
TEXAS
PARKS &
WILDLIFE
Coastal Studies Program

ENVIRONMENTAL WATER QUALITY CHARACTERIZATION OF THE TEXAS COAST FROM NATIONAL COASTAL ASSESSMENT DATA

by

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Texas Water Development Board

Acknowledgements

Sponsors

- *EPA's Office of Research and Development*

Contract Laboratories

- *HESS, Inc.*
- *University of Texas Marine Science Institute*
- *Texas A&M Oceanography Department*
- *Texas A&M Center for Coastal Studies*

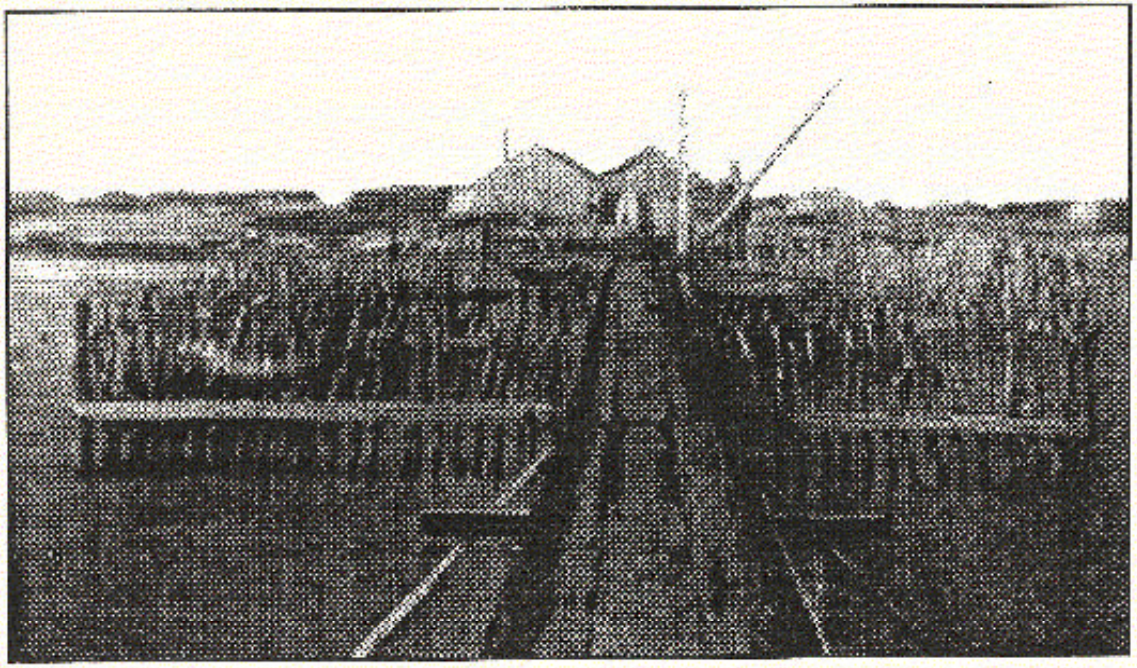
Personnel

- *Michael Weeks*
- *Steven Mitchell*
- *Jennifer Bronson*
- *Charles Smith*
- *Coastal Fisheries technicians, biologists and ecosystem leaders.*
- *Resource Protection biologists.*
- *Environmental Chemistry Laboratory personnel.*

AGENDA

- Historical perspective
- Study design
- Sampling parameters and methods
- Results
- Summary

Historical Perspective



The Fulton turtle pens, with processing plant in background. Worker, center right, gives size perspective.

—Courtesy Gayle Atwood, from the 1889-1891 *Report on the Coastal Fisheries of Texas*, from the Library of The University of Texas at Austin.

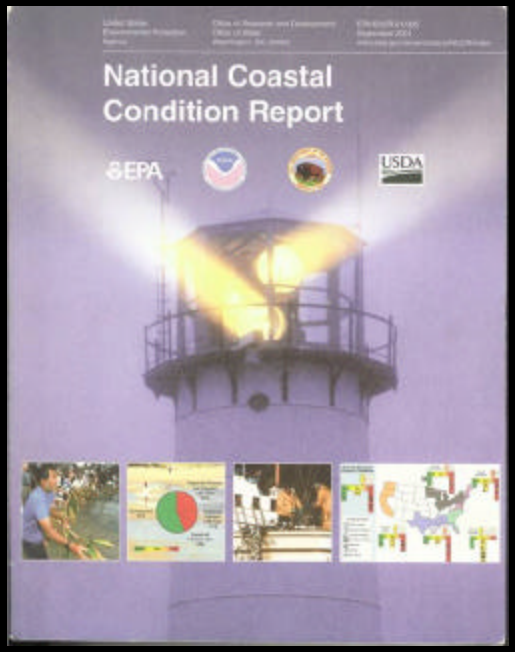
EPA's EMAP-E Program

- Assess ecological conditions using environmental monitoring data from multiple spatial and temporal scales

- From 1991 to 1995 EMAP collected data on ecological indicators from estuaries in the Gulf of Mexico

- "The Ecological Condition of Estuaries in the Gulf of Mexico", was published in July 1999.

- The "National Coastal Condition Report I" was published in 2001.



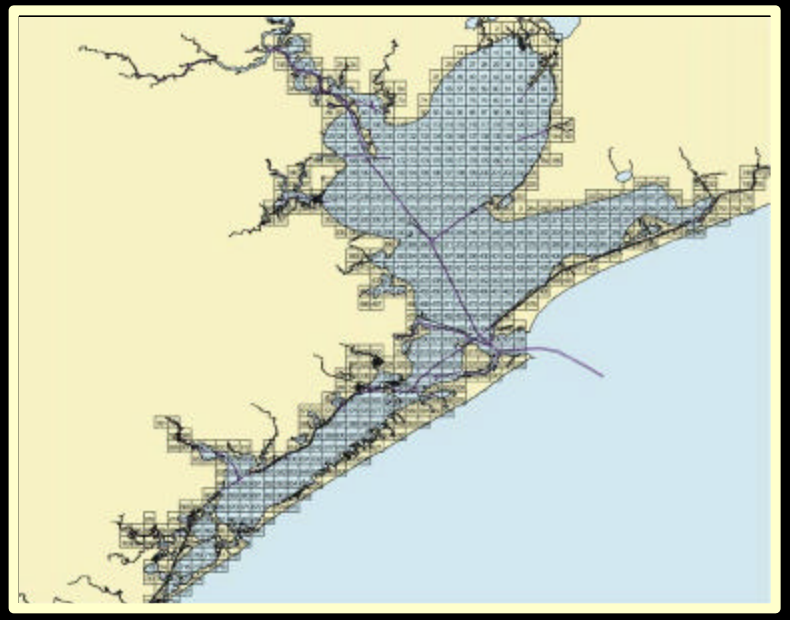
Texas NCA Program

- 1999
  - Nine stations are sampled for DO as part of the Gulf of Mexico Program's JGSMP
- 2000
  - Forty-four stations are sampled for Coastal 2000
  - Two boat technique used to reduce station time
- 2001
  - Fifty-nine stations are sampled for NCA
  - OW funds 9 stations in Galveston Bay
  - Galveston Bay Estuary Program volunteers in the field
  - Center for Coastal studies assists in collection of ULM

Texas NCA Program

- 2002
  - Ninety-nine stations are sampled
  - CBBEP funds 50 stations in their region
  - CCS collects samples in the CB region
  - bio-bags are used for the collection of benthos samples
  - GBEP assists in the field in SL and GB
- 2003
  - 107 water and 81 sediment stations are sampled
  - TCEQ partners with TPWD for GB sampling
  - Galveston Bay Foundation volunteers in field
  - GBEP continues to assist in the field
  - CCS collects samples in the CB region

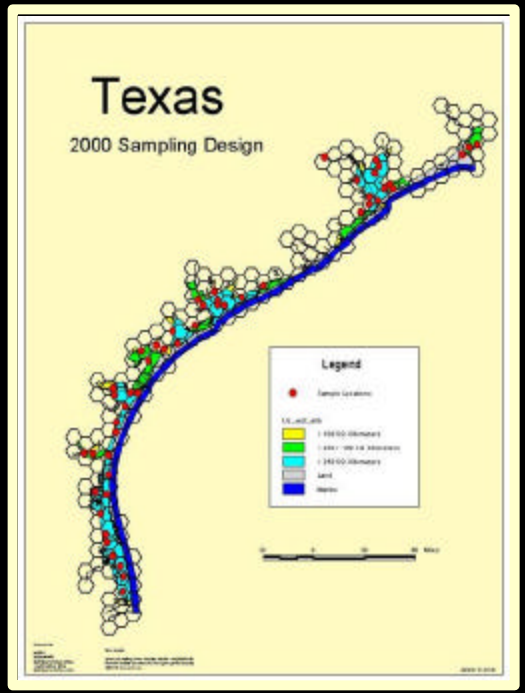
Study Design



- Stations are initially selected from the spatial grid of the TPWD Coastal Fisheries Division's fisheries independent monitoring program.

- Selections for July and August are sent to EPA in Gulf Breeze for selection using a hexagonal grid.

- Design allows for an unbiased estimate of ecological condition



Sampling Parameters and Methods

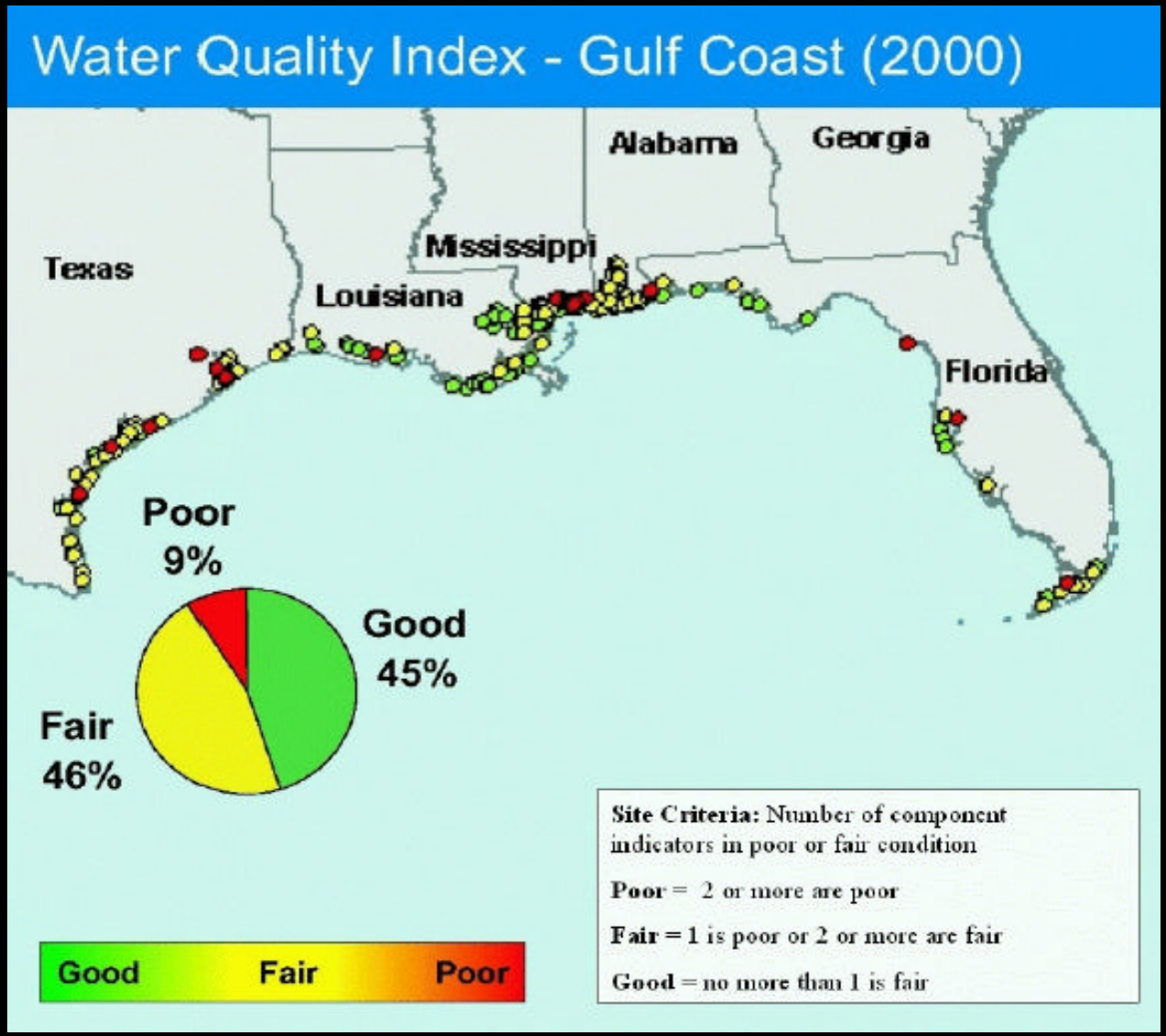
Sampling Parameters

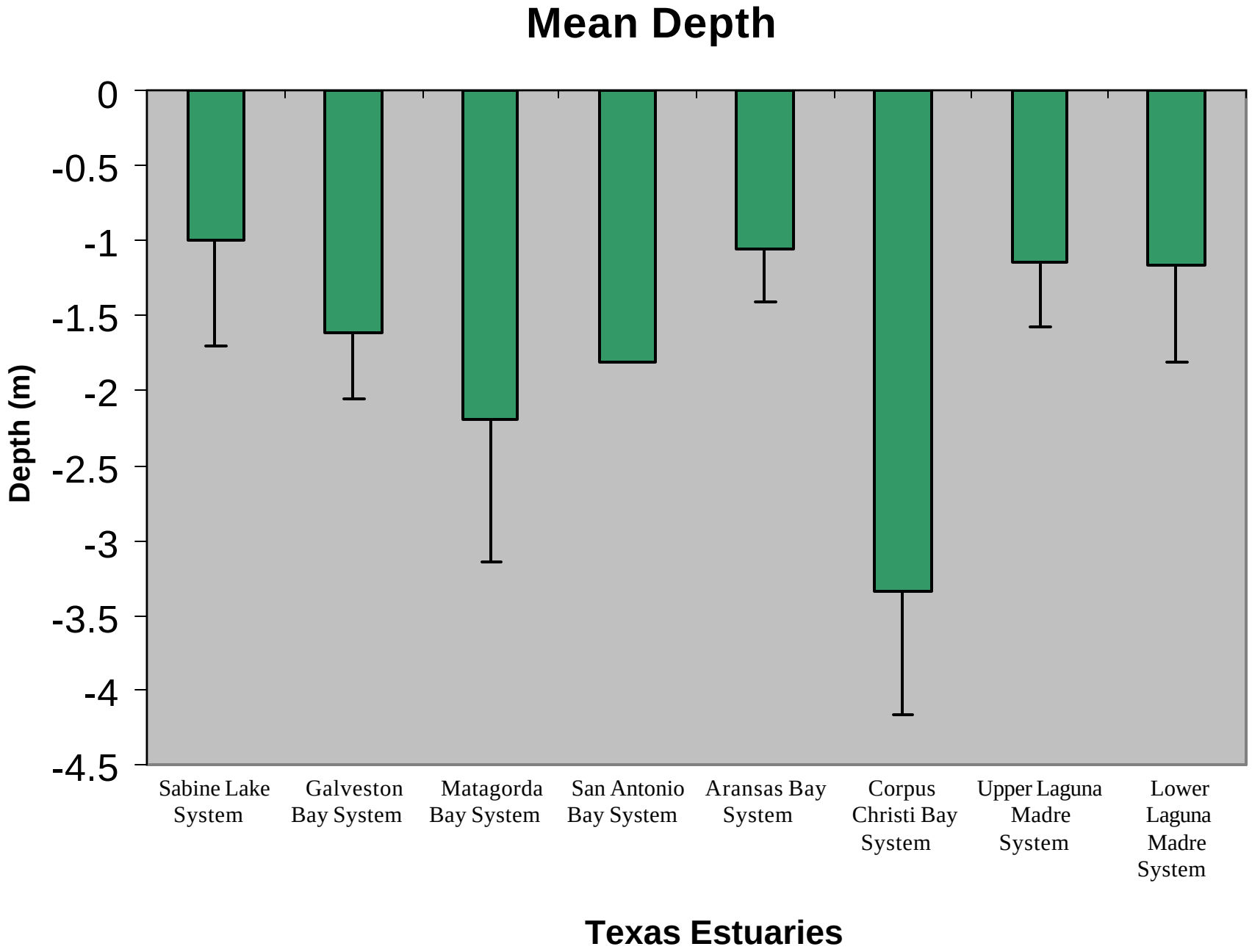
- Water Quality
- Sediment Quality
- Tissue Quality
- Biotic Communities

Water Parameters

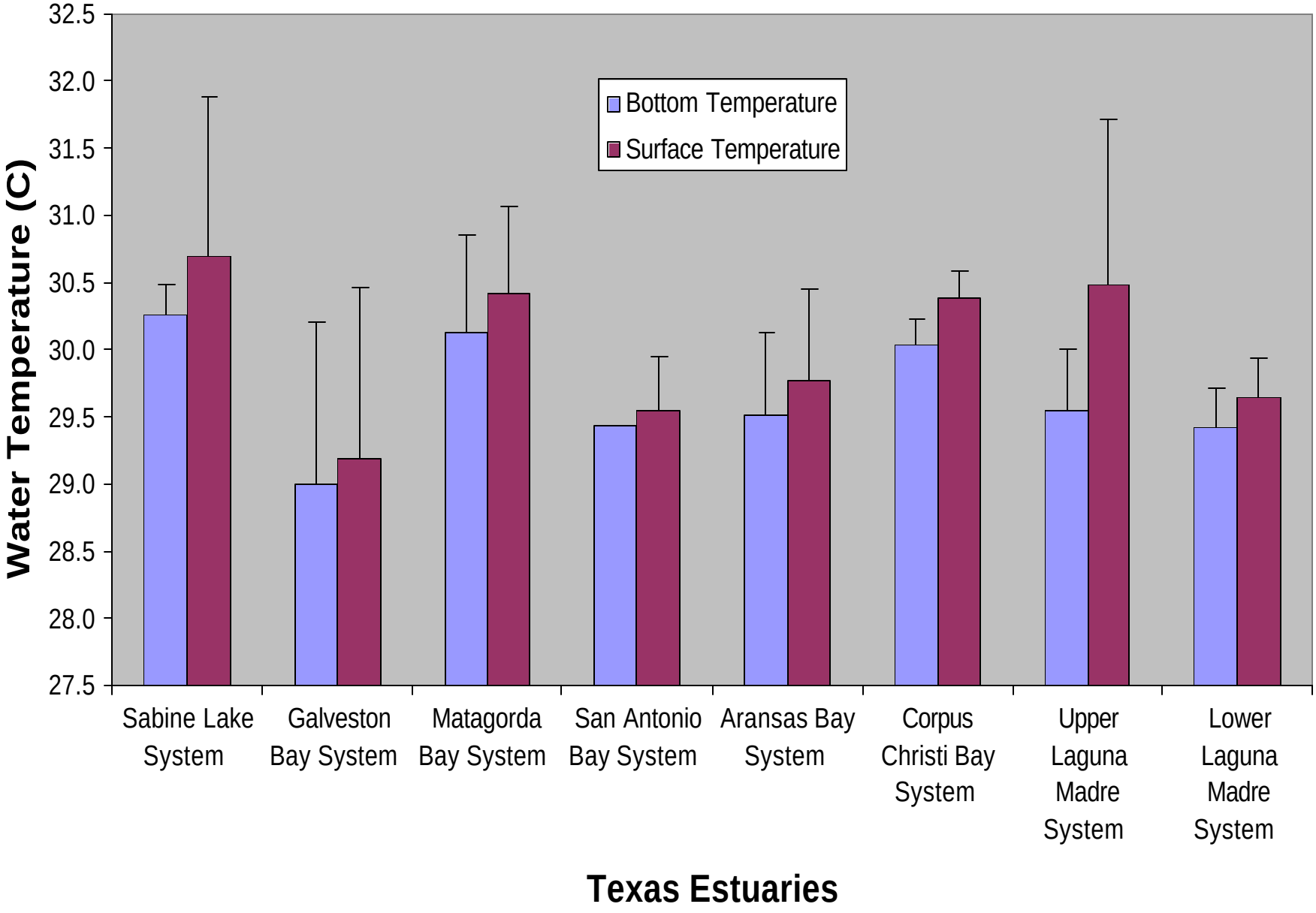
- Temperature, salinity, pH, dissolved oxygen
- Total Suspended Solids (TSS)
- Light transmissivity
- Nutrients
- Chlorophyll a

Results

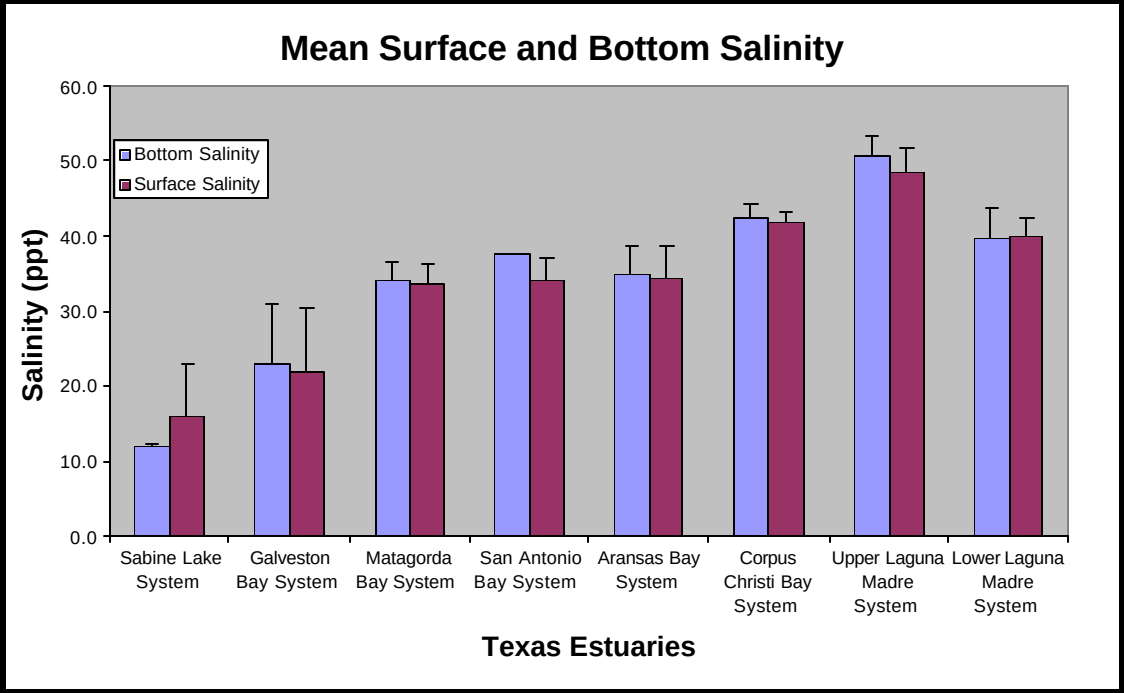

Water Quality Index - Gulf Coast (2000)
Alabama
Georgia
Texas
Mississippi
Louisiana
Florida
Poor
9%
Good
45%
Fair
46%
Good
Fair
Poor
Site Criteria: Number of component indicators in poor or fair condition
Poor = 2 or more are poor
Fair = 1 is poor or 2 or more are fair
Good = no more than 1 is fair

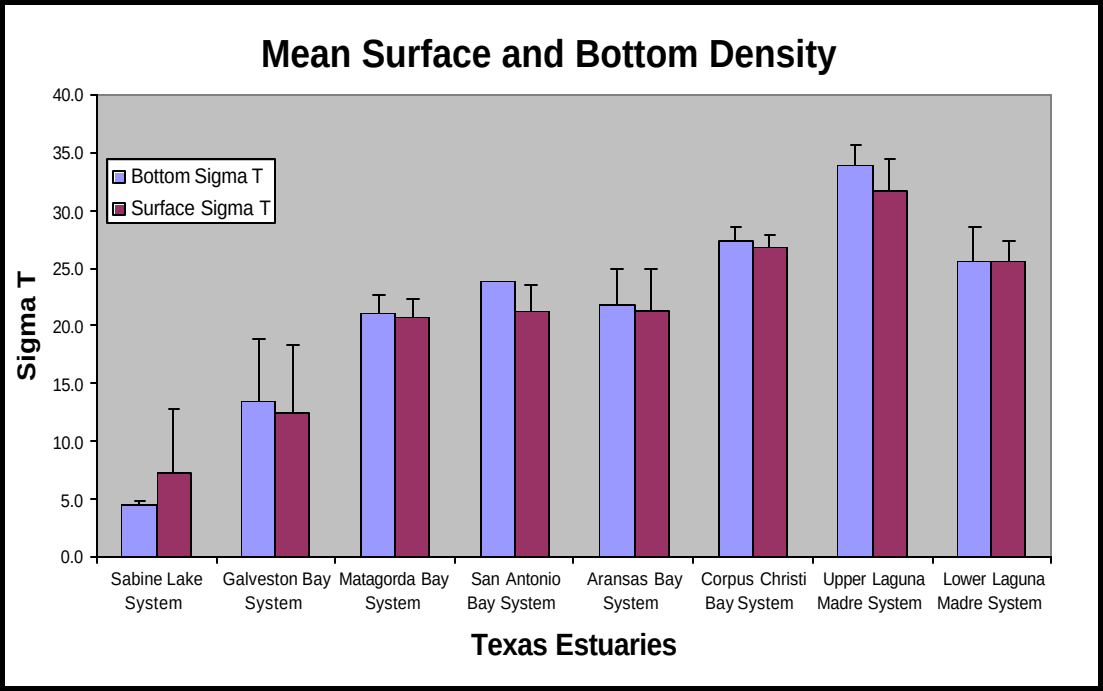

Mean Depth
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
Depth (m)
Sabine Lake System
Galveston Bay System
Matagorda Bay System
San Antonio Bay System
Aransas Bay System
Corpus Christi Bay System
Upper Laguna Madre System
Lower Laguna Madre System
Texas Estuaries

Mean Surface and Bottom Water Temperature



- Salinities predictably increase from north to south.
- Bottom salinities are, in general, greater than surface salinities.

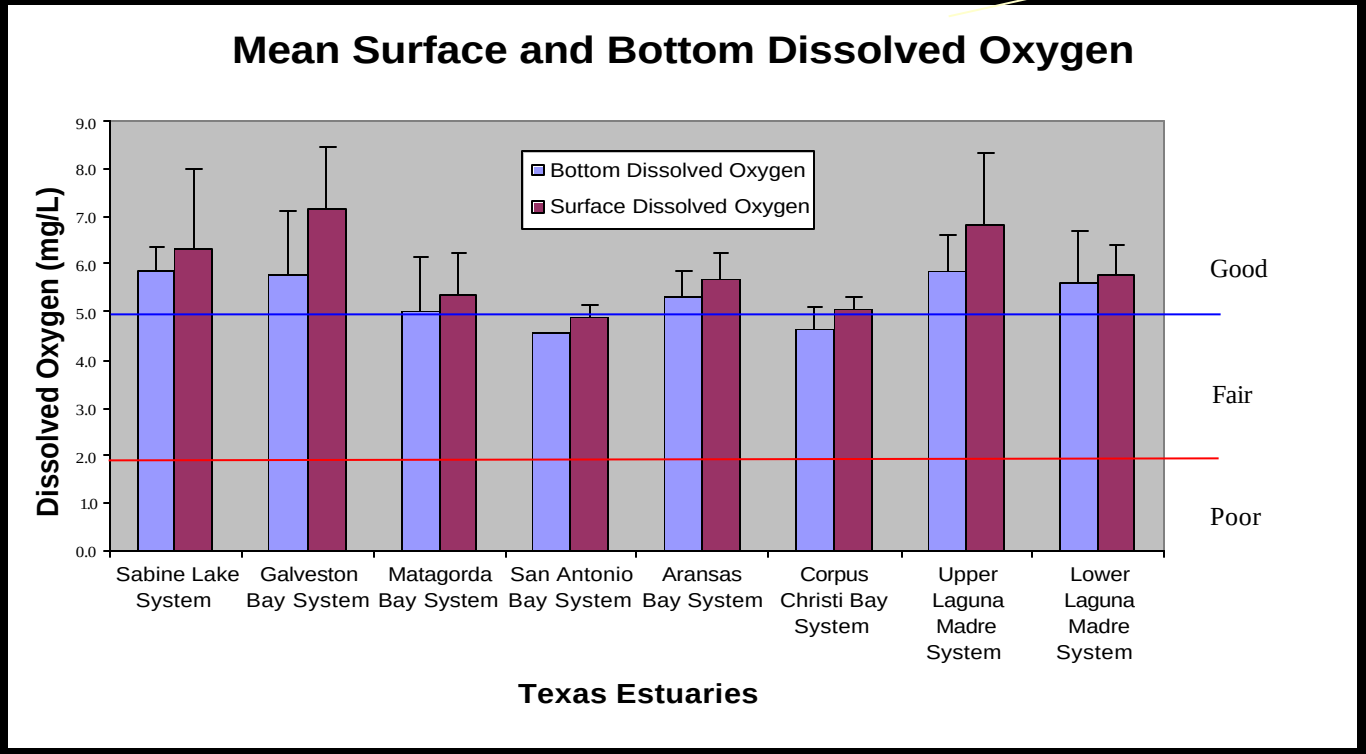




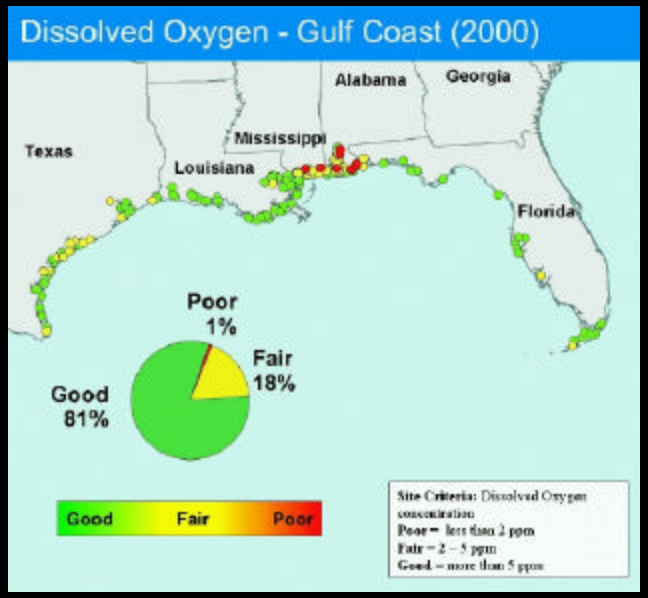
- Densities mimic salinities along the coast.
- Density was calculated using the following formula.

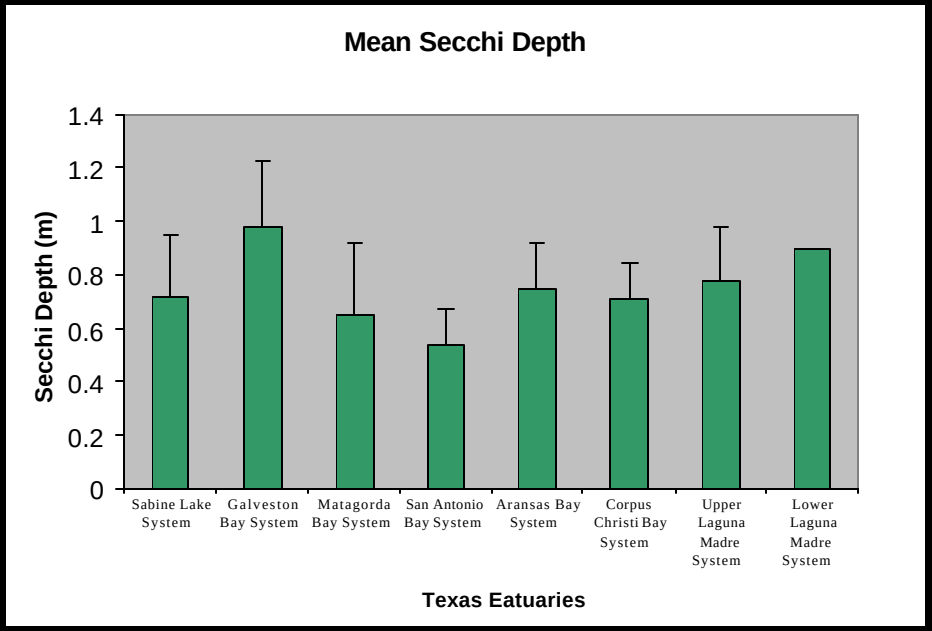
$$s = E1 / (T + 67.26) + E2$$

```
E2 = (B2 * S0 + B1) * S0
B2=((1.667E-8*T-8.164E-7)*T+1.803E-5)*T
B1=((-1.0843E-6*T+9.8185E-5)*T-0.0047867)*T+1
E1=(((-1.4380306E-7*T-0.00198248399)*T-
    0.545939111)*T+4.53168426)*T
S0=((6.76786136E-6*S-4.8249614E-4)*S+
    0.814876577)*S-0.0934458632
```



- Surface dissolved oxygen was greater than bottom values.
- Mean dissolved oxygen was slightly lower in the mid-coast.
- Two mid-coast bays had only fair levels of dissolved oxygen.



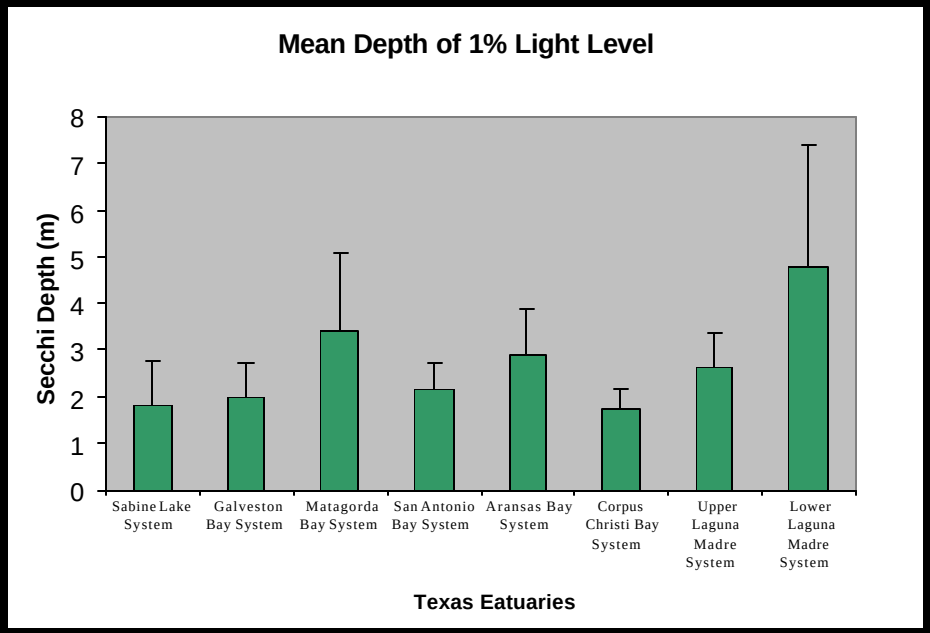


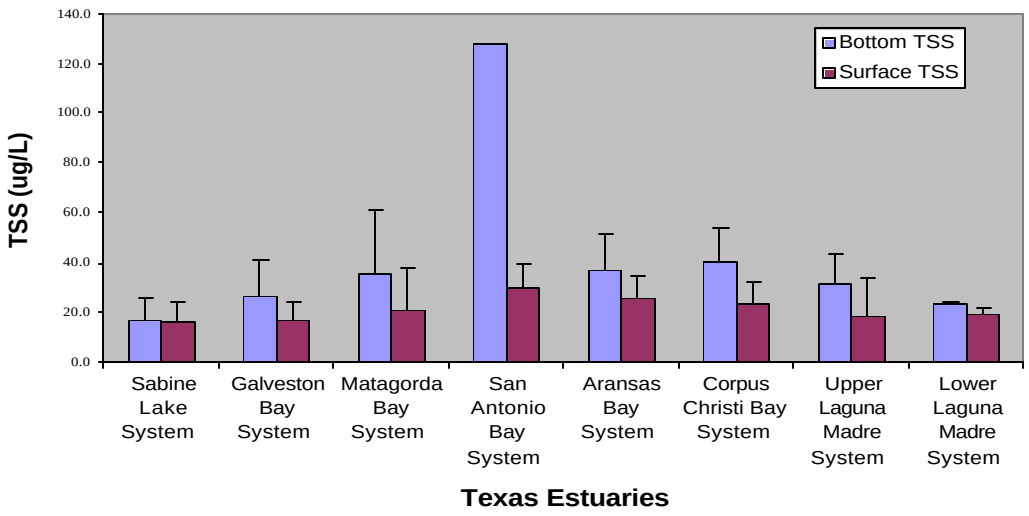
- Secchi depths were greatest in Galveston Bay
- Secchi depths are problematic in the shallow Laguna Madre

- The depth at which light is 1% of the surface ambient light is calculated:

$$Z(1\%) = (\ln(I_o) - \ln(I_z)) / k_d$$

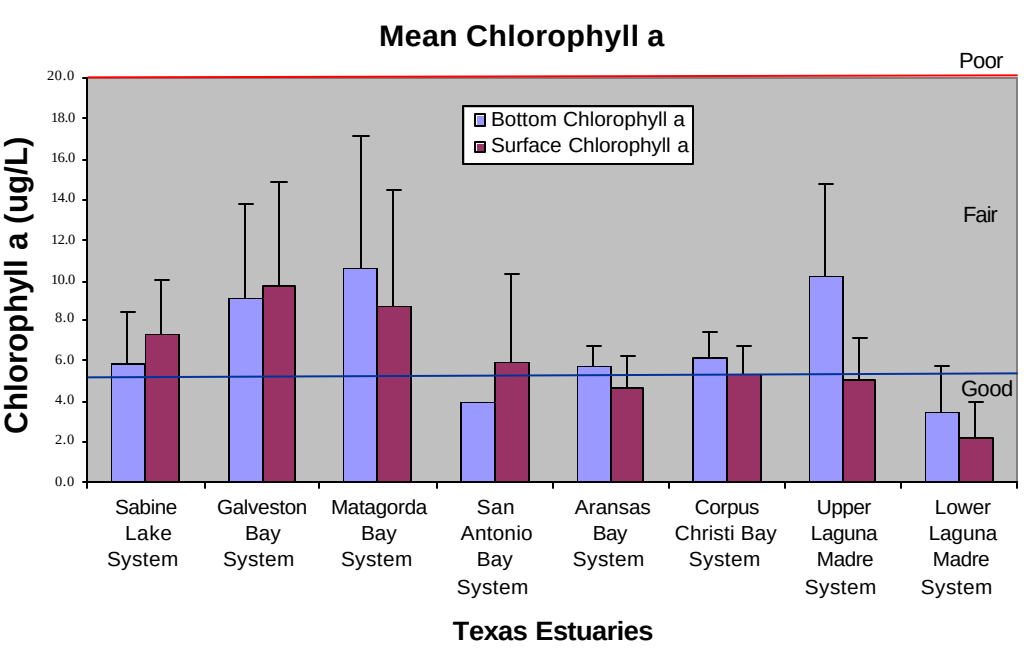
Where I_o is incident radiation at 0.5m, L_z is 1% of I_o and k_d is the extinction coefficient.

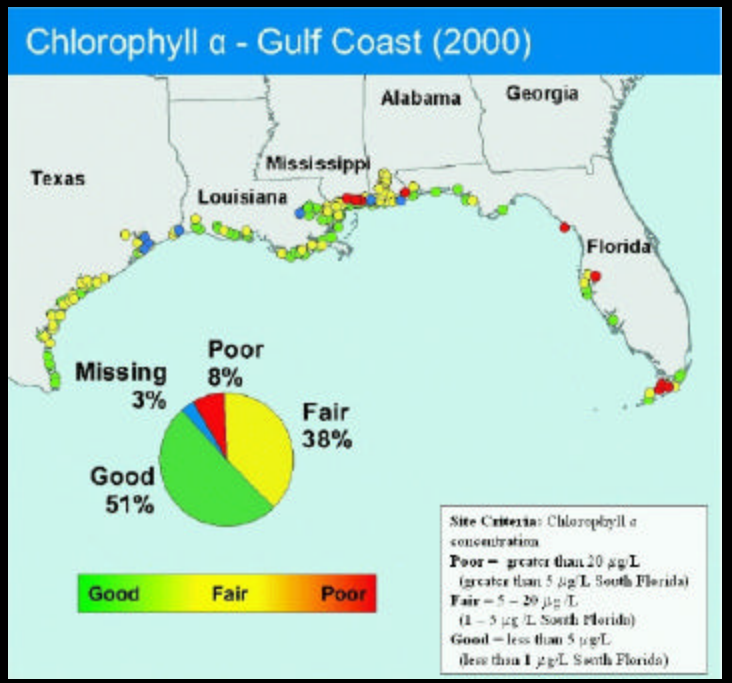


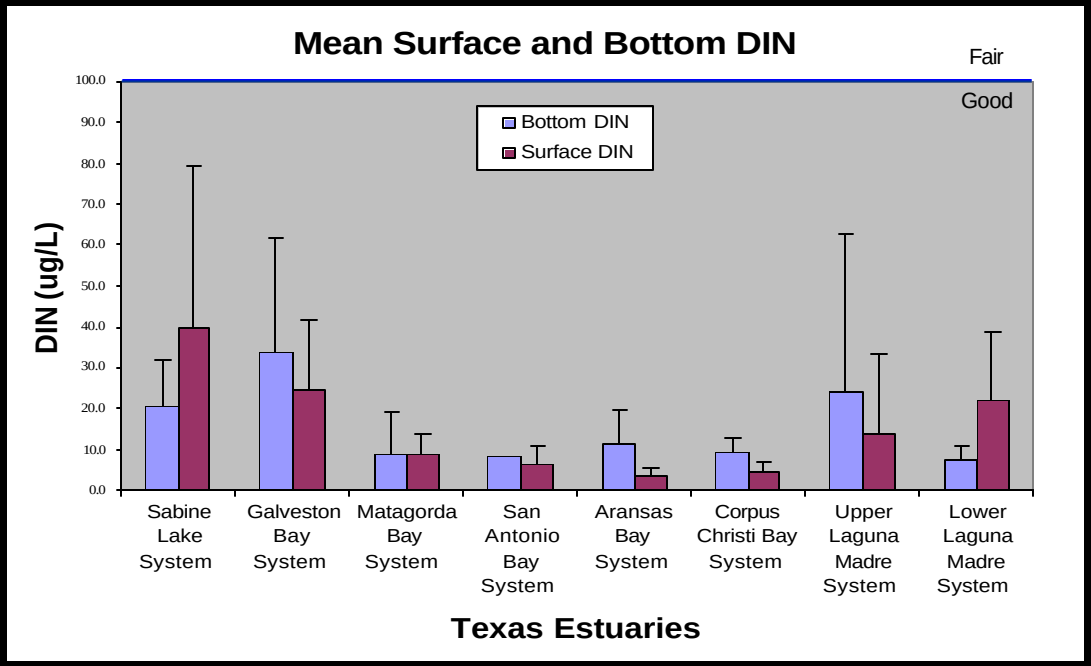


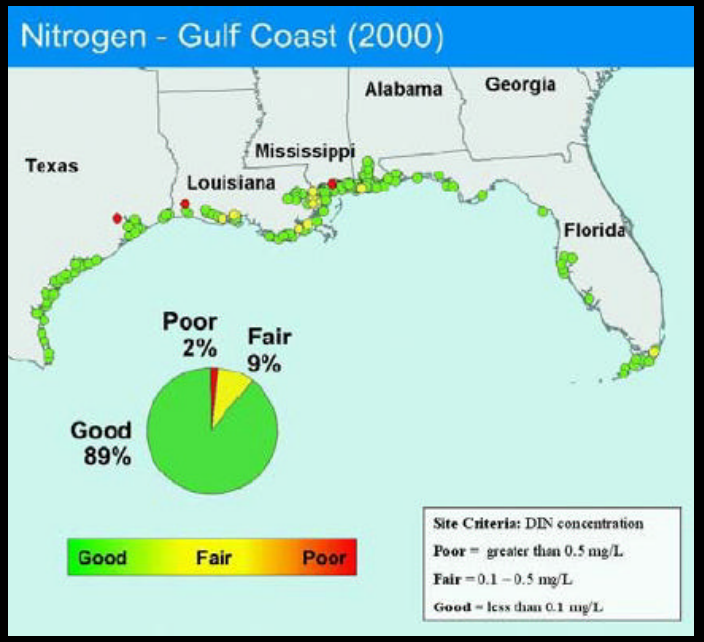
- Bottom TSS is greater in all bay systems

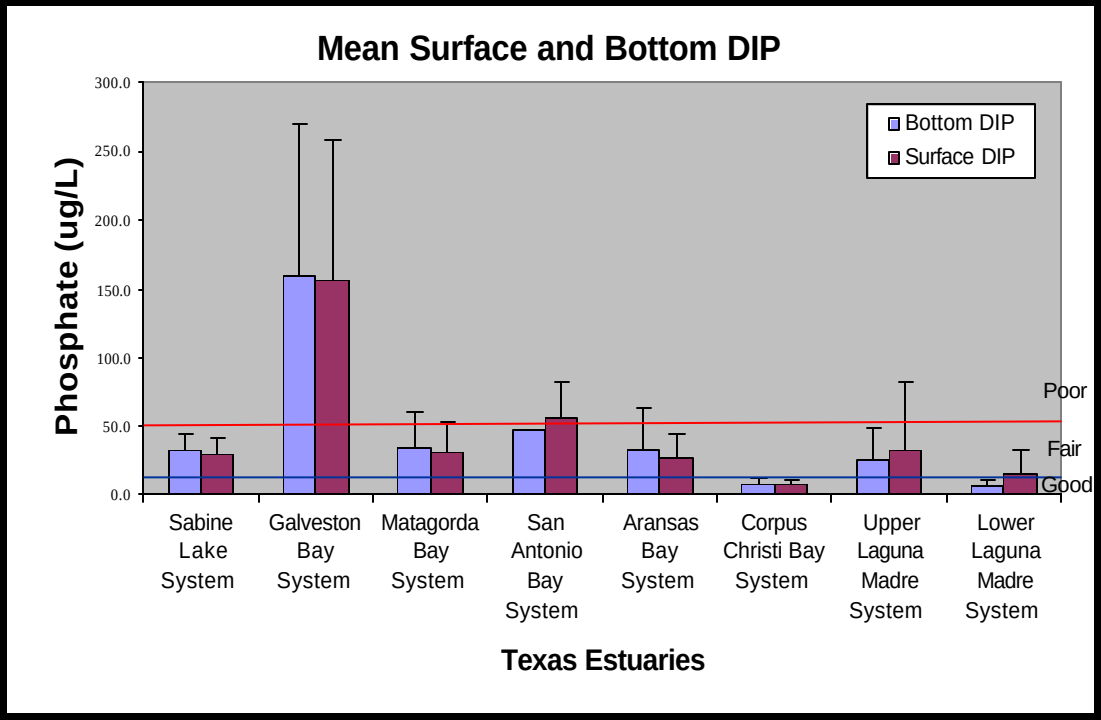
- Chlorophyll a levels were fair to good along the Texas coast

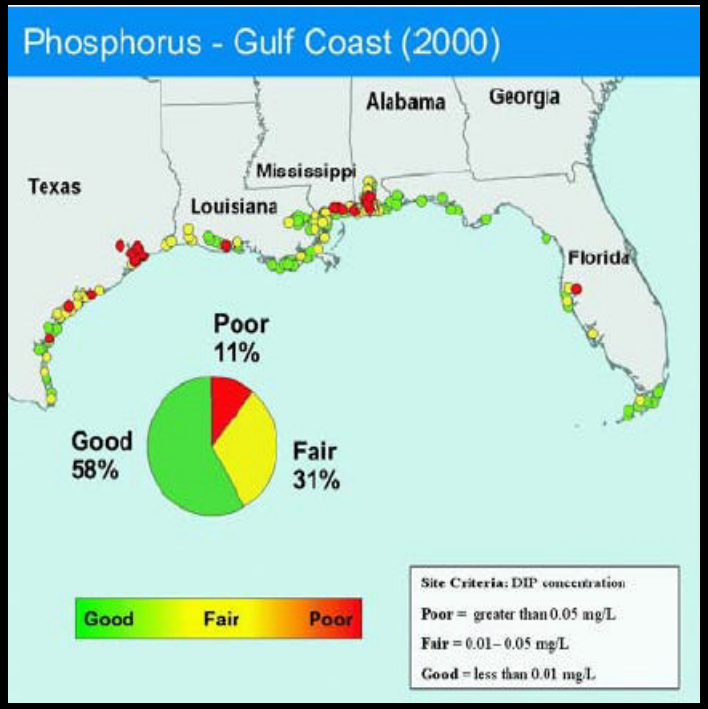





Mean Surface and Bottom DIN
Fair
Good
Bottom DIN
Surface DIN
DIN (ug/L)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Sabine Lake System
Galveston Bay System
Matagorda Bay System
San Antonio Bay System
Aransas Bay System
Corpus Christi Bay System
Upper Laguna Madre System
Lower Laguna Madre System
Texas Estuaries

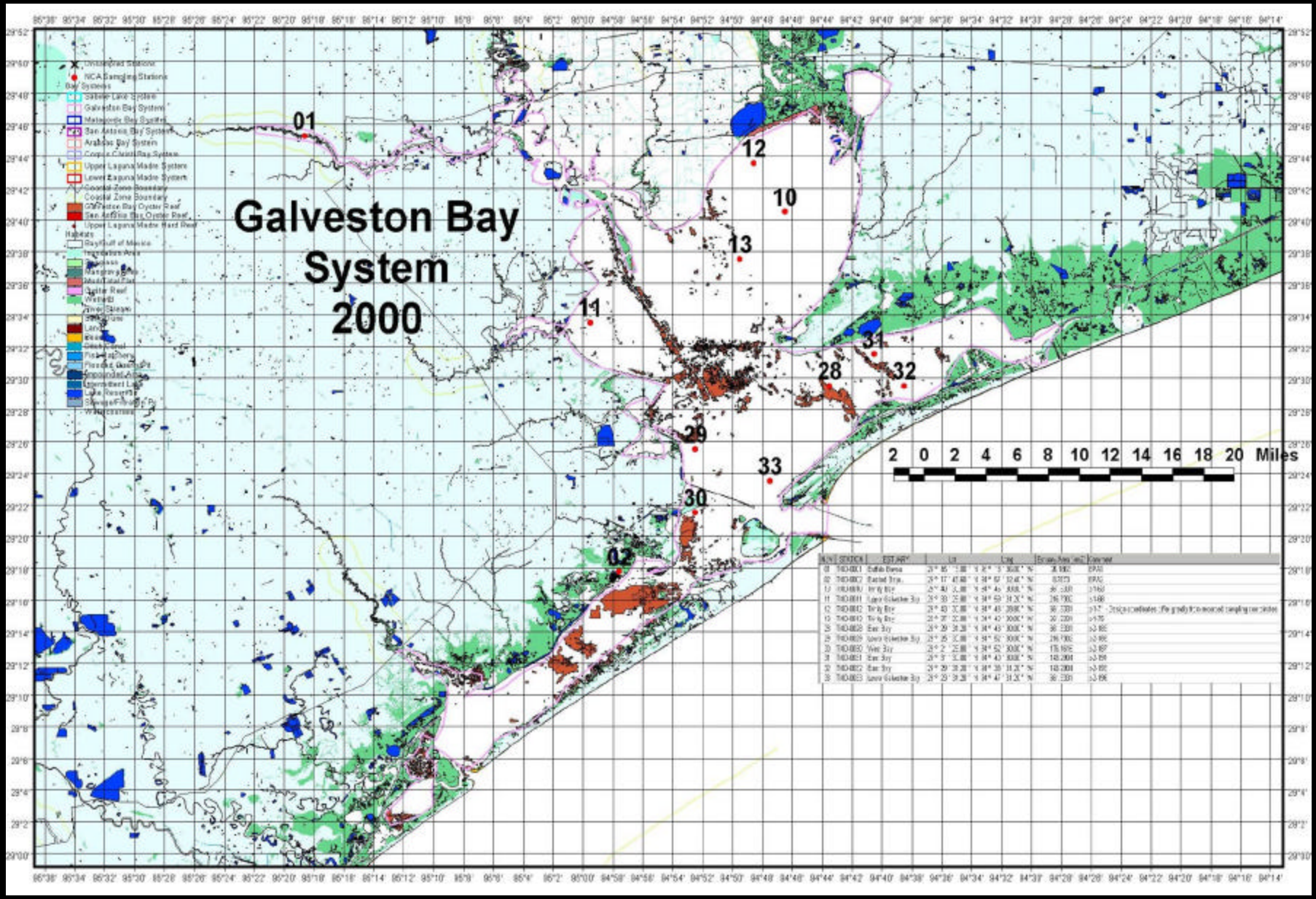

Nitrogen - Gulf Coast (2000)
Alabama
Georgia
Mississippi
Texas
Louisiana
Florida
Poor 2%
Fair 9%
Good 89%
Good
Fair
Poor
Site Criteria: DIN concentration
Poor = greater than 0.5 mg/L
Fair = 0.1 – 0.5 mg/L
Good = less than 0.1 mg/L


Mean Surface and Bottom DIP
Bottom DIP
Surface DIP
Phosphate (ug/L)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Poor
Fair
Good
Sabine Lake System
Galveston Bay System
Matagorda Bay System
San Antonio Bay System
Aransas Bay System
Corpus Christi Bay System
Upper Laguna Madre System
Lower Laguna Madre System
Texas Estuaries

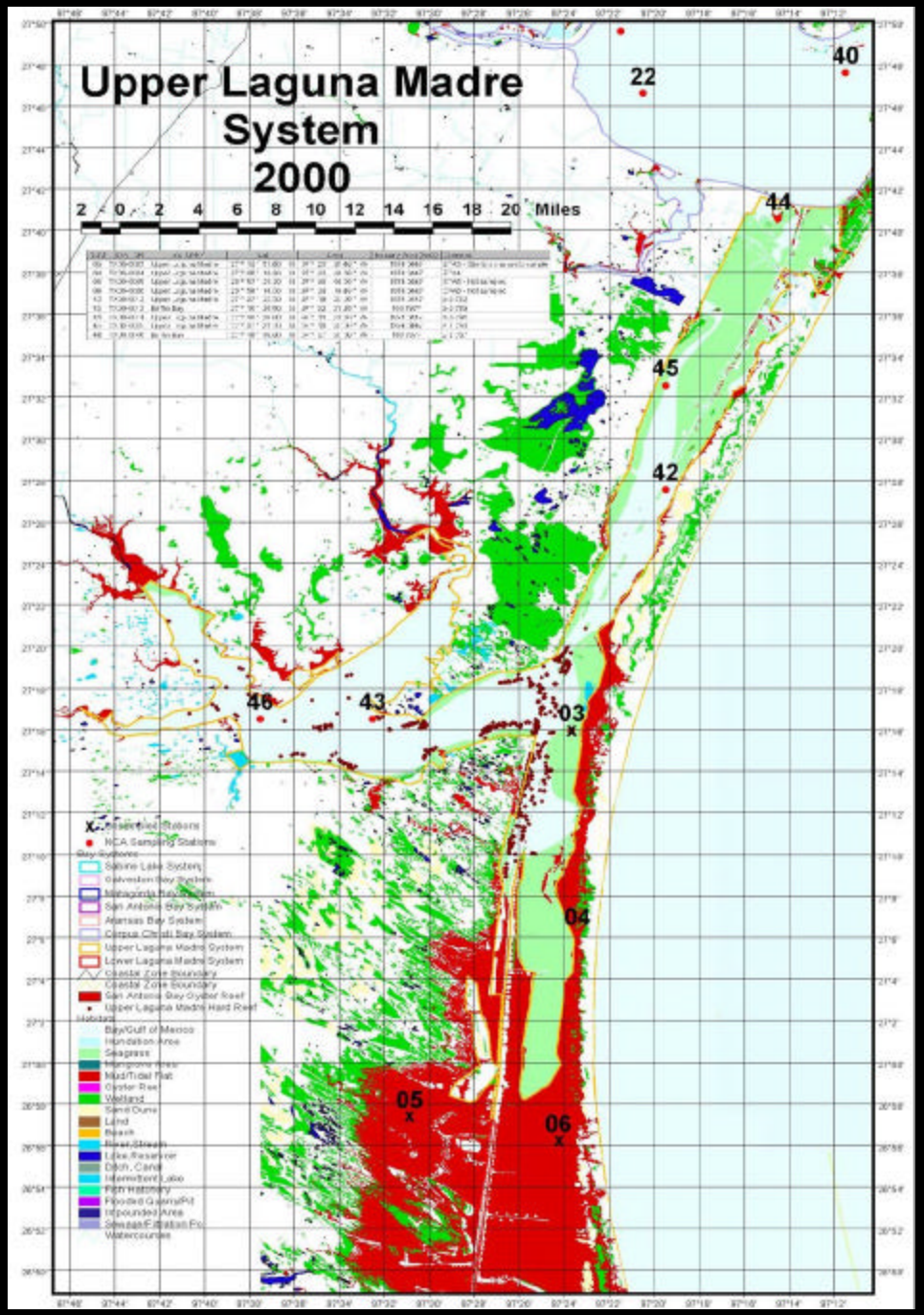

Phosphorus - Gulf Coast (2000)
Alabama
Georgia
Mississippi
Texas
Louisiana
Florida
Poor 11%
Good 58%
Fair 31%
Good
Fair
Poor
Site Criteria: DIP concentration
Poor = greater than 0.05 mg/L
Fair = 0.01 – 0.05 mg/L
Good = less than 0.01 mg/L

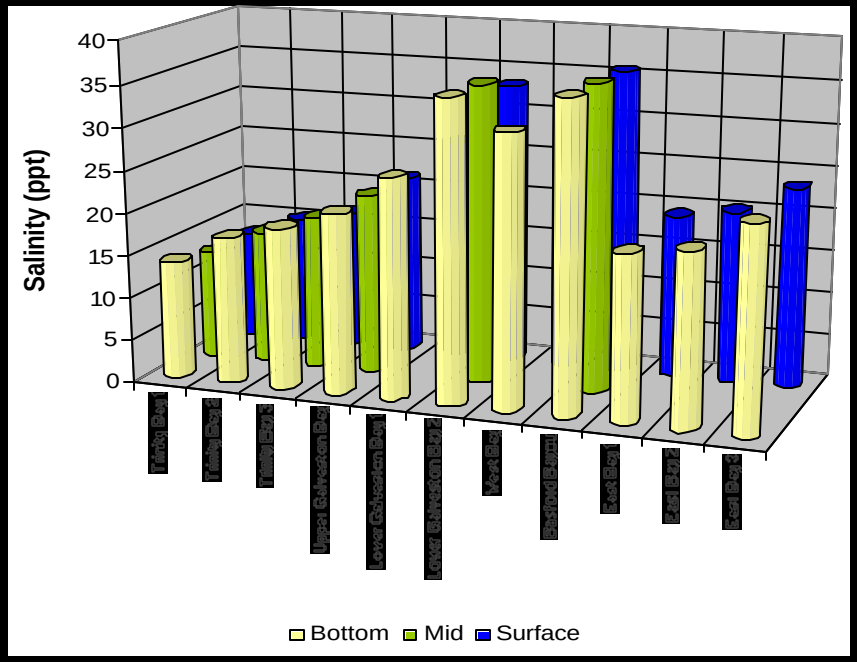
Comparison of Galveston Bay and Upper Laguna Madre

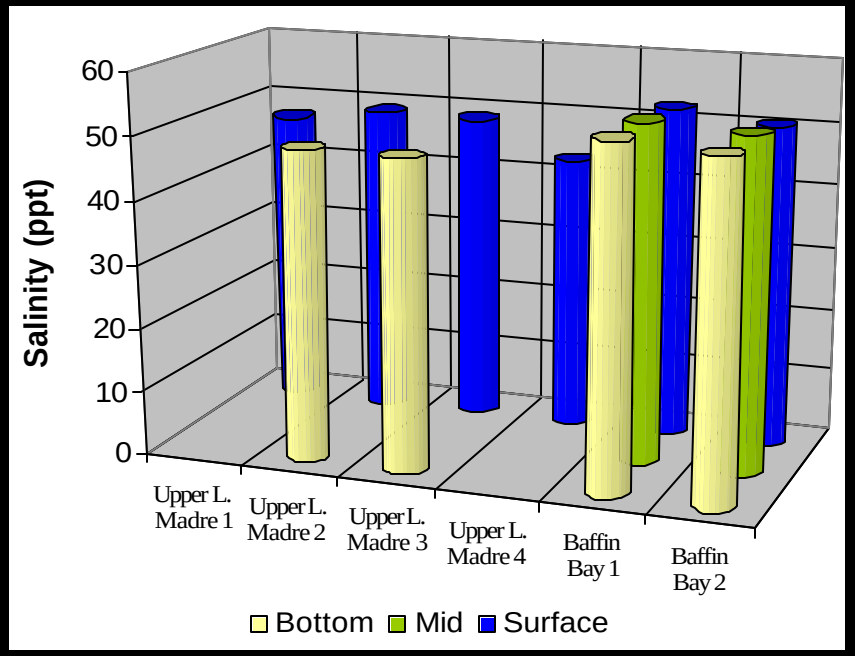
Galveston Bay Sampling Station Locations

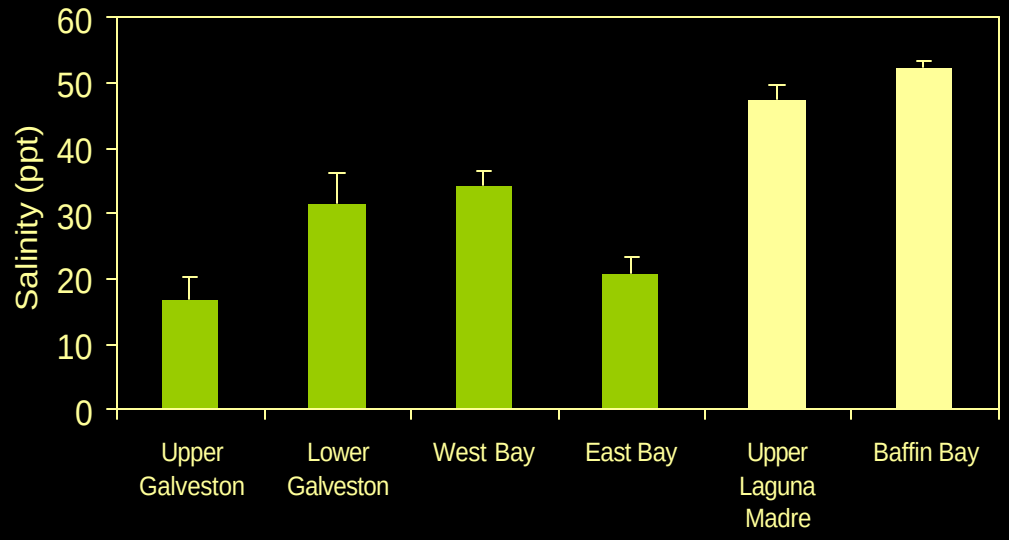


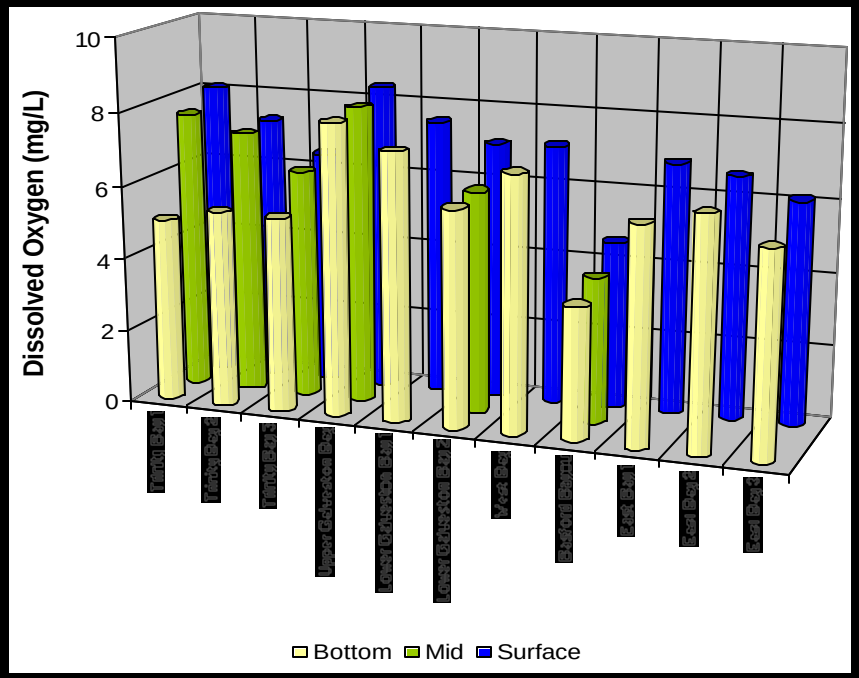
Upper Laguna Madre Sampling Station Locations

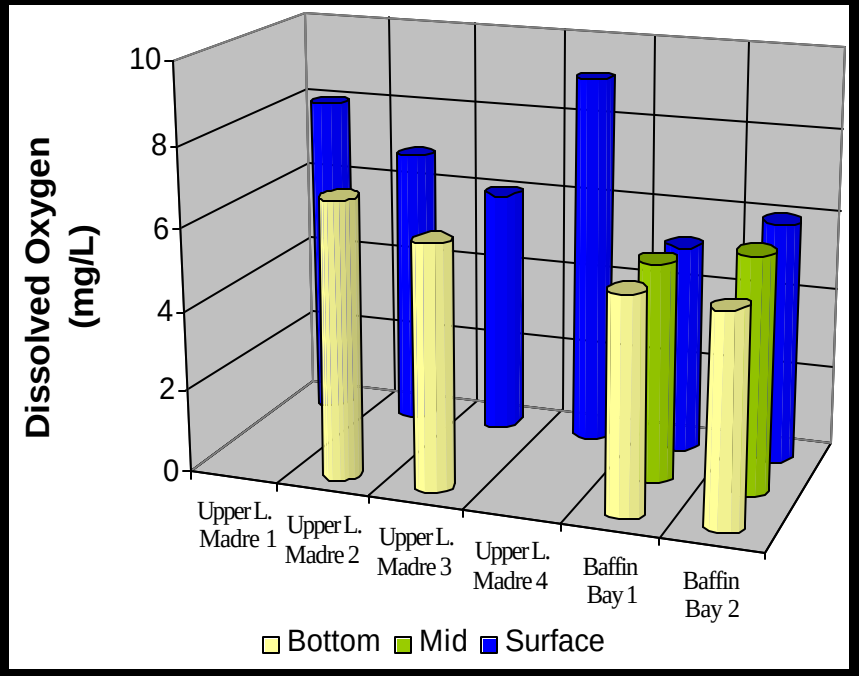


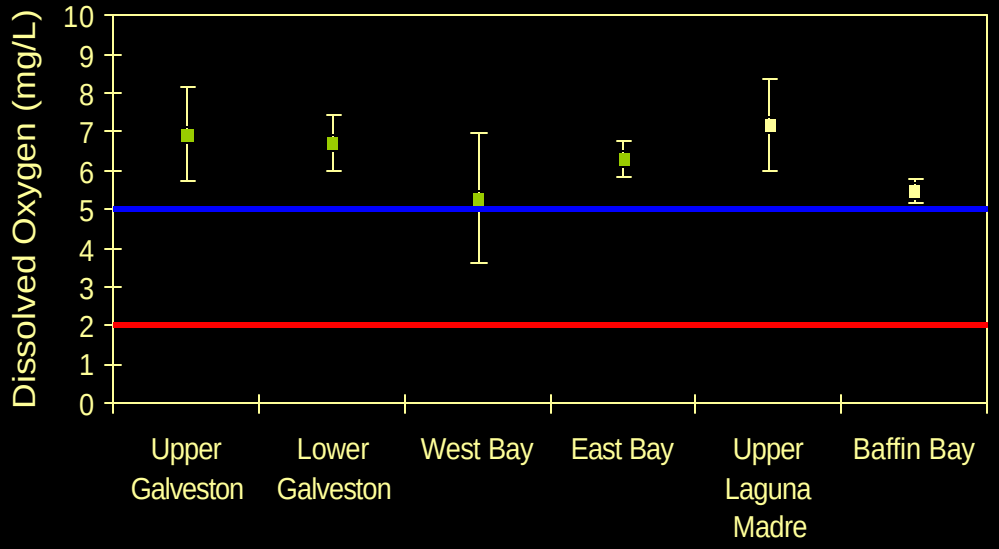

Salinity (ppt)
40
35
30
25
20
15
10
5
0
Bottom
Mid
Surface

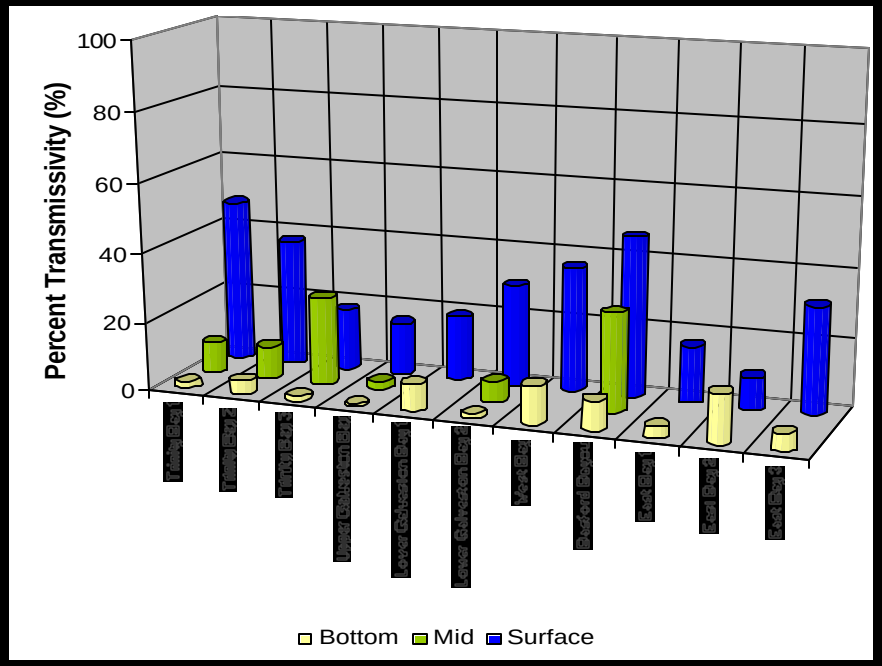

Salinity (ppt)
60
50
40
30
20
10
0
Upper L. Madre 1
Upper L. Madre 2
Upper L. Madre 3
Upper L. Madre 4
Baffin Bay 1
Baffin Bay 2
Bottom
Mid
Surface

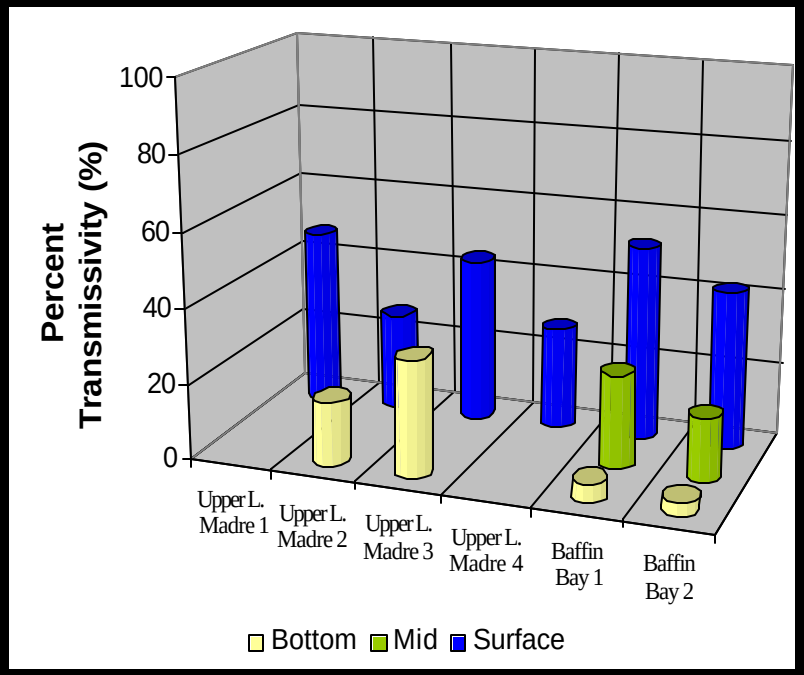

Salinity (ppt)
60
50
40
30
20
10
0
Upper Galveston
Lower Galveston
West Bay
East Bay
Upper Laguna Madre
Baffin Bay

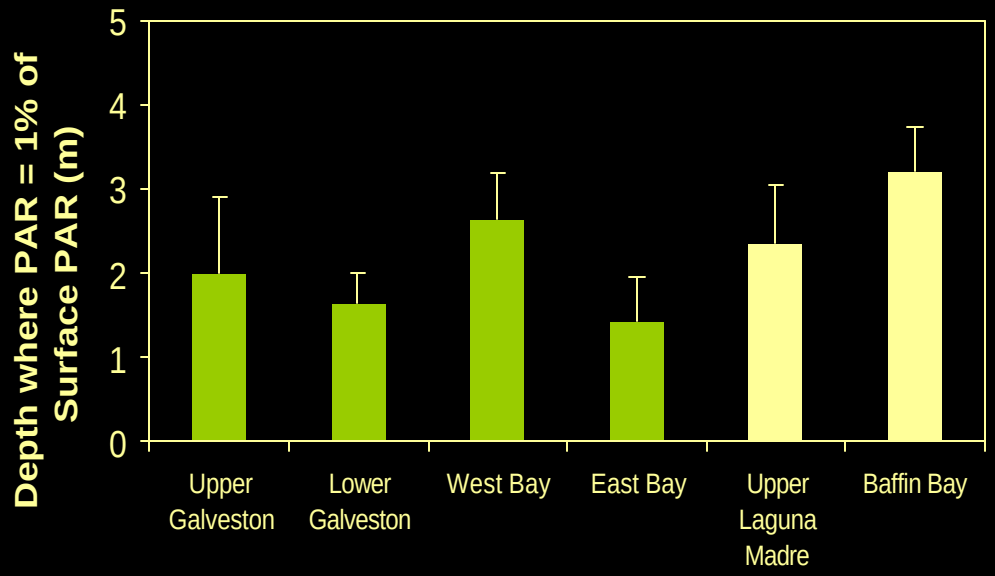

Dissolved Oxygen (mg/L)
10
8
6
4
2
0
Bottom
Mid
Surface

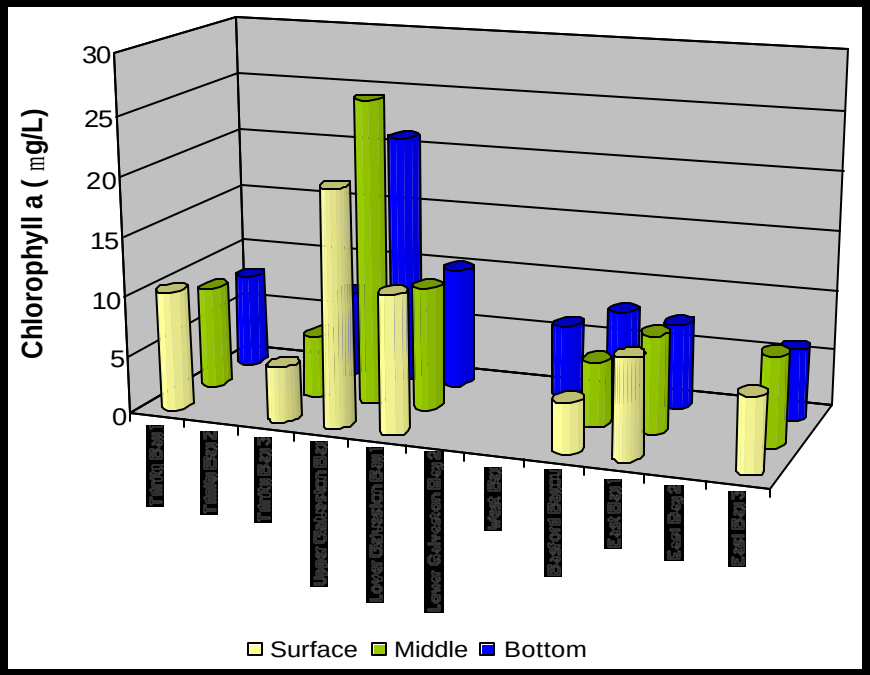

Dissolved Oxygen (mg/L)
10
8
6
4
2
0
Upper L. Madre 1
Upper L. Madre 2
Upper L. Madre 3
Upper L. Madre 4
Baffin Bay 1
Baffin Bay 2
Bottom
Mid
Surface

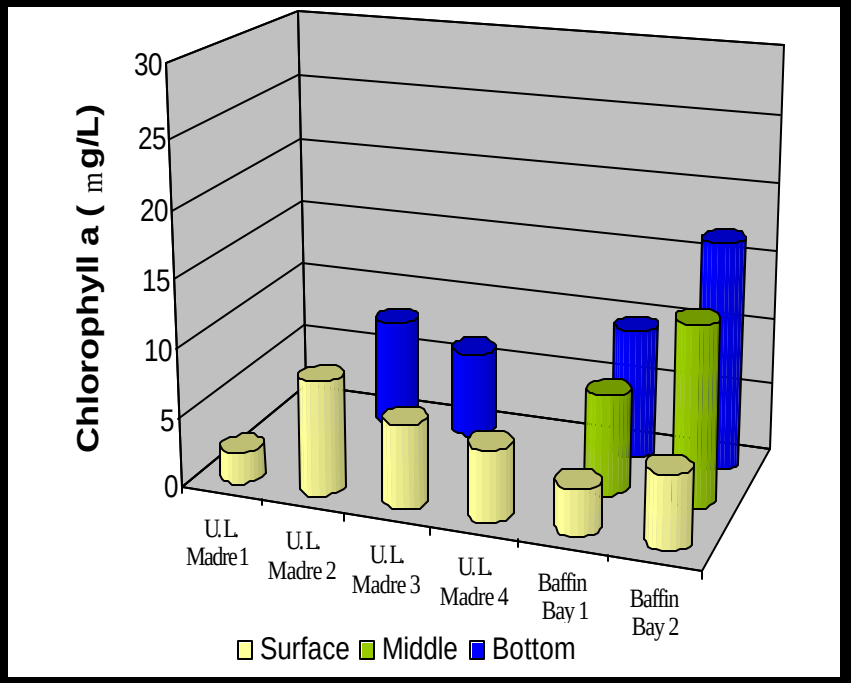

Dissolved Oxygen (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Upper Galveston
Lower Galveston
West Bay
East Bay
Upper Laguna Madre
Baffin Bay

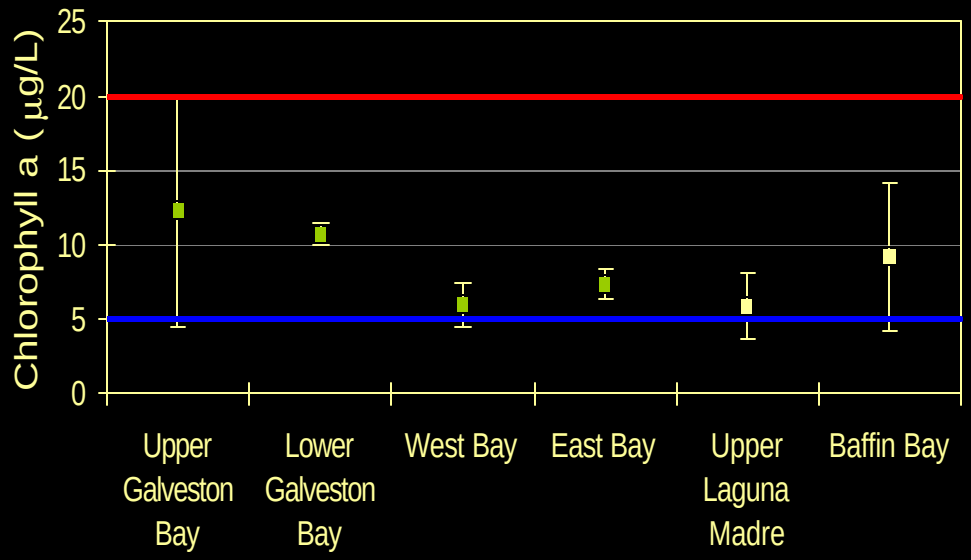

Percent Transmissivity (%)
100
80
60
40
20
0
Bottom
Mid
Surface

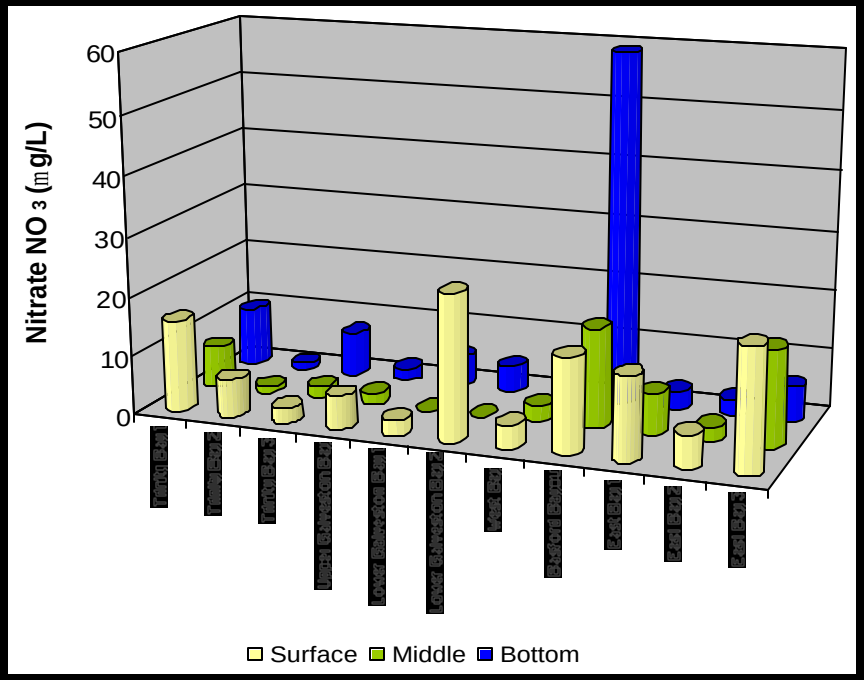

Percent Transmissivity (%)
100
80
60
40
20
0
Upper L. Madre 1
Upper L. Madre 2
Upper L. Madre 3
Upper L. Madre 4
Baffin Bay 1
Baffin Bay 2
Bottom
Mid
Surface

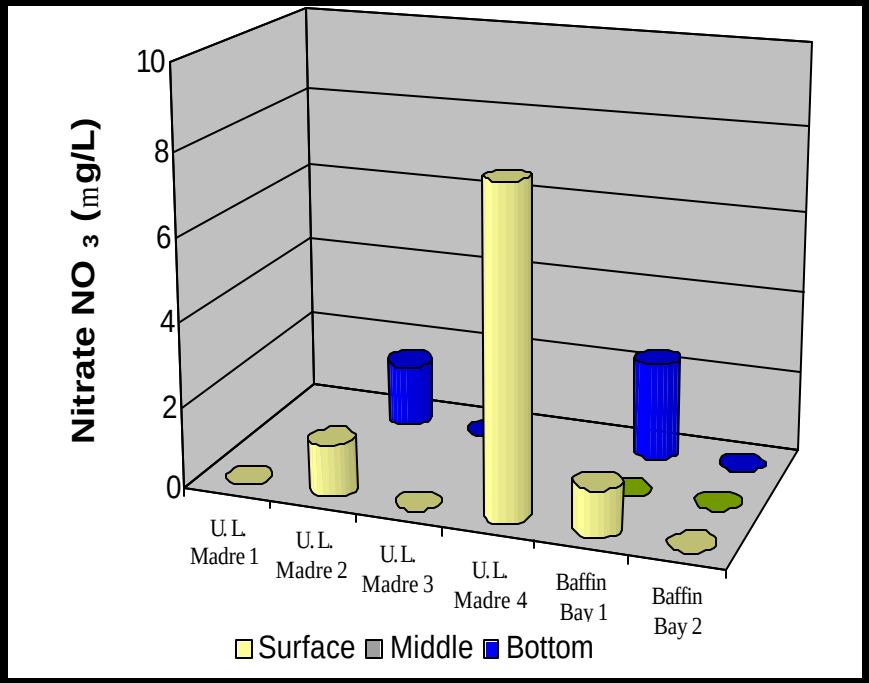

Depth where PAR = 1% of Surface PAR (m)
5
4
3
2
1
0
Upper Galveston
Lower Galveston
West Bay
East Bay
Upper Laguna Madre
Baffin Bay

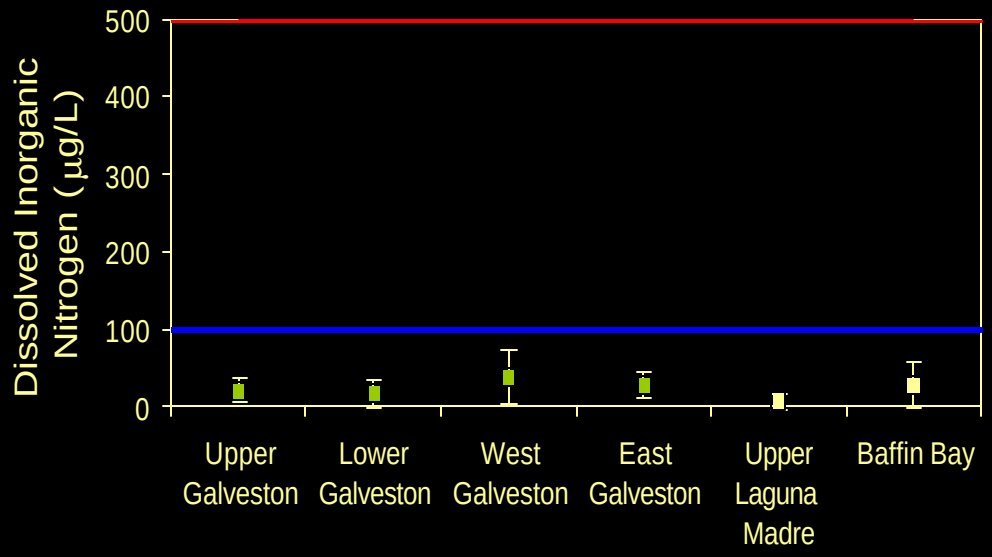

Chlorophyll a (mg/L)
30
25
20
15
10
5
0
Surface
Middle
Bottom

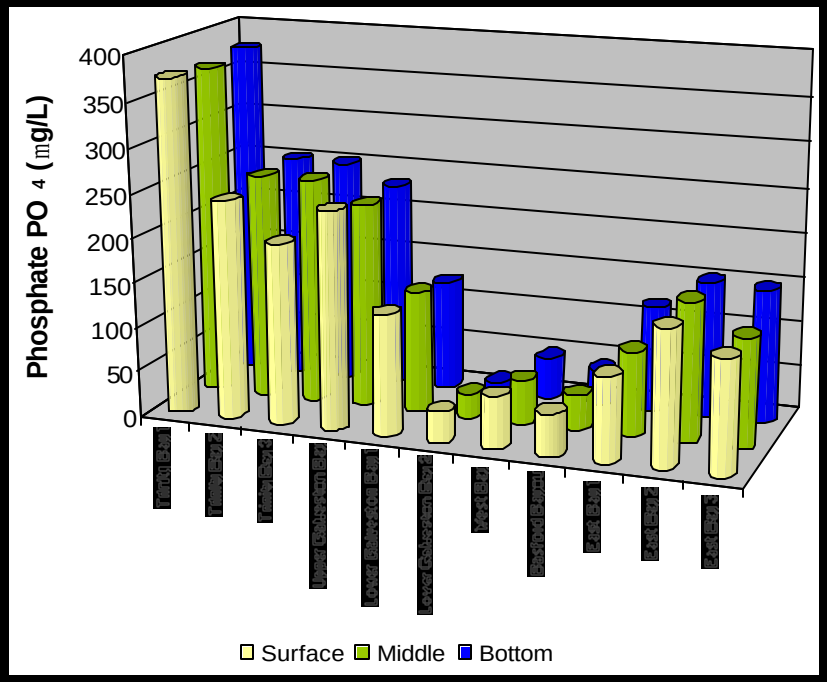

Chlorophyll a (mg/L)
30
25
20
15
10
5
0
U.L. Madre 1
U.L. Madre 2
U.L. Madre 3
U.L. Madre 4
Baffin Bay 1
Baffin Bay 2
Surface
Middle
Bottom

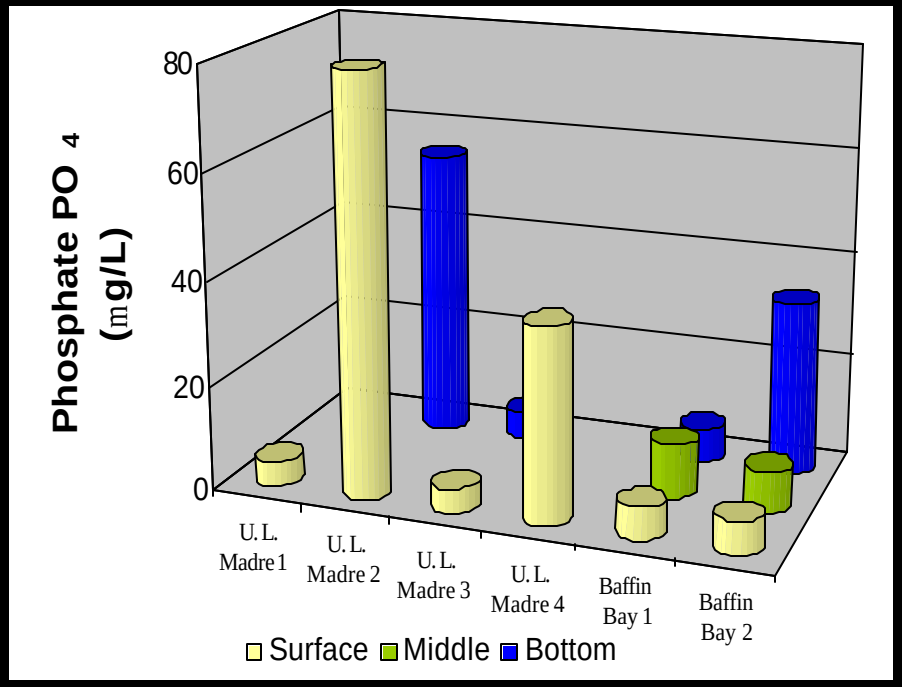

Chlorophyll a (µg/L)
25
20
15
10
5
0
Upper Galveston Bay
Lower Galveston Bay
West Bay
East Bay
Upper Laguna Madre
Baffin Bay

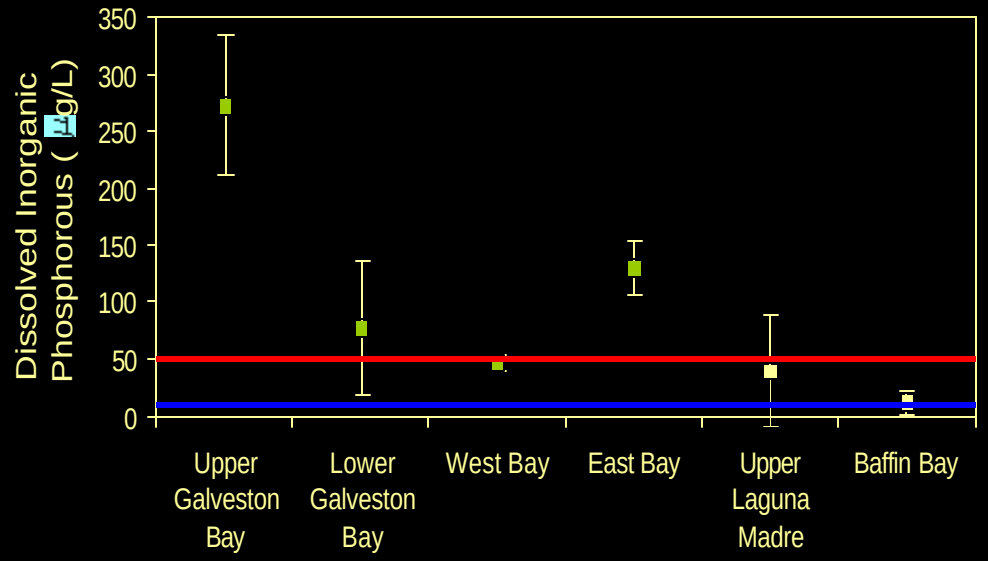

Nitrate NO 3 (mg/L)
60
50
40
30
20
10
0
Surface
Middle
Bottom


Nitrate NO 3 (mg/L)
10
8
6
4
2
0
U.L. Madre 1
U.L. Madre 2
U.L. Madre 3
U.L. Madre 4
Baffin Bay 1
Baffin Bay 2
Surface
Middle
Bottom

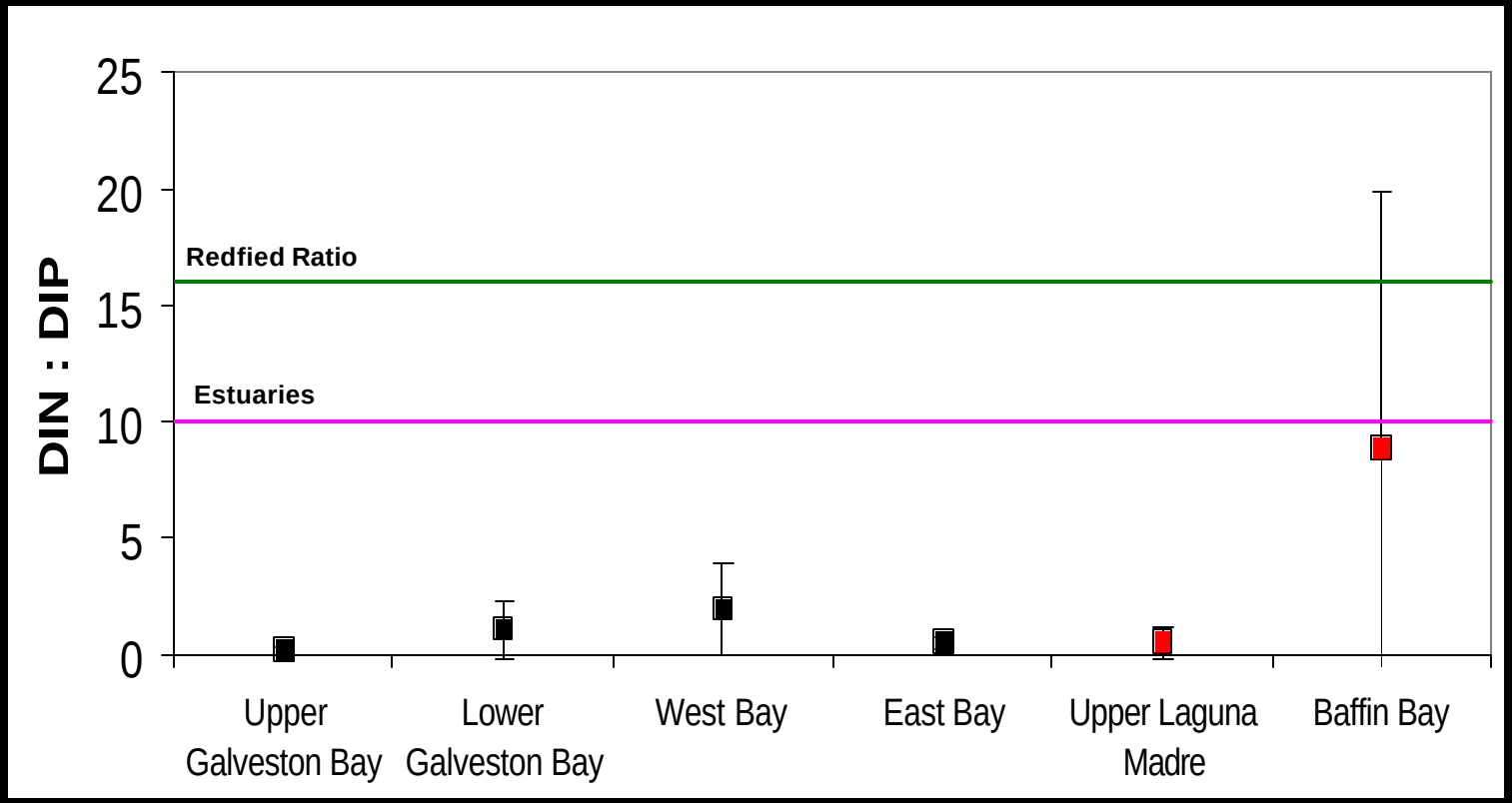

Dissolved Inorganic Nitrogen (µg/L)
500
400
300
200
100
0
Upper Galveston
Lower Galveston
West Galveston
East Galveston
Upper Laguna Madre
Baffin Bay


Phosphate PO 4 (mg/L)
400
350
300
250
200
150
100
50
0
Surface
Middle
Bottom

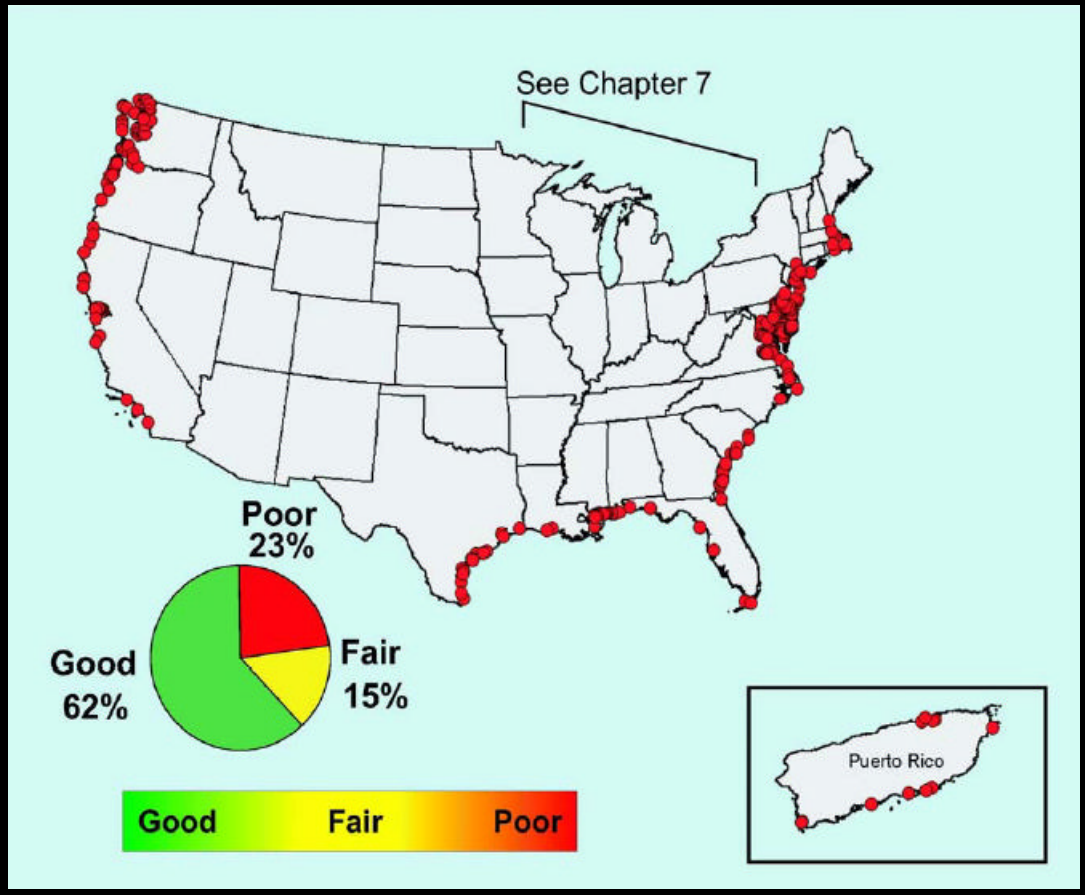

Phosphate PO 4 (mg/L)
80
60
40
20
0
U. L. Madre 1
U. L. Madre 2
U. L. Madre 3
U. L. Madre 4
Baffin Bay 1
Baffin Bay 2
Surface
Middle
Bottom


Dissolved Inorganic Phosphorous (g/L)
350
300
250
200
150
100
50
0
Upper Galveston Bay
Lower Galveston Bay
West Bay
East Bay
Upper Laguna Madre
Baffin Bay

N:P Ratios in Galveston Bay and the Upper Laguna Madre



Details on EPA's Water Clarity Metric



Proposed Water Clarity Indicator for Gulf of Mexico and Southeast Estuaries

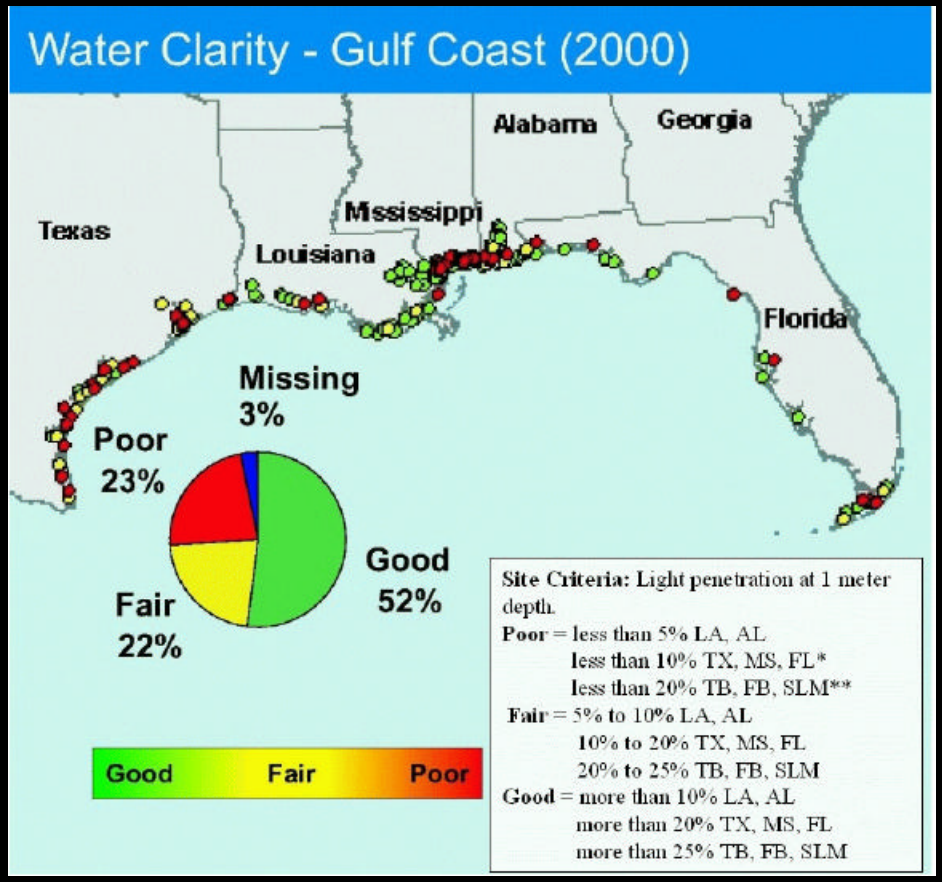
•Using secchi depth and the light extinction coefficient, *k*, an alternate water clarity indicator is calculated.

•GOM and SE estuaries were divided into 3 turbidity classes based on regional expectations for light penetration related to SAV distribution - low, moderate, and high.

•Water clarity indicator compares a sample *k* calculated from the measured secchi depth to a range of reference *k* to determine Good, Fair, or Poor water clarity.

•Reference *k* values are calculated separately for the 3 classes of estuaries.

•This allows the comparison and scoring to take into account the expected water clarity conditions in a region.



Turbidity Class	Expected Transmissivity at 1 m depth		Constant
	Poor Clarity	Good Clarity	
Low	< 20%	> 40%	1.7
Moderate	< 10%	> 25%	1.4
High	< 5%	> 10%	1.0

REFERENCE: $k = \ln (L_z / L_s) / -z$ where, z = 1 m and L_z / L_s represents the expected transmissivity ratios in table above (e.g., 0.2 and 0.4 for less turbid estuaries)

SAMPLE: $k = c / \text{secchi}$ where, c = constant in table above and secchi = measured secchi depth in meters

The table for comparison then becomes:

Turbidity Class	Reference *k*			Constant
	Good Clarity	Fair Clarity	Poor Clarity	
Low	< 0.916	0.916 - 1.609	> 1.609	1.7
Moderate	<1.386	1.386 - 2.303	> 2.303	1.4
High	< 2.303	2.303 - 2.996	> 2.996	1.0

Calculate sample *k* and compare to reference *k* as follows:
If sample *k* is less than reference *k* for good clarity then water clarity is GOOD.
If sample *k* is between reference *k*'s for good and poor clarity then water clarity is FAIR.
If sample *k* is greater than reference *k* for poor clarity then water clarity is POOR.

See table below for examples from the Gulf of Mexico.

Station	Class	Good Ref *k*	Poor Ref *k*	Constant	Secchi depth (m)	Sample *k*	Score
TX00-0037	Turbid	1.386	2.303	1.4	0.65	2.15	Fair
LA00-0013	More Turbid	2.303	2.996	1.0	0.50	2.00	Good
FL00-0004	Turbid	1.386	2.303	1.4	0.20	7.00	Poor
TX00-0004	Less Turbid	0.916	1.609	1.7	0.56	3.04	Poor

Proxy for secchi depth is calculated from the calculated depth of the 1% light level using the following:

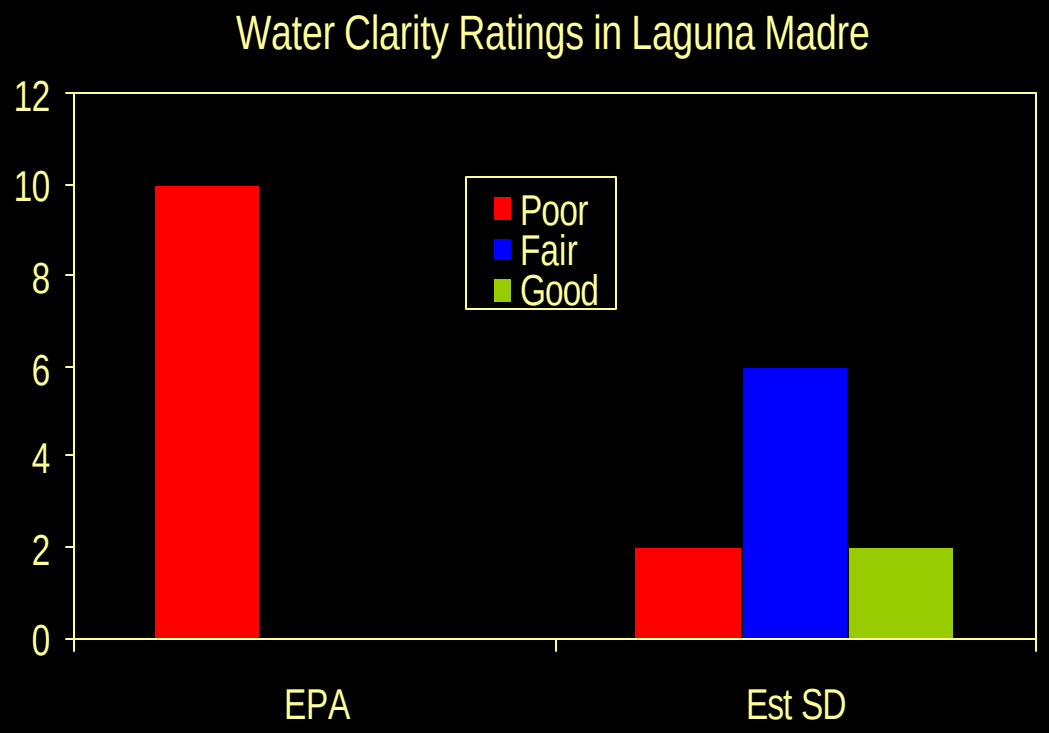
$$SD_{est} = Z_e / m$$

Where m = 2.0

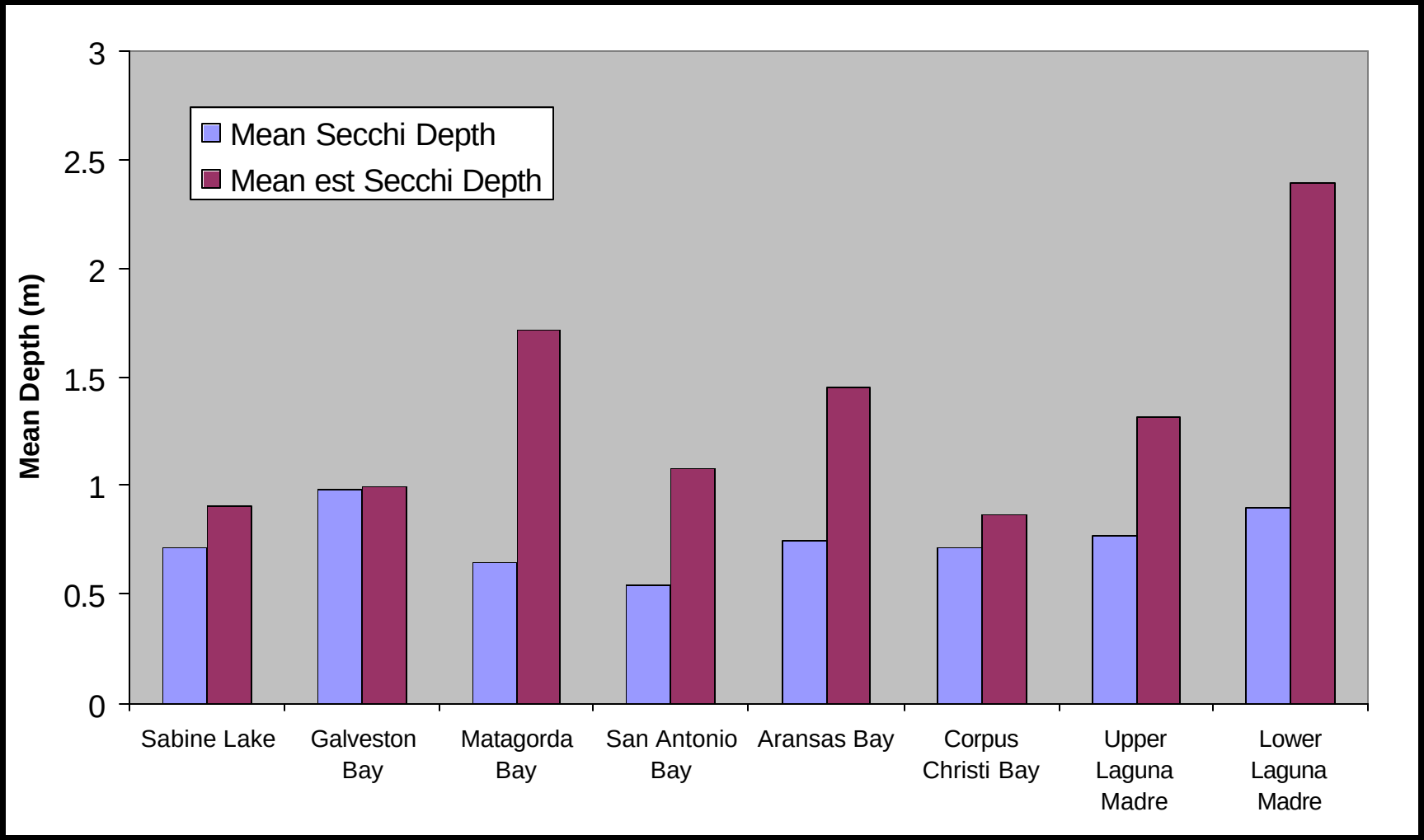
Results

Comparison of EPA calculated water clarity measures and those calculated with secchi depth estimated from the calculated 1% light level for the Laguna Madre:

EPA	Estimate
3.036	1.894
1.889	1.204
2.125	1.212
1.889	1.104
3.400	1.960
1.700	0.951
2.231	0.364
1.889	1.033
1.889	0.929
1.889	0.773



Comparison of Mean Secchi Depth and estimated Secchi Depth for the Texas bays



Summary

- In general, water quality conditions along the Texas coast are fair to good.
  - Dissolved oxygen was borderline fair to good along the middle coast
  - Water clarity was greatest in the Lower Laguna Madre
  - Chlorophyll a was fair along the upper coast and fair to good along the rest of the coast
  - DIN was well into the good range
  - DIP was mostly in the fair range, with Galveston Bay well into the poor range

Summary (cont.)

- Patterns of water quality conditions differed between Galveston Bay and the Upper Laguna Madre.
  - Salinities increased downbay while the Upper Laguna system had higher salinities in the upper reaches
  - Patterns of dissolved oxygen showed coherence in the sub-systems, with all in the good range
  - Upper reaches of both systems had higher chlorophyll a
  - DIN was in the good range for all sub-systems, but showed no patterns
  - DIP showed a pattern of high concentrations in the upper reaches, and then decreasing downbay
  - N:P ratios were very low, suggesting N limitation
- A new method for calculating water clarity is needed, particularly for the Laguna Madre.

National Coastal Assessment -- What next?

- Currently planning for the 2004 sampling season
- Working with TCEQ to include NCA database in the Texas 305(b) reporting process
- Developing indicators of ecosystem health in concert with the GBEP and CBBEP
- Hoping for continued funding of NCA by EPA's Office of Water

Thank You

Questions ??