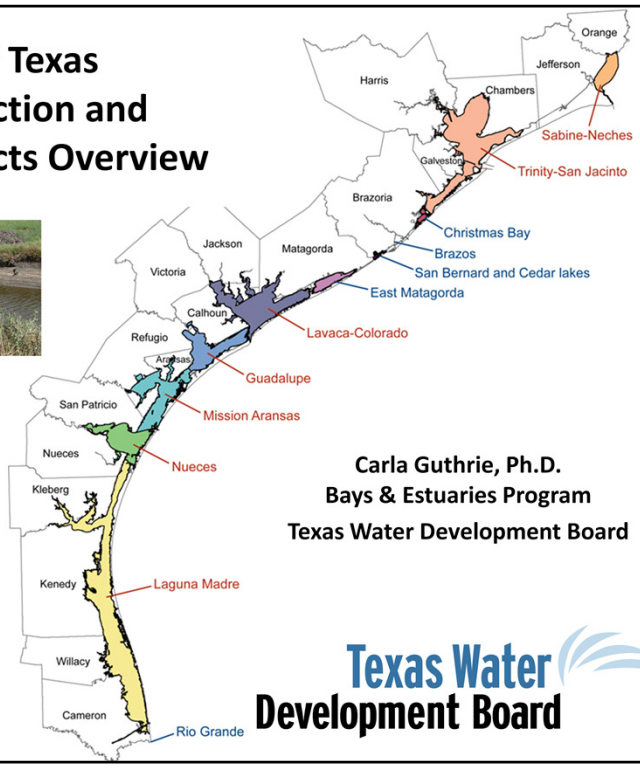
State of Texas
Data Collection and
Drought Impacts Overview



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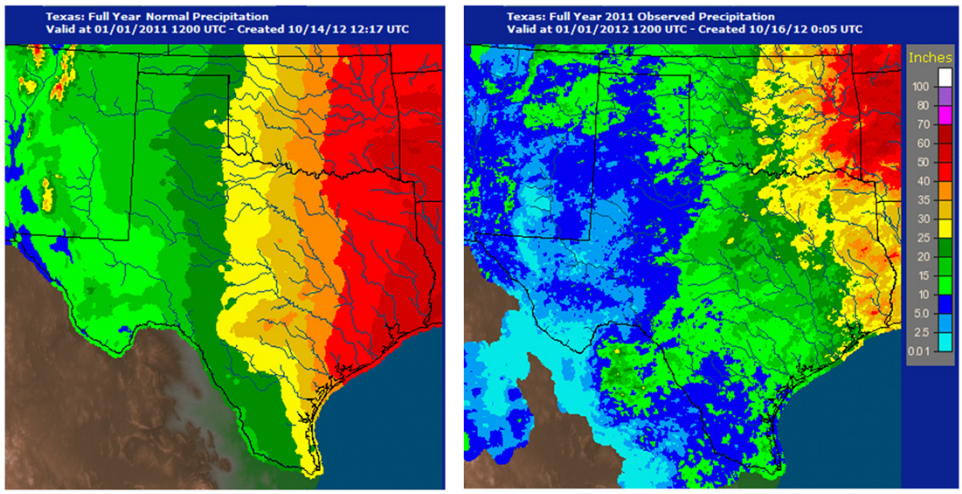
Bays & Estuaries Program
Texas Water Development Board

Texas Water Development Board

Normal Calendar Year Precipitation vs. Observed 2011 Precipitation



National Weather Service Advanced Hydrologic Prediction Service (http://water.weather.gov)

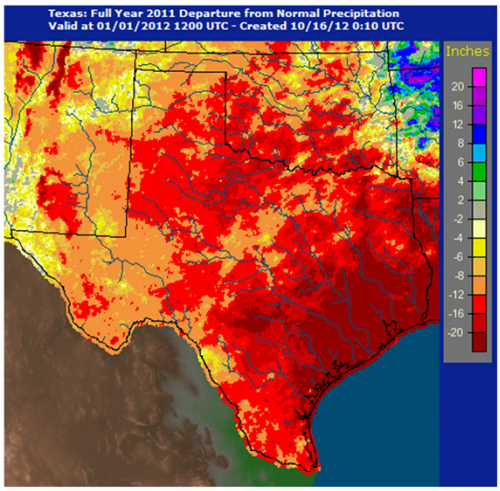
During lunch we will be hearing more about drought from the State Climatologist, Dr. John Nielsen-Gammon – However, in order to talk about streamflow conditions which affect freshwater inflows to the bays, I want to remind everyone of the precipitation conditions – or lack thereof – that we experienced across the state during 2011.

According to the National Weather Service, in 2011, Texas received an average of about 15 inches of rain. Normal, is near 28 - 35 inches per year. (It also was the 3rd warmest year on record.)

You can see by the map on the LEFT the distribution of precipitation during a "normal" year, where East Texas receives upwards of 60" and Far West Texas (El Paso) receives no more than 10 inches.

However, the map on the RIGHT shows the distribution of precipitation during 2011. Nearly half the State had rainfall amounts typical of El Paso (less than 10 inches), and East Texas had half the normal rainfall.

2011 Departure from Normal Precipitation

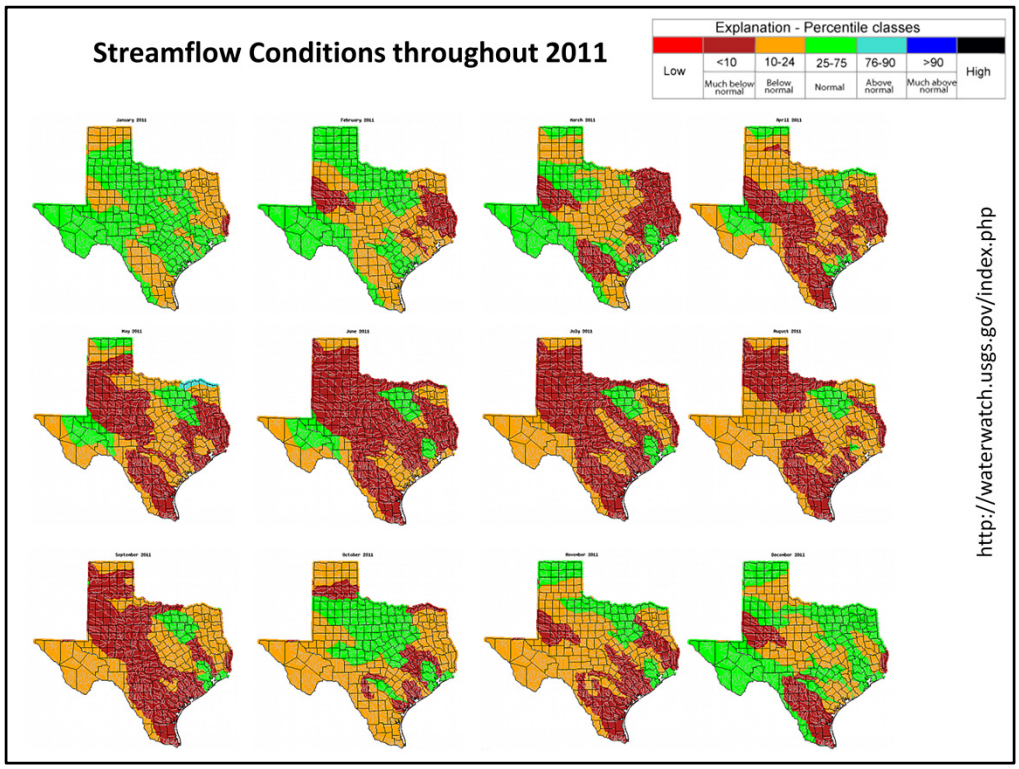


National Weather Service Advanced Hydrologic Prediction Service (http://water.weather.gov)

This map is showing the same information but in terms of the departure from normal precipitation. (where the colors on the map correspond to your thinking or experience of what happened in 2011!!)

From this map, the mid- and upper coastal region of Texas experience a precipitation deficit of -20 or more inches, and all of the State experienced precipitation deficits compared to normal rainfall.

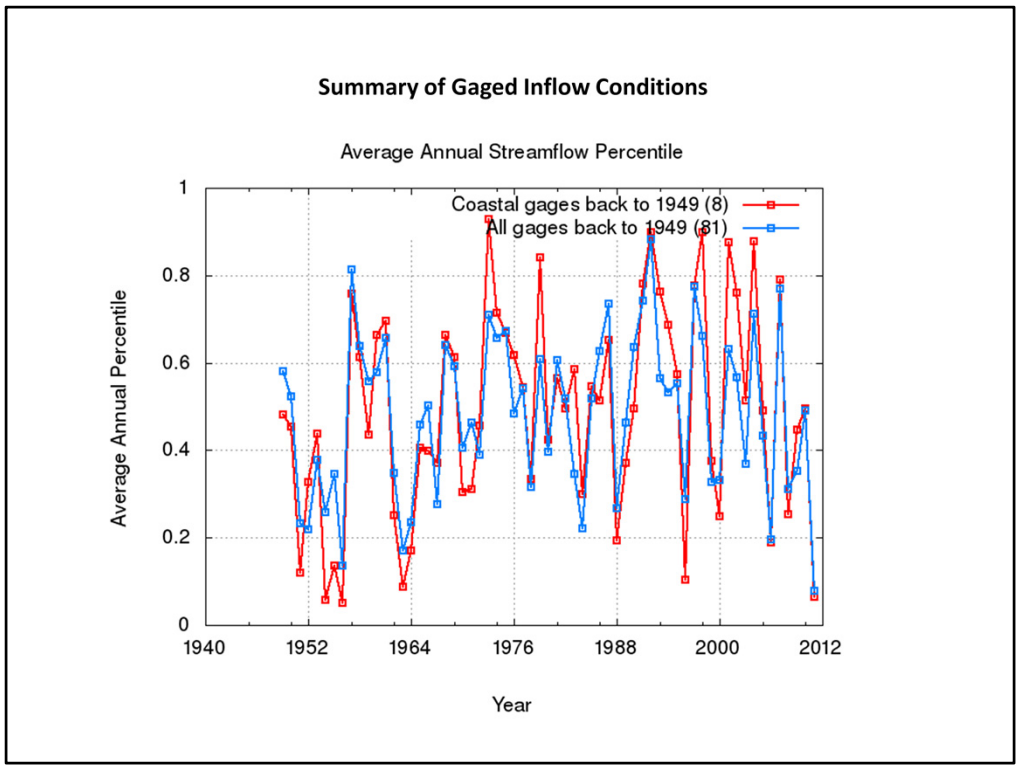
As you know, this lack of precipitation, combined with very warm temperatures, impacted streamflow volumes throughout the State.



[Original presentation contained a movie of these images; this slide replaces the movie with the individual images.)

Here, is a movie of the changing streamflow conditions across the state from January 2011 to December 2011.
In January, State is largely in “Normal” stream flow conditions, with areas of “Below Normal” plus “Much Below Normal” along the TX-LA border (Orange, Jasper, Newton Counties).

By March/April/May, large areas of Texas were “Below Normal” or “Much Below Normal”. These areas expanded to dominate most of the State through September. --- with areas of some relief showing up in October, November and December.

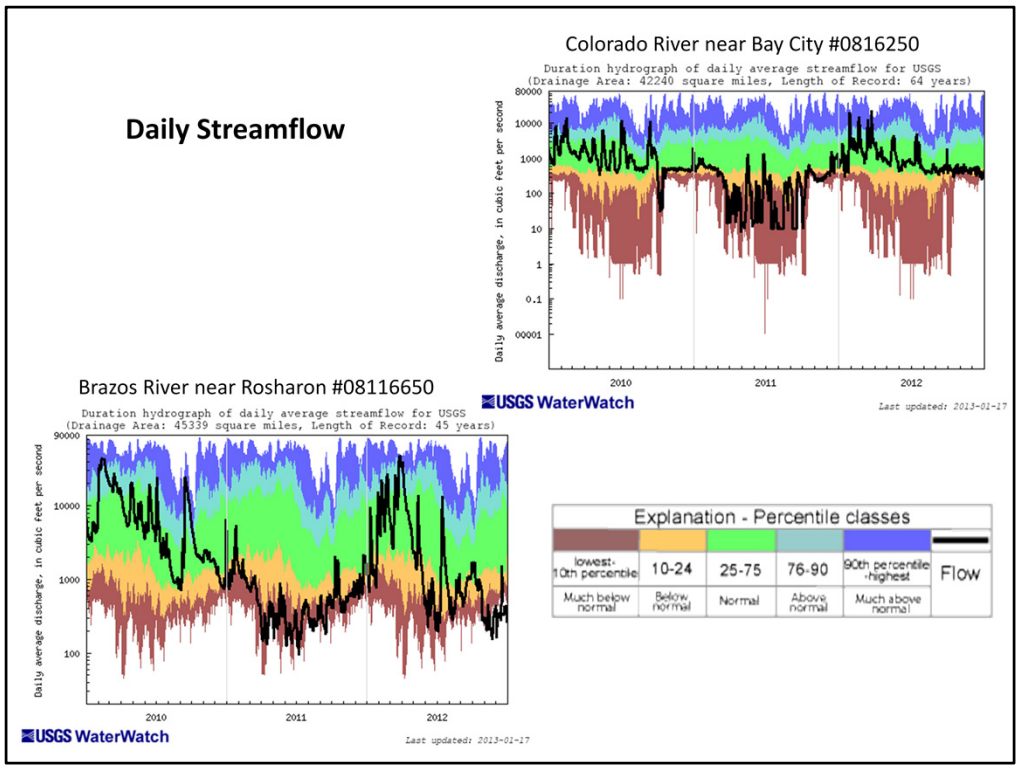


This summary graphic shows the Average of Annual Streamflow Percentiles for stream gages across the state (blue) as compared to those in coastal basins (red) from 1949 – 2011.

Each data point represents the average percentile flow of all gages during that year. (NOTE: statewide = 81 gages and coastal = only 8 gages in this comparison. Gages were selected with an appropriate period of record.)

In 2011, both statewide and coastal streams had average flow percentiles near 0.1. This is the lowest percentile condition on record for this collection of statewide gages, but similar conditions occurred in coastal gages during the 1950's and early 1960's. Essentially, for all gages to have an average percentile flow of 0.1 – all had to have below normal flows or a fair number had to have even lower flow percentiles than 0.1!

Overall, coastal gages tended more towards having higher flows in times of plenty and less flow during times of not. When years were (wetter), coastal gages showed higher flows than the statewide gages (notice the red data points above the blue), occasionally above 0.8. During (drier) years, coastal gages more often had flows below 0.2. Thus, the range of variation in streamflow historically has been greater for coastal gages than for inland stream gages – However, this analysis considered only eight coastal gages, so some of the variation may be due to the small sample number of gages used in the analysis.

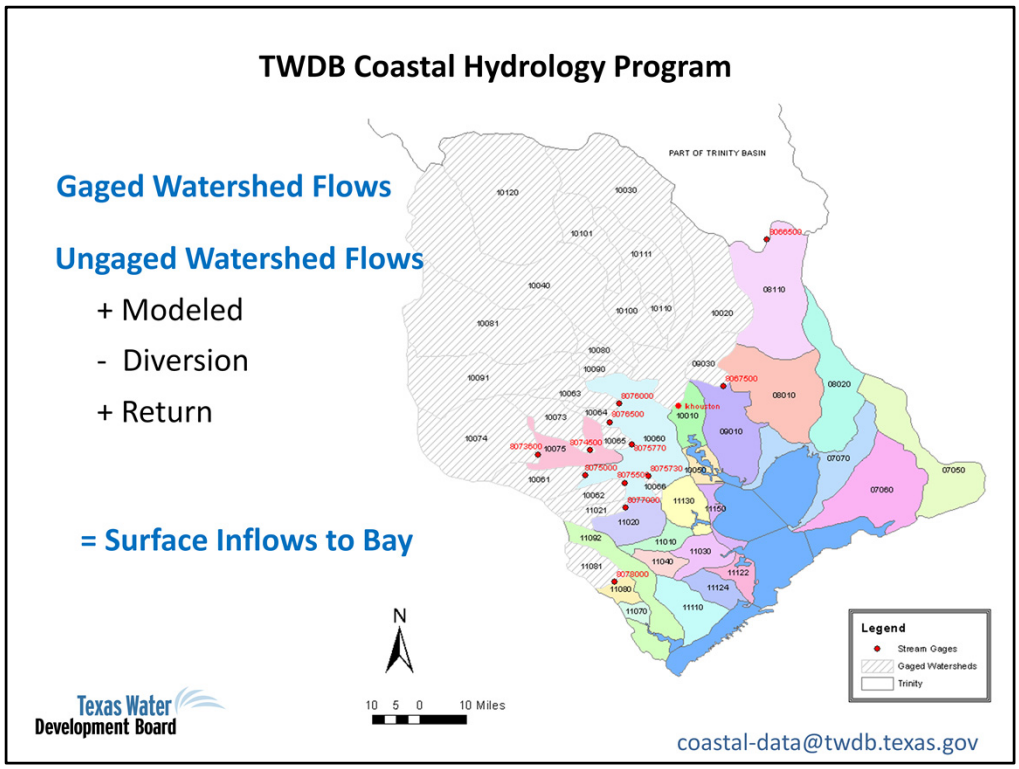


This slide shows two examples of streamflow volumes during 2011 as compared to flows during other years. Admittedly, I selected the most astounding gages to showcase here…. You can see on the Colorado River near Bay City (TOP RIGHT), streamflows plummeted during the end of 2010 through 2011, typically falling within the lowest 10th percentile (MUCH below normal).

On the BOTTOM LEFT are flows at the Brazos River near Rosharon gage. Flows here also lived Much Below Normal throught most of 2011….and if I recall correctly, Mike Turco of USGS reported measuring salinities at this gage –which is 50 miles upstream of the river mouth.

These patterns are repeated in many coastal gages for a portion of or much of 2011 and in some cases new record lows were recorded.

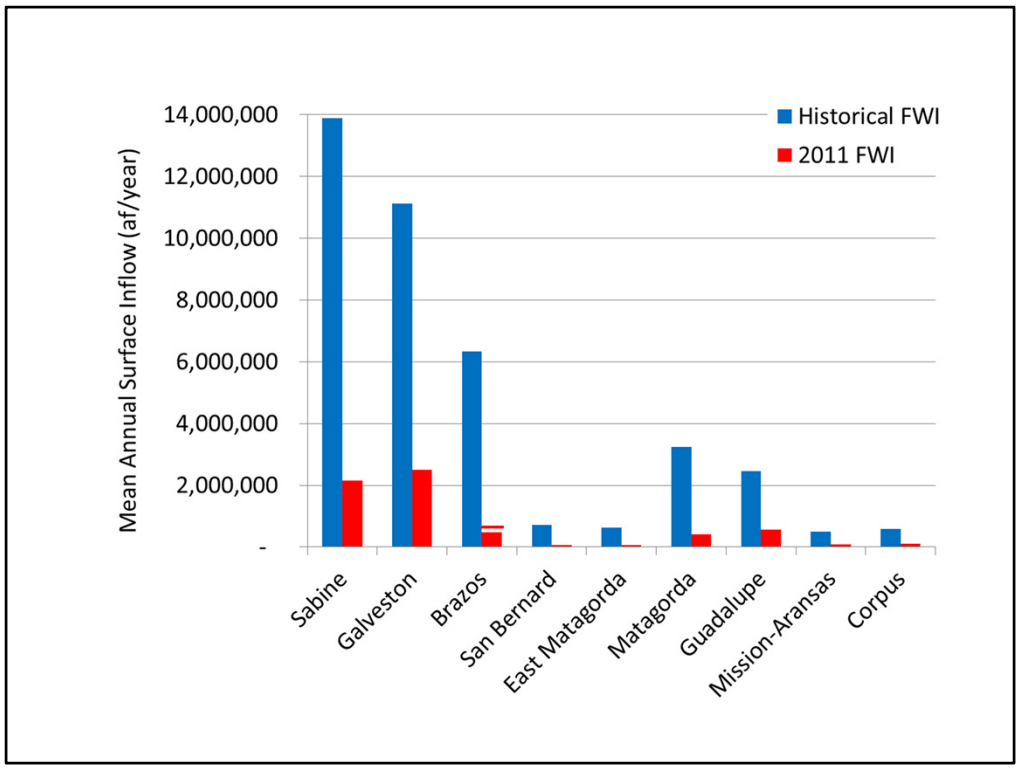
As expected low precipitation and low streamflow conditions affected the volume of freshwater inflow reaching the bays and estuaries.



But.. Before showing the inflow totals for the estuaries during 2011, I should first briefly go over TWDB's Coastal Hydrology program -- which estimates surface (freshwater) inflows to all of the major estuaries, as well as the Brazos River Estuary, San Bernard/Cedar Lakes Estuary, and East Matagorda Bay.

Freshwater inflow estimates are based on USGS streamflow gage data for watersheds with streamgages. A rainfall-runoff model (TxRR) is used to determine streamflow in watersheds without stream gages, but then diversion and return flow data (obtained from TCEQ or the STWM or other sources) are accounted for.

Inflows are available as monthly or annual inflows from 1941 – 1976 for most estuaries. From 1977 to present, TWDB can provide daily freshwater inflow estimates. However, the estimates are not real-time or even near real-time. The data I will show today is preliminary and is missing diversion and return flow data for 2011.

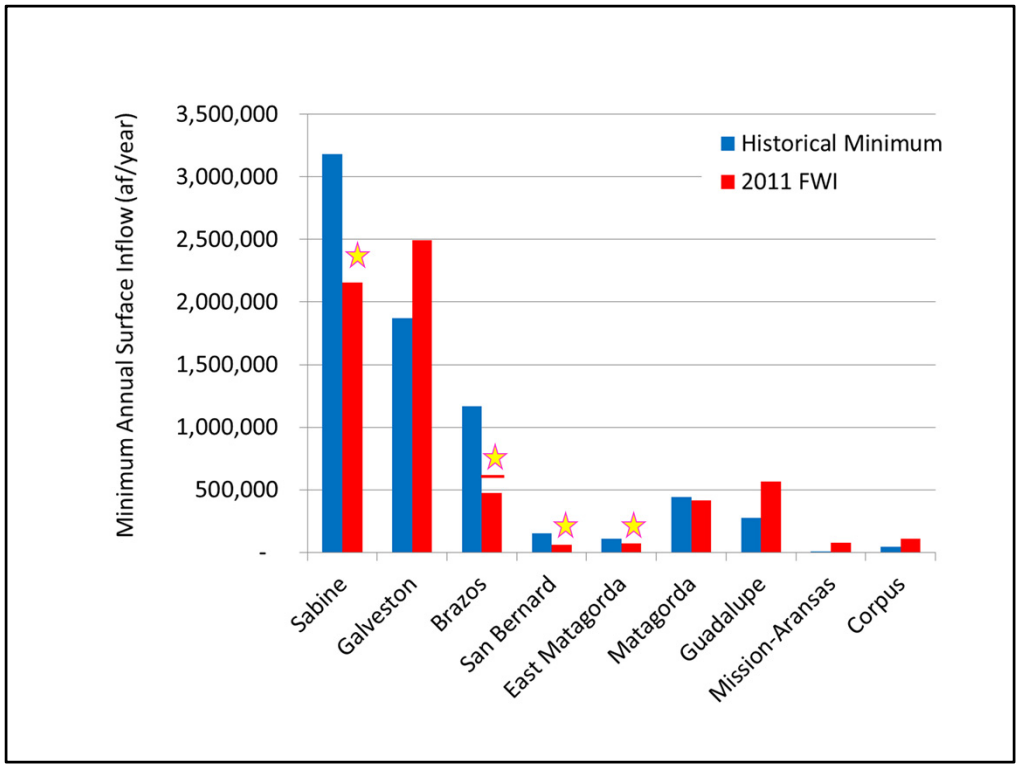


Preliminary data *Does not include diversion and return flow data for any basin; Brazos is “gage only” but red line estimates gage + modeled using avg modeled inflow over the period of record* *Laguna Madre inflows are still being developed*

This slide shows MEAN Annual Inflow to all of the major estuaries (and a few minor estuaries) for the Year 2011 (red) as compared to the historical period of record (1941 – 2010 or sometimes 1977 – 2010; blue).

I’m not sure that the message this slide offers is any surprise to anyone in this room, but the reduced volumes still are shocking to see.. especially when paired next to what we know to be average inflow for these systems.

(NOTE: Laguna Madre inflows are not available at this time.)



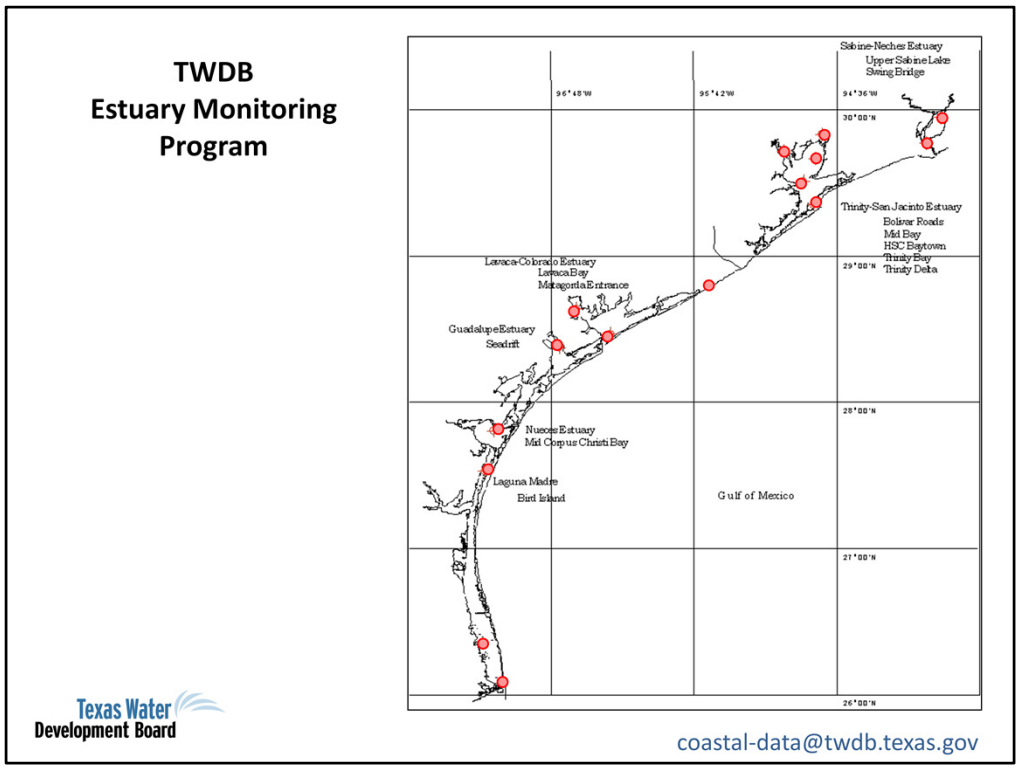
Preliminary data *Does not include diversion and return flow data for any basin. .. Brazos is “gage only” but red line estimates gage + modeled using avg modeled inflow over the period of record* *Laguna Madre inflows are still being developed*

This slide shows MINIMUM Annual Inflow to all of the major estuaries (and a few minor estuaries) for the Year 2011 (red) as compared to the historical period of record (1941 – 2010 or sometimes 1977 – 2010; blue).

Record minimum annual freshwater inflow occurred for Sabine, San Bernard, East Matagorda, and Matagorda. A record also may have been set for the Brazos – however we haven’t completed analysis for this basin. Gaged inflows certainly were the lowest recorded, but we need to account for ungaged (modeled) flows, diversions and returns. [Red bars higher than Blue bars]

We still need to account for diversions and returns in all of the basins, but even so, it is likely these minimum inflow records will hold for Sabine, San Bernard, East Matagorda, and probably for Matagorda Bay as well

All other bay systems experienced their lowest minimum annual inflow during either: 1956 (Galveston, Guadalupe), 1950 (Mission-Aransas), 1962 (Corpus).

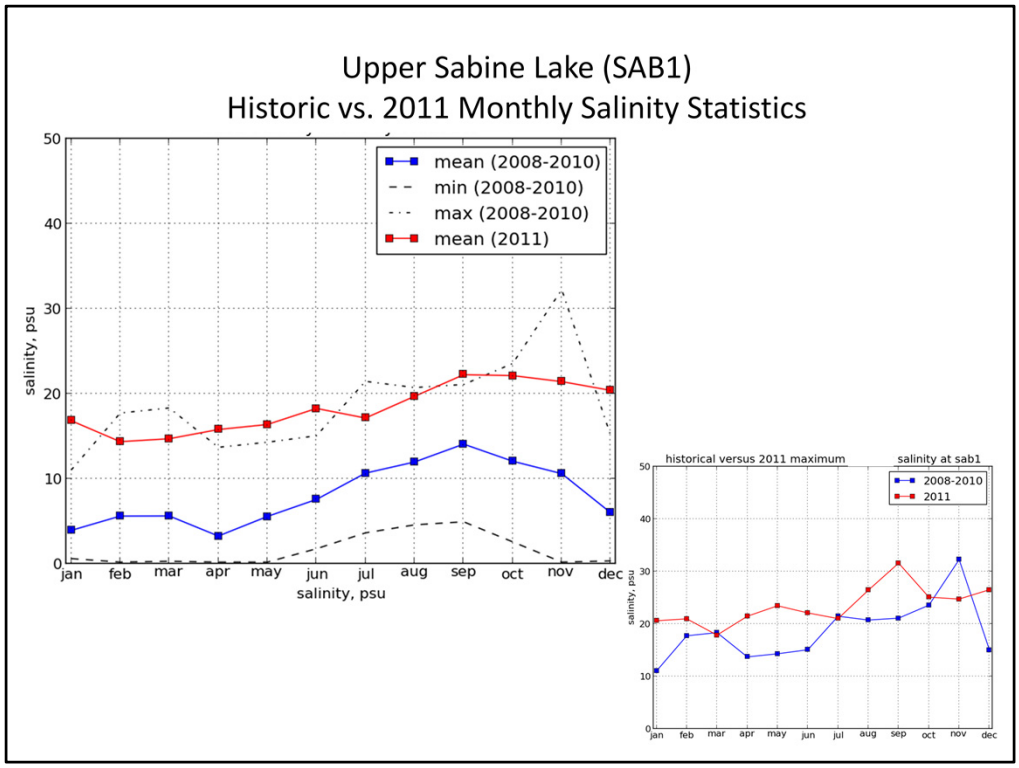


Since the late 1980's TWDB has supported a coast-wide network of datasondes – primarily to measure hourly salinity and water level along the Texas coast. The datasondes were put in place to collect data for use in calibrating our TxBLEND and other hydrodynamic and salinity transport models and for analysis of various salinity-ecology relationships. Some sites have data for other water quality parameters, such as DO which we try to collect at all upper estuary stations.

In recent years, TPWD has maintained and serviced all of the sites for TWDB. However, TWDB staff or other partners collect data as part of special projects, such as in the Keith Lake/Salt Bayou system, the wetlands of the San Bernard National Wildlife Refuge, Nueces Delta, and Rio Grande.

We are currently developing a database to hold this data – and any other salinity data that others will allow us to host – The data is available upon request (see email address) but at this time is not on our website.

Today, I will show some data from upper Sabine Lake, Trinity Bay, Lavaca Bay, San Antonio Bay, and Corpus Christi.

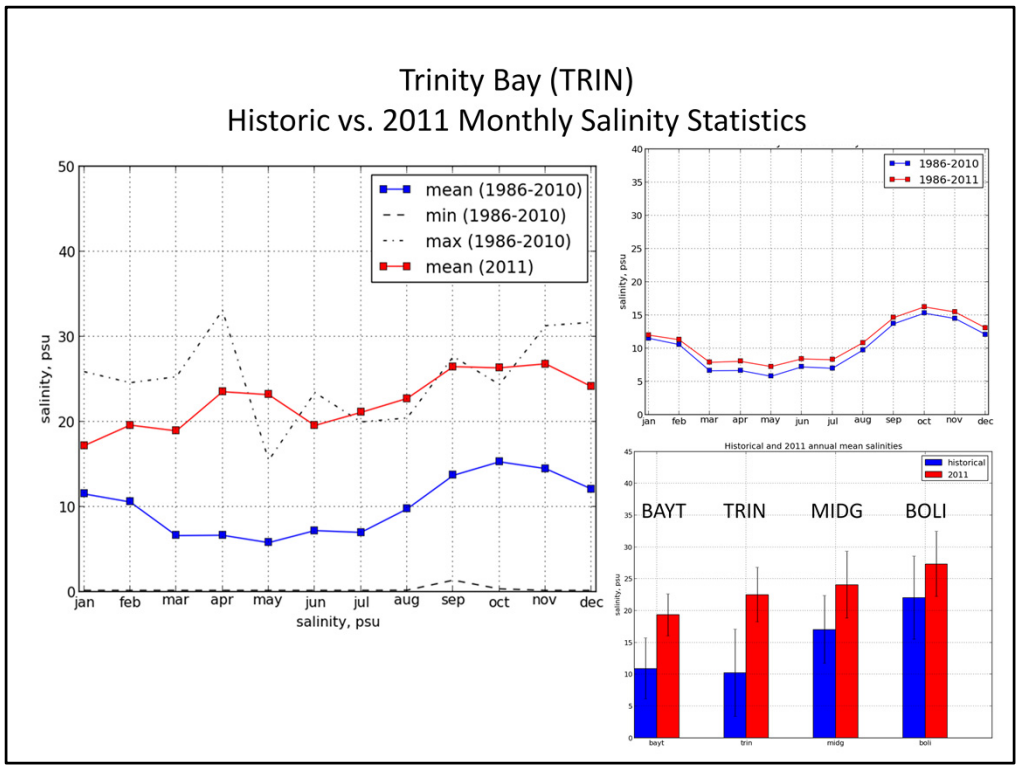


The next few slides will show similar graphs as to the one on the LEFT. You can see the historic mean monthly salinity (blue) throughout the year as compared to mean monthly salinity in 2011 (red). Also plotted are the min and maximum recorded salinities in each month (dotted lines).

Salinity in Upper Sabine Lake was clearly higher than historic values and increased throughout the year, with some monthly average salinity values being higher than the highest previously recorded salinity maximum. (April – June, September).

The slide on the LOWER RIGHT compares previously recorded maximum salinity values to the maximum values recorded in 2011. Nine of the 12 months had daily salinity values which exceeded the historic maximum; 2 of 12 months practically tied historic maximum; only November of 2011 had a lower maximum daily salinity than the historic maximum.

LOWER SABINE (SAB2, SWBR): Showed the same pattern for mean salinity.



Again, Trinity Bay monthly average salinity exceeded historic monthly salinity in all months (LEFT). Four months had an average salinity value greater than previously recorded maximum values (May, July, August, October).

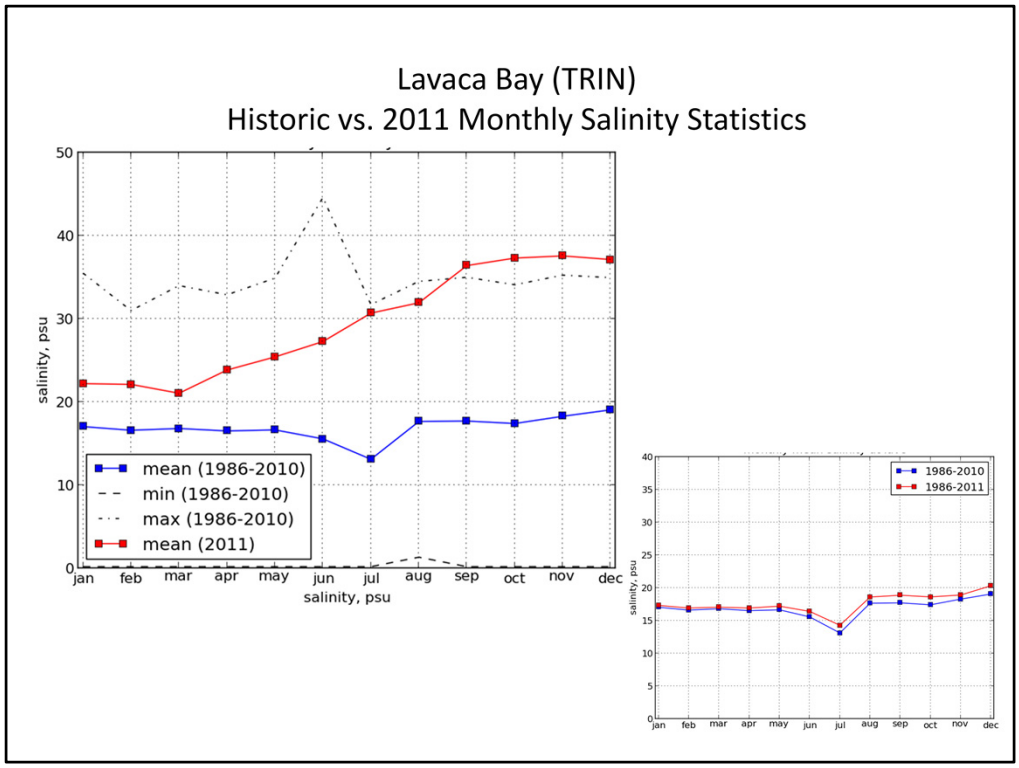
The TOP RIGHT graph shows how the long-term mean (Blue, 1986 -2010) recorded for the TRIN station changed as a result of conditions in 2011. The red line shows the new mean monthly values of salinity at TRIN, when 2011 data is included in the average – slight shift upwards for all months.

OTHER GALVESTON BAY LOCATIONS are shown on BOTTOM RIGHT: (bar chart shows annual mean $\pm$ s.d.)

BAYTOWN (BAYT) – BAYT had a similar pattern of mean monthly salinity as TRIN, though mean values tended to remain below 20psu most of the year. Also, eight of 12 months recorded new salinity maximums.

MIDGALVESTON (MIDG) -- MIDG monthly salinities where not as elevated as at the TRIN station and remained similar to the historic mean.

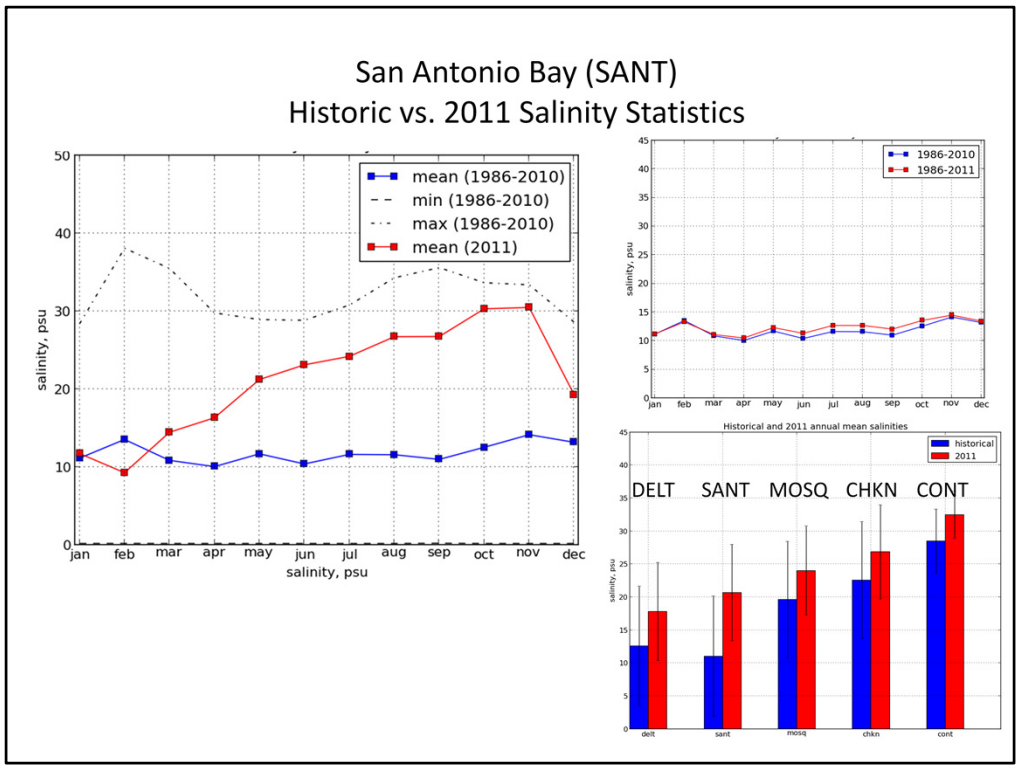
BOLIVAR (BOLI) – 2011 Maximum daily salinity approached historic maximums (1990 – 2010) during the last half of the year, but only exceeded in Oct/Nov and only by 1 -2 psu. Also 2011, mean monthly salinity was well above the historic mean.



Lavaca Bay salinities historical average below 20 ppt. In 2011, you can see that the values were above 20ppt and even exceeded 30ppt.

By the end of the year, maximum recorded salinity values were exceeding historic maximums.

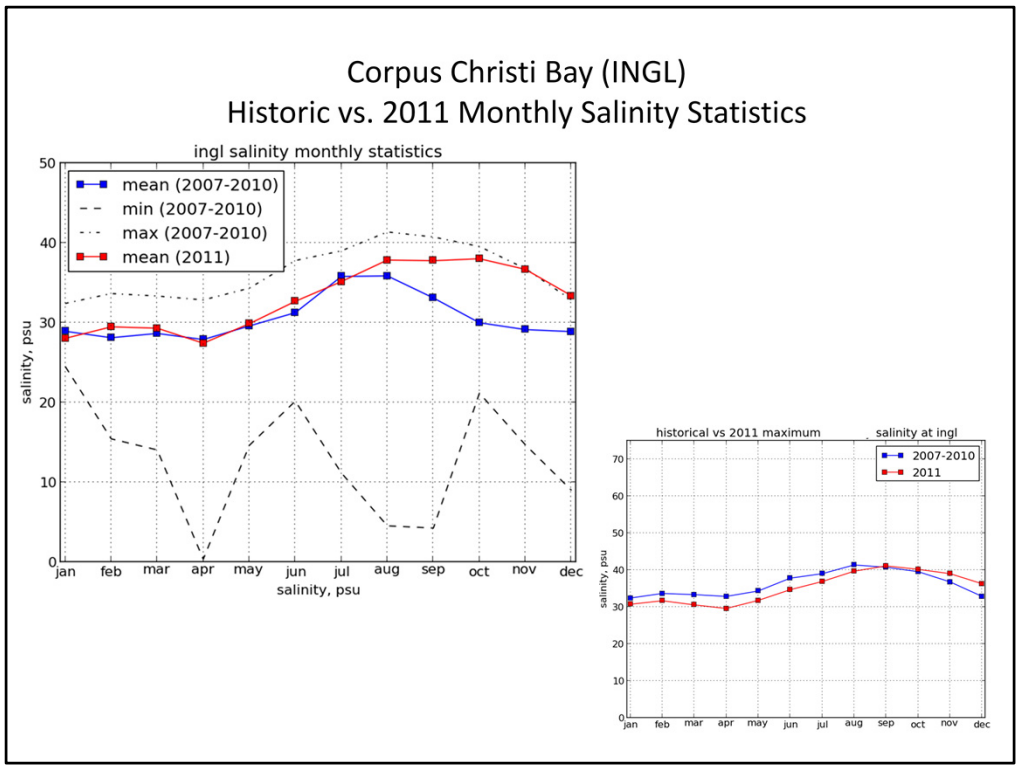
Changes to the Long-term Mean: Inset graphic shows the historic (1986-2010) monthly mean salinity as compared to the new historic mean when 2011 is included – slight shift upwards for mean monthly salinity during the last half of the year.



San Antonio Bay at SANT also showed a large departure from historic mean monthly salinity, which translated to somewhat of an increase in the long-term mean once 2011 values were included.

Changes to the Long-term Mean: Inset graphic shows the historic (2003-2010) monthly mean salinity as compared to the new historic mean when 2011 is included – slight shift upwards for mean monthly salinity during the summer months (May – Oct).

(bar chart shows annual mean ± s.d.; SANT (2003 - 2010) and all others (~2008 – 2011))

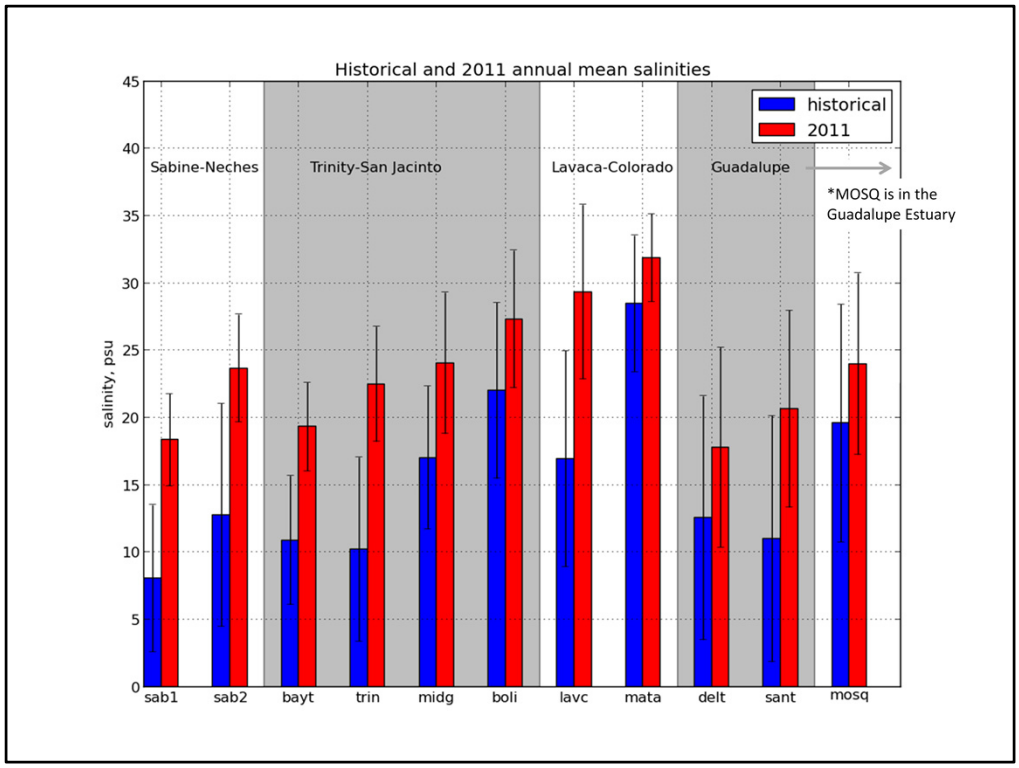


Corpus Christi Bay at INGL showed the least overall impact of the drought (of these stations presented).

Maximums: Recorded salinity values only slightly exceeded the historic (2007 – 2010) maximums from September – December.

Changes to the Long-term Mean: The period of record at this site covers only five years for this analysis… therefore it is hard to know the effect of 2011, but generally, the historic mean was shifted slightly upwards as a result of the high salinity conditions during the latter part of the year.

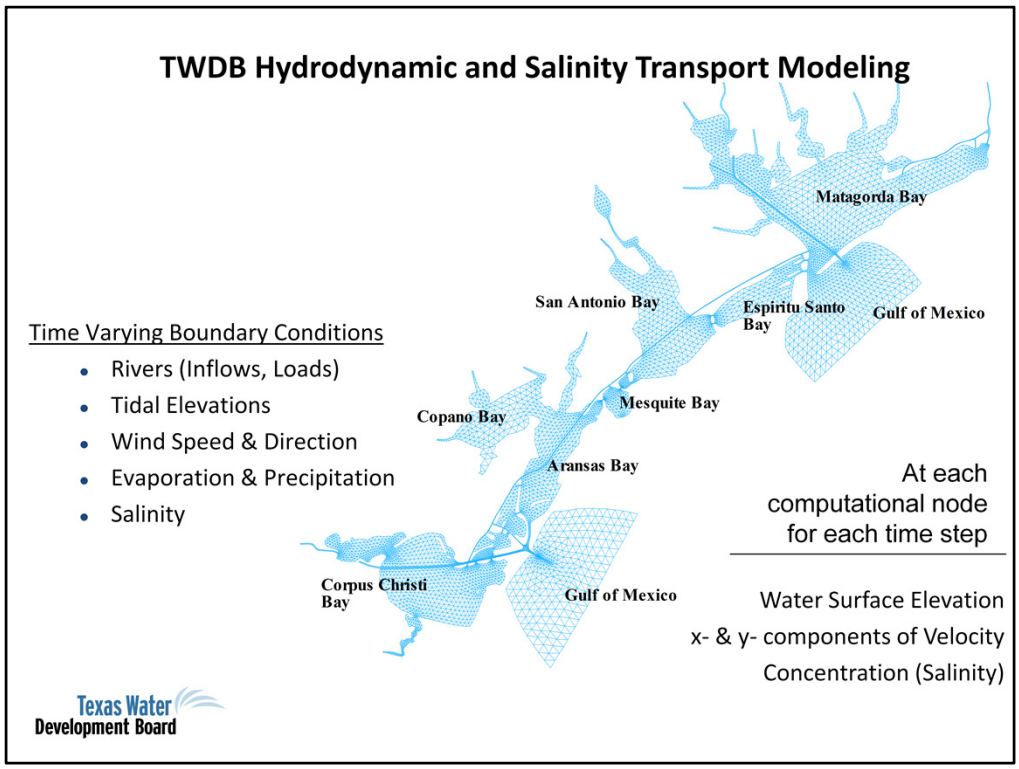
2012 salinities for the first part of the year were above “normal” but appeared to be trending downwards by July – though not all 2012 data has been processed.



It is hard to go through all of the stations we have in the network, but here is a snap shot of mean annual salinity for stations in five estuaries. Overall, the pattern is that 2011 mean annual salinity was substantially higher than historic means.

(bar chart shows annual mean $\pm$ s.d.)

*NOTE: MOSQ was accidentally excluded from the Guadalupe Estuary stations. It is one of the three Guadalupe Estuary stations shown on this plot.



Finally, I want to mention that in addition to hydrology and salinity datasets, TWDB staff maintain hydrodynamic and salinity transport models of the estuaries to use in a variety of applications, from freshwater inflow analysis to oil spill response and recovery and even to assist in the towing of large oil platforms.

At this time, I don't have any simulations of bay conditions during 2011 – it would have been nice, but it's just wasn't available.

Our primary model is the TxBLEND model, it is a 2-D vertically averaged model which has been used by all of the BBEST teams during the SB3 process. We also have 3-D models in development for some bay systems. The models rely on several inputs (inflow, tidal elevation, wind, etc.) in order to simulate patterns of salinity and water movement in the bays.

Summary of Conditions in 2011

- Annual Freshwater Inflow to the estuaries was at or near historic minimums all along the coast.
- All bays (except Corpus Christi at INGL) showed a substantial increase in monthly mean salinity – from the upper estuary to the Gulf passes
- Maximum salinity values were near historic records and many new records of daily or monthly salinity maximums were set.
- TWDB can provide, upon request, data for coastal inflows, salinity, and modeling assistance
- TWDB staff will continue to explore the impacts of recent drought years

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Texas Water Development Board

THANKS FOR ALL THE HELP!!!

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TPWD Staff for maintaining the Datasonde Program