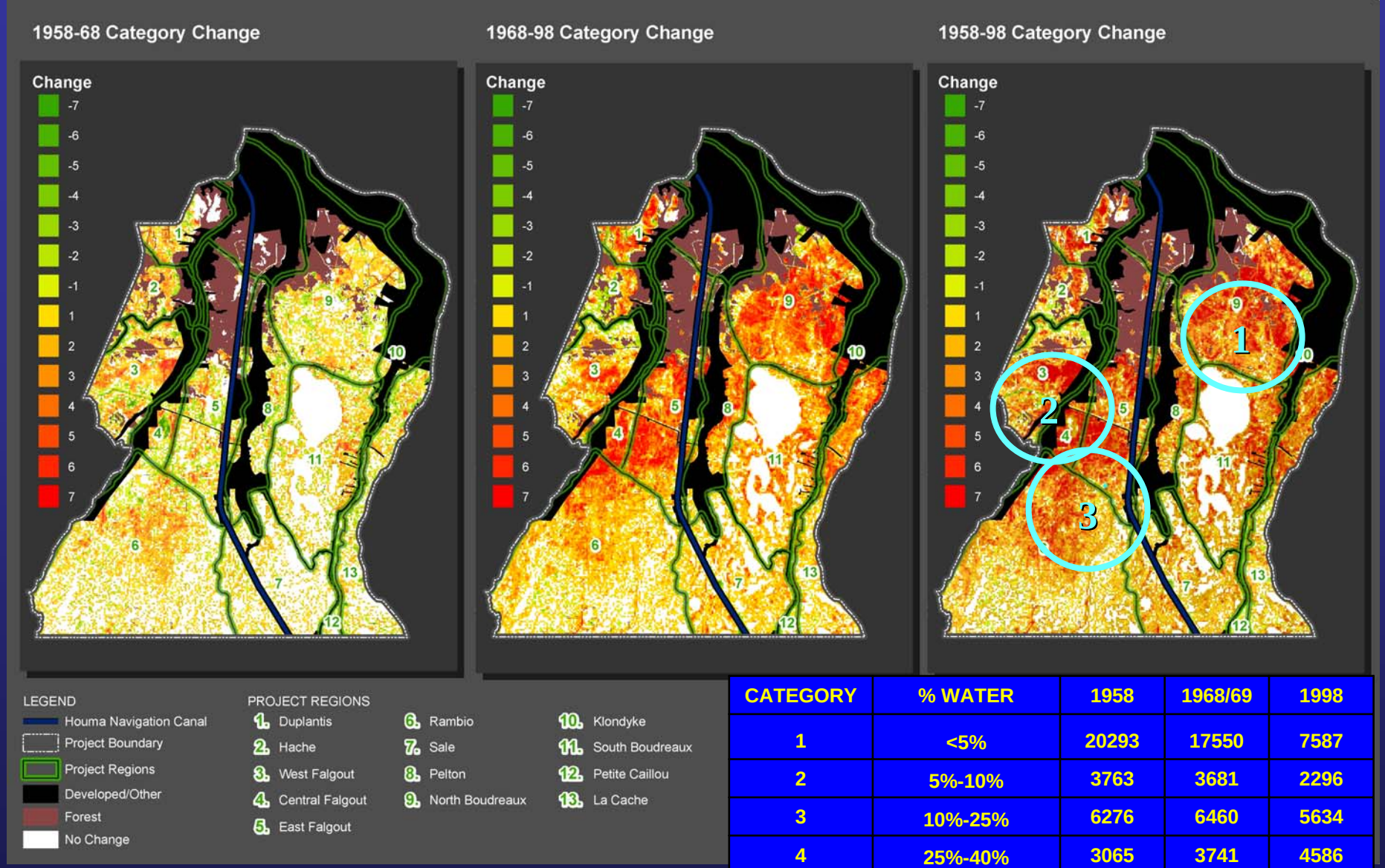
- Minimal change in % water between 1958 and 1968/69
  - Could be due to difference in quality and scale of the photography
- Three hot spots – areas that exhibit substantial change in metric values



- LSI difference illustrates the change in landscape complexity
- Moderate change in northern Boudreaux and Rambio regions between 1958–1968/69
- Same regions experiencing the majority of change by 1998 – more extensive

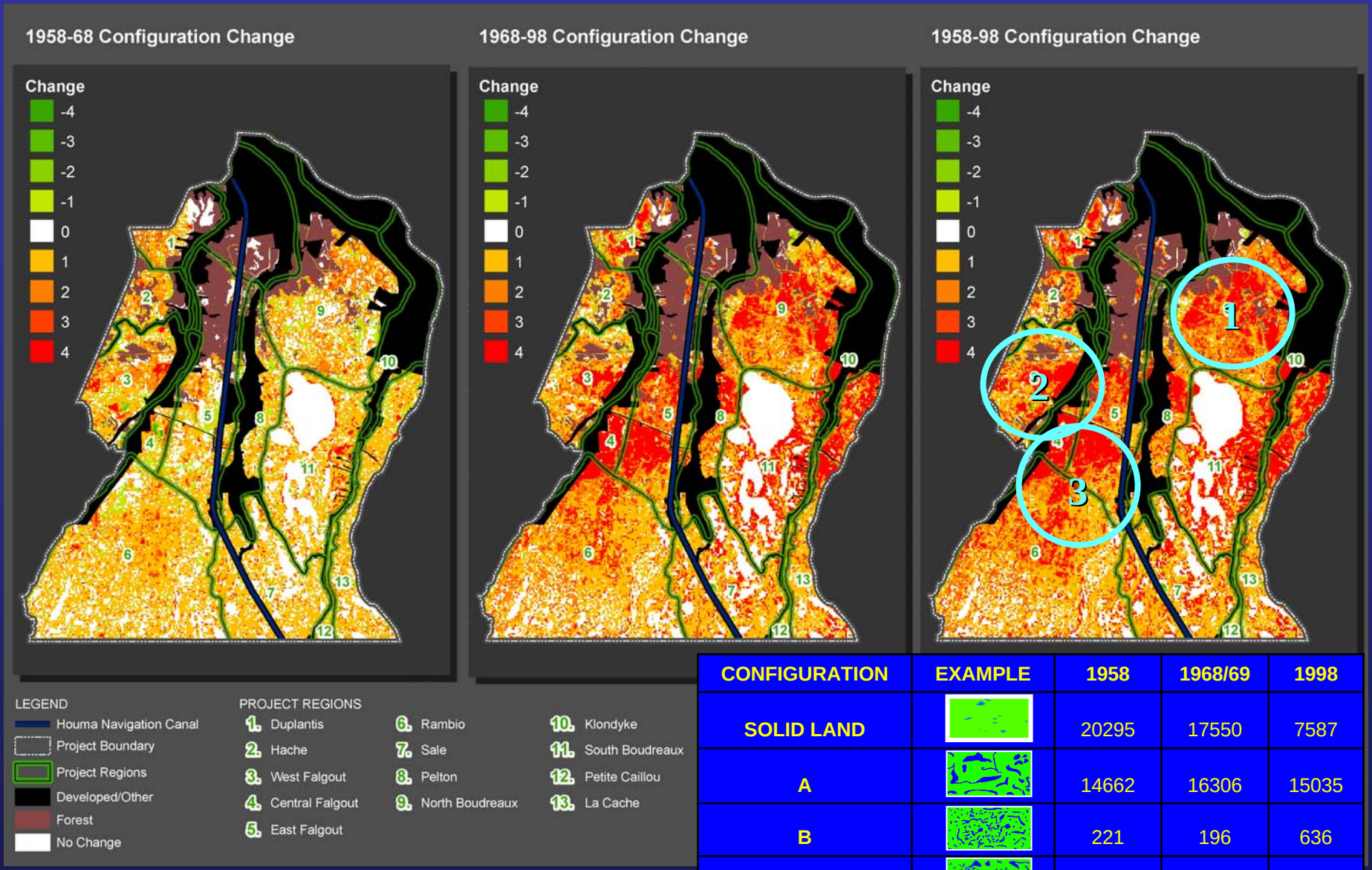
Landscape Analysis (cont.)

- Visual assessments were used to establish metric value thresholds for automated classification.
  - Those thresholds and classification criteria were applied to all metrics.
- Category Classification:
  - The change in ratio of water to marsh—used to identify areas of extreme land change
- Configuration Classification:
  - The change in shape, distribution, and connectivity of water within the marsh—used to identify areas of extreme configuration changes



CATEGORY	% WATER	1958	1968/69	1998
1	<5%	20293	17550	7587
2	5%-10%	3763	3681	2296
3	10%-25%	6276	6460	5634
4	25%-40%	3065	3741	4586
5	40%-60%	2515	3213	5162
6	60%-80%	1644	2095	4605
7	80%-100%	4172	4990	11860

Summary count of category classes



CONFIGURATION	EXAMPLE	1958	1968/69	1998
SOLID LAND		20295	17550	7587
A		14662	16306	15035
B		221	196	636
C		736	593	2007
WATER		5816	7085	16465

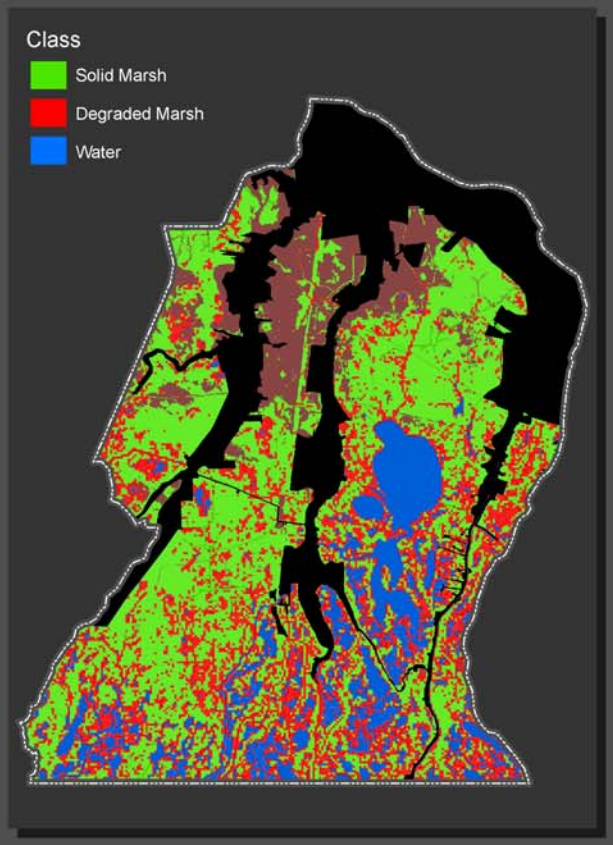
Summary count of category classes

Landscape Analysis (cont.)

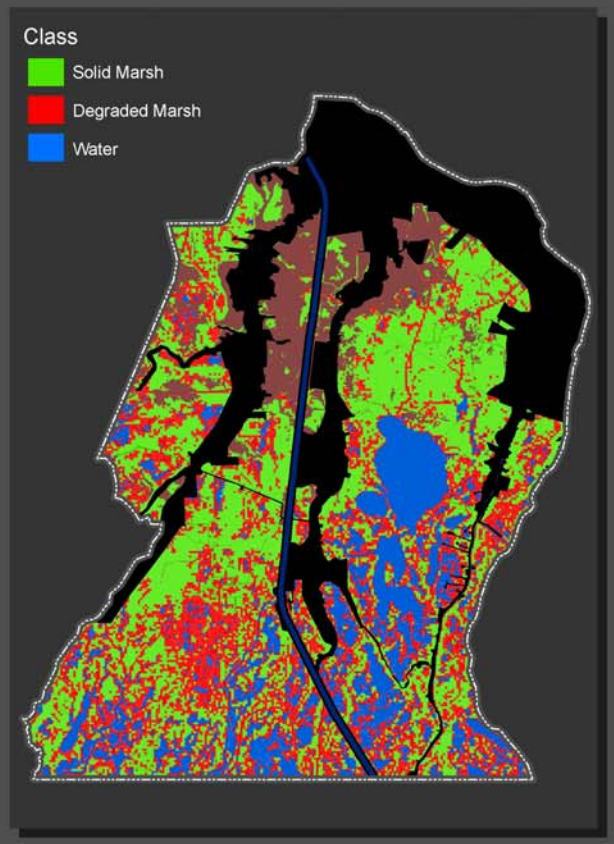
- Fragmentation Classification:
  - Two tier class system – category and configuration
  - Complex method used to perform class scale analysis of marsh fragmentation and condition
- Degradation Classification
  - Less complex method used to analyze marsh degradation
  - Combines fragmentation classes – based on level of degradation

% of WATER	Marsh Classes	Dozier (1983) Categories
0%-10%	Solid marsh	1, 2a, 2b
10%-60%	Degraded marsh	2c, 3a, 3b, 3c,
		4a, 4b, 4c,5a, 5b, 5c
>60%	Water	6,7

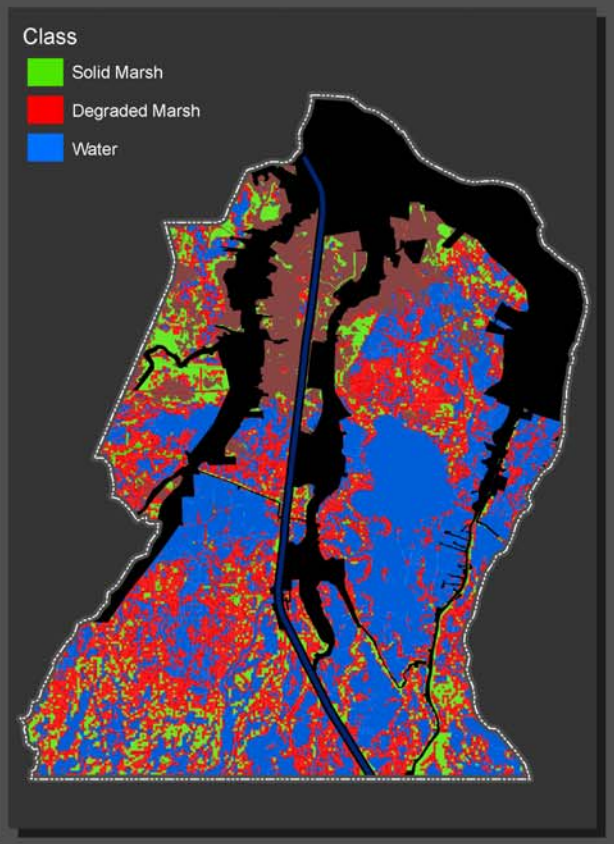
1958 Marsh Degradation Classification



1968 Marsh Degradation Classification



1998 Marsh Degradation Classification



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Map Produced By:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Coastal Restoration Field Station
Baton Rouge, LA

Image Source:
1998 Digital Orthophoto Quarter Quadrangle
Date: November 06, 2006
Map ID: USGS-NWRC 2007-11-0064

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Buffer/Zone Analysis

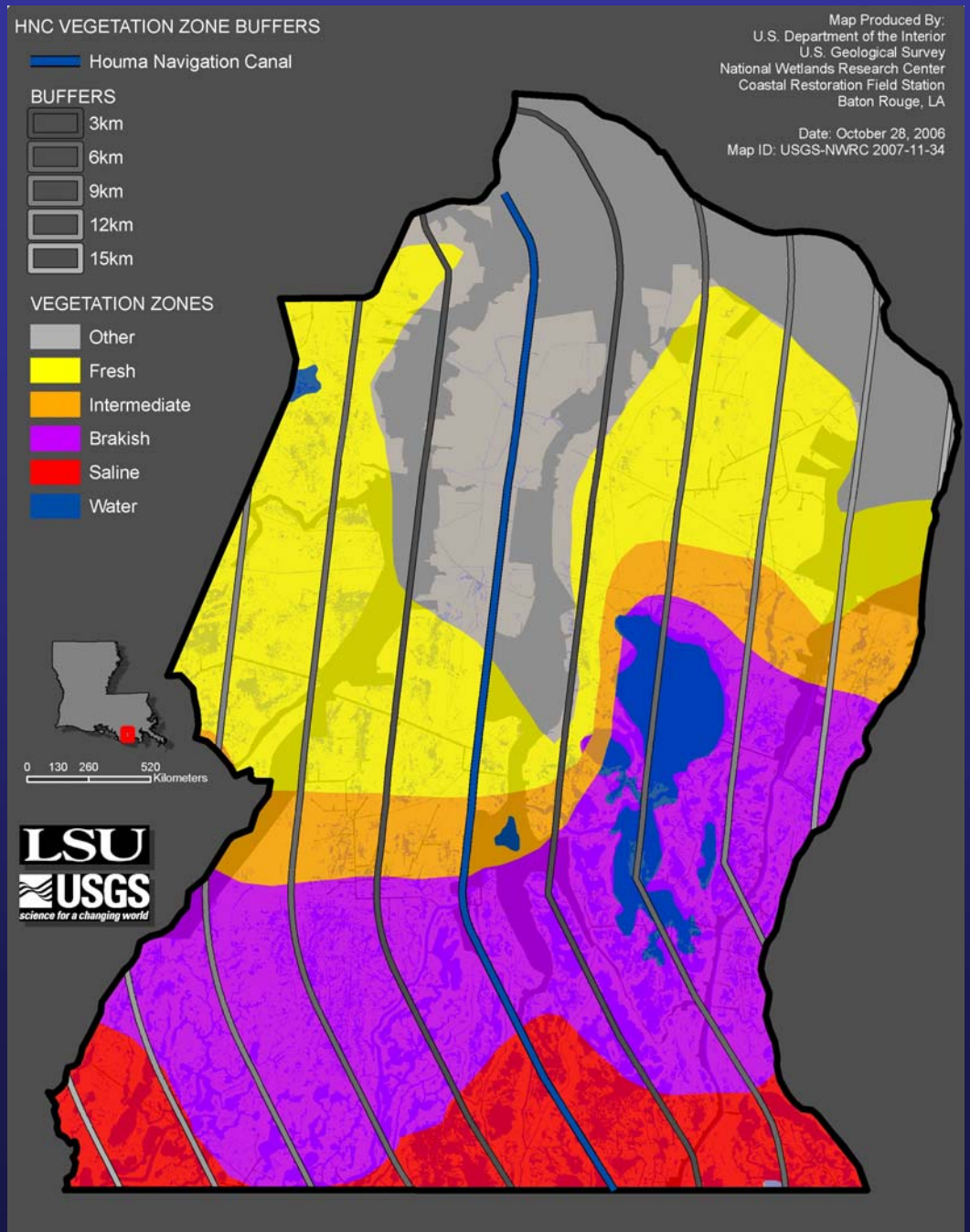
Buffers

- 3 km interval buffers from the HNC
  - (3, 6, 9, 12, 15, 18)
- Examine marsh change with respect to distance from HNC

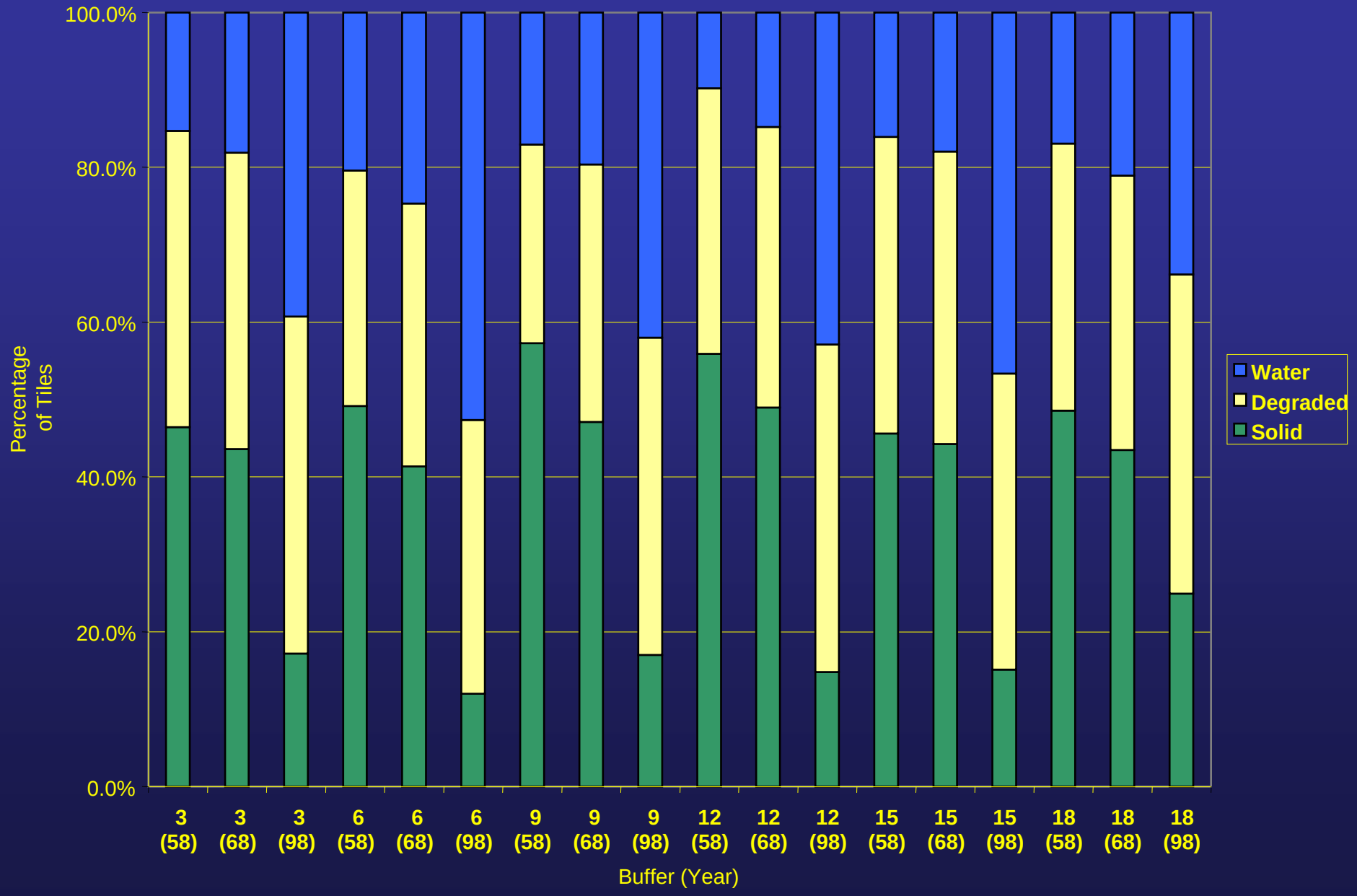
Marsh Zones

- 1968 Vegetation zones
  - (Chabreck, Joanen, and Palmisano)
- Examine landscape change with respect to marsh type

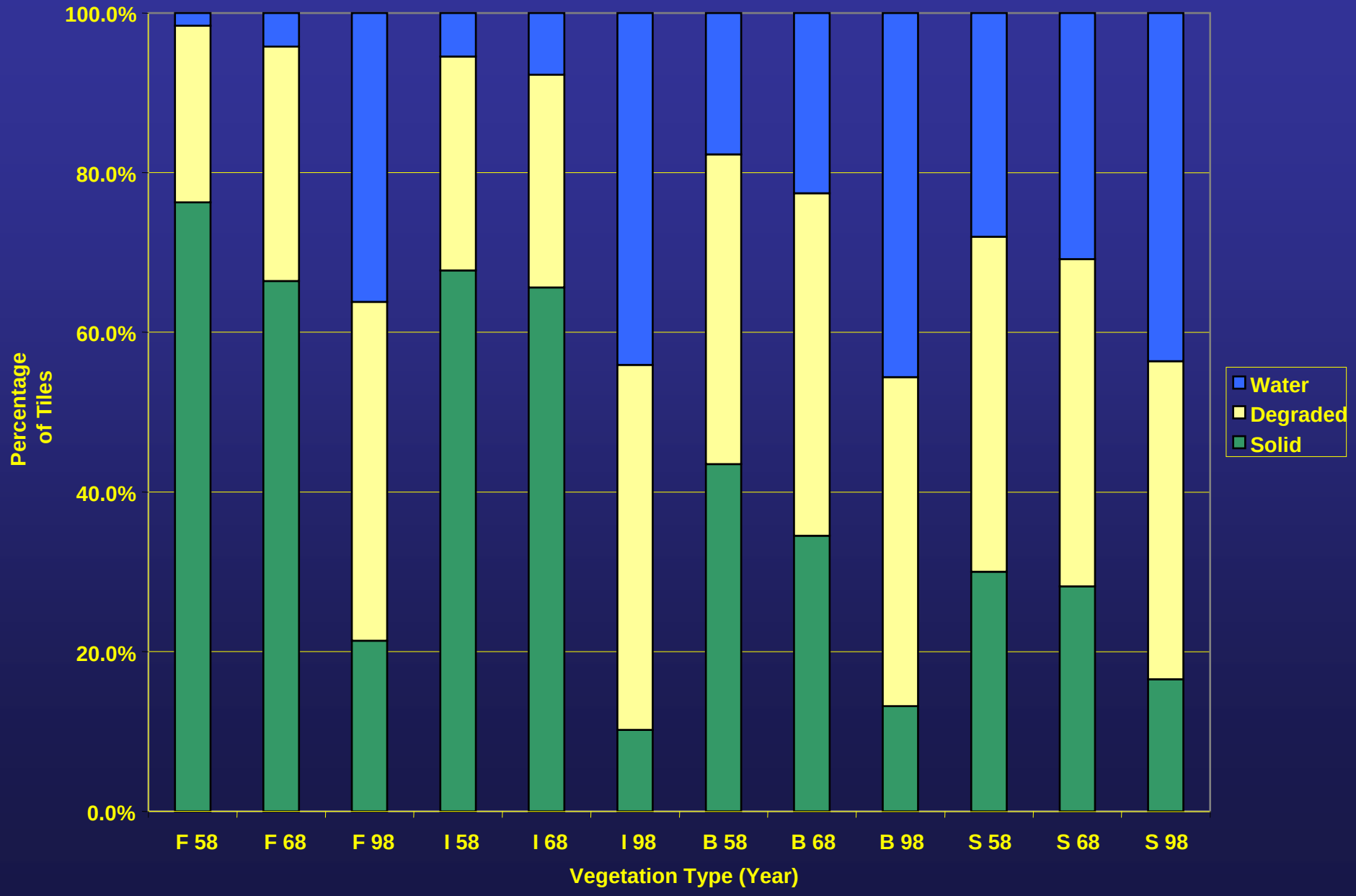
Project Area Vegetation and Buffer Zones



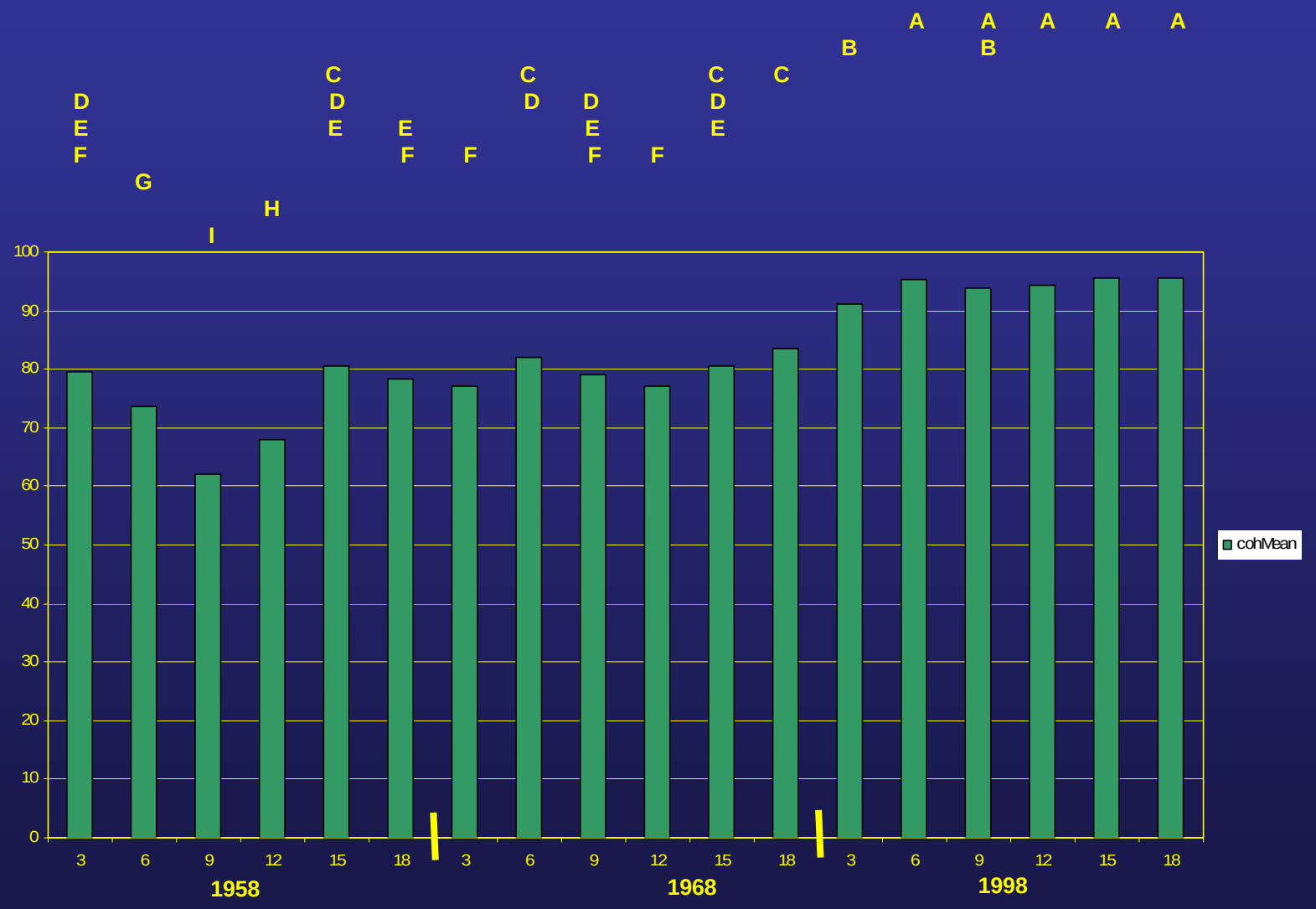
Marsh Condition by Buffer Zone and Years



Marsh Zone by Year



Correlation Analysis (Duncan) of Buffer Zones and Years



Preliminary Findings and Next Steps

Landscape:

- Overall the project area underwent a dramatic shift from solid marsh in 1958 to a landscape that is highly degraded in 1998
- Isolated three hotspots of change:
  - Hot Spot 1 – north and east of Lake Boudreaux
  - Hot Spot 2 – northwest of Falgout Canal
  - Hot Spot 3 – southeast of Falgout Canal
- Possible cause of hotspots
  - Active faulting in the Boudreaux region
  - Location canal and salinity pathways in the Falgout regions

Preliminary Findings and Next Steps

Buffer/Vegetation Zones:

- Metric value changes not correlated to distance from HNC
- Changes appear more related to vegetation than buffer zones
  - With greater change occurring in fresher zones

Next Steps

- Continue examination of finer scale changes between 1958 and 1968/69 data
- Examine statistical relationships between vegetation zones and change in metric values

Reference

Chabreck, R. H., T. Joanen, and A.W. Palmisano. 1968. Vegetative type map of the Louisiana Coastal Marshes. Louisiana Department of Wildlife and Fisheries, NewOrleans, LA.