Effects of Hurricane Harvey on the Water Quality of the Galveston Bay Estuary, Texas

George Guillen, J. Oakley and K. Fazioli

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UHCL

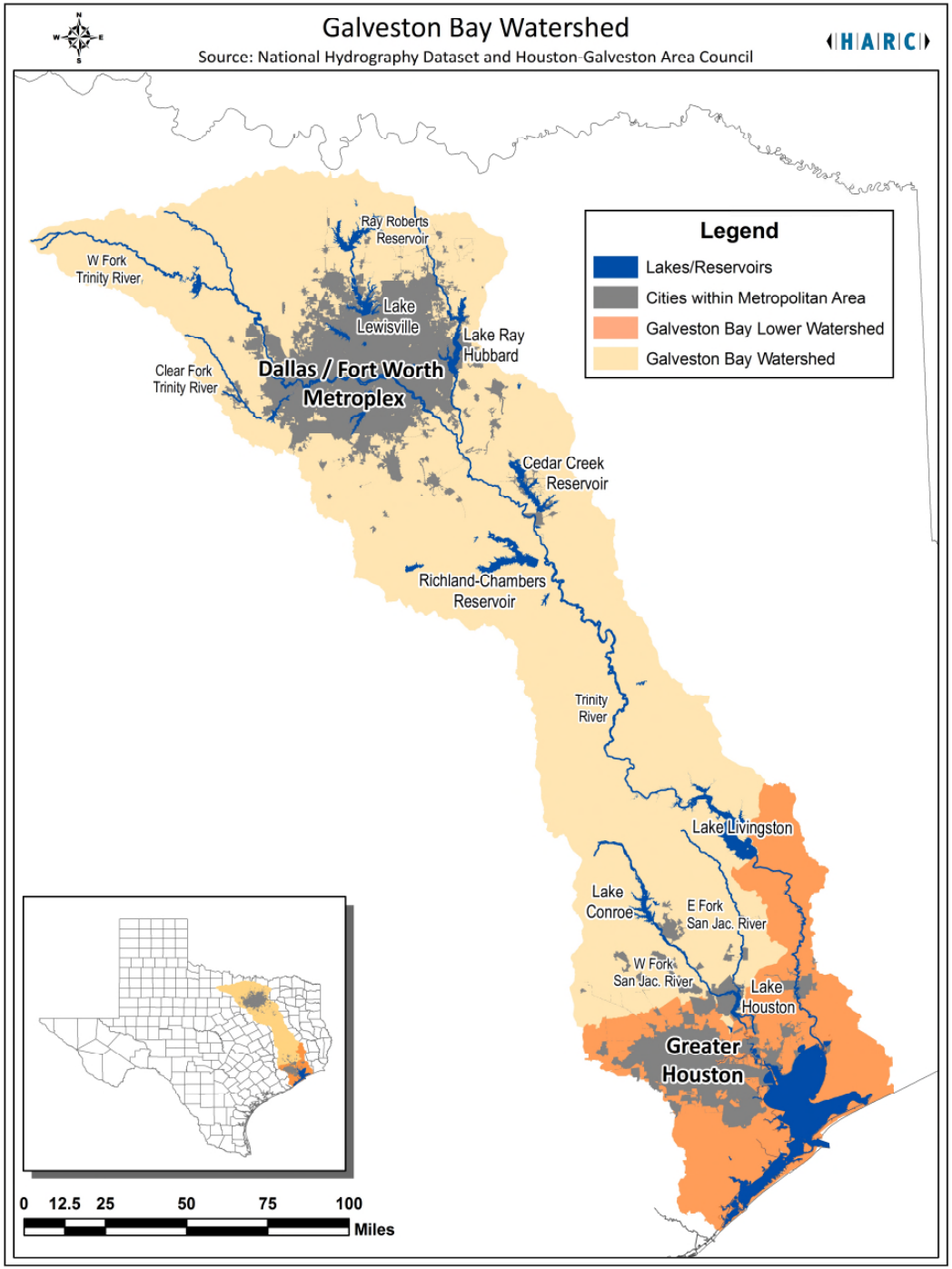
University of Houston Clear Lake

Galveston Bay

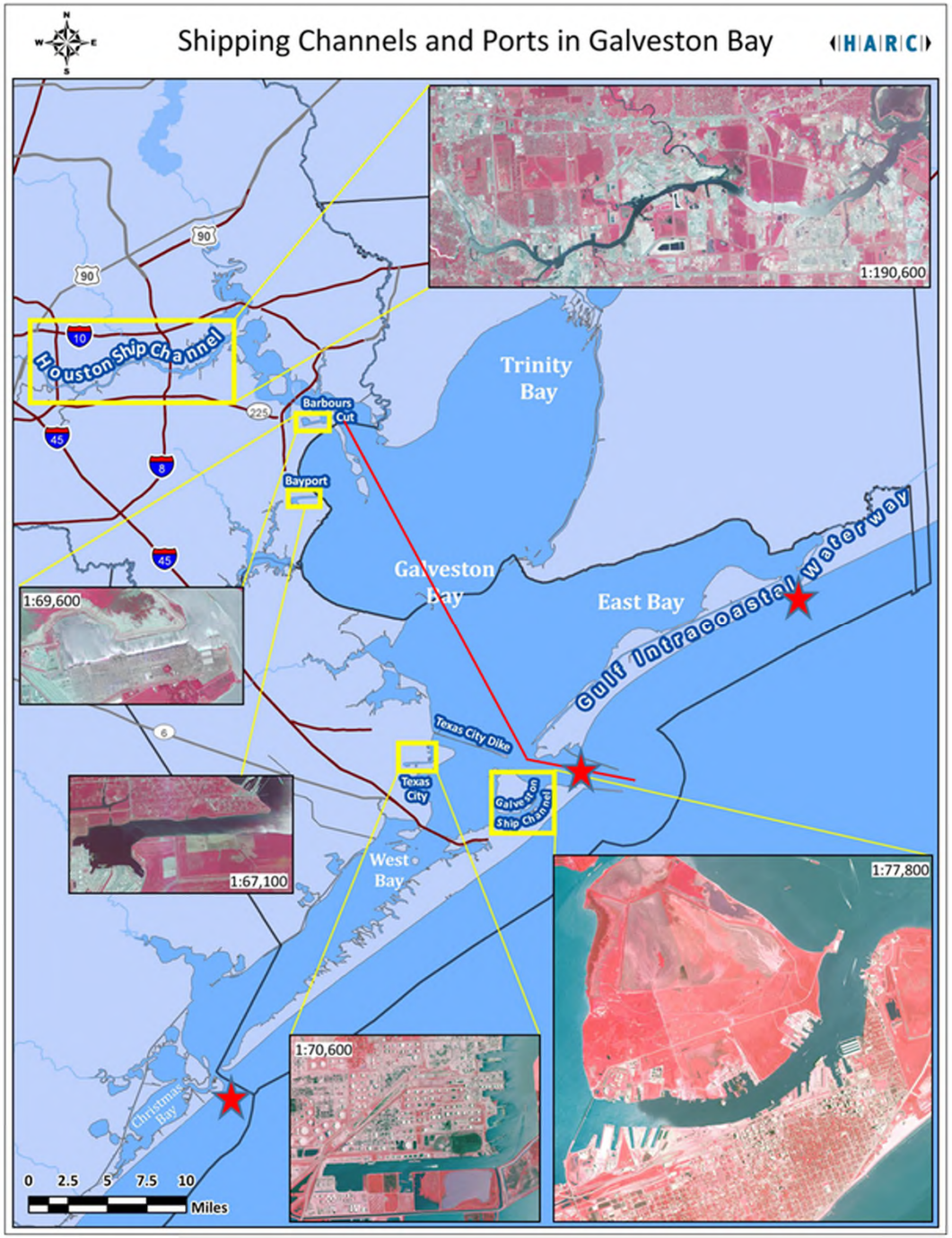
Background Information

- The largest estuary in Texas (600 mi^2) with the 4th most populous metropolitan area in U.S.
- The drainage basin includes Dallas/Fort Worth and Houston.
- **Freshwater inputs** intc the estuary from the **Trinity (55%)** and San **Jacinto (26%)** Rivers respectively.[1]

[1](Guthrie et al. 2012; NOAA 1988).



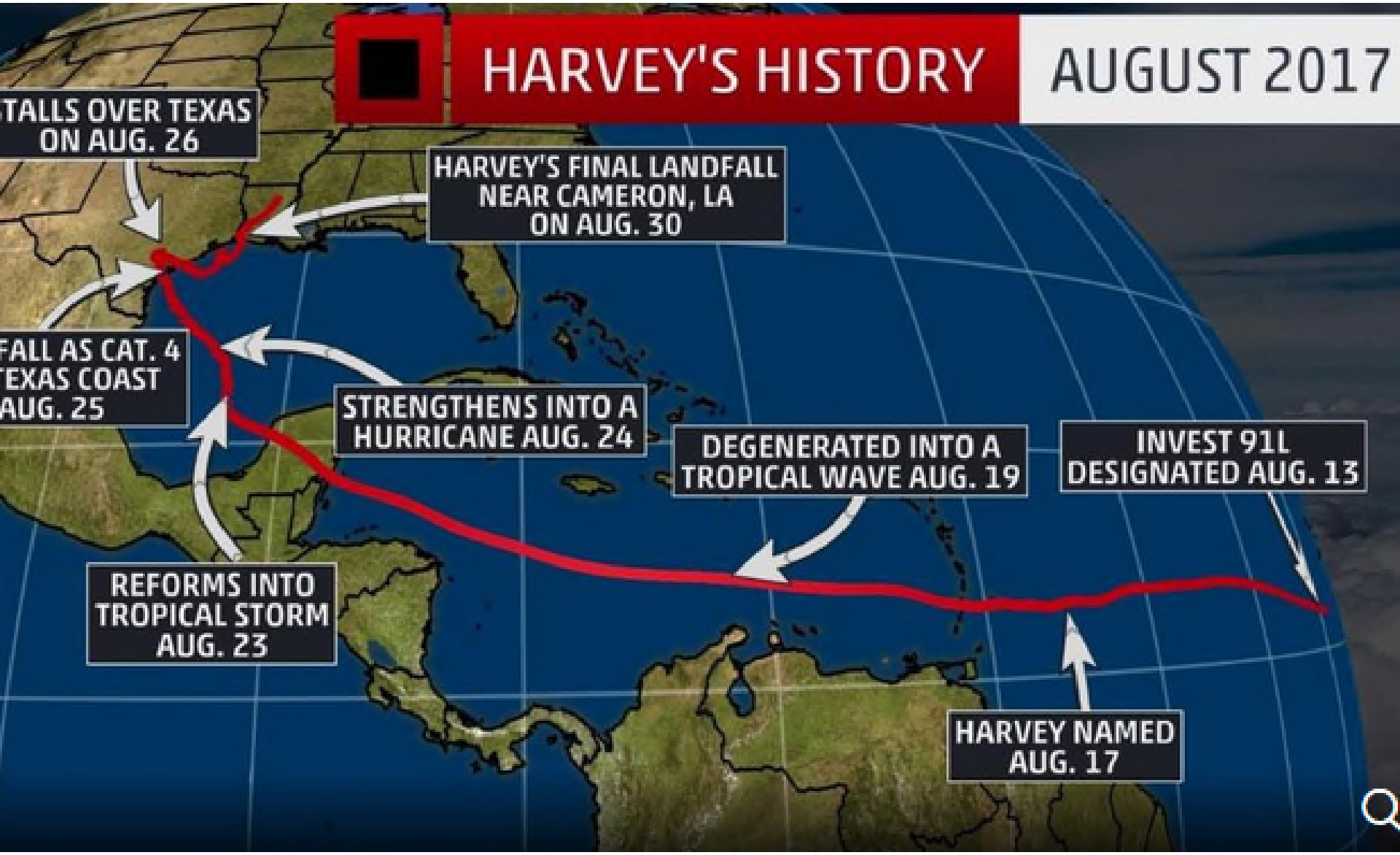
- Avg. inflows – 7.9M ac-ft/yr.
- Avg. salinity 15.1 ppt < 5 to 35 ppt. Driven by freshwater inflow into the system.[2]
- Bay (< 12 ft);channels (20-55 ft).
- Avg tide range: 1.4 ft wind important.
- Major outlets – Bolivar Roads; San Luis Pass



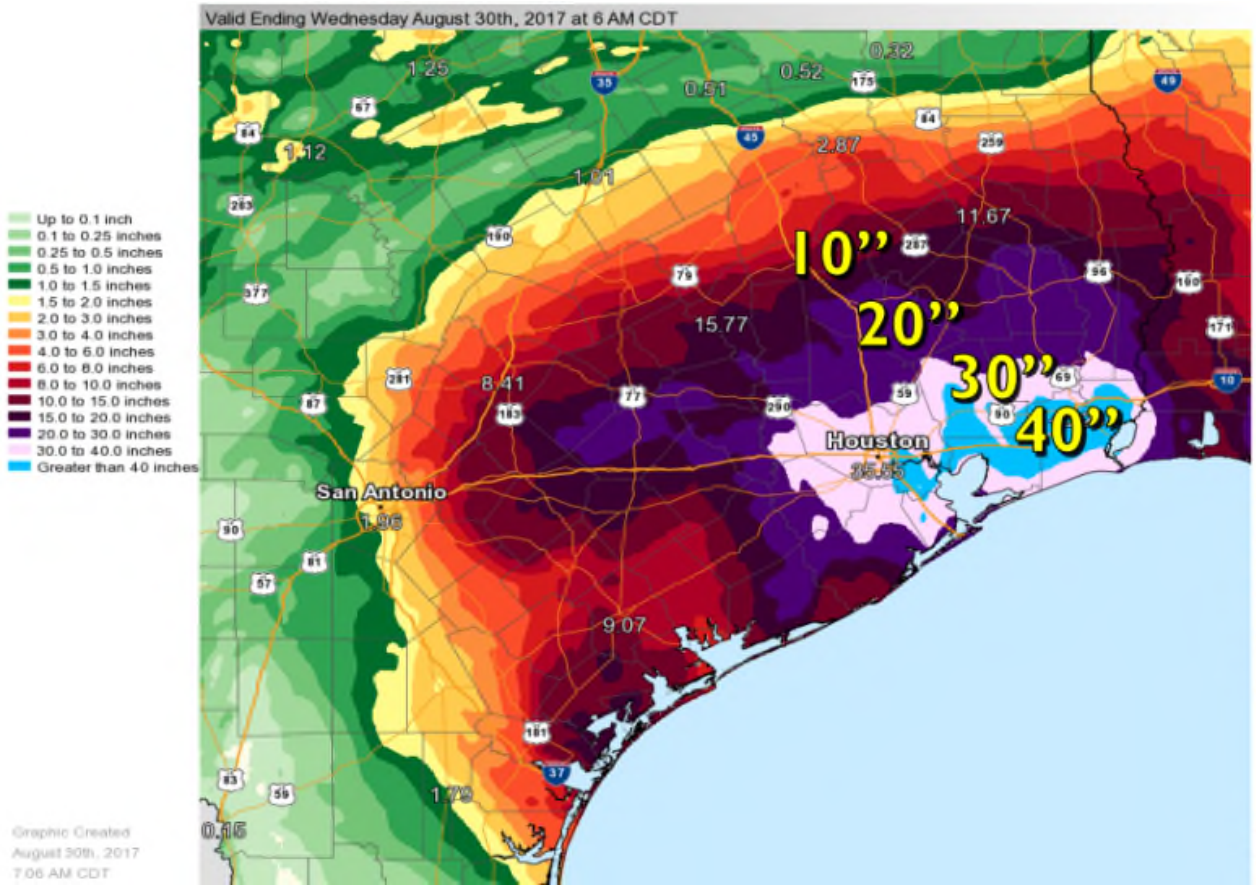
[2](Pinckney et al. 2017).

Hurricane Harvey

Background Information



her.com/storms/hurricane/news/tropical-storm-harvey-forecast-texas-louisiana-arkansas



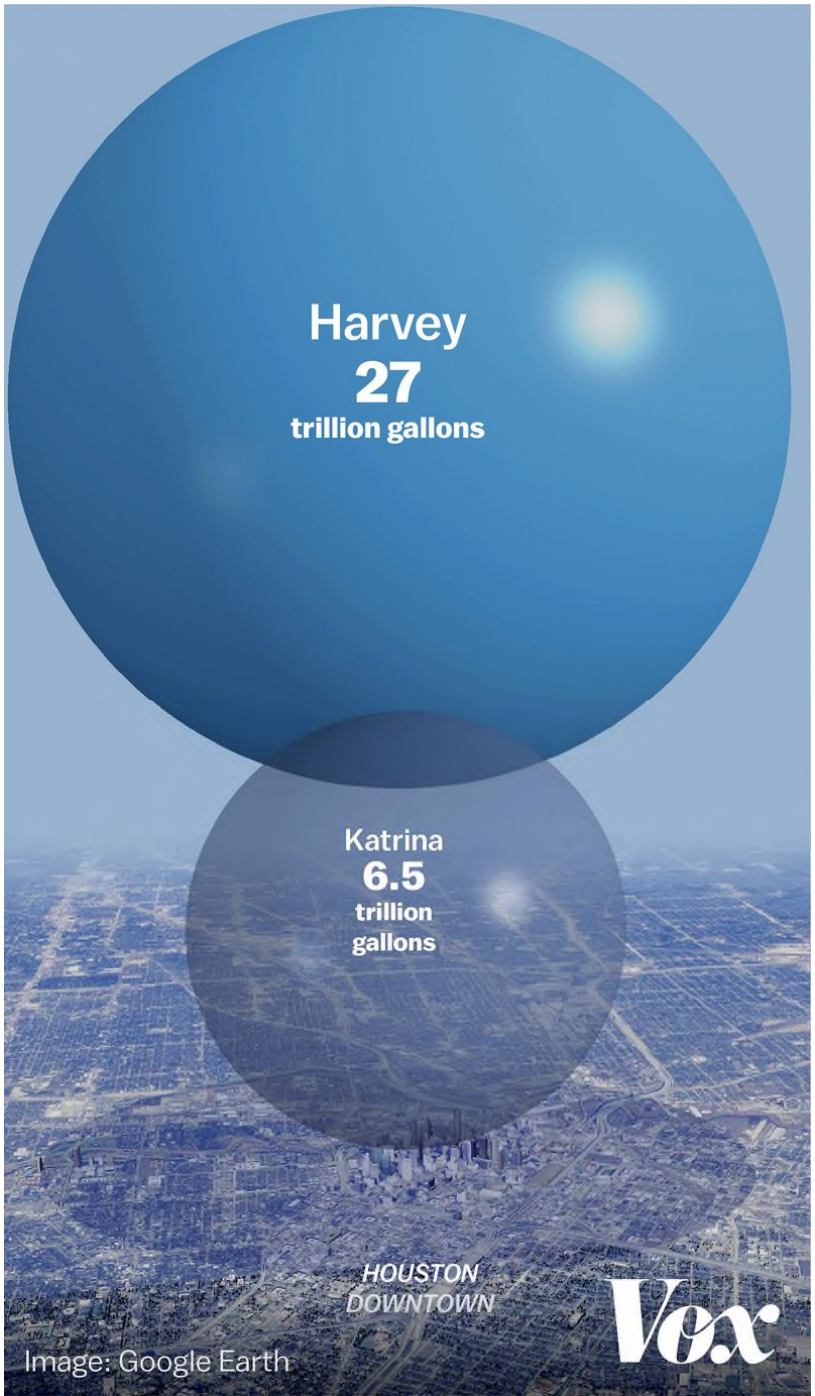
5 Day Point Rainfall Amounts in Inches

- Harvey continued to produce record breaking **rainfall totals** of **45 to over 50 inches**… with continued rainfall
- **Cedar Bayou - 51.88**
- **Berry Bayou - 44.88**
- **League City - 49.84**
- **Mary’s Creek - 49.80**
- **Goose Creek - 44.08**
- **Greens Bayou - 41.36**
- **Buffalo Bayou - 35.60**
- **Addicks Dam - 33.44**

Agency View

An interactive map of the Harris County Flood Control District

Point rainfall data courtesy



= 82.9 million ac-ft. across Texas and Louisiana

1 of 2

FILE - In this Aug. 29, 2017, file photo, water from Addicks Reservoir flows into neighborhoods as floodwaters from Tropical Storm Harvey rise in Houston. A new report on the damage caused by Hurricane Harvey says the U.S. has never experienced the amount of rainfall across such a vast area as that brought by Harvey when it struck Texas. The report released this week by the Harris County Flood Control District says more rain fell over a five-day period, and on such a broad area, than at any time since records have been kept. (AP Photo/David J. Phillip, File)

ource: NASA Earth Observatory https://earthobservatory.nasa.gov/images/90866/texas-
aters-run-brown-after-harvey

Hurricane Harvey

- Late August 2017
- Exceeded all rainfall total records for contiguous USA (Oldenborgh et al. 2017).
- Rain began Friday morning, August 25th with the first heavy band entering the area August 26th. Heavy rain bands continued to sweep across the entire area through Tuesday, August 29th. The majority of the rainfall occurred during a 4 day period.
- Total estimated inflow during August 25 to September 20, 2017 was 11.5 million ac-ft.
- Greater than the average annual freshwater inflow to the system based on the 65-year period of record (1941-2018) (Schoenbaechler 2018; Guthrie et al. 2012).

Objective

- Characterize the amount of freshwater inflow into Galveston Bay due to Harvey
- Describe the spatio-temporal response of physicochemical variables (precipitation, flows, water level, temp, pH, salinity, dissolved oxygen, nutrients, indicator bacteria, turbidity)
- Biological response – marsh communities, dophin populations, nekton
- Presentation today focused on items in red.

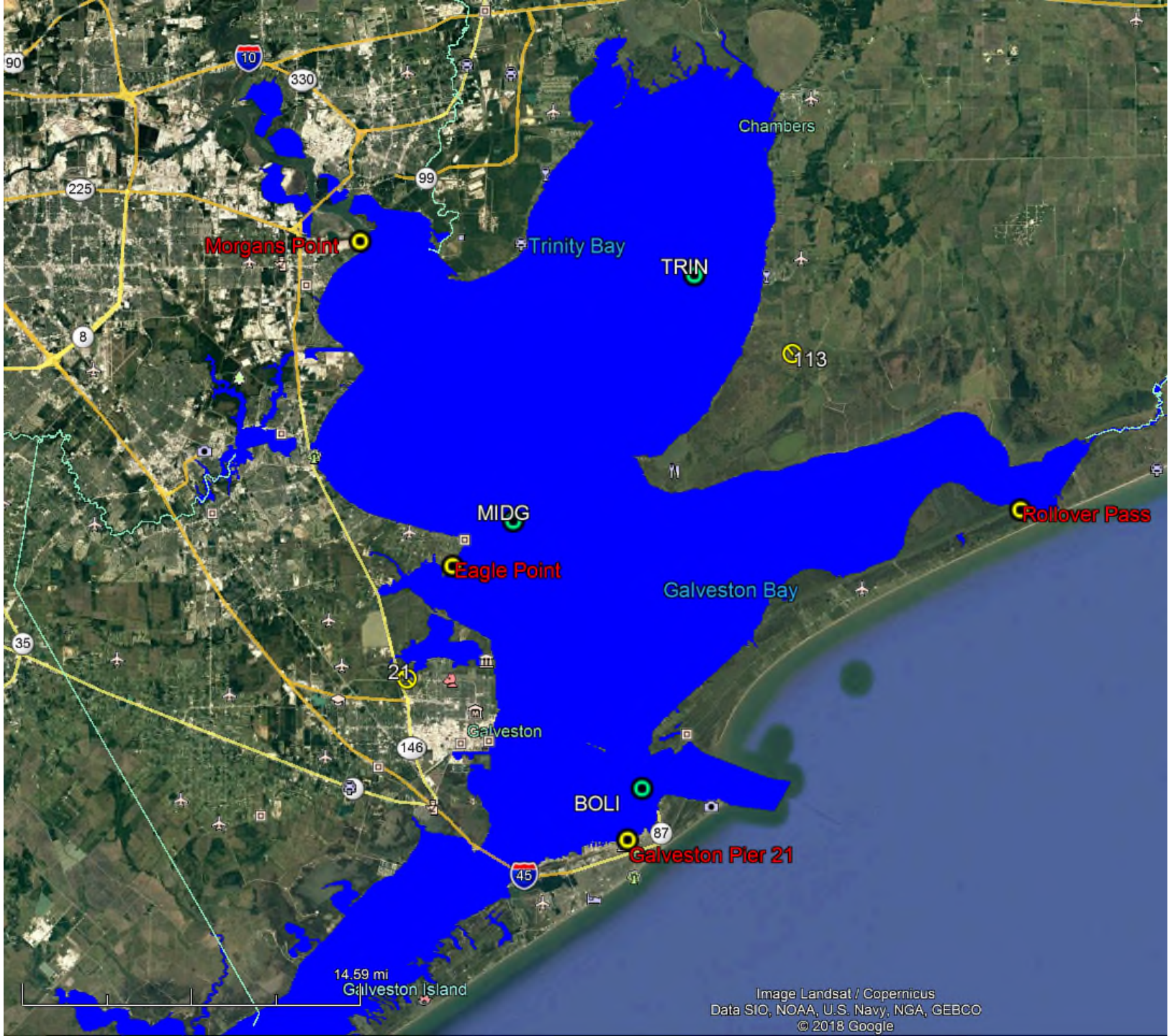
Methods: Data Sources

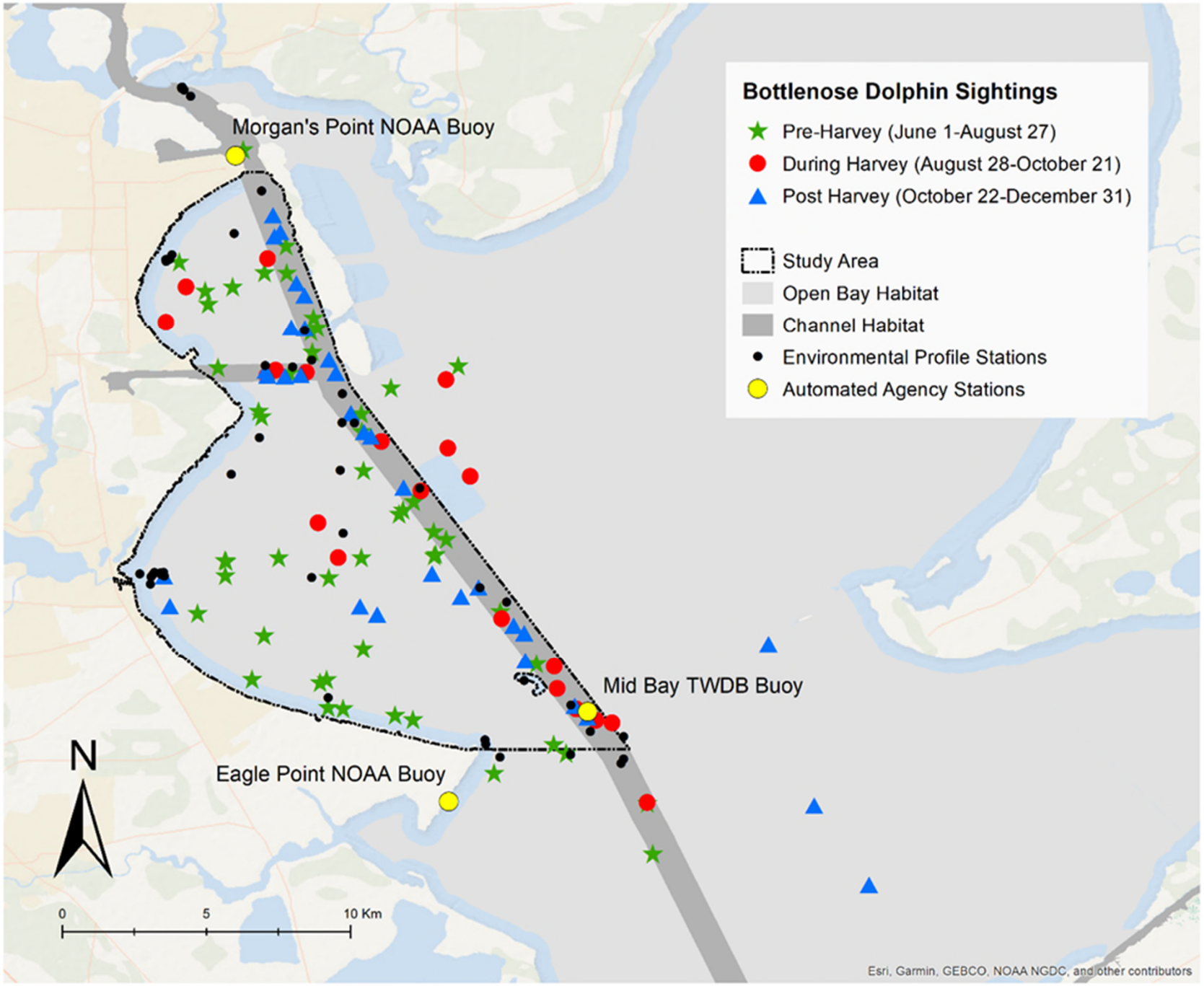
Continuous

- Texas Water Development Board (TWDB): Temp, salinity, pH, DO
- NOAA Co-Op: tide, temp, salinity
- USGS: flow/stage
- Harris County Flood control district: flow/stage/weather – not presented in detail
- NWS Meteorological - summary data
- NASA imagery – not presented

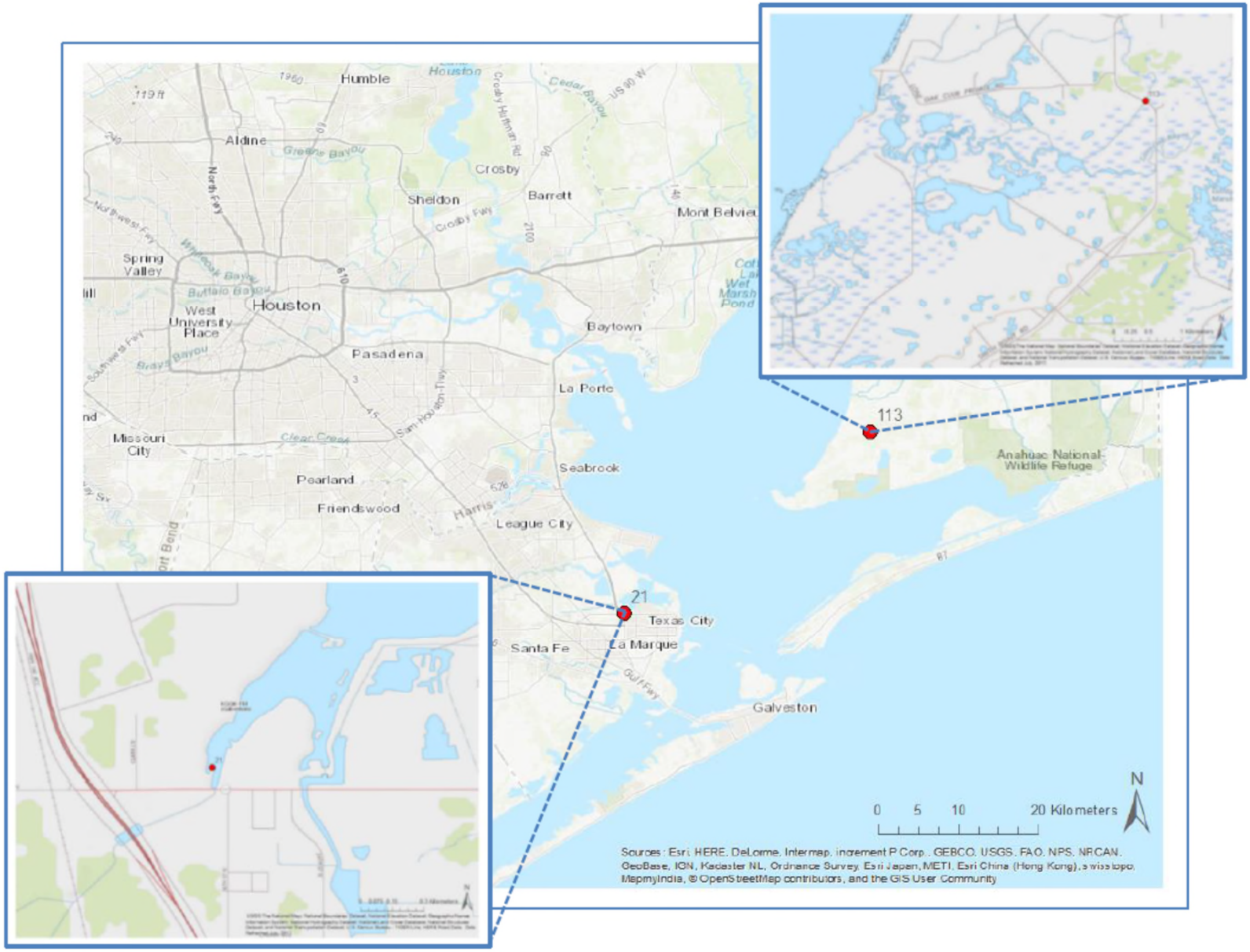
Point Samples & Vertical Profiles

- UHCL-EIH/GBF – marine mammal surveys
- UHCL-EIH – marsh studies TPWD SWG
- Galveston Bay Foundation citizens monitoring – not presented
- Tx Shellfish Monitoring – not presented
- Tx Beach Watch/GLO – not presented
- TPWD/TCEQ – routine monitoring – not presented


Morgans Point
Trinity Bay
TRIN
Chambers
113
MIDG
Eagle Point
Rollover Pass
Galveston Bay
21
Galveston
BOLI
Galveston Pier 21
14.59 mi
Galveston Island
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2018 Google


Bottlenose Dolphin Sightings
Pre-Harvey (June 1-August 27)
During Harvey (August 28-October 21)
Post Harvey (October 22-December 31)
Study Area
Open Bay Habitat
Channel Habitat
Environmental Profile Stations
Automated Agency Stations
Morgan's Point NOAA Buoy
Mid Bay TWDB Buoy
Eagle Point NOAA Buoy
N
0
5
10 Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

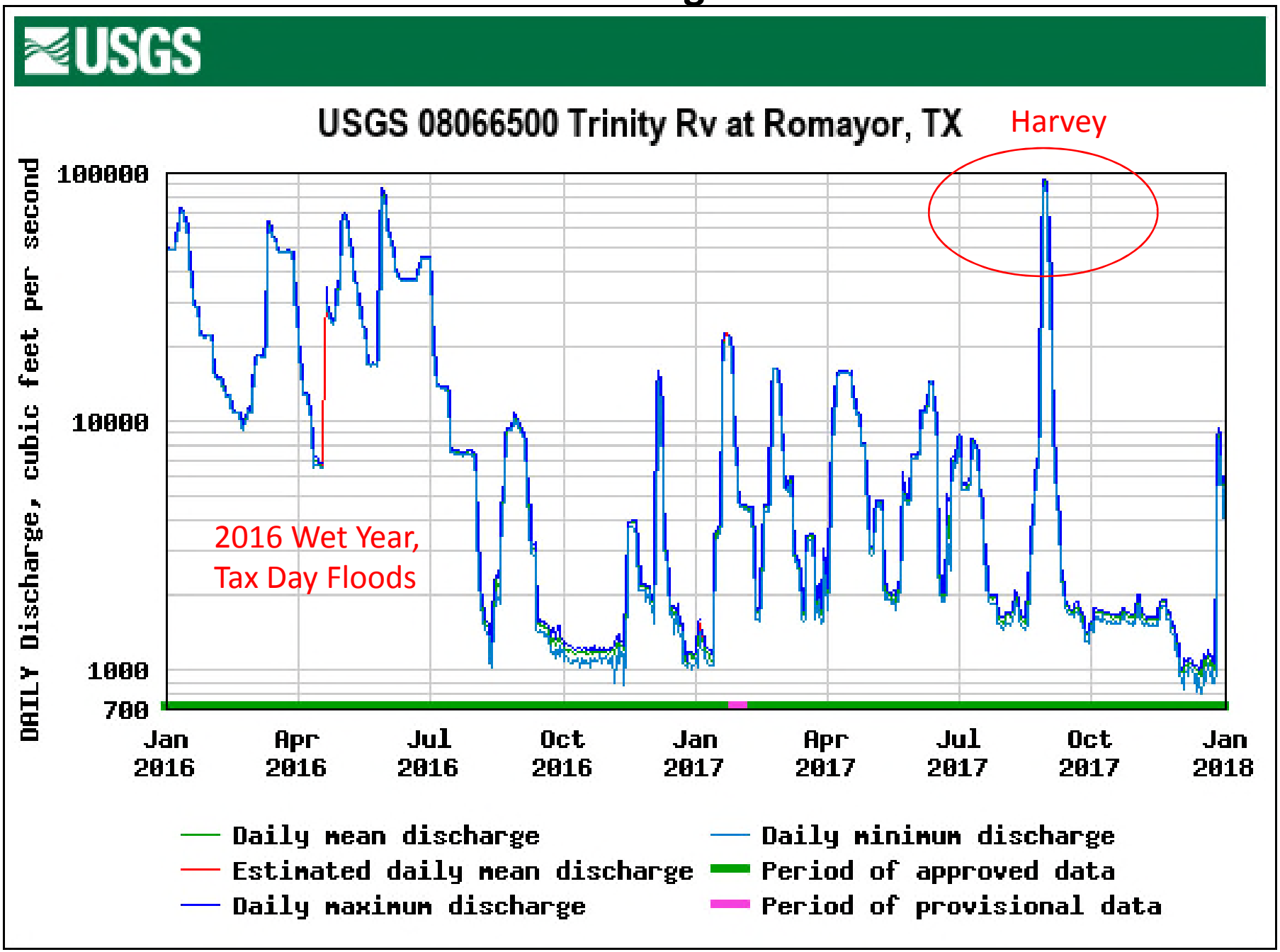
Site 113 Wetland



Site 21 Wetland

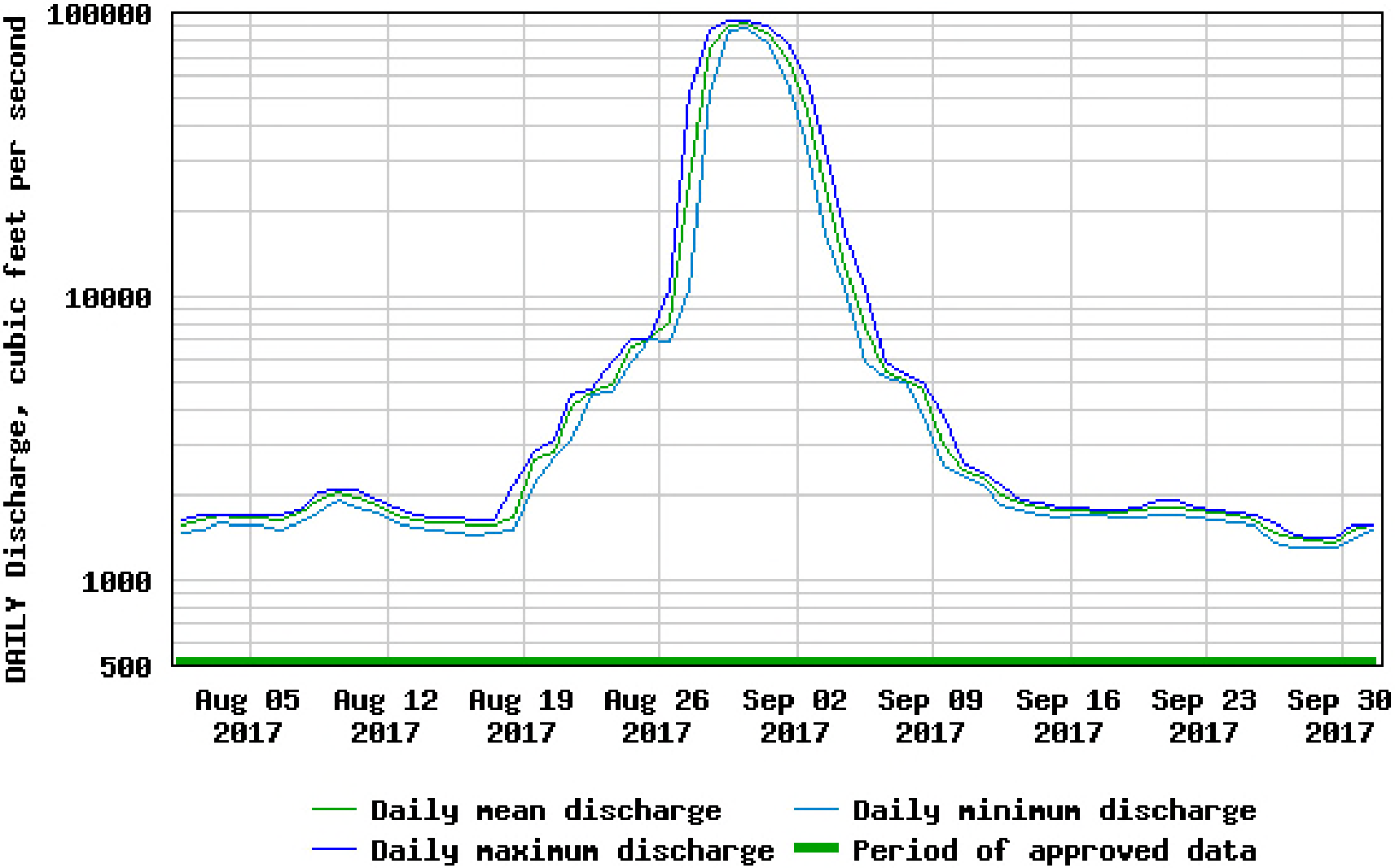
Results

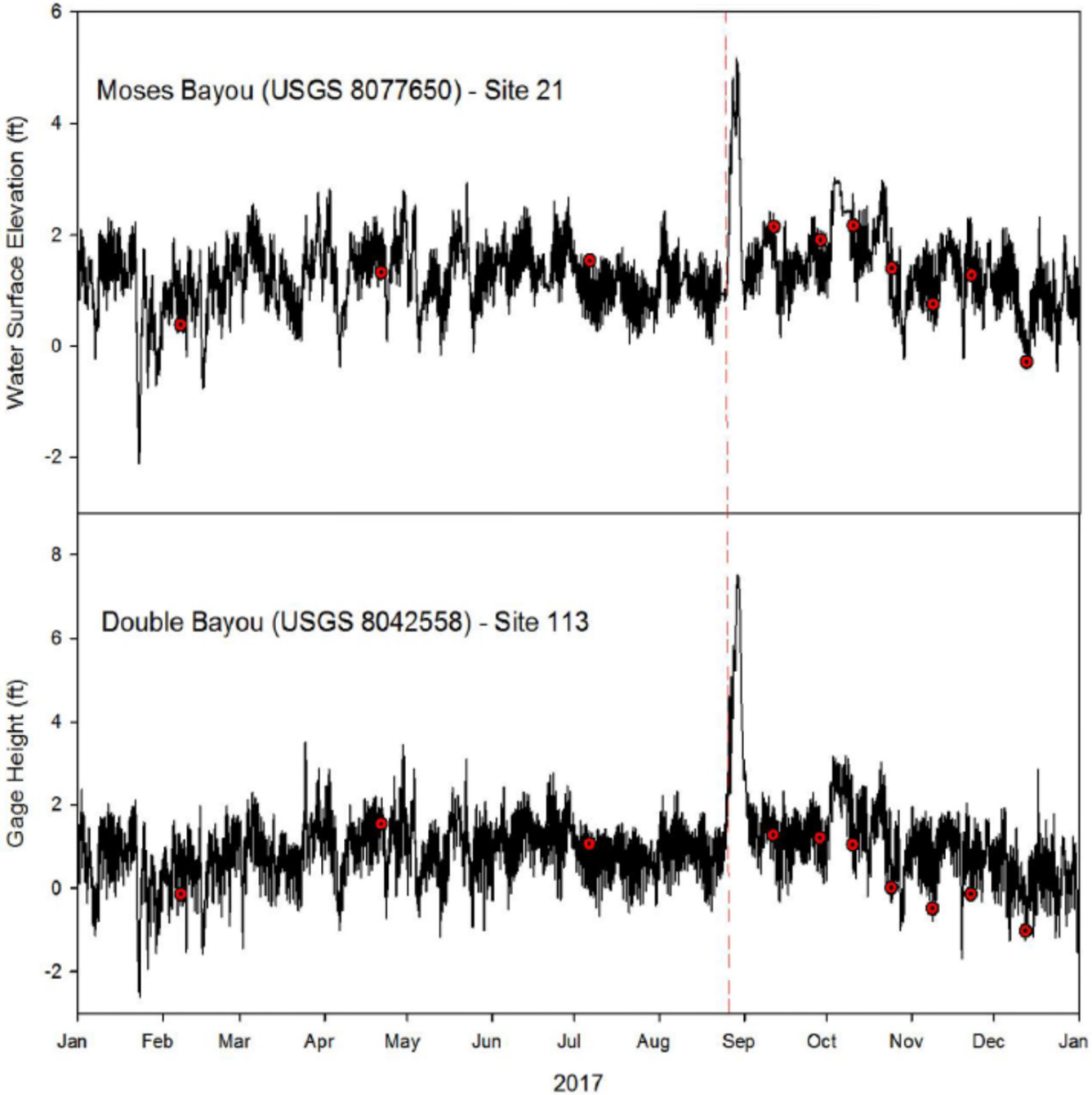
Below Lake Livingston Reservoir

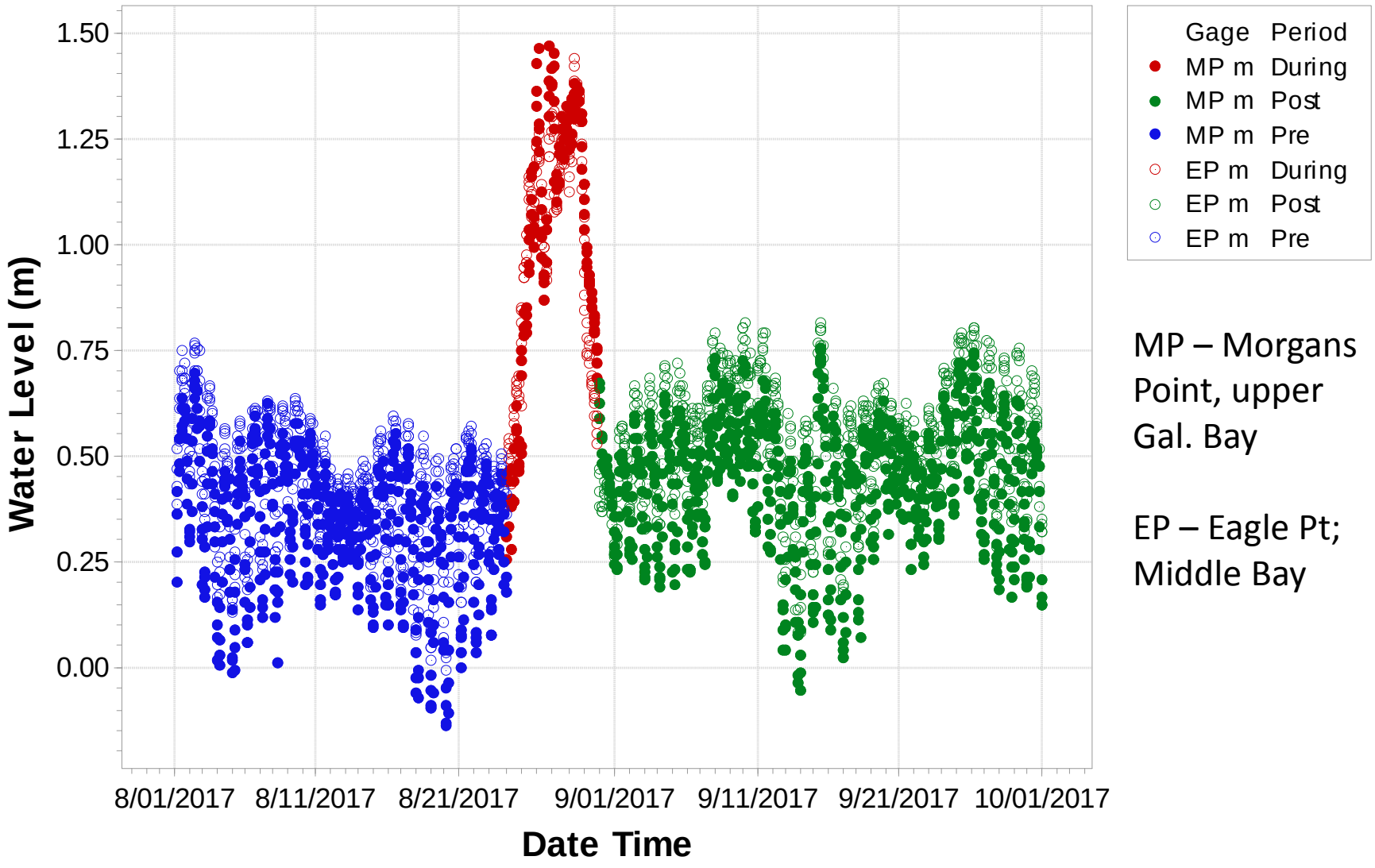


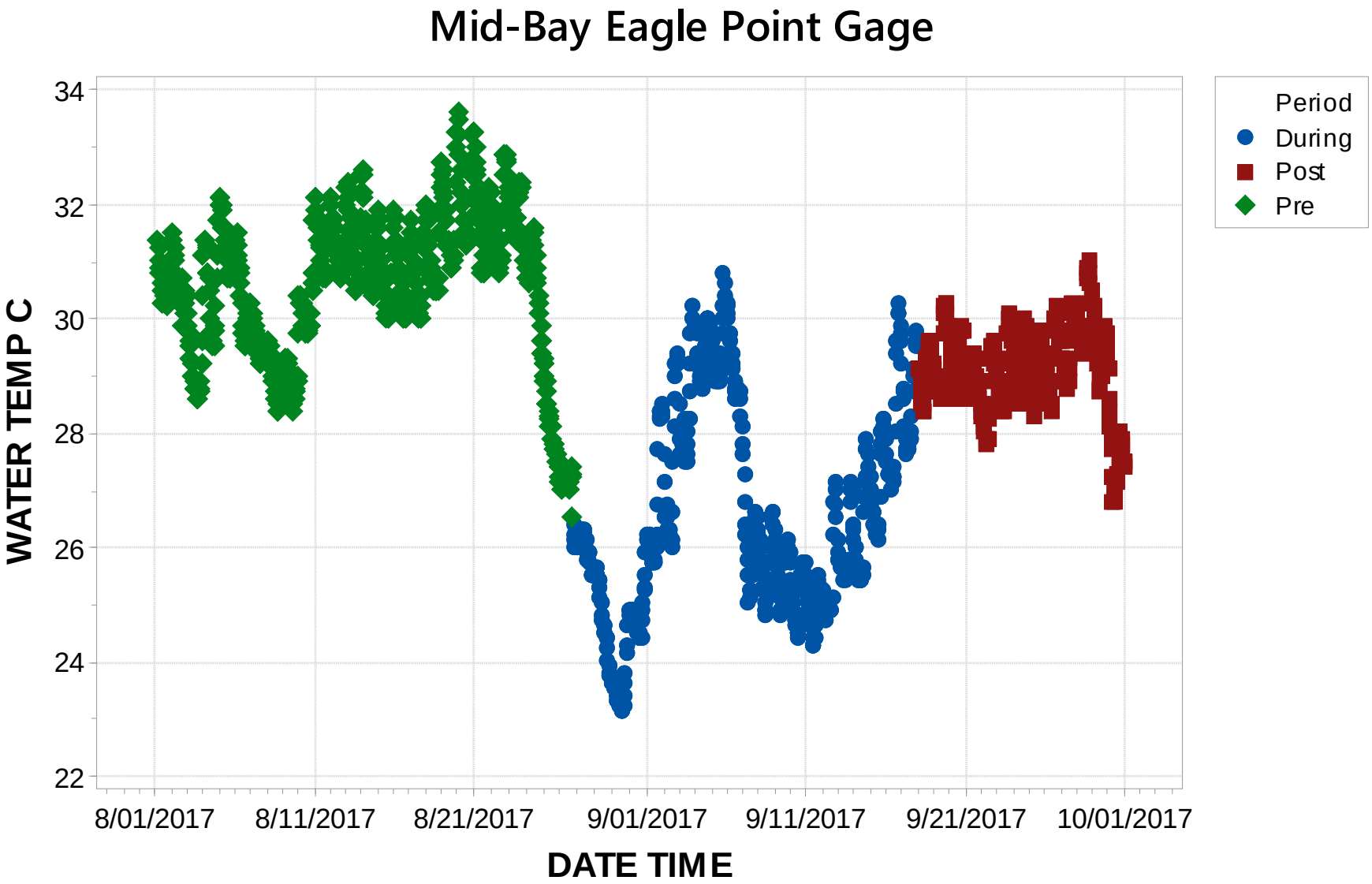
USGS

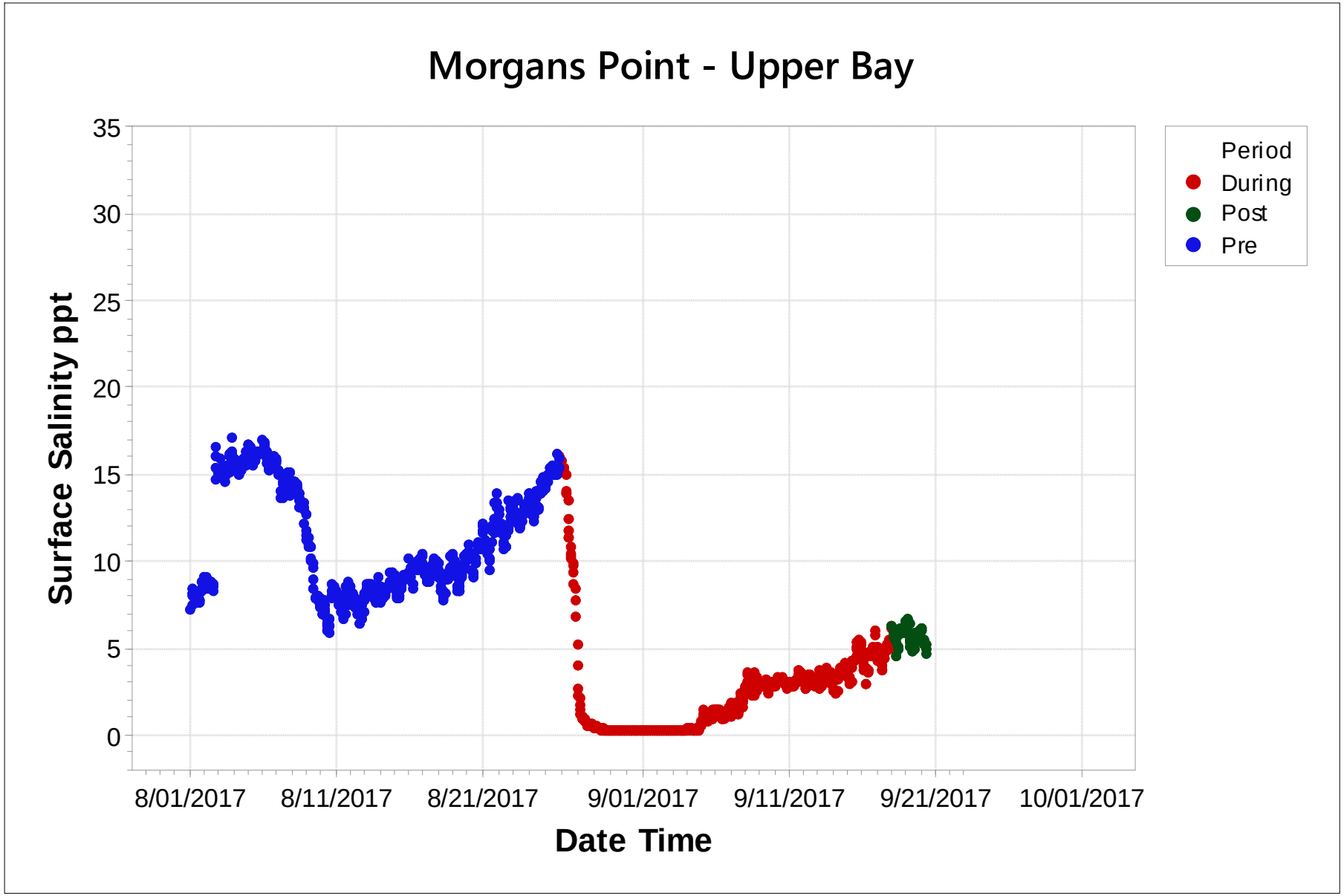
USGS 08066500 Trinity Rv at Romayor, TX

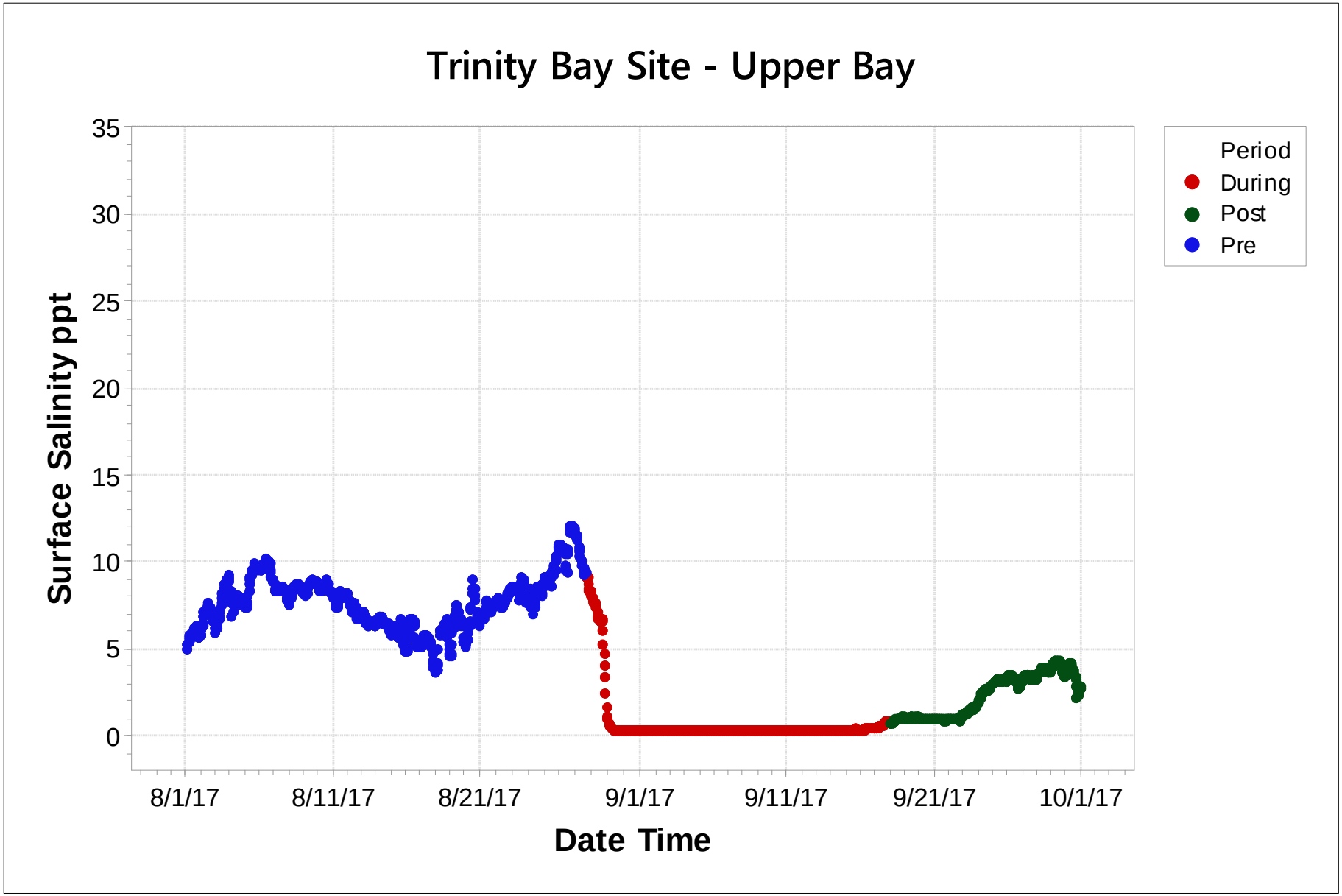


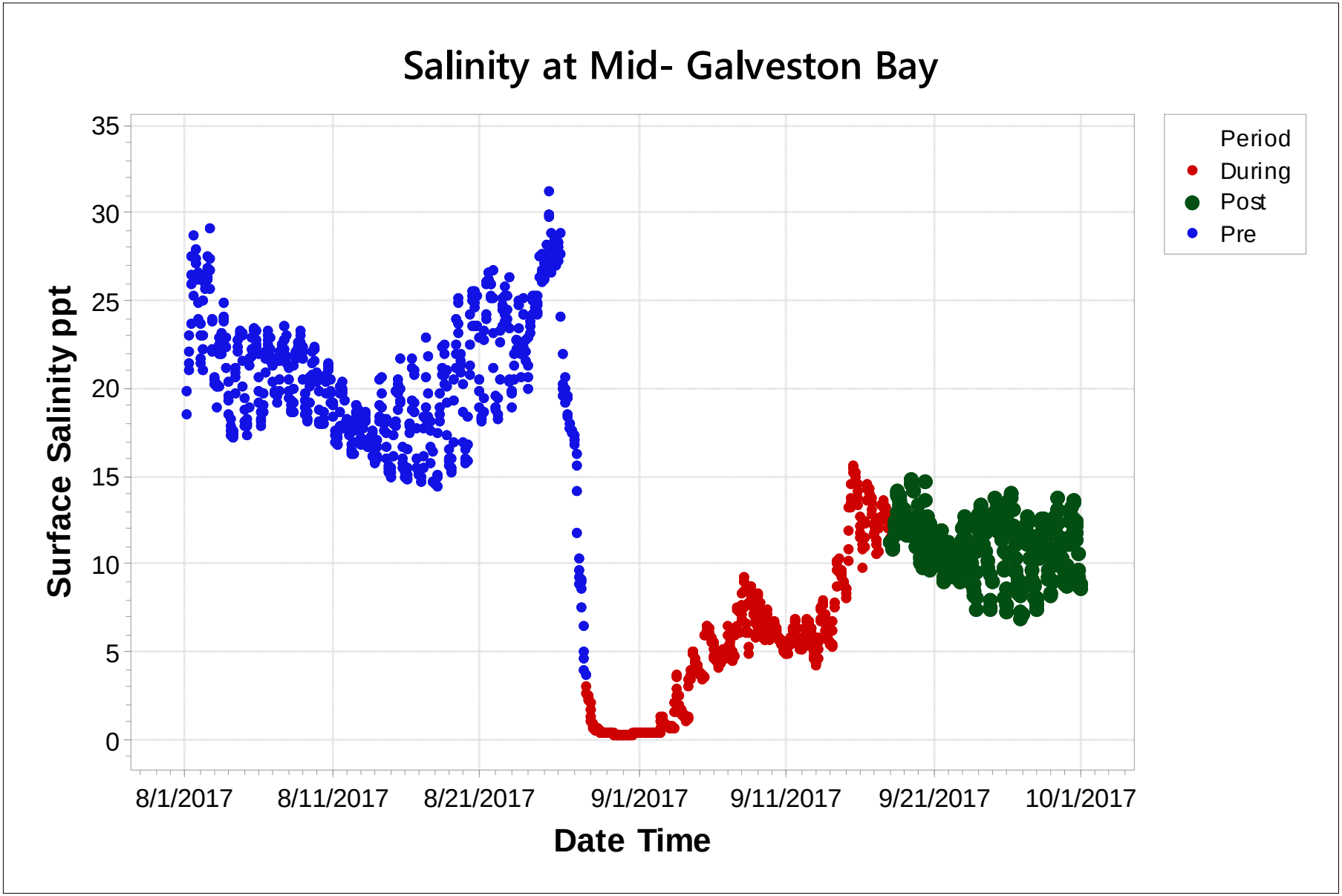

Moses Bayou (USGS 8077650) - Site 21
Water Surface Elevation (ft)
6
4
2
0
-2
Double Bayou (USGS 8042558) - Site 113
Gage Height (ft)
8
6
4
2
0
-2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
2017


Water Level (m)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
8/01/2017
8/11/2017
8/21/2017
9/01/2017
9/11/2017
9/21/2017
10/01/2017
Date Time
Gage Period
MP m During
MP m Post
MP m Pre
EP m During
EP m Post
EP m Pre
MP – Morgans Point, upper Gal. Bay
EP – Eagle Pt; Middle Bay

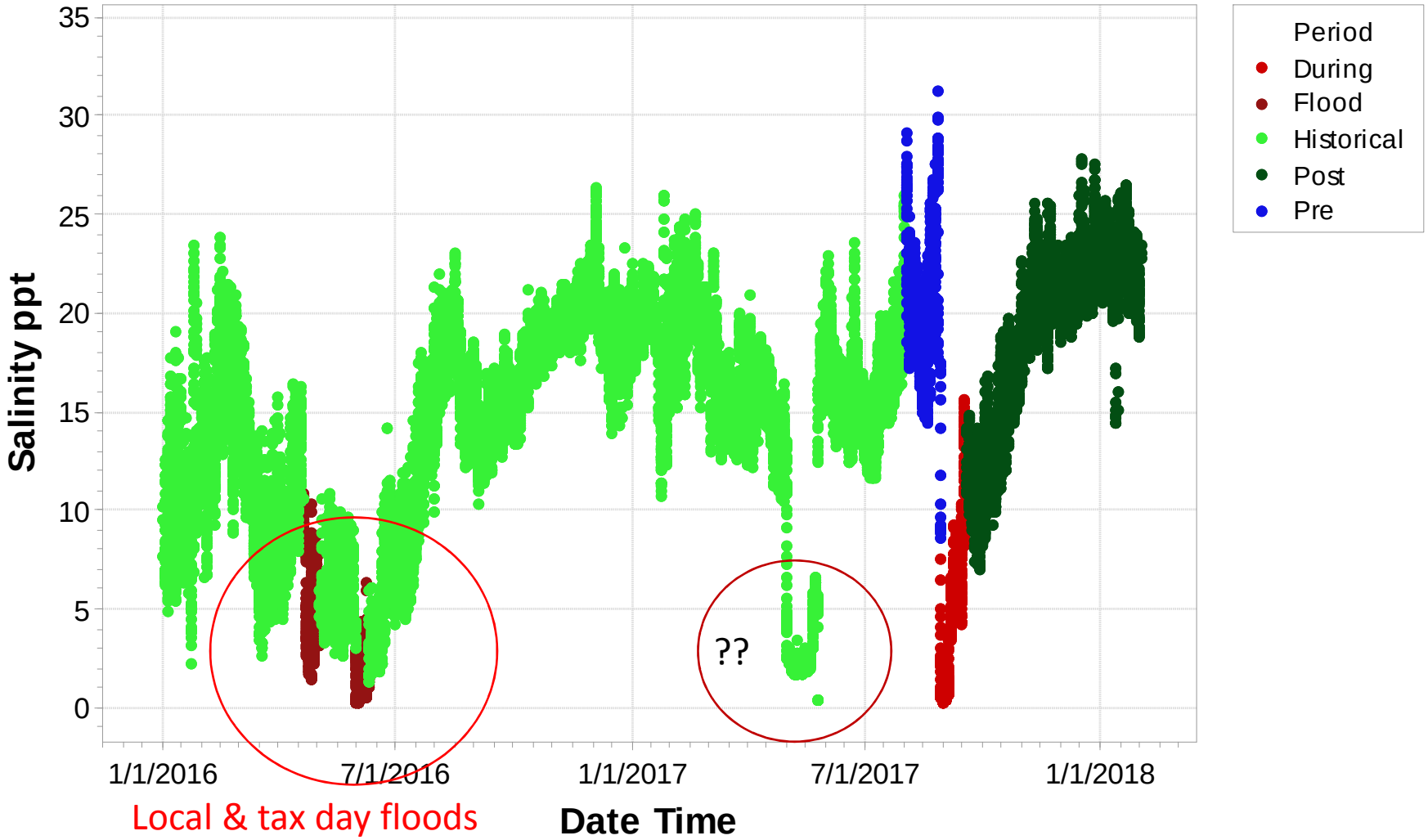

Mid-Bay Eagle Point Gage
WATER TEMP C
34
32
30
28
26
24
22
8/01/2017
8/11/2017
8/21/2017
9/01/2017
9/11/2017
9/21/2017
10/01/2017
DATE TIME
Period
During
Post
Pre

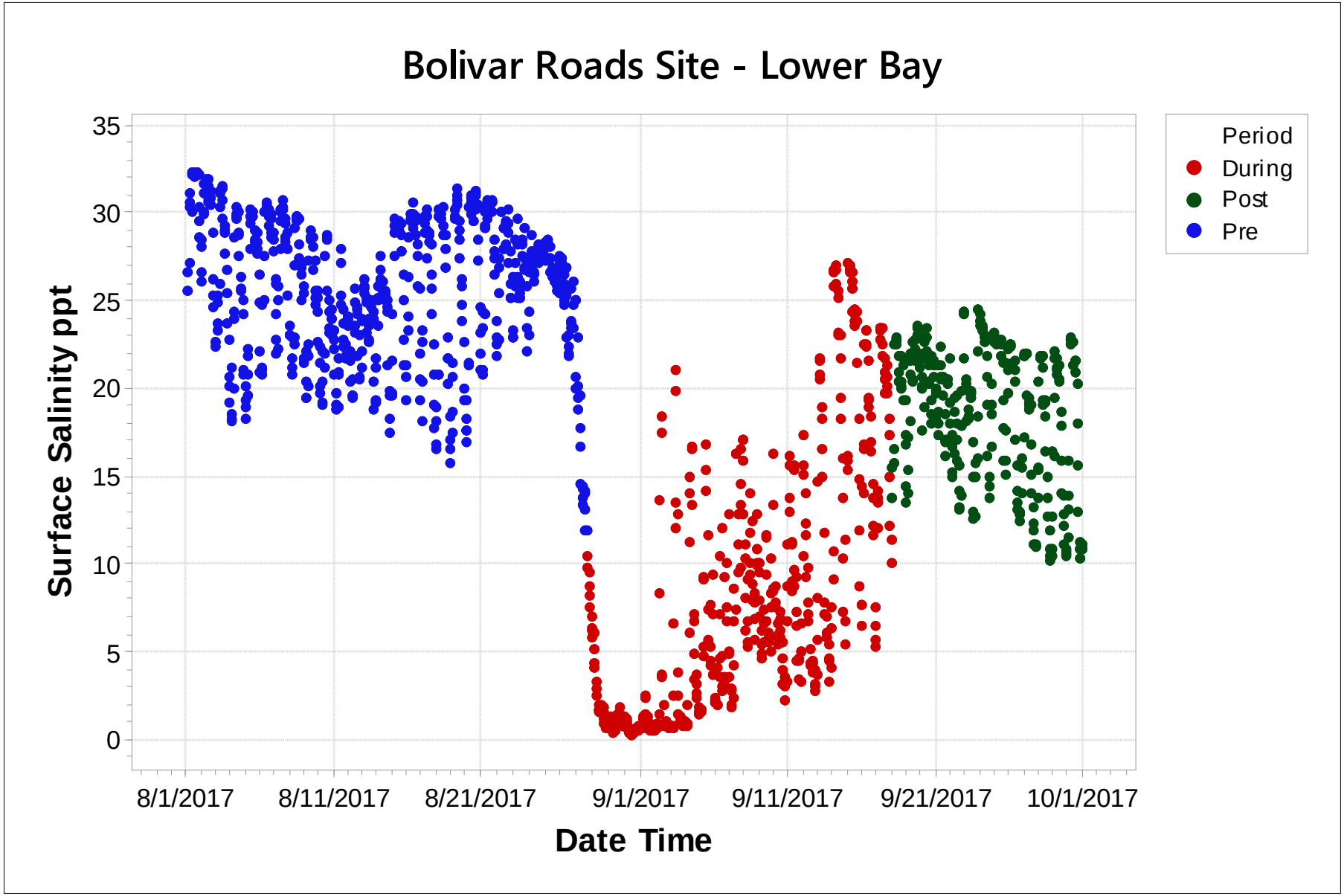

Morgans Point - Upper Bay
Surface Salinity ppt
35
30
25
20
15
10
5
0
8/01/2017
8/11/2017
8/21/2017
9/01/2017
9/11/2017
9/21/2017
10/01/2017
Date Time
Period
During
Post
Pre


Trinity Bay Site - Upper Bay
Surface Salinity ppt
35
30
25
20
15
10
5
0
8/1/17
8/11/17
8/21/17
9/1/17
9/11/17
9/21/17
10/1/17
Date Time
Period
During
Post
Pre

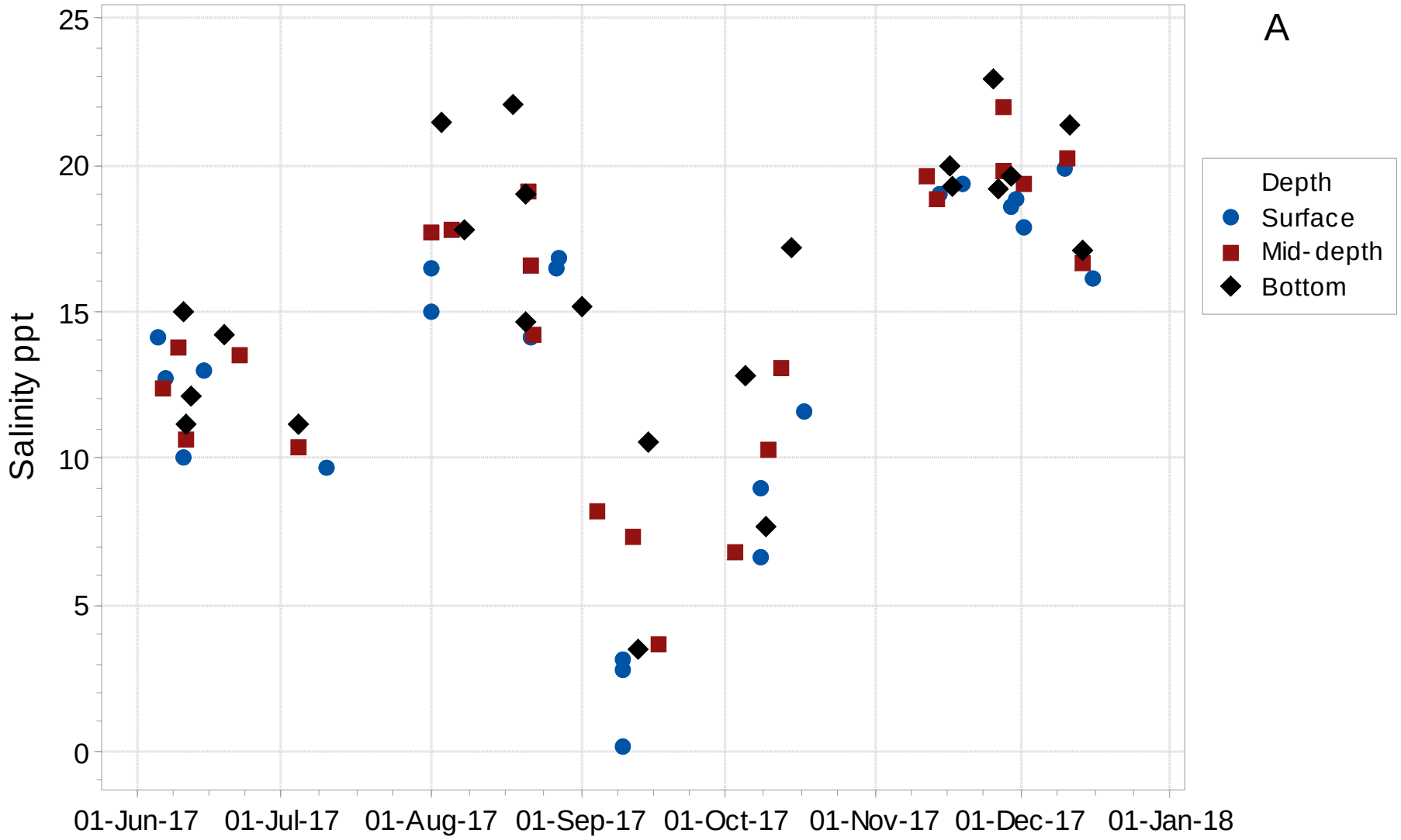

Salinity at Mid- Galveston Bay
Surface Salinity ppt
35
30
25
20
15
10
5
0
8/1/2017
8/11/2017
8/21/2017
9/1/2017
9/11/2017
9/21/2017
10/1/2017
Date Time
Period
During
Post
Pre

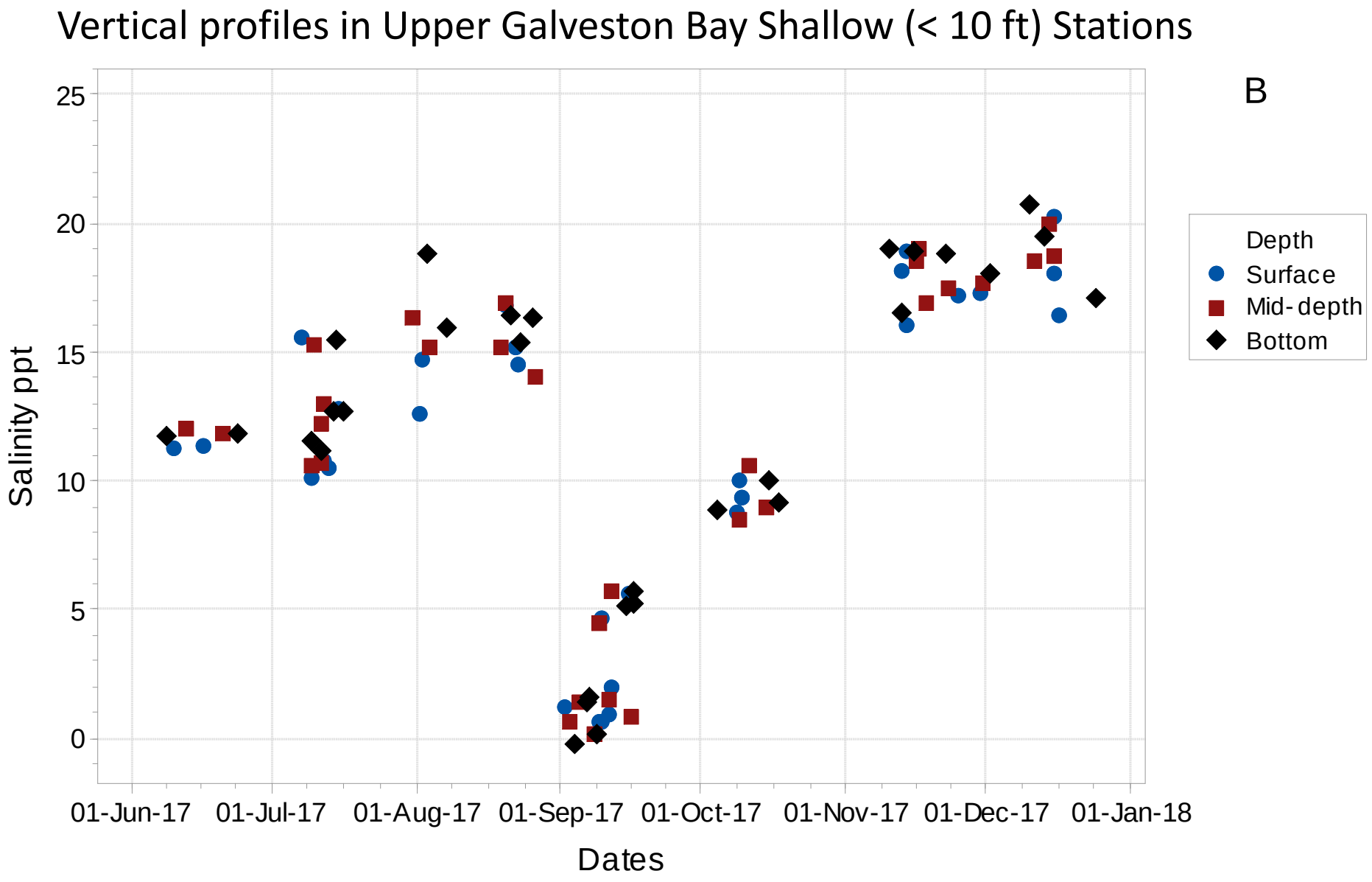
Middle Bay Extended Time Series - Other Local Floods



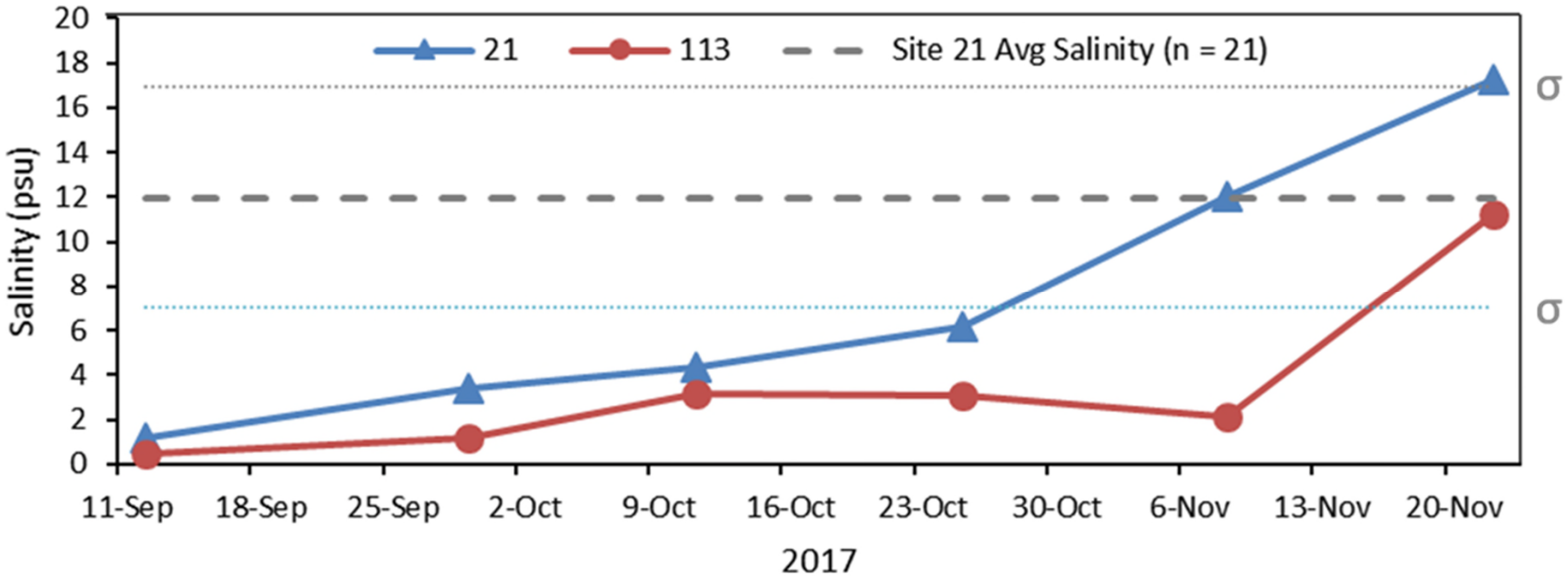

Bolivar Roads Site - Lower Bay
Surface Salinity ppt
35
30
25
20
15
10
5
0
8/1/2017
8/11/2017
8/21/2017
9/1/2017
9/11/2017
9/21/2017
10/1/2017
Date Time
Period
During
Post
Pre

Vertical profiles in Upper Houston Ship Channel = Max Depth 50 ft




Vertical profiles in Upper Galveston Bay Shallow (< 10 ft) Stations
B
Salinity ppt
25
20
15
10
5
0
01-Jun-17
01-Jul-17
01-Aug-17
01-Sep-17
01-Oct-17
01-Nov-17
01-Dec-17
01-Jan-18
Dates
Depth
Surface
Mid-depth
Bottom

Wetland Survey Sites



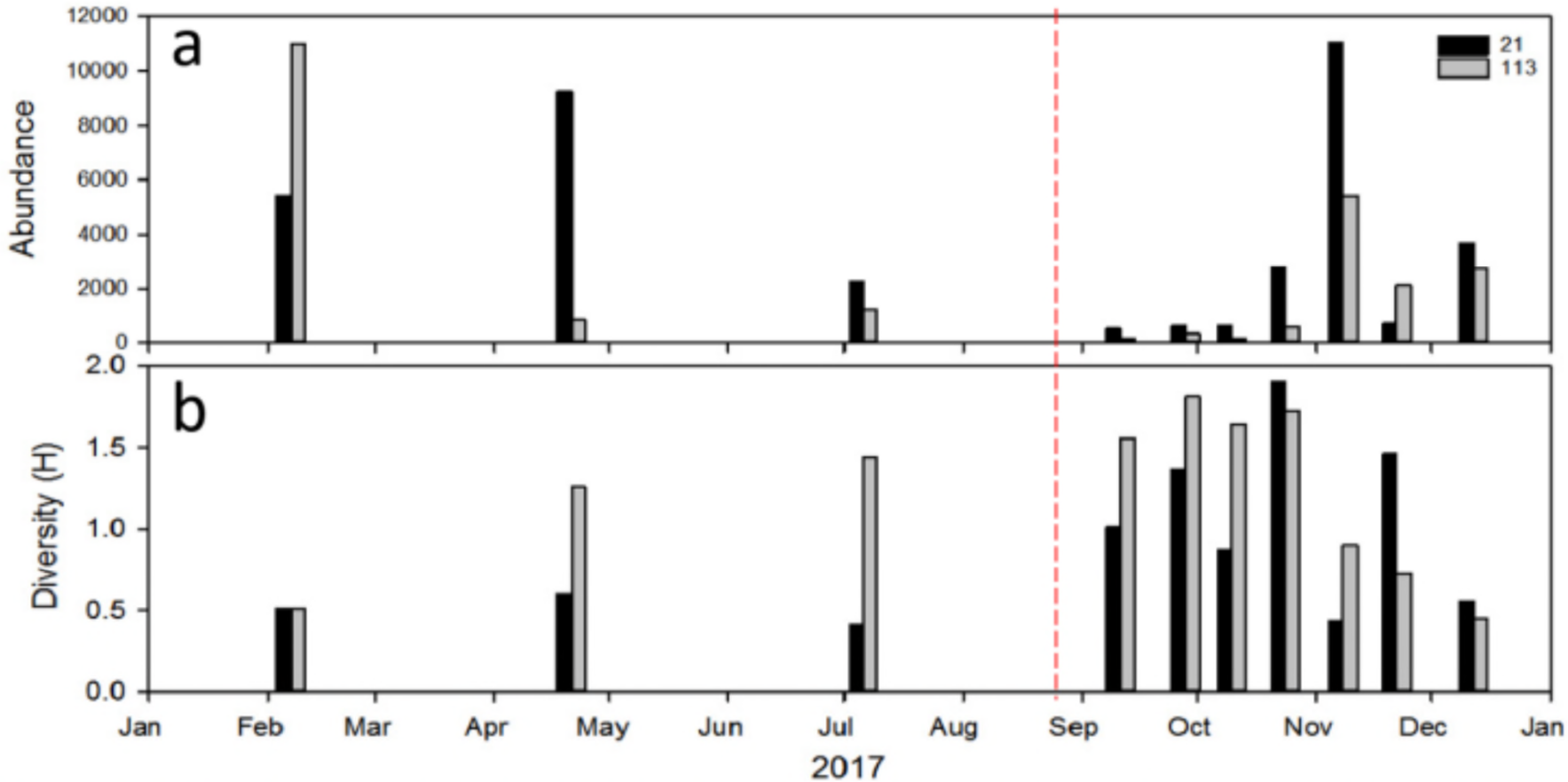


Figure 59 a) Abundance and b) Shannon Weiner diversity of seine catch by sampling event at sites 21 (black bars) and 113 (grey bars). The red dashed line denotes the landfall date of Hurricane Harvey.

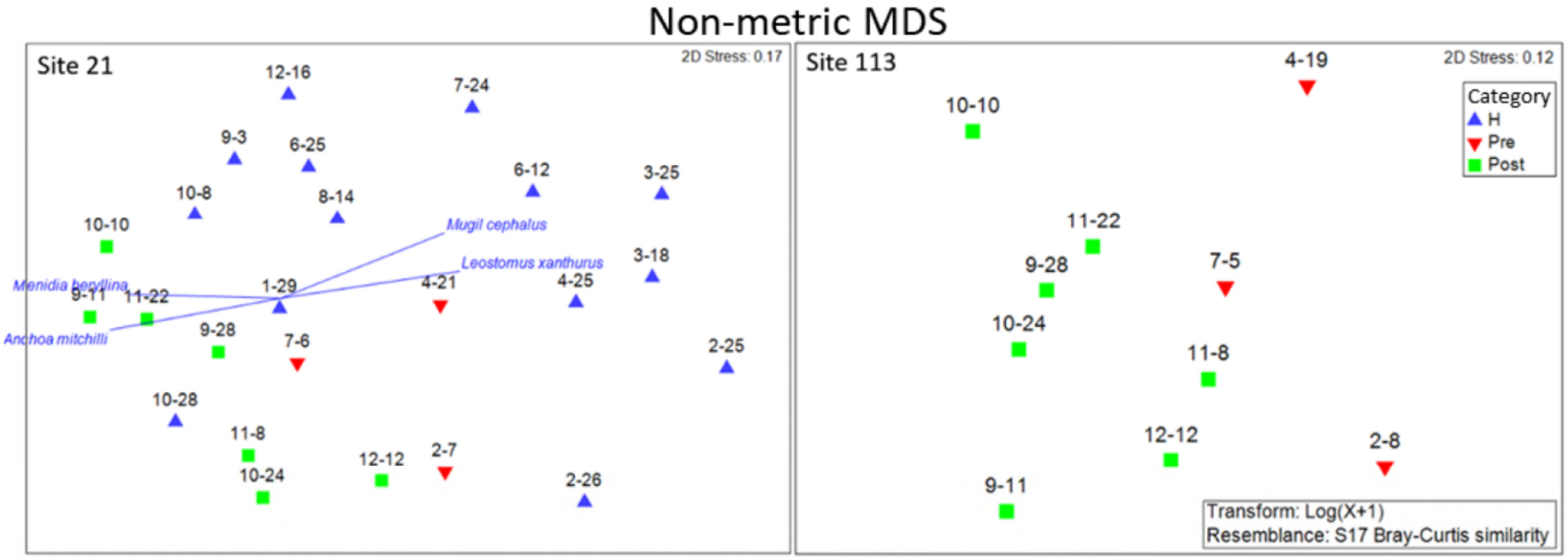


Figure 60 nMDS plots of nekton communities by site. Events labeled by month-day sampled, historic data "H" (Guillen et al. 2015) as blue triangle, 2017 data prior to flood "Pre" (red upside-down triangles) and post-flood data "Post" (green squares). Ordinations on Site 21 for 4 species with highest correlation to MDS1.

Conclusions

- Harvey completely flushed Galveston Bay
- Enormous quantities of sediment were discharged into the Gulf of Mexico
- Water temperature of the bay was dropped 3 C within a short time; shading and rainfall.
- The salinity of the entire estuary was reduced from average levels of 27 ppt to < 0.5 ppt for a period of over (8/28 – 9/3/17) 1 week and remained depressed for months.
- Species composition shifted. Lower numbers of organisms but higher diversity.
- The implications on estuarine productivity and organisms are still being examined.
- The existence of a robust monitoring network (state, federal, academic, volunteer) allowed documentation of many of the effects of the storm.

Questions