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Coastal Texas Region 1 (CTR1) Estuarine Numerical Modeling Report

Jennifer McAlpin, Cassandra Ross, and Jared McKnight

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Abstract

The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate vessels even in the event of providing storm surge protection. The U.S. Army Engineer District, Galveston, requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, to perform hydrodynamic and salinity modeling of proposed storm surge protection measures at the Houston Ship Channel entrance to the Gulf of Mexico. The modeling results are necessary to provide data for environmental analysis. The model setup and validation are presented as well as the results of project year zero (2035) and project year 50 (2085) with and without project results. Overall, the protection measures had little effect on bay salinity and velocity patterns, but it does generate significant local changes in velocity patterns near the structure location. The structure also greatly impacts the tidal prism — the exchange of water into and out of the bay system on each tide — as well as the tidal amplitudes within the bays.

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Preface

The model investigation presented in this report was authorized and funded by the U.S. Army Corps of Engineers, Galveston District, under Work Unit 145745, Coastal Texas Region 1 Protect and Restore.

The work was performed at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL), Vicksburg, MS. Direct supervision was provided by Dr. Cary Talbot, Chief, Flood and Storm Protection Division, and Mr. Keith Flowers, Chief, River and Estuarine Engineering Branch. At the time of publication of this report, Mr. Jeffrey R. Eckstein was the Deputy Director of ERDC-CHL, and Dr. Ty V. Wamsley was the Director.

COL Ivan P. Beckman was the Commander of ERDC, and Dr. David W. Pittman was the Director.

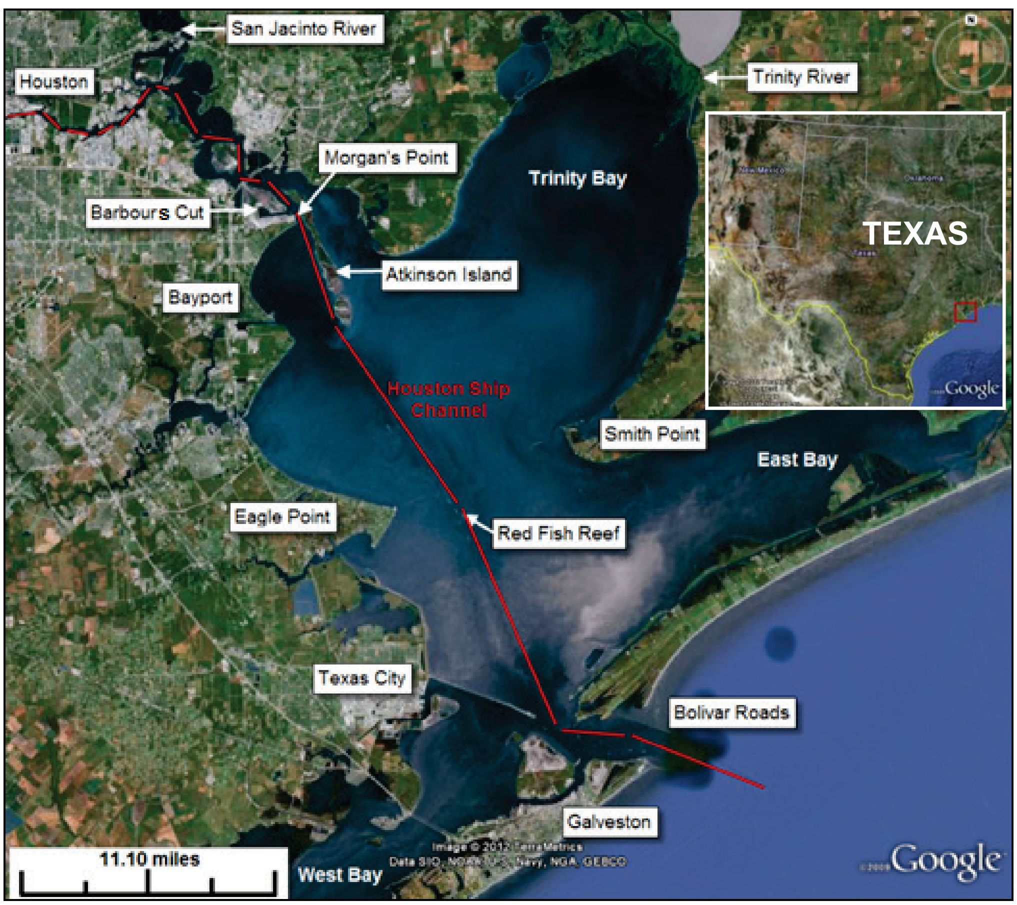
1 Introduction

1.1 Background

Since the early 1800s, vessels have transited Galveston Bay both to and from Galveston and Houston (Galveston Bay Estuary Program 2002).

Galveston Bay is a tidal estuary such that the effect of the tide on the water surface elevation is observed from the Gulf of Mexico to locations near Houston, TX. The Houston Ship Channel (HSC) is a deep-draft navigation channel that allows for vessel passage from the Gulf to the city of Houston, approximately 53 miles upstream. Since 1903, Operations and Maintenance dredging has been conducted in the bay to maintain authorized channel dimensions. Figure 1 shows the HSC as it passes through Galveston Bay from its entrance at Bolivar Roads to the Port of Houston.

Figure 1. HSC area map.



The navigation channel acts as a flow pathway for salinity to travel upstream since high-saline water is heavier than fresh water and tends to flow up-channel along the channel bottom. The net drift is flood in much of the channel (Tate and Berger 2006) (i.e., the tendency is for suspended material to move upstream into the bay.) The velocity magnitudes drop in the Atkinson Island reach due to tidal reflections from the bay boundary. The flow tends to stratify more as a result in this reach, and material from farther downstream in the estuary will tend to collect near Atkinson Island.

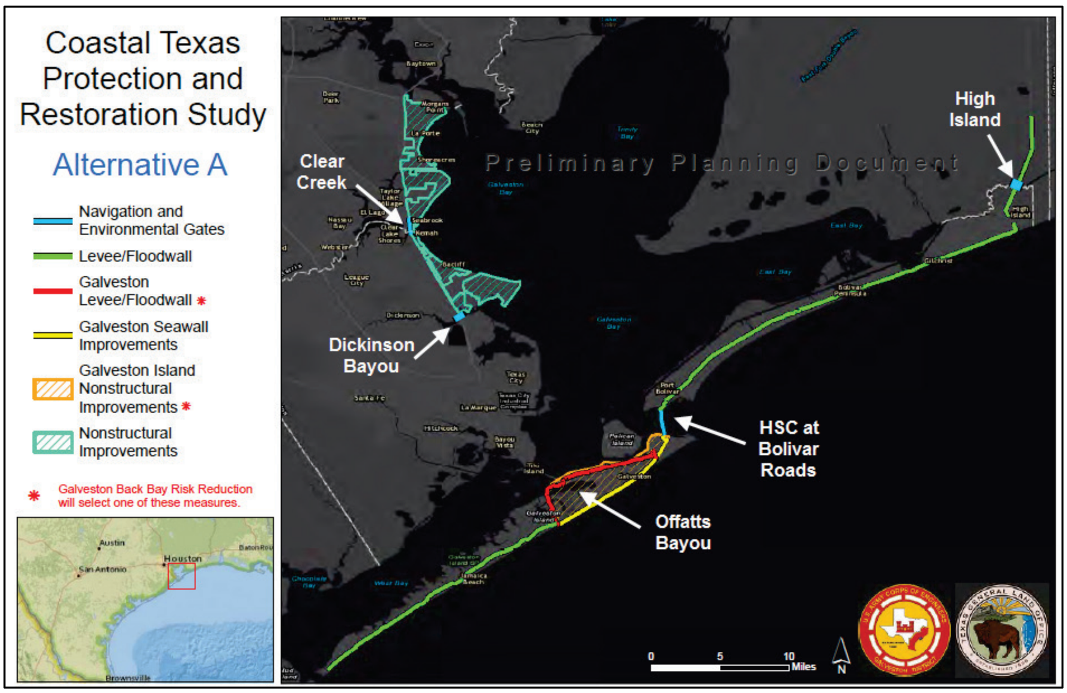
The behavior of the salinity and hydrodynamics in Galveston Bay during May through June is different than the remainder of the year due to a salinity drop in the northern Gulf of Mexico as the Mississippi, Sabine-Neches, and Atchafalaya Rivers and other northern Gulf river systems provide a significant influx of fresh water. When the salinity in the Gulf of Mexico drops, the salt water tends to evacuate from the bay. A reduction in bay salinity could result in different suspended concentrations and fresh deposit characteristics during this time period compared to data collected at other times during the year. If this is the case, sediment would tend to collect farther down the channel toward Red Fish Reef during this period.

The U.S. Army Corps of Engineers (USACE), Galveston District (SWG), recently enlarged the Houston Ship Channel from a 12.2-meter (m) (40-foot [ft]) depth by 122 m (400 ft) width to a 13.7 m (45 ft) depth by 162 m (530 ft) width. Previously, a three-dimensional (3D) numerical model study was implemented at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL), to evaluate the salinity and circulation impact of this enlargement. In Berger et al. (1995a) the model was shown to represent the salinity and circulation in the earlier channel configuration. Berger et al. (1995b) used the model to predict the impact of the enlarged channel. Carrillo et al. (2002) used the model to evaluate the addition of barge lanes along the ship channel flanks. Tate and Berger (2006) looked into possible reasons for increased shoaling in the ship channel by analyzing vessel effects and sediment properties in the area. In Tate et al. (2008), the sediment model was validated using the same hydrodynamic model, and the results included the effects of vessel transport on the sedimentation patterns. The model was utilized again to investigate proposed changes to the Bayport Flare (Tate and Ross 2012).

1.2 Objective

In 2016, SWG requested the ERDC-CHL to perform hydrodynamic and salinity transport modeling of proposed storm surge protection measures (Figure 2). The modeling results are necessary to provide data for hydrodynamic and salinity analysis as well as ecological models to determine impacts on aquatic habitat. The model results of project year zero (2035) and project year 50 (2085) with and without project results are documented.

Figure 2. Tentatively selected plan — Proposed coastal protection (figure from SWG).



1.3 Approach

A 3D Adaptive Hydraulics (AdH) model was developed and validated for simulation of hydrodynamics, salinity, and sediment transport. Previous modeling efforts used TABS-MDS as the finite element code. This code is no longer supported by CHL, requiring a new model to be built utilizing the latest technology and updated to present conditions. The model was validated to available field data for all parameters and then utilized to test project alternatives for present and future conditions. For all simulations, the model was set up to run for 2 years. The first year was a spin-up period to obtain an accurate initial salinity field as well as an accurate sediment bed, and the second year was used for all analyses.

The model development and boundary condition definitions for the hydrodynamic, salinity, and sediment transport model as well as the model to field data comparisons, including water surface elevation, velocity, salinity, and HSC dredge volumes are documented in a separate report (McAlpin and Ross 2019). Chapter 2 focuses on the plan alternatives and simulation periods. Chapter 3 focuses on the comparisons of these modifications to the present condition for hydrodynamics, salinity, and HSC sedimentation. Chapter 4 provides the conclusions of this numerical model study.

2 Plan Alternatives

Documentation of the plan alternatives includes the geometric modifications to the system, defined as *project*, as well as the input conditions for the *present* project year zero (2035) and *future* project year 50 (2085).

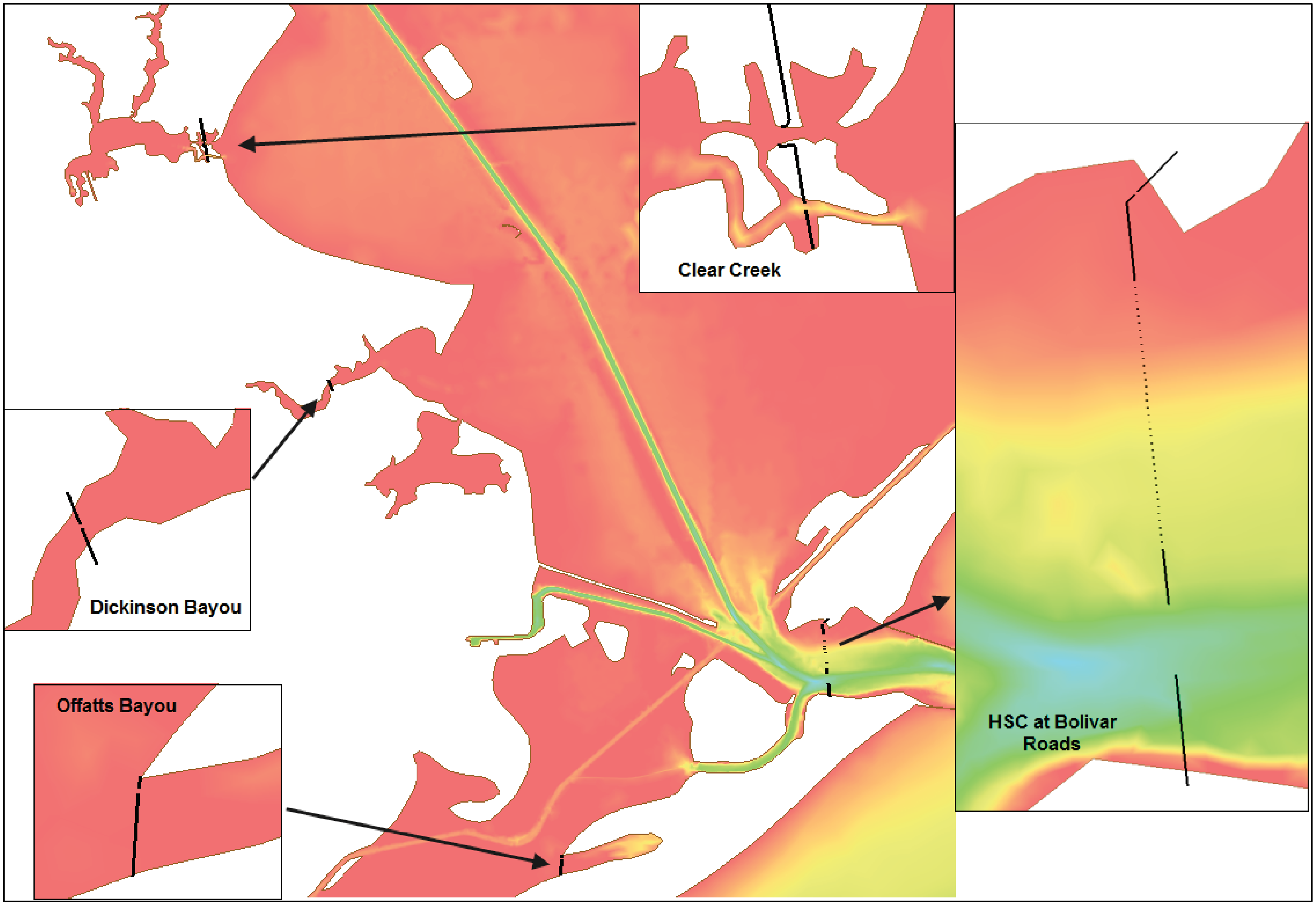
2.1 Project modifications

SWG developed several potential storm surge protection plans. These plans were analyzed for cost/benefit based on construction, mitigation for habitat adjustment, and other factors. The final tentatively selected plan (TSP) analyzed with the AdH model is "Alternative A," which includes a levee/floodwall along Bolivar Peninsula and Galveston Island, improvements to the Galveston seawall, a ring levee around the city of Galveston, and several gate closure structures — across the HSC at Bolivar Roads, High Island, Offatts Bayou, Dickinson Bayou, and Clear Creek. Figure 2 shows the TSP as defined by the sponsor.

The 3D AdH numerical model only includes the structures that impact the flow in the model domain. High Island is not included in the model domain because the flow along the Gulf Intercoastal Waterway in this area does not typically produce a measureable impact on salinity in the bays. The floodwalls and levees are placed on land and do not interfere with daily flows in the area; therefore, these structures are also not included in the AdH model. The structures at Clear Creek, Dickinson Bayou, Offatts Bayou, and the HSC at Bolivar Roads are included in the model. These structures are modeled in a completely open state since these analyses are intended to determine how the gate housings impact the everyday conditions in the bays — Trinity Bay, Galveston Bay, East Bay, and West Bay. SWG provided drawing files indicating the exact placement of the structures and openings, shown in Figure 3.

The structures at Clear Creek, Dickinson Bayou, and Offatts Bayou consist of a single opening 112 ft wide with varying sill elevations: Clear Creek sill elevation -10 ft, Dickinson Bayou sill elevation -9 ft, and Offatts Bayou sill elevation -15 ft. The structure for the HSC at Bolivar Roads includes a single 1200 ft wide, -60 ft sill elevation navigation gate at the ship channel with 39, 100 ft environmental gates (22 having a -30 ft sill elevation and 17 having a -15 ft sill elevation). All elevations are referenced to Mean Lower Low Water.

Figure 3. TSP structures to be included in the AdH model domain.



2.2 Input conditions

Most USACE design projects require analysis over a 50-year project life span; therefore, analysis at some year zero and year 50 are required. This type of analysis requires projecting future inputs to the numerical model. Sea level rise (SLR) curves are available to determine the adjustments necessary for potential changes to the tidal elevation. Predictions of future freshwater inflows are often available and primarily include urban growth projections. However, future wind conditions, sediment loads, and rainfall/evaporation are much more difficult to determine. For this project, the 2010 validation year was determined suitable as a base or starting point for the year zero (present – 2035) and year 50 (future – 2085) model inputs. (For details of the 2010 model boundary conditions, see McAlpin and Ross 2018.) The tidal water surface elevation, freshwater inputs, and sediment loads (because they are based on the freshwater input) are the only model inputs that will vary from the 2010 base condition. All simulations will be made for a 2-year period with the first year-long simulation serving to generate an accurate initial salinity field and initial sediment bed. Data availability for each input parameter will determine if consecutive years of data are used for the 2-year simulations or if a single year of data is repeated.

Given the variability in several input parameters for the present and future conditions, great care should be taken when reviewing the model results. Changes from present to future must be understood with no project in place to understand the project impacts. In other words, comparison of with and without project should be done on the present conditions and the future conditions separately and only mixed when well understood.

2.2.1 Sea level rise (SLR)

The tidal boundary condition at the Gulf of Mexico is based on harmonics and measured data from National Oceanic and Atmospheric Administration gages at Freeport (8772447) and Sabine Pass (8770822), Texas. To account for potential SLR at year zero (2035) and year 50 (2085), USACE EC 1165-2-212, *Sea-Level Change Considerations for Civil Works Programs,* guidance was used (USACE 2011). The 2010 data applied for the model validation were adjusted to 2017 based on the low SLR curve to obtain 2017 conditions. The intermediate SLR projection curve was then applied to the 2017 adjusted elevations. Table 1 provides the elevation shift applied to the 2010 tide elevation for the year 2035 and year 2085 model scenarios. The elevation shift was constant over the length of the model boundary and the time of the model simulation for each year.

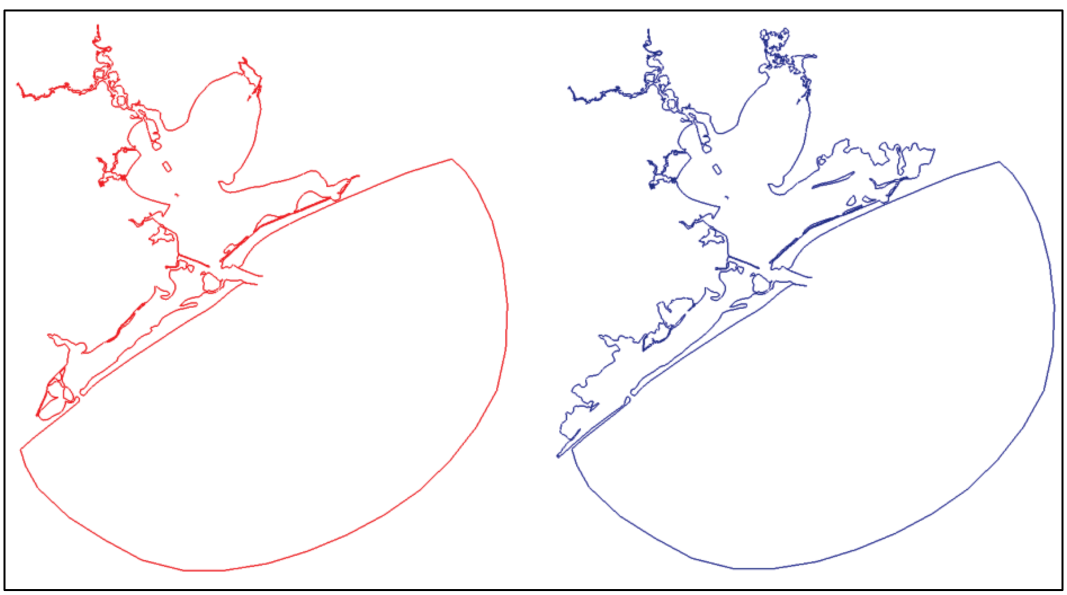
Table 1. SLR adjustment for model tidal boundary conditions.

Adjustment Period	SLR Curve	Elevation Shift
2010 to 2017	Low	0.148 ft (0.0451 m)
2017 to 2035	Intermediate	0.490 ft (0.149 m)
2017 to 2085	Intermediate	2.14 ft (0.652 m)

2.2.2 Mesh adjustment for future SLR

Since SLR will allow for more wetted area around the perimeter of Trinity Bay, West Bay, and East Bay, additional model domain area is included for the future condition simulations. It is assumed that the low-lying areas around the bays will not be altered to prevent them from wetting over time. Approximately 446 square kilometers were added to account for the additional wetted area based on the 2085 projected SLR. Figure 4 shows the model domain boundary. The red outline indicates the present condition mesh domain whereas the blue outline indicates the domain limit for the future condition mesh.

Figure 4. Present and future condition model domain boundary (red – present; blue – future).



2.2.3 Freshwater inflow

Freshwater inflow into the model domain was applied at the two major rivers – Trinity River and San Jacinto River – and at seven ungaged flow locations. These flow values were obtained from the Texas Water Development Board (TWDB) hydrology model, which computes flows for the area from the 1970s to present (Schoenbaechler and Guthrie 2012). SWG determined that years 1985 and 1986 were typical flow conditions for the region and would be a good estimate of future flow patterns. Based on findings by SWG in coordination with TWDB, the freshwater flow into the Trinity and Galveston Bay system will decline by approximately 12% over the 50-year project life. This reduction is primarily due to projections of increased water needs for the surrounding municipalities, meaning that more volume will be diverted for local water supply and less will be available to enter the bay system.

For year 2035 (present) conditions, 2009 (spin-up year) and 2010 (analysis year) inflows are used for all freshwater inflow locations. Figure 5 shows the year 2035 inflows. For year 2085 (future) conditions, 88% of the 1985 (spin-up year) and 1986 (analysis year) freshwater inflows are used for the Trinity River and San Jacinto River, and 88% of the 2009 and 2010 inflows are used at the ungaged locations. Figure 6 shows the 2085 inflows.

Figure 5. Year 2035 (present) freshwater inflows.

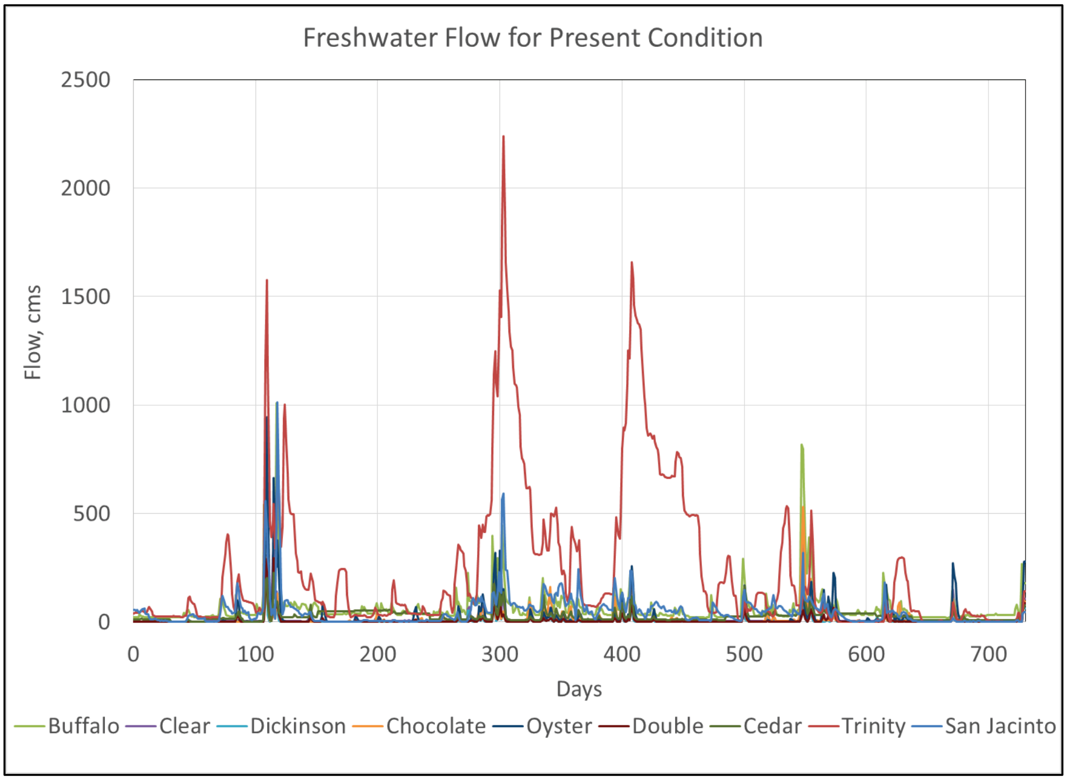
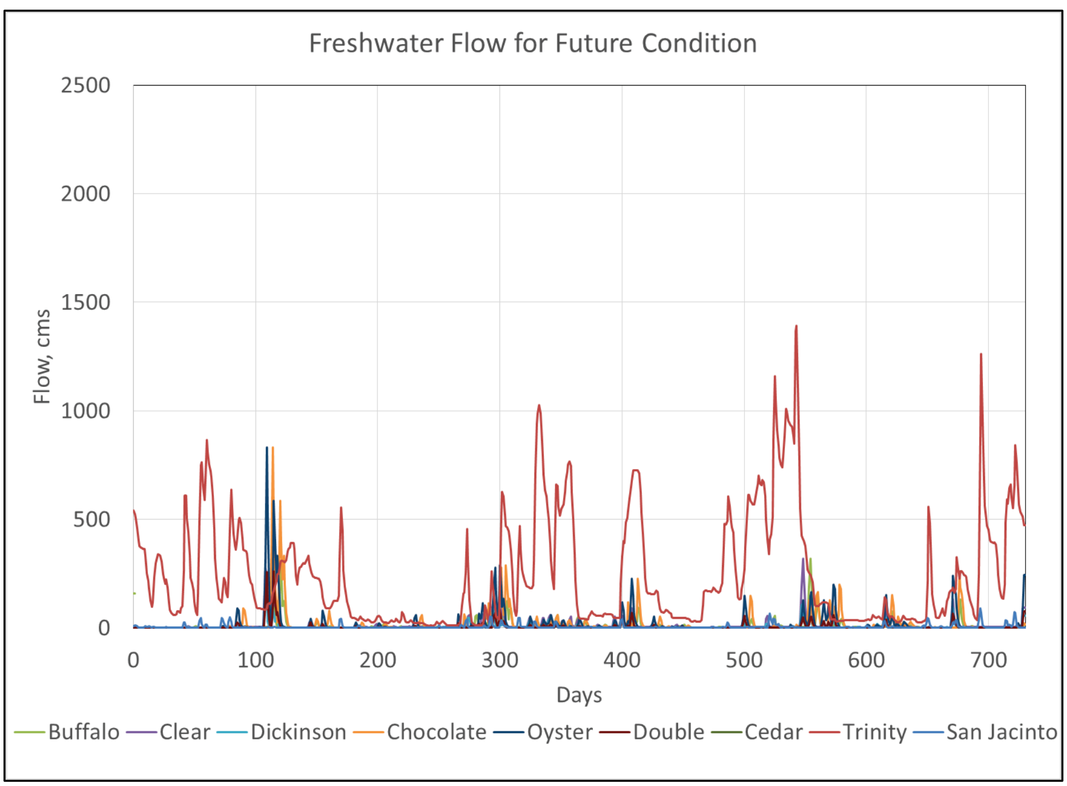


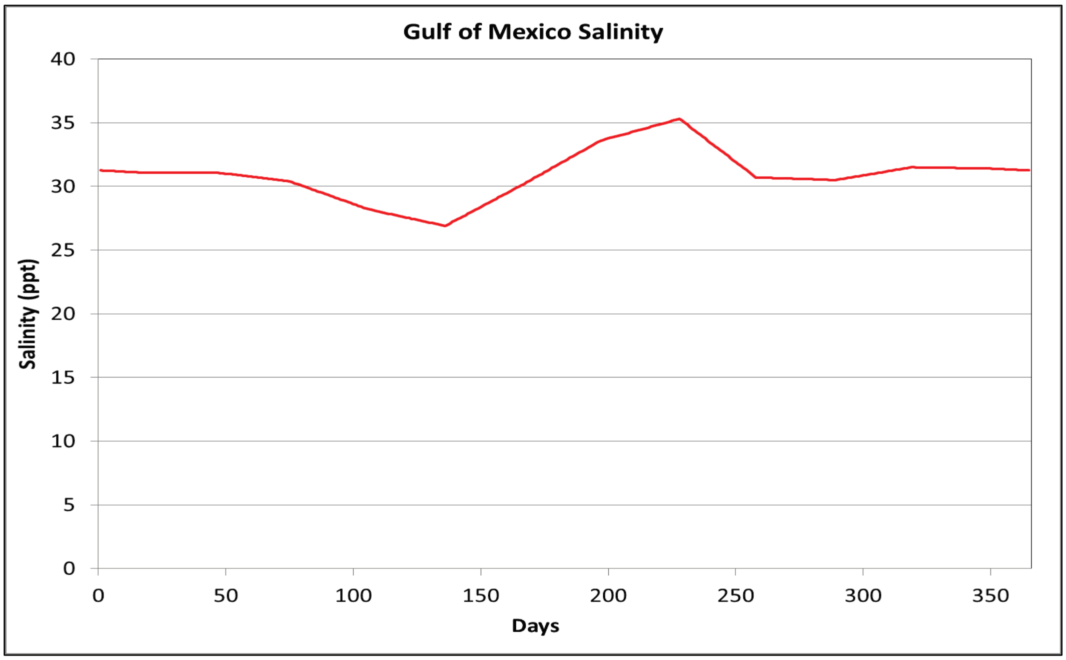
Figure 6. Year 2085 (future) freshwater inflows.



2.2.4 Salinity

The salinity input at the model's ocean boundary is unchanged from the model validation and shown in Figure 7 (McAlpin and Ross 2018). The time-varying boundary condition is based on monthly averages over a 15-year period. The single year of data was repeated such that the same input was applied for the spin-up year and the analysis year.

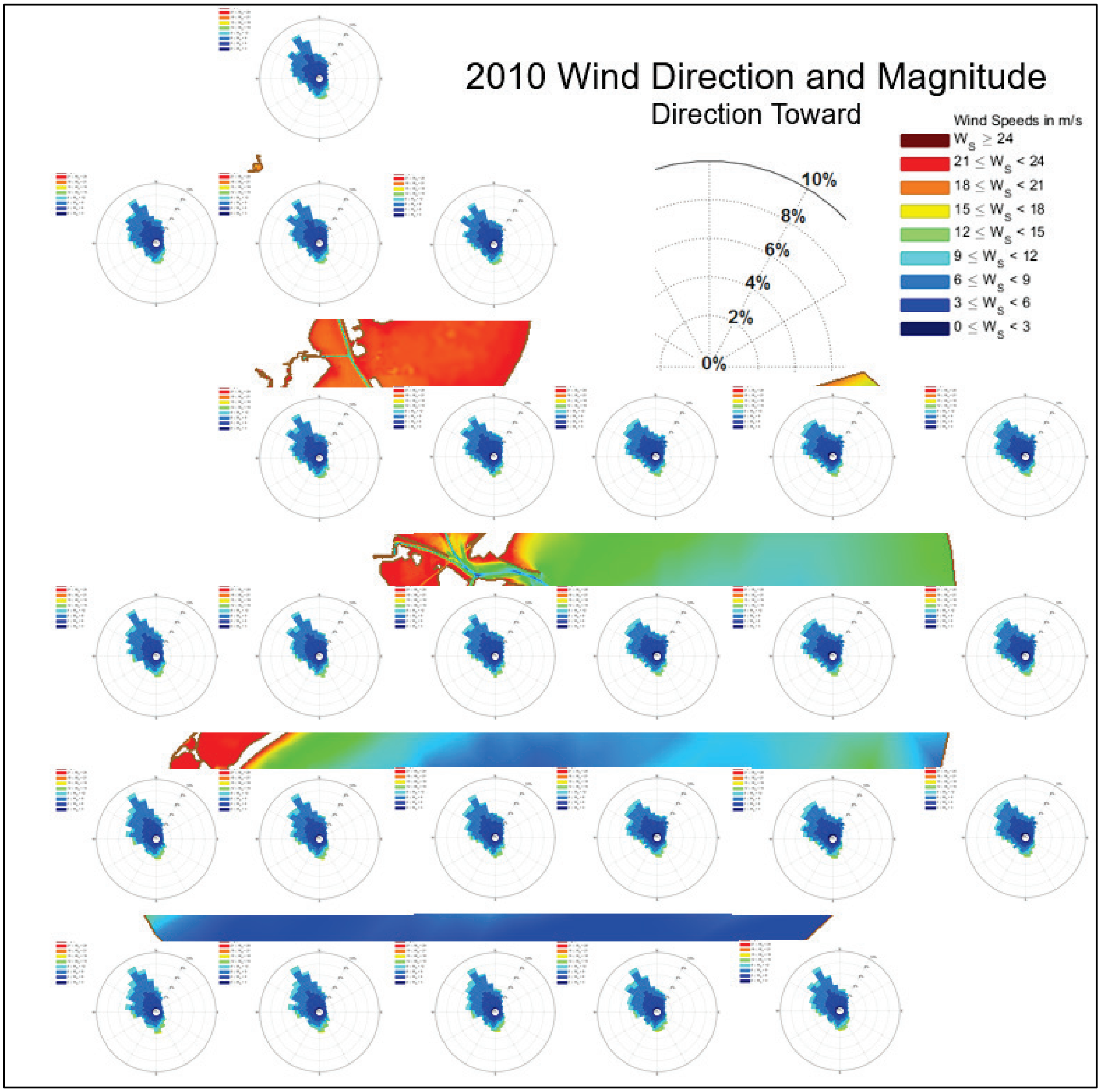
Figure 7. Salinity Boundary Condition for present and future conditions.



2.2.5 Wind

The 2010 wind data set was obtained from the Wave Information Studies computed wind field at 26 points in the vicinity of the model domain. This data set was maintained from the model validation (McAlpin and Ross 2018). This wind data set was unchanged and repeated for the spin-up and analysis years for the present and future conditions. Figure 8 shows the 2010 wind rose for the 26 computed wind series locations.

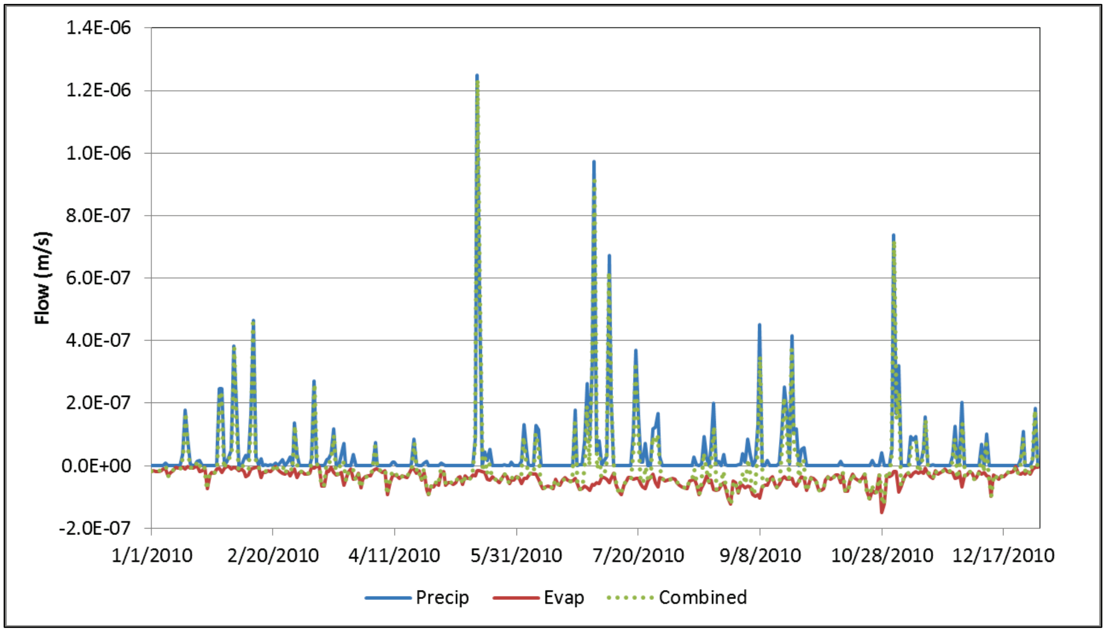
Figure 8. 2010 wind rose at all sites for 2035 (present) and 2085 (future) alternatives.



2.2.6 Meteorological conditions

Precipitation and evaporation were included in the alternative conditions as in the model validation (McAlpin and Ross 2018). The 2010 data from the TWDB were applied equally over the model domain. The data were unchanged and repeated for the spin-up and analysis years for the present and future conditions. Figure 9 shows the time series of the meteorological data.

Figure 9. 2010 meteorological conditions for 2035 (present) and 2085 (future) alternatives.



2.2.7 Sediment

The sediment grain and bed parameters are maintained from the validation effort (McAlpin and Ross 2018). The loads are applied to the two major rivers in the same manner as in the model validation — by applying a rating curve that correlates river discharge with the total concentration.

Figure 10 shows the 2035 sediment loads, which are based on 2009 and 2010 inflow data. Figure 11 shows the 2079 loads, which are based on the reduced 1985 and 1986 inflow data. These total loads are divided equally among the five simulated grain classes when applied in the model. No sediment is applied at the ungaged inflow locations, as done in the model validation.

The model validation (McAlpin and Ross 2018) details sediment loads that are not included in this model. These include unaccounted sediment loads from the ungaged freshwater inflows, from wind-generated wave erosion along the shallows, and from vessel-induced erosion in the bays. A historical scaling method for each channel segment was determined to be the best option to account for the combined effect of the various unknown loads.

Figure 10. Year 2035 (present) total sediment load.

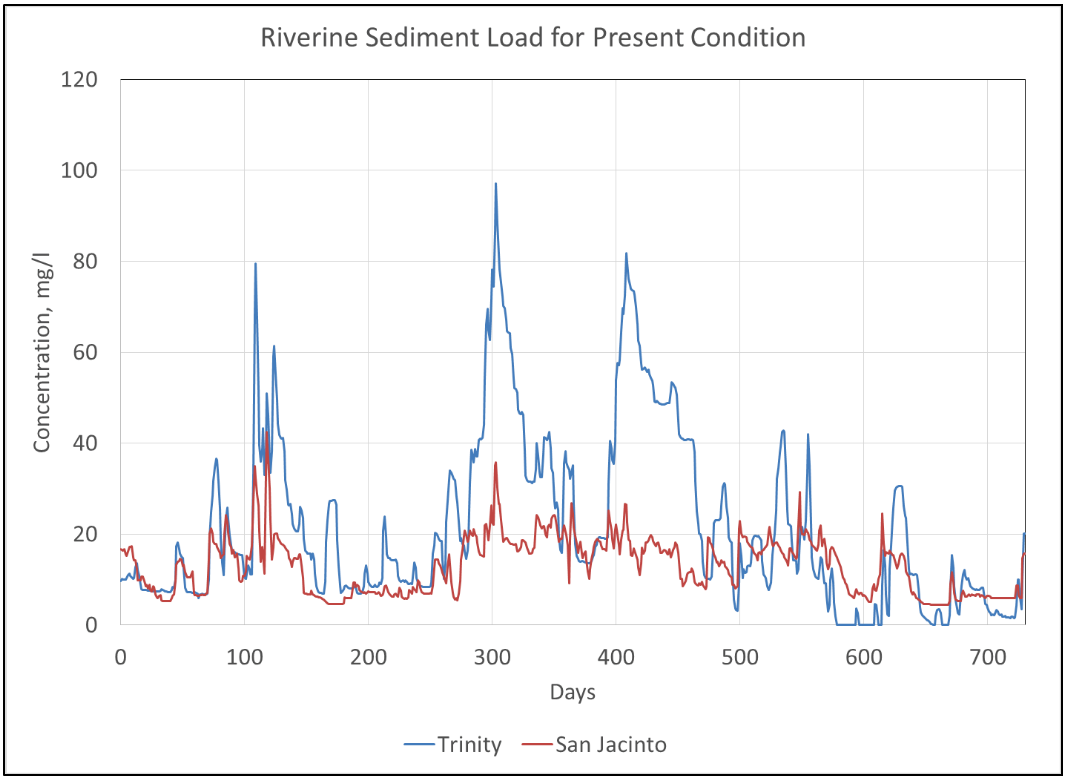
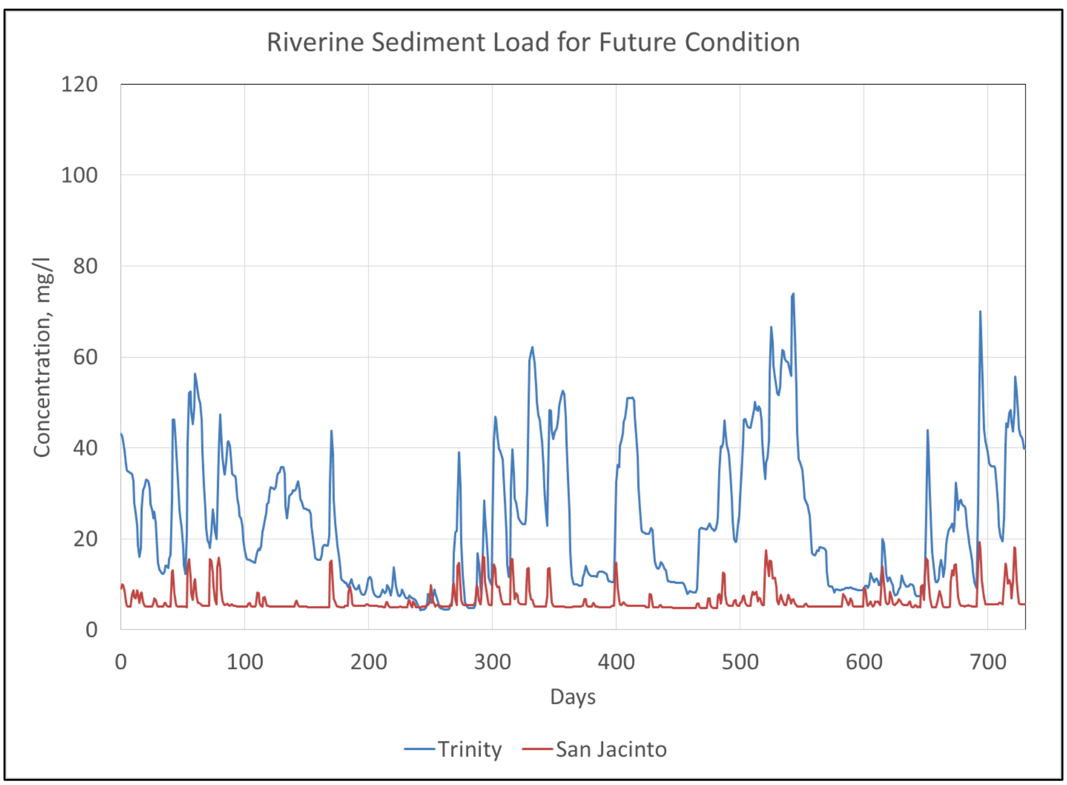


Figure 11. Year 2085 (future) total sediment load.



3 Model Results

The four alternatives — present without project (PWOP), present with project (PWP), future without project (FWOP), and future with project (FWP) — were simulated using 3D AdH as stated in the previous chapters. Present is year 2035, and future is year 2085, assuming a 50-year project lifespan. The results include changes in salinity, velocity, and water level throughout the model domain under the various alternative conditions. Additionally, changes to the shoaling in the HSC will be observed.

Comparison of with and without project should be done on the present conditions and the future conditions separately to isolate impacts due to the project alone. Given the variability in several input parameters for the present and future conditions, it is not recommended to compare present and future results directly unless careful consideration is given to understanding the difference in the present and future input parameters.

Several locations were identified for specific analysis such as time history, percent-less-than, and maximum/minimum/average computations of salinity and velocity magnitude. These locations will also be used to analyze tidal amplitude throughout the system. These locations are shown in Figure 12 and labeled in Table 2. A subset of these locations, the circled points and the shaded rows in Table 2, will be included in the text. Analysis plots and images for all locations will be included in the appendices.

The results provided in this section are for the year-long analysis period. Two seasonal analysis periods were determined by the sponsors as periods when salinity changes are most crucial to aquatic habitat: April – September and July – September. Salinity maximum/minimum/average analyses and mean vertical distribution profiles were performed for the 23 locations for both time periods. Additionally, isohaline plots of mean surface and bottom salinity for each seasonal period are provided for each alternative. These seasonal analysis results are provided in Appendix A: Seasonal Salinity Analysis.

Figure 12. Point analysis locations. Circled locations discussed in this section.

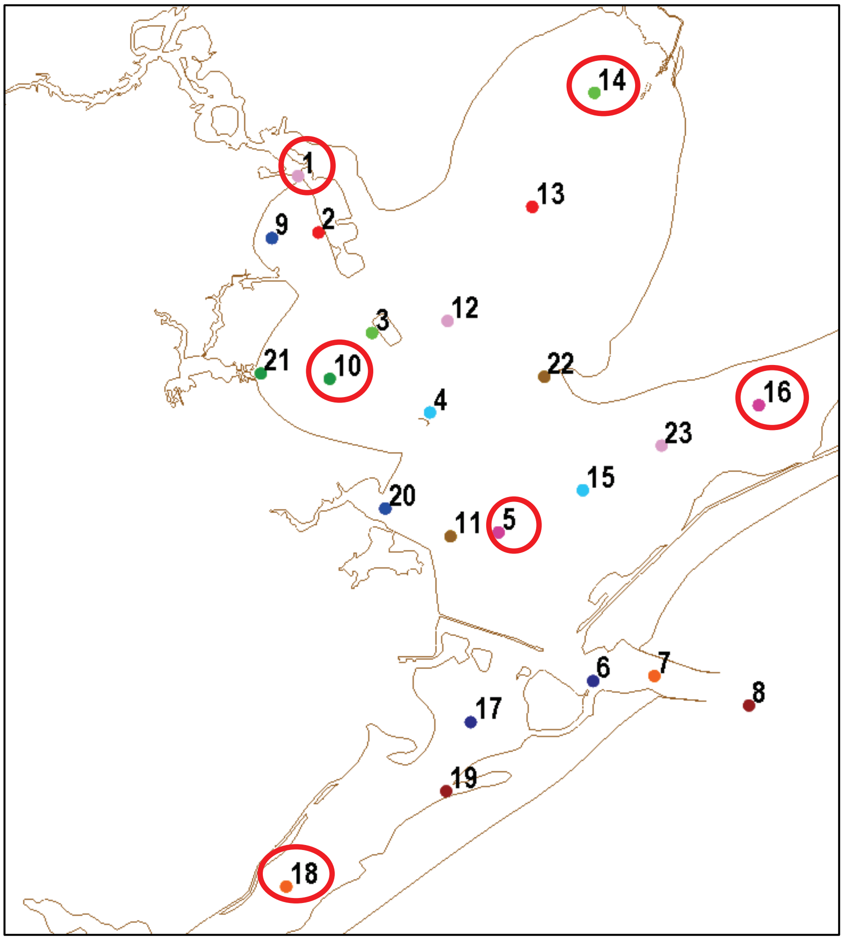


Table 2. Point analysis location names. Highlighted locations discussed in this section.

Point #	Name
1	HSC at Morgan's Point
2	HSC at Atkinson Island
3	HSC at Mid Bay Marsh
4	HSC at Red Fish Reef
5	HSC at Lower Galveston Bay
6	HSC at Bolivar Roads
7	HSC at Entrance
8	HSC at Gulf
9	Upper Galveston Bay 1
10	Upper Galveston Bay 2
11	Lower Galveston Bay
12	Lower Trinity Bay

Point #	Name
13	Mid Trinity Bay
14	Upper Trinity Bay
15	Western East Bay
16	Eastern East Bay
17	Eastern West Bay
18	Mid West Bay
19	Offatts Bayou
20	Dickinson
21	Clear Creek
22	Smith Point
23	Mid East Bay

3.1 Tidal prism and amplitude

Changes to the system geometry can impact the tidal exchange into a bay environment such as Galveston and Trinity Bays. This TSP alternative greatly impacts the cross-sectional area of the entrance into the bays, which will allow for changes in the volume of flow being exchanged through the inlets. The tidal prism is a calculation of the volume of water that enters and leaves through the inlets with each tide. This volume was computed for all tides over the analysis year, and the average tidal prism was computed. Table 3 lists the volume of the average tidal prism for each alternative as well as the percentage change in the with project alternative as compared to the without project alternative for present and future conditions for all structure locations. The change is a reduction between 13% and 17% — indicating that the structures restricting the flow into and out of the HSC at Bolivar Roads are limiting the volume of water entering and exiting the bays as well as the structures at the smaller water bodies. This analysis assumes all structures are in place for the project alternative; therefore, much of the reduction at the bayous is due to the restriction created by the large structure at Bolivar Roads.

Table 3. Average tidal prism volume for analysis year.

	PWP (m^3)	PWOP (m^3)	PWP % change from PWOP	FWP (m^3)	FWOP (m^3)	FWP % change from FWOP
Bolivar Roads	460,814,707	532,995,012	-13.5	556,945,721	667,353,415	-16.5
Offatts Bayou	1,067,941	1,265,050	-15.6	1,006,517	1,199,537	-16.1
Dickinson Bayou	490,992	571,414	-14.1	454,839	542,866	-16.2
Clear Creek	3,044,955	3,544,931	-14.1	2,792,991	3,326,102	-16.0

The tidal amplitude is the change in the water level from low tide to high tide and vice versa. The tidal prism gives an overall impact on the water exchange whereas the tidal amplitude may vary at locations depending on where the system modifications are made and changes in the flow patterns within the system. Table 4 shows the percentage change between present without and with project alternatives and future without and with project alternatives for all locations shown in Figure 12. The amplitude comparisons between with and without project range between 8% and -21%. The Gulf of Mexico location shows unchanged tidal amplitudes, and the HSC entrance location shows an increase in the with project amplitude — expected since the restriction in the flow area will force water to pile up on the Gulf side of the project. The present and future comparisons show the greatest impact at Bolivar Roads, which is the location closest to the project site on the bay side. The percentage change in amplitude is generally greater for the future comparison than for the present, and the comparisons within the bay vary by location, but all show a decrease in the tidal amplitude for the project condition as compared to the without project. The magnitude of change in the tidal amplitude values is shown for the HSC locations in Figure 13 and the bay locations in Figure 14. The change in amplitudes varies between 0 m and 0.07 m for the various locations and alternatives, with most locations showing a with project reduction in amplitude of approximately 0.05 m.

Table 4. Percent change in tidal amplitude from the without project alternatives for present and future conditions.

	Present % Change from Without Project	Future % Change from Without Project
HSC at Morgan's Point	-12.82	-18.42
HSC at Atkinson Island	-12.82	-18.42
HSC at Mid Bay Marsh	-13.16	-16.22
HSC at Red Fish Reef	-13.51	-16.67
HSC at Lower Galveston Bay	-14.29	-18.18
HSC at Bolivar Roads	-20.00	-21.88
HSC at Entrance	5.56	8.82
HSC at Gulf	0.00	0.00
Upper Galveston Bay 1	-10.00	-12.82
Upper Galveston Bay 2	-7.69	-10.53
Lower Galveston Bay	-10.53	-13.89
Lower Trinity Bay	-10.26	-10.53
Mid Trinity Bay	-10.00	-12.82
Upper Trinity Bay	-9.76	-12.50
Western East Bay	-10.53	-11.11
Eastern East Bay	-12.82	-10.53
Eastern West Bay	-13.16	-16.22
Mid West Bay	-12.82	-13.16
Offatts Bayou	-13.16	-16.22
Dickinson	-13.51	-13.89
Clear Creek	-12.82	-15.79
Smith Point	-13.16	-13.51
Mid East Bay	-15.79	-16.22

Figure 13. Tidal amplitude comparison at HSC points for all alternatives.

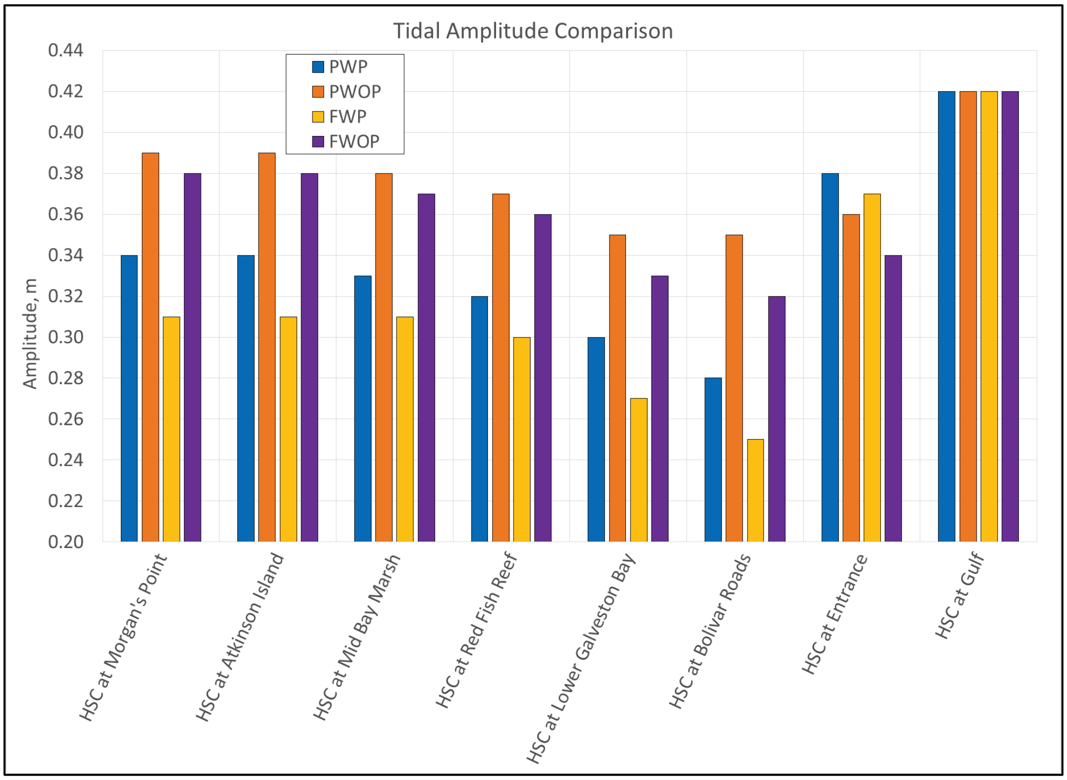
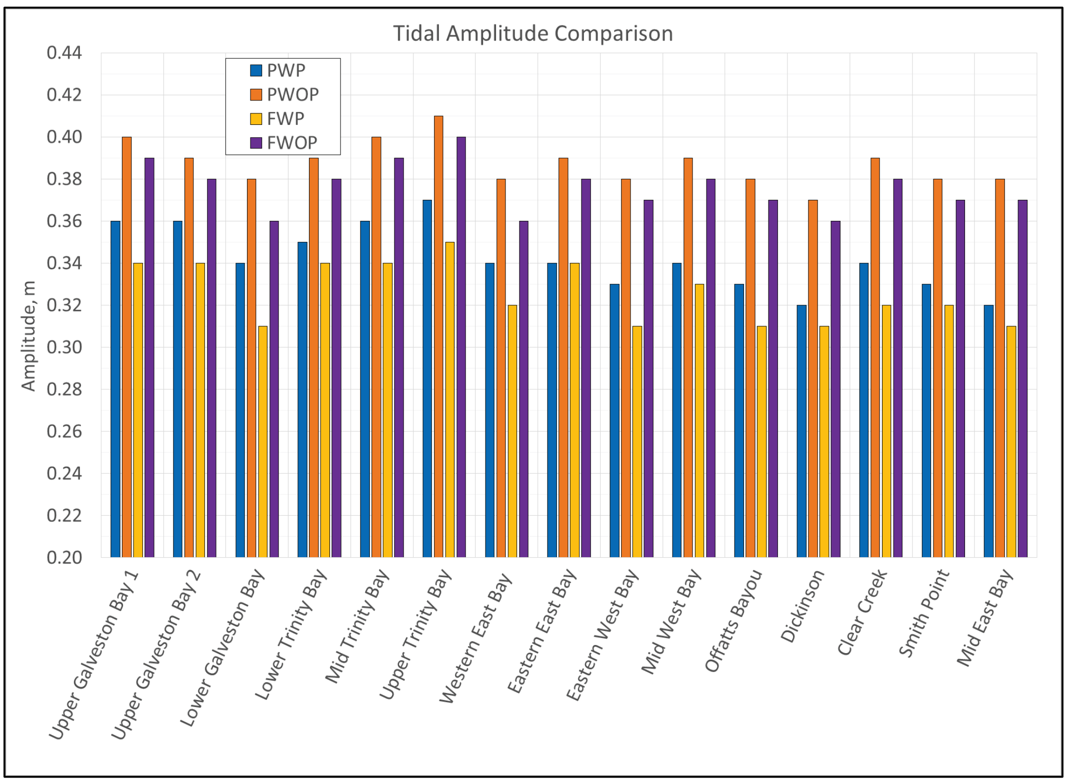


Figure 14. Tidal amplitude comparison at bay points for all alternatives.



3.2 Salinity isohaline plots

To view the salinity magnitude throughout the bays, isohaline plots at 5 parts per thousand (ppt) intervals are provided for mean salinity over the year-long analysis period (Figure 15 through Figure 22). Seasonal isohaline plots are provided in Appendix A: Seasonal Salinity Analysis.

Figure 15. Mean surface salinity over year-long analysis period for PWP.

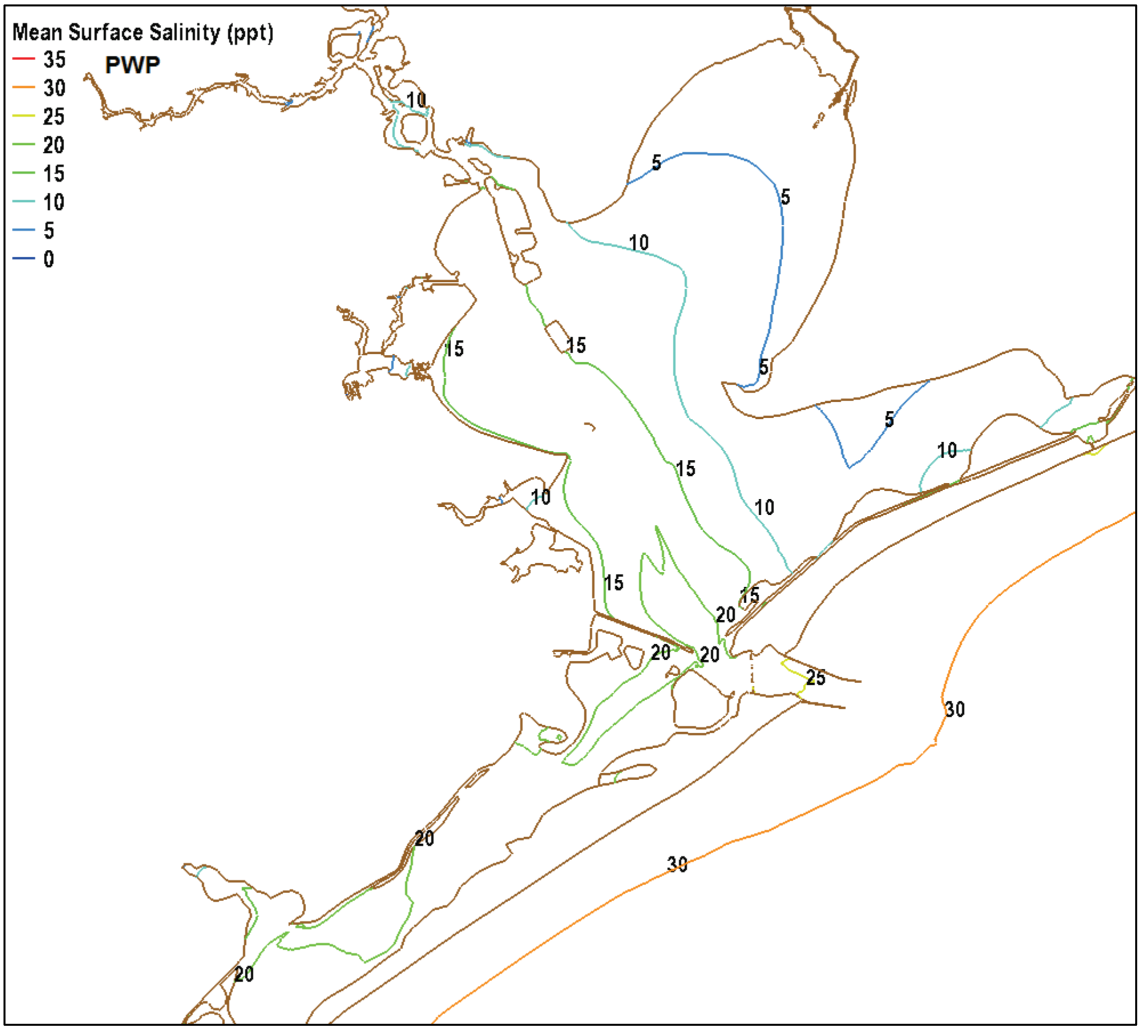


Figure 16. Mean bottom salinity over year-long analysis period for PWP.

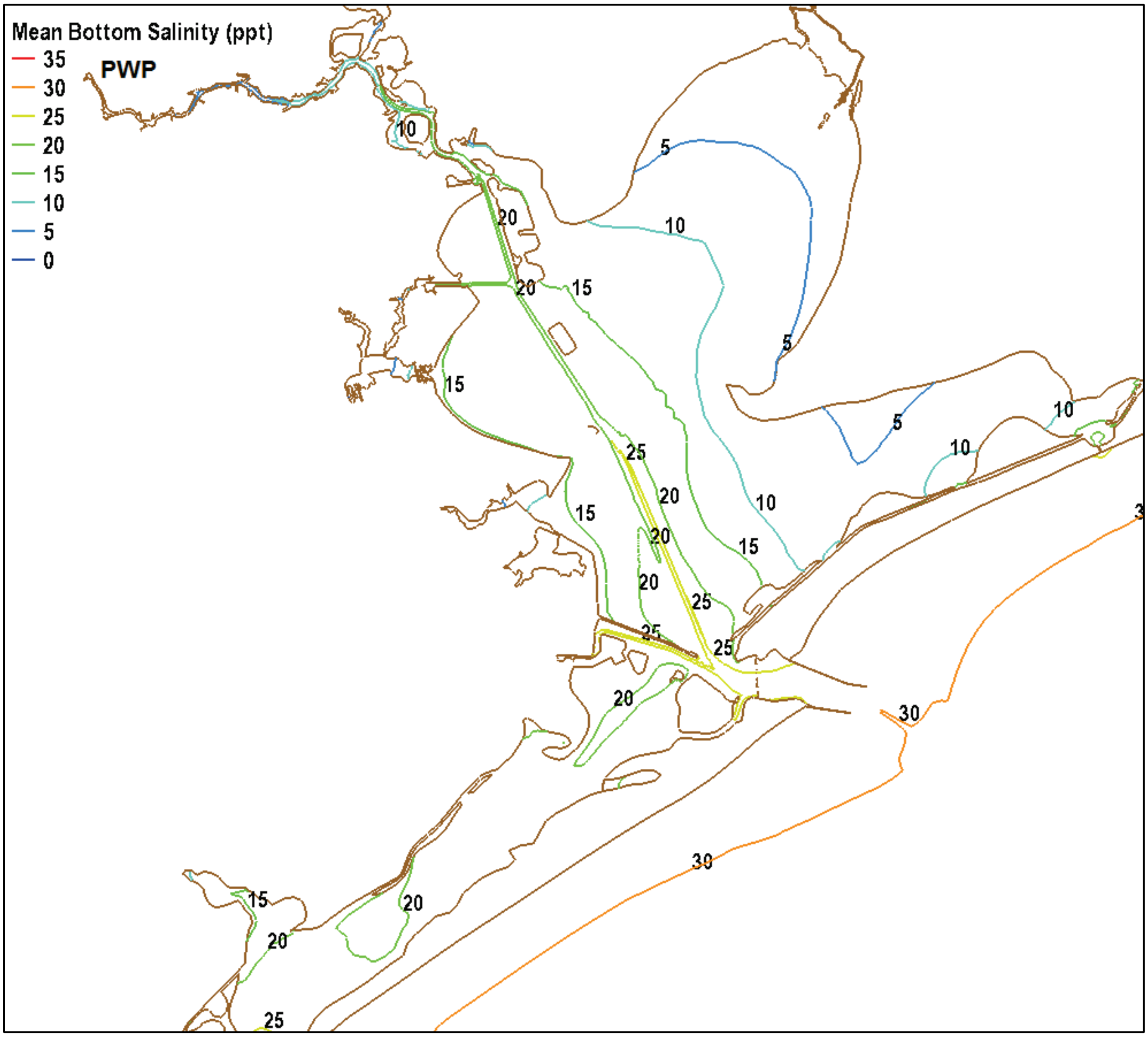


Figure 17. Mean surface salinity over year-long analysis period for PWOP.

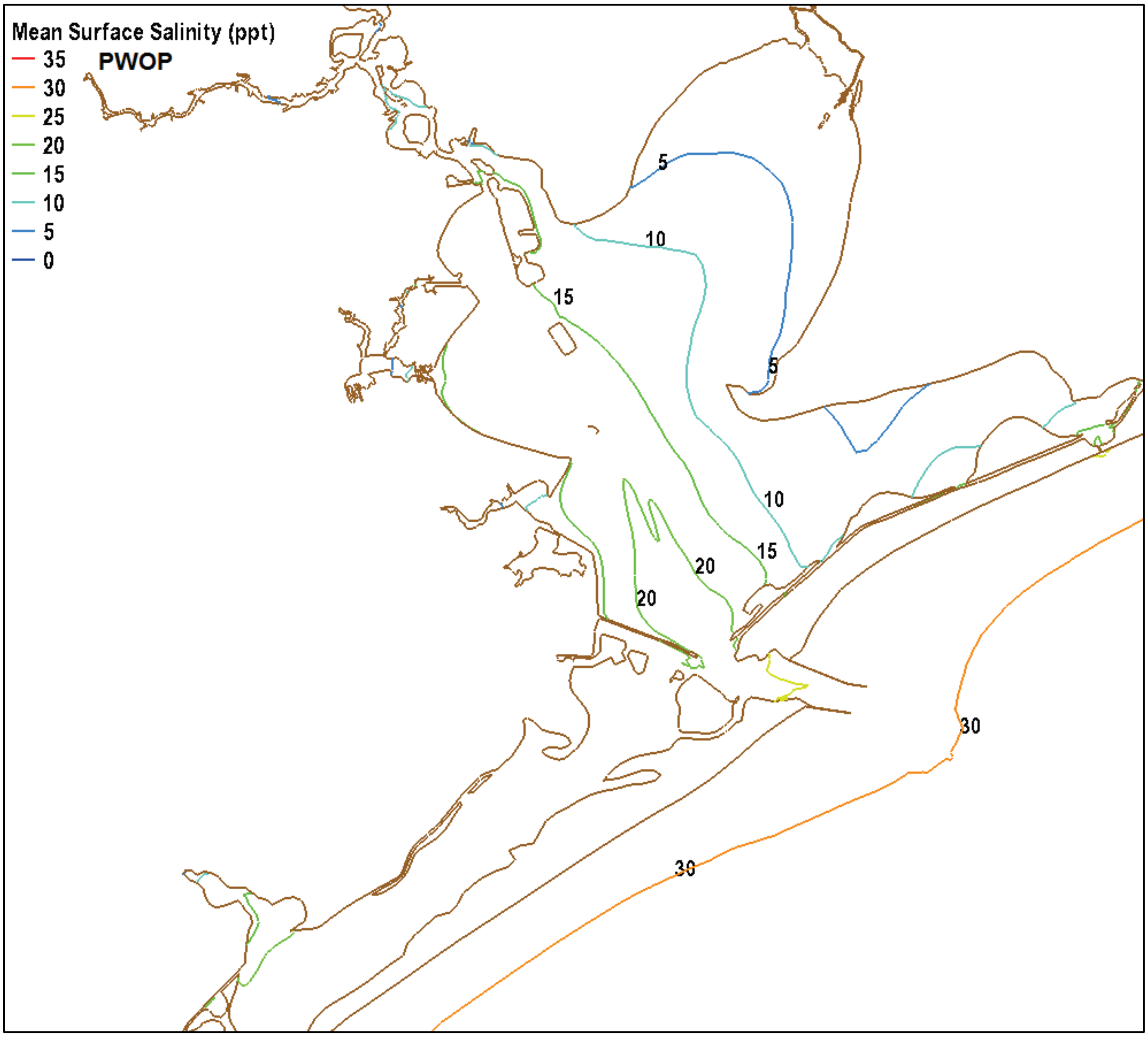


Figure 18. Mean bottom salinity over year-long analysis period for PWOP.

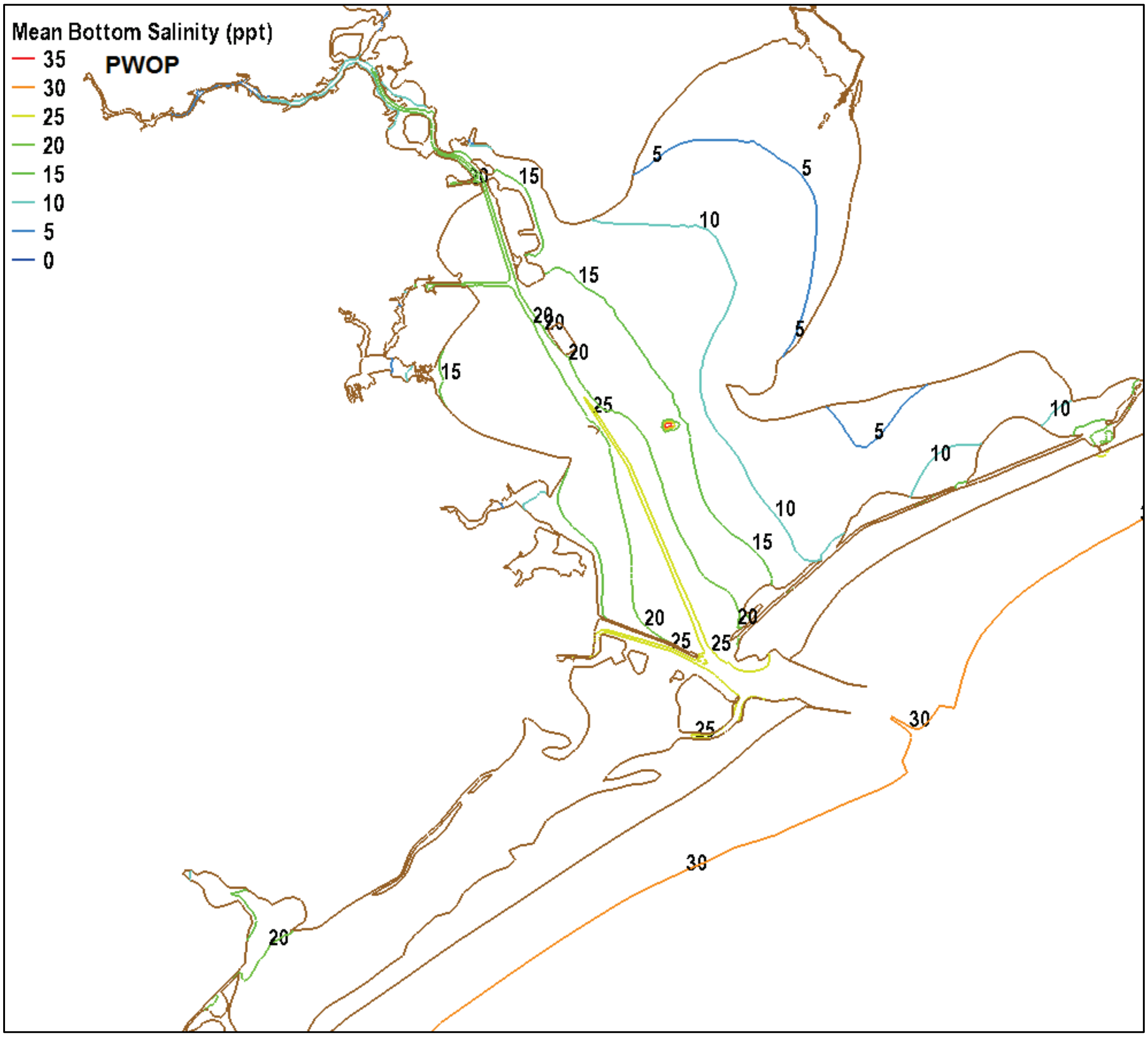


Figure 19. Mean surface salinity over year-long analysis period for FWP.

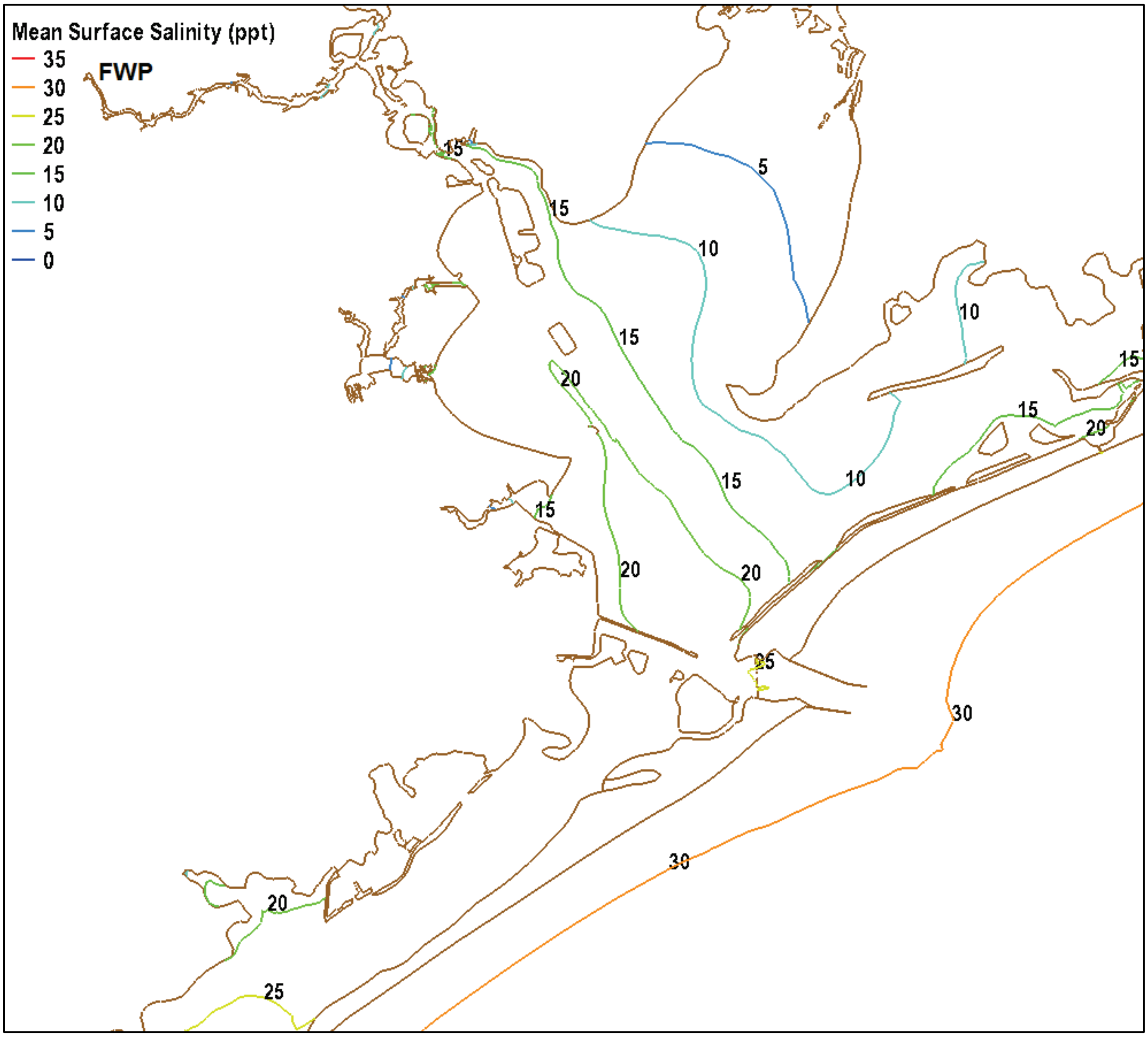


Figure 20. Mean bottom salinity over year-long analysis period for FWP.

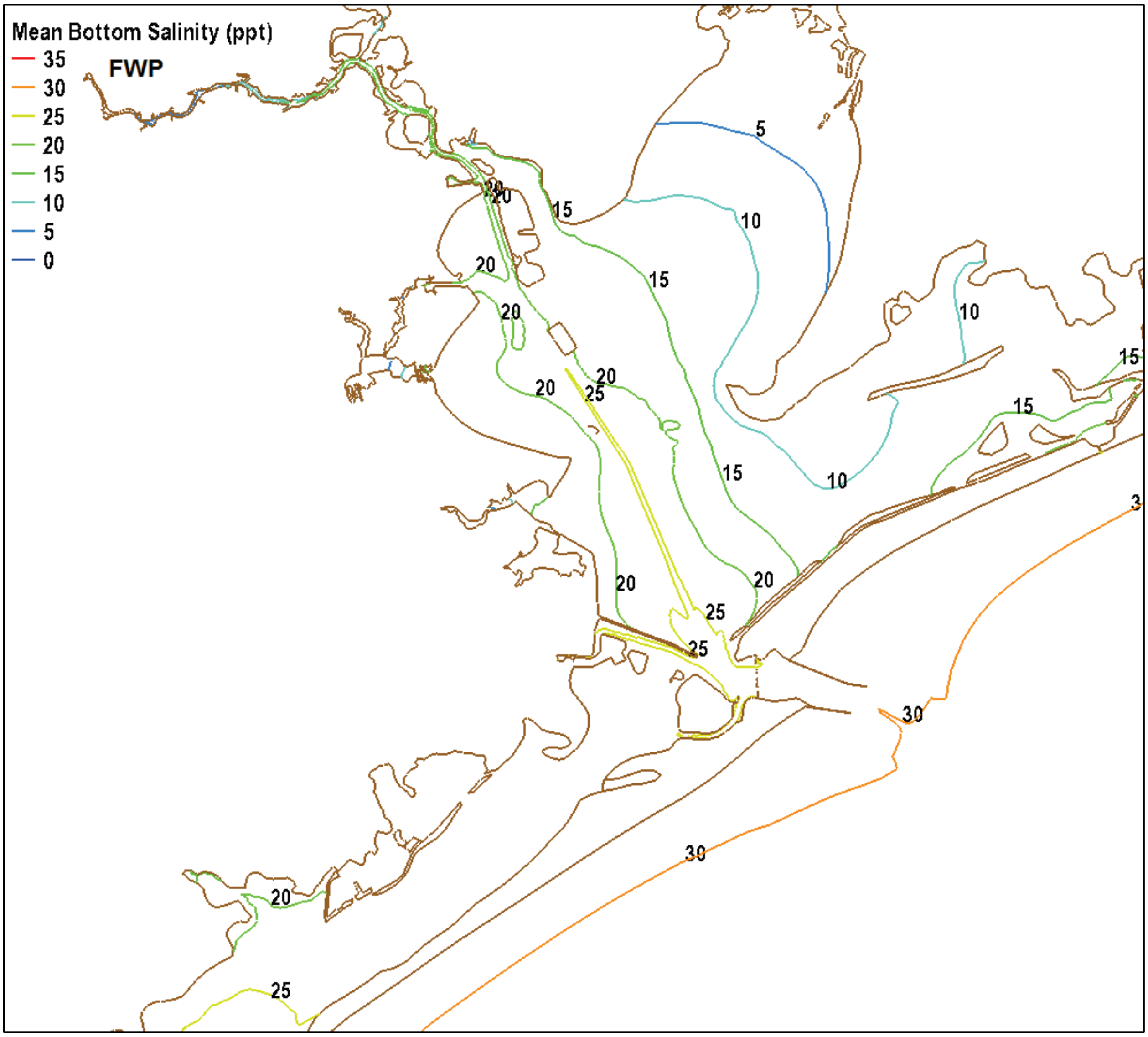


Figure 21. Mean surface salinity over year-long analysis period for FWOP.

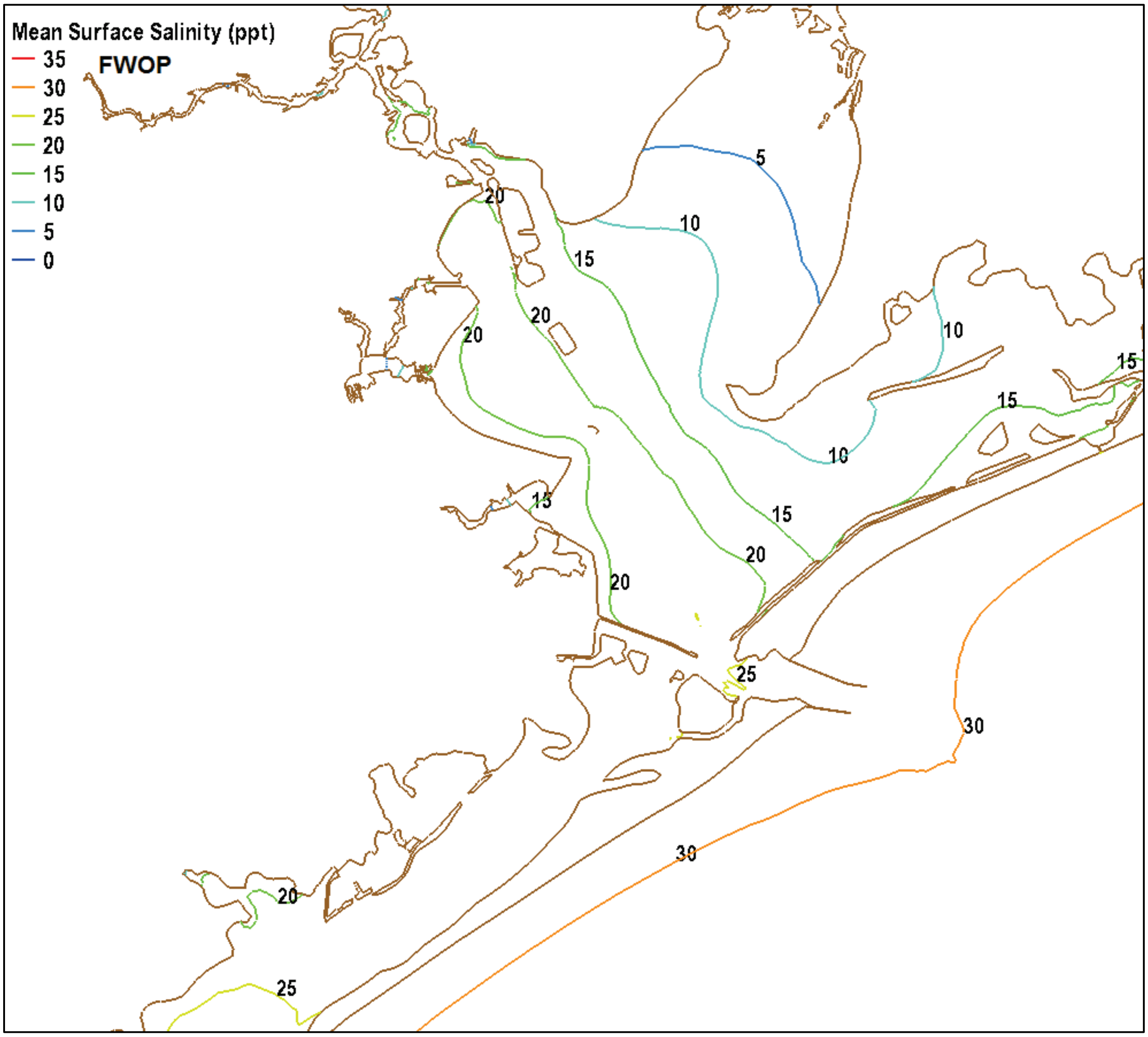
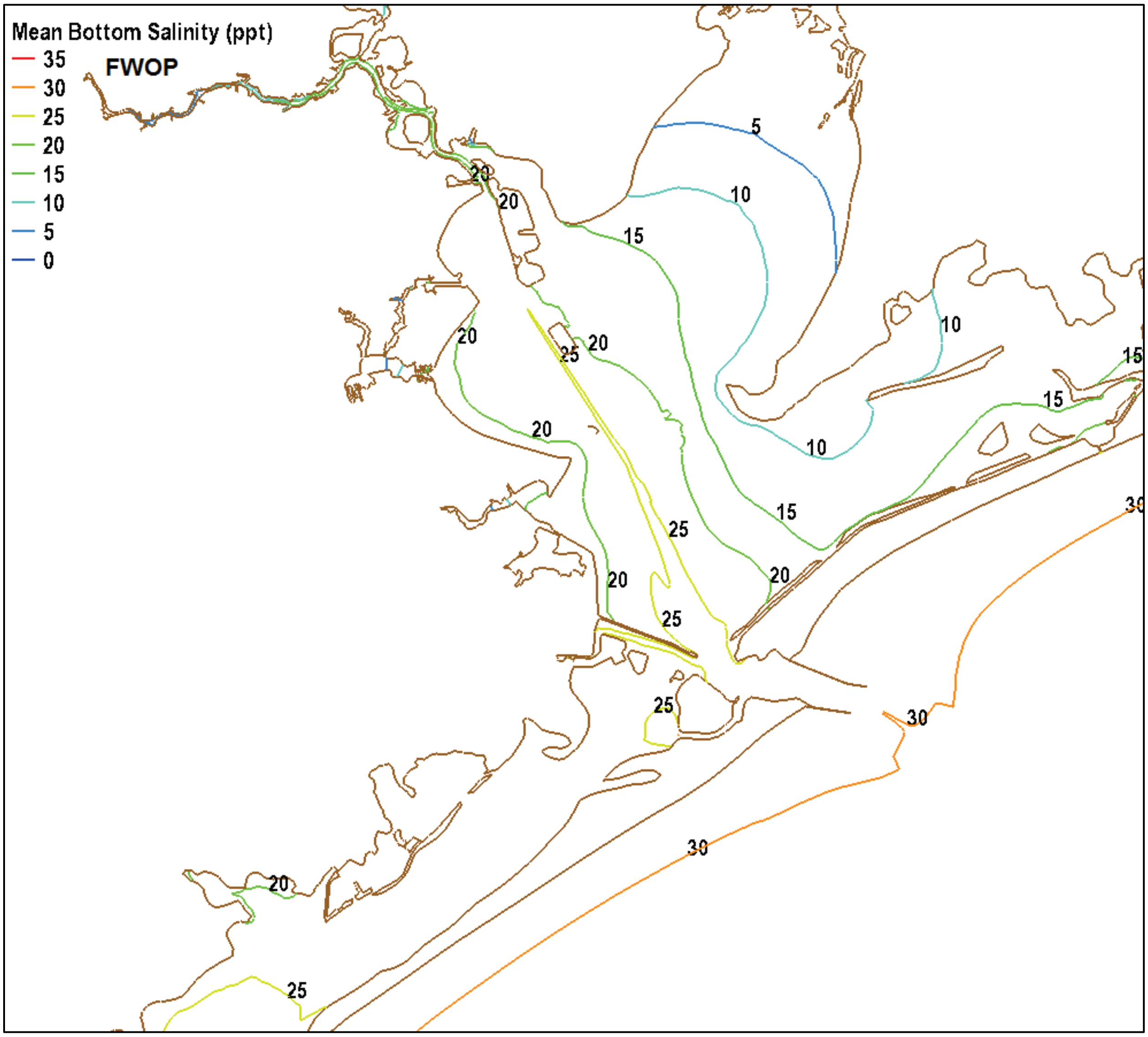


Figure 22. Mean bottom salinity over year-long analysis period for FWOP.



3.3 Salinity point analysis

Time history of salinity is shown for several points within the HSC and several in the bays. Also provided are plots showing the maximum, average, and minimum salinity at each location for the year-long analysis period. The salinity shown in the plots is bottom values, which will be larger or equal in magnitude than the surface values due to the density stratification of salt water. For all plots of salinity, PWP is blue, PWOP is orange, FWP is yellow, and FWOP is purple.

Additionally, percent-less-than plots are provided to show how the bottom salinity varies over the year-long analysis period. The maximum salinity value is given at 100% and the minimum value at 0%. The 50% salinity value indicates that the salinity is less than this value for 50% of the analysis time and greater than this value 50% of the time.

Vertical salinity profiles are also included for all of the salinity analysis points.

Figure 23 through Figure 46 show the point salinity analysis at the six selected locations. The results for the 23 locations are provided in Appendix B: Salinity Point Analysis. Additionally, seasonal point salinity analyses are provided in Appendix A: Seasonal Salinity Analysis.

The variation in salinity between present and future conditions is large as expected. The rise in water surface elevation due to sea level changes as well as a reduction in freshwater inflow for future conditions generates very different salinity magnitudes throughout the analysis year. In most locations, the mean salinity is larger for the future conditions. However, the variation in salinity between with and without project alternatives is fairly small for most locations over the simulation year — generally less than 2 ppt. The salinities are almost identical near the HSC entrance but begin to diverge farther into the system at Mid Bay Marsh and Morgan’s Point. However, the change in the mean salinity between with and without project remains within 2 ppt. The maximum salinity comparisons between with and without project are slightly higher for some locations but still less than a 5 ppt difference. The time history of salinity includes dotted lines for 10 ppt and 15 ppt thresholds. The with project conditions generally maintain the same pattern of the salinity over time as the without project but do increase above these thresholds for short periods of time at some locations.

Figure 23. Salinity time history at HSC at Morgan's Point.

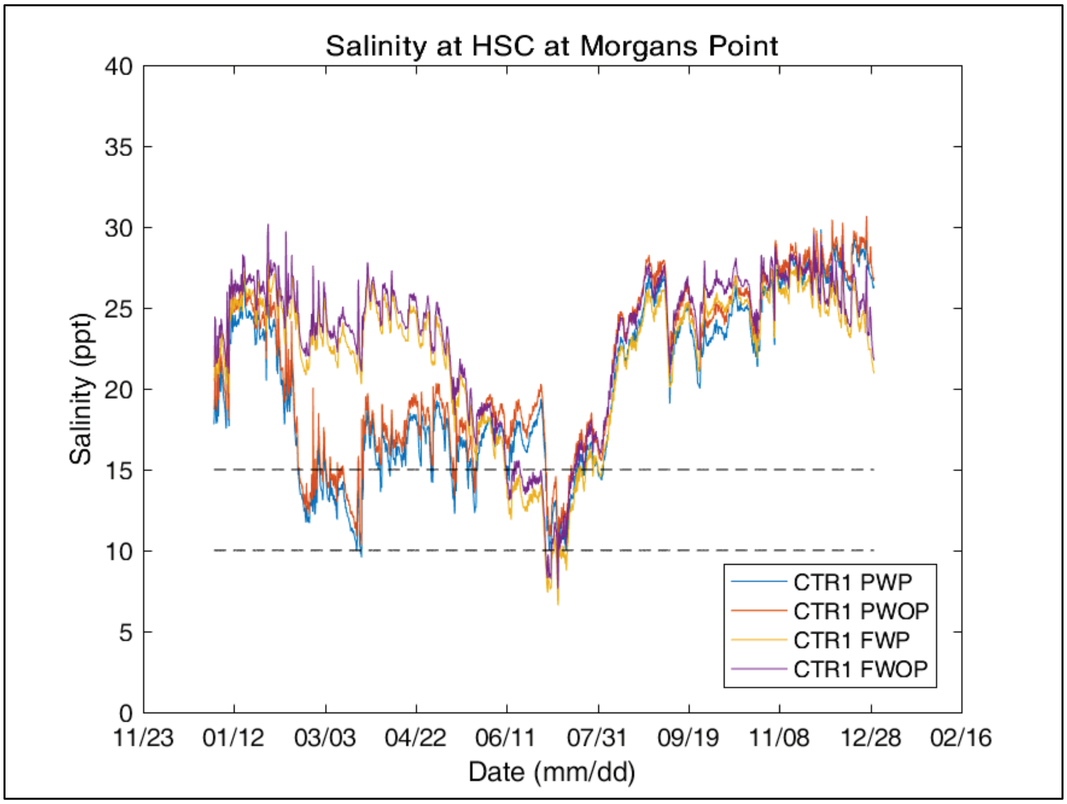


Figure 24. Maximum, mean, and minimum salinity at HSC at Morgan’s Point

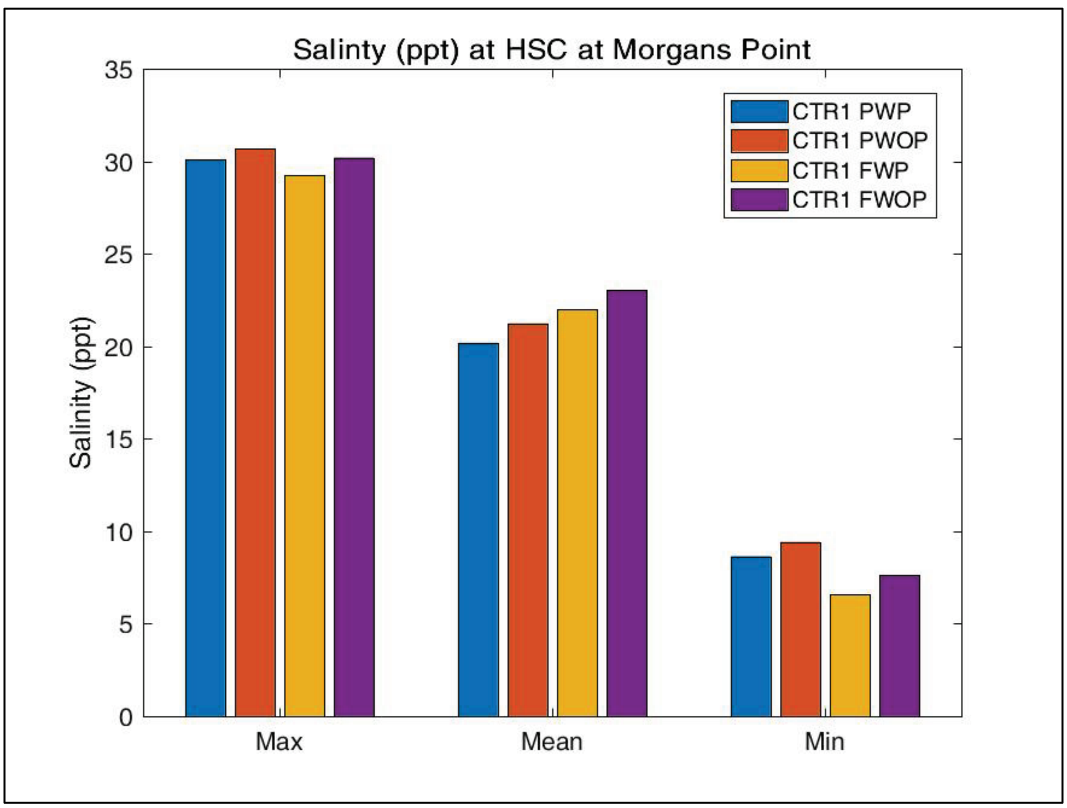


Figure 25. Percent-less-than salinity at HSC at Morgan's Point.

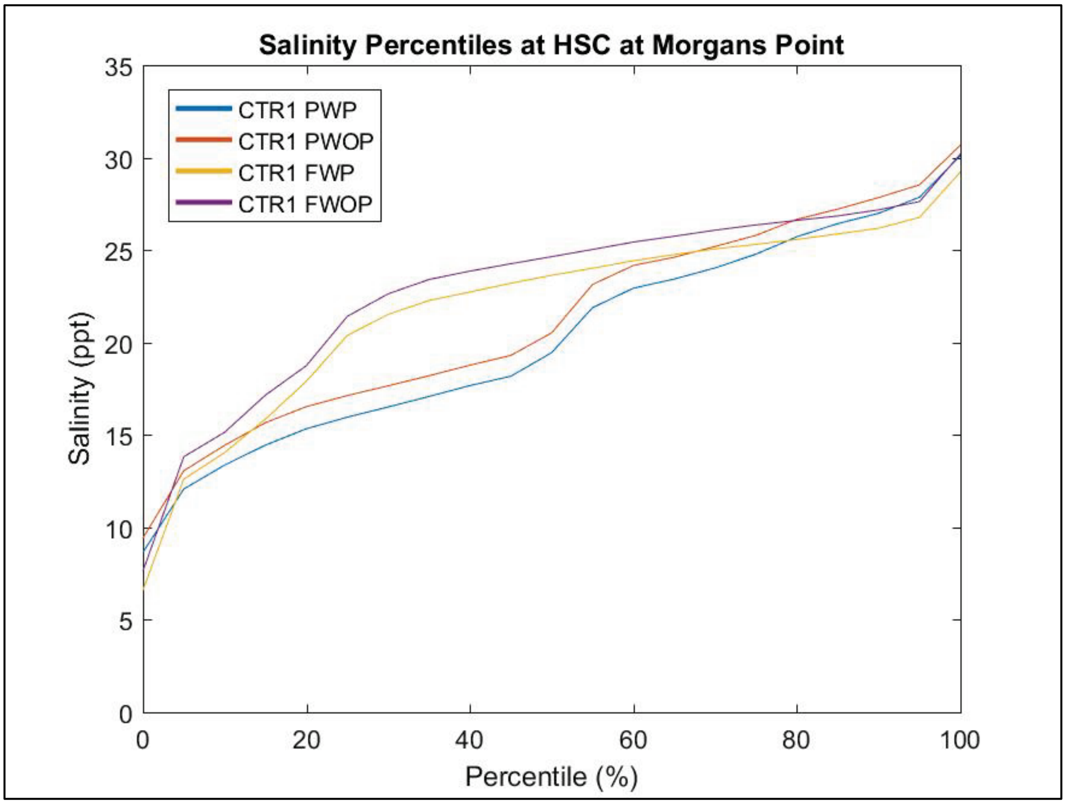


Figure 26. Vertical salinity profile at HSC at Morgan's Point.

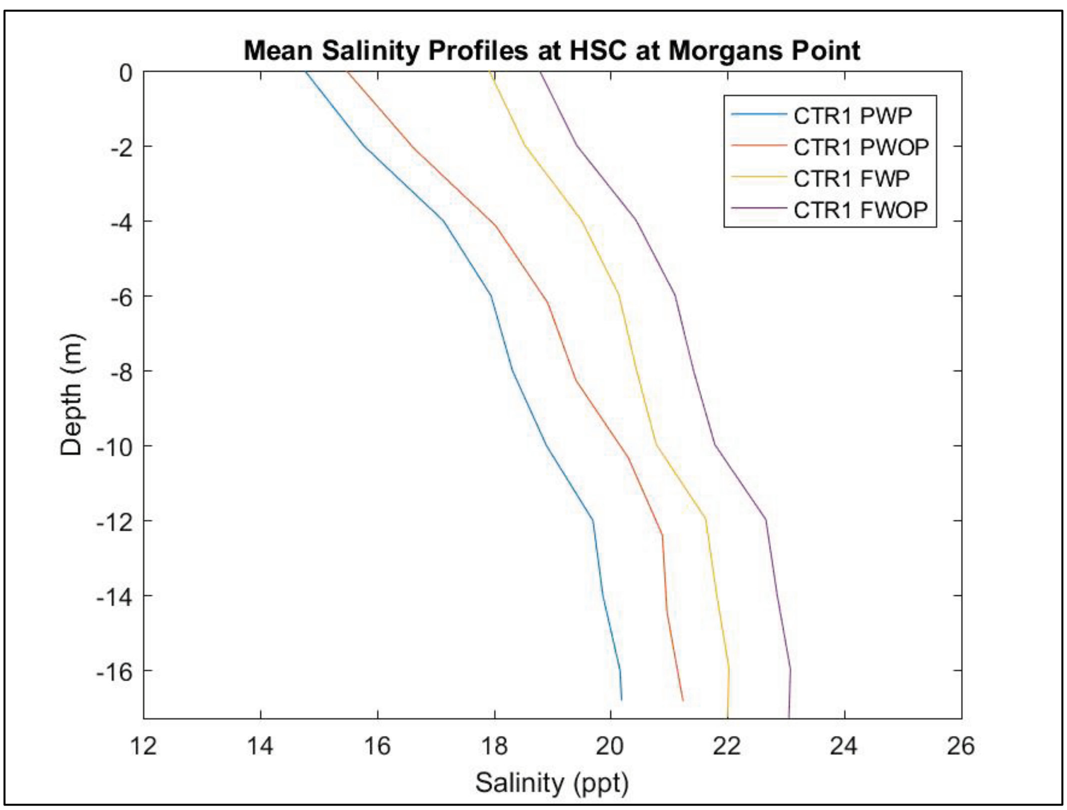


Figure 27. Salinity time history at HSC at Lower Galveston Bay.

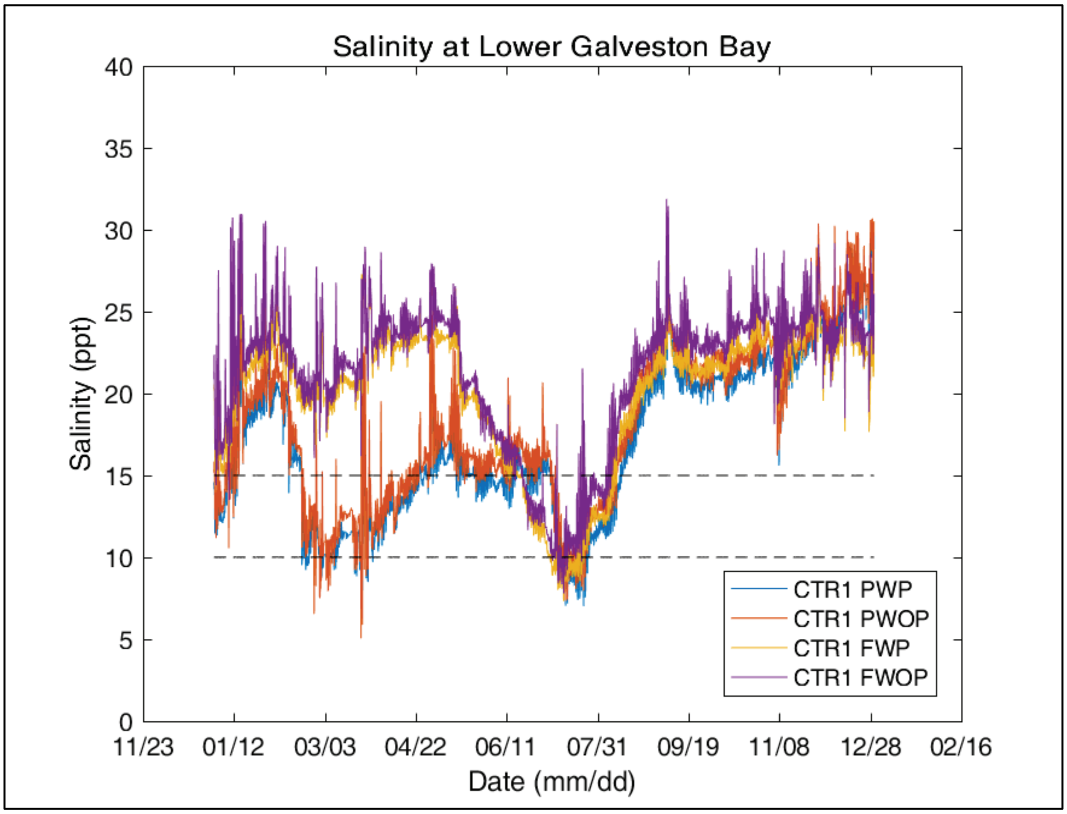


Figure 28. Maximum, mean, and minimum salinity at HSC at Lower Galveston Bay.

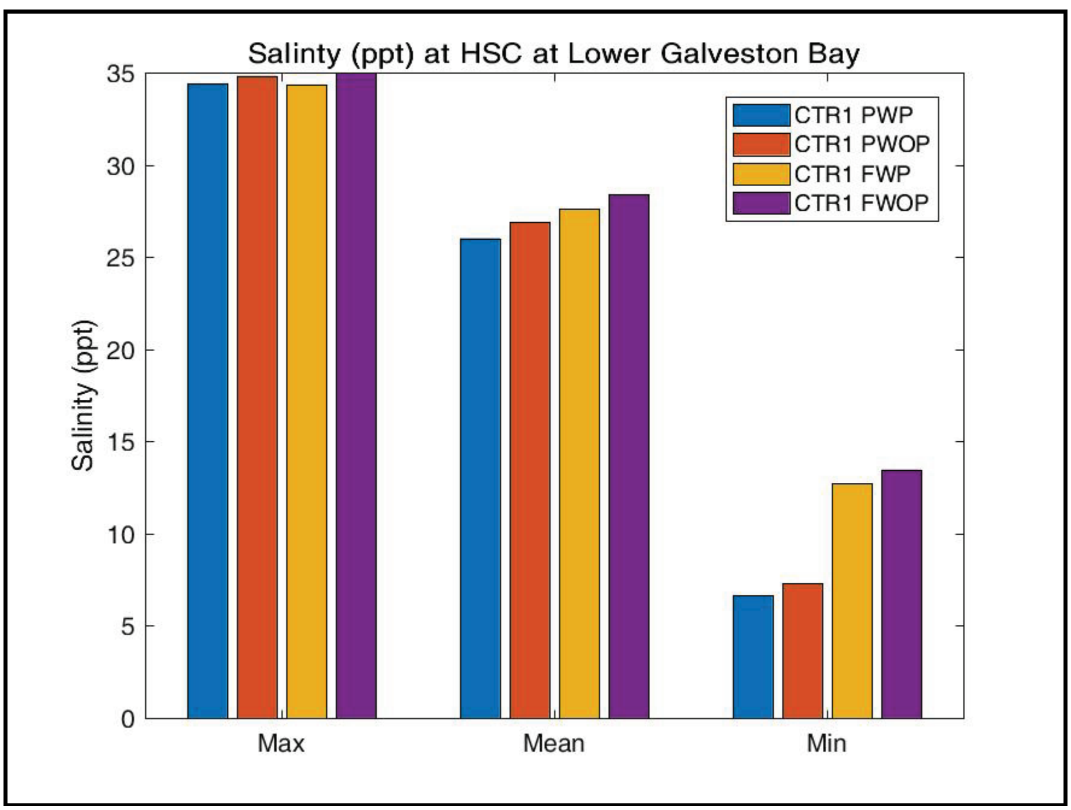


Figure 29. Percent-less-than salinity at HSC at Lower Galveston Bay.

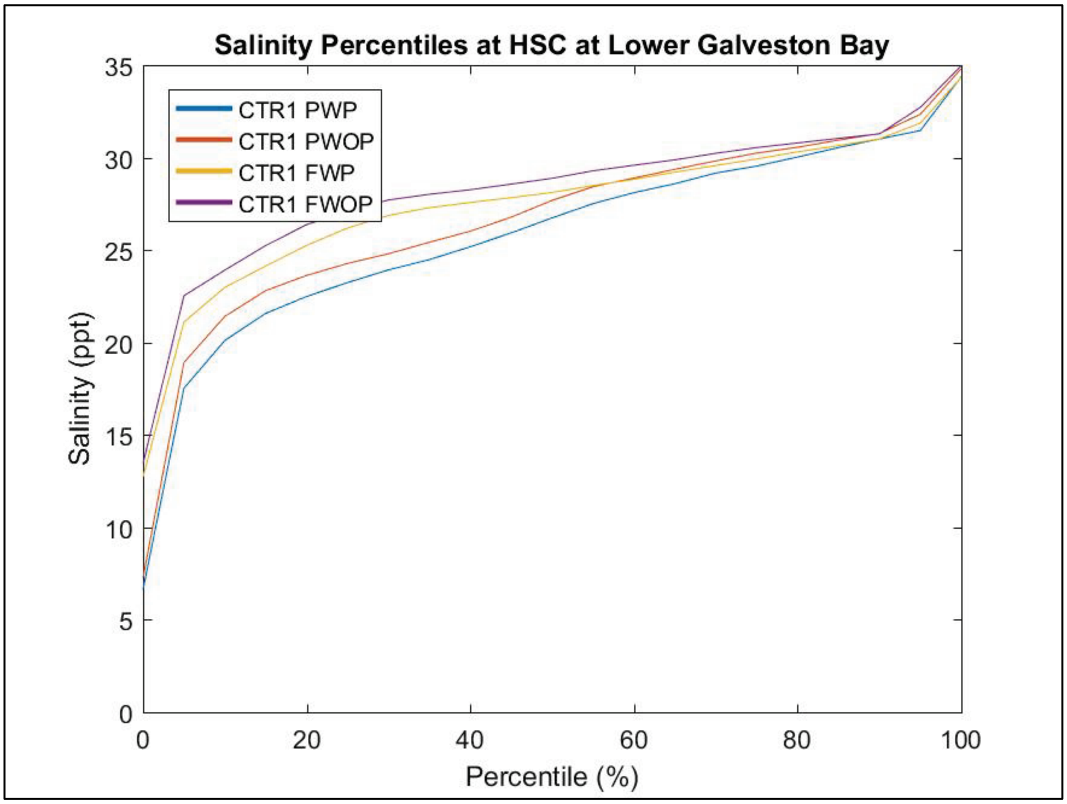


Figure 30. Vertical salinity profile at HSC at Lower Galveston Bay.

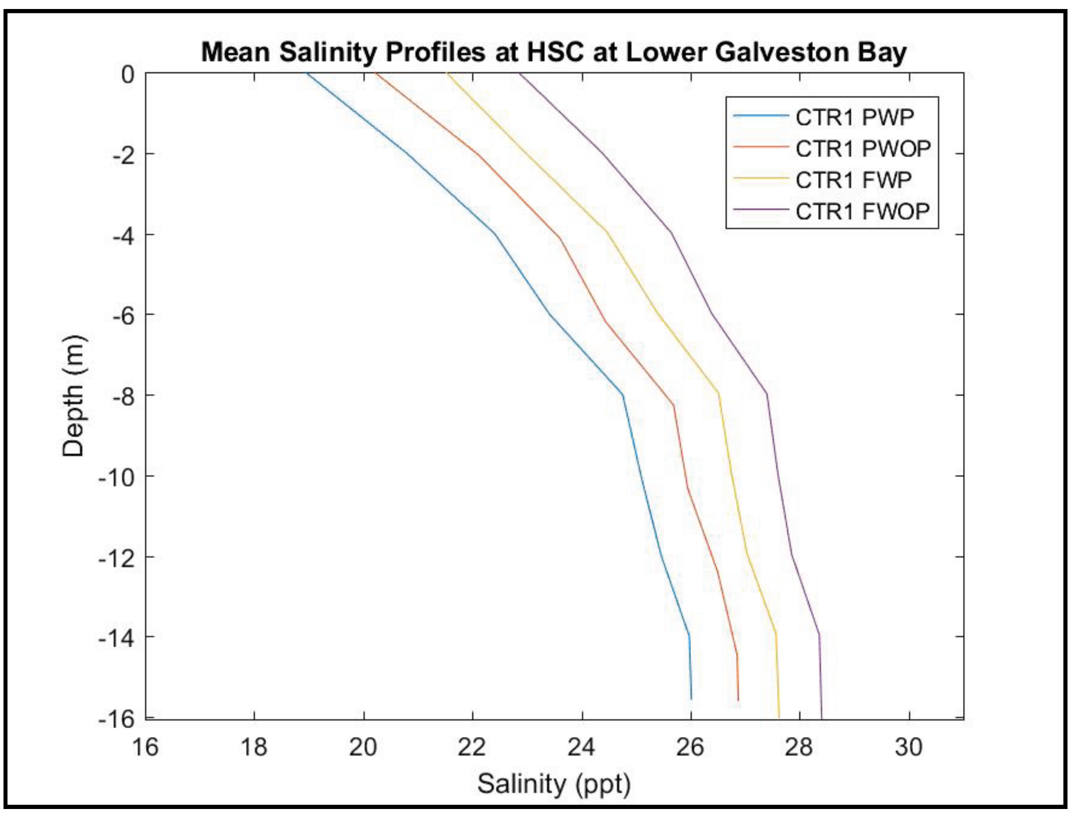


Figure 31. Salinity time history at Upper Galveston Bay 2.

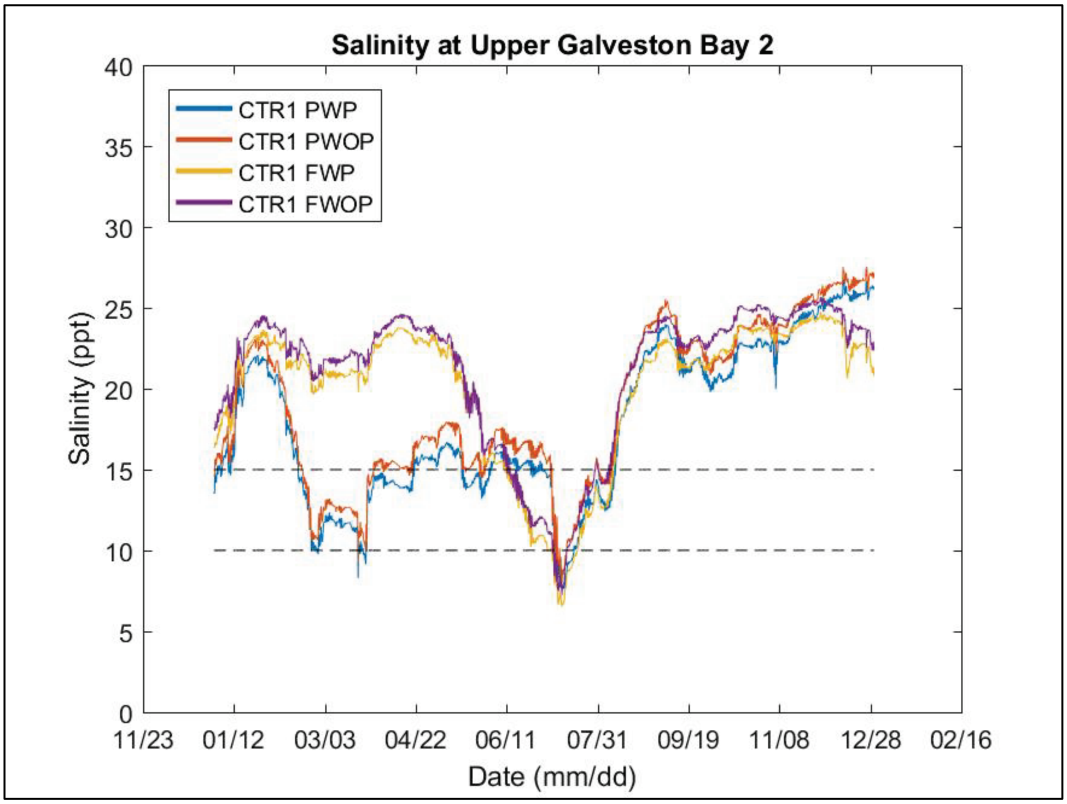


Figure 32. Maximum, mean, and minimum salinity at Upper Galveston Bay 2.

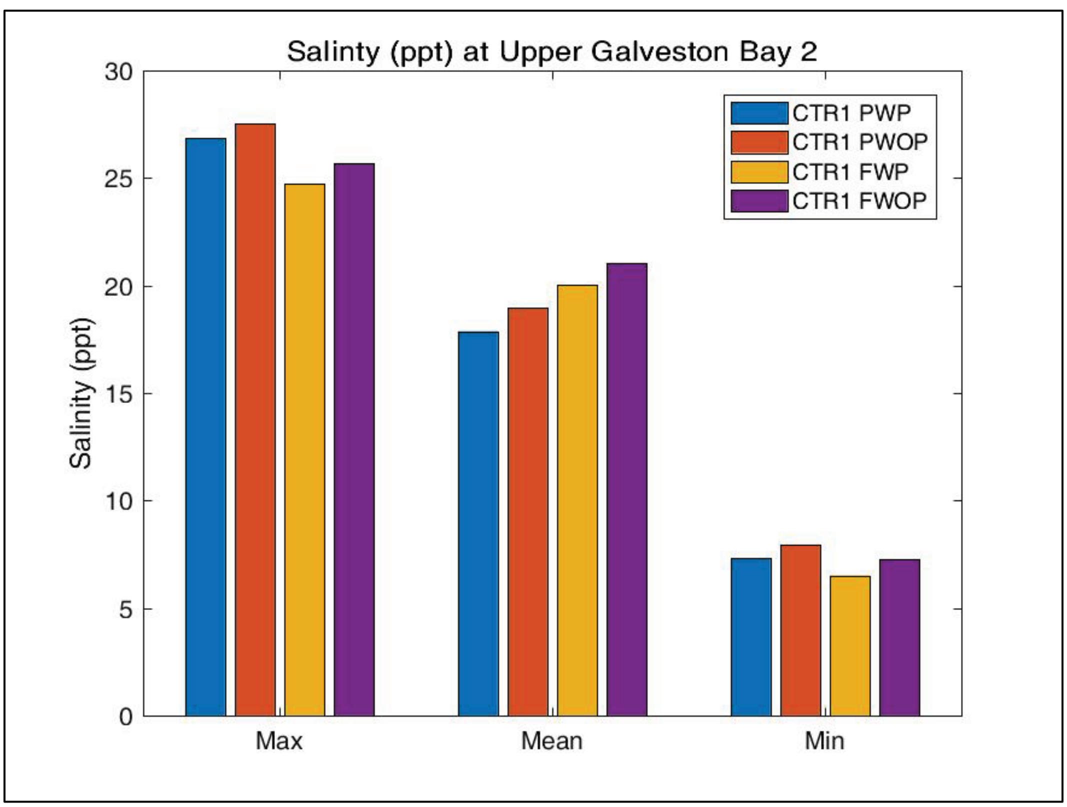


Figure 33. Percent-less-than salinity at Upper Galveston Bay 2.

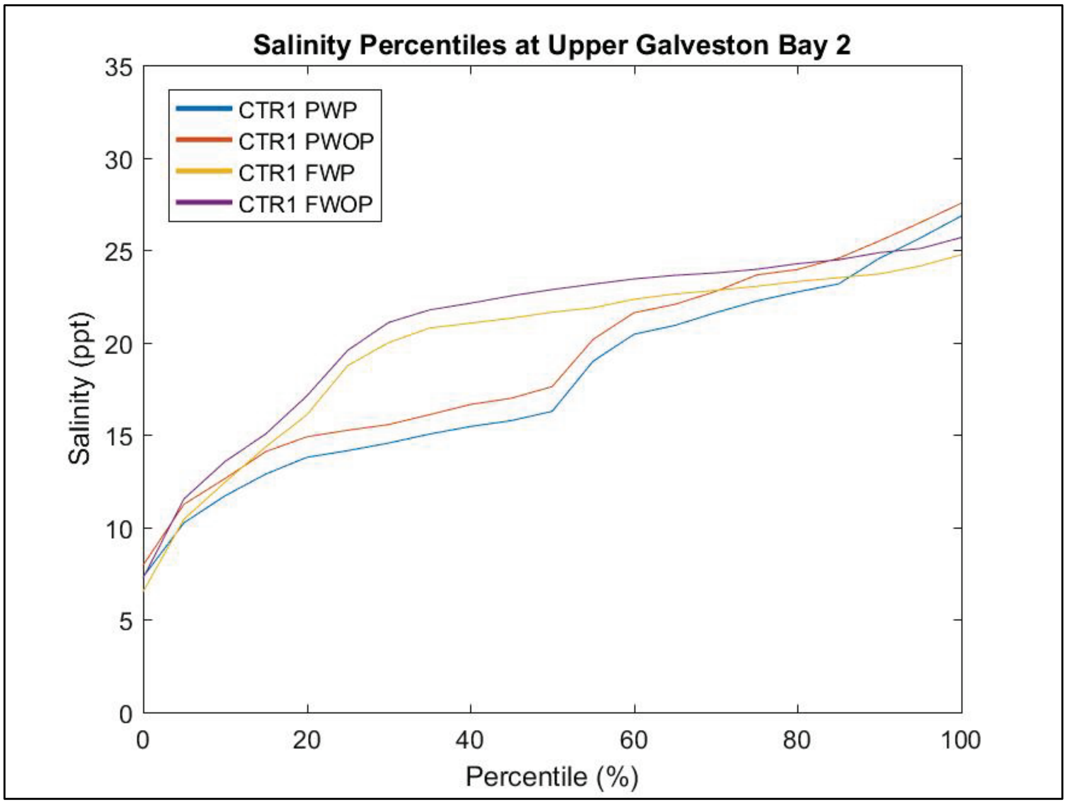


Figure 34. Vertical salinity profile at Upper Galveston Bay 2.

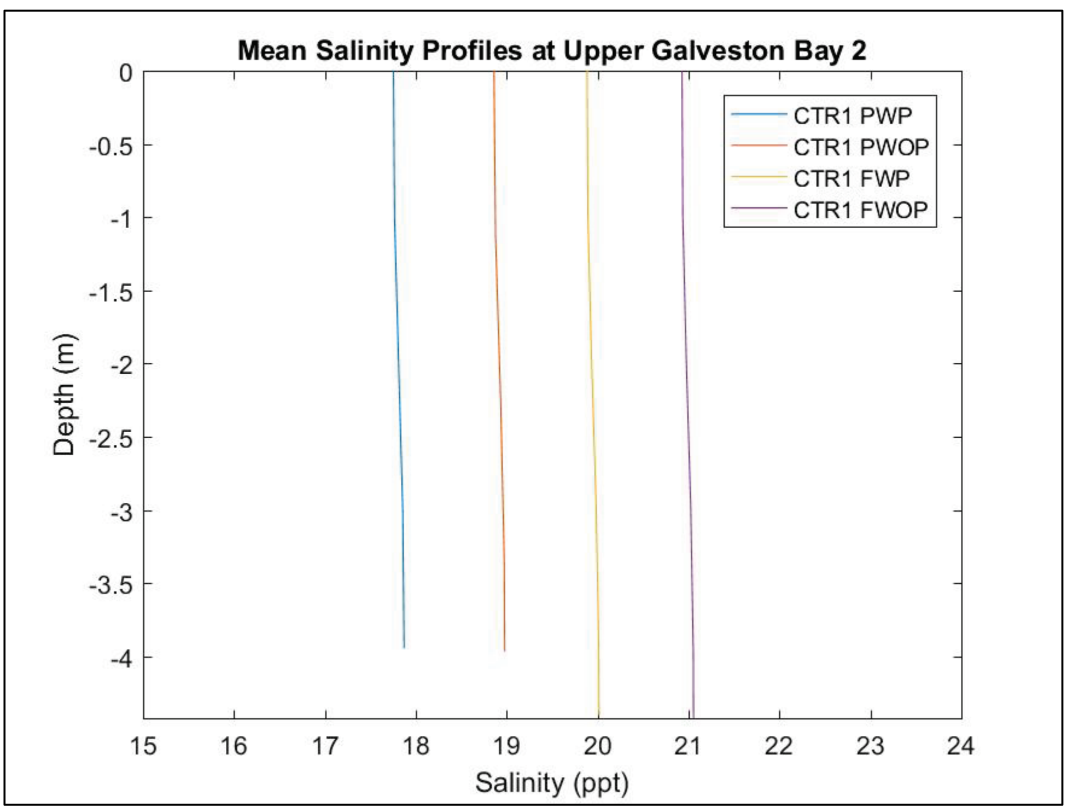


Figure 35. Salinity time history at Upper Trinity Bay.

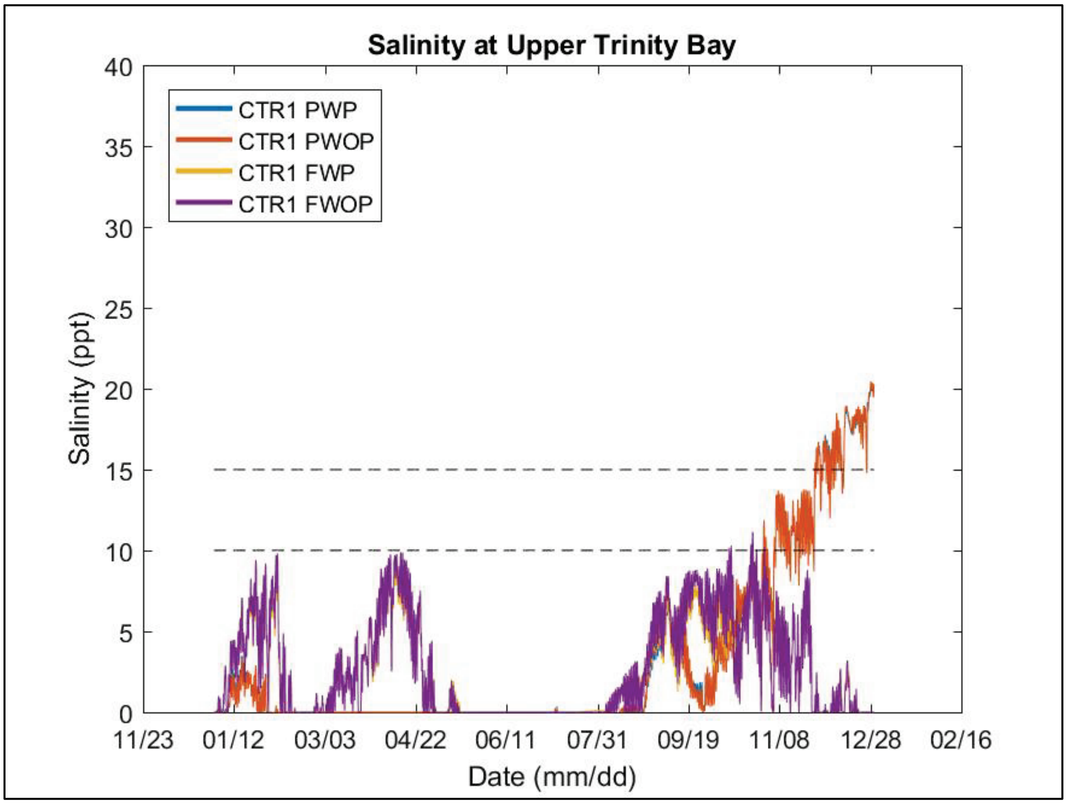


Figure 36. Maximum, mean, and minimum salinity at Upper Trinity Bay.

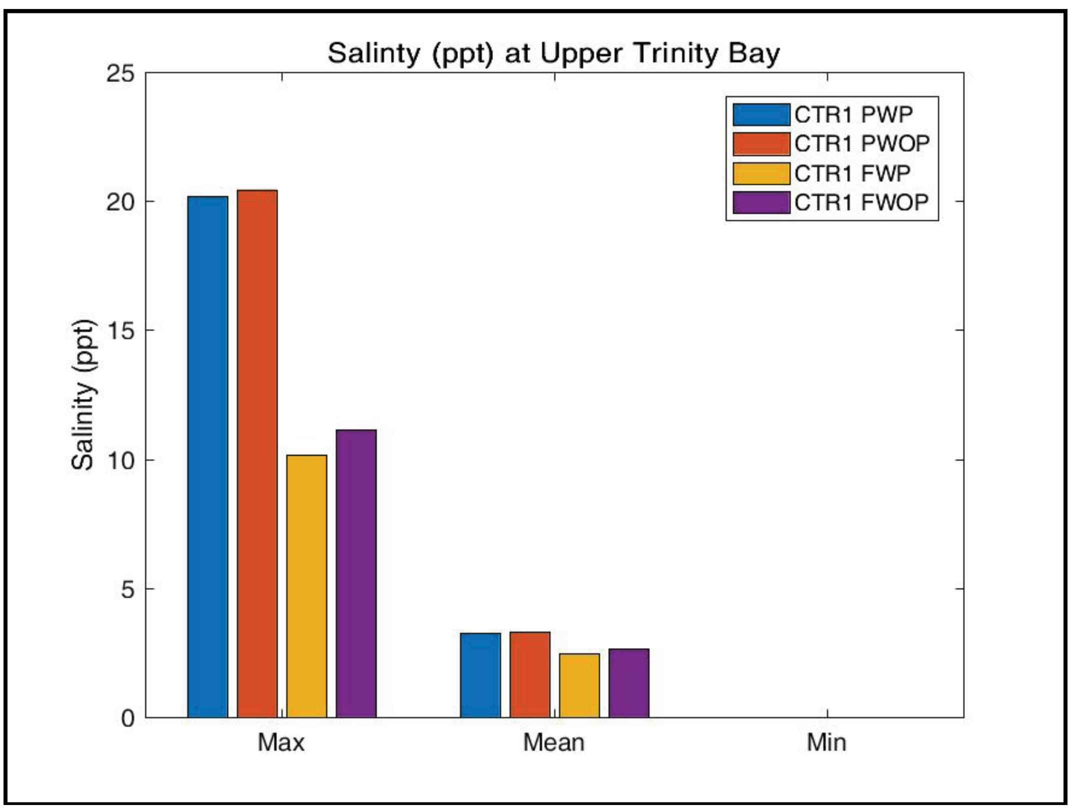


Figure 37. Percent-less-than salinity at Upper Trinity Bay.

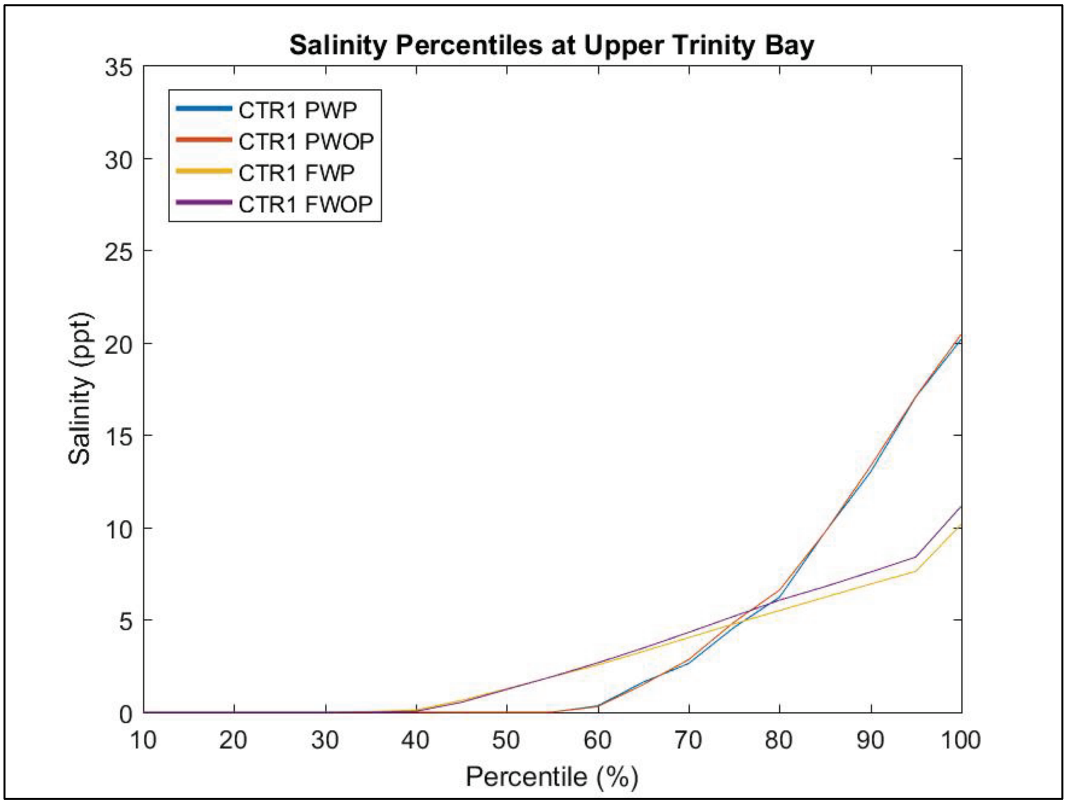


Figure 38. Vertical salinity profile at Upper Trinity Bay.

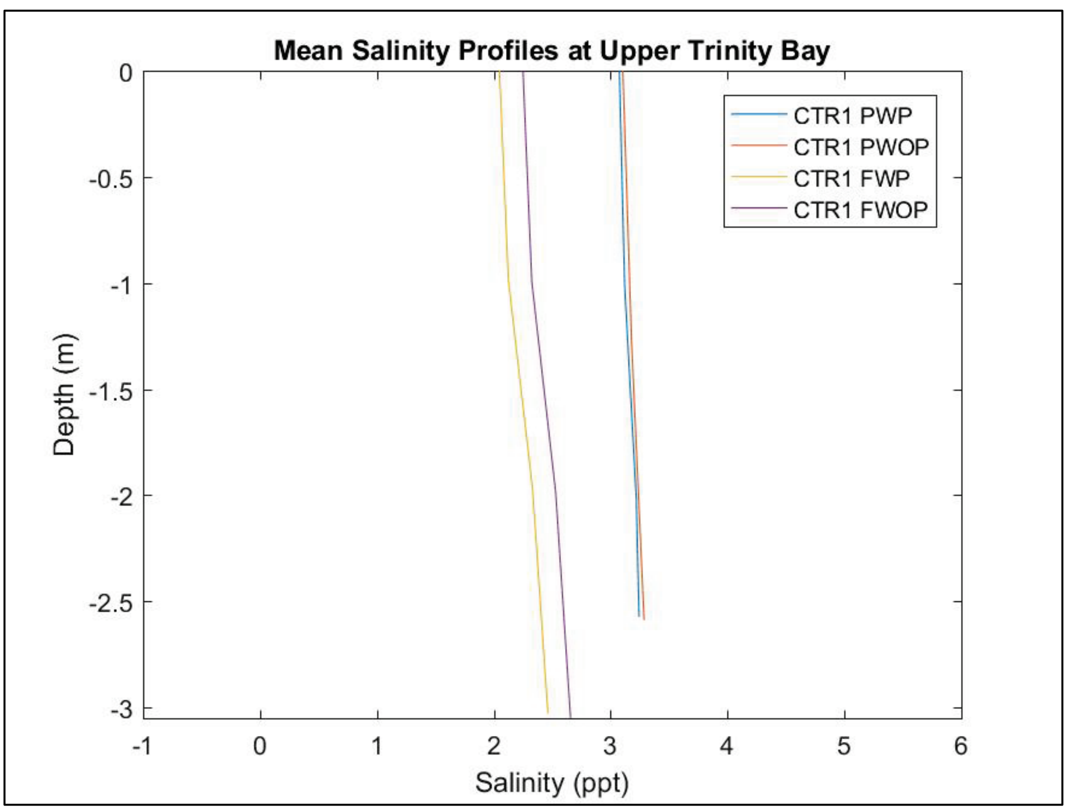


Figure 39. Salinity time history at Eastern East Bay.

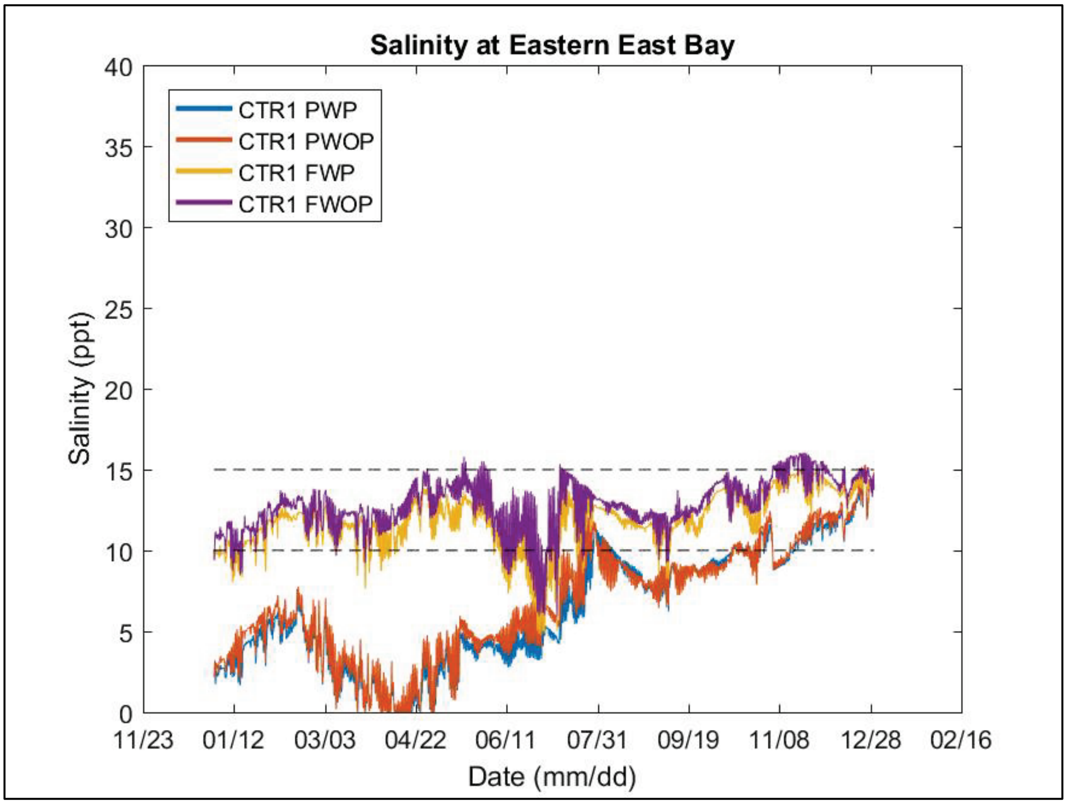


Figure 40. Maximum, mean, and minimum salinity at Eastern East Bay.

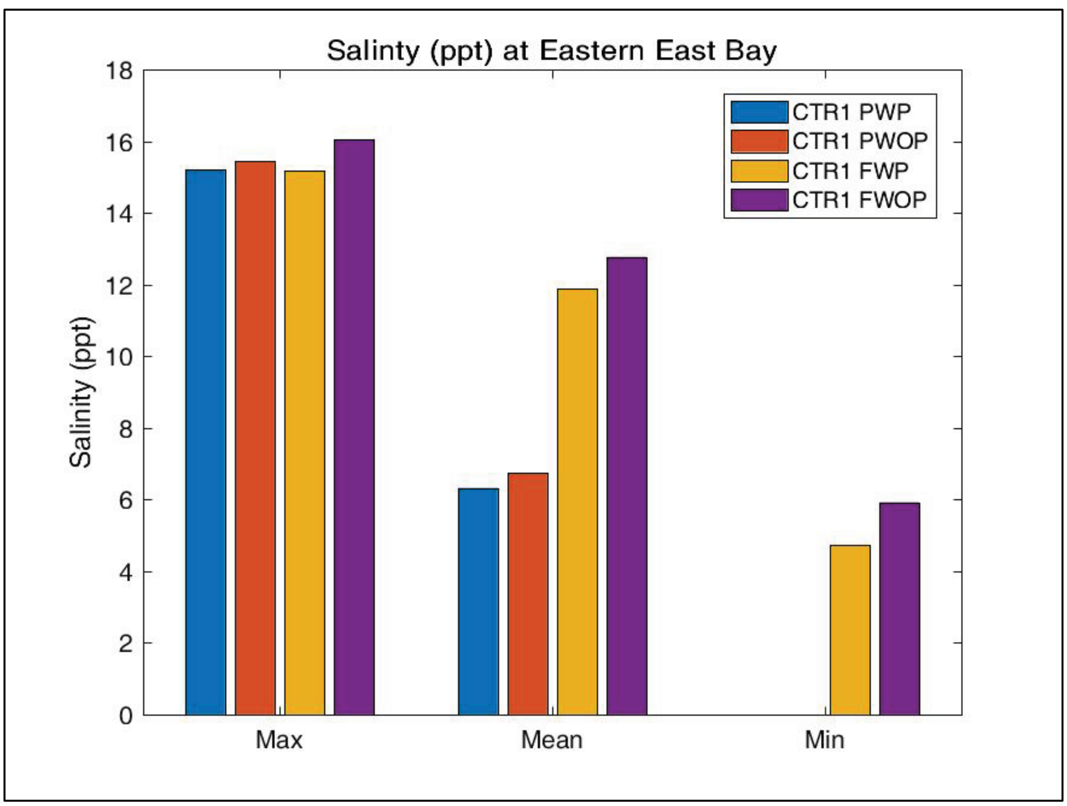


Figure 41. Percent-less-than salinity at Eastern East Bay.

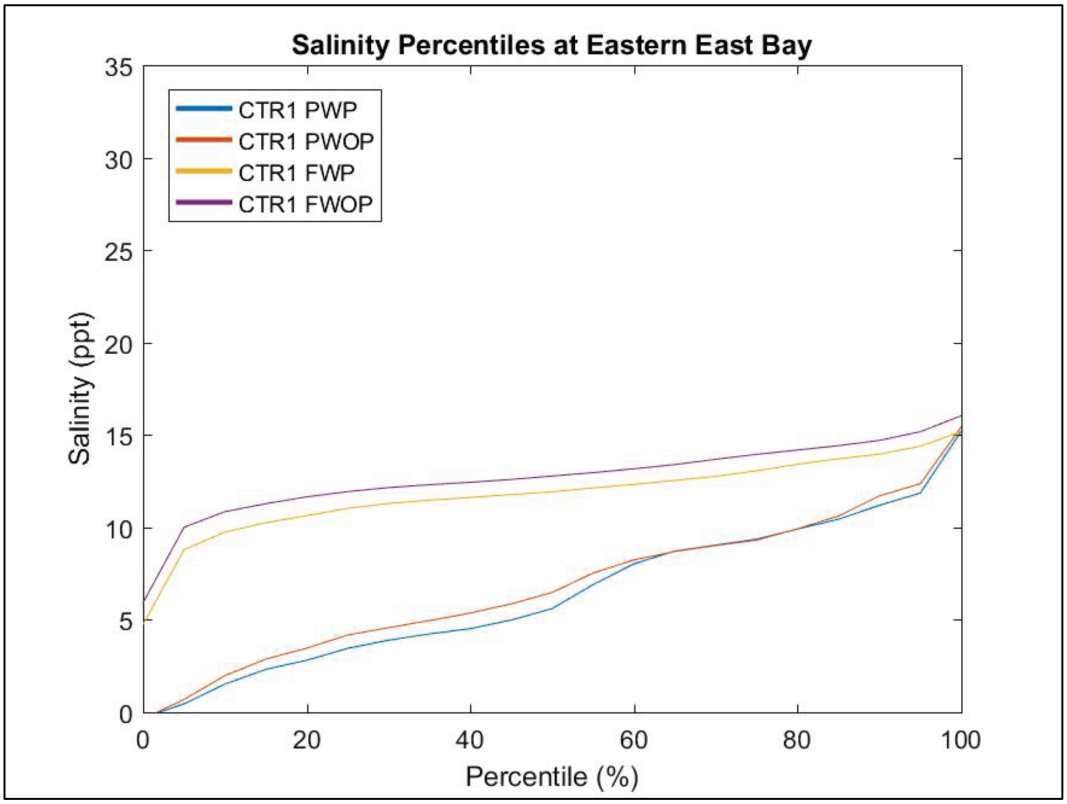


Figure 42. Vertical salinity profile at Eastern East Bay.

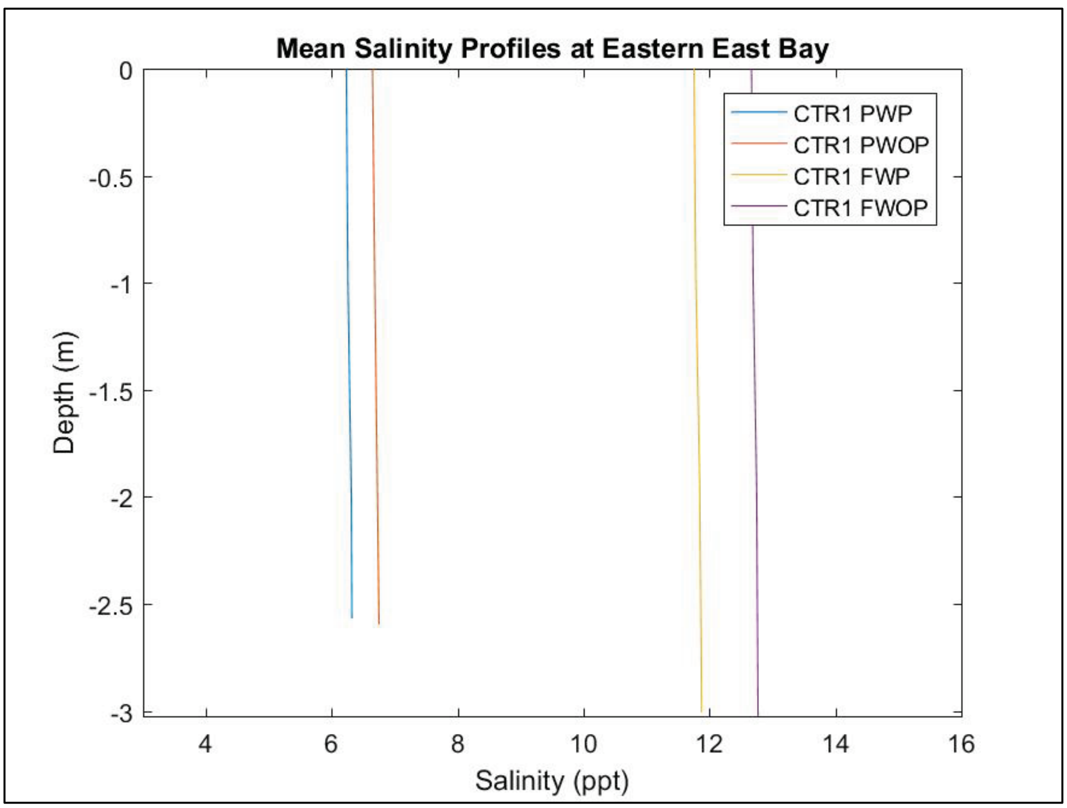


Figure 43. Salinity time history at Mid West Bay.

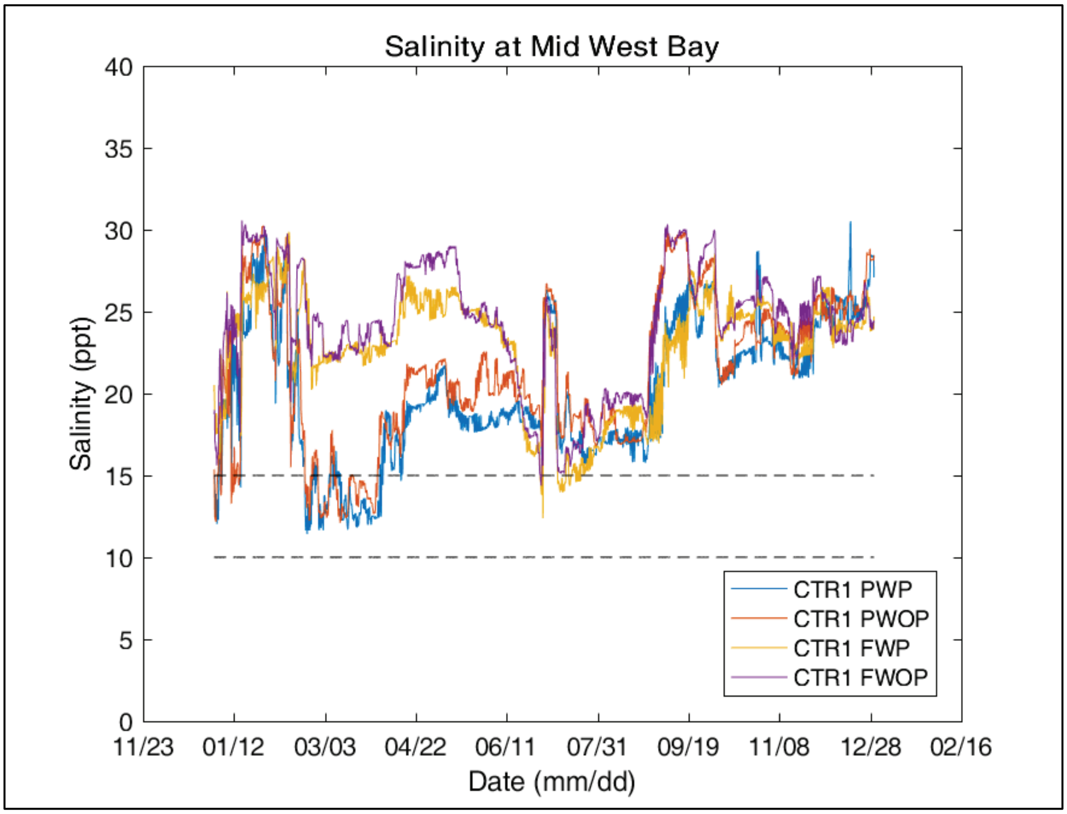


Figure 44. Maximum, mean, and minimum salinity at Mid West Bay.

Figure 45. Percent-less-than salinity at Mid West Bay.

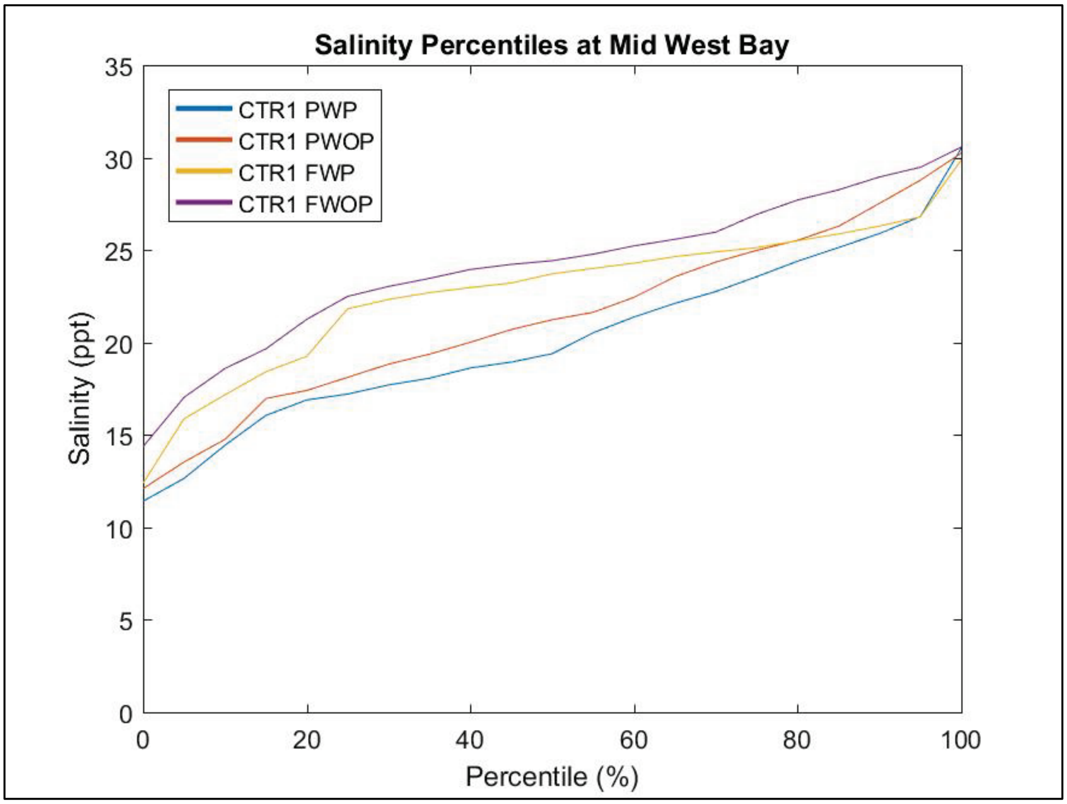
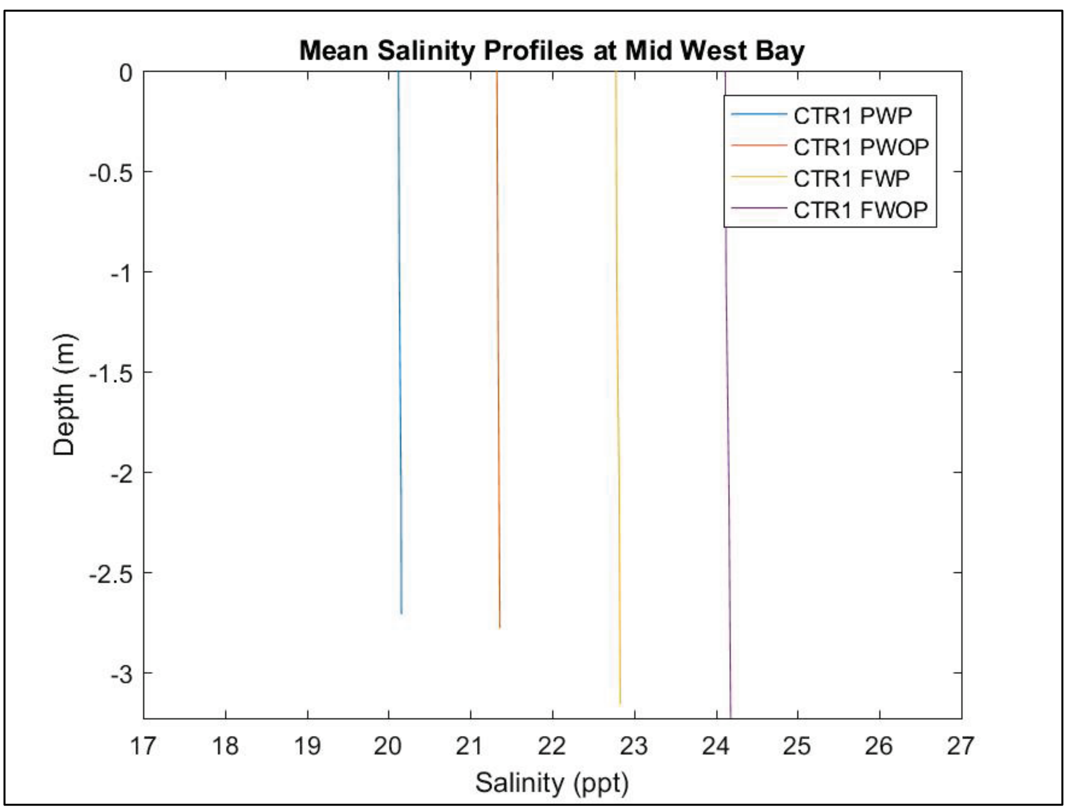


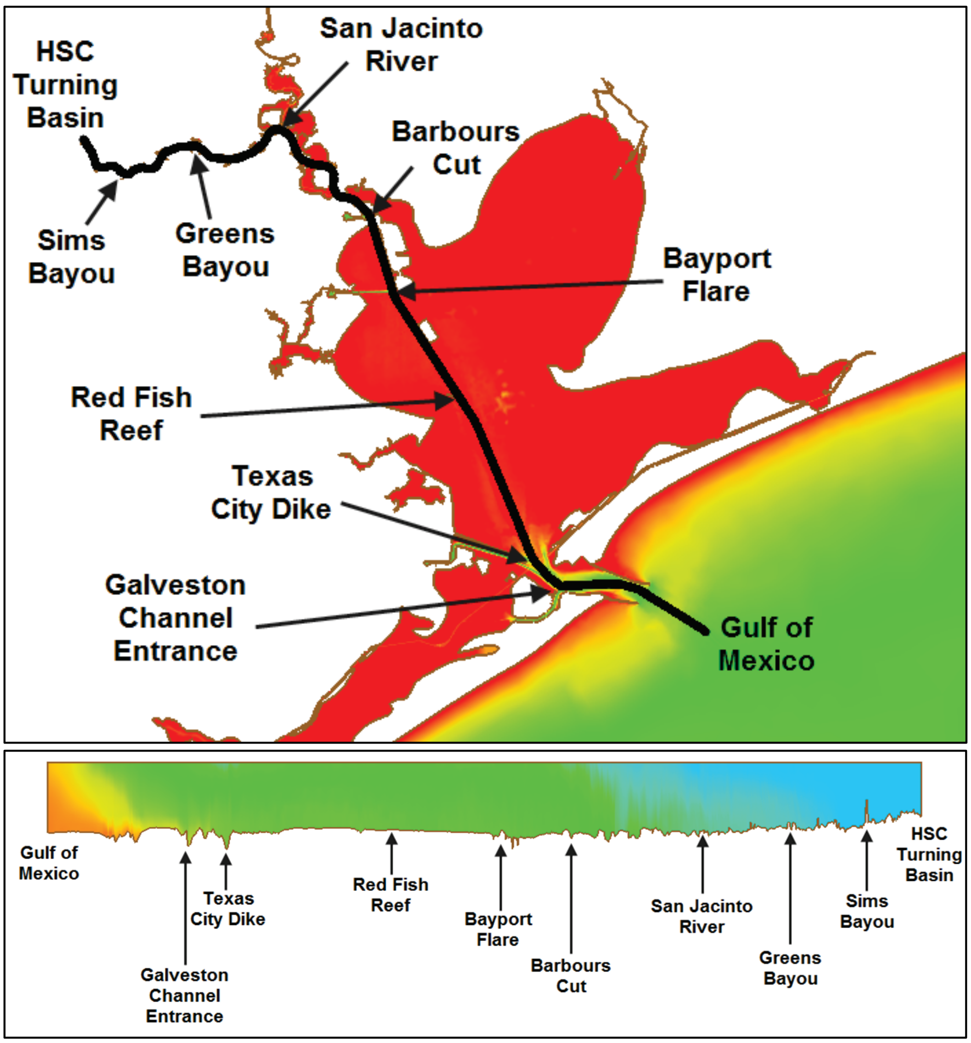
Figure 46. Vertical salinity profile at Mid West Bay.



3.4 Salinity HSC slice analysis

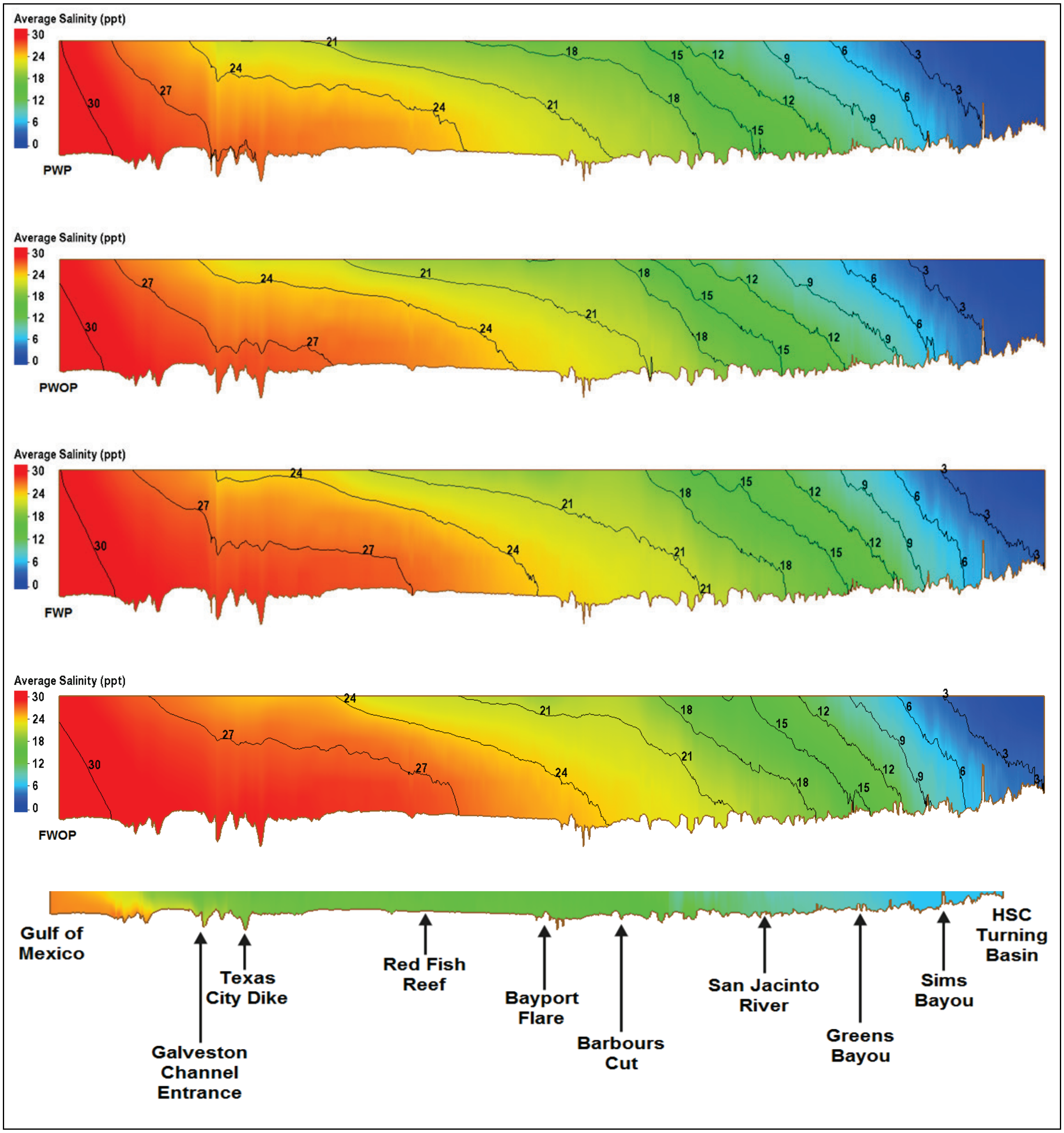
A slice along the center of the HSC from the Gulf of Mexico to the HSC Turning Basin allows for the comparison of the salinity wedge migration along the ship channel. These results are for mean salinity over the year-long analysis period. Figure 47 shows the location of key features along the HSC for reference. Figure 48 shows the mean salinity along the HSC for all four alternatives.

Figure 47. HSC slice analysis reference map.



The salinity is impacted by the structures across the HSC at Bolivar Roads. The with project mean salinity slice results show a sharp contour change at the structure location indicating that a sharp gradient occurs when the structure is in place. A much smoother salinity gradient is observed in the without project alternatives. The project impacts extend through the bay portion of the HSC up to the point where the San Jacinto River enters the HSC but begin to match the without project results in the upper-most portion of the HSC. The future condition salinity pushes farther up the HSC than the present condition as expected due to the increased water level and the reduction of freshwater flow in the future conditions.

Figure 48. HSC average salinity slice results.



3.5 Velocity magnitude point analysis

Time history of velocity over the year-long analysis period is difficult to view graphically. However, the maximum, average, and minimum velocity magnitude and percent-less-than velocity magnitude for both surface and bottom values at each location for the year-long analysis period are provided. For all plots of velocity magnitude, PWP is blue, PWOP is orange, FWP is yellow, and FWOP is purple.

The percent-less-than plots are provided to show how the velocity magnitude varies over the analysis period. The maximum velocity magnitude value is given at 100%, and the minimum value at 0%. The 50% velocity magnitude value indicates that the magnitude is less than this value for 50% of the analysis time and greater than this value for 50% of the time.

Figure 49 through Figure 72 show the point velocity magnitude analysis at the six selected locations. The results for the 23 locations are provided in Appendix C: Velocity Magnitude Point Analysis.

As with the salinity analysis, the velocity magnitudes for the with project condition do not vary greatly at locations in the bays. The velocity magnitudes do drop at most locations for both surface and bottom, but this reduction in the mean velocity magnitude is less than 0.1 meter per second (m/s) and typically more on the order 0f 0.05 m/s or less. Locations in West Bay and on the western perimeter of Galveston Bay show a slight increase in velocity magnitude for surface or bottom, but again, the change in the mean velocity magnitude is less than 0.1 m/s. The change in maximum velocity magnitude is often greater than that for the mean; however, the percent-less-than plots support that these large values are not experienced much during the analysis year (shown by the steep slope in the lines between 95% and 100%).

Figure 49. Bottom velocity magnitude percent-less-than for HSC at Morgan's point.

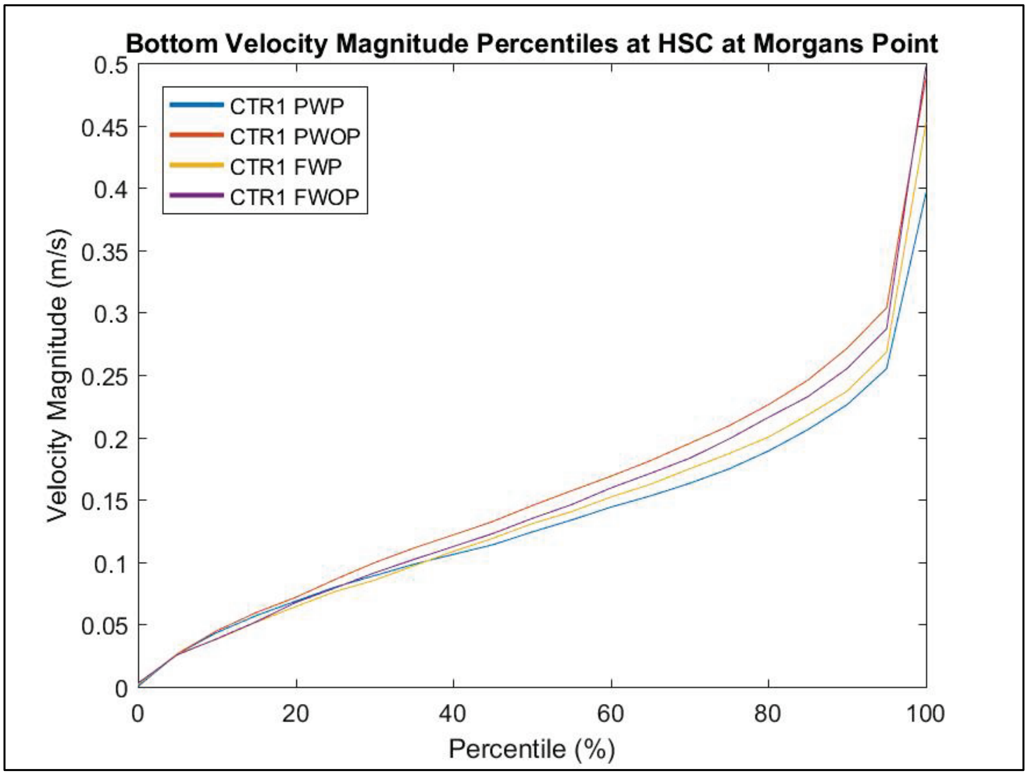


Figure 50. Bottom velocity magnitude maximum, mean, and minimum at HSC at Morgan's Point.

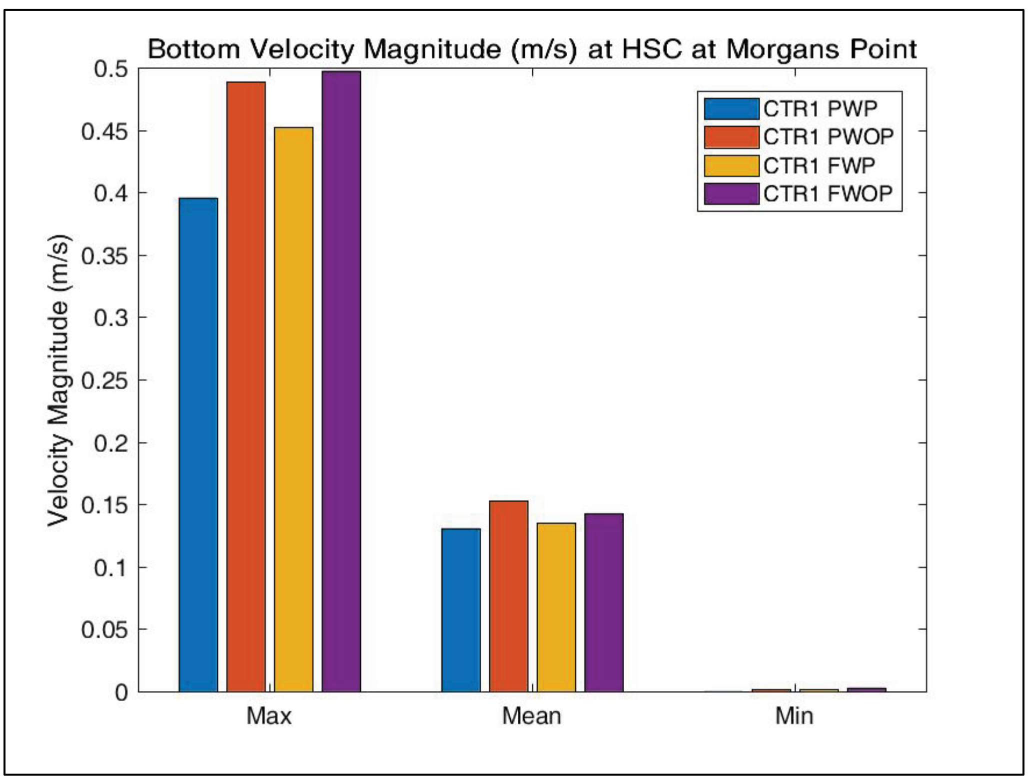


Figure 51. Surface velocity magnitude percent-less-than for HSC at Morgan's point.

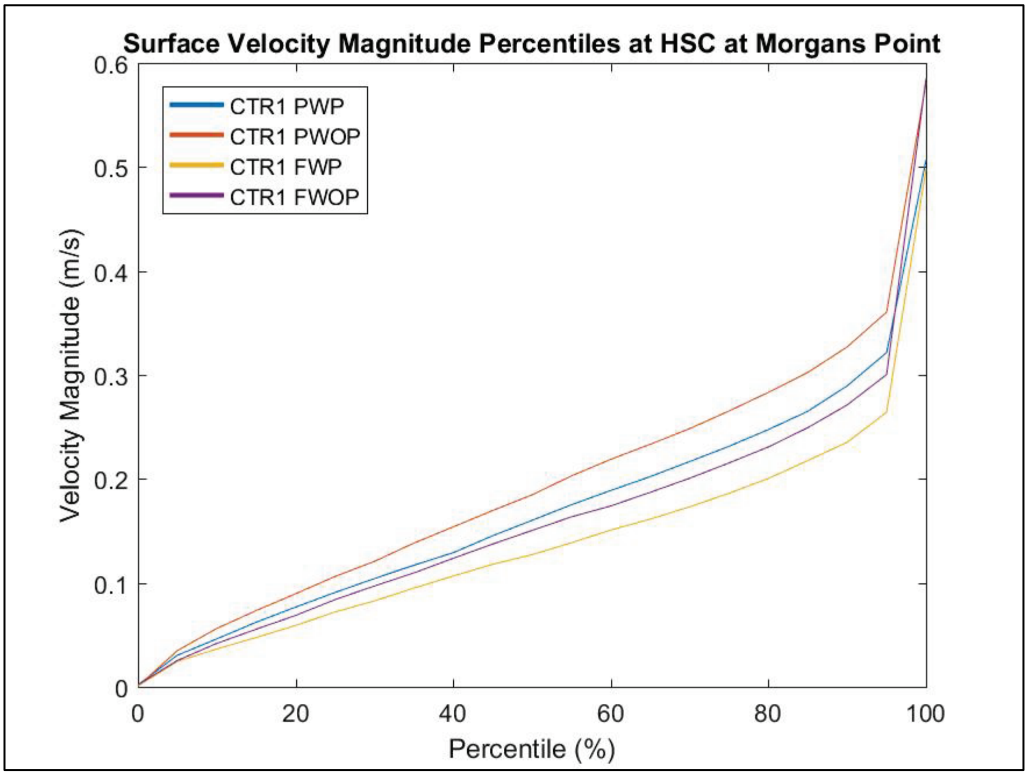


Figure 52. Surface velocity magnitude maximum, mean, and minimum at HSC at Morgan's Point.

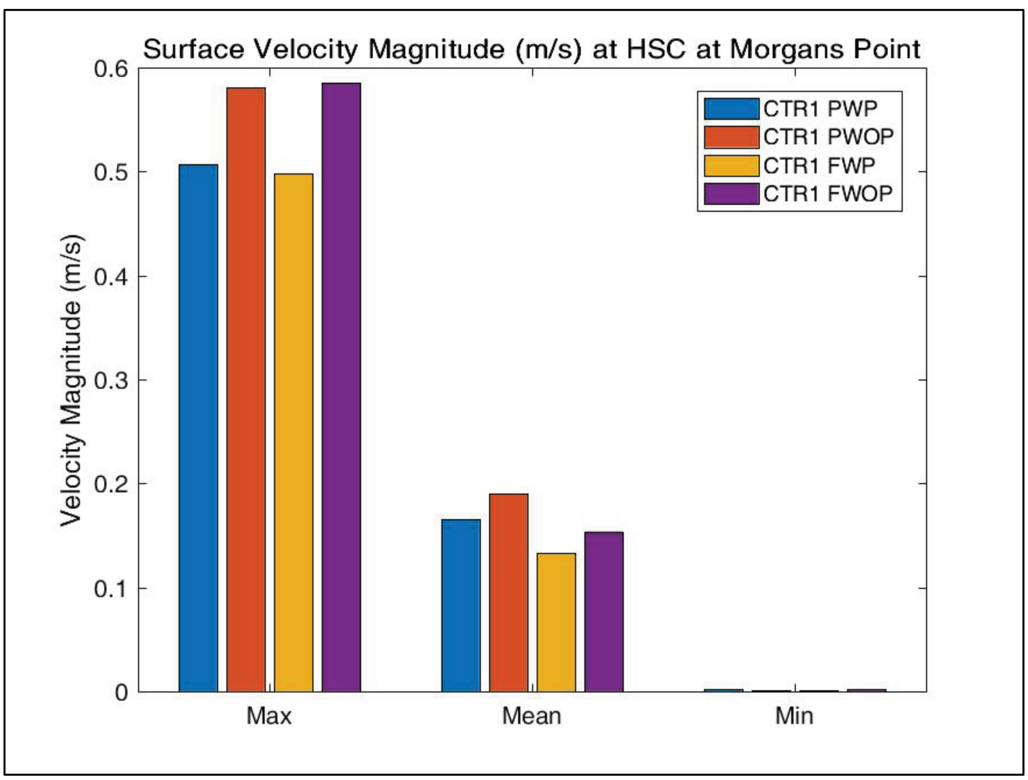


Figure 53. Bottom velocity magnitude percent-less-than for HSC at Lower Galveston Bay.

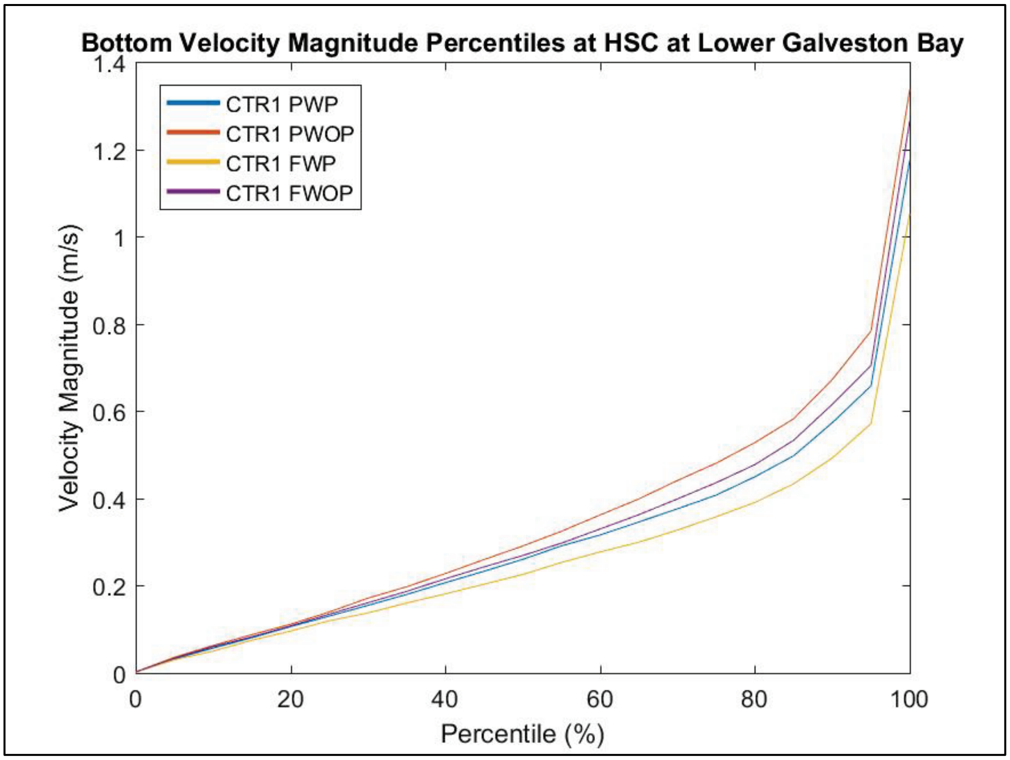


Figure 54. Bottom velocity magnitude maximum, mean, and minimum at HSC at Lower Galveston Bay.

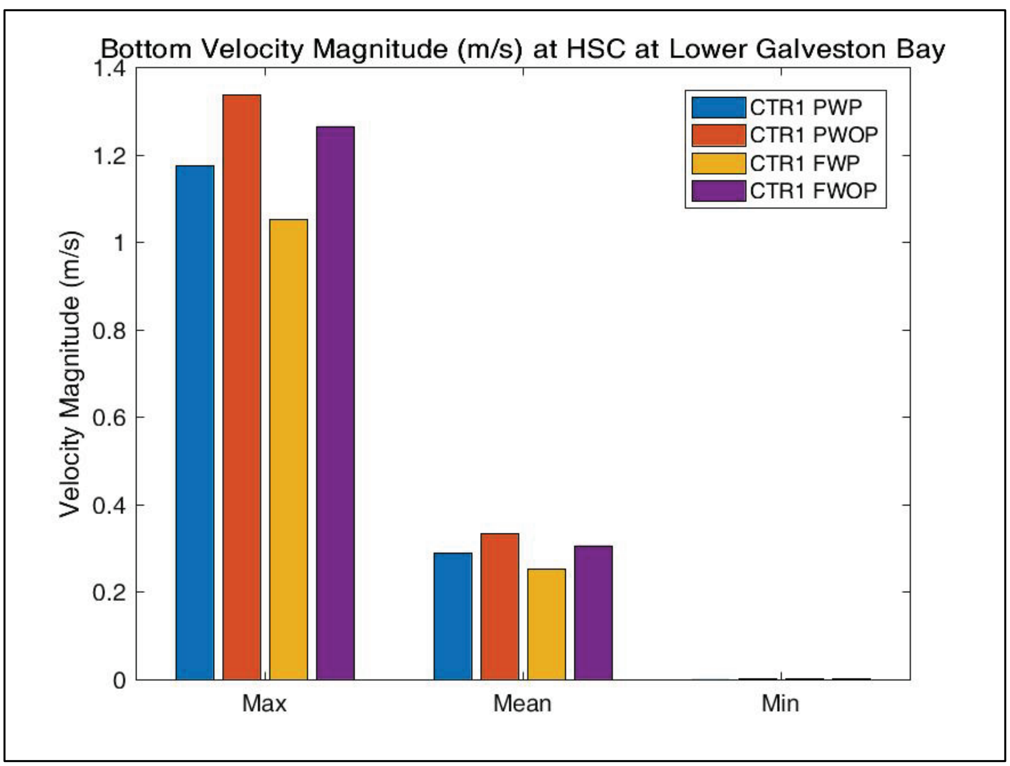


Figure 55. Surface velocity magnitude percent-less-than for HSC at Lower Galveston Bay.

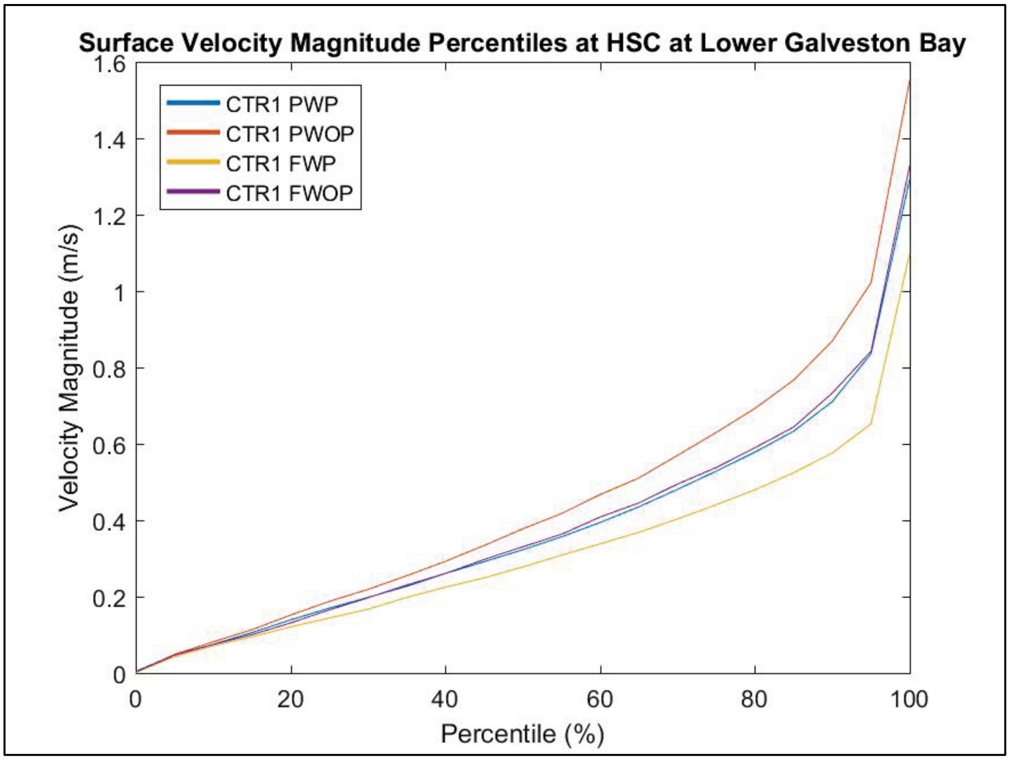


Figure 56. Surface velocity magnitude maximum, mean, and minimum at HSC at Lower Galveston Bay.

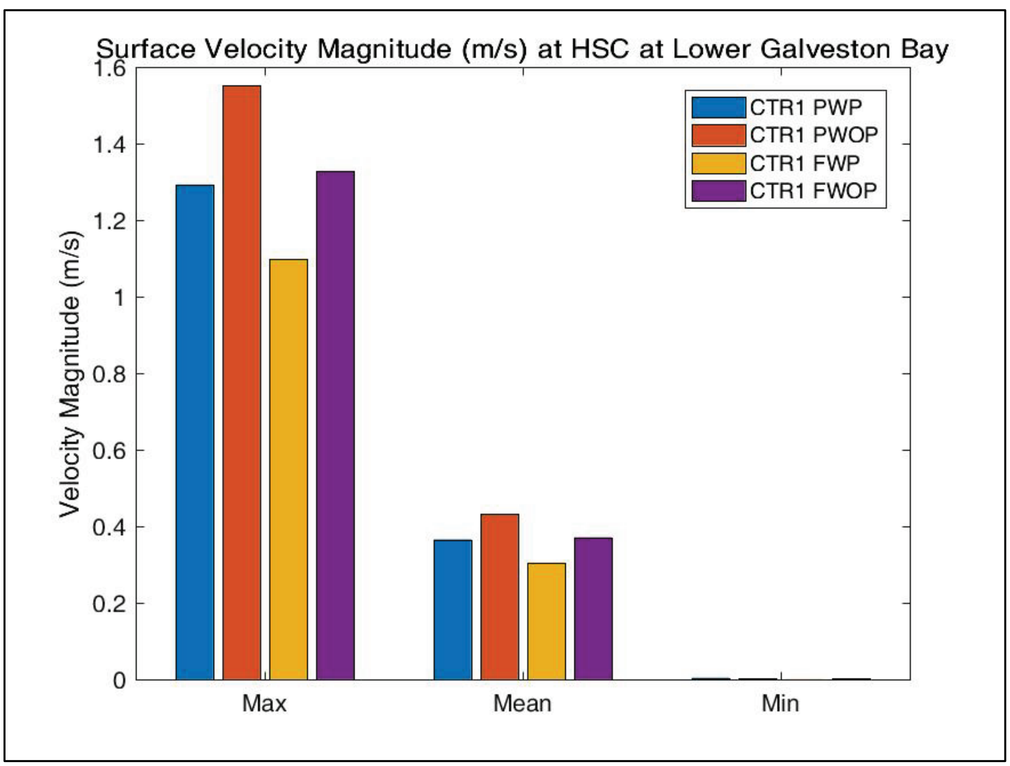


Figure 57. Bottom velocity magnitude percent-less-than for Upper Galveston Bay 2.

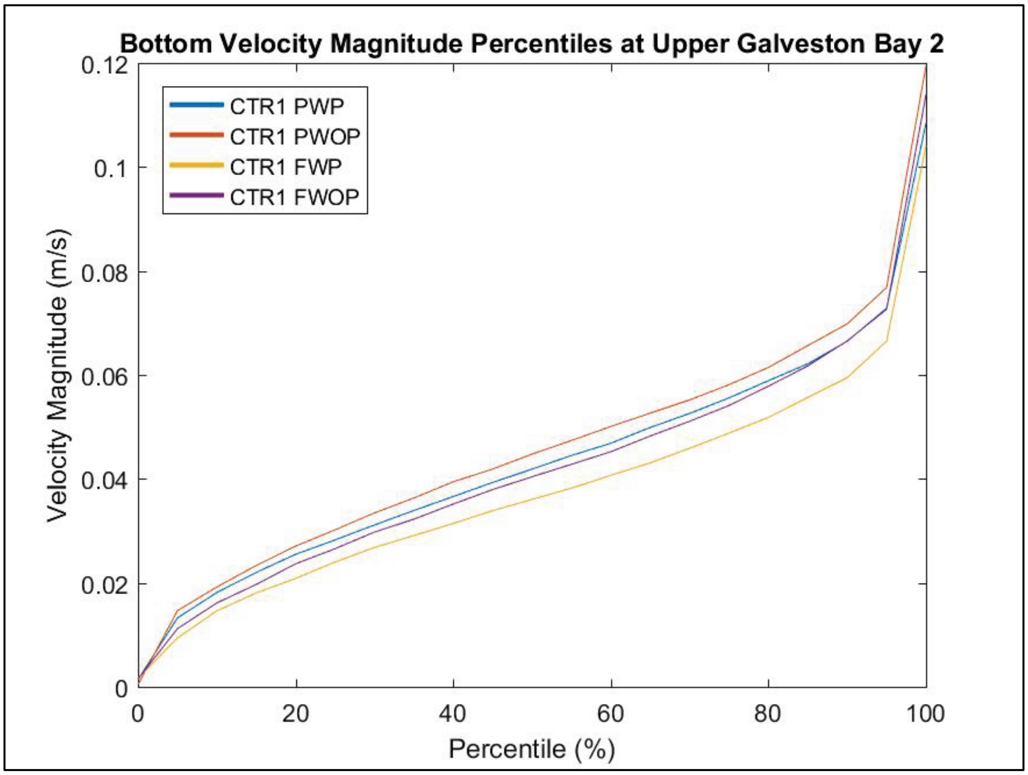


Figure 58. Bottom velocity magnitude maximum, mean, and minimum at Upper Galveston Bay 2.

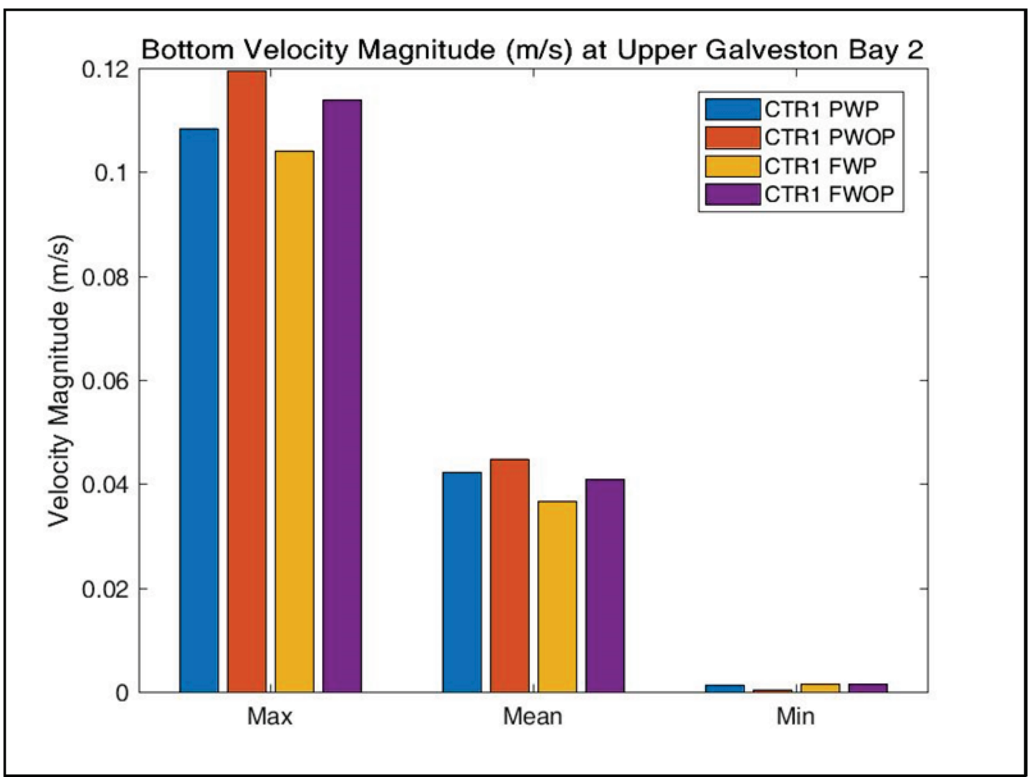


Figure 59. Surface velocity magnitude percent-less-than for Upper Galveston Bay 2.

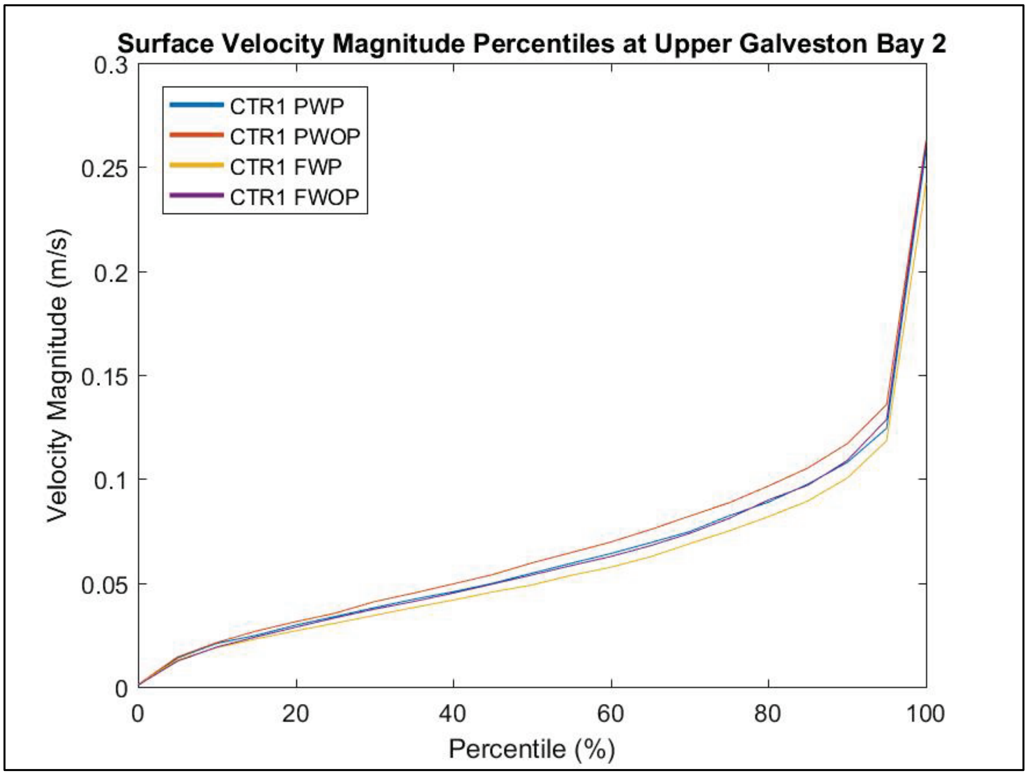


Figure 60. Surface velocity magnitude maximum, mean, and minimum at Upper Galveston Bay 2.

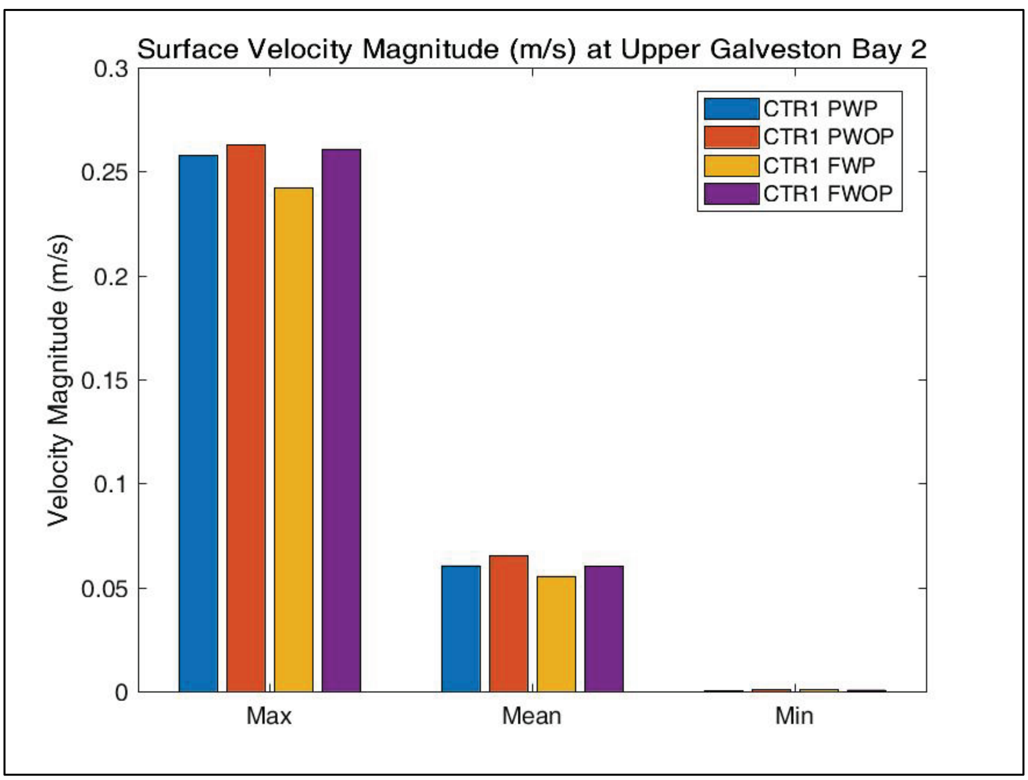


Figure 61. Bottom velocity magnitude percent-less-than for Upper Trinity Bay.

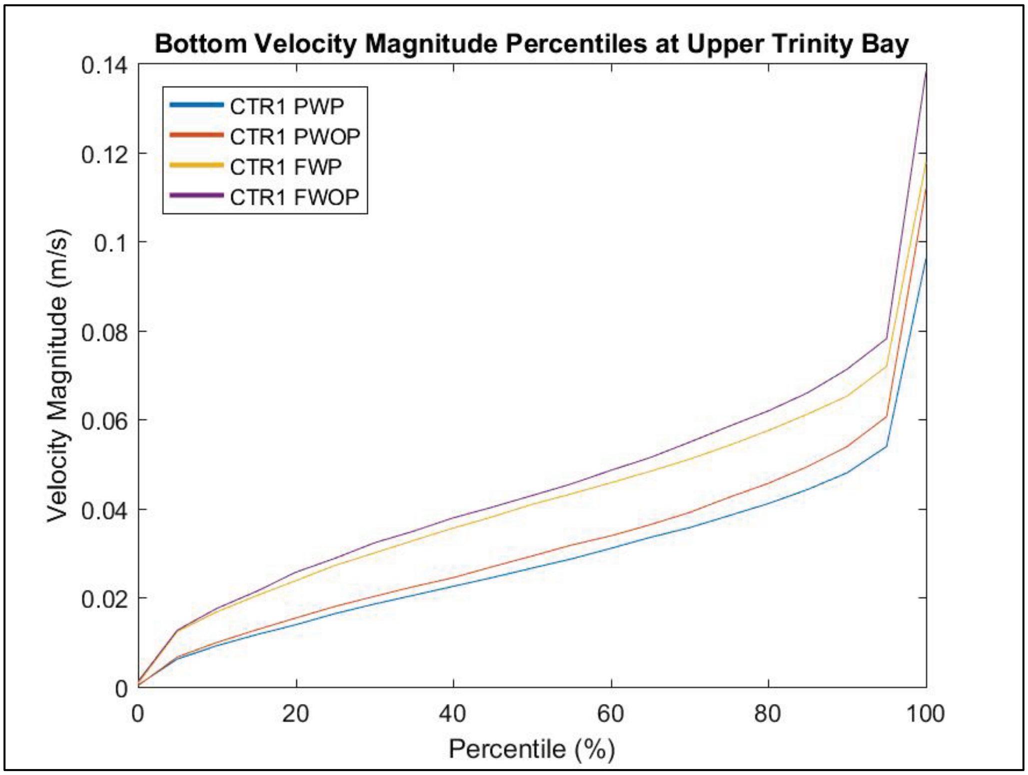


Figure 62. Bottom velocity magnitude maximum, mean, and minimum at Upper Trinity Bay.

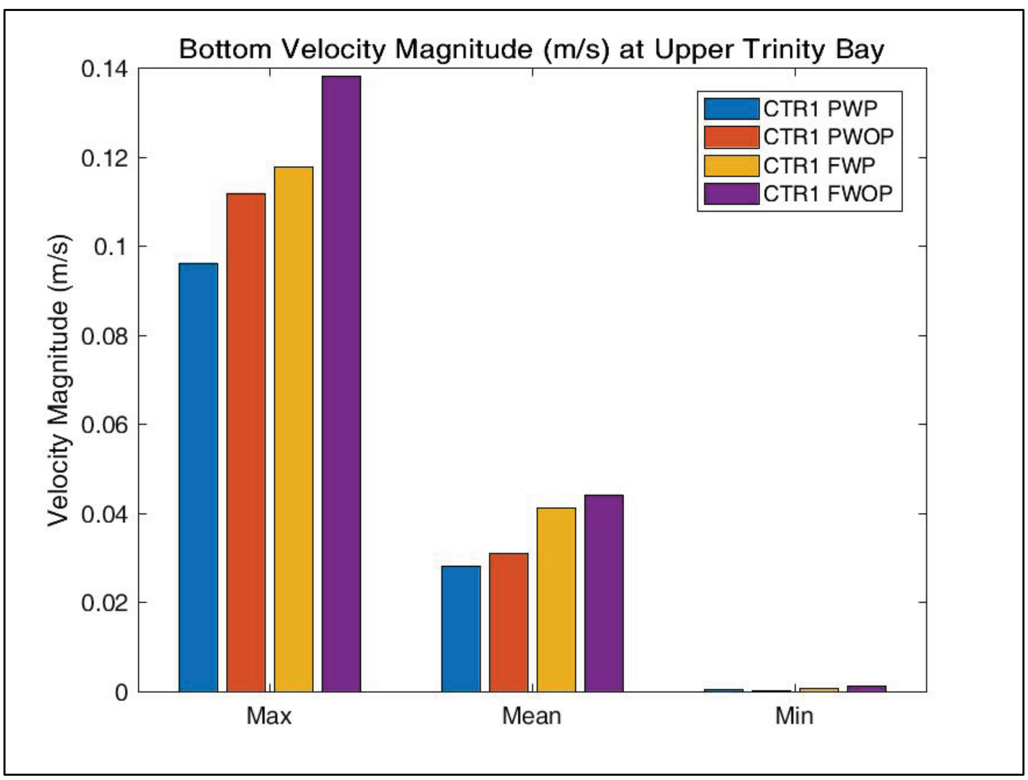


Figure 63. Surface velocity magnitude percent-less-than for Upper Trinity Bay.

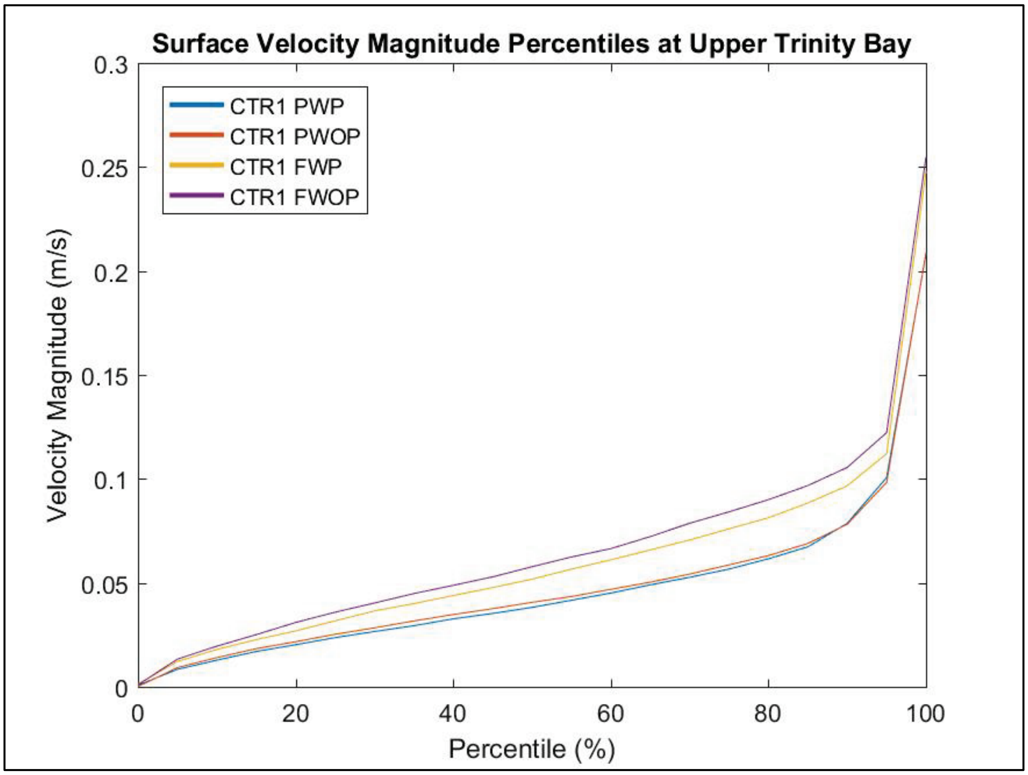


Figure 64. Surface velocity magnitude maximum, mean, and minimum at Upper Trinity Bay.

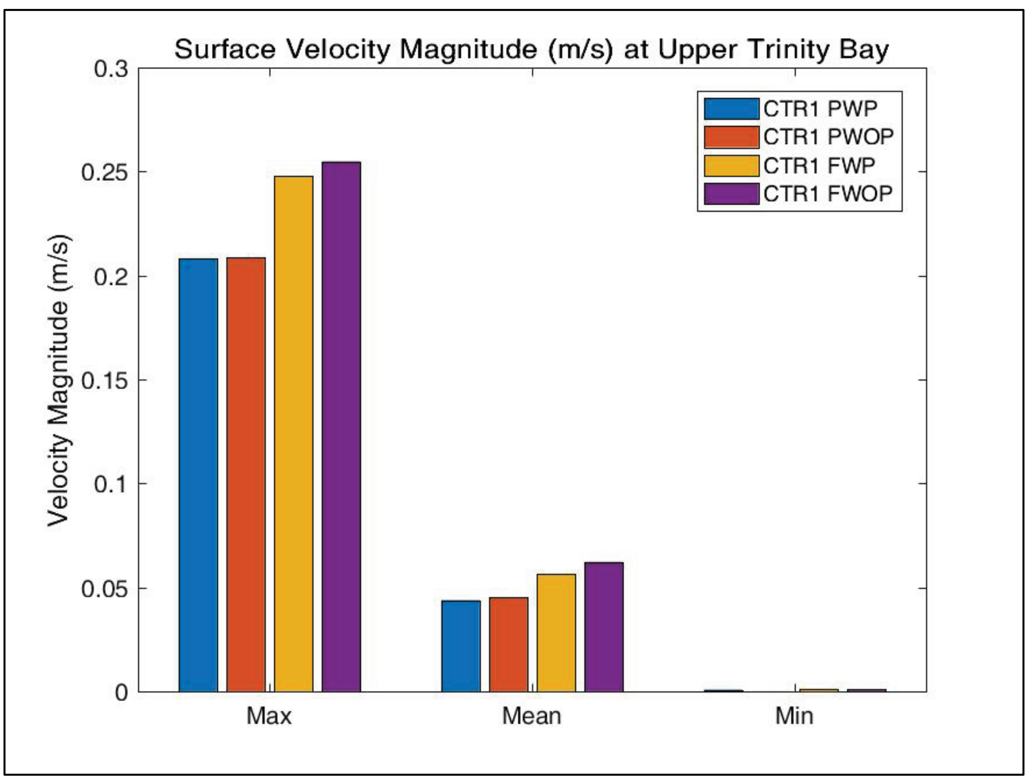


Figure 65. Bottom velocity magnitude percent-less-than for Eastern East Bay.

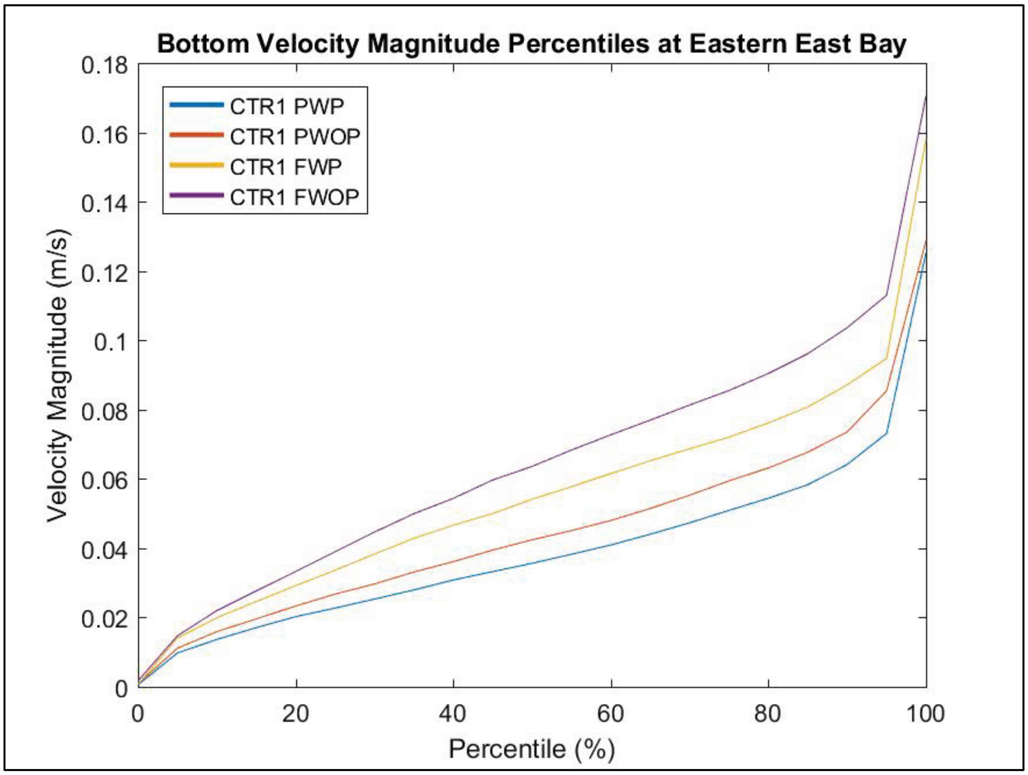


Figure 66. Bottom velocity magnitude maximum, mean, and minimum at Eastern East Bay.

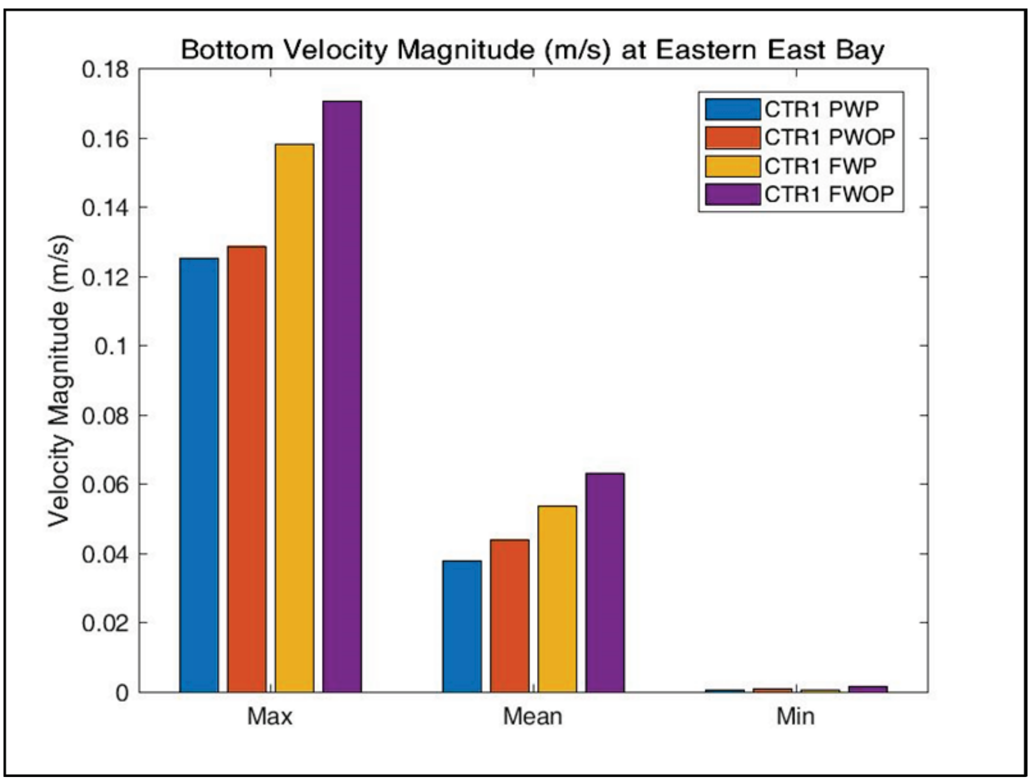


Figure 67. Surface velocity magnitude percent-less-than for Eastern East Bay.

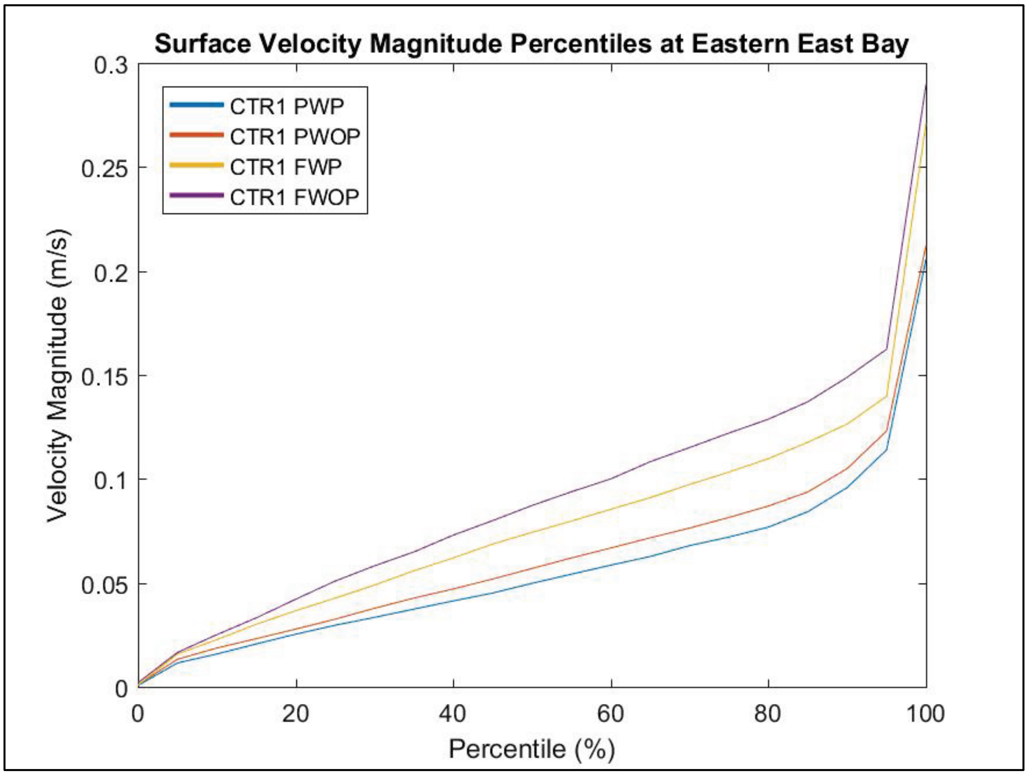


Figure 68. Surface velocity magnitude maximum, mean, and minimum at Eastern East Bay.

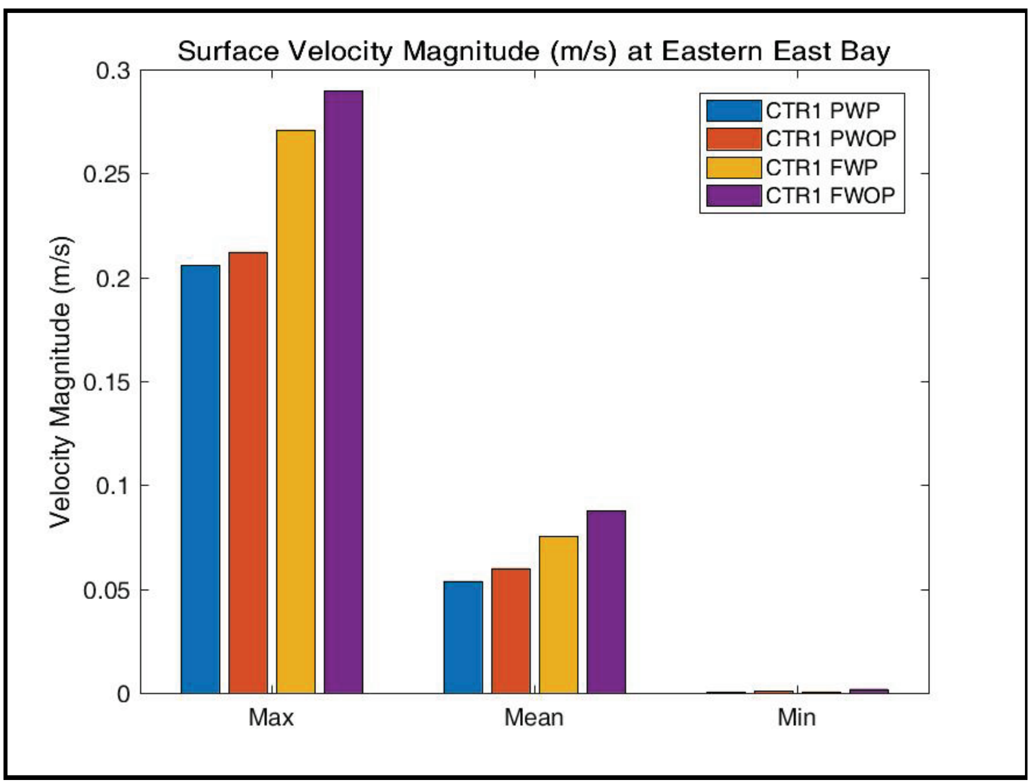


Figure 69. Bottom velocity magnitude percent-less-than for Mid West Bay.

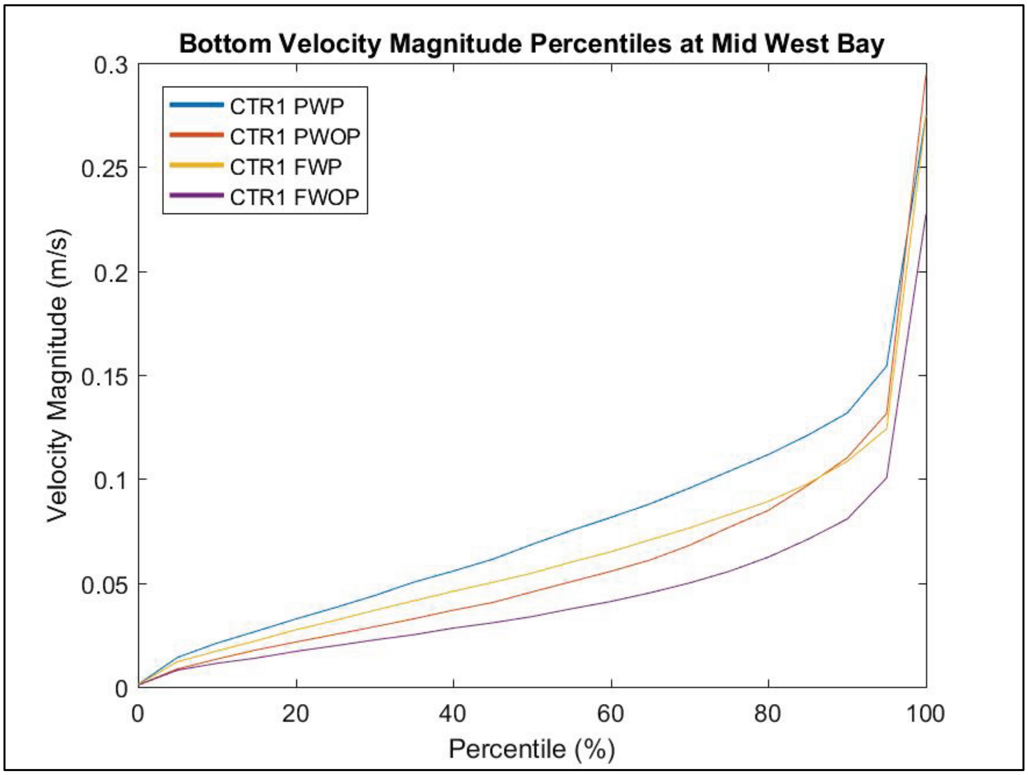


Figure 70. Bottom velocity magnitude maximum, mean, and minimum at Mid West Bay.

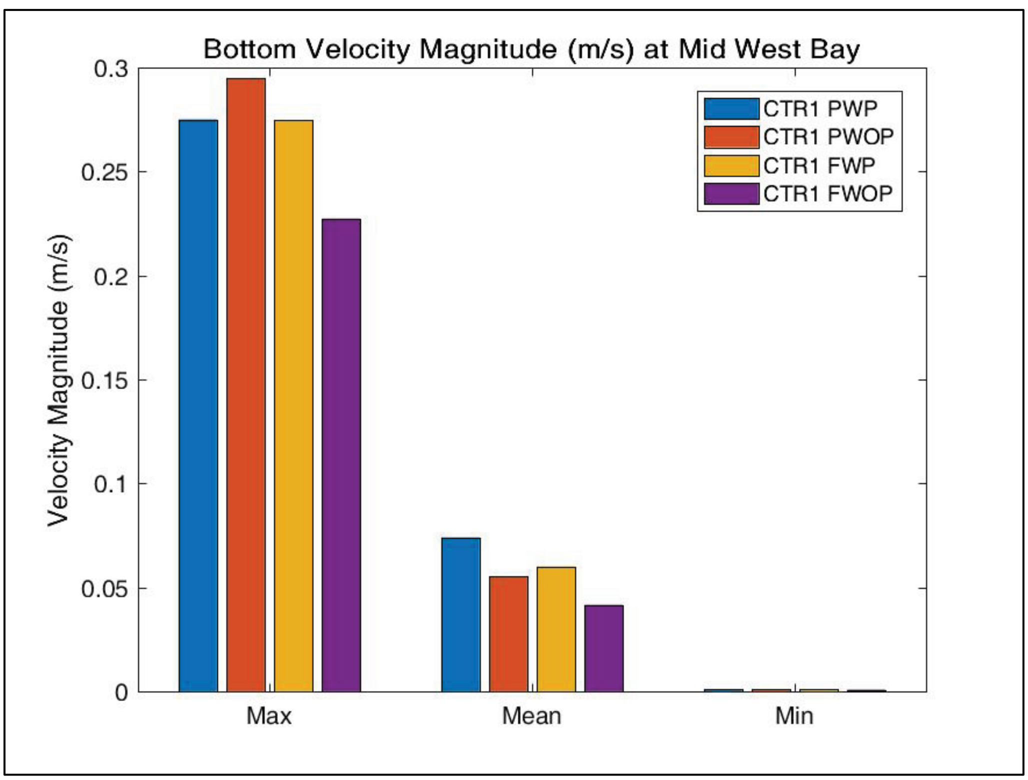


Figure 71. Surface velocity magnitude percent-less-than for Mid West Bay.

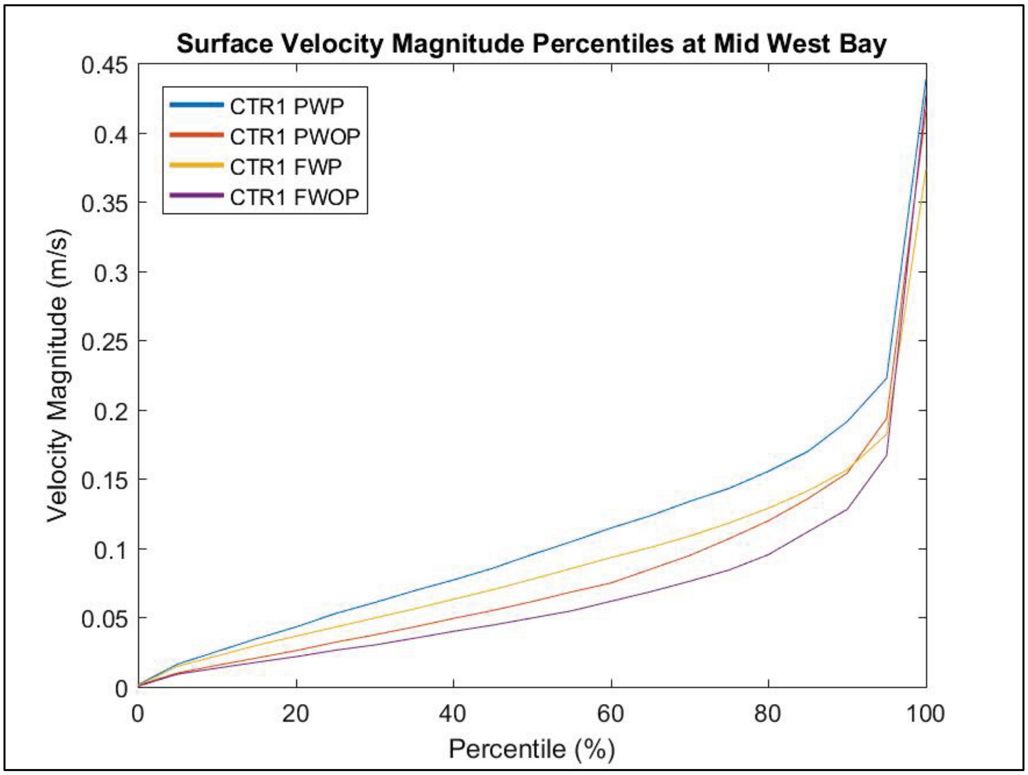
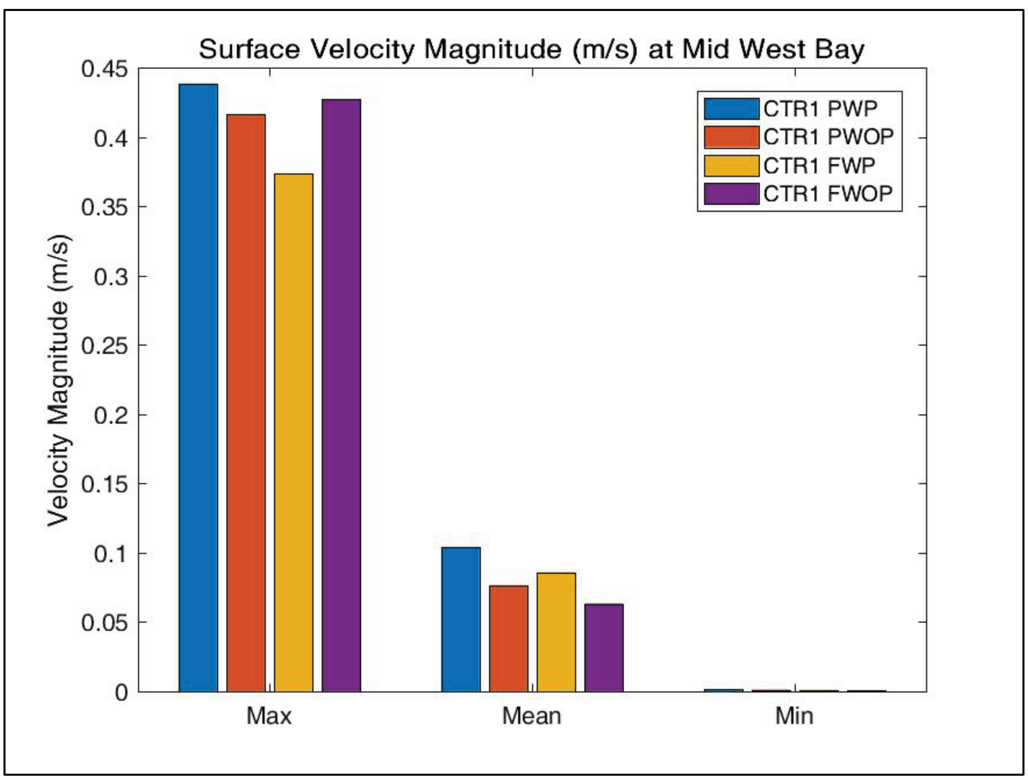


Figure 72. Surface velocity magnitude maximum, mean, and minimum at Mid West Bay.



3.6 Residual velocity analysis

Residual velocity is the velocity that remains when the tidally varying velocity has been averaged out. This vector defines the predominant flow direction and speed of a particle of water. Although the tide will cause the particle to move back and forth, there is generally a flow direction that is a little stronger than the other, allowing for a particle to migrate along a certain path. Typically, in a tidally driven environment with a deep navigation channel such as the HSC, the predominant flow direction is upstream along the channel bottom and downstream along the channel surface. The surface and bottom velocity comparisons for with project and without project are shown in Figure 73 through Figure 76. The red vectors indicate the direction of the with project residual velocity and the black vectors, the without project. The contours represent the difference in the velocity magnitudes — with project minus without project such that positive values (reds/yellows) indicate the with project residual velocity magnitude is greater and negative values (blues) indicate that the without project residual velocity magnitude is greater. Residual velocity comparisons for the structure locations — Bolivar Roads, Clear Creek, Dickinson Bayou, and Offatts Bayou — are provided in Appendix D: Residual Velocity at Structure Locations.

The comparisons show that the residual vector directions are very similar for with and without project alternatives. There are locations where they vary, especially in the vicinity of the TSP structures, but the general flow patterns are maintained. The area of the most variation is at the HSC entrance area where the primary structures are placed. The restriction of the tidal exchange forces the flows to take alternative pathways causing changes to flow patterns in the Galveston Channel and eastern West Bay, including Offatts Bayou, which is also impacted by a storm surge protection structure. Differences between without project and with project residual velocities are observed into the Gulf of Mexico beyond the jetties. However, the change in the residual velocity magnitudes are less than 0.05 m/s in Trinity Bay and Galveston Bay. The velocity magnitudes and vectors also show variation along the western area of Galveston Bay, which is explained by the surge protection structures across Dickinson Bayou and Clear Creek, although these difference are on the order of 0.01 m/s or less.

Given the small change in the residual velocity magnitude and direction in Trinity Bay between with and without project alternatives for both future and present conditions, the residence time of a particle in Trinity Bay will likely be impacted very little. However, once that particle moves into lower Galveston Bay and near the structure location, its movement will be impacted more due to the velocity direction and magnitude changes that occur immediately around the structures in the with project condition. If a particle becomes trapped in an eddy, it can remain in the system for an unknown length of time (see Appendix D).

Figure 73. Surface average residual velocity comparison for present conditions. (red vectors – with project; black vectors – without project).

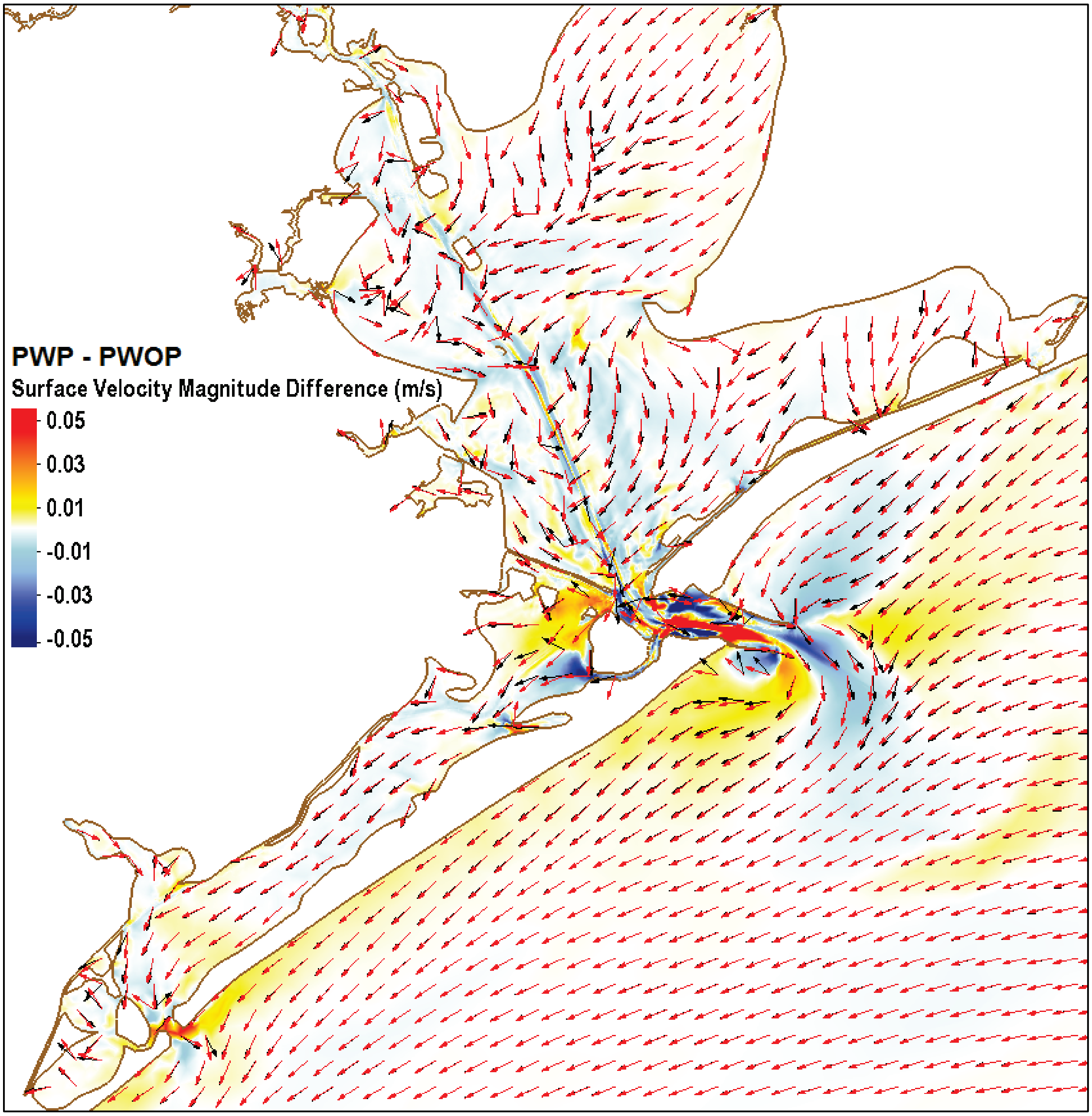


Figure 74. Bottom average residual velocity comparison for present conditions.
(red vectors – with project; black vectors – without project).

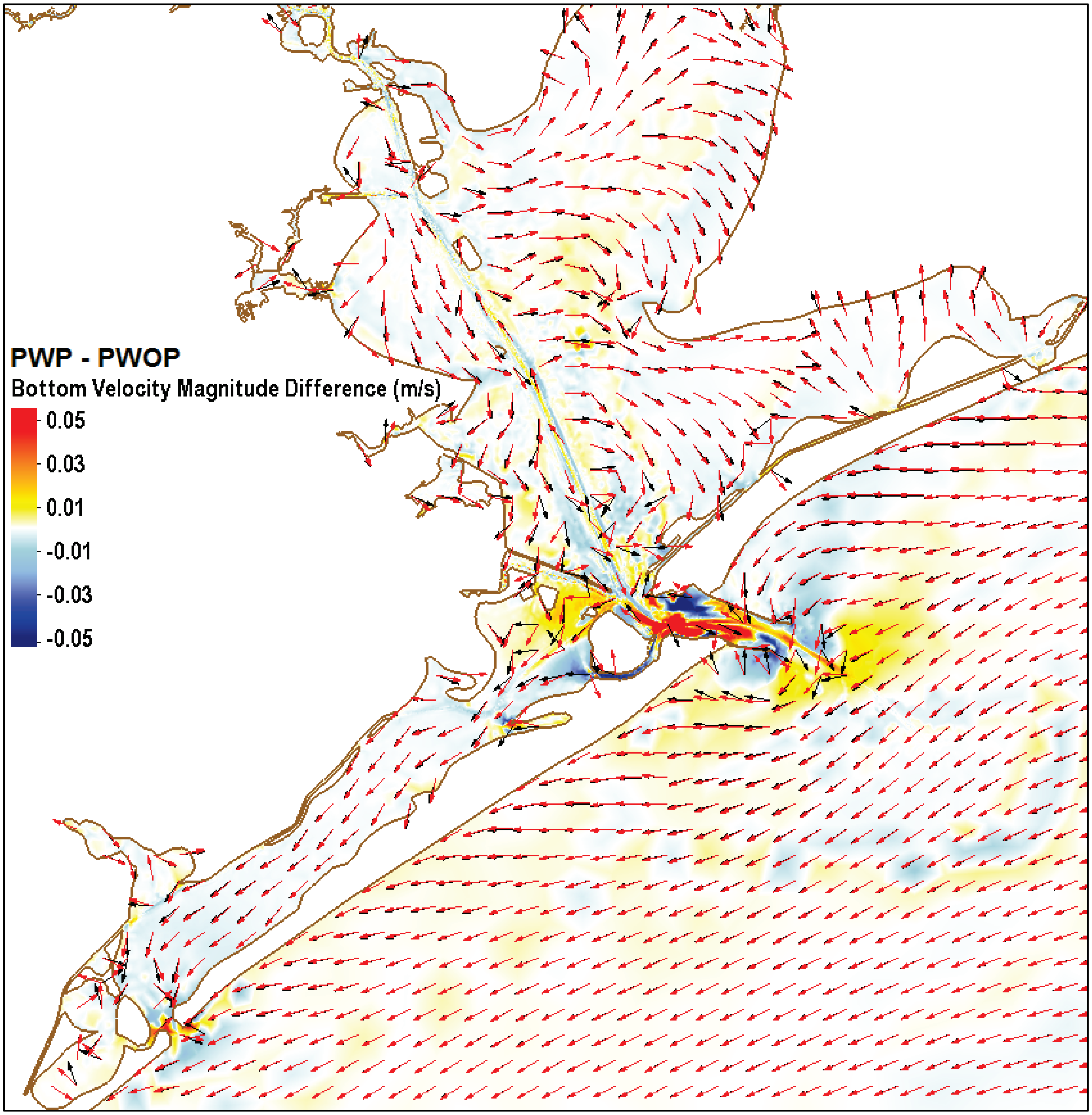


Figure 75. Surface average residual velocity comparison for future conditions. (red vectors – with project; black vectors – without project).

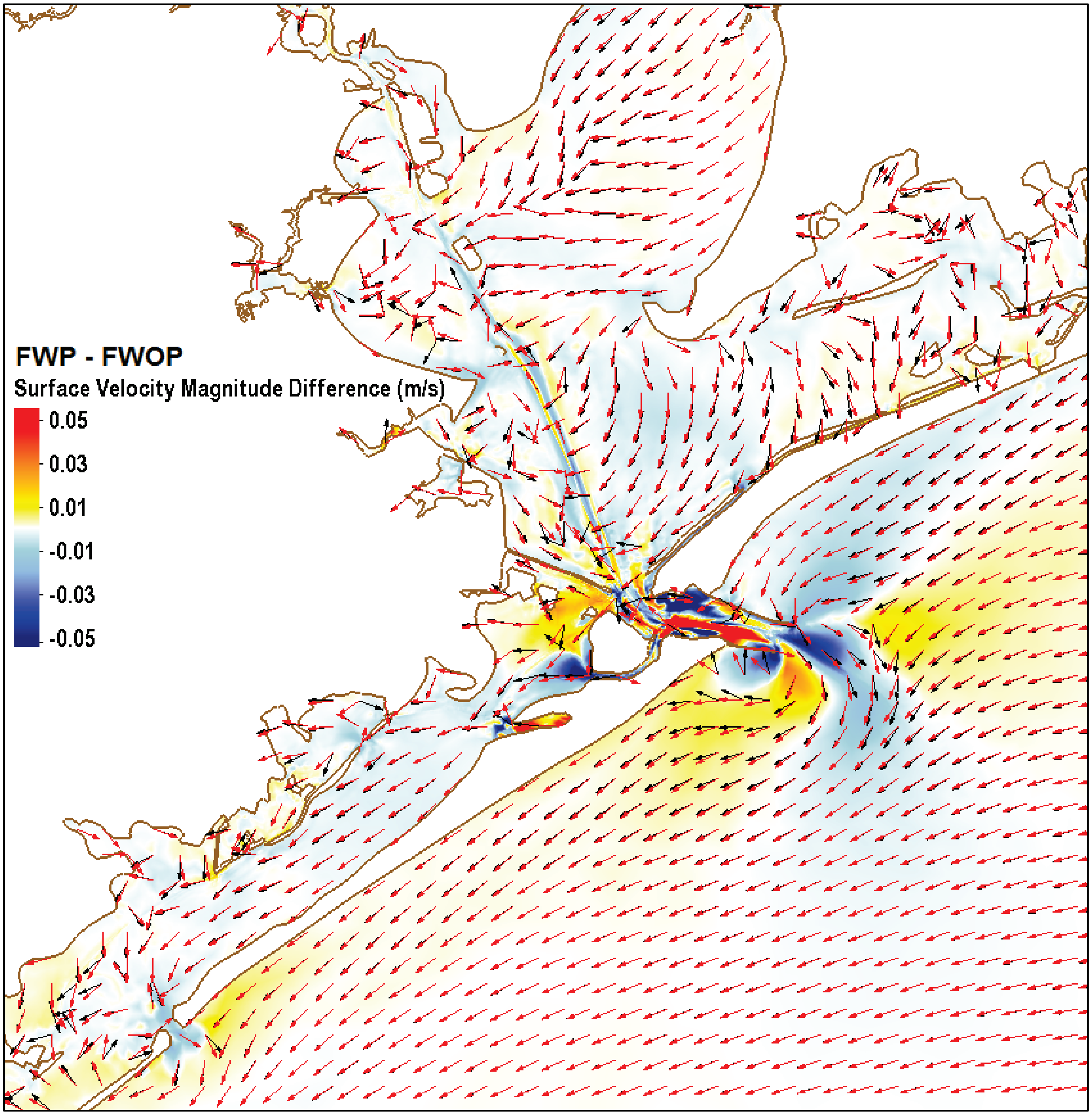
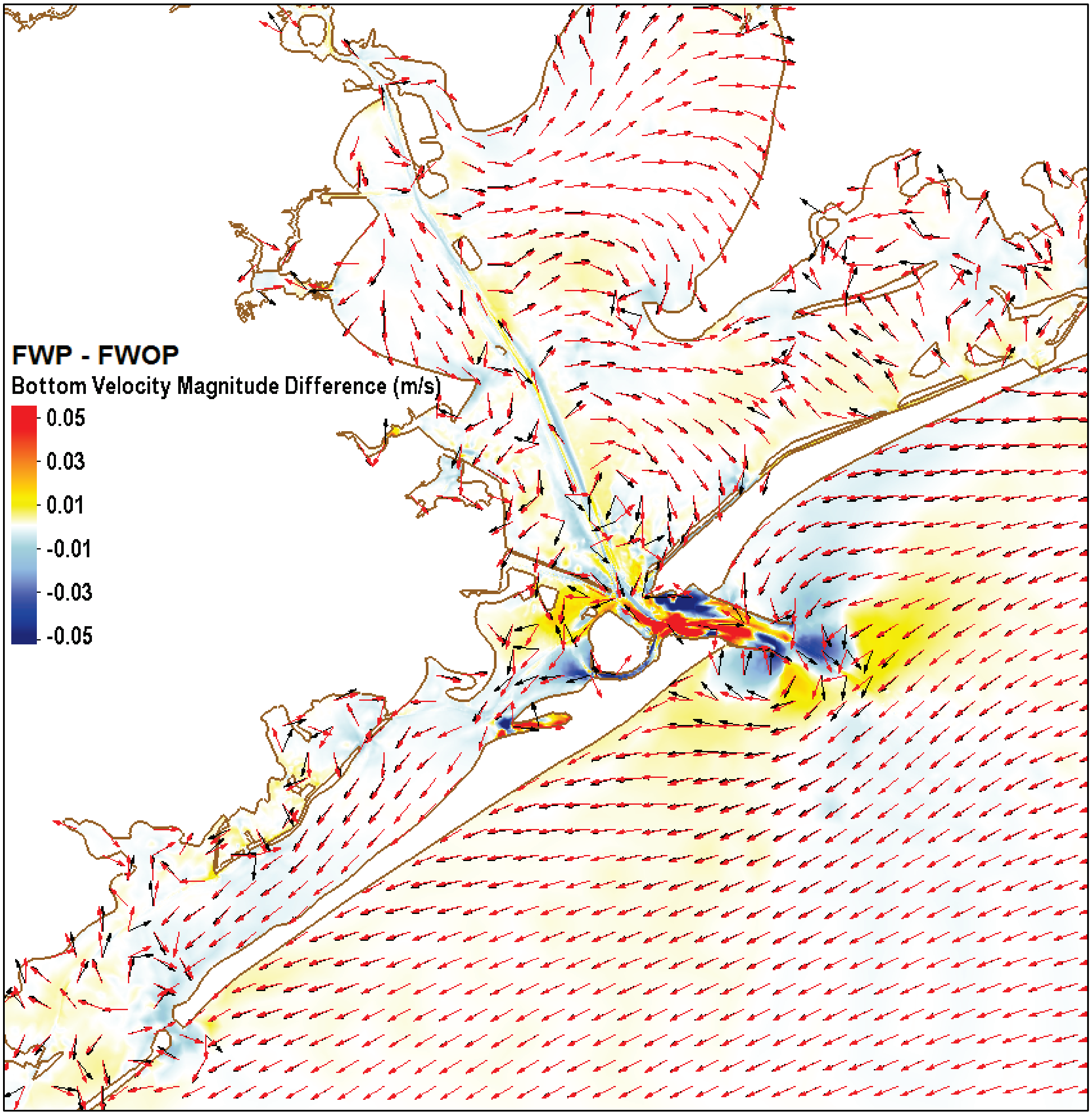


Figure 76. Bottom average residual velocity comparison for future conditions. (red vectors – with project; black vectors – without project).



3.7 Flushing analysis

To determine how the system flushes, which is tied directly to the tidal prism, a freshwater fraction comparison and a tracer analysis were performed on several areas of the model domain. The change in the salinity in the bays due to the project conditions and the impact of the project conditions on the ability of a particle to exit the area are critical to maintaining adequate environmental habitat.

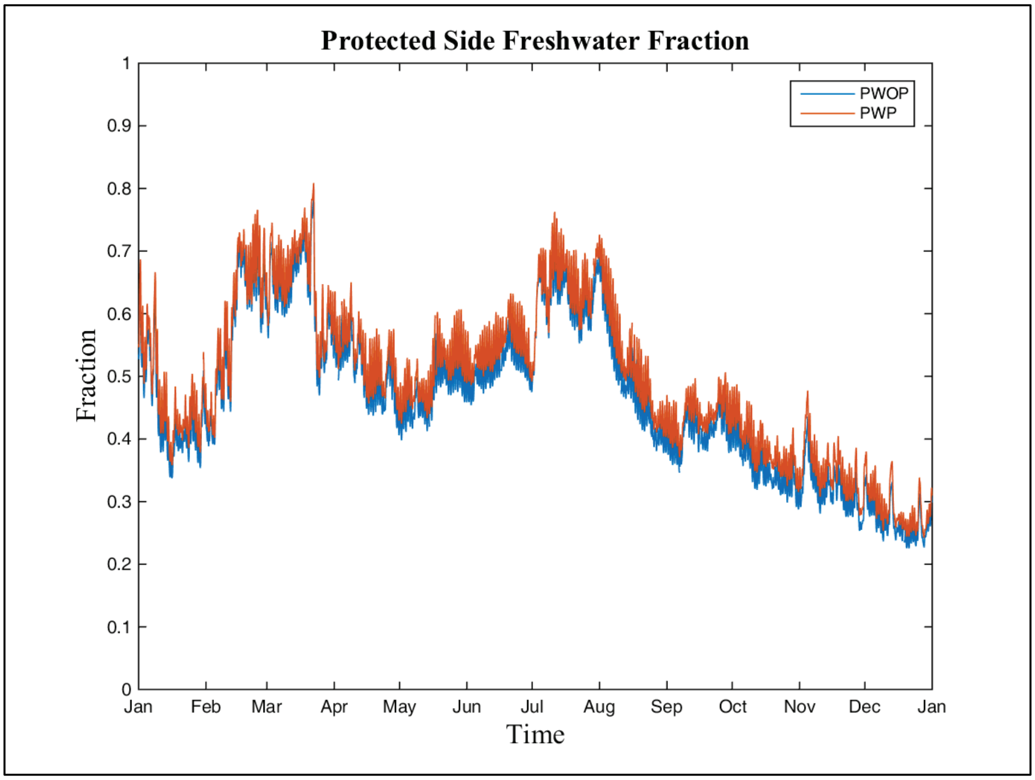
3.7.1 Freshwater fraction

The freshwater fraction for the entire bay portion of the model as well as for the various bays (Trinity, East, and West) was calculated based on the equation in Dyer (1973). As the salt intrudes into a bay, the freshwater fraction will decrease. As more freshwater enters a bay, the freshwater fraction will increase. The present conditions (2035) are used for these analyses. Fractions of 1.0 indicate completely fresh, and fractions of 0.0 indicate ocean salinity. This analysis is performed on all of the 3D mesh nodes, so variations from surface to bottom are included in the overall fraction computation.

The initial analysis computes the impact of the Bolivar Roads structure on the salinity on the inland or protected side of the structures, including Trinity Bay, Galveston Bay, East Bay, West Bay, and the HSC to the main turning basin (i.e., the red area in Figure 77). Figure 78 shows the freshwater fraction for the red portion of the domain over the year-long analysis period (present conditions) for without project (blue) and with project (orange).

Figure 77. Freshwater fraction analysis domain (red area).

Figure 78. Freshwater fraction for protected side of the Bolivar Roads structure.



The individual bay analysis computes the impact of the Bolivar Roads structure on the salinity in certain areas of the domain, particularly Trinity Bay (blue), East Bay (yellow) and West Bay (green) as shown in Figure 79. Figure 80 through Figure 82 provide the freshwater fraction for each bay area of the domain over the year-long analysis period (present conditions) for without project (blue) and with project (orange).

Trinity Bay is very fresh over most of the simulation period due to large freshwater inflows from the Trinity River. The fall/winter period shows more salt in this area as the freshwater flows reduce and higher saline water is able to work its way into the system. The difference between the without and with project fraction is extremely small. The East and West Bay fractions show more variability but over time as well as more variation between without and with project conditions. The with project freshwater fraction is higher than the without project, indicating that the tidal prism is being reduced thereby reducing the amount of high-saline water entering the bays from the Gulf of Mexico.

Figure 79. Bay freshwater fraction analysis areas.

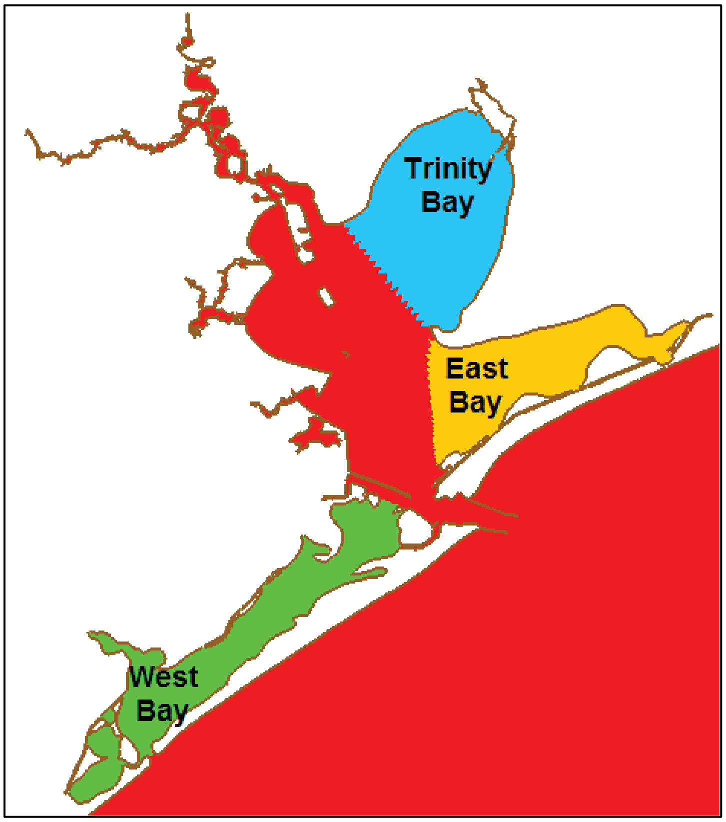


Figure 80. Freshwater fraction for Trinity Bay.

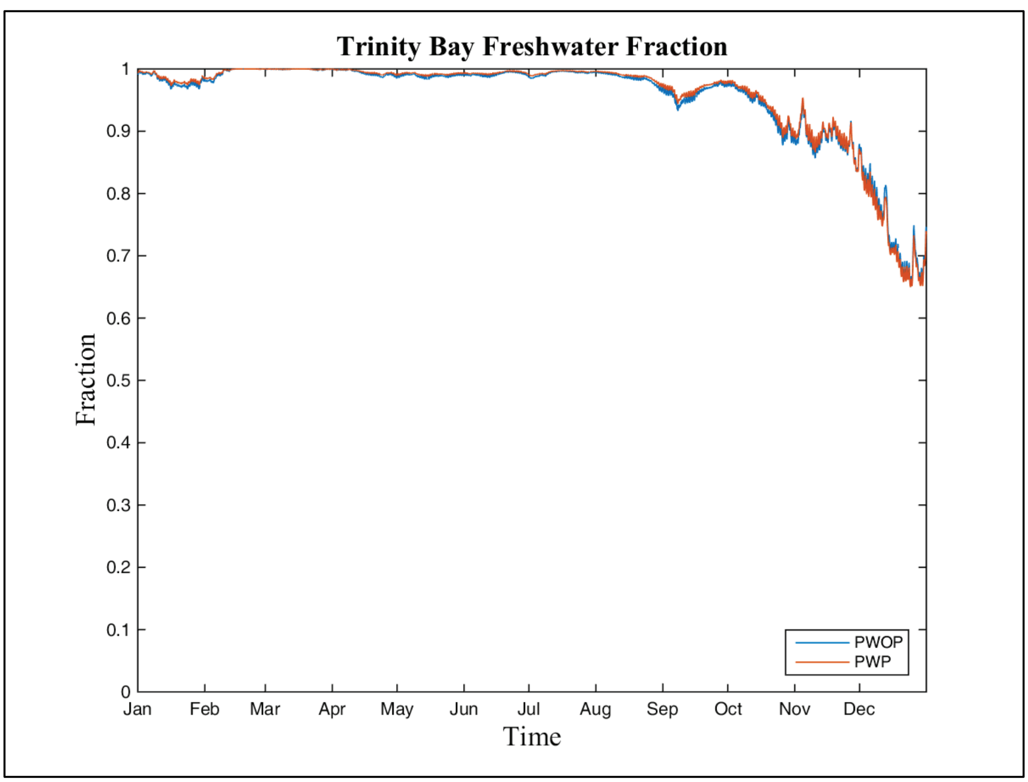


Figure 81. Freshwater fraction for West Bay.

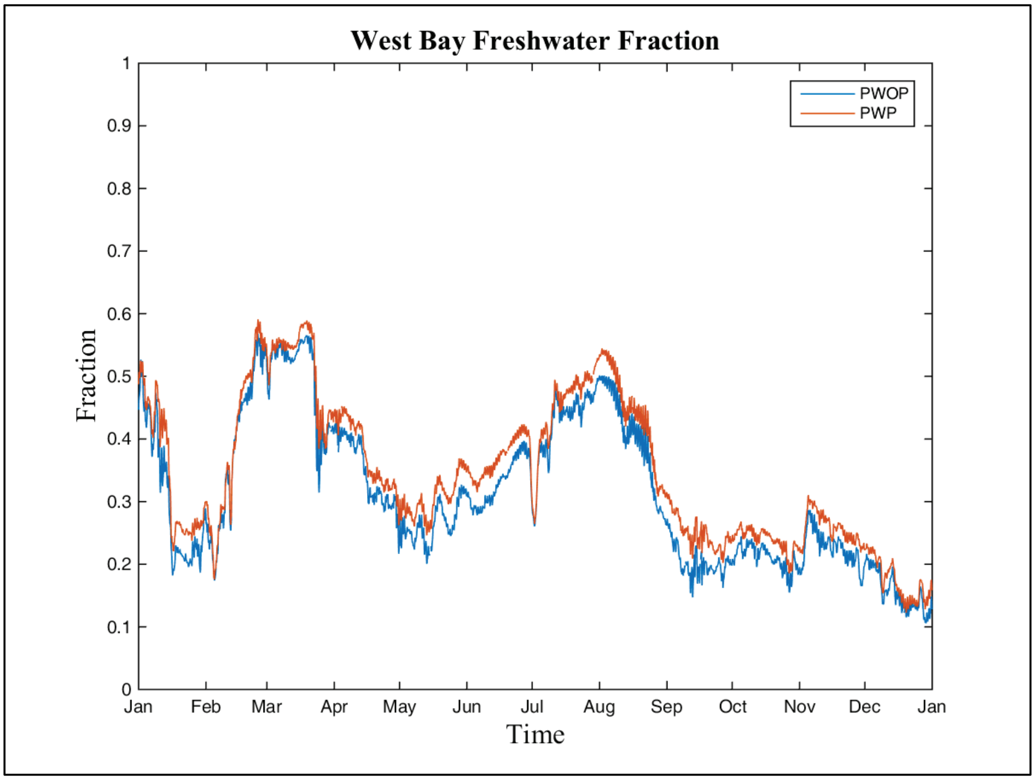
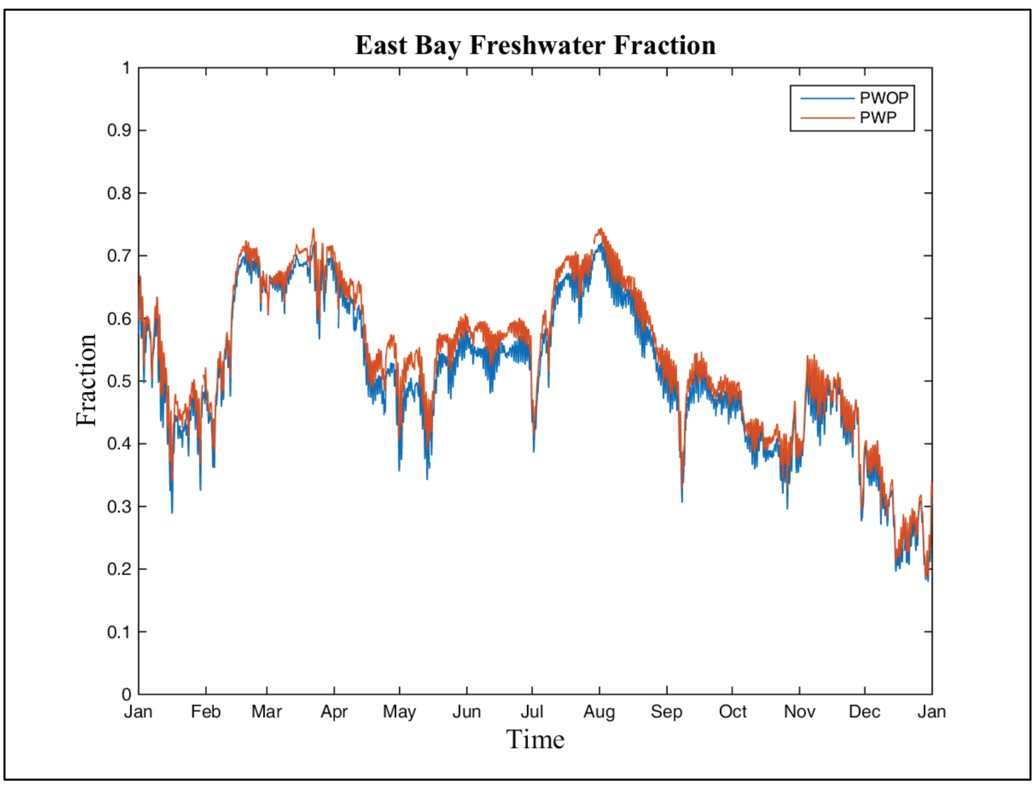


Figure 82. Freshwater fraction for East Bay.



3.7.2 Tracer analysis

As a means to estimate the residence time of a particle of water or some other quantity attached to it or to understand the trapping efficiency of the system, a tracer analysis was performed. This analysis uses the present conditions (year 2035) — including winds, tides, SLR, river inflows, salinity, and rainfall/evaporation — and starts at January 1. Obviously, the driving forces and initial conditions will greatly impact the movement of the water in the bays. The results of this analysis will vary if the simulation were run beginning at a different time of the calendar year or with conditions from another time period. However, the impacts due to the project conditions are relevant regardless of the period of the simulation.

Trinity Bay, East Bay, and West Bay are defined with a specific tracer (see Figure 79). All three bays begin with a concentration of 1.0 at time 0. No tracer is applied at any inflows. Each tracer is tracked in the various bays to determine its residence time in its bay (scaled 0-1). Without project and with project simulations are performed.

The time history plots for each bay (Figure 83 through Figure 85) show the tracer fraction as it is moved around due to the forcings included in the model (tides, freshwater flow, winds, etc.). Table 5 provides conversion information for the dates provided in the tracer fraction figures. Each plot shows the constituent mass as it is moved from the bay in which it started — this is not a time to exit through Bolivar Roads. The tracer fractions reduce quickly for Trinity Bay and West Bay. East Bay shows a significant reduction initially, but the circulation causes more of the tracer to remain in the bay over a longer time period. Material from Trinity Bay will enter East Bay and West Bay over time. However, no measureable amount of the East and West Bay tracers enter Trinity Bay — not unexpected since the predominant flow direction for the bays is ebb, or out of the estuary.

Table 5. Date conversion to days and hours.

Date	January 1	February 1	March 1	April 1	May 1	June 1
Days	0	31	59	90	120	151
Hours	0	744	1416	2160	2880	3624

Figure 83. Trinity Bay tracer fraction over125 days of analysis year.

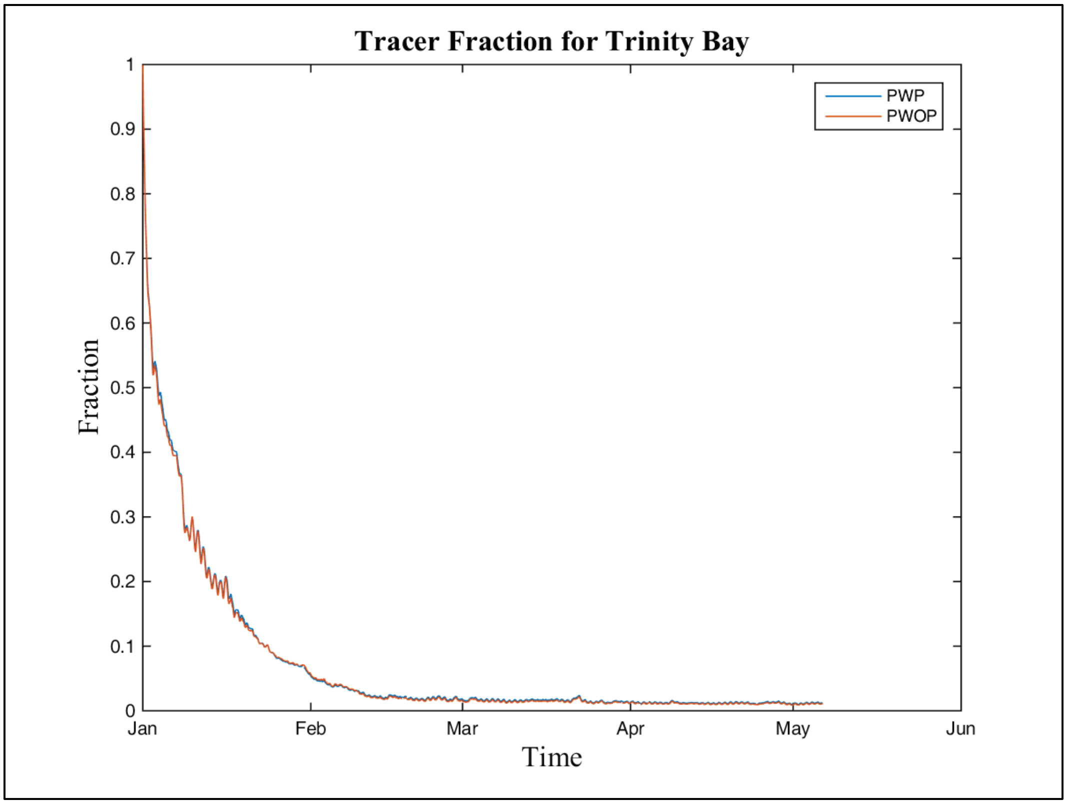


Figure 84. East Bay tracer fraction over 125 days of analysis year.

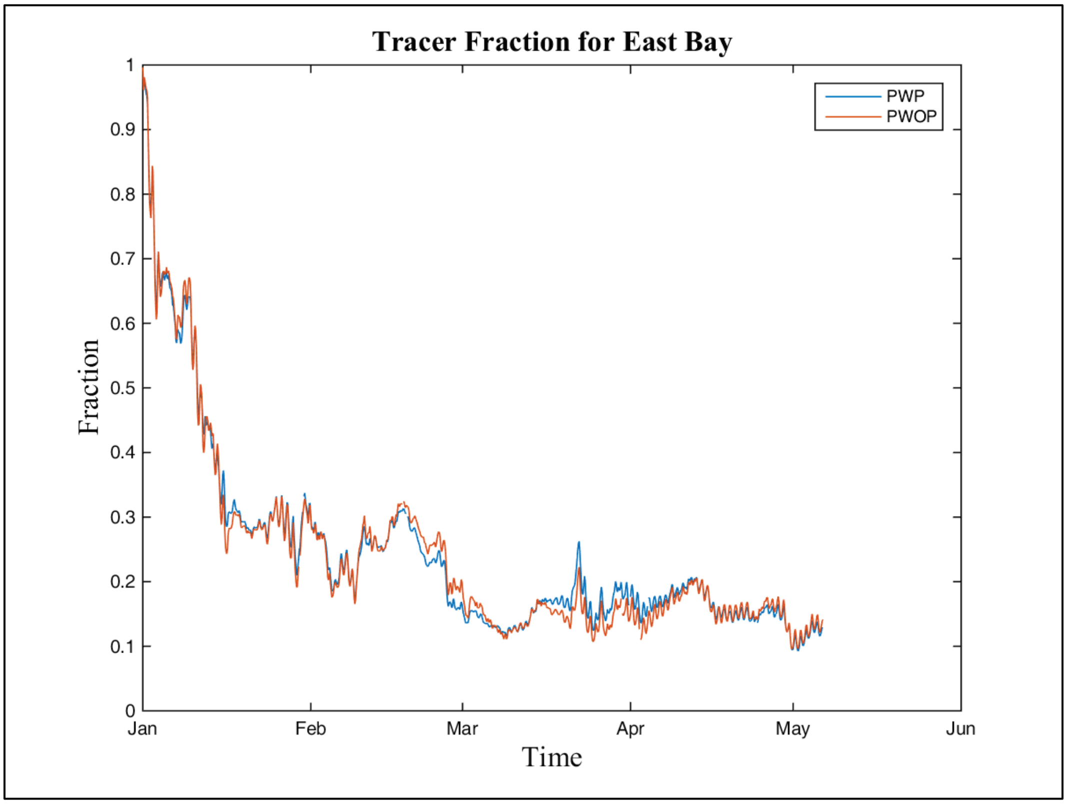
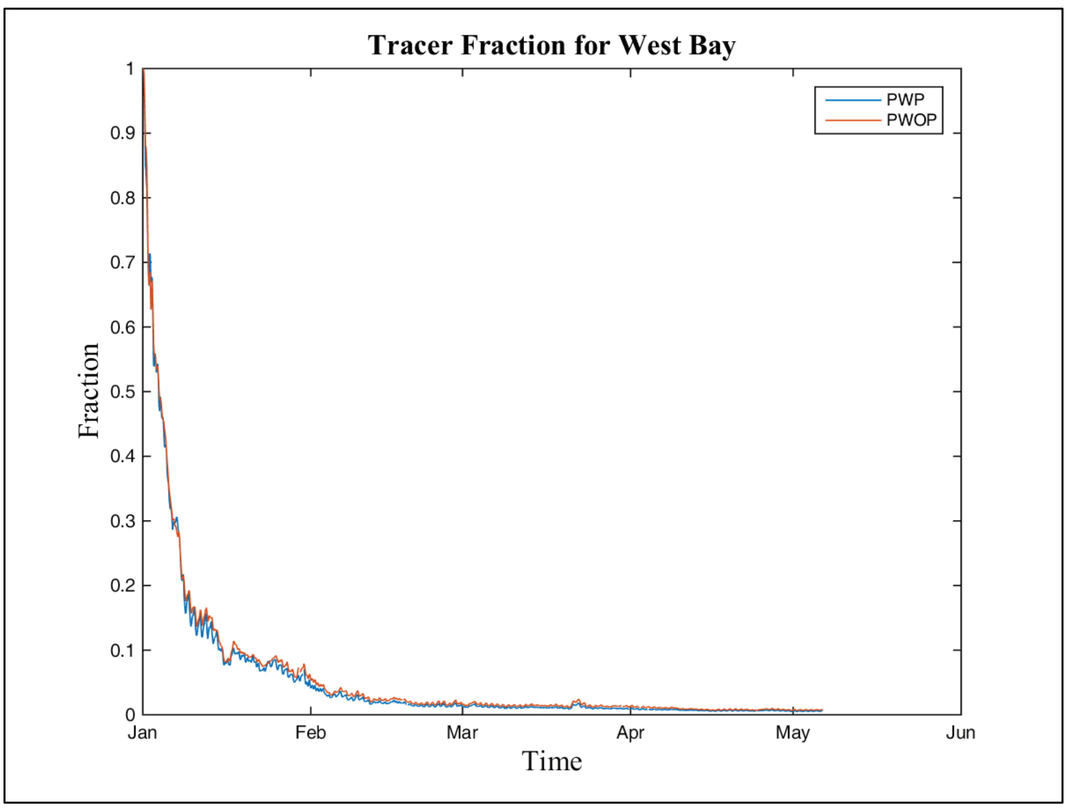


Figure 85. West Bay tracer fraction over 125 days of analysis year.



Spatial contour plots of the tracer results for with and without project at 25-day intervals are provided for each bay tracer in Appendix E: Tracer Analysis over Full Domain.

The residence time of the tracer in each bay can be defined multiple ways. Marr (2013) defines it as the time required to reduce the concentration to 37% of the initial value (0.37 for these analyses). Kraus et al. (2006) define the residence time as time necessary to reduce the concentration by 50% (0.5 for these analyses). Table 6 gives the time to reach each of these residence time criteria for with and without project conditions for all three bays. Regardless of the reduction amount deemed appropriate to determine residence time, the tracer fractions reduce beyond the residence time thresholds quickly for Trinity Bay and West Bay — fewer than 5 days — with the difference between with and without project only a few hours. East Bay requires a longer time to reduce the concentration below the residence time threshold — 10 to 14 days. Although there is no difference in the with and without project results to reach 50% reduction, there is almost a 1-day increase in the time required for the tracer in East Bay to reduce to 37% when the project structures are in place.

Table 6. Tracer residence times for each bay.

	50% Reduction (days)	
	PWP	PWOP
Trinity Bay	2.875	2.75
East Bay	10.125	10.125
West Bay	3	3.125
	37% Reduction (days)	
	PWP	PWOP
Trinity Bay	6.75	6.625
East Bay	14.125	13.375
West Bay	4.625	4.75

3.8 Shoaling analysis

The sediment analysis is based on the historic dredge records from the USACE annual reports as done in the model validation (McAlpin and Ross 2018). These volumes are provided for several reaches of the HSC as noted in the dredge template shown in Figure 86. This template is used to show

how the alternative shoaling estimates from the numerical model compare to each other for each channel reach. A scale factor based on 2005 field data was determined for each reach of the HSC during the model validation process. This scale factor is then used to determine appropriate shoaling volumes for every additional simulation period. The scale factor accounts for features not included in the numerical model that impact the sediment transport within the system, such as wind wave resuspension and vessel movement.

Figure 86. HSC dredge template for shoaling analysis.

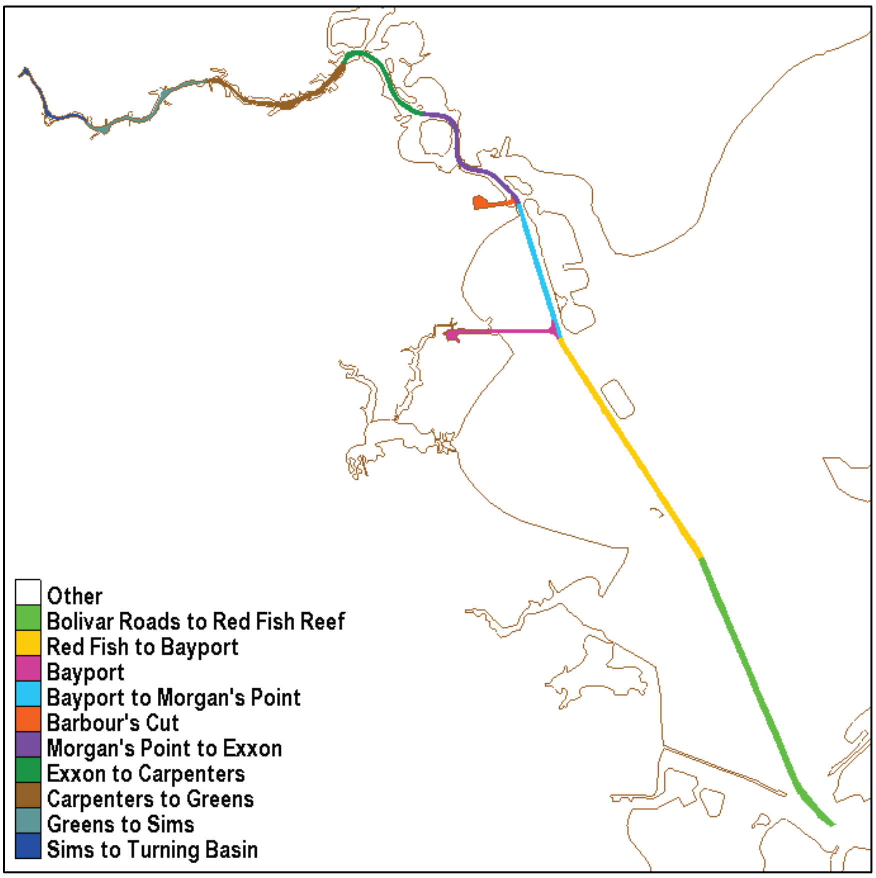


Figure 87 shows the scaled shoaling volume within each segment for the 2010 base condition and all four alternatives —PWP, PWOP, FWP, and FWOP. The with project shoaling in the HSC for the present condition shows a reduction in shoaling for all reaches except Bolivar Roads to Red Fish Reef. The with project shoaling in the HSC for the future condition shows a small reduction in shoaling at the uppermost reaches of the HSC — above Carpenters Bayou. The lower reaches show almost identical shoaling volumes for with and without project or a small increase in the shoaling with project. The with and without project comparisons for the future condition show smaller changes than the present condition. The future condition includes a reduction in the sediment loads due to lower freshwater inflows which is likely the cause of this overall lower shoaling volume for the future condition simulations. However, the increased tidal volume and lower velocities in the HSC for the future condition appears to be causing slightly more sediment to deposit in the lower reaches of the HSC when the project is in place.

The Bolivar Roads to Red Fish Reef reach is located immediately upstream of the TSP location and in a very dynamic area with or without the project in place. This area consists of mostly sand and hardened material. Although there are large velocities passing through the structures, the reduction in the tidal exchange is likely trapping material on the bay side of the structures. The velocities in the HSC are primarily reduced with project except at the TSP location; therefore, material from the Trinity River that transits the southern side of Trinity Bay and enters the HSC just downstream of Red Fish Reef will not have as strong a force to move upstream in the HSC when the project is in place.

Figure 88 shows the model computed, unscaled bed displacement along the HSC from the Texas City Dike to the Houston Turning Basin. These results show a similar pattern to those in Figure 87, although no scaling has been done to ensure a correlation to historic data as in the shoaling volume plot. However, the comparison between with and without project will remain if scaled to replicate actual shoaling volumes/depths. The plot does show that the with project alternatives decrease the deposition along the HSC for the present condition while the future condition shows that the bay portions of the HSC see more shoaling with the project in place. The deposition along the channel does not, however, indicate a shift in the shoaling locations for the with project alternatives. It is not uncommon for channel modifications to change the flow patterns such that the turbidity maximum (the location where the sediment tends to collect and often tied to the location of the salinity wedge) moves upstream, especially in the case of channel deepening. Assuming the sediment loads and resuspension forces are unchanged, this TSP does not appear to generate large shoaling increases along the HSC.

Figure 87. Shoaling results by reach for all alternatives.

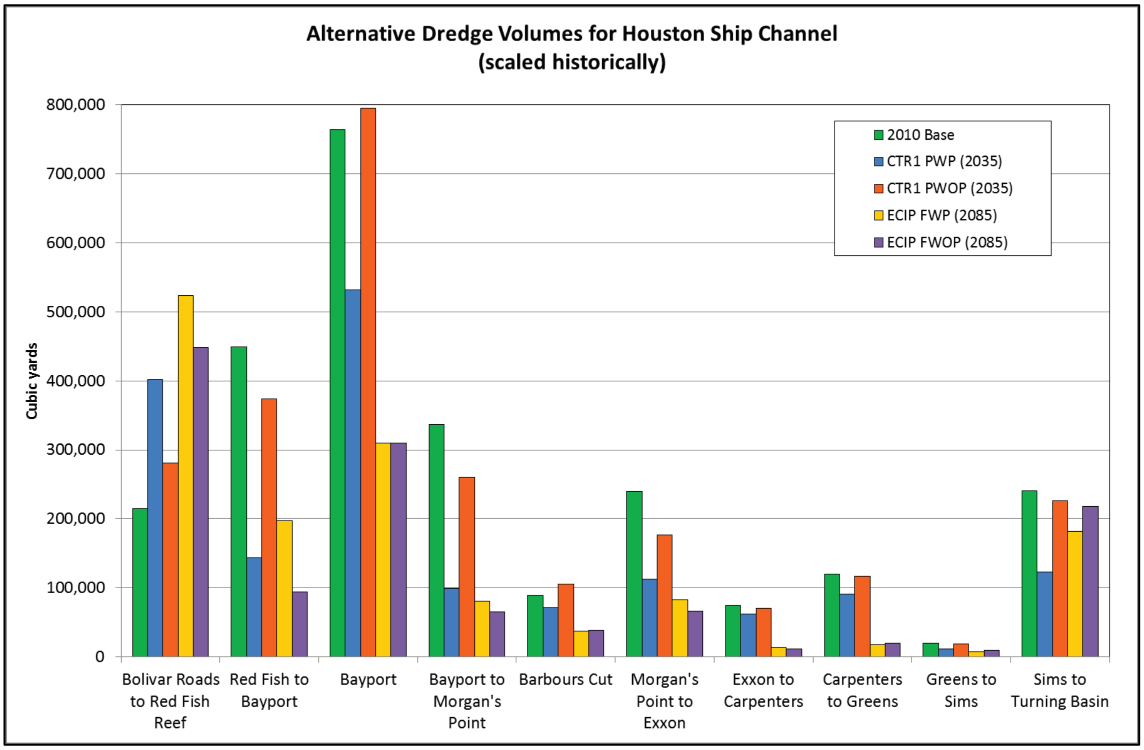
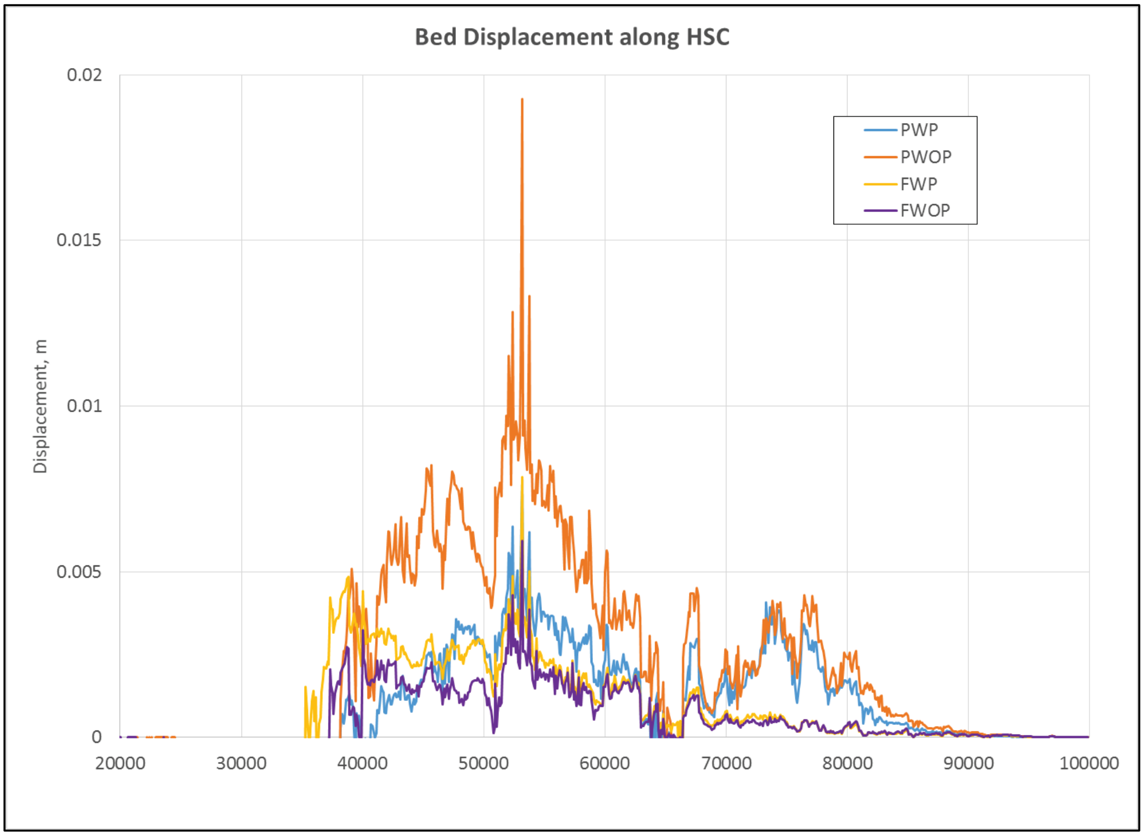


Figure 88. Modeled bed displacement along HSC (non-scaled, focus on the change).



3.9 Hydrodynamic analysis at the TSP location

The numerous structures at the location of the TSP, crossing the HSC and shallows at Bolivar Roads, are going to impact local velocity and water levels in the area. The reduction in cross-sectional area due to the structures forces a head difference across the structures, which could impact navigation at certain times of the daily tidal signal. Figure 89 shows the TSP as defined in the model along with a red observation arc through the navigation structure. Figure 90 shows several days of tidal water surface elevation for the present and future condition with the selected analysis tide (day 499 of the 2-year simulation; May 22 of the analysis year) circled in red. The tidal signal is identical for present and future conditions; the future condition is simply raised due to SLR. This day does experience a large amplitude during a spring tide period, but the amplitude is not uncommon for this area. The water surface elevation across the structure at several points during this day is shown along with the surface velocity magnitude and vectors for each alternative in Figure 91 through Figure 94. The velocity magnitude is contoured from 0 to 3 m/s, and the velocity vector length is fixed and intended to show direction only. The water surface elevation plot shows both the present and future condition results; the present conditions (solid lines) utilize the vertical axis to the left, and the future conditions (dotted lines) utilize the vertical axis to the right. Note that the present and future scales are not identical, but the gridlines do line up with a value for both axes.

The largest surface velocity magnitudes as well as the largest head difference across the navigation structure occur at high tide and low tide as expected for the progressive wave behavior observed at Bolivar Roads (Savant and Berger 2015). The extreme water levels during the daily tide create jets of high magnitude velocity on the side of the structure to which the flow is directed — bay side for incoming flow and gulf side for outgoing flow. For this tidal signal, surface velocities through the navigation structure exceed 2 m/s (6.6 ft/s) in places. Eddies form on the backside of the structures, which may have impacts on navigation. During slack water, the velocity magnitudes are much lower through the navigation structure, but the velocity directions may be such that navigation is impaired. These vectors should be analyzed carefully when designing the final structure configuration such that navigation restrictions are fully understood.

The water surface elevation change across the navigation structure (or head difference) can also impact safe navigation and should be reviewed carefully. Table 7 provides the head difference along the observation arc for all alternatives at each of the analyzed tidal conditions. For this tidal signal, the head difference at high- and low-tide conditions ranges between 0.14 and 0.2 m for the present and future conditions. For this signal, the low-tide condition produces a greater water surface elevation difference than the high-tide condition.

Figure 89. Observation arc (red) for analyzing water surface elevation change through TSP navigation structure.

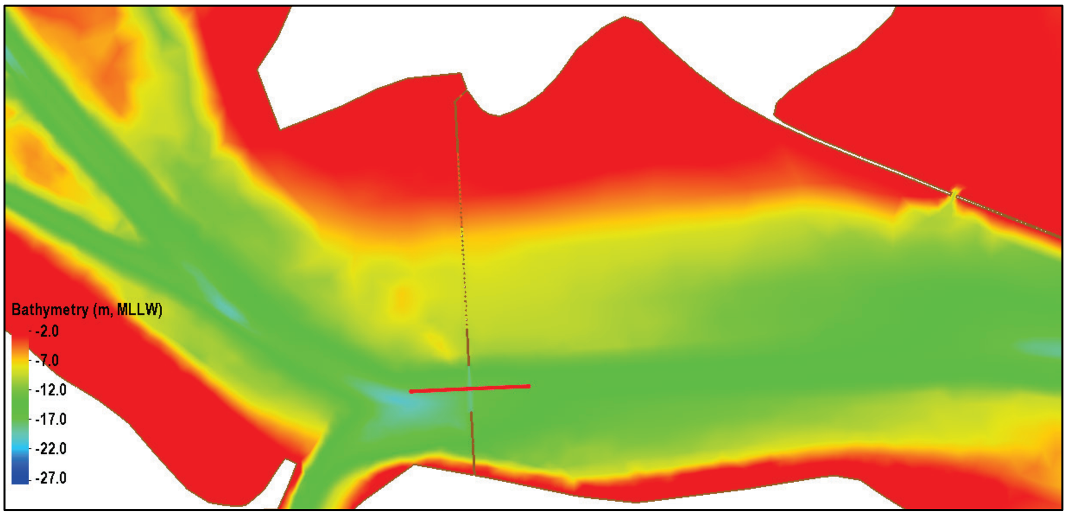


Figure 90. Future and present tide condition with analysis day circled in red.

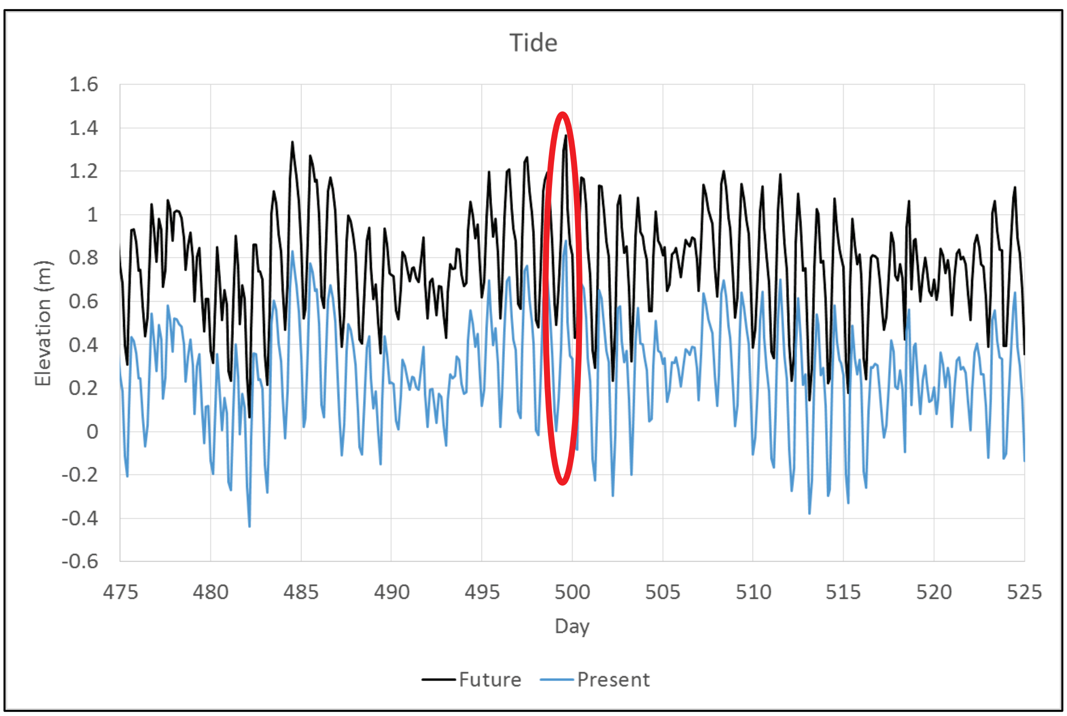


Figure 91. Velocity and water surface elevation at the TSP location at low tide.

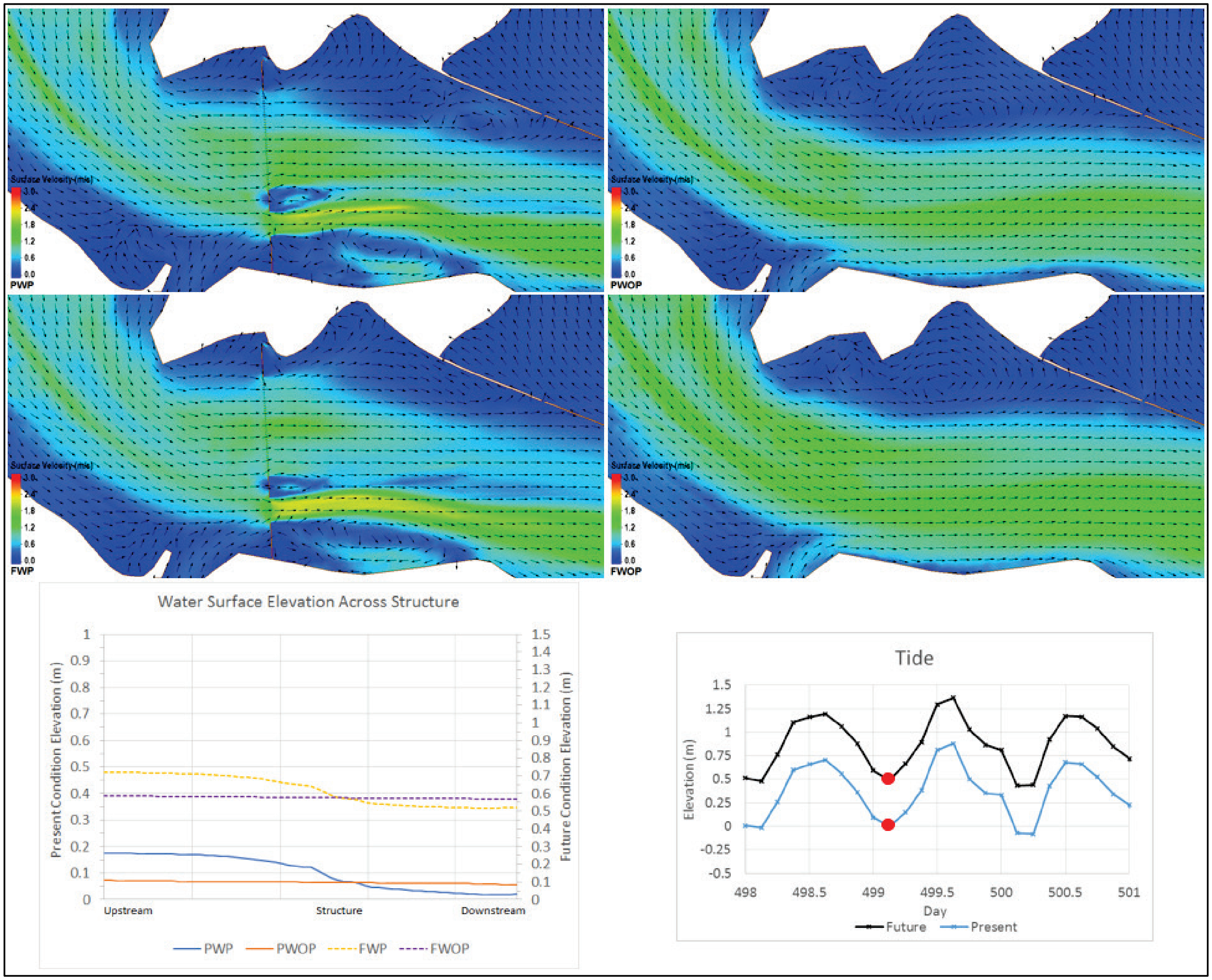


Figure 92. Velocity and water surface elevation at the TSP location at slack water during rising tide.

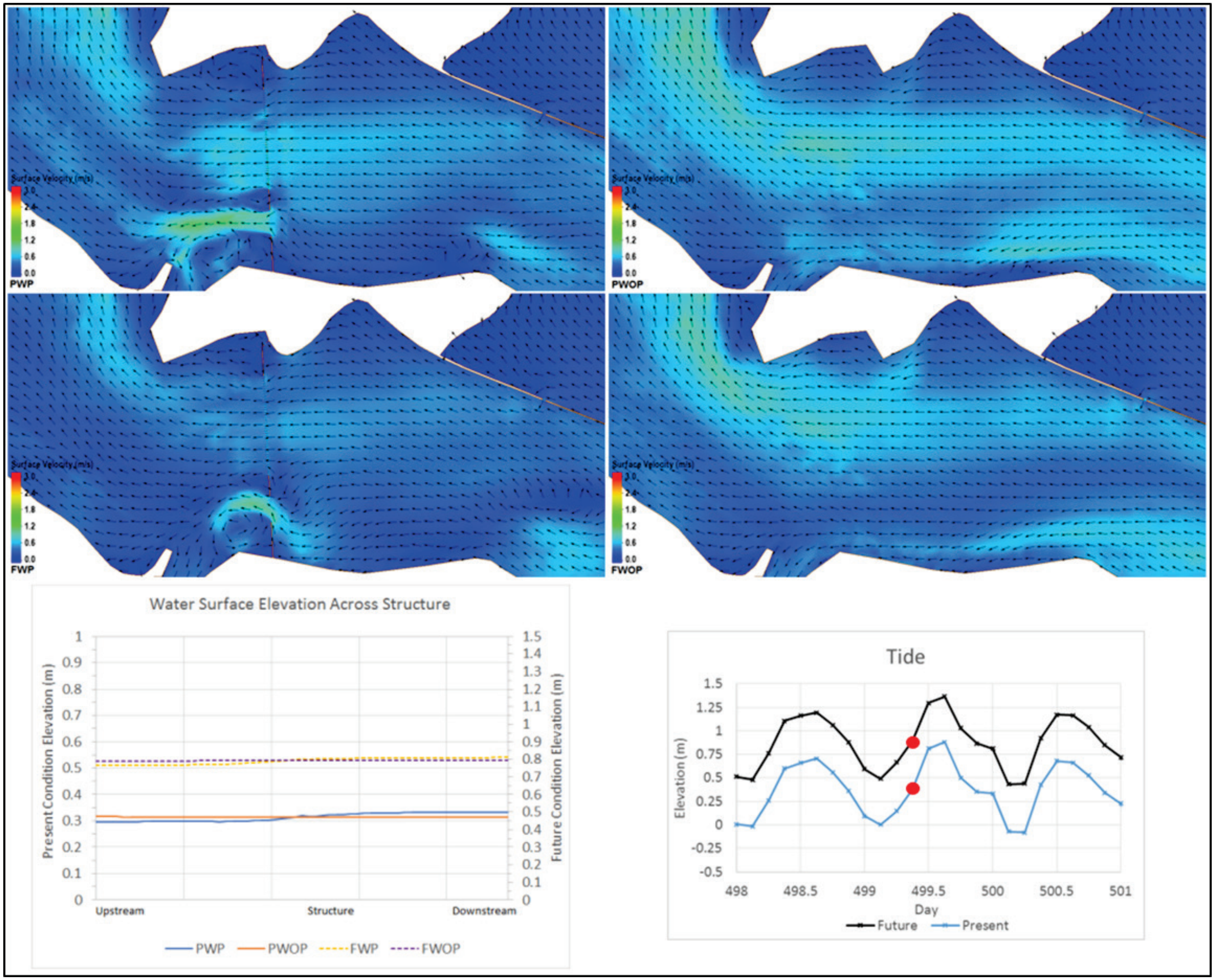


Figure 93. Velocity and water surface elevation at the TSP location at high tide.

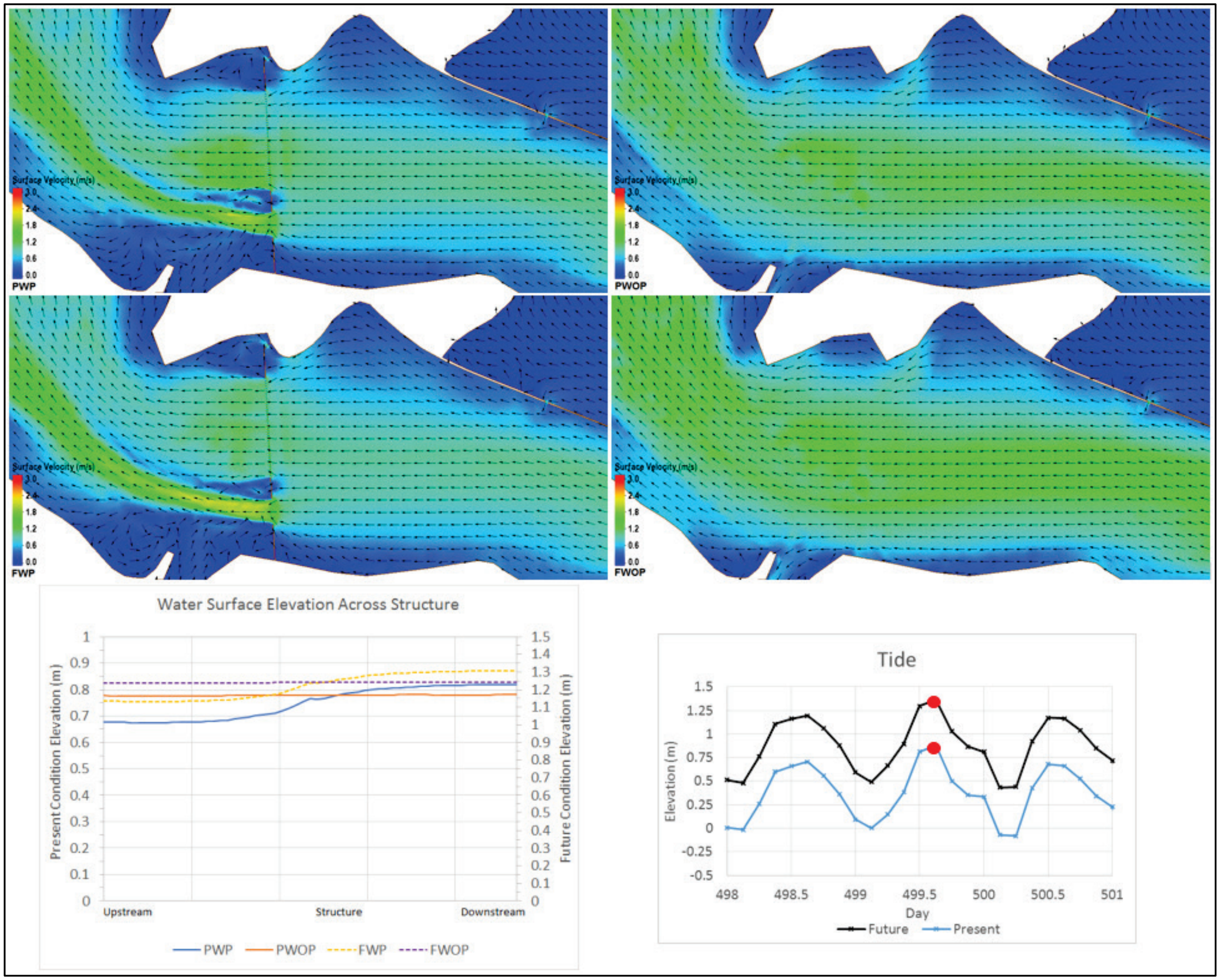


Figure 94. Velocity and water surface elevation at the TSP location at slack water during falling tide.

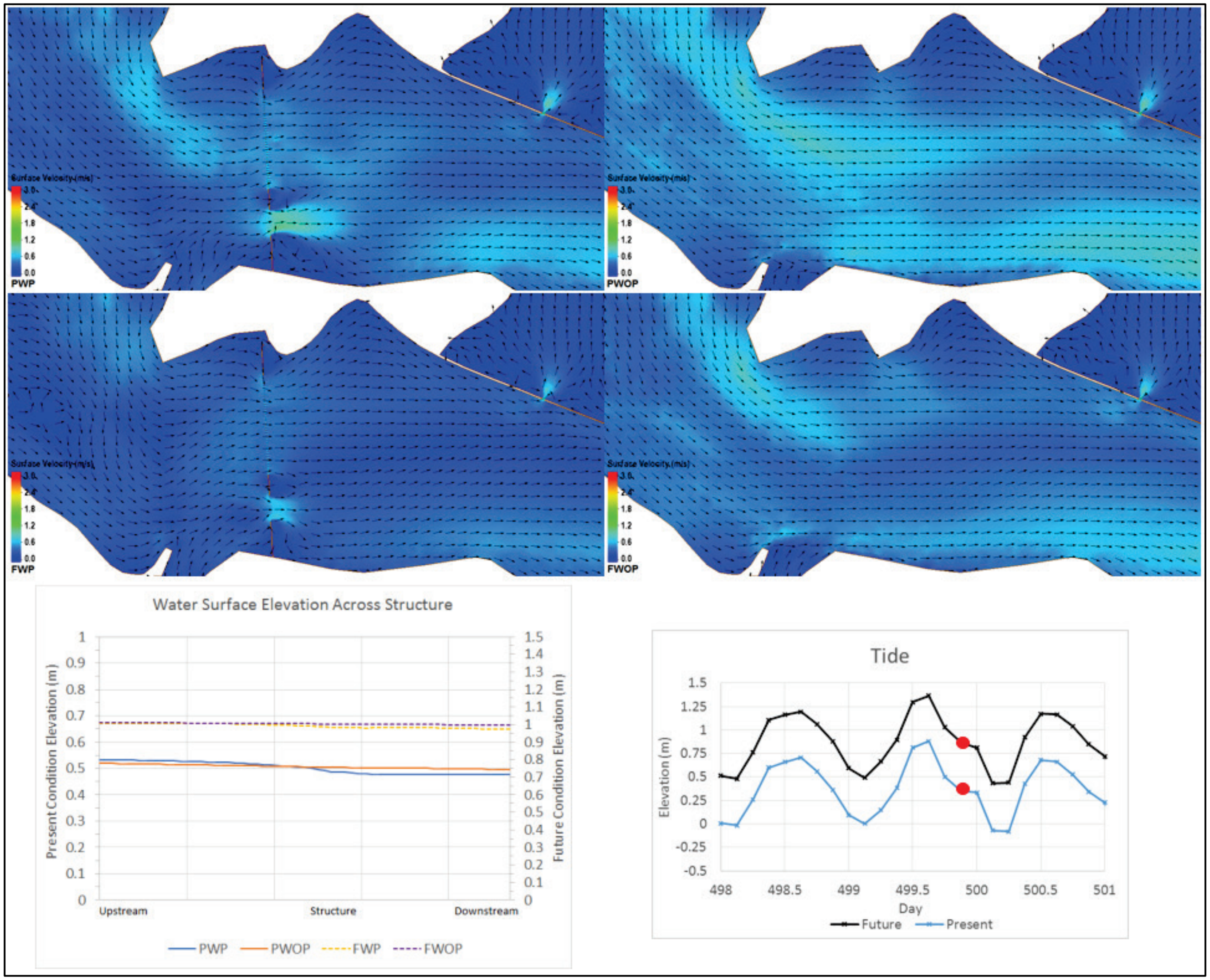


Table 7. Water surface elevation change (head difference) across the navigation structure.

Tide Condition	Head Difference (m)			
	PWP	PWOP	FWP	FWOP
Low Tide	0.156	0.017	0.200	0.022
Rising Tide Slack	0.039	0.002	0.047	0.006
High Tide	0.144	0.003	0.174	0.003
High Tide Slack	0.056	0.023	0.033	0.016

4 Conclusions

This report documents the 3D AdH numerical model results for the Coastal Texas, Region 1, estuarine modeling of the TSP. The plan alternative is discussed as well as the model boundary conditions for present and future conditions. For this study, *present* is year 2035 and *future* is year 2085. SLR is included in the model alternatives as are modifications to freshwater inflows and sediment loads.

The four alternatives — PWOP, PWP, FWOP, and FWP – are simulated over a 2-year period with the first year for bed and salinity initialization and the second year for analysis of hydrodynamic, salinity, and sediment results. Overall, this alternative had little effect on bay salinity and velocity patterns, but it does generate significant local changes in velocity patterns near the TSP location. The TSP also greatly impacts the tidal prism — the exchange of water in and out of the bay system on each tide — as well as the tidal amplitudes within the bays.

The salinity was analyzed at 23 locations along the HSC and in the surrounding bays. On average, the salinity did not vary by more than 2 ppt between with and without project conditions at any location. At some locations, the maximum or minimum salinity values varied by more, but these are extreme values and likely only occur a couple of times throughout the simulation year. The percent-less-than plots of salinity show the range of salinity values for all locations over the simulation period and again, show little variation between with and without project results.

The average tidal prism and average tidal amplitudes at the 23 locations did vary between with and without project over the simulation year. The tidal prism change with the project alternative in place is a 13.5% and 16.5% reduction for the present and future conditions, respectively. The tidal amplitudes also reduced at all bay side locations — between 9% and 22%. The tidal amplitude increased at locations on the Gulf side of the TSP closures.

The velocity magnitudes vary little between with and without project for locations away from the TSP. The mean surface and bottom velocity magnitude generally drops when the project is in place, but this change is less than 0.1 m/s at all 23 analysis points and for most locations is 0.05 m/s or less. The residual velocity indicates the predominant flow direction and magnitude when the tide oscillation is removed from the velocity throughout the model domain. The change from the without project condition is greatest in areas at and immediately around where the modifications are made. There are impacts to velocity magnitude into the bay areas, but they are much smaller than the impacts at the locations of the modifications.

The salinity flushing is not changed greatly due to the proposed structures. The freshwater fraction analysis shows that the with project condition does cause salinity to remain in the various bays slightly longer than the without project condition, but this magnitude of this difference is quite small. The constituent tracer analysis also supports the limited impact of the project condition on the ability of material to move within the bay system.

The alternative condition indicates a reduction in the shoaling along the HSC when compared to the without project results for the present condition. The largest changes are in the areas upstream of Red Fish Reef and near the Bayport channel and flare. The alternative condition reduces the velocity that is pushing sediment into this area. The future condition shows a slight increase in the shoaling with the project in place, but the change in volume is small compared to that for the present condition. The shoaling volume results should be reviewed in connection with HSC dimension requirements to determine the overall impacts of the channel shoaling analysis and how they relate to dredging requirements.

The hydrodynamics at the TSP location show high velocity magnitudes, eddy formations, and large water surface elevation changes across the structures. These patterns should be reviewed in coordination with navigation requirements such that the final TSP design provides for safe navigation throughout the typical tidal conditions for the area.

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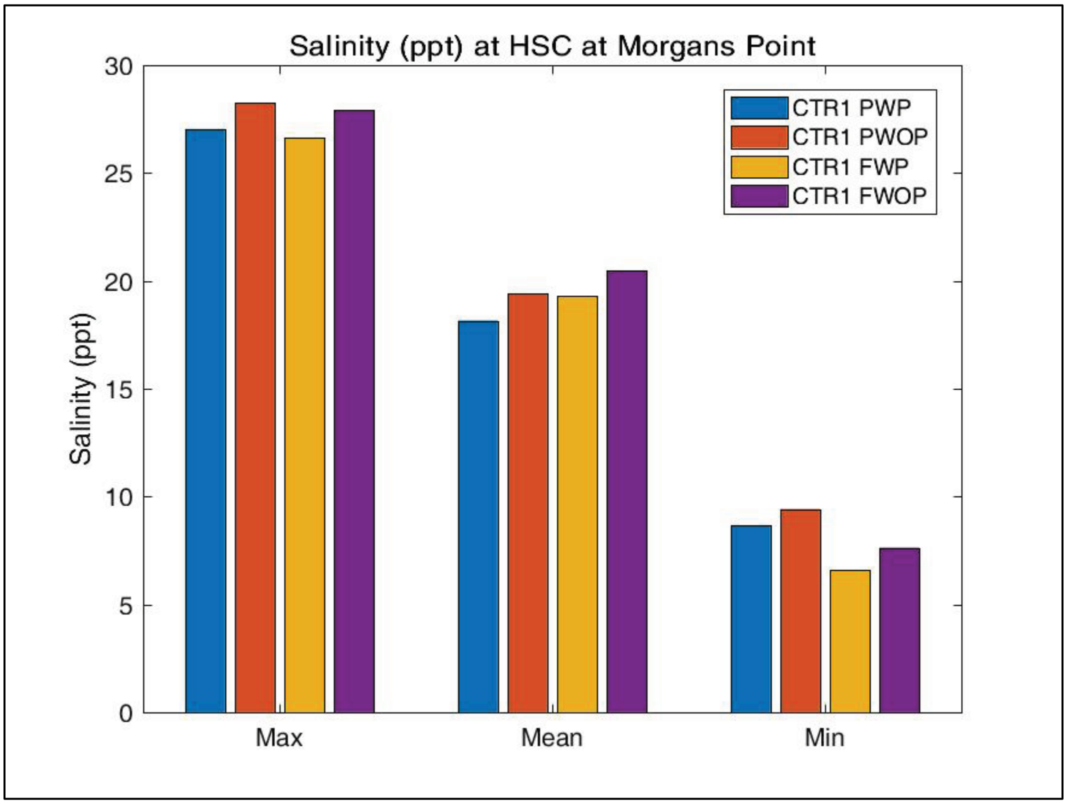
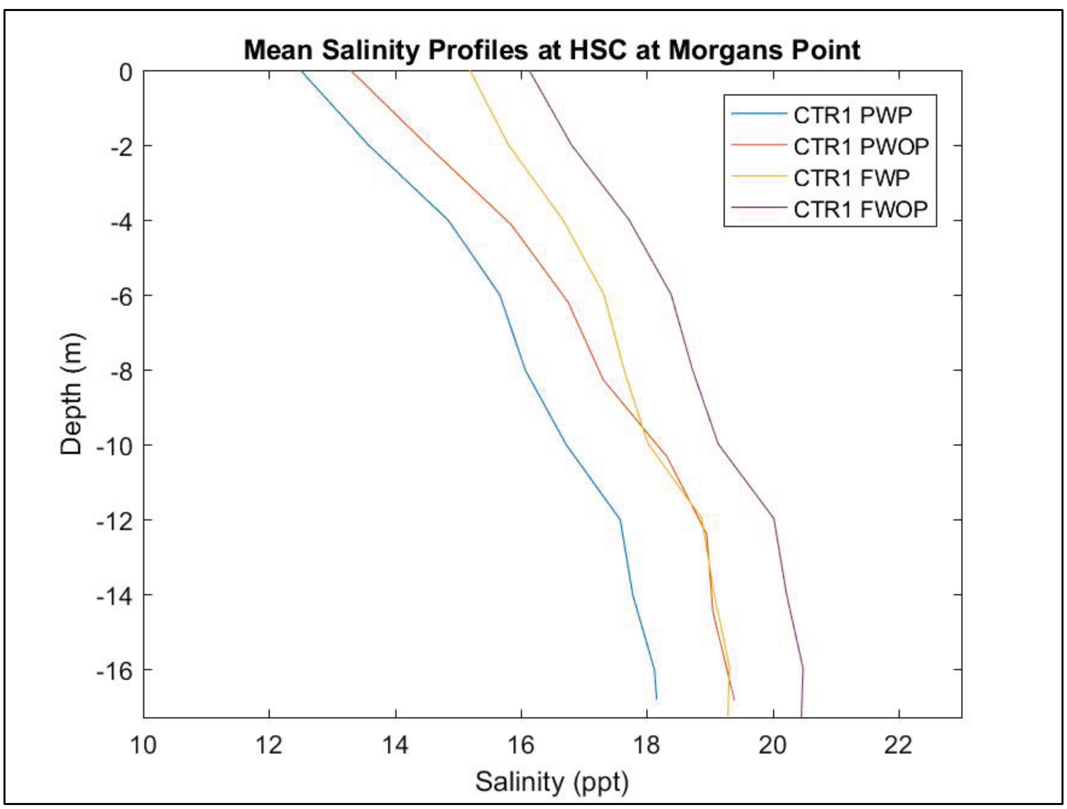
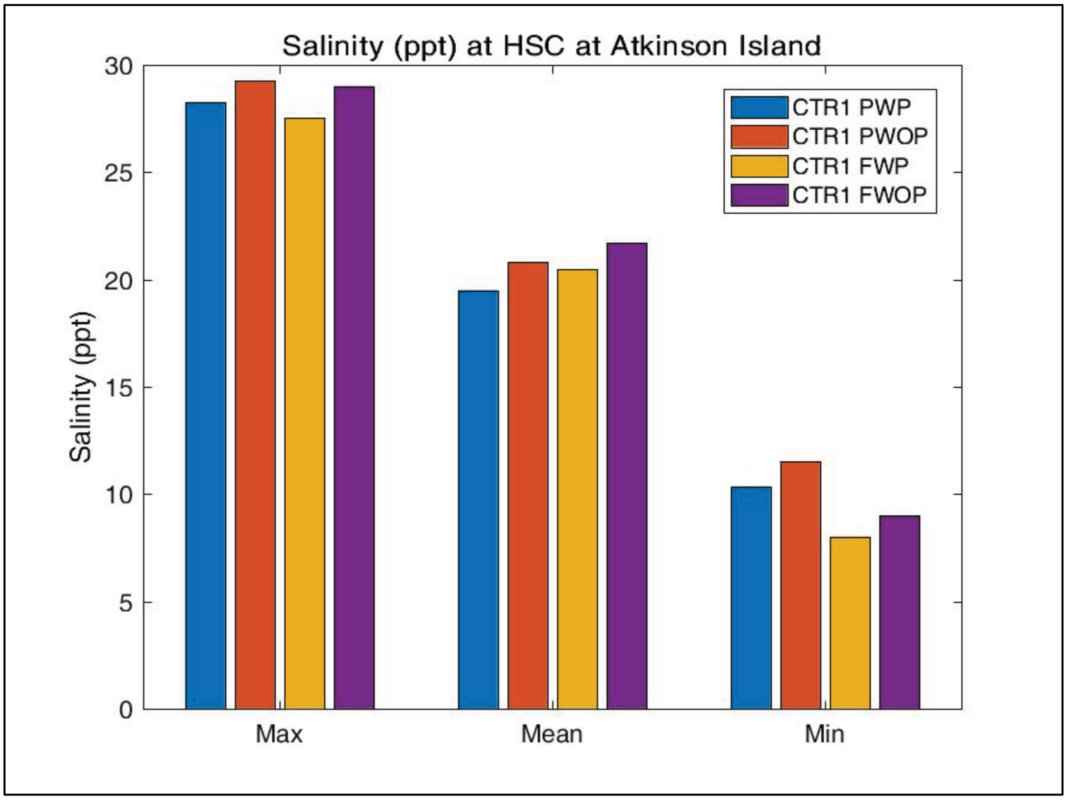
Appendix A: Seasonal Salinity Analysis

Two seasonal analysis periods were determined by the sponsors as periods when salinity changes are most crucial to aquatic habitat: April – September and July – September. Salinity maximum/minimum/average analyses and mean vertical distribution profiles were performed for the 23 locations for both time periods. Additionally, isohaline plots of mean surface and bottom salinity for each seasonal period are provided for each alternative.

April 1 – September 30






Salinity (ppt) at HSC at Atkinson Island
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
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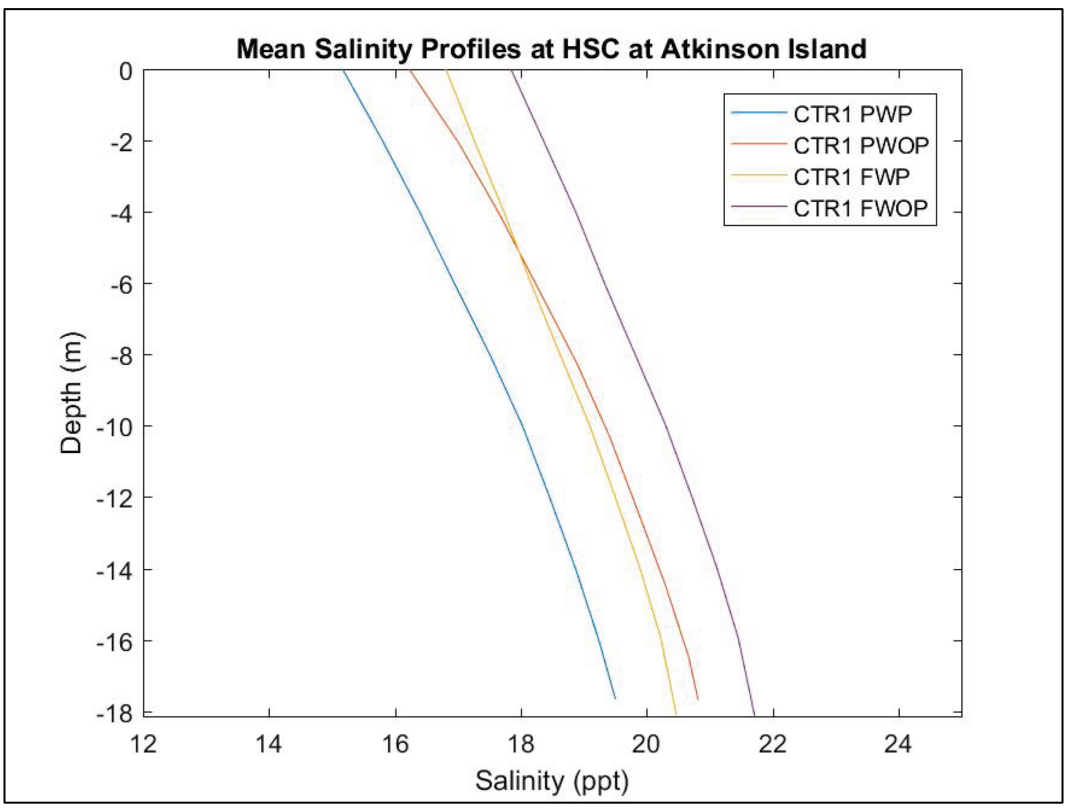
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at HSC at Atkinson Island
Depth (m)
0
-2
-4
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-10
-12
-14
-16
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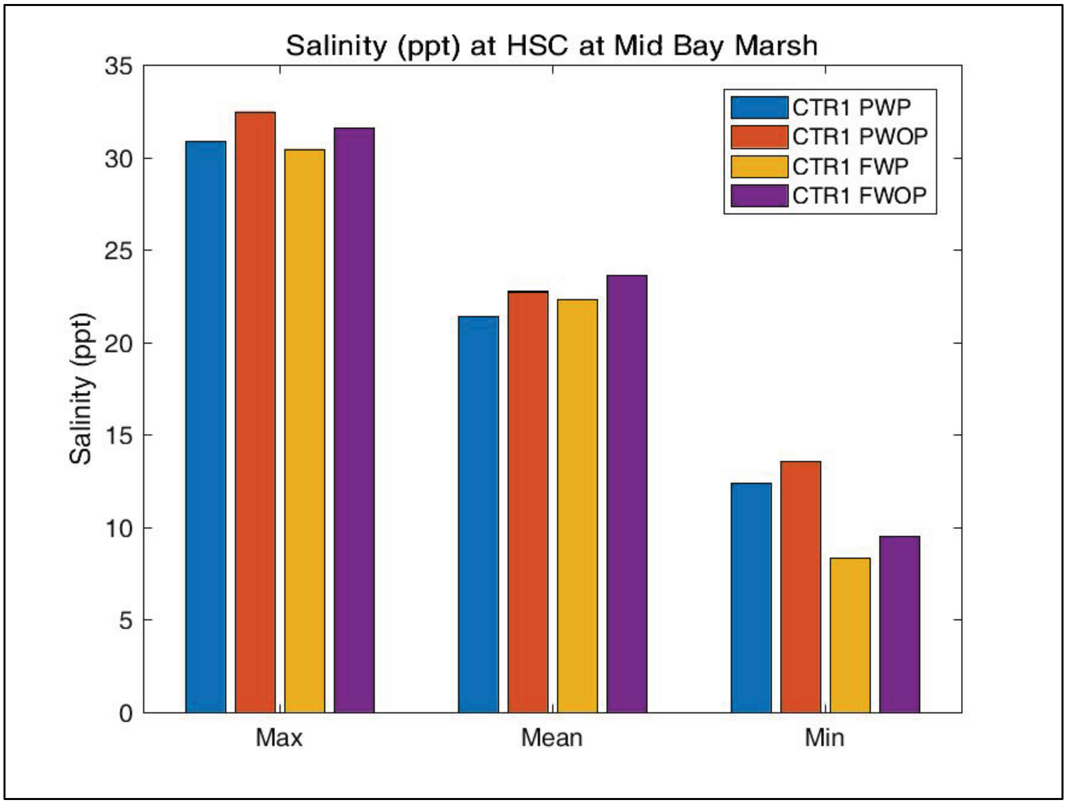
14
16
18
20
22
24
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Mid Bay Marsh
Salinity (ppt)
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20
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5
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Max
Mean
Min
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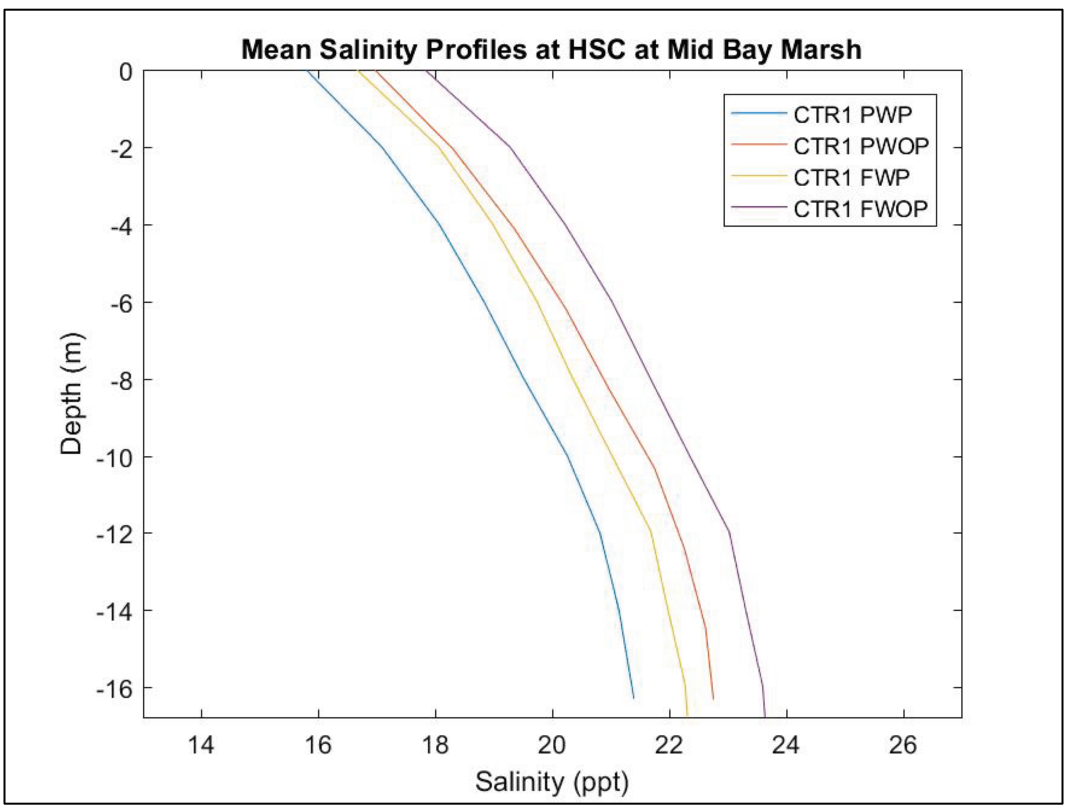
CTR1 FWP
CTR1 FWOP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Depth (m)
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-14
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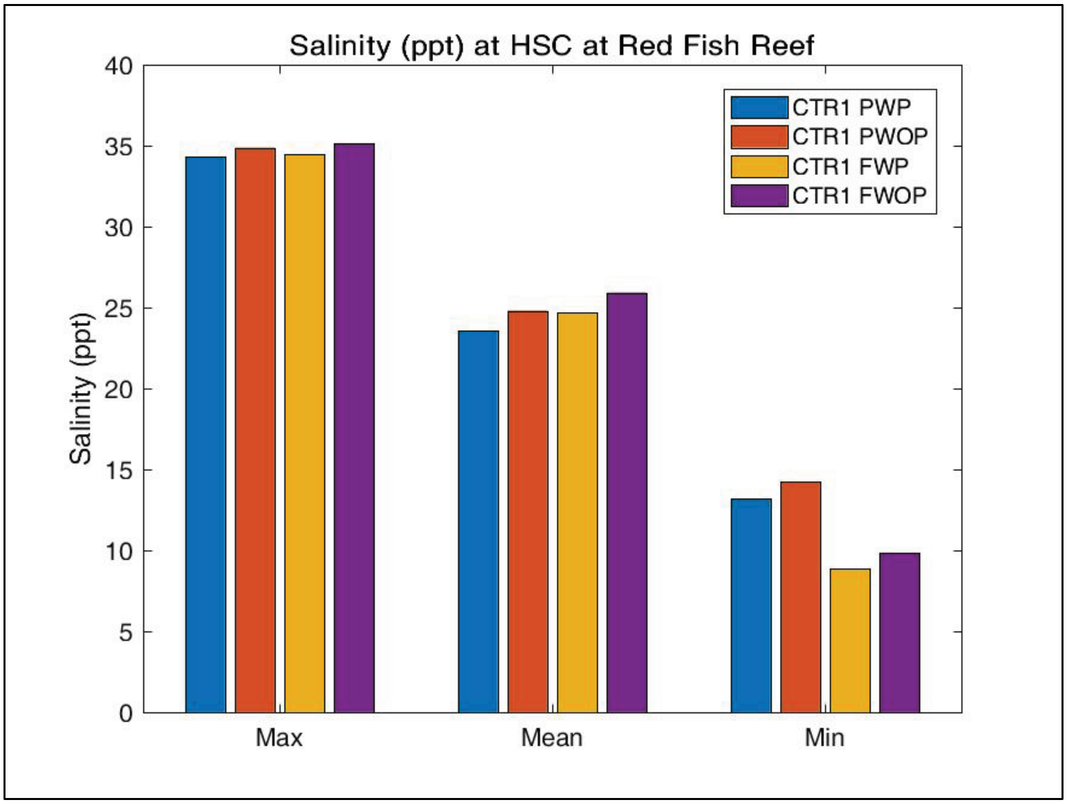
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Red Fish Reef
Salinity (ppt)
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Max
Mean
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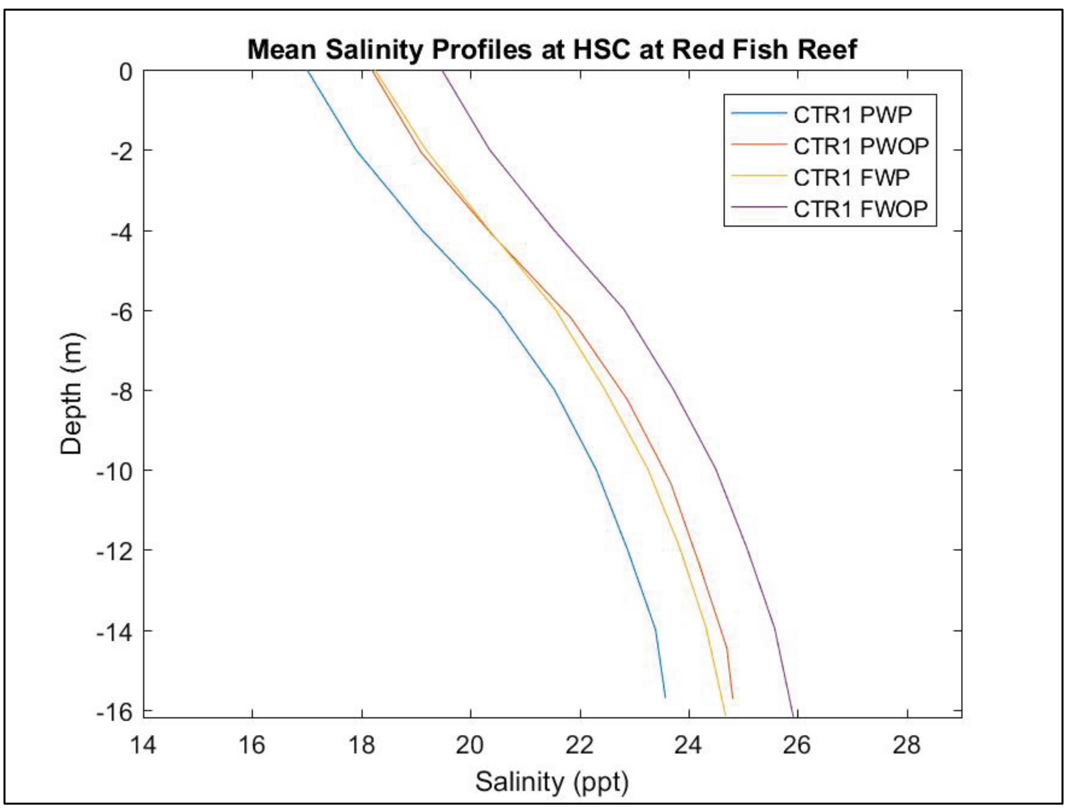
CTR1 FWP
CTR1 FWOP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Depth (m)
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-14
-16
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26
28
Salinity (ppt)
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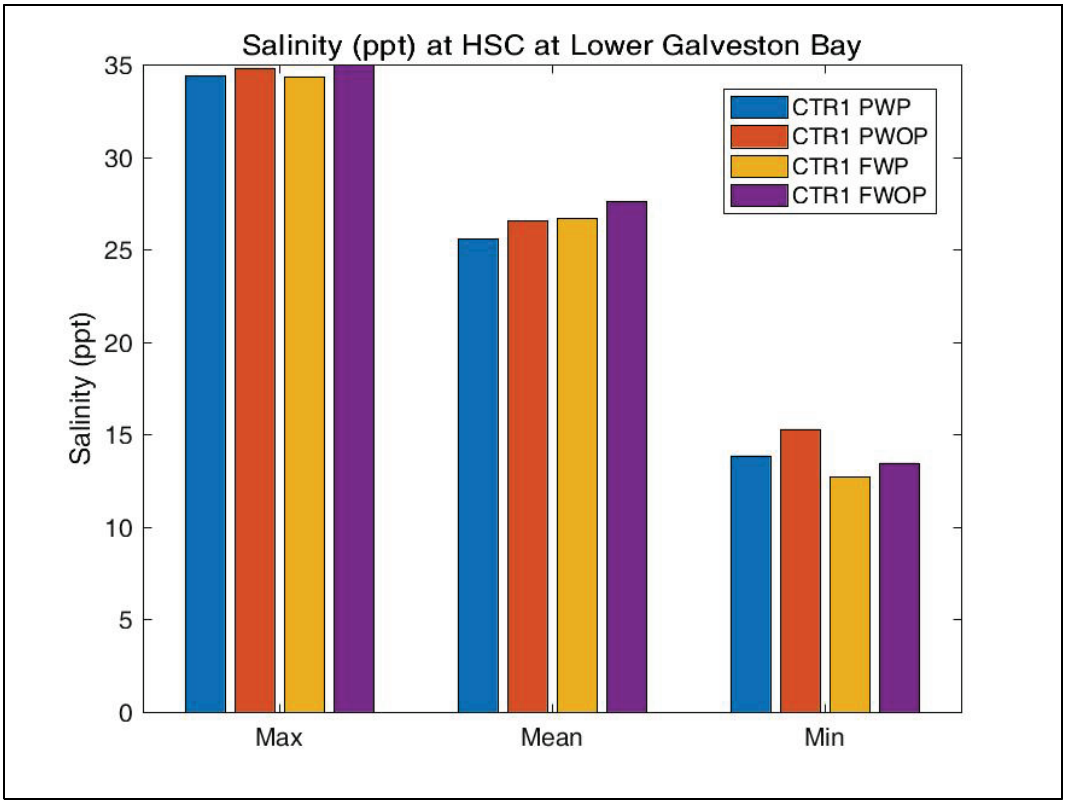
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Salinity (ppt)
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30
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20
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10
5
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Max
Mean
Min
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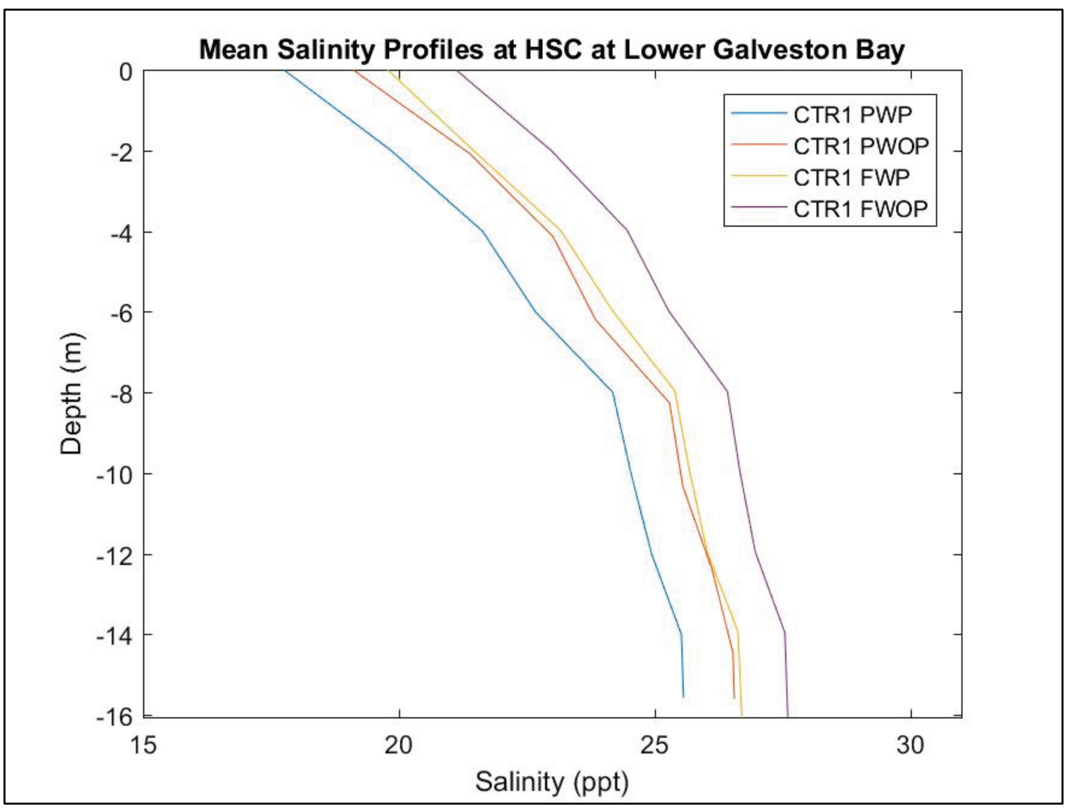
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Depth (m)
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-8
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30
Salinity (ppt)
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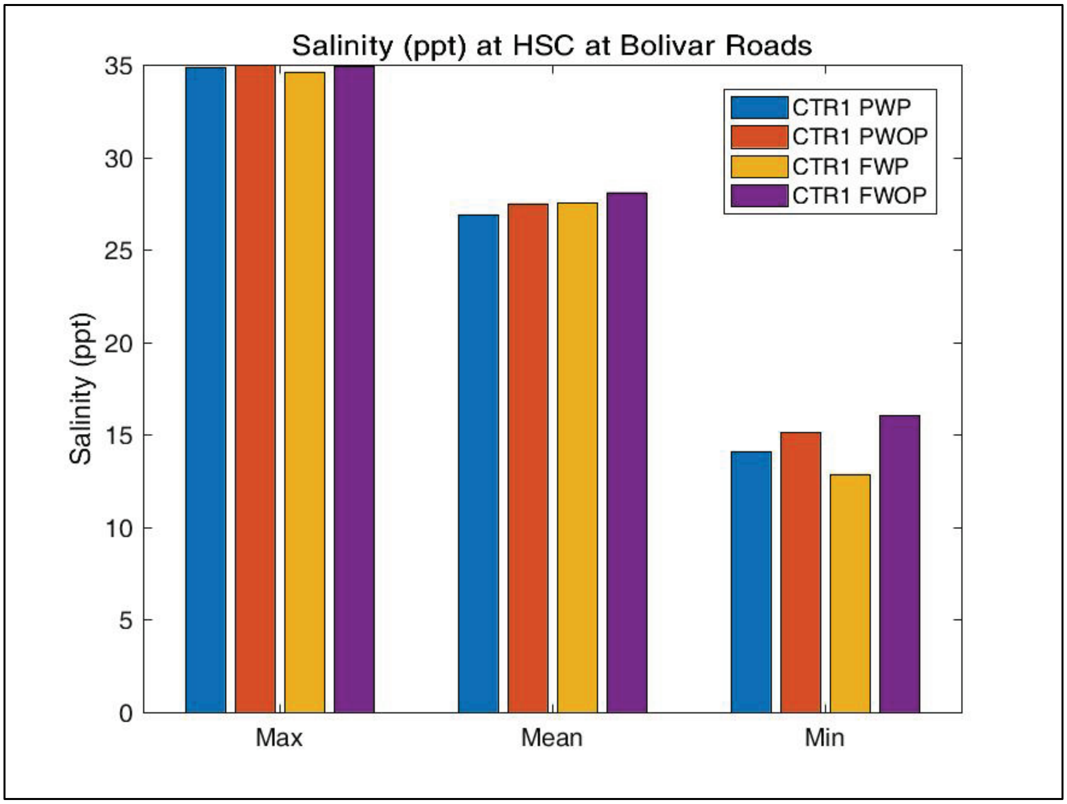
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Bolivar Roads
Salinity (ppt)
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30
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20
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10
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Max
Mean
Min
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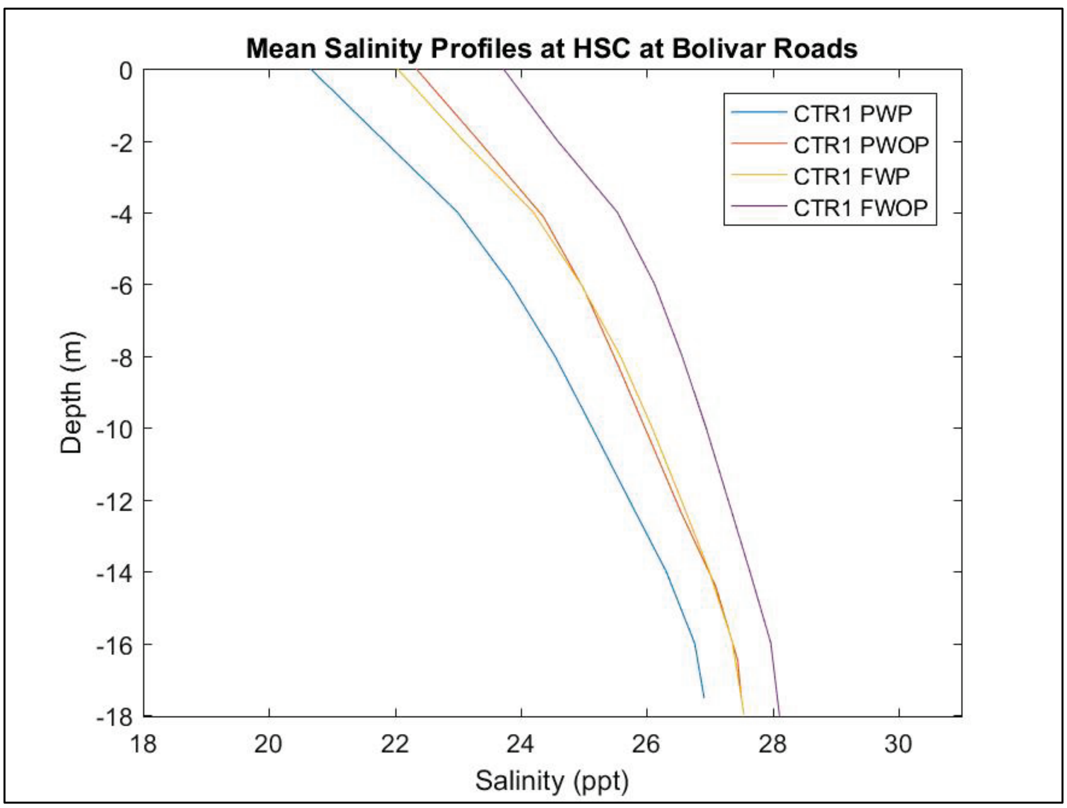
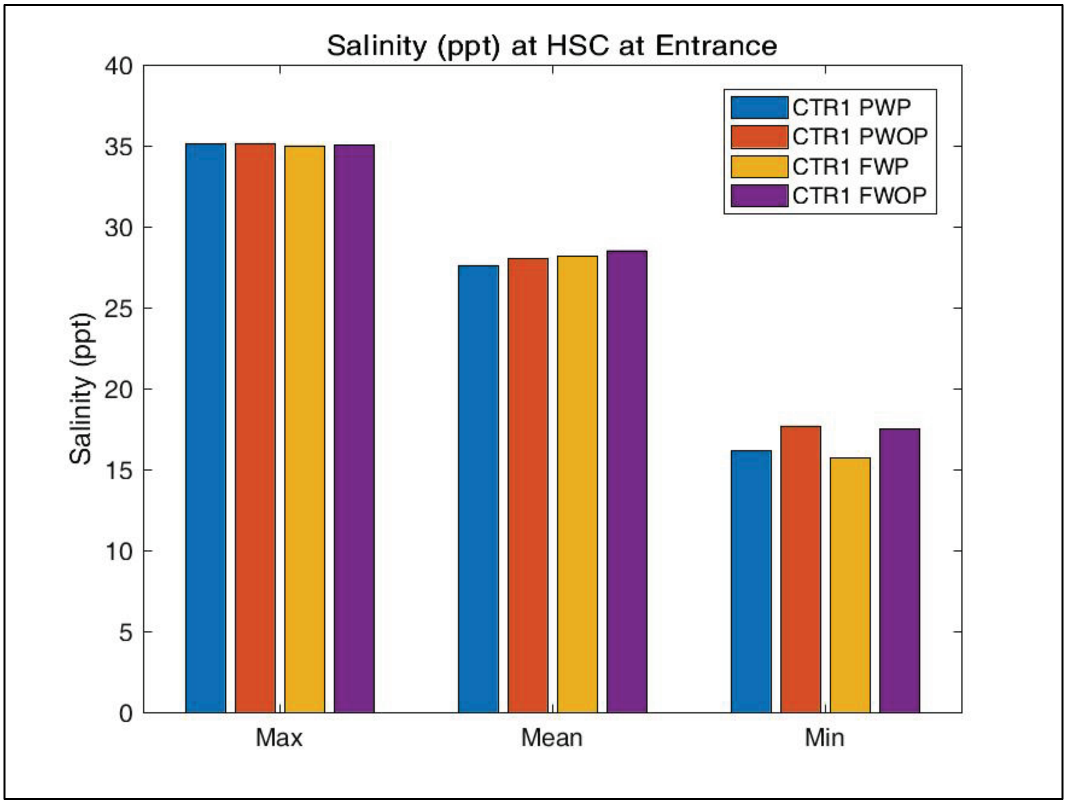
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at HSC at Bolivar Roads
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
18
20
22
24
26
28
30
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Entrance
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
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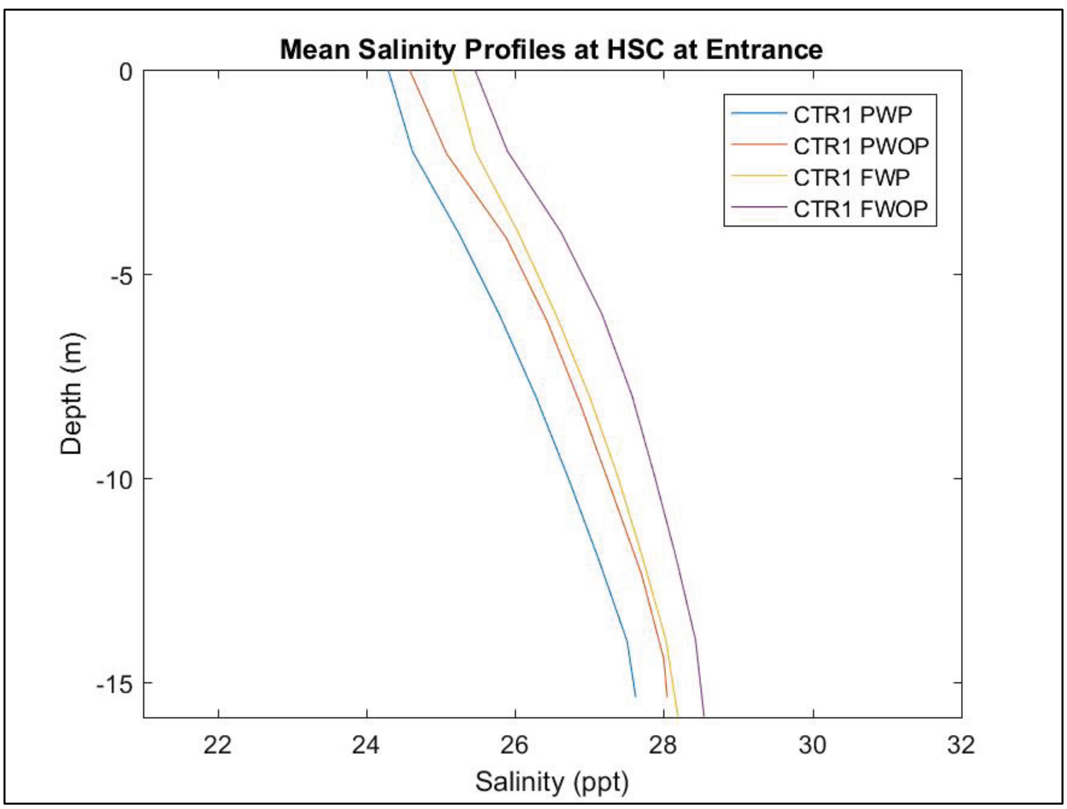
35
30
25
20
15
10
5
0
Max
Mean
Min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Depth (m)
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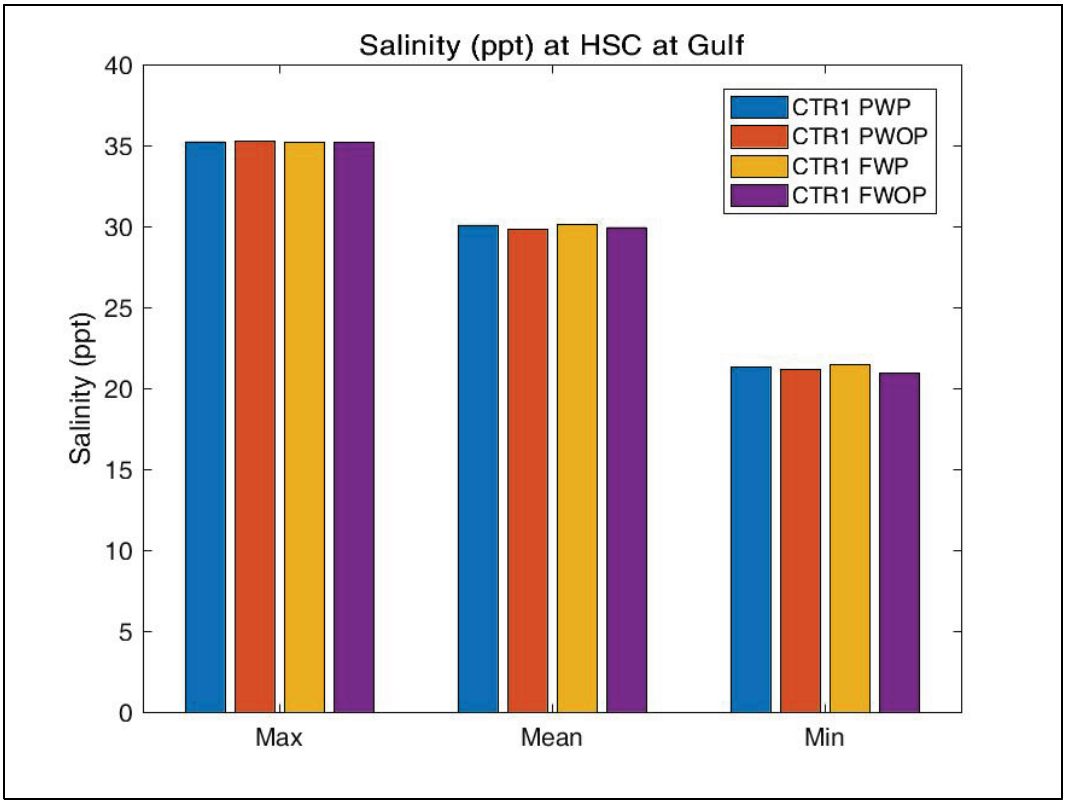
22
24
26
28
30
32
Salinity (ppt)


Salinity (ppt) at HSC at Gulf
Salinity (ppt)
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35
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Max
Mean
Min
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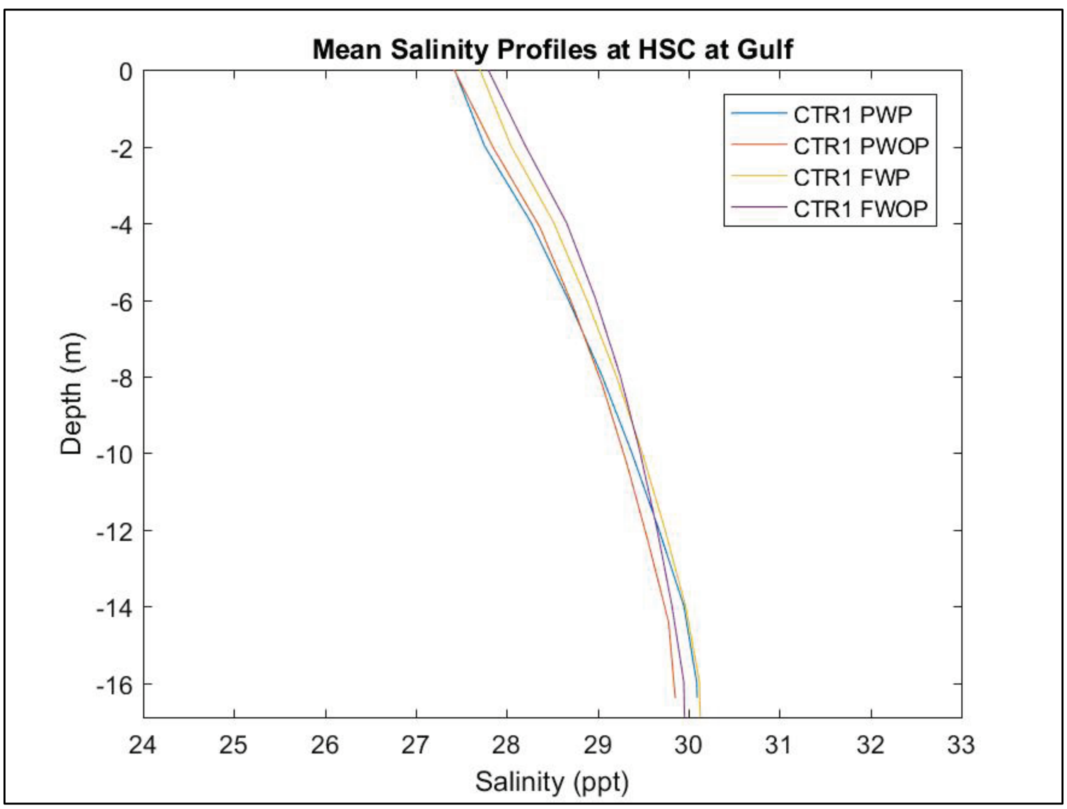
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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-14
-16
24
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31
32
33
Salinity (ppt)
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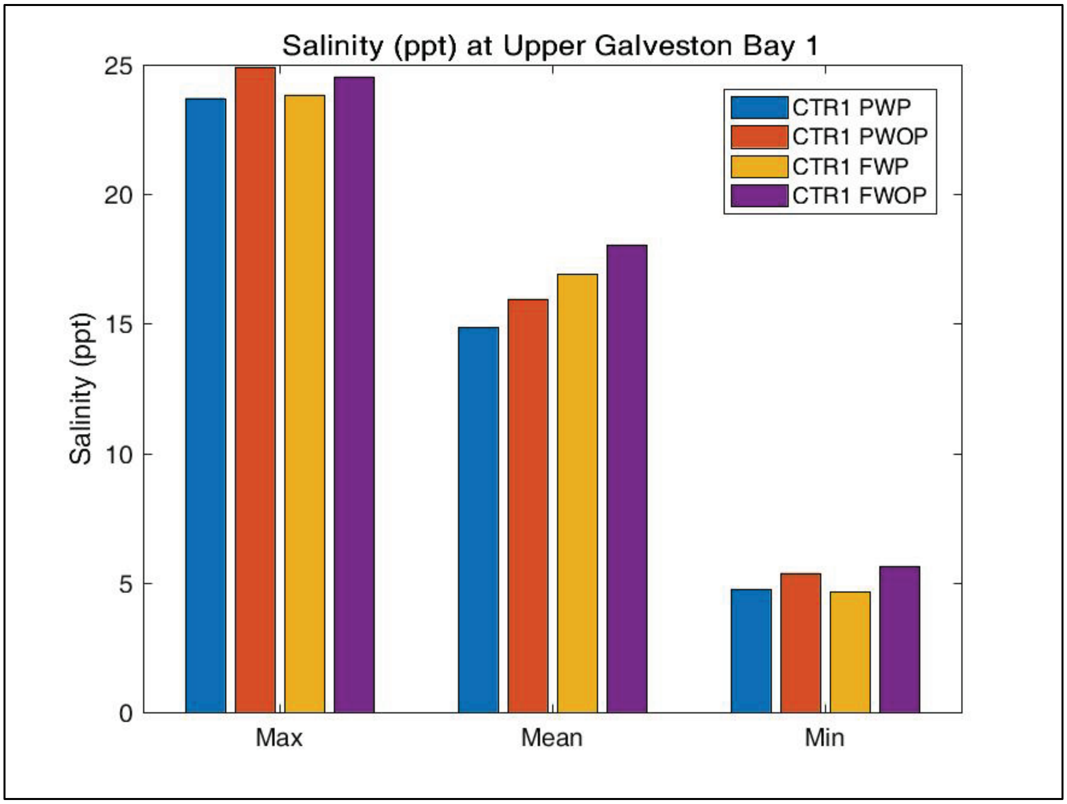
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Upper Galveston Bay 1
Salinity (ppt)
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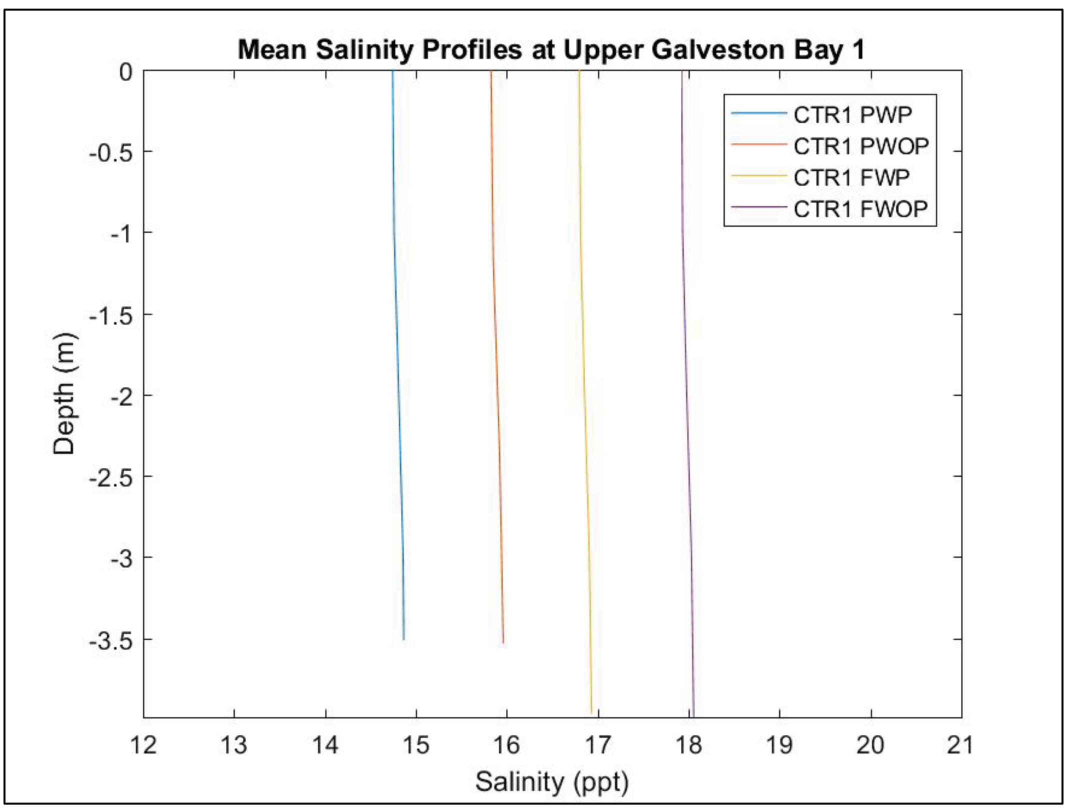
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at Upper Galveston Bay 1
Depth (m)
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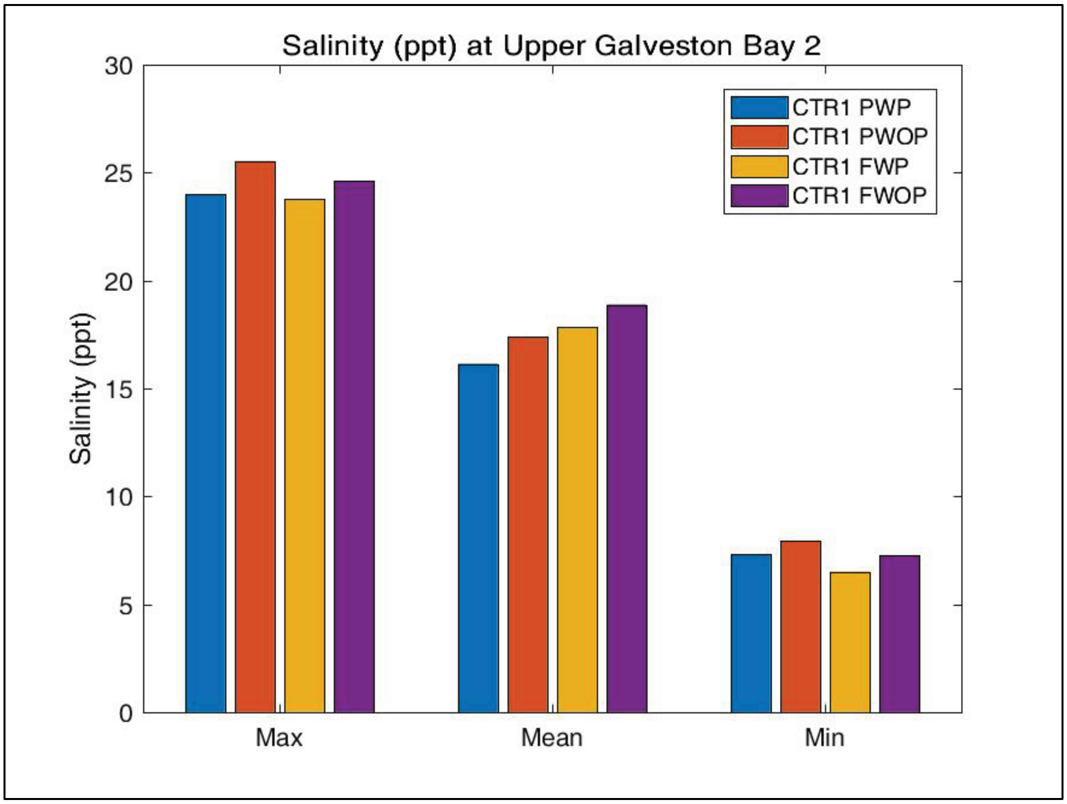
-2
-2.5
-3
-3.5
12
13
14
15
16
17
18
19
20
21
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Mean
Min
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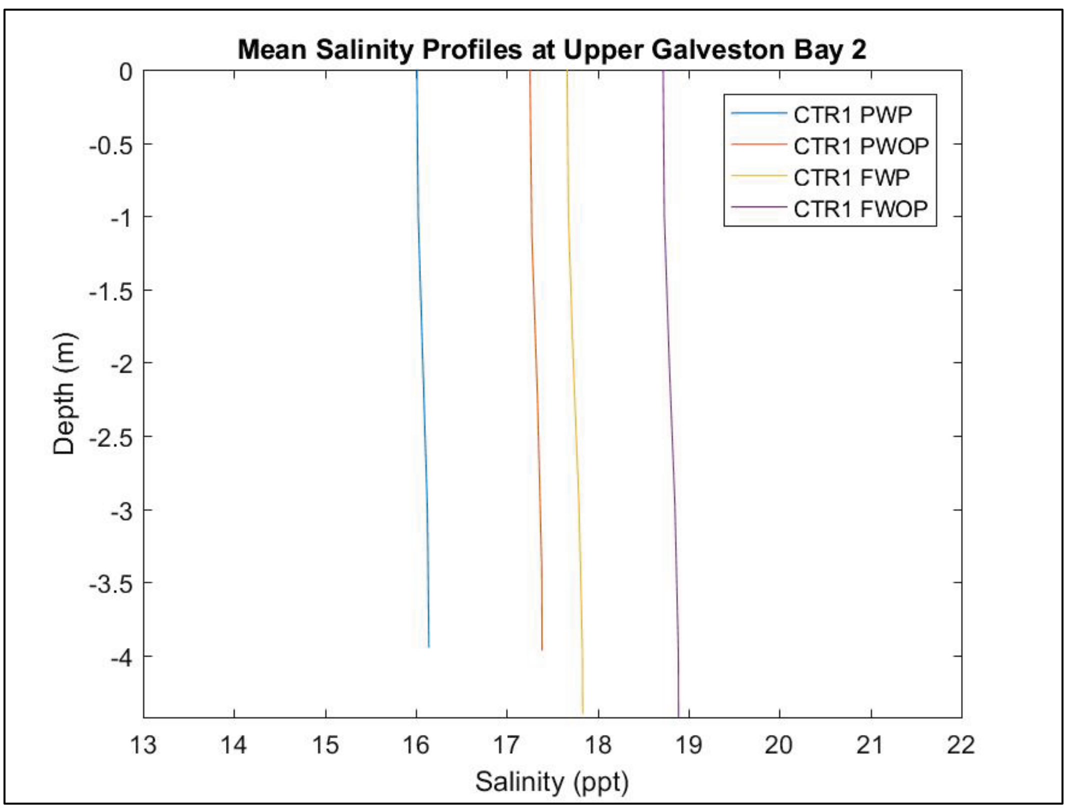
CTR1 FWP
CTR1 FWOP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-3
-3.5
-4
13
14
15
16
17
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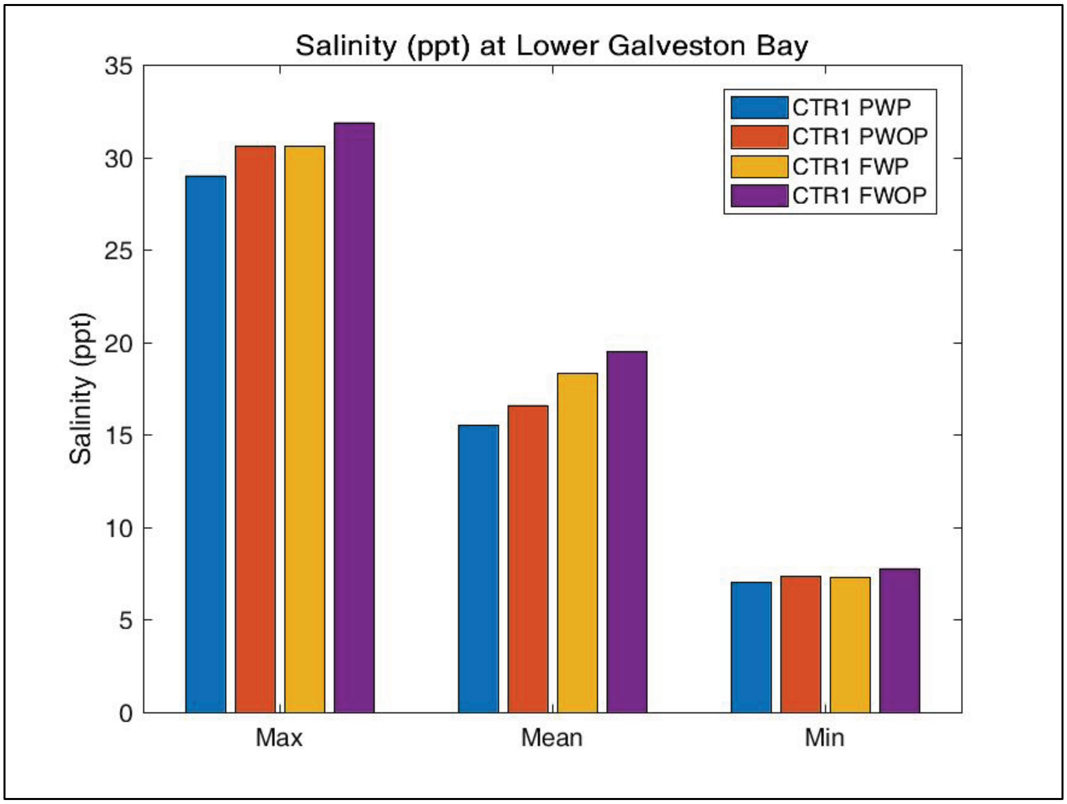
19
20
21
22
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Salinity (ppt)
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25
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10
5
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Max
Mean
Min
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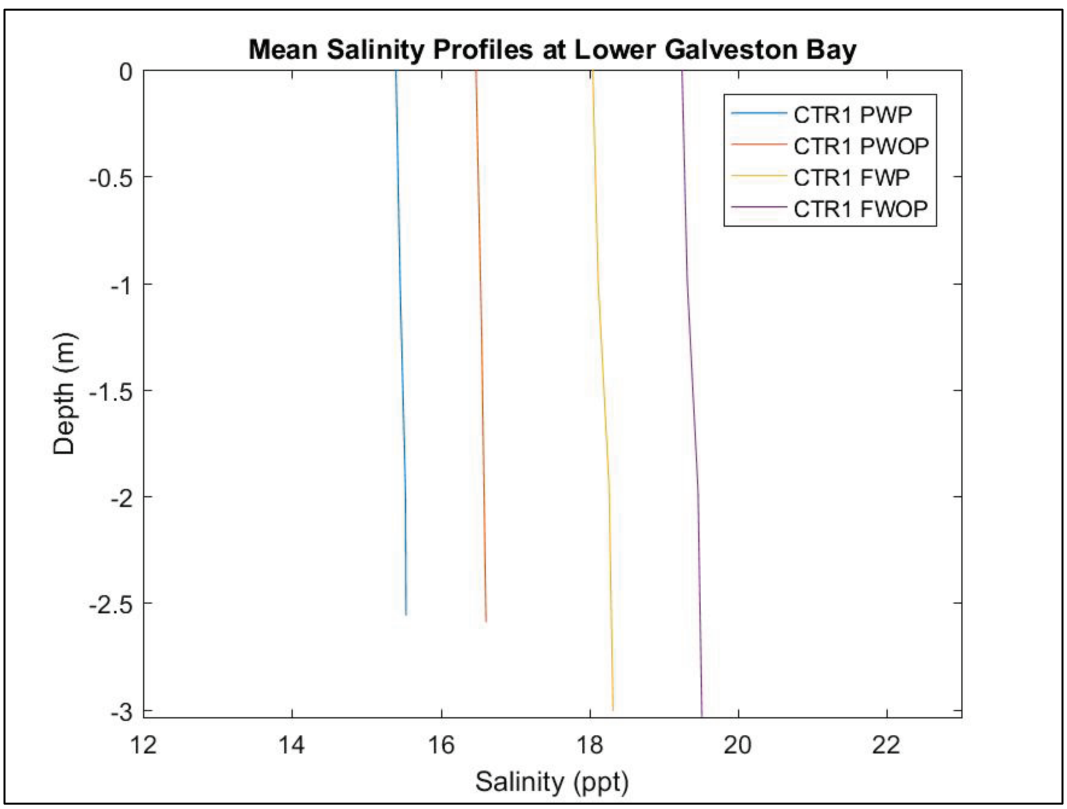
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at Lower Galveston Bay
Depth (m)
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-2.5
-3
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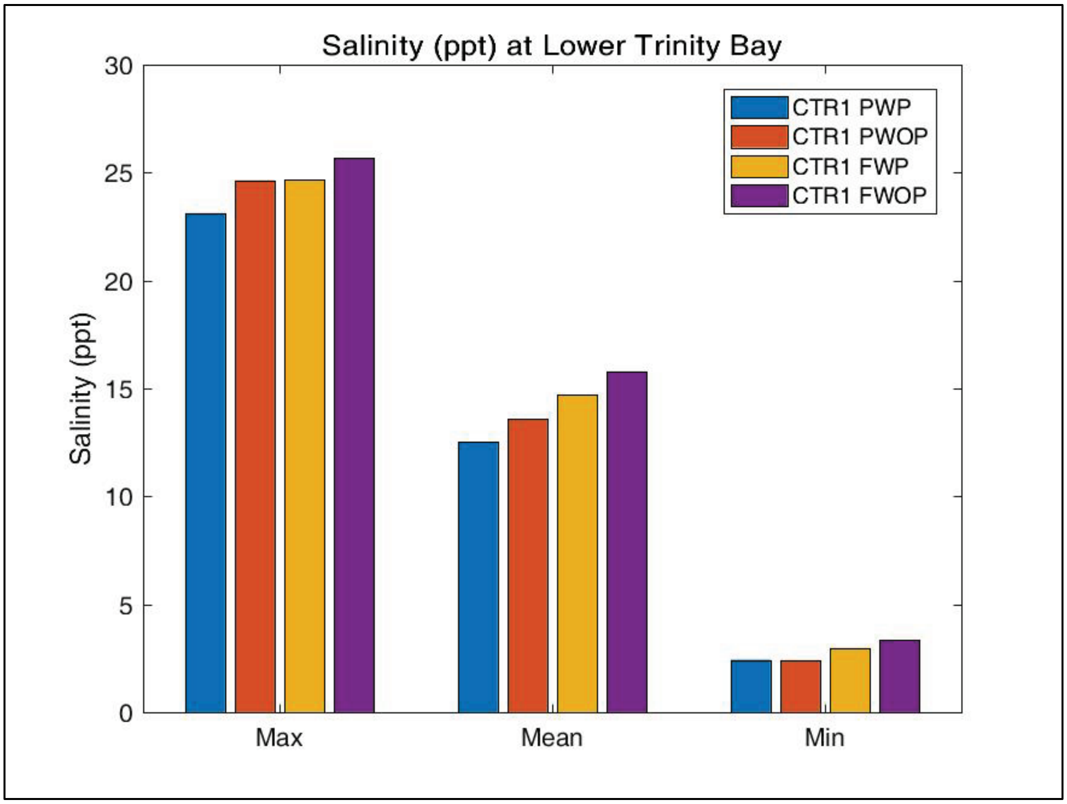
14
16
18
20
22
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Salinity (ppt)
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25
20
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Max
Mean
Min
CTR1 PWP
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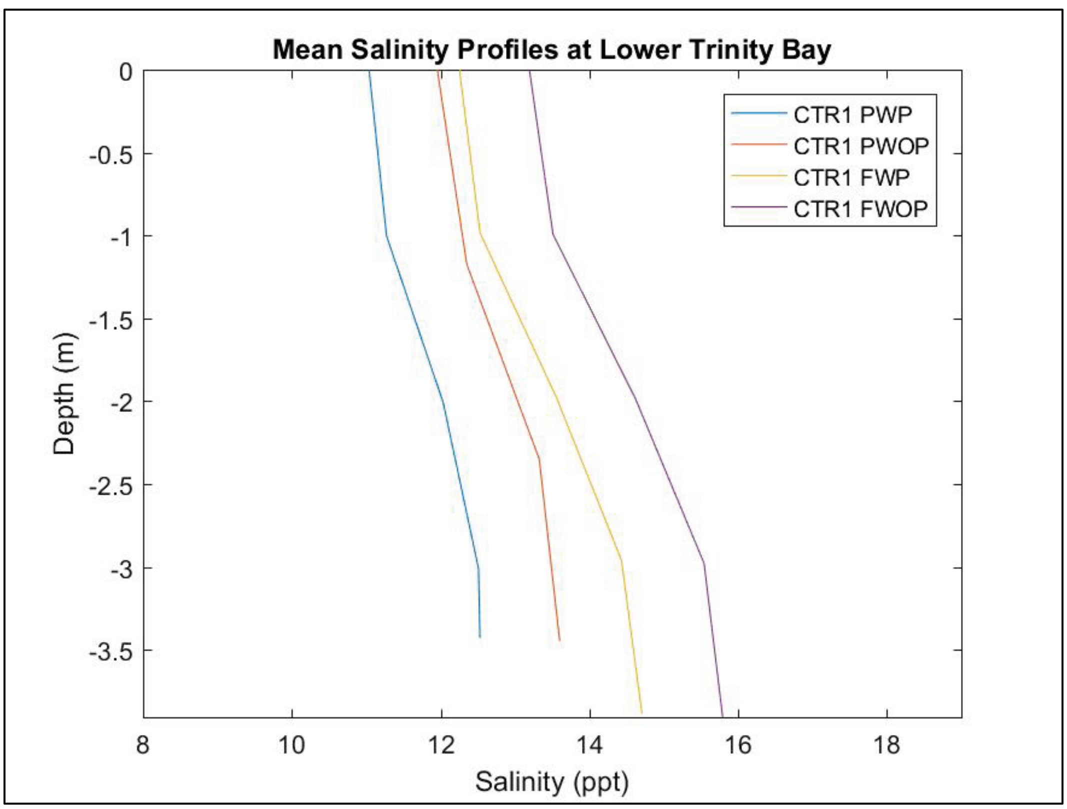
CTR1 FWP
CTR1 FWOP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Depth (m)
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-2
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-3
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10
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14
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18
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
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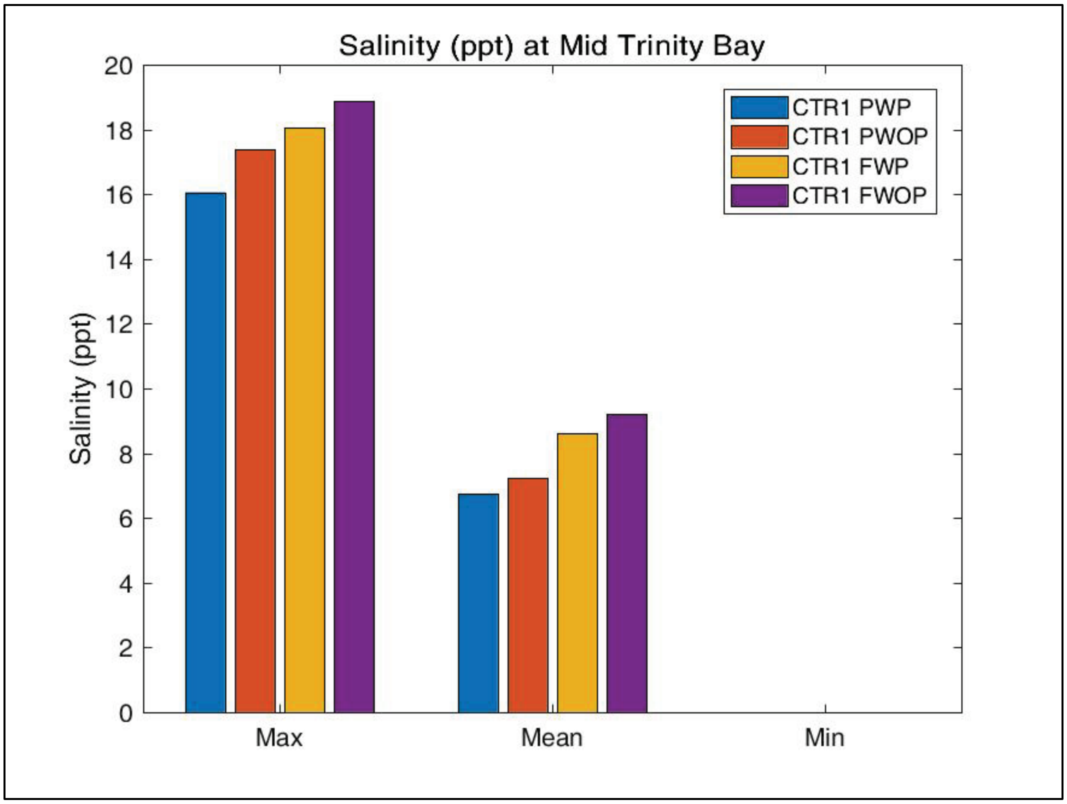
CTR1 FWOP


Salinity (ppt) at Mid Trinity Bay
Salinity (ppt)
20
18
16
14
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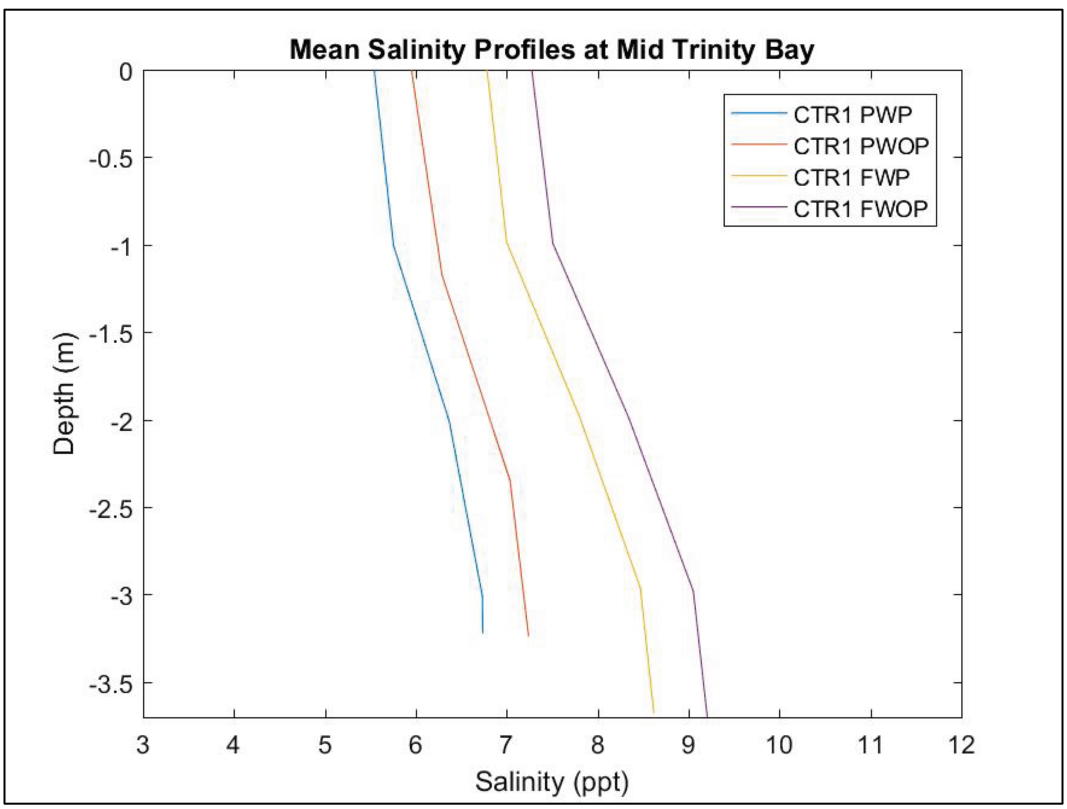
10
8
6
4
2
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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Depth (m)
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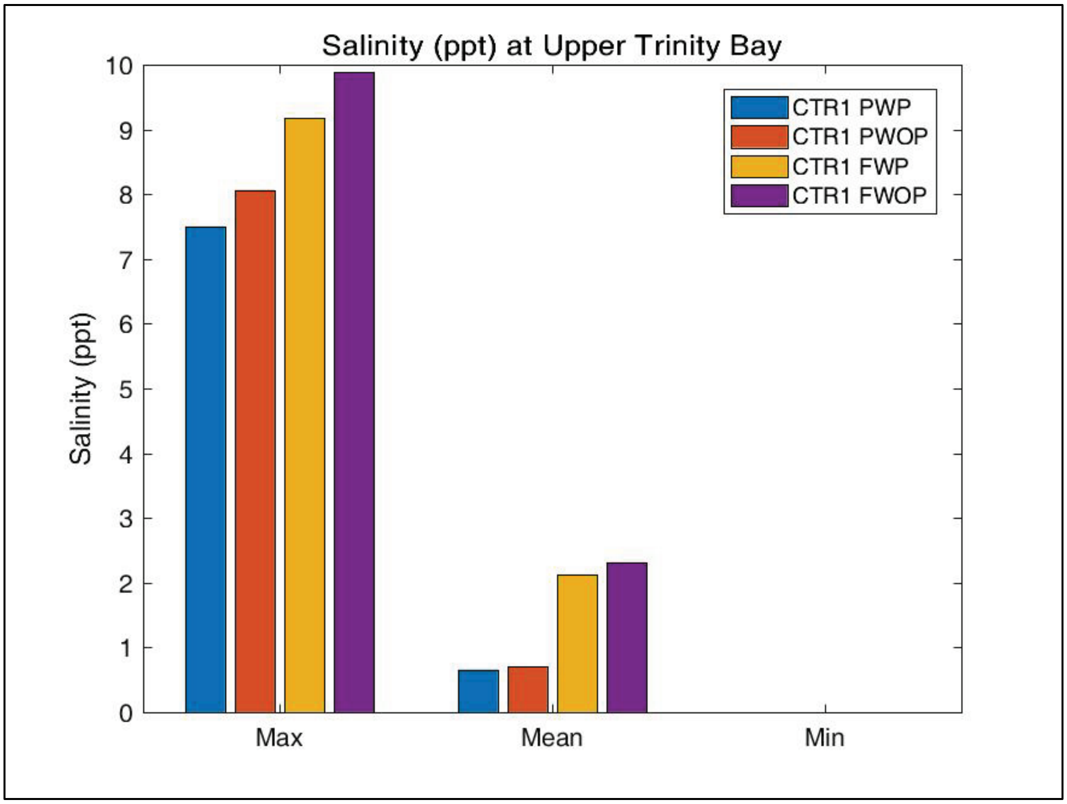
-1.5
-2
-2.5
-3
-3.5
3
4
5
6
7
8
9
10
11
12
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP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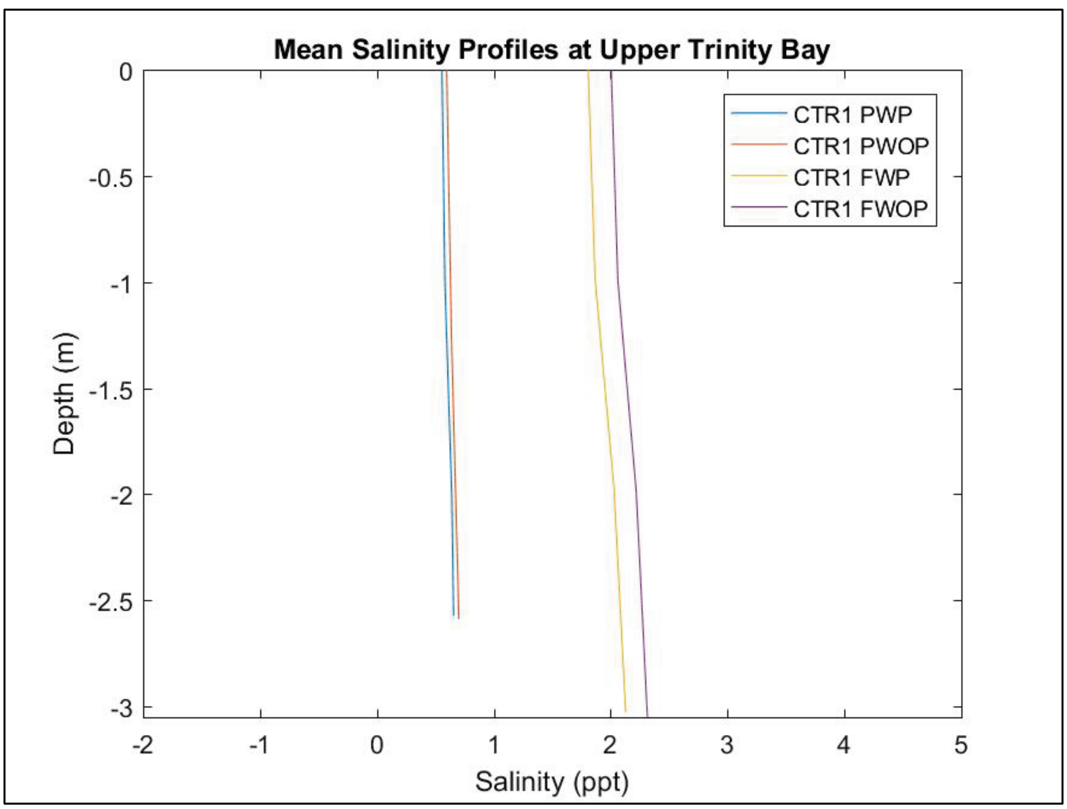
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Depth (m)
0
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-1.5
-2
-2.5
-3
-2
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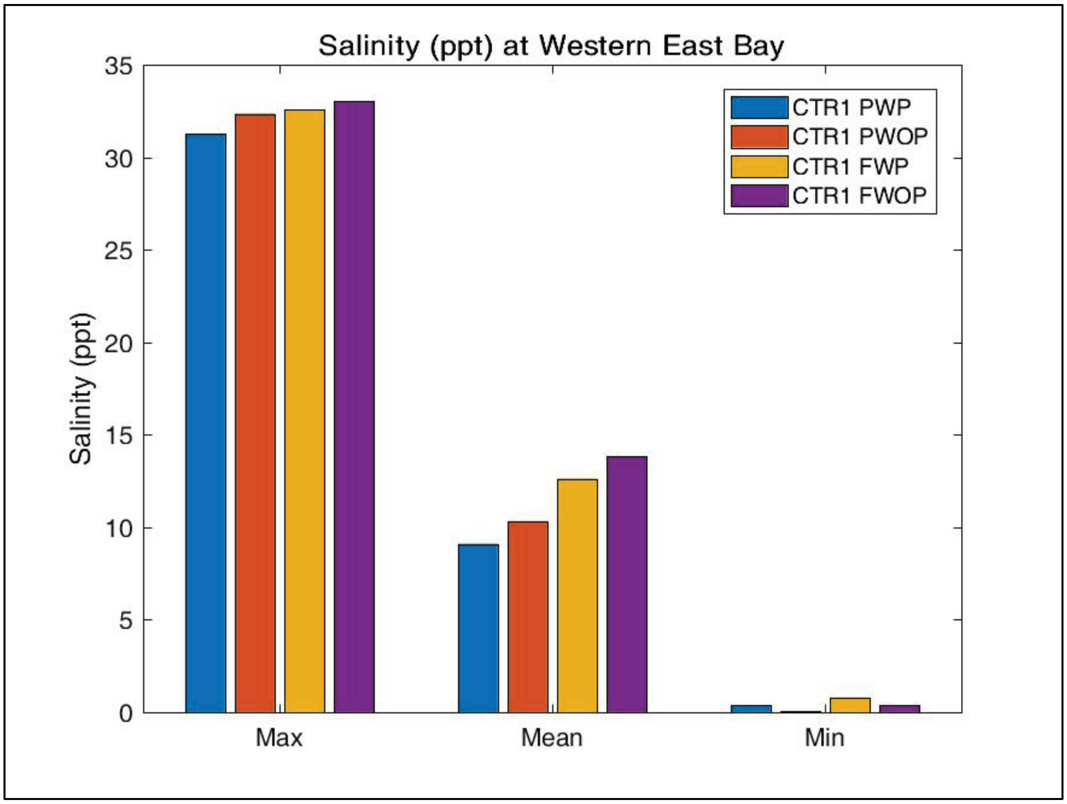
2
3
4
5
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Western East Bay
Salinity (ppt)
35
30
25
20
15
10
5
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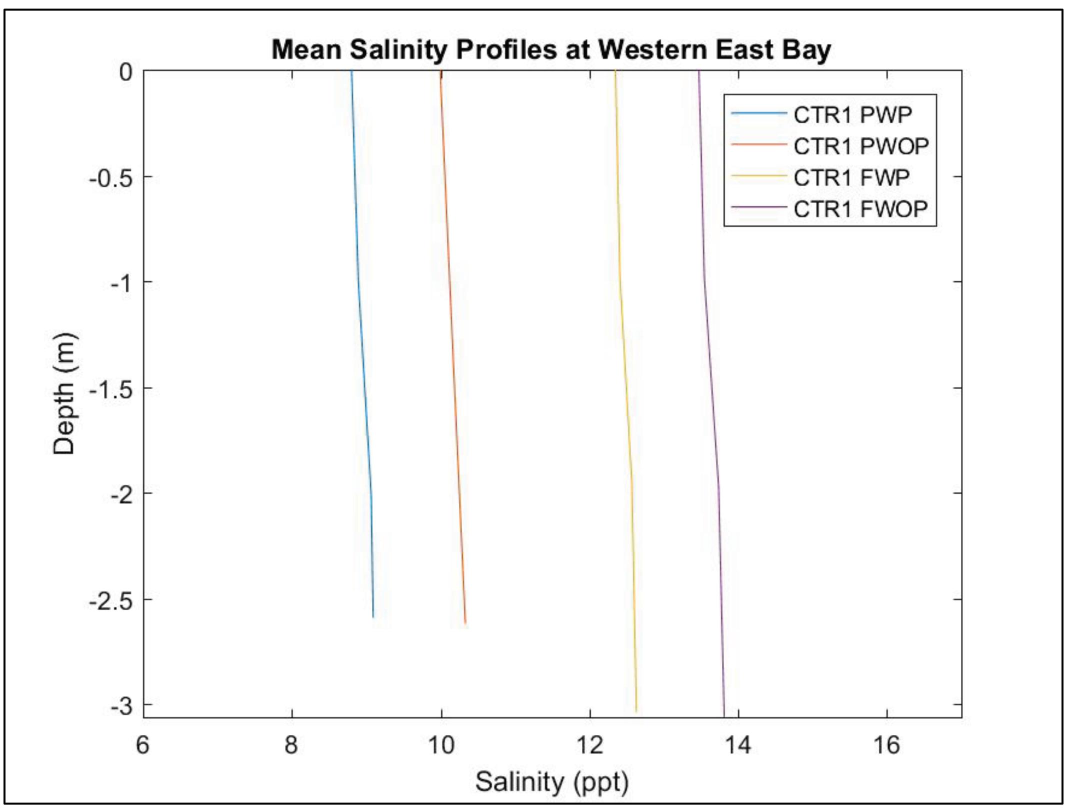
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at Western East Bay
Depth (m)
0
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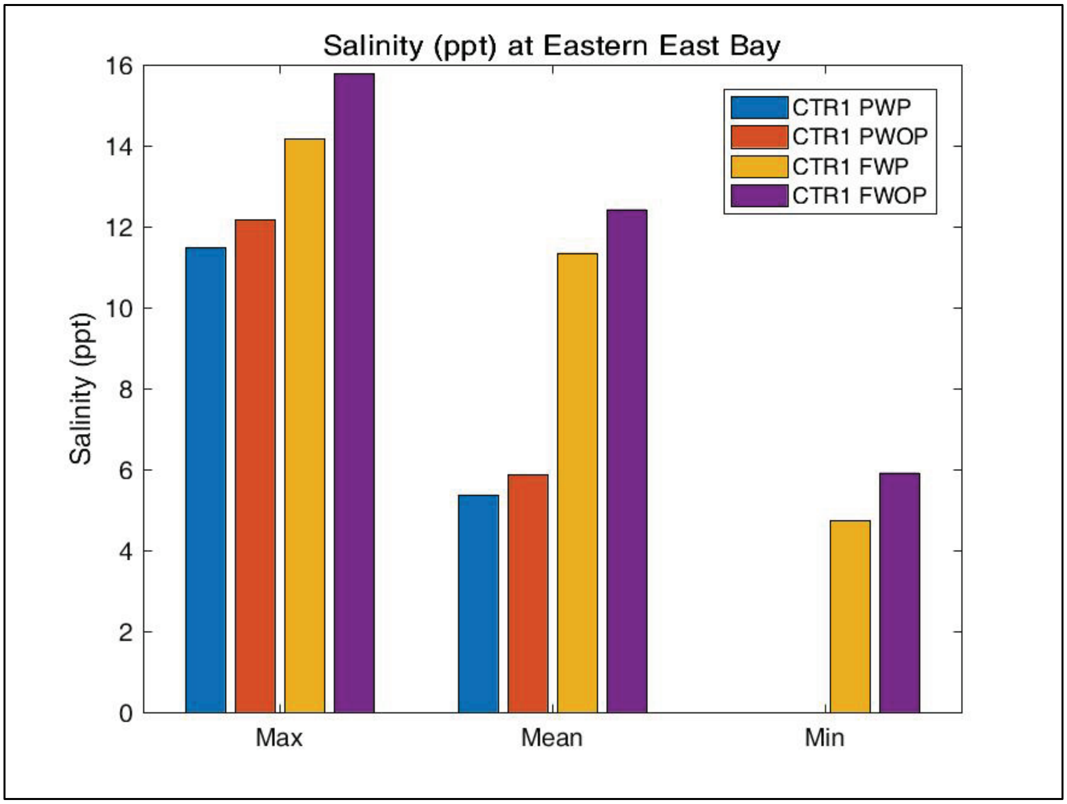
-1
-1.5
-2
-2.5
-3
6
8
10
12
14
16
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Eastern East Bay
Salinity (ppt)
0
2
4
6
8
10
12
14
16
Max
Mean
Min
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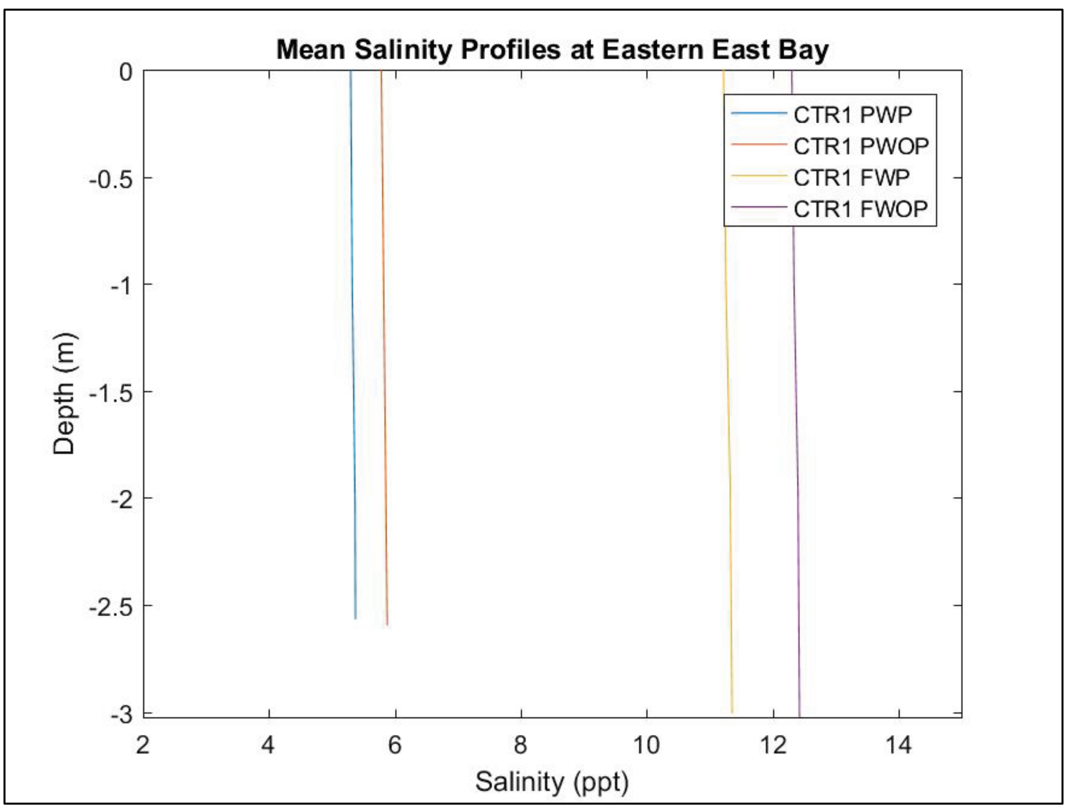
CTR1 FWP
CTR1 FWOP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Depth (m)
0
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-1
-1.5
-2
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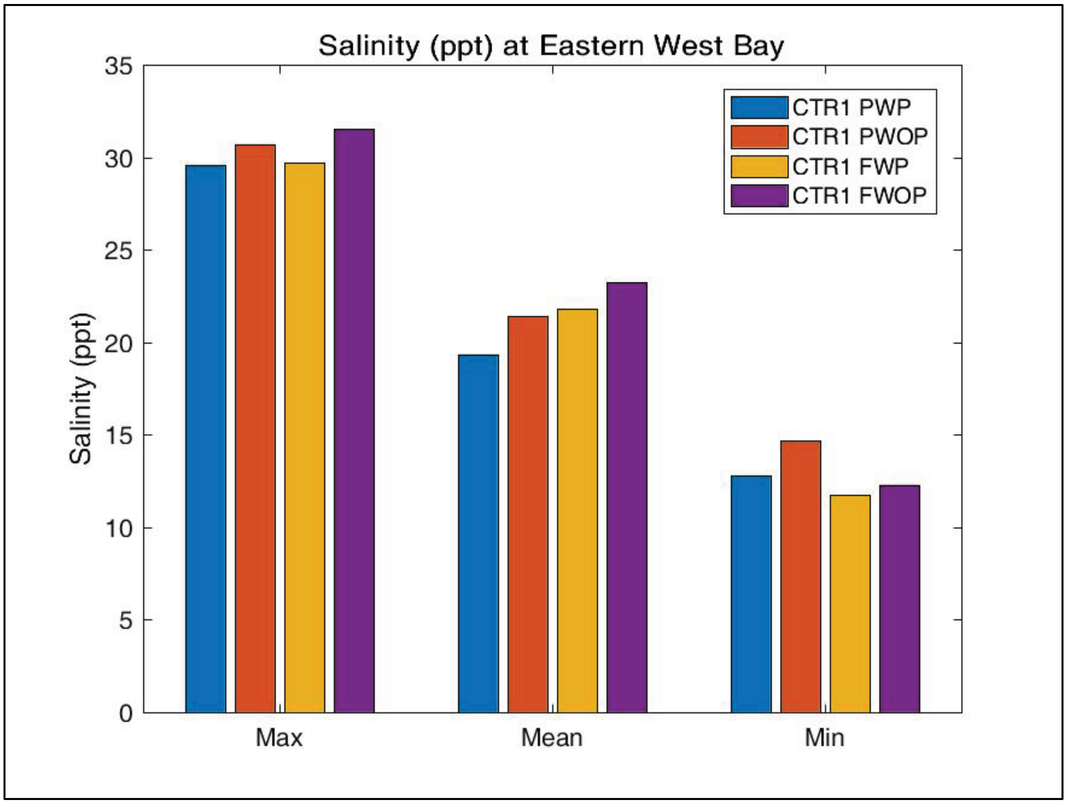
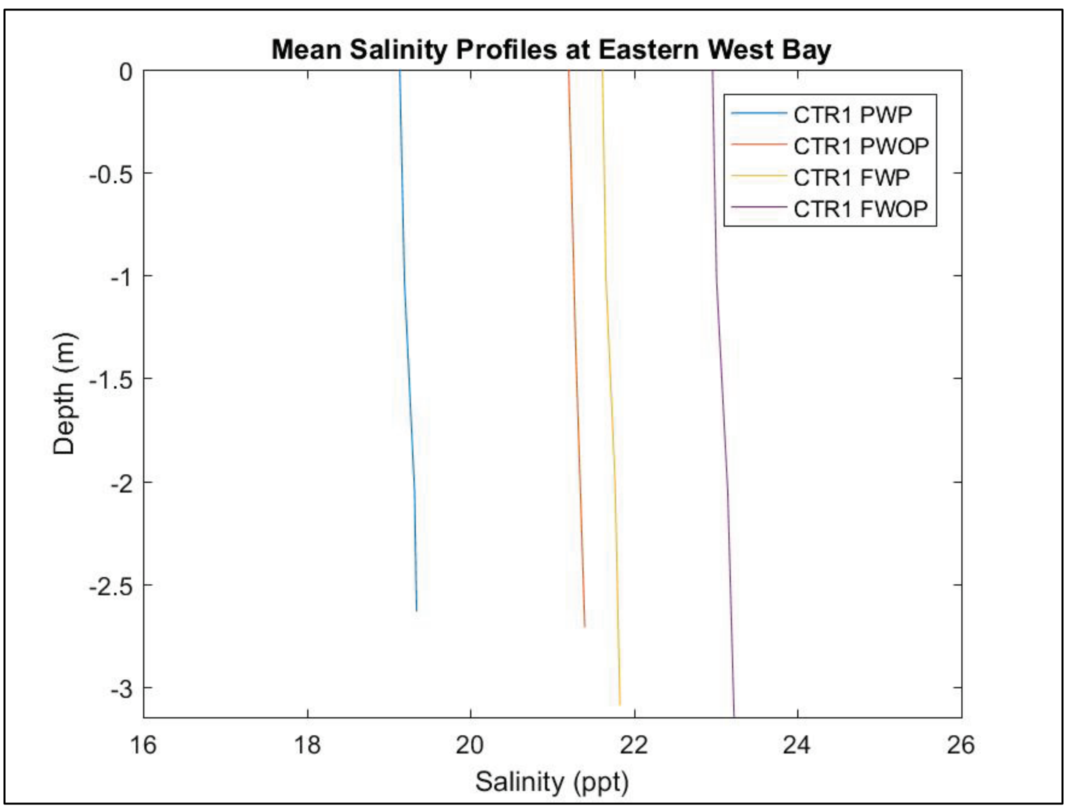
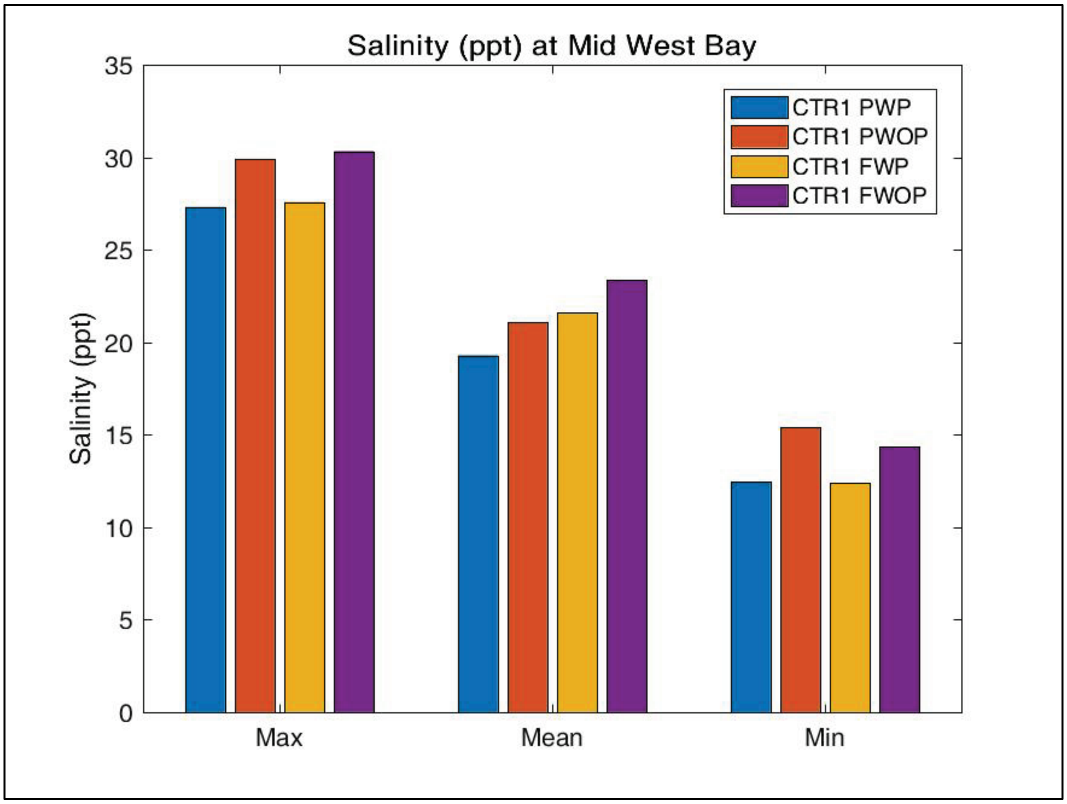
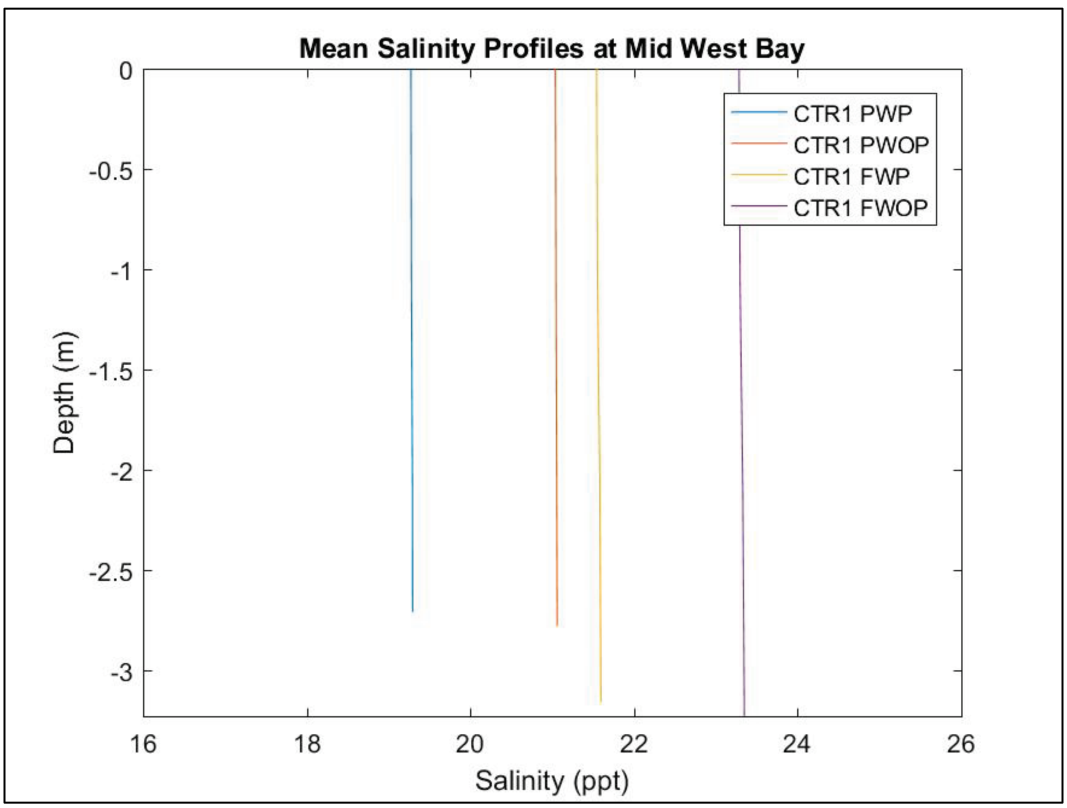
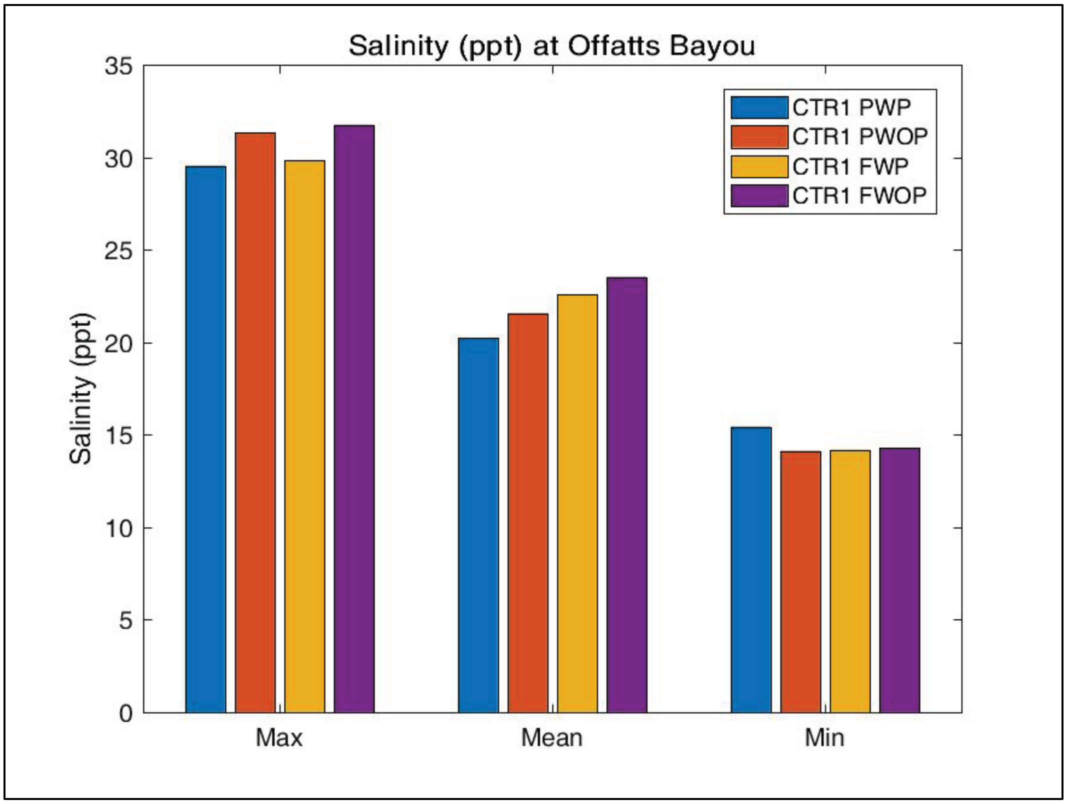
-3
Salinity (ppt)
2
4
6
8
10
12
14
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

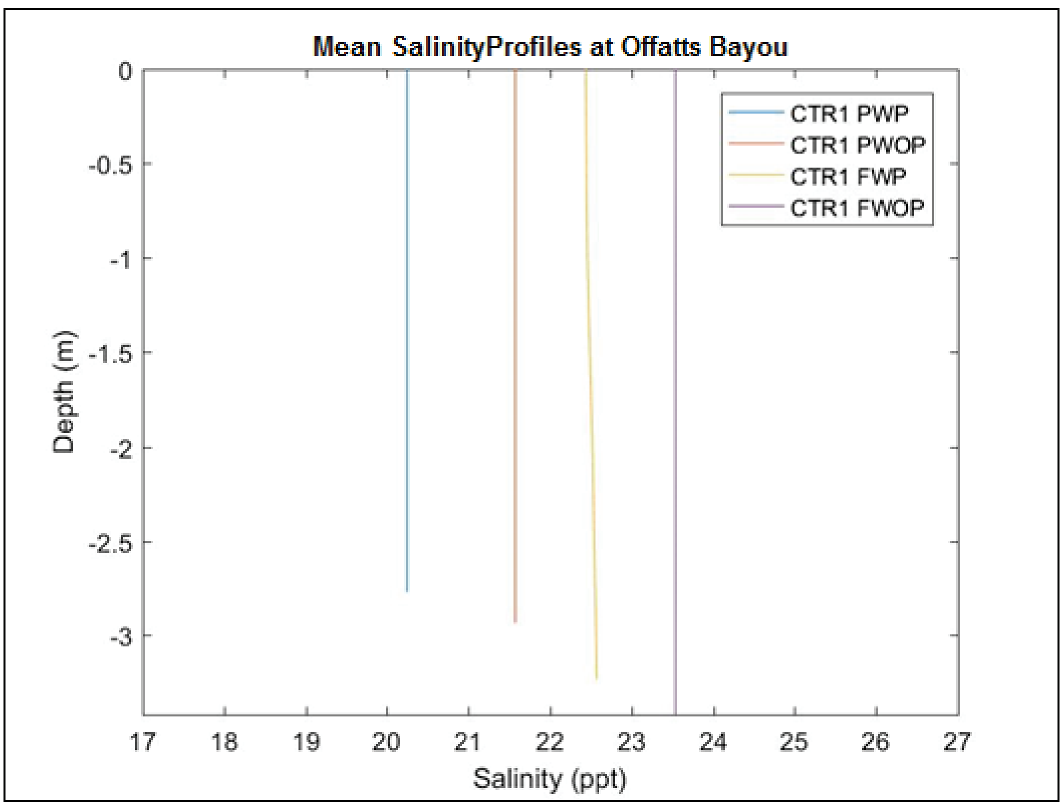

Salinity (ppt) at Eastern West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

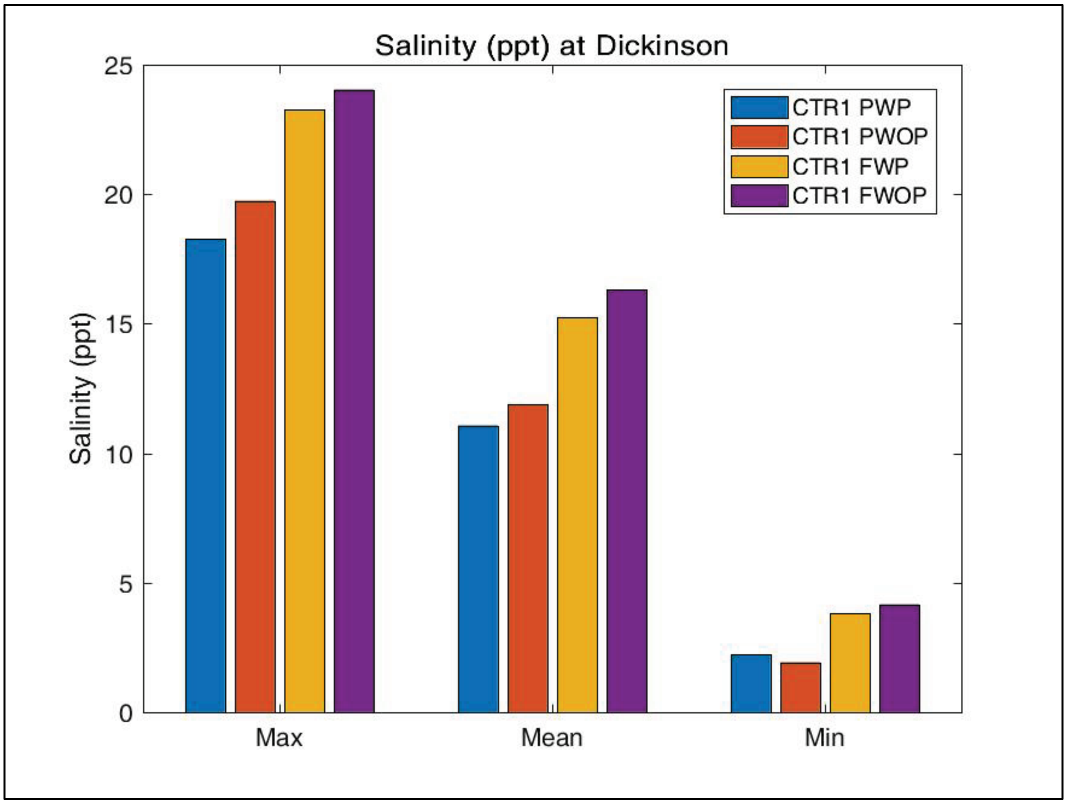

Mean Salinity Profiles at Eastern West Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
16
18
20
22
24
26
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

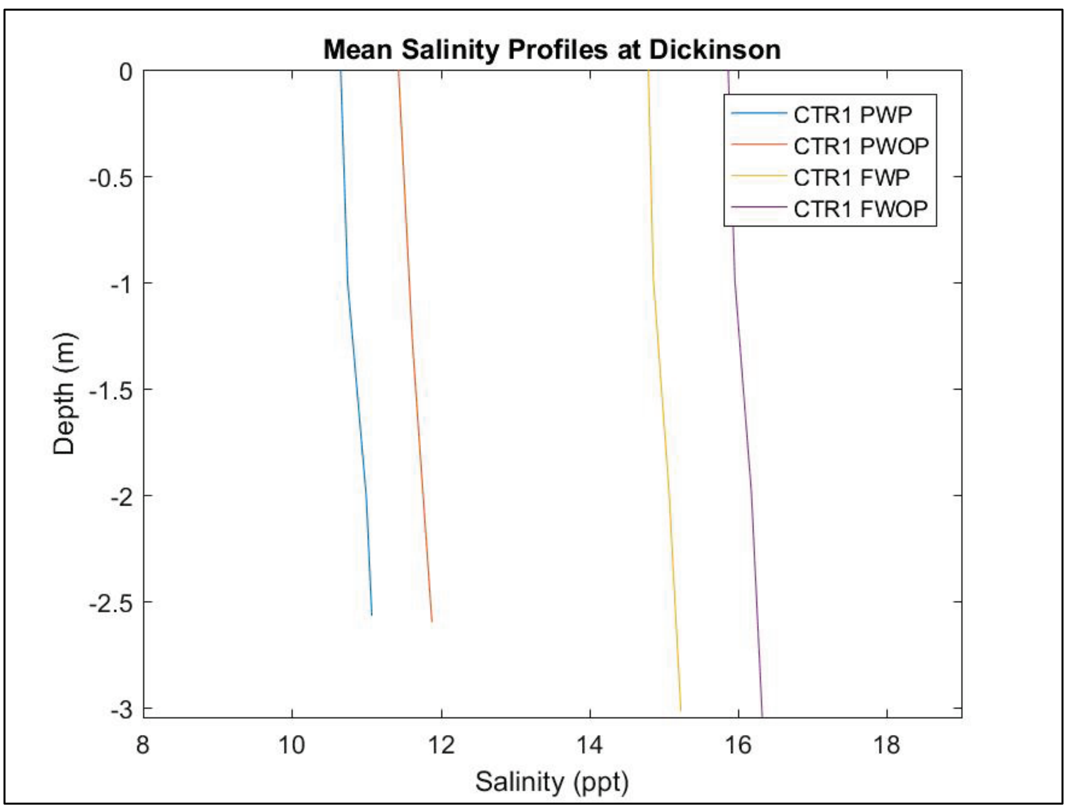

Salinity (ppt) at Mid West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

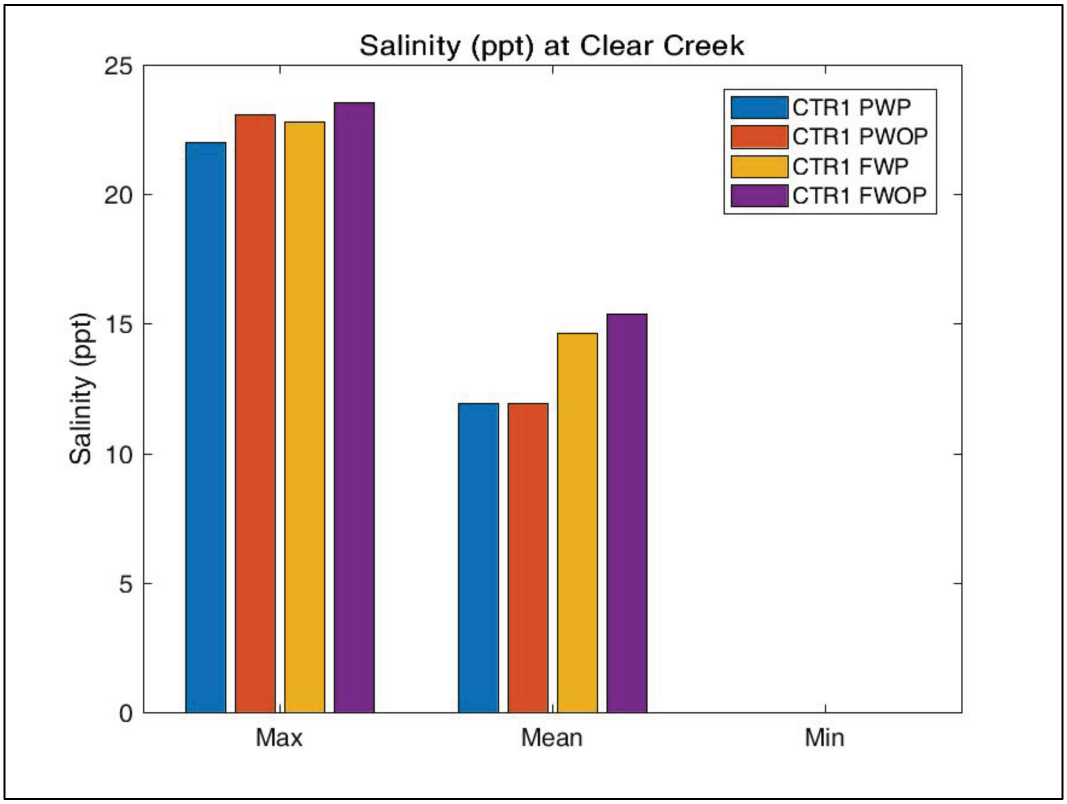

Mean Salinity Profiles at Mid West Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
16
18
20
22
24
26
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

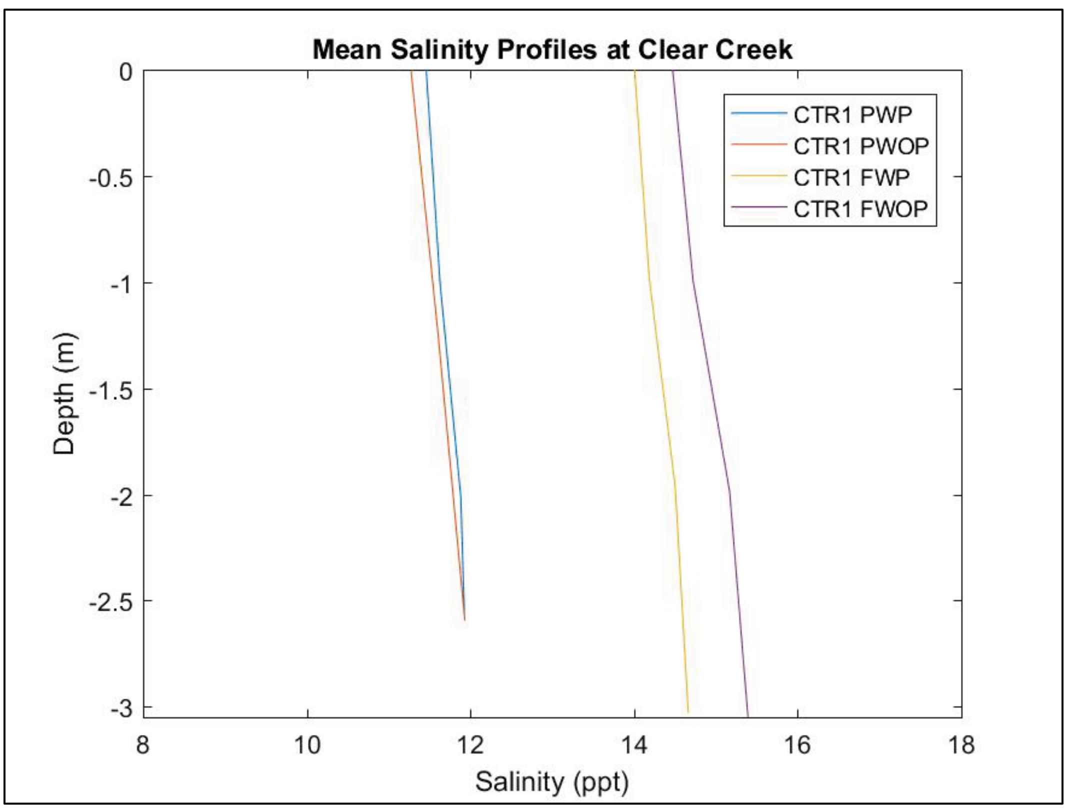

Salinity (ppt) at Offatts Bayou
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Max
Mean
Min
0
5
10
15
20
25
30
35

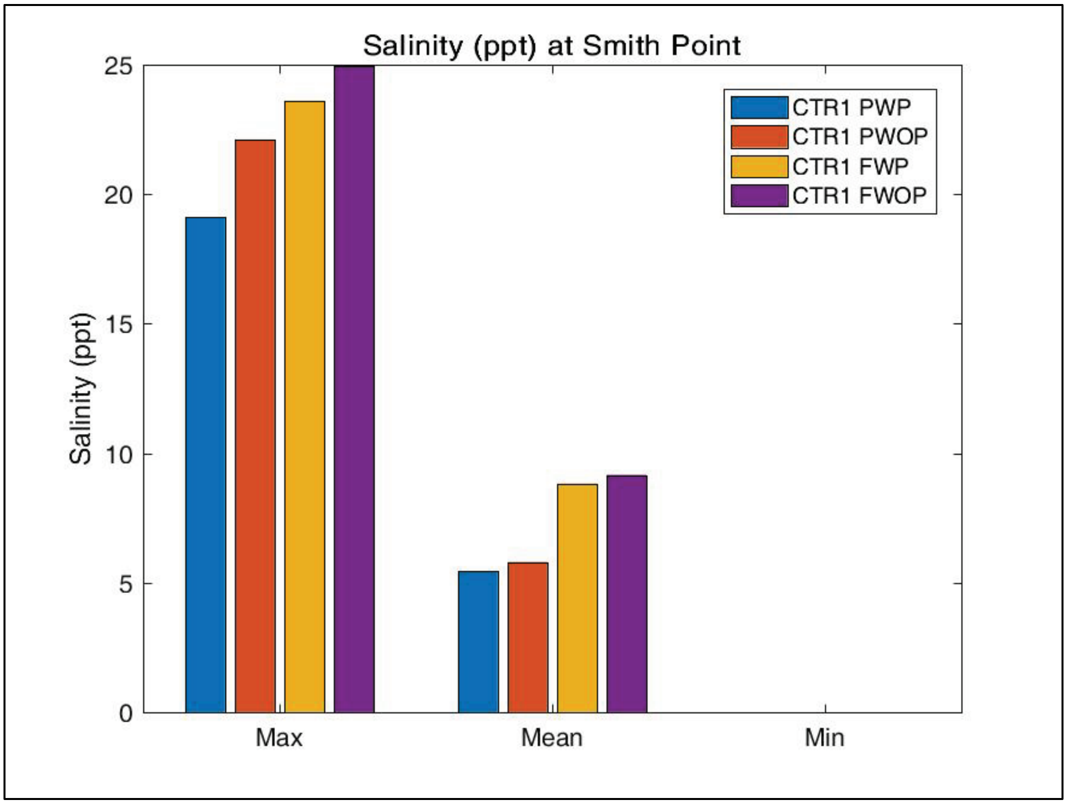

Mean SalinityProfiles at Offatts Bayou
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-0.5
-1
-1.5
-2
-2.5
-3
17
18
19
20
21
22
23
24
25
26
27

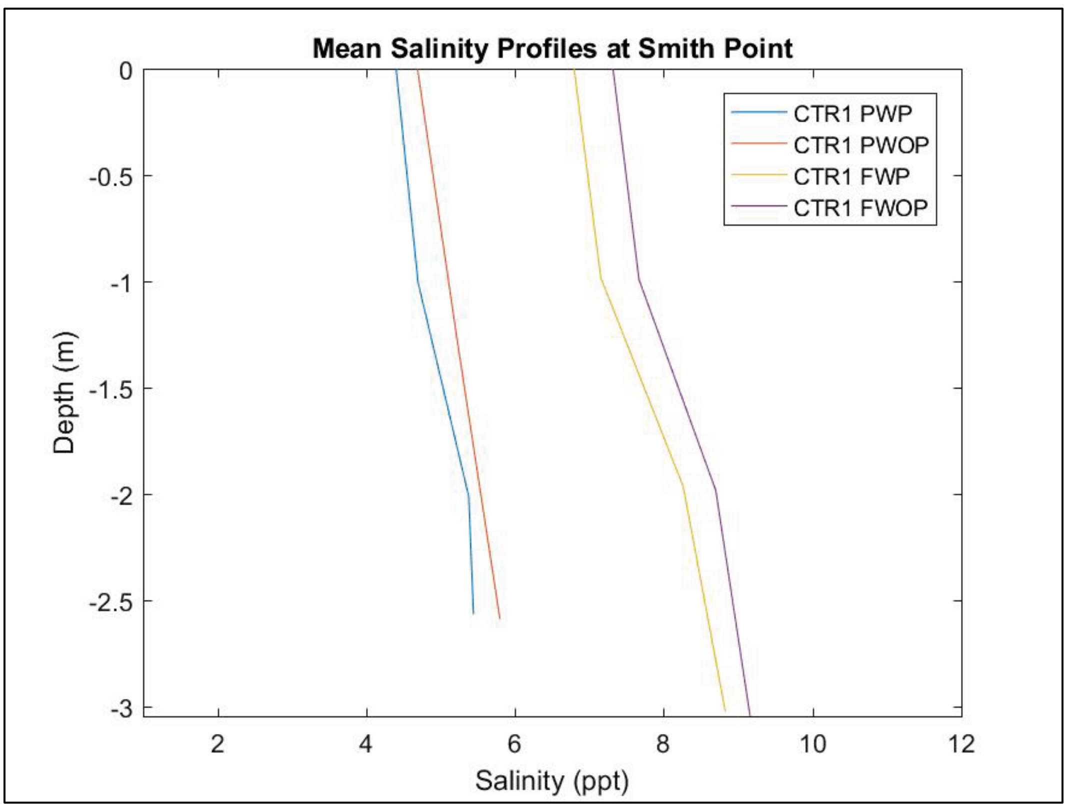

Salinity (ppt) at Dickinson
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

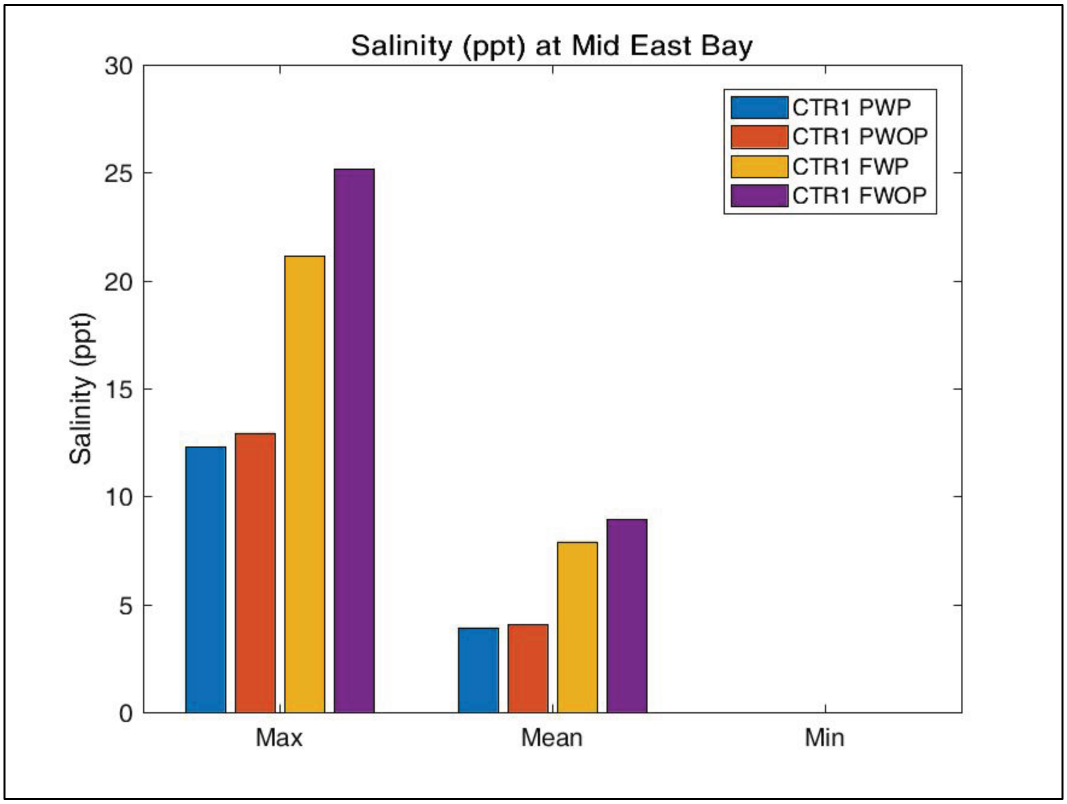

Mean Salinity Profiles at Dickinson
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
8
10
12
14
16
18
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

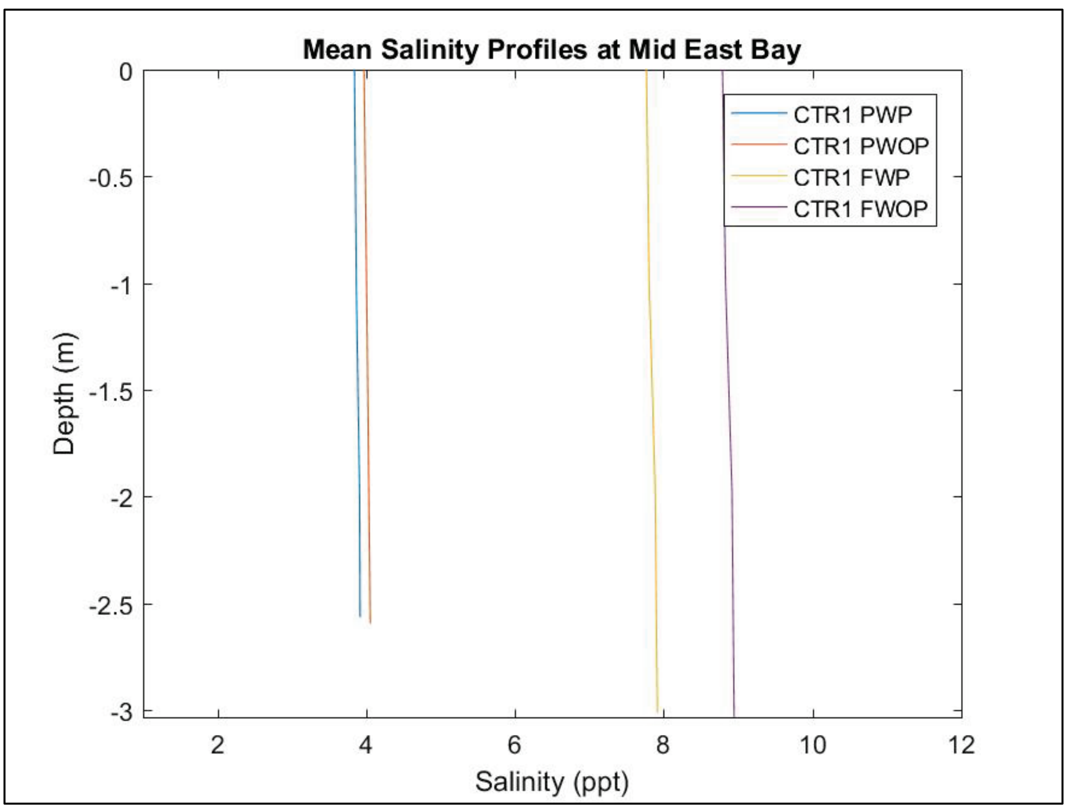

Salinity (ppt) at Clear Creek
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

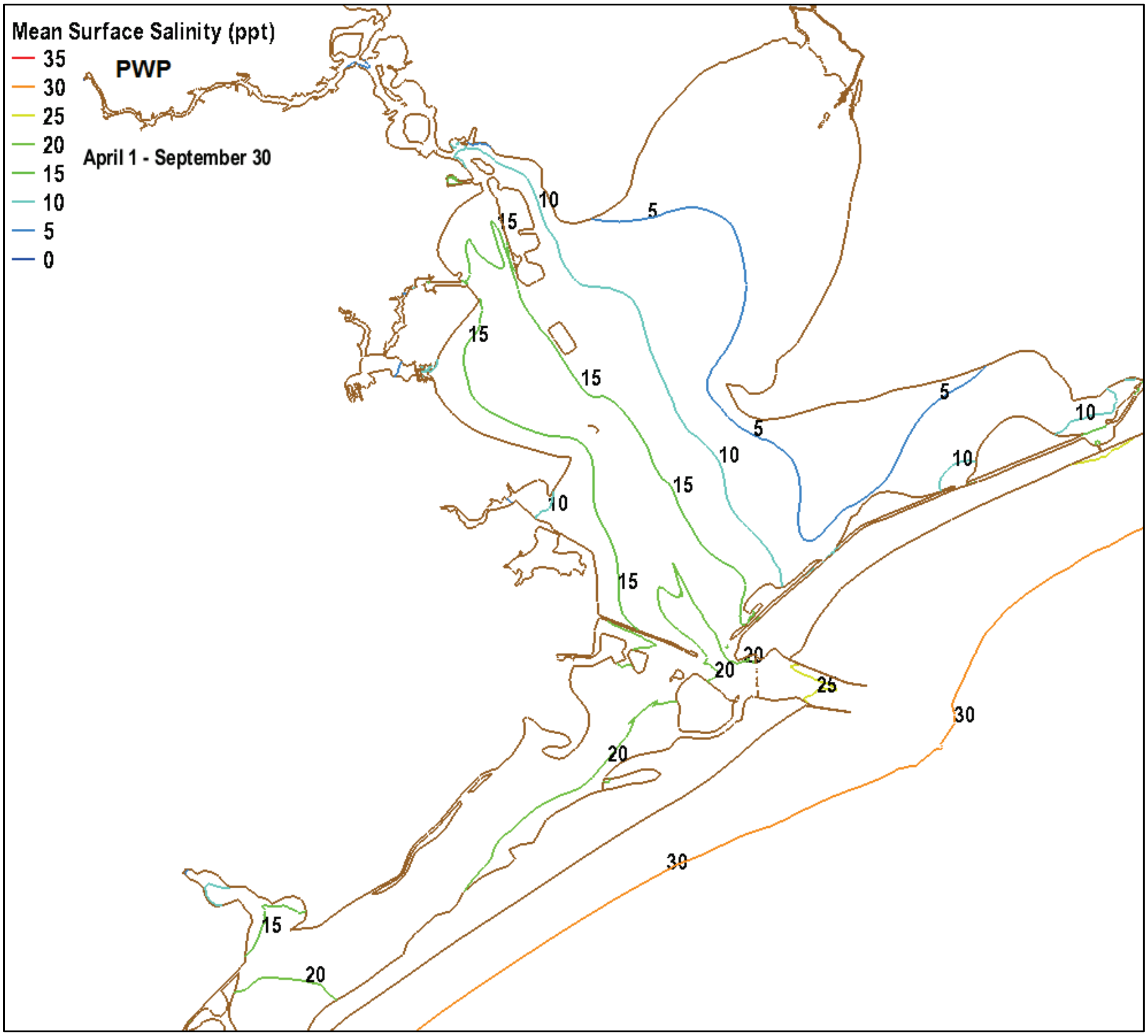

Mean Salinity Profiles at Clear Creek
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
8
10
12
14
16
18
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

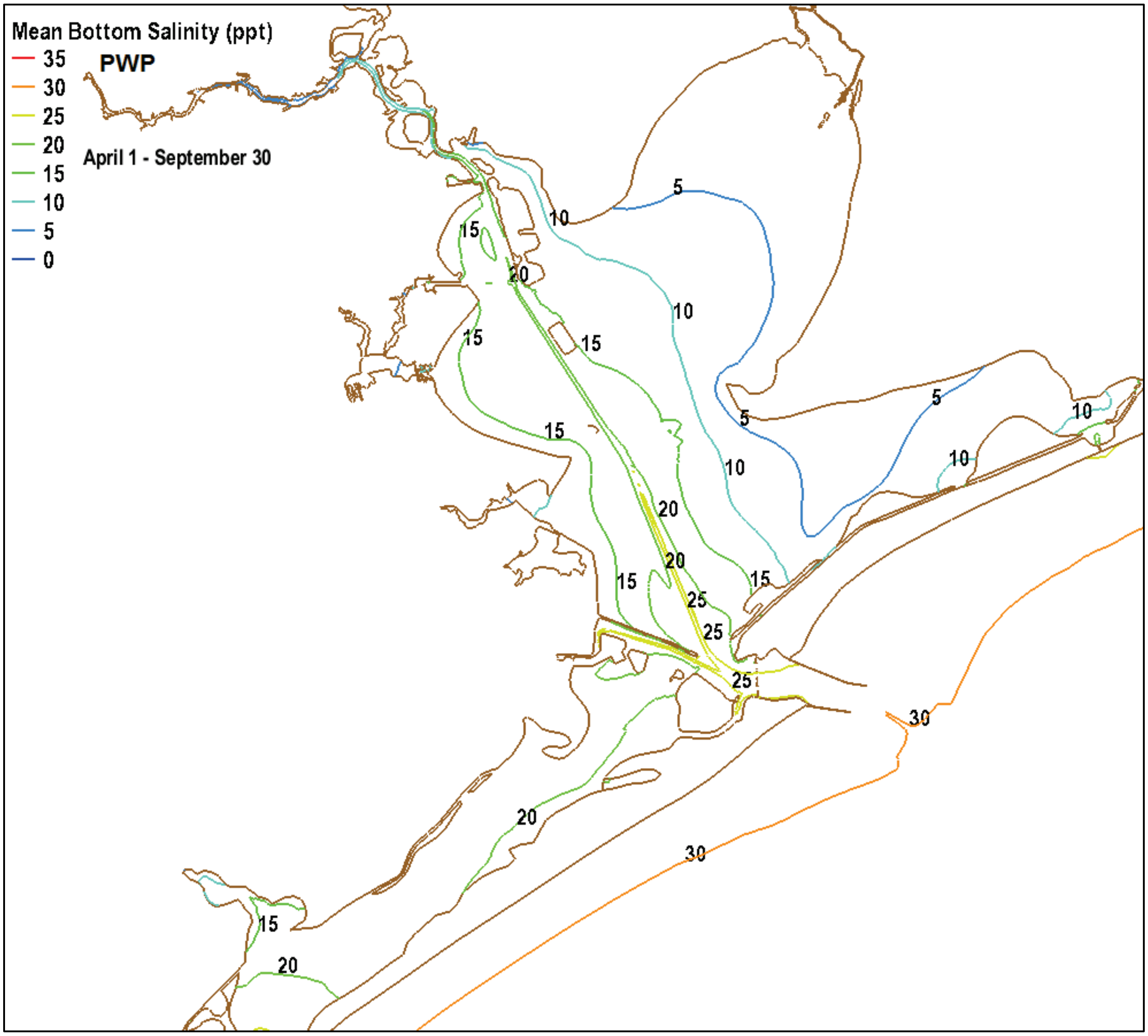

Salinity (ppt) at Smith Point
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

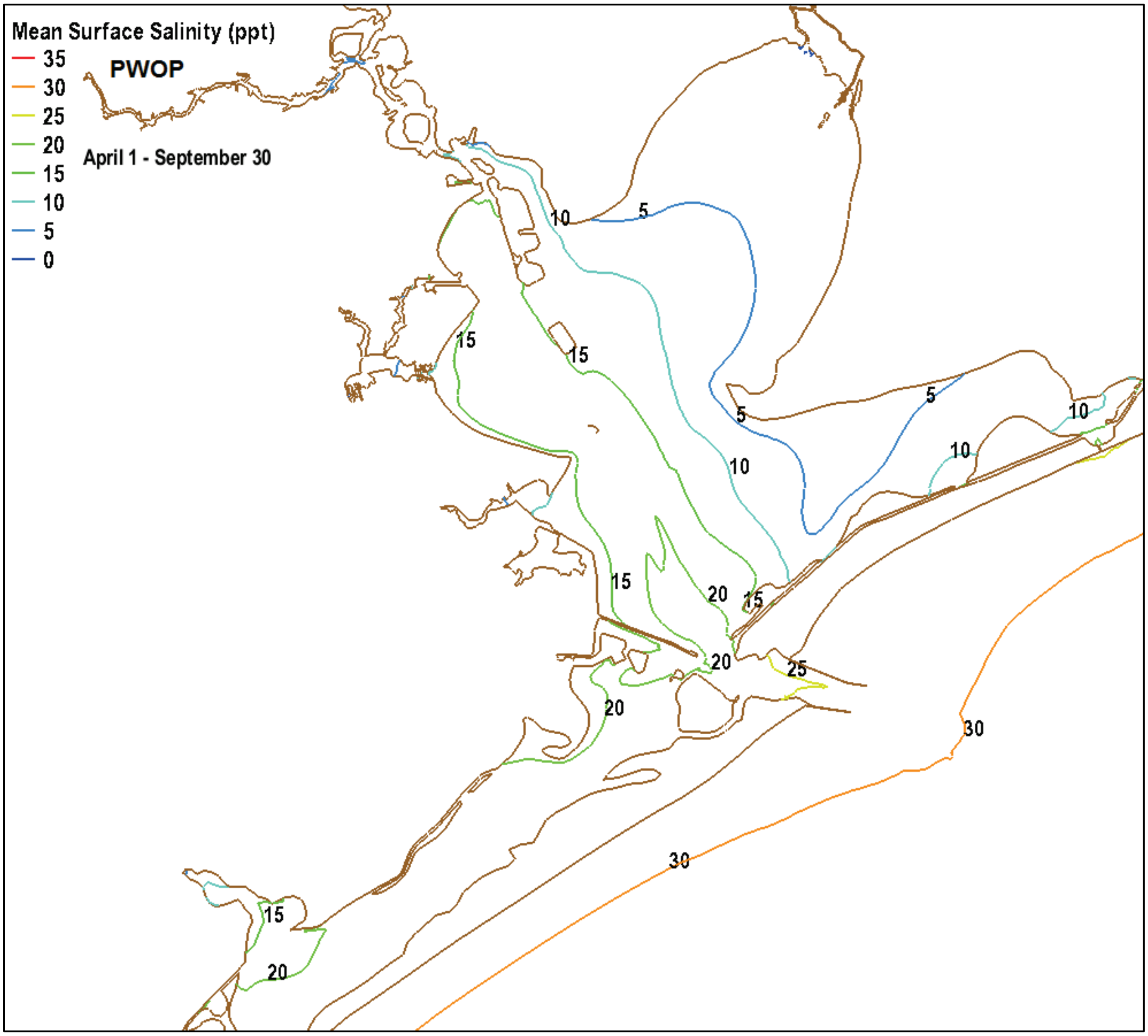

Mean Salinity Profiles at Smith Point
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
2
4
6
8
10
12
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Mid East Bay
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

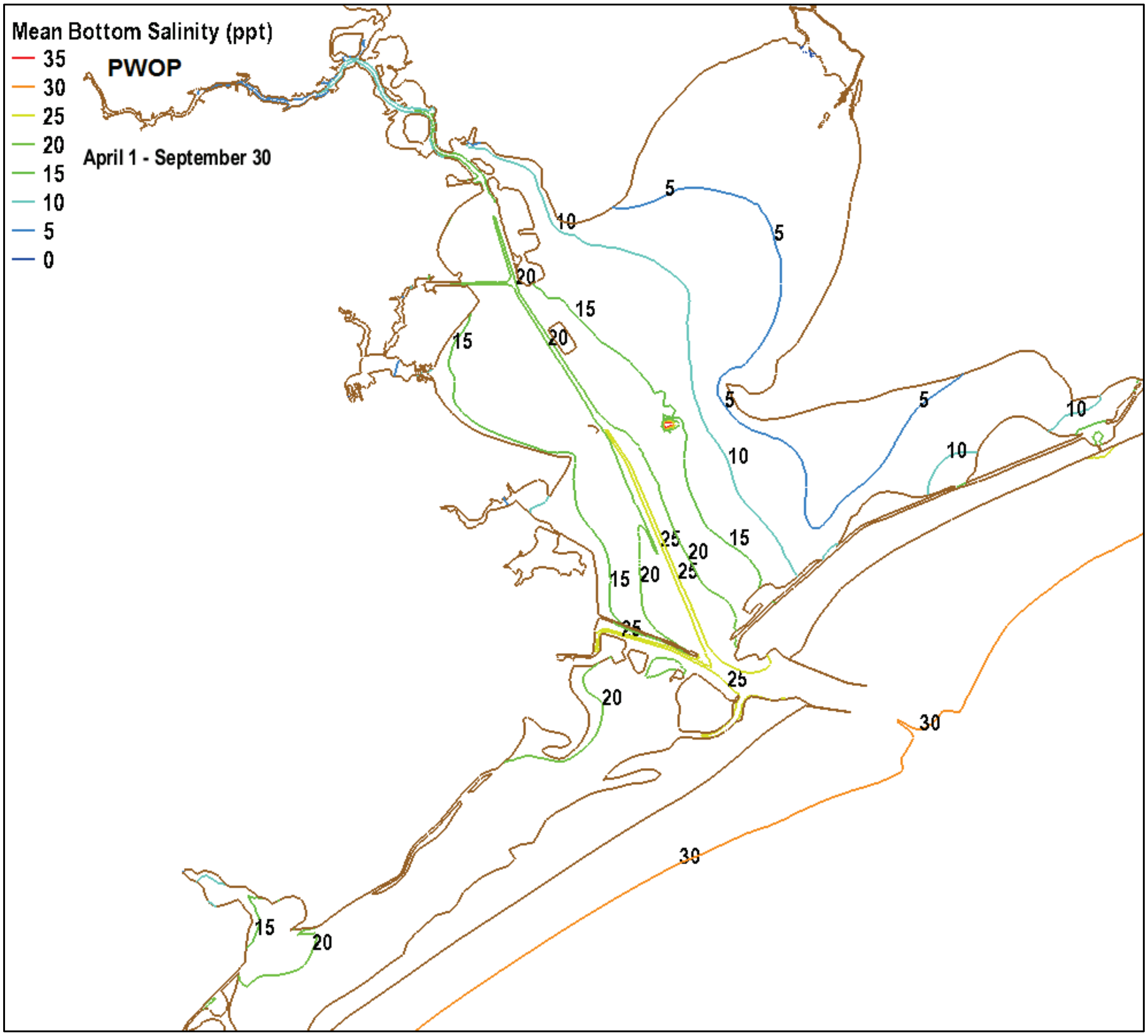

Mean Salinity Profiles at Mid East Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
2
4
6
8
10
12
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

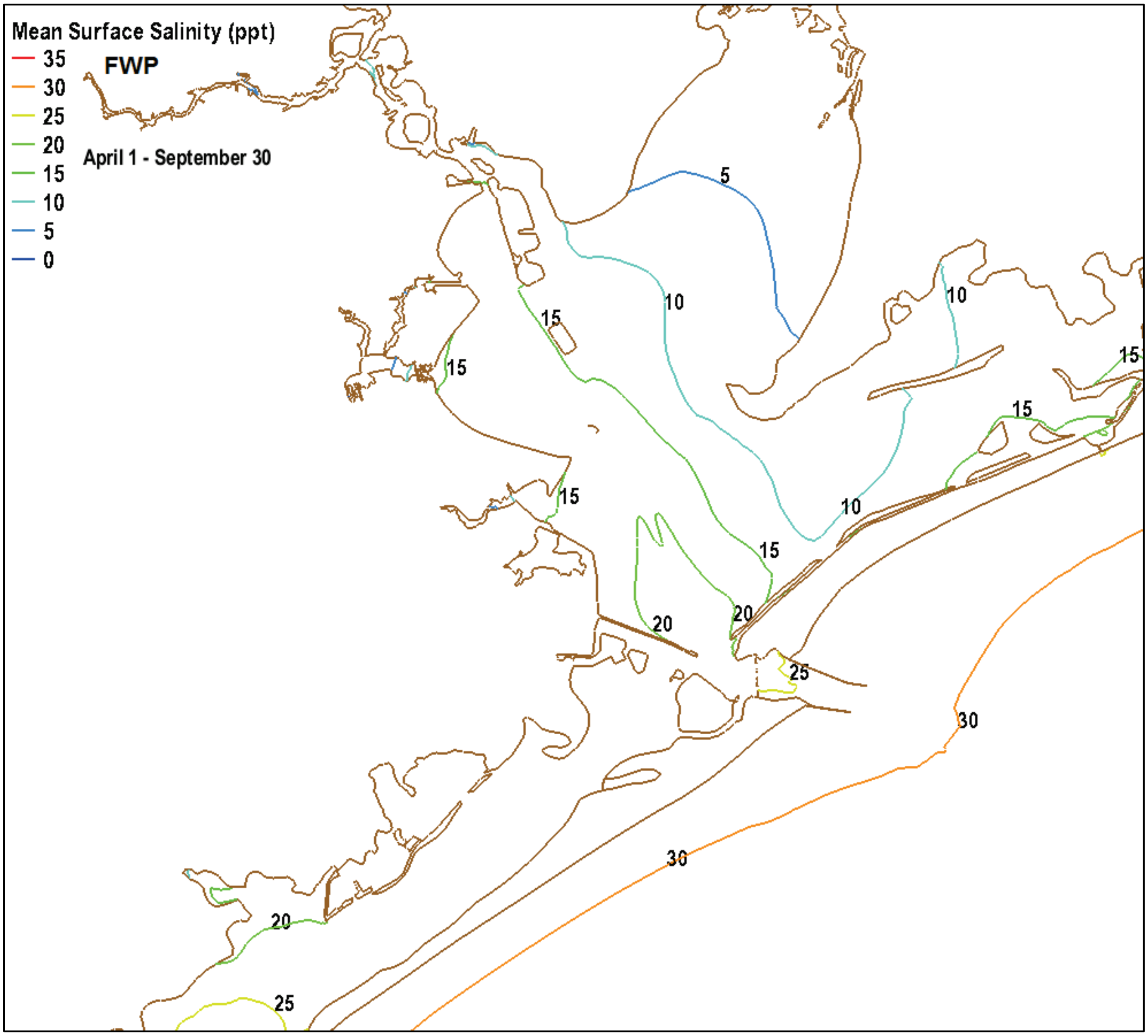

Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
PWP
April 1 - September 30
10
5
15
15
15
5
10
15
10
5
10
10
15
20
20
25
20
30
30
15
20

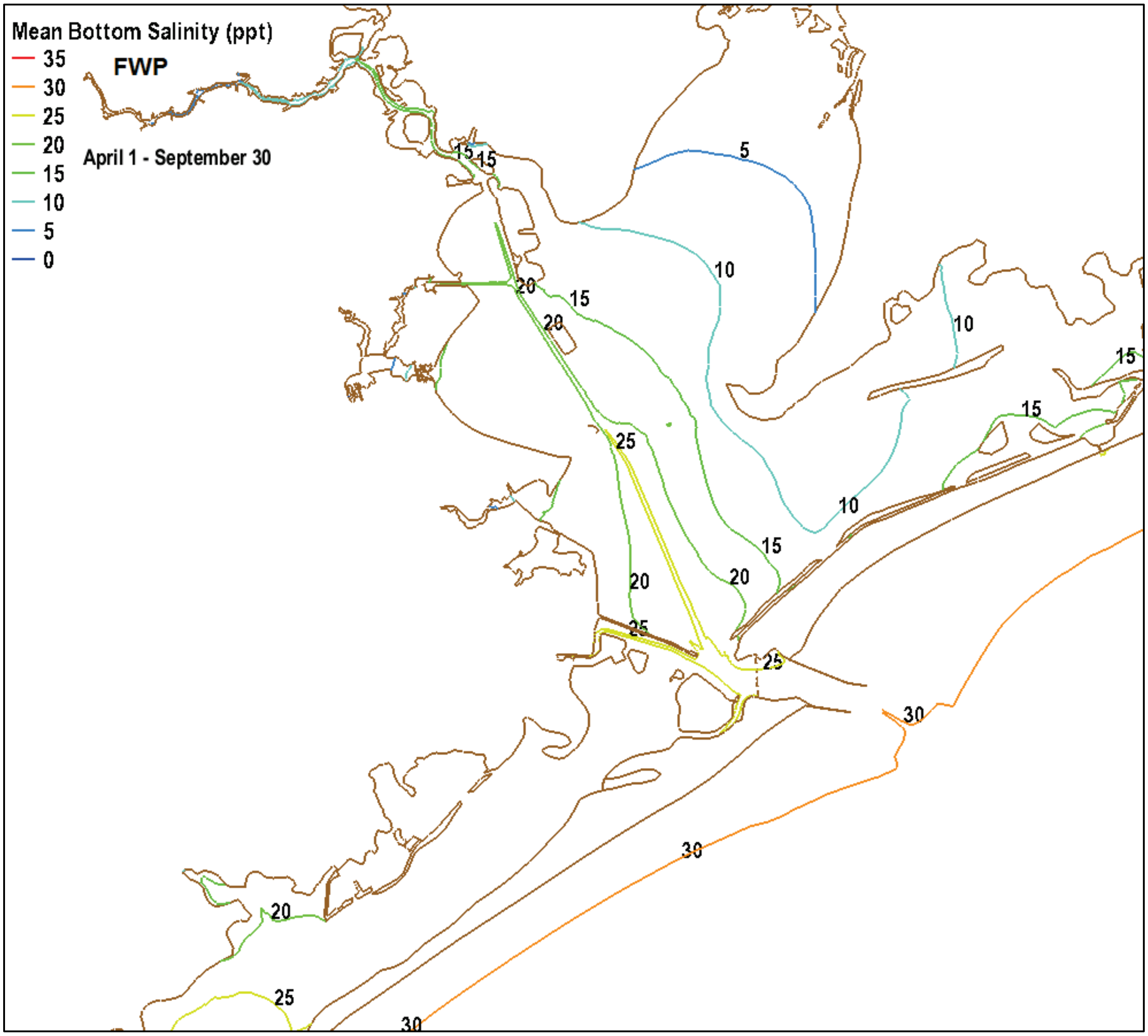

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
PWP
April 1 - September 30
5
10
15
20
25
30

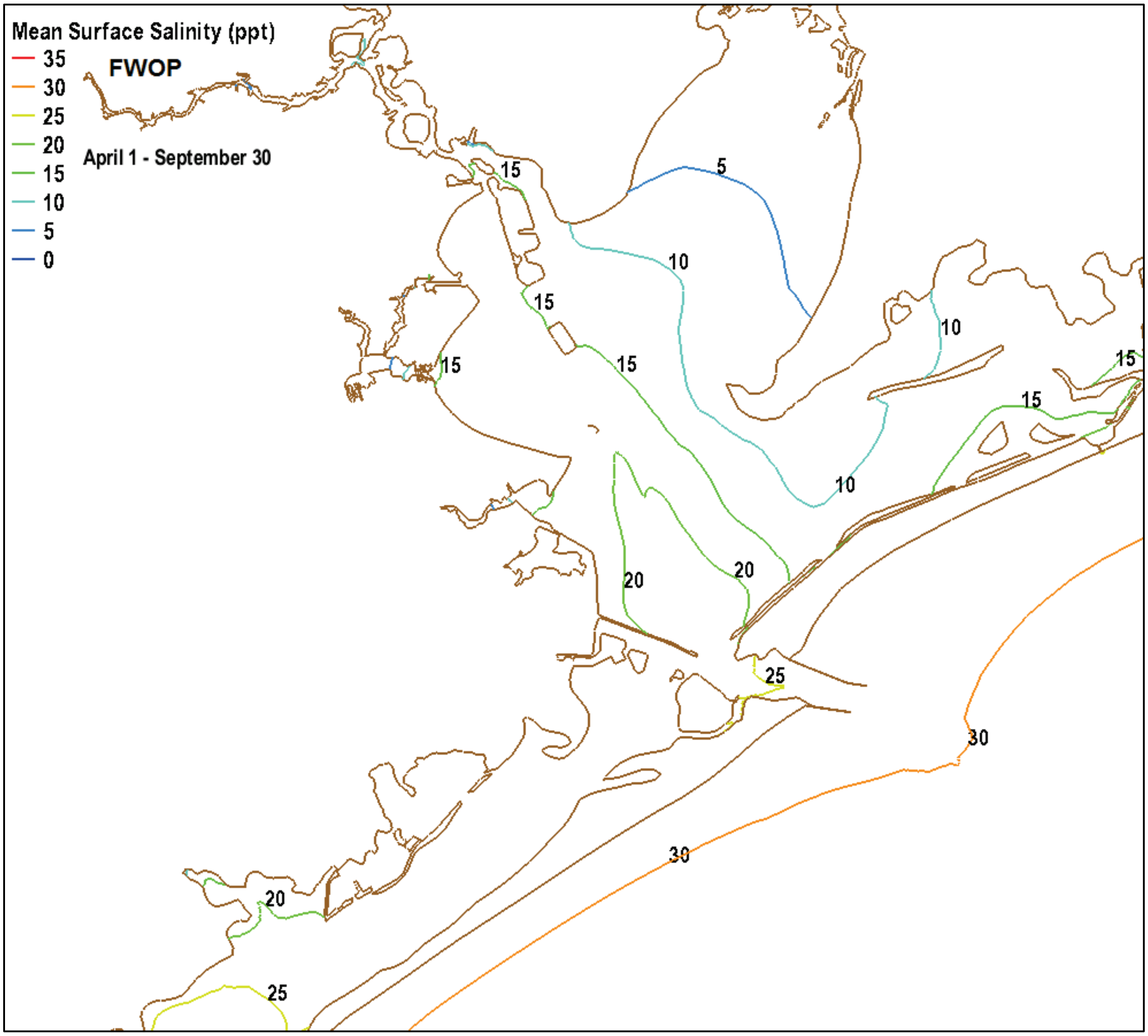


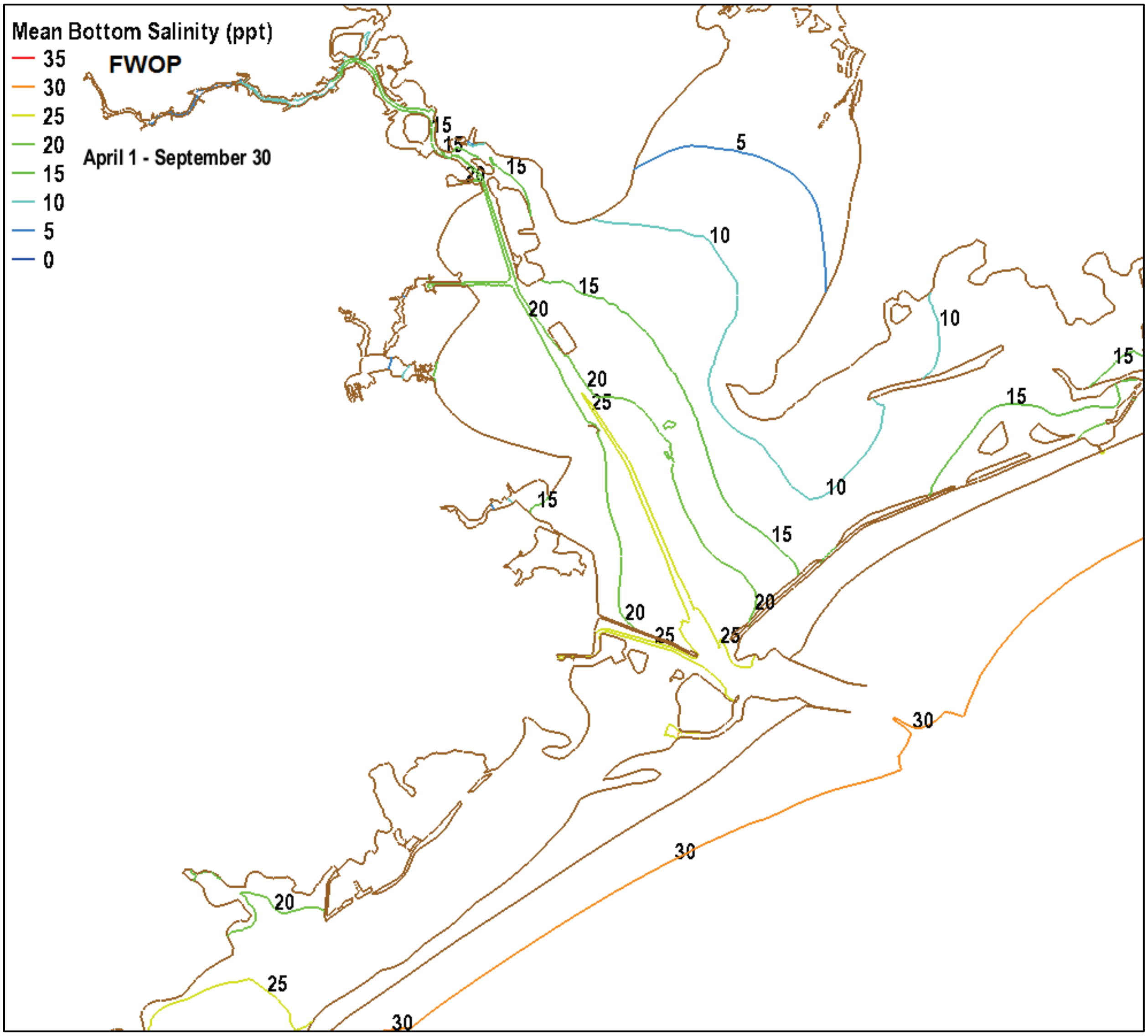
Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
PWOP
April 1 - September 30
10
5
15
15
5
5
10
10
10
15
20
15
20
25
20
30
30
15
20


Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
PWOP
April 1 - September 30
5
5
10
20
15
15
20
5
5
10
10
10
25
20
15
15
20
25
25
25
20
30
30
15
20

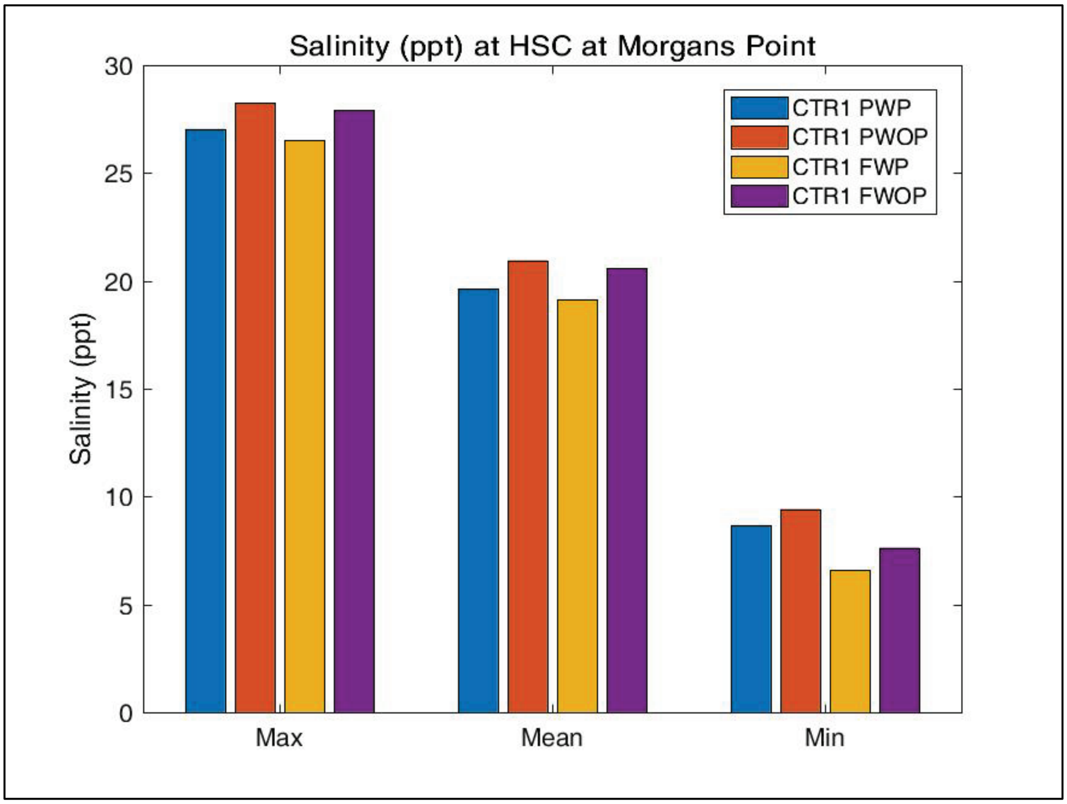

Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
FWP
April 1 - September 30
5
10
15
15
15
10
10
15
15
20
20
25
30
30
20
25

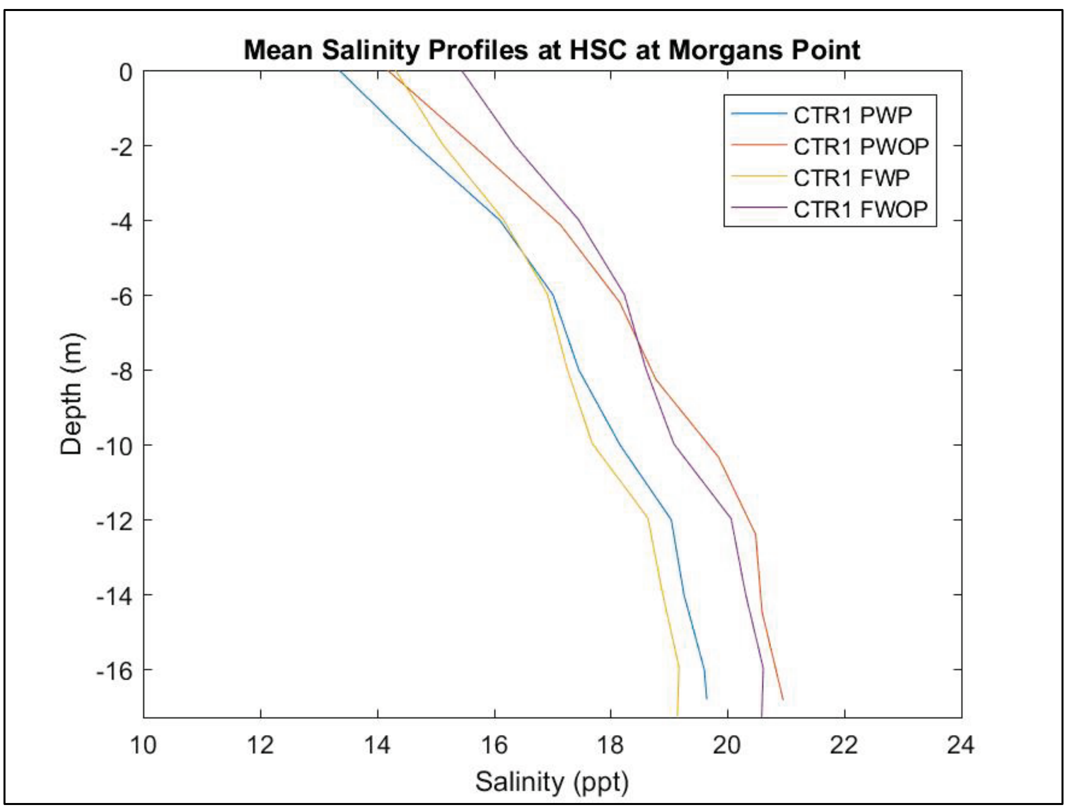

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
FWP
April 1 - September 30
5
10
15
20
25
30

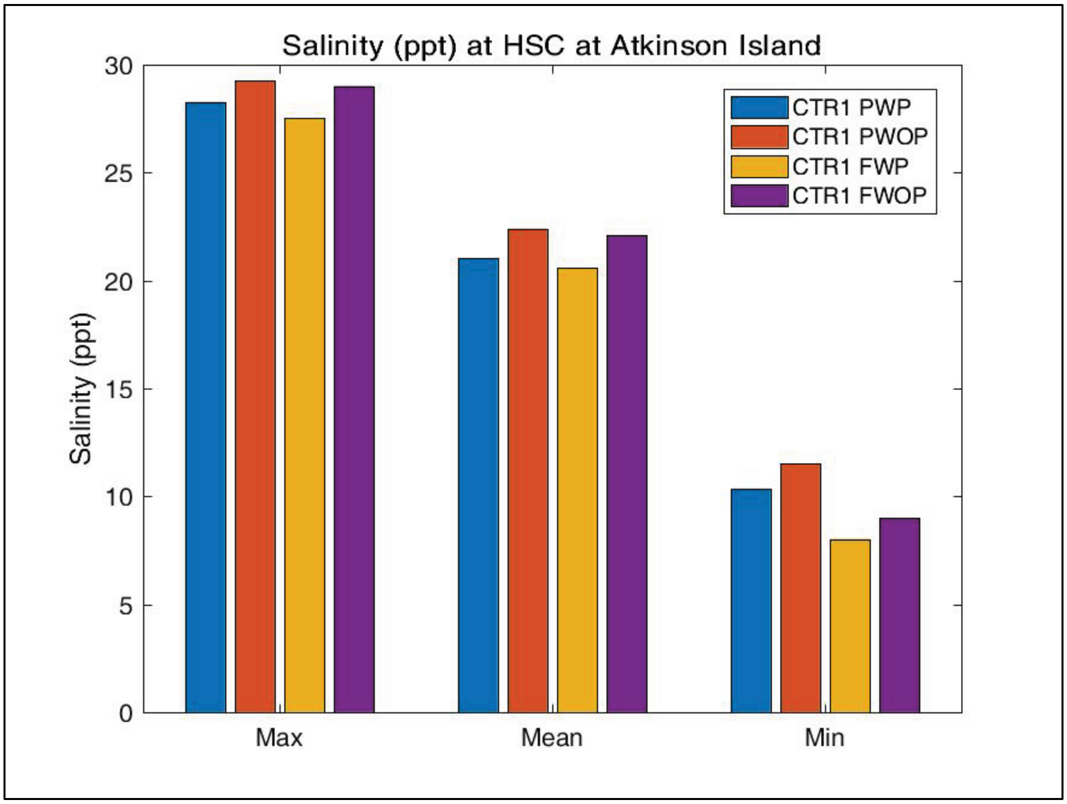

Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
FWOP
April 1 - September 30
15
5
10
15
10
15
15
15
15
10
20
20
25
30
30
20
25

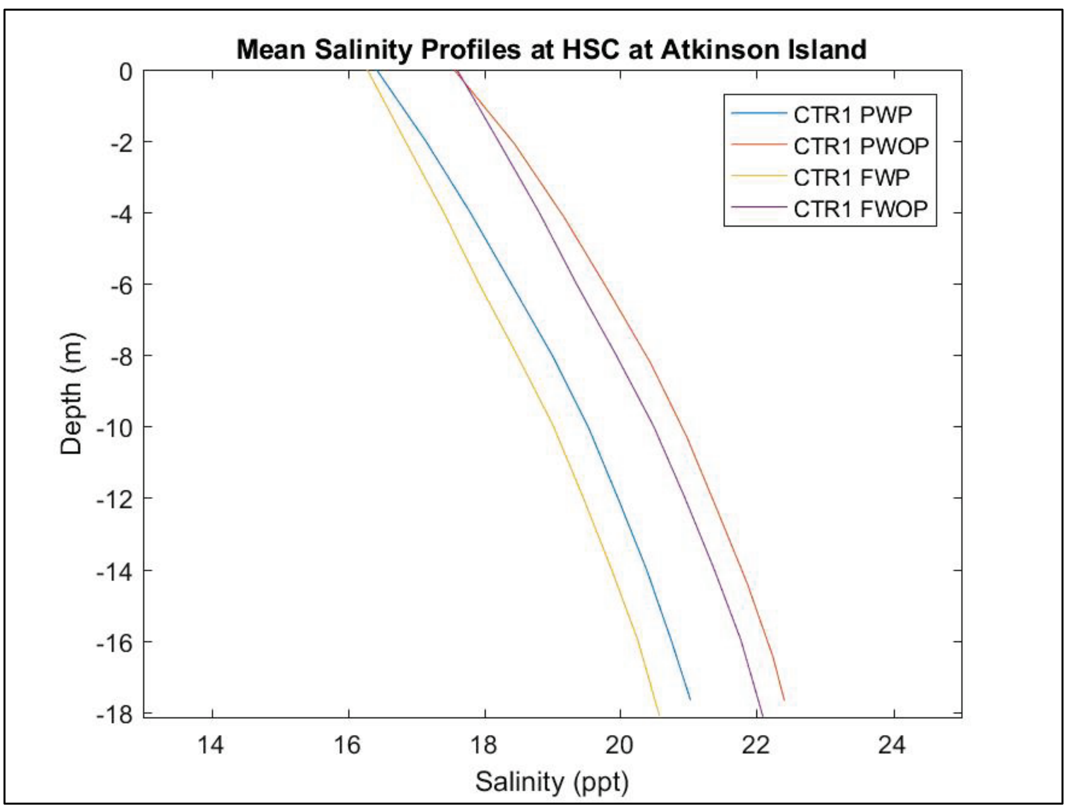

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
FWOP
April 1 - September 30
15
15
20
15
5
10
15
20
10
15
20
25
15
10
15
20
25
25
20
30
30
20
25
30

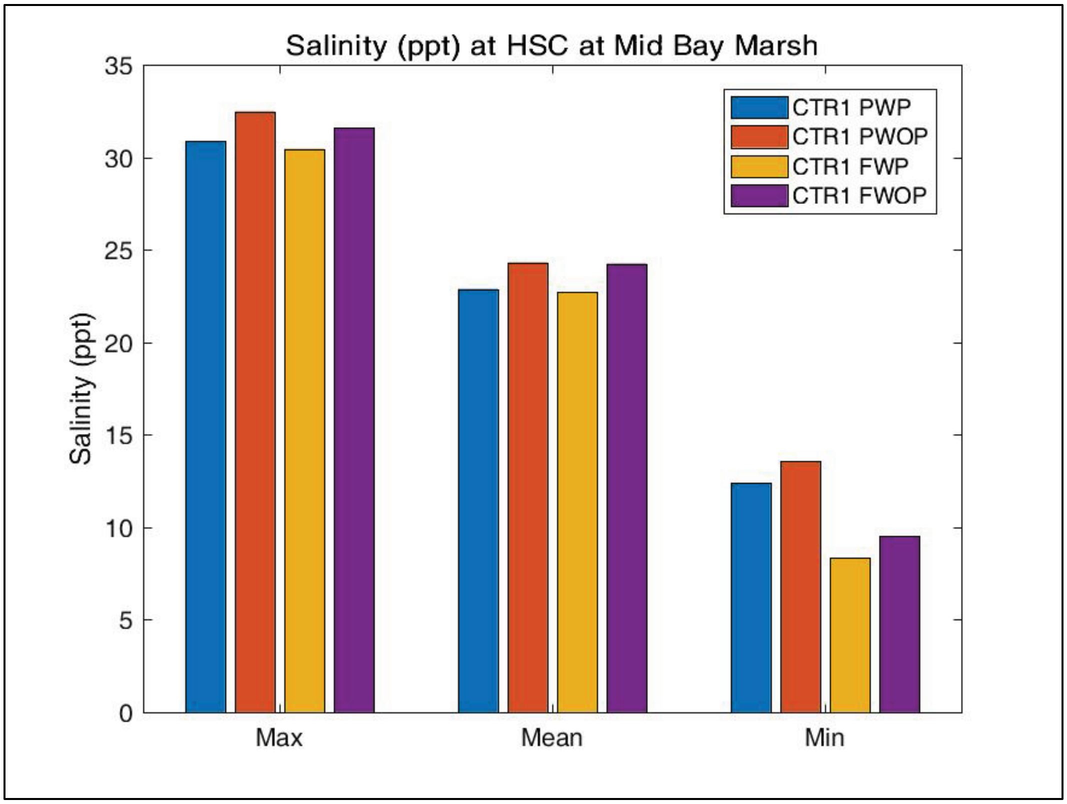
July 1 – September 30

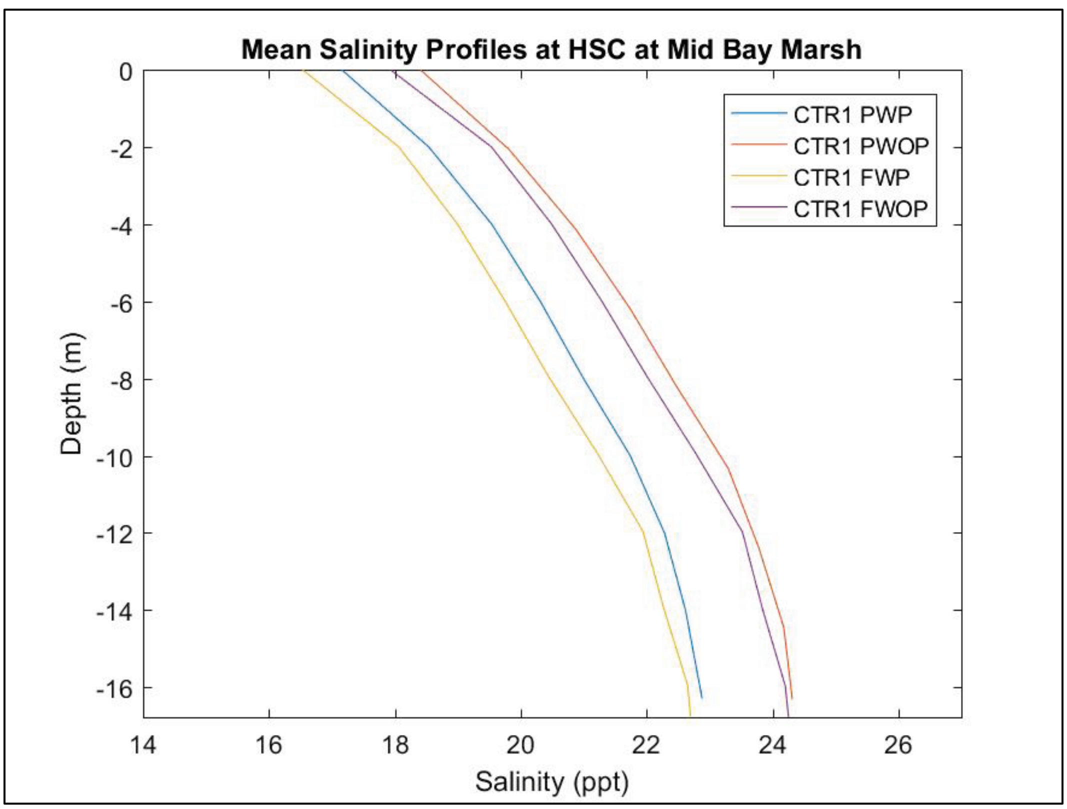


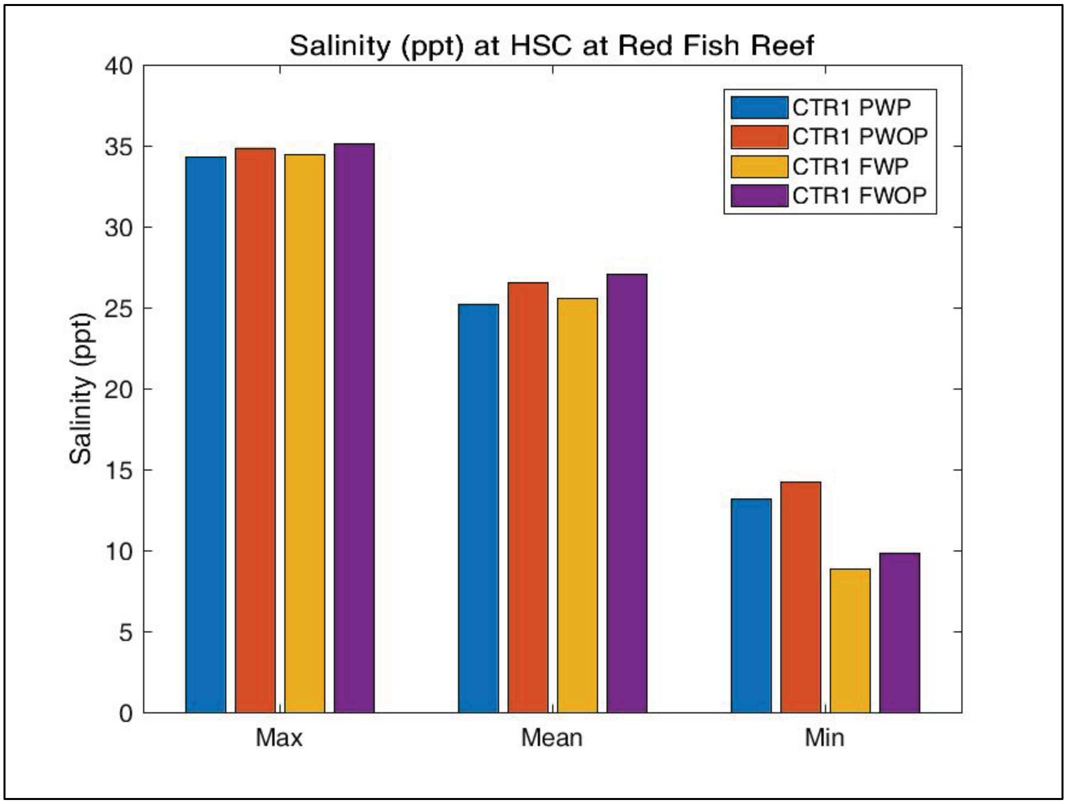


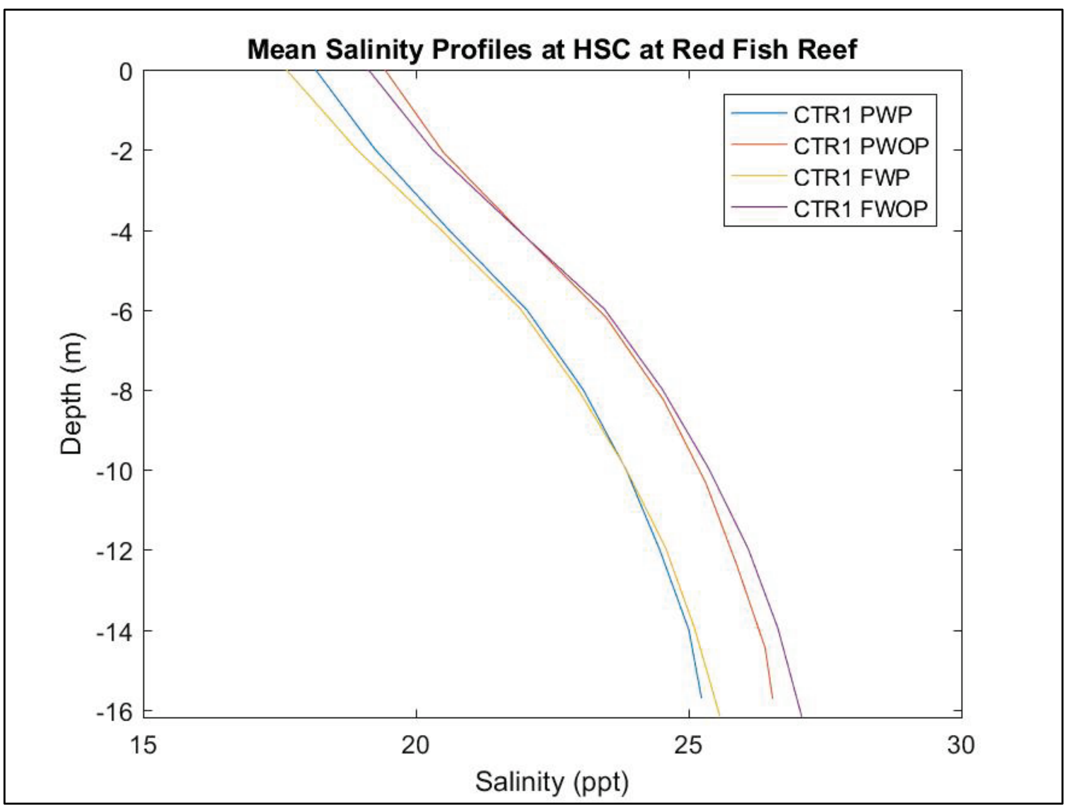

Salinity (ppt) at HSC at Atkinson Island
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

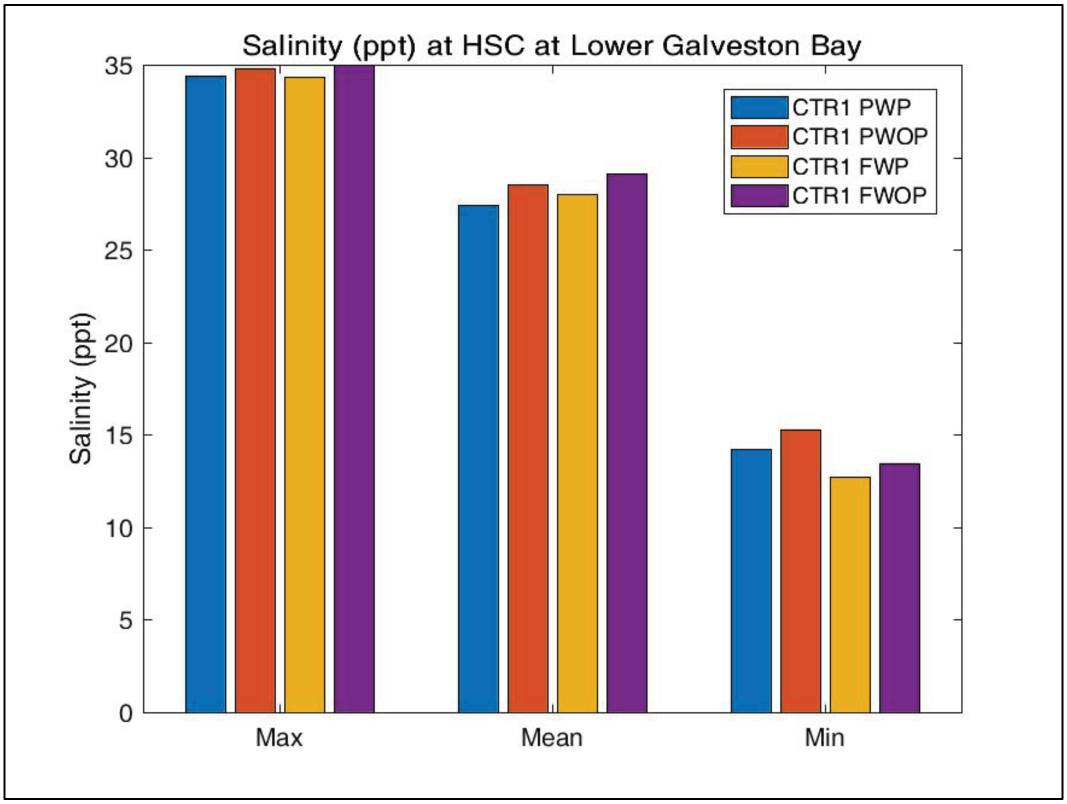

Mean Salinity Profiles at HSC at Atkinson Island
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
14
16
18
20
22
24
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

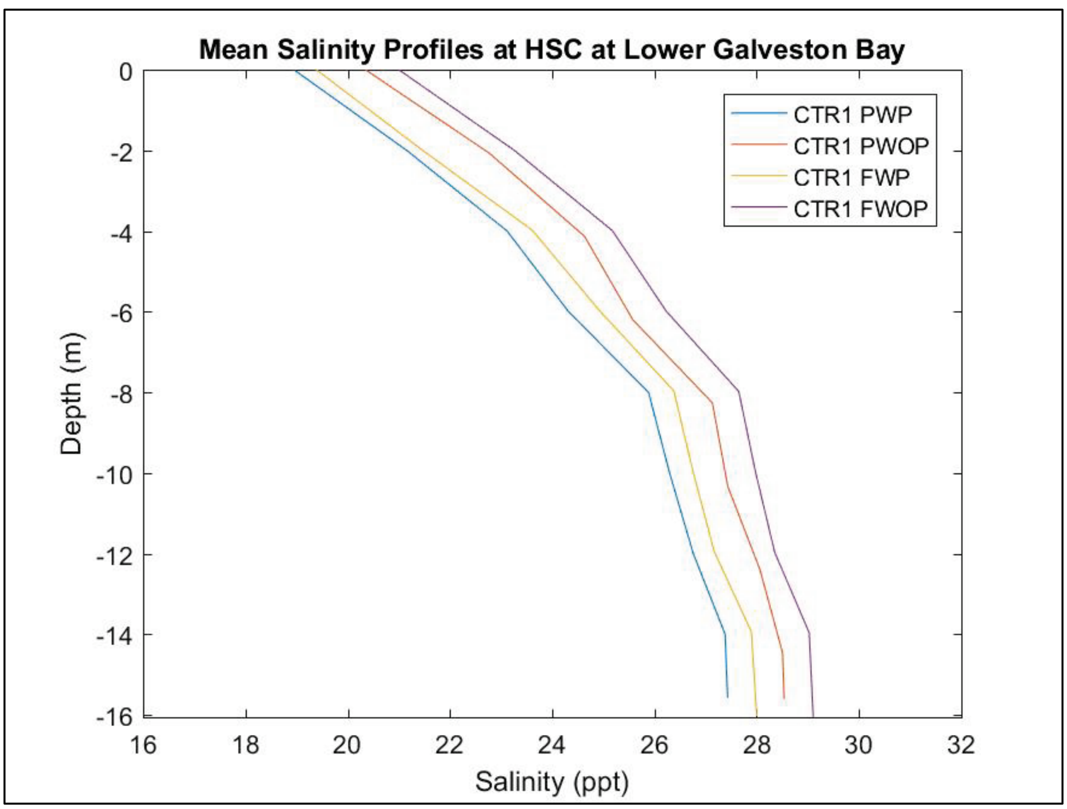

Salinity (ppt) at HSC at Mid Bay Marsh
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Max
Mean
Min
0
5
10
15
20
25
30
35

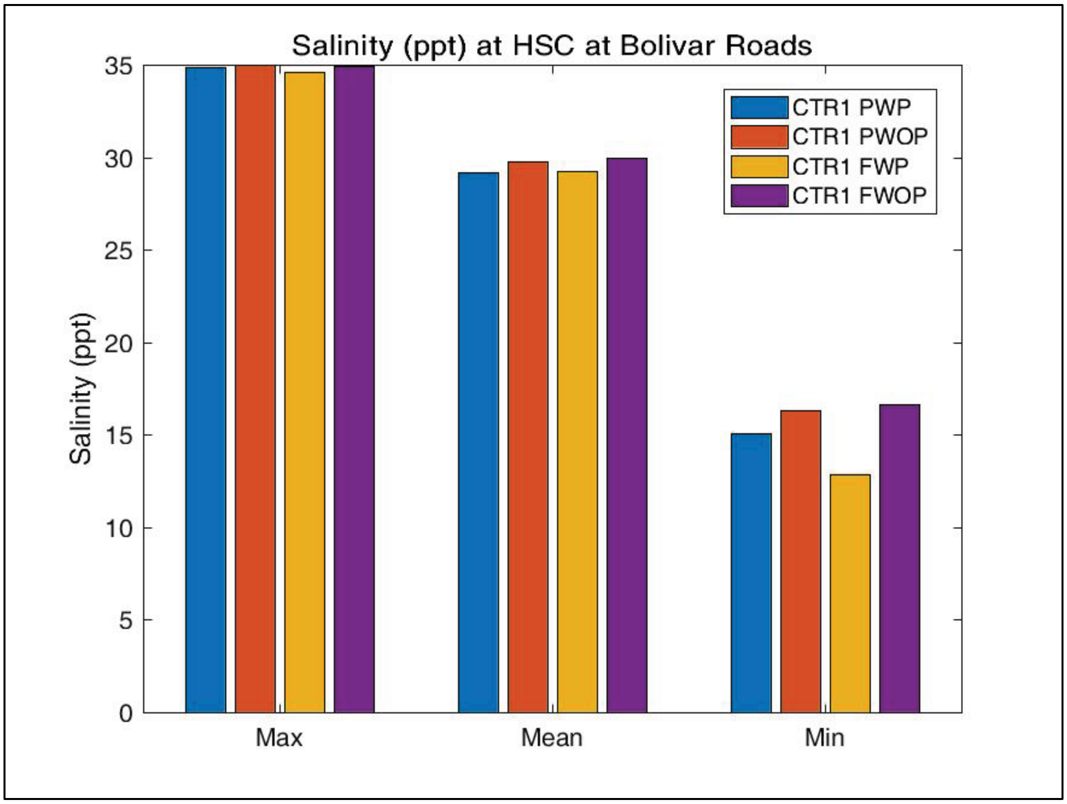

Mean Salinity Profiles at HSC at Mid Bay Marsh
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-2
-4
-6
-8
-10
-12
-14
-16
14
16
18
20
22
24
26

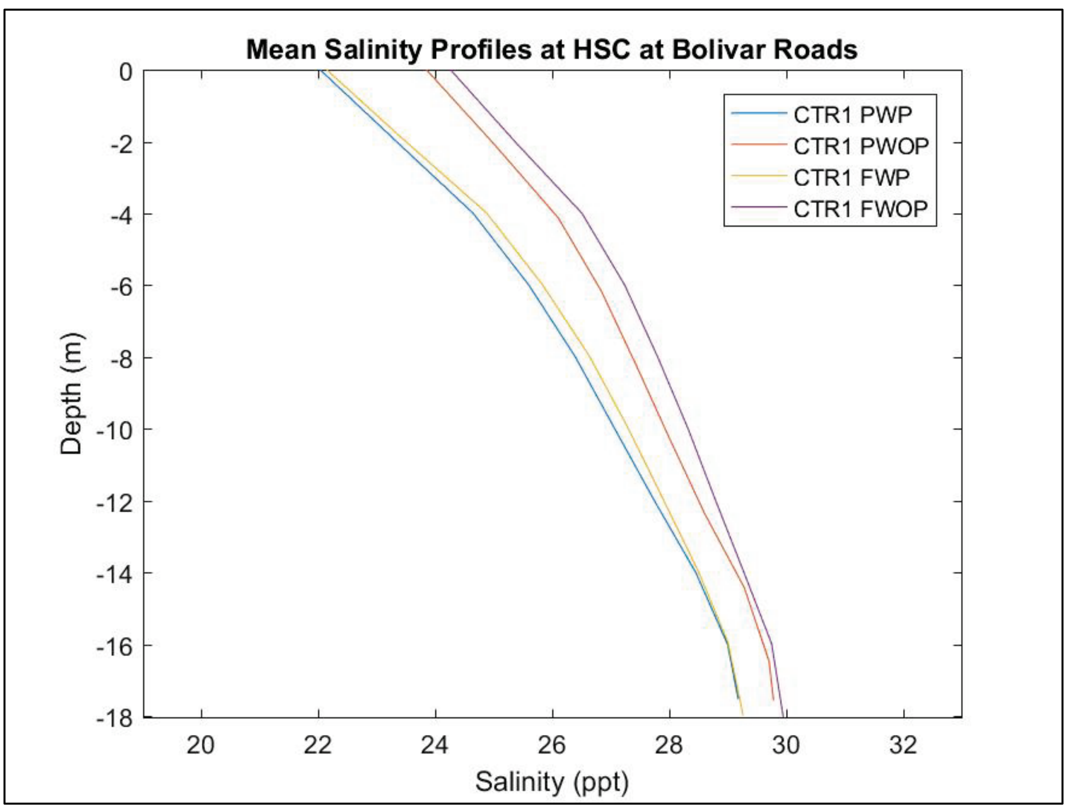

Salinity (ppt) at HSC at Red Fish Reef
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Max
Mean
Min
0
5
10
15
20
25
30
35
40

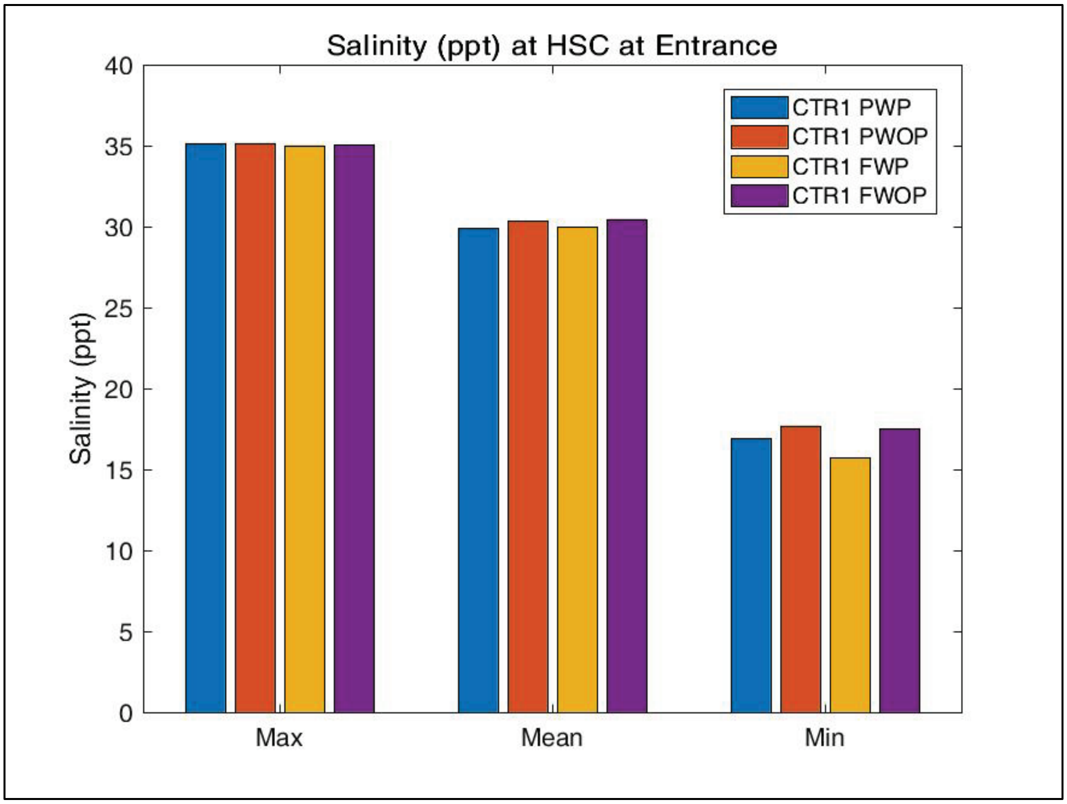

Mean Salinity Profiles at HSC at Red Fish Reef
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-2
-4
-6
-8
-10
-12
-14
-16
15
20
25
30

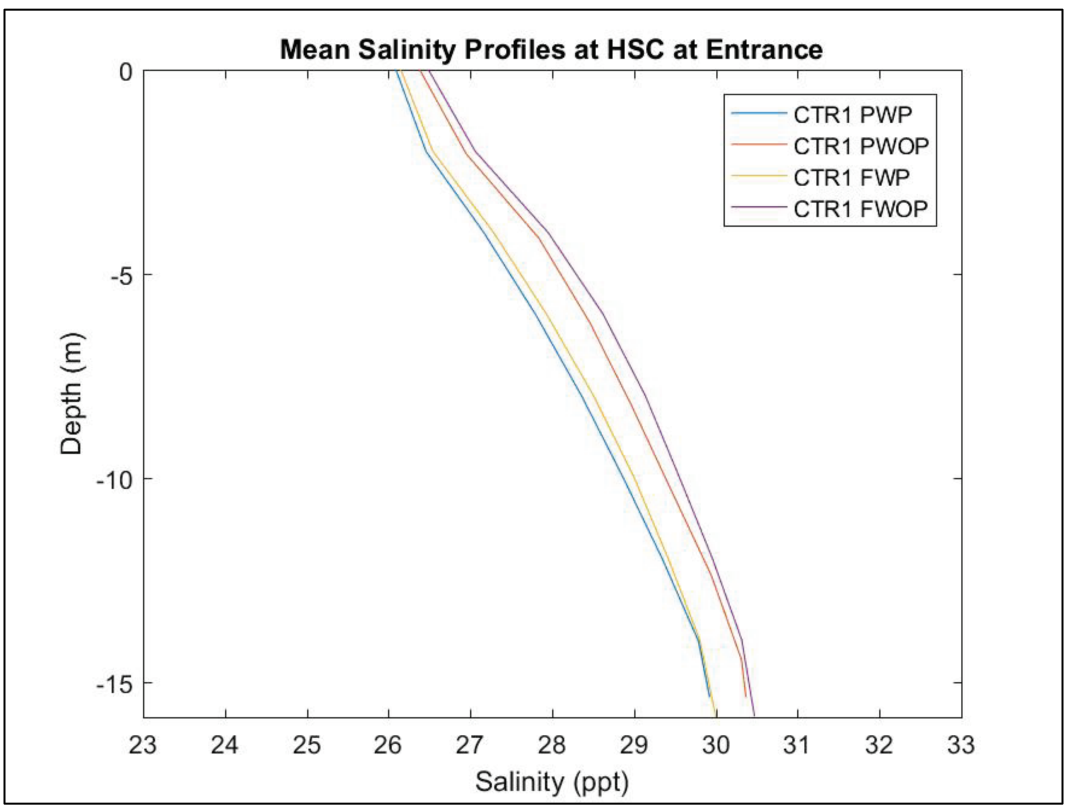

Salinity (ppt) at HSC at Lower Galveston Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

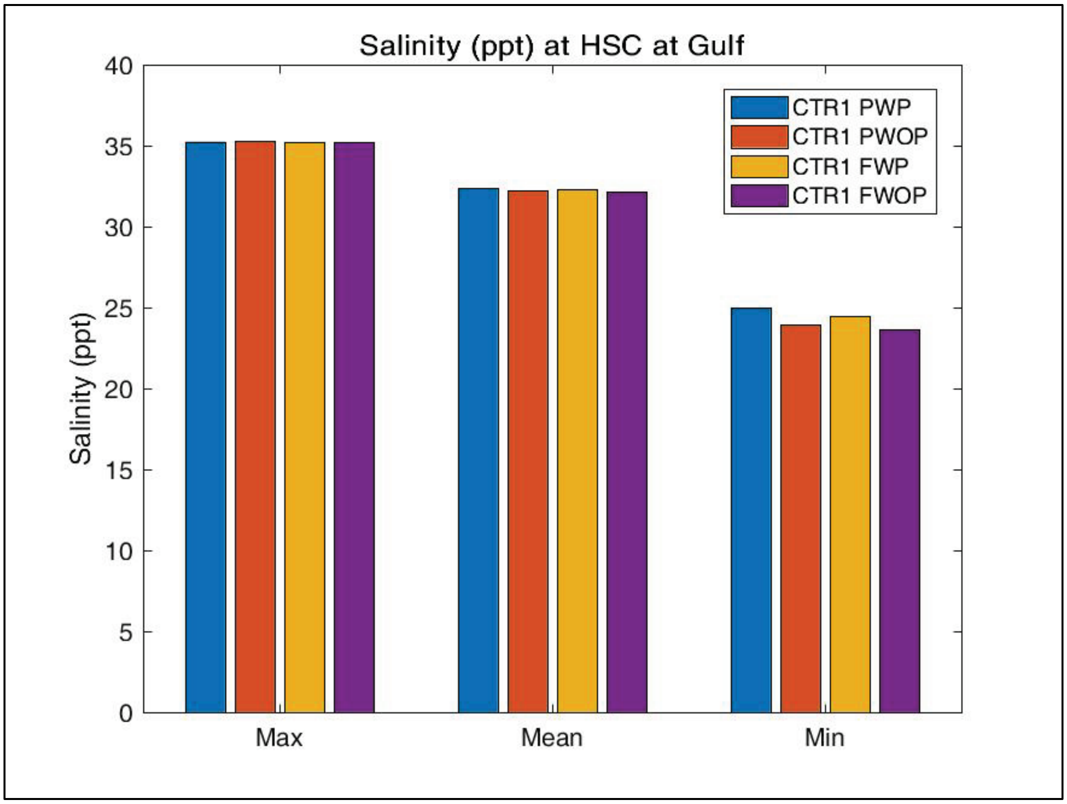

Mean Salinity Profiles at HSC at Lower Galveston Bay
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
16
18
20
22
24
26
28
30
32
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Bolivar Roads
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

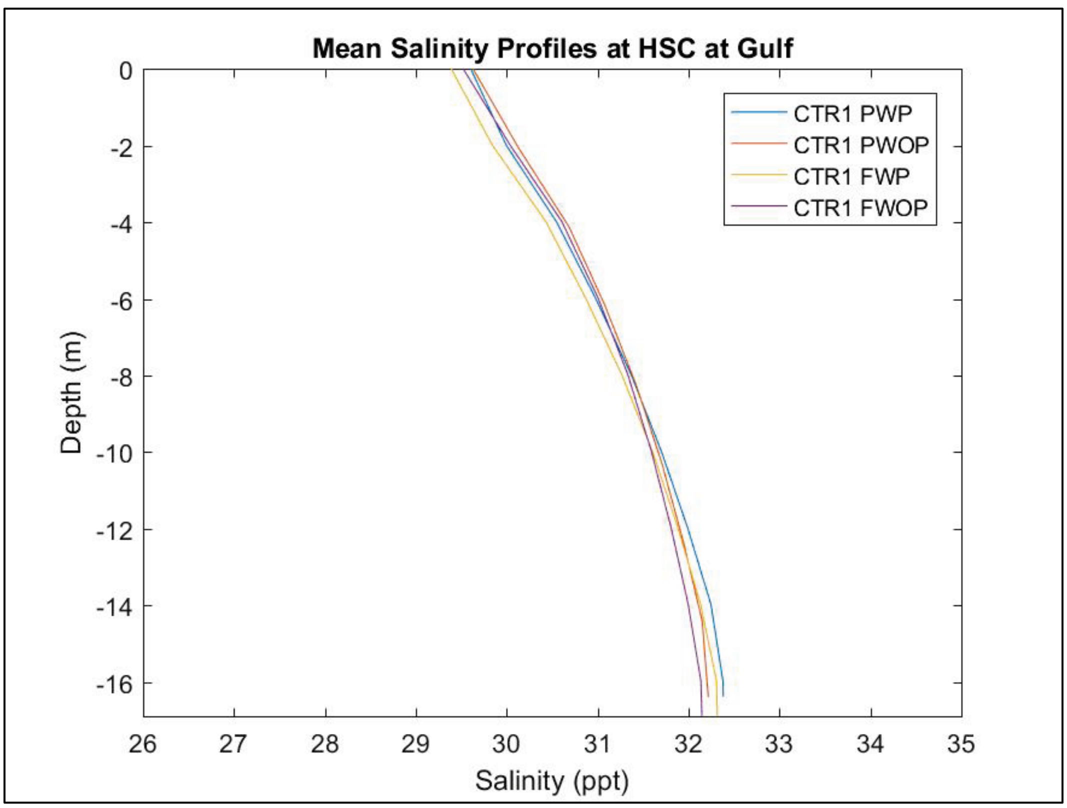

Mean Salinity Profiles at HSC at Bolivar Roads
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
20
22
24
26
28
30
32
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Entrance
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

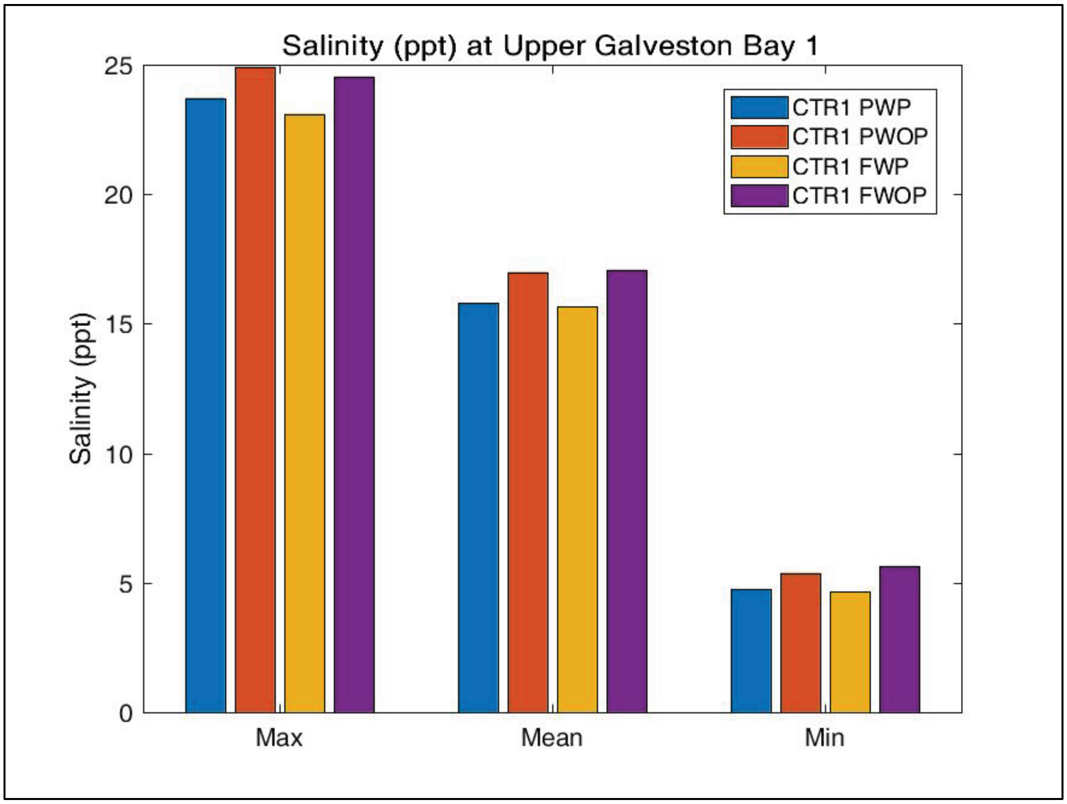

Mean Salinity Profiles at HSC at Entrance
Depth (m)
0
-5
-10
-15
23
24
25
26
27
28
29
30
31
32
33
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

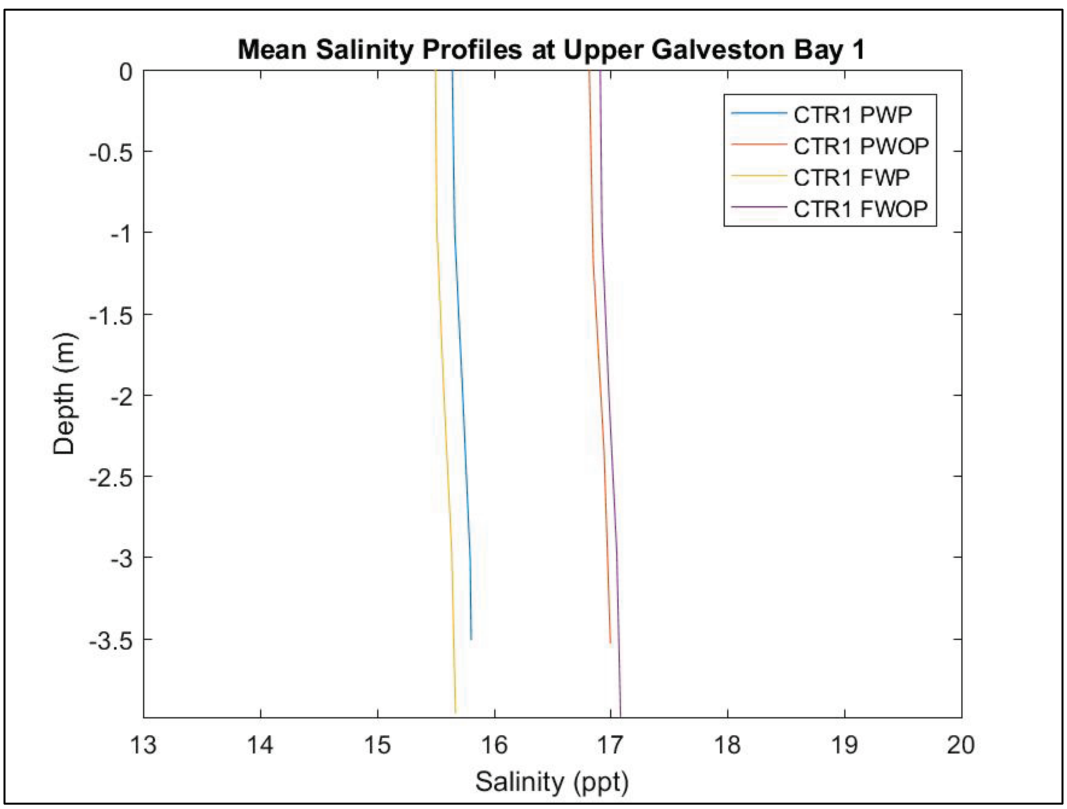


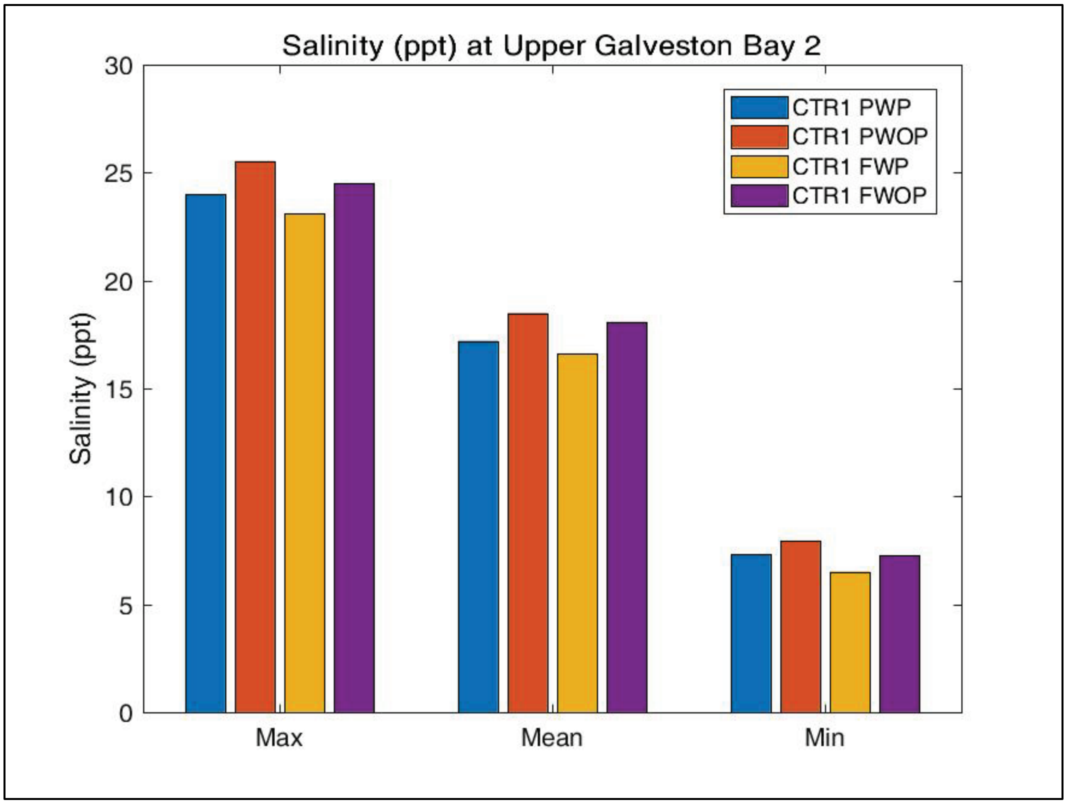
Salinity (ppt) at HSC at Gulf
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

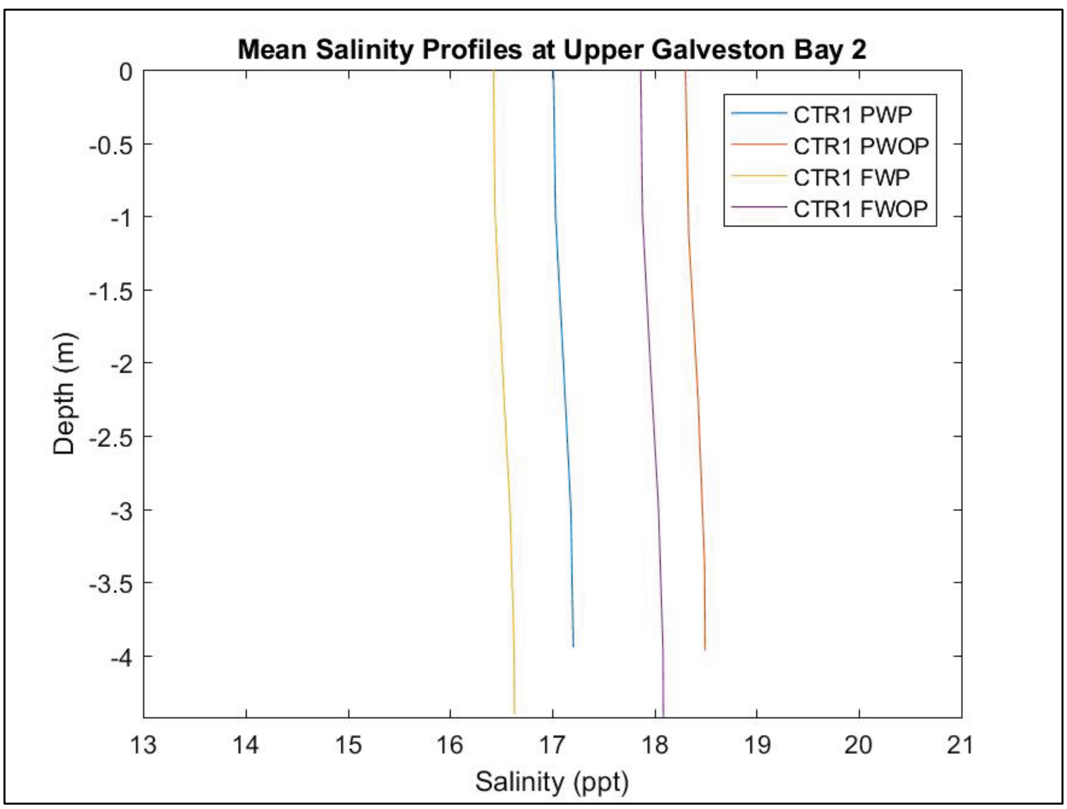


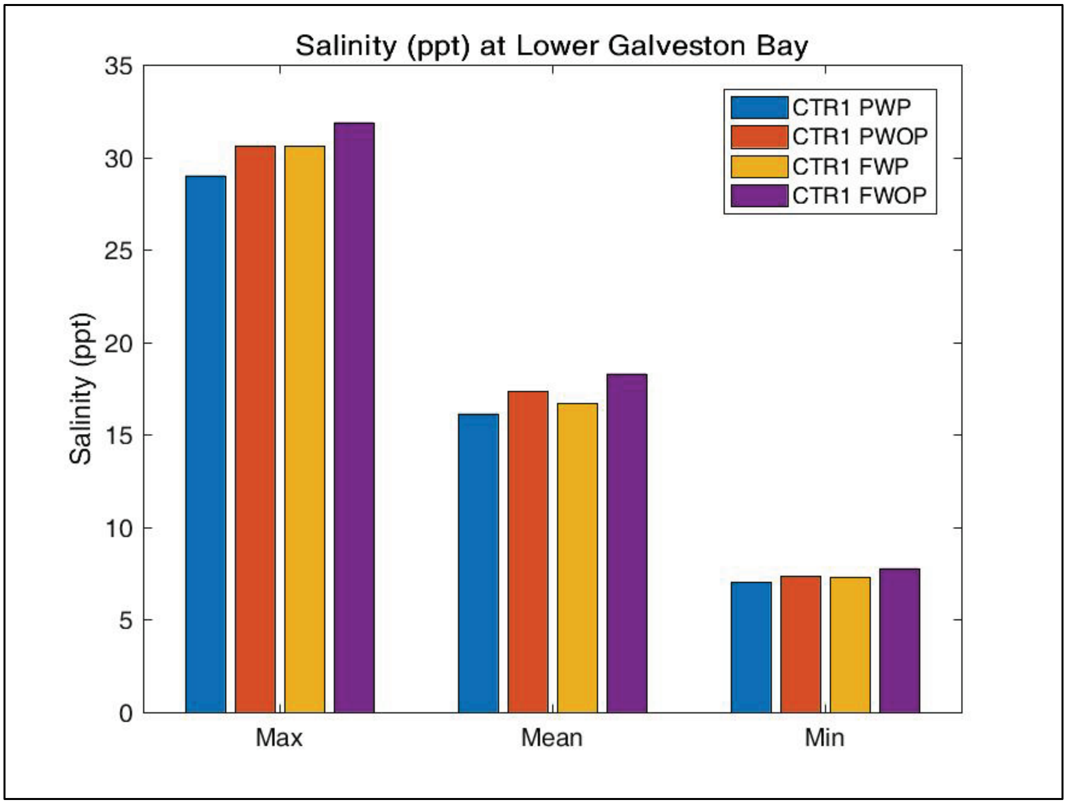
Mean Salinity Profiles at HSC at Gulf
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
26
27
28
29
30
31
32
33
34
35
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

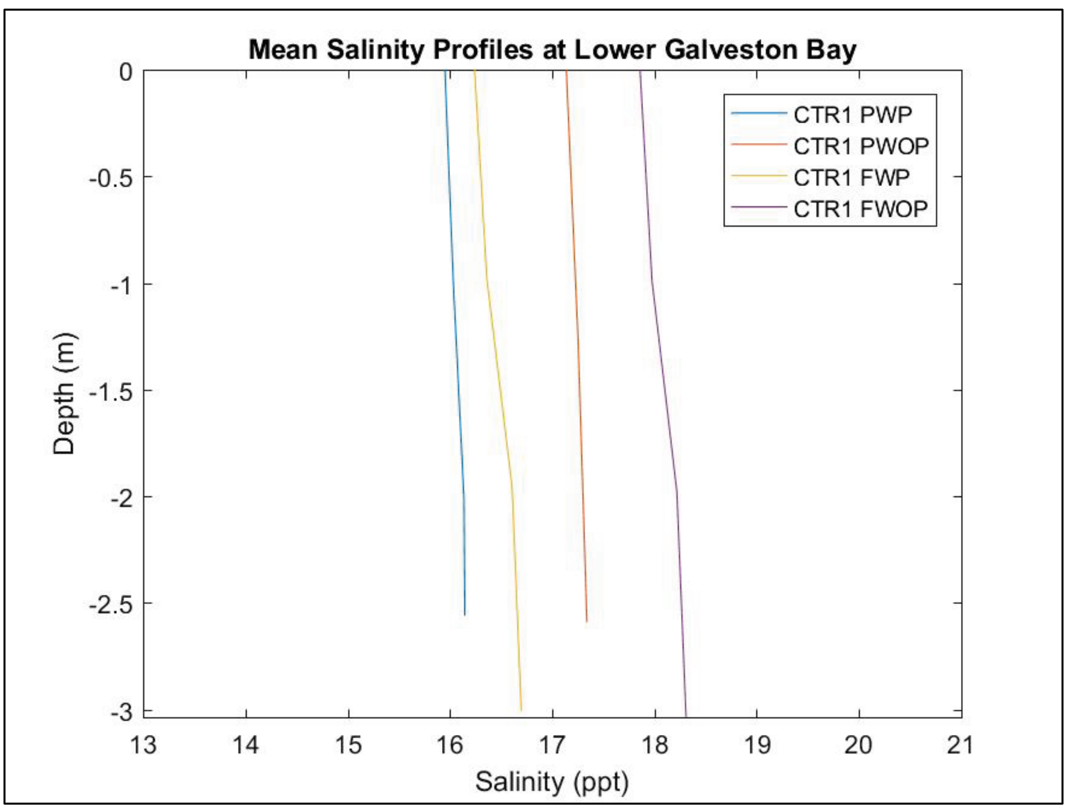

Salinity (ppt) at Upper Galveston Bay 1
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

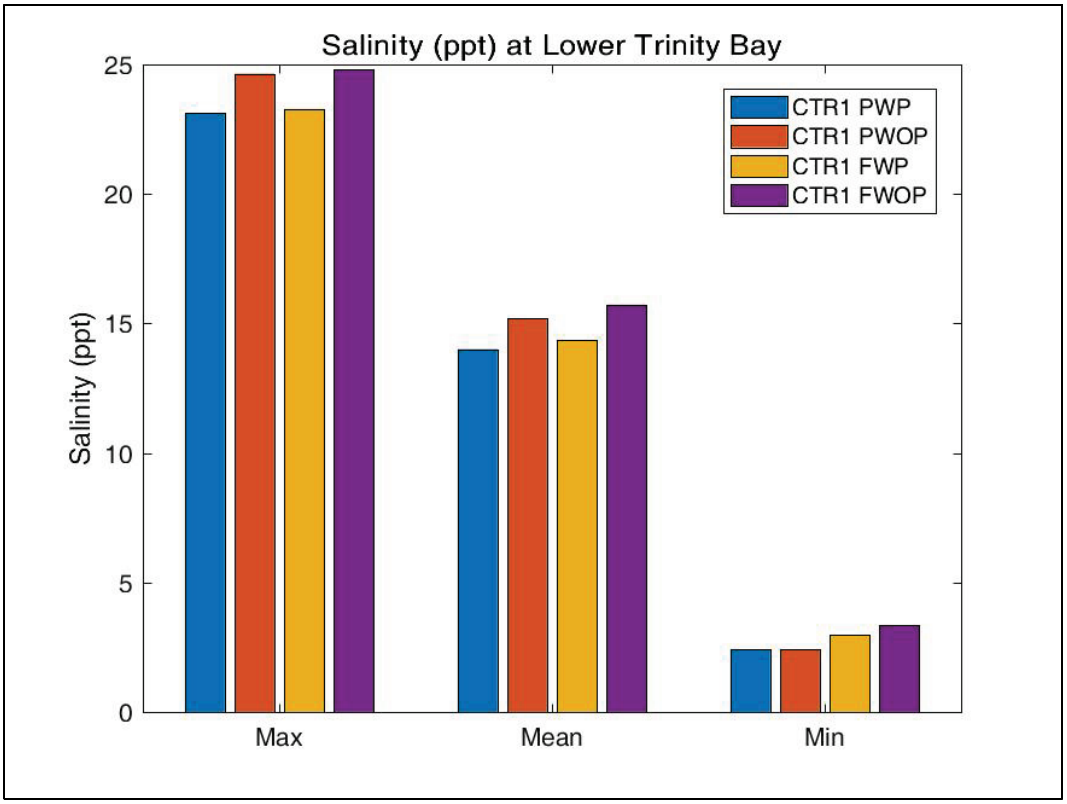

Mean Salinity Profiles at Upper Galveston Bay 1
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
13
14
15
16
17
18
19
20
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

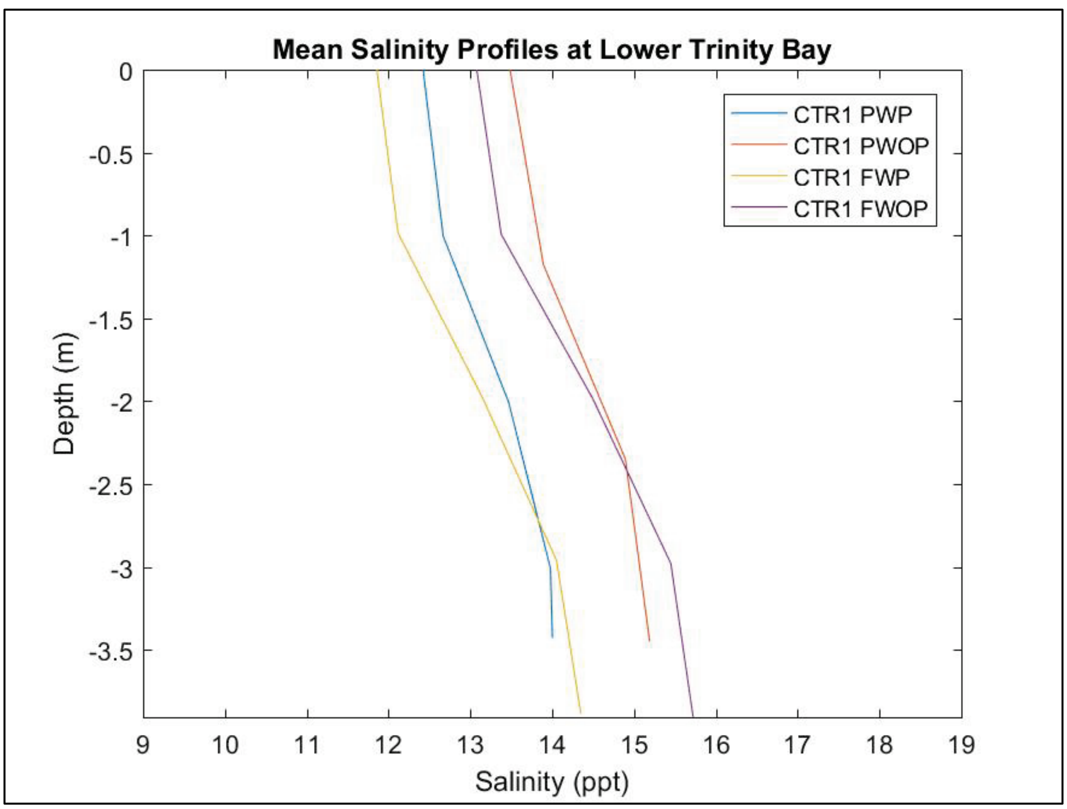

Salinity (ppt) at Upper Galveston Bay 2
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

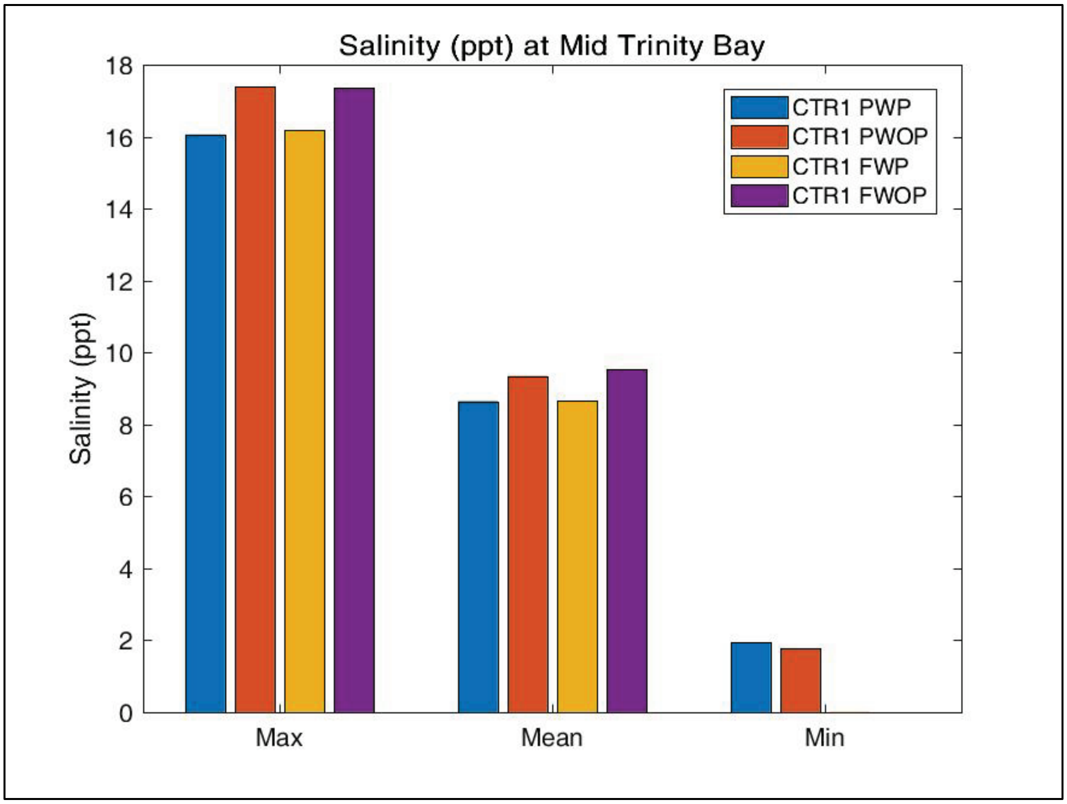

Mean Salinity Profiles at Upper Galveston Bay 2
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
13
14
15
16
17
18
19
20
21
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

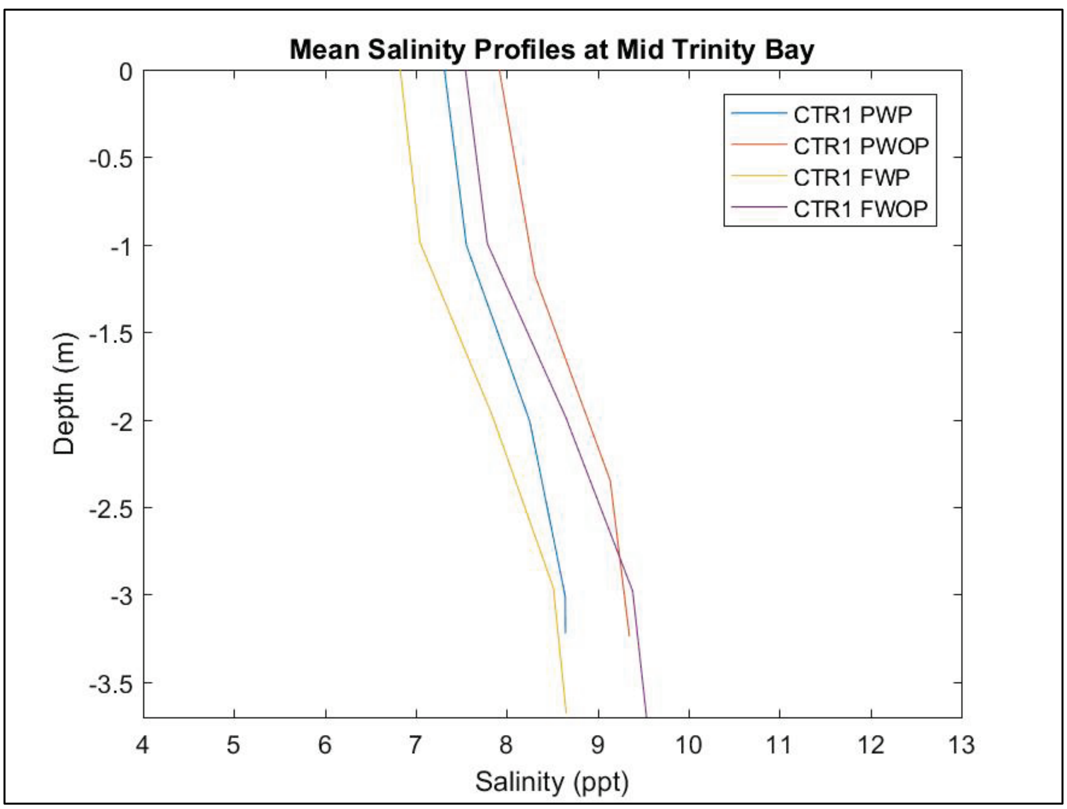

Salinity (ppt) at Lower Galveston Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

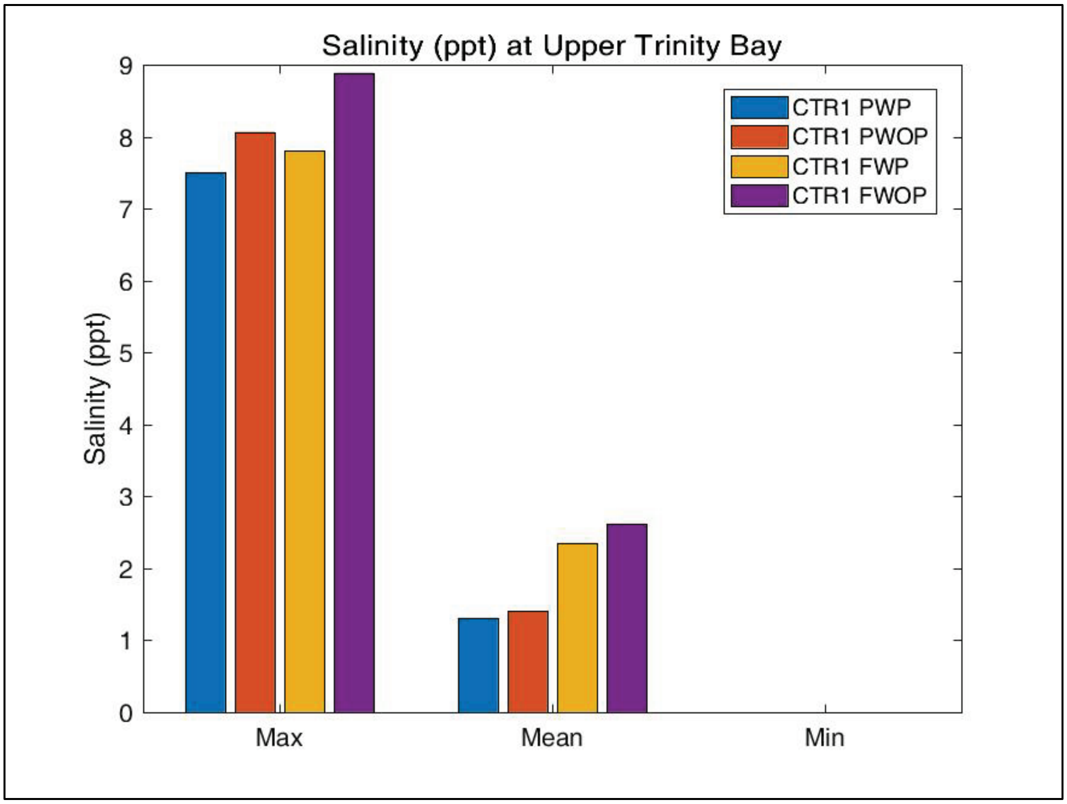

Mean Salinity Profiles at Lower Galveston Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
13
14
15
16
17
18
19
20
21
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

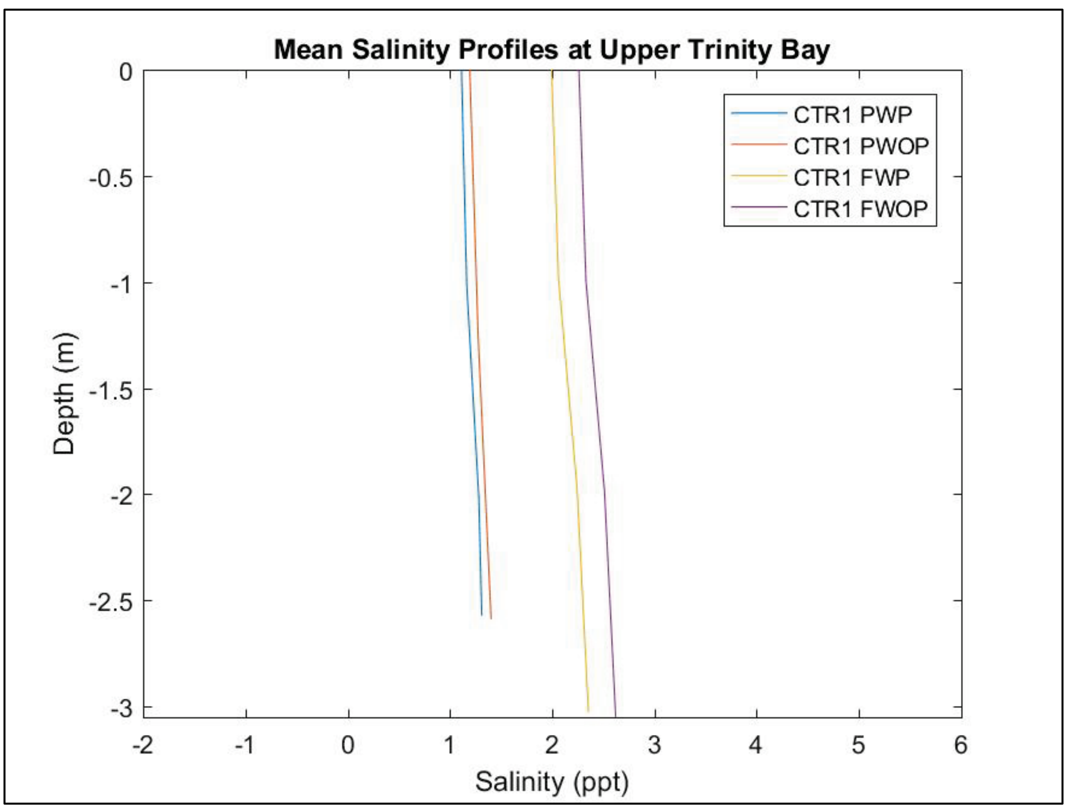

Salinity (ppt) at Lower Trinity Bay
Salinity (ppt)
0
5
10
15
20
25
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

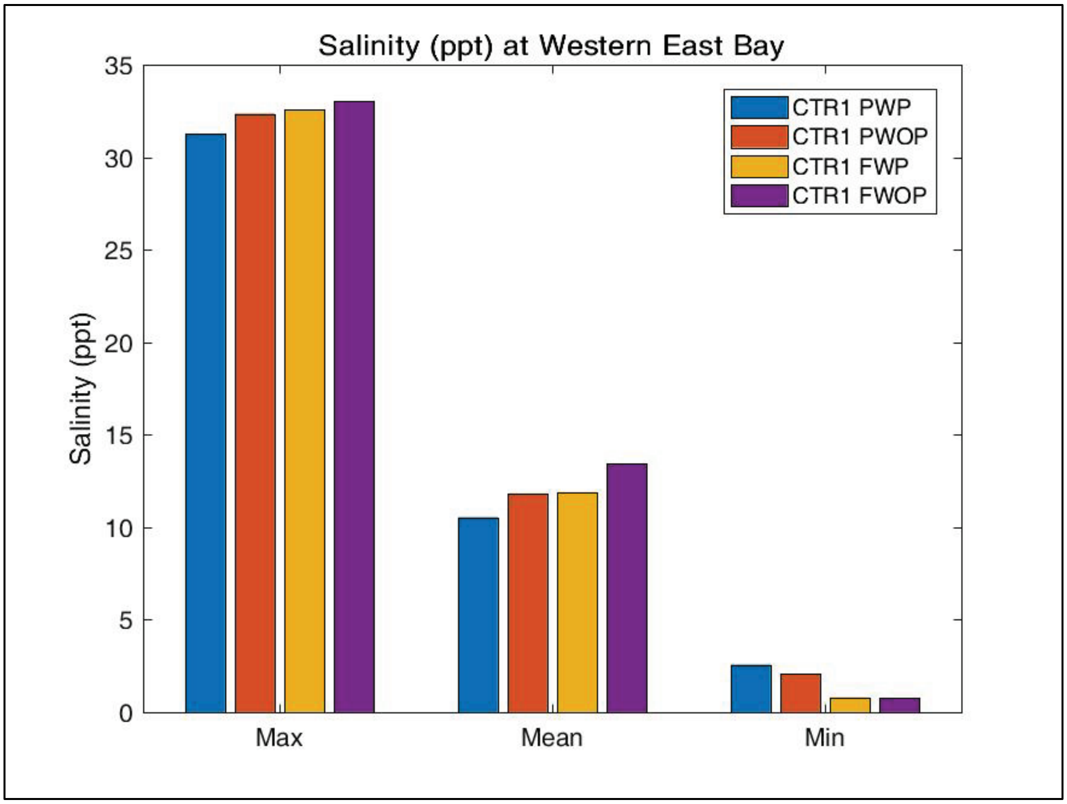

Mean Salinity Profiles at Lower Trinity Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
9
10
11
12
13
14
15
16
17
18
19
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

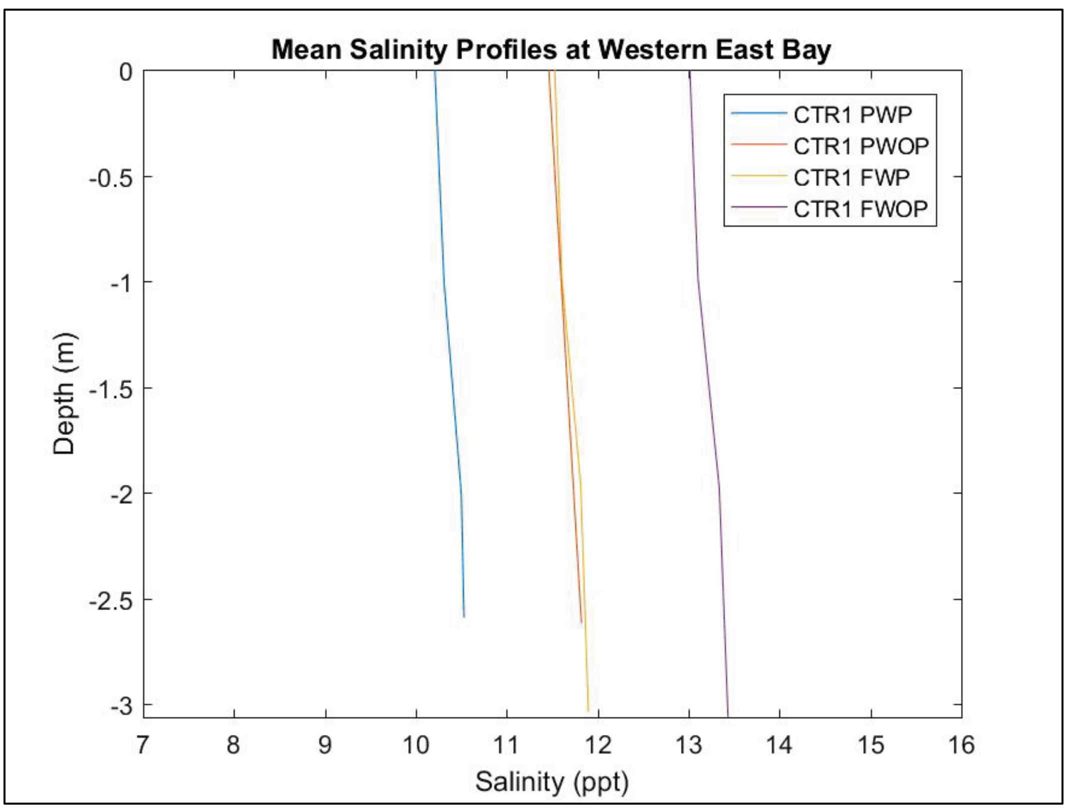

Salinity (ppt) at Mid Trinity Bay
Salinity (ppt)
0
2
4
6
8
10
12
14
16
18
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

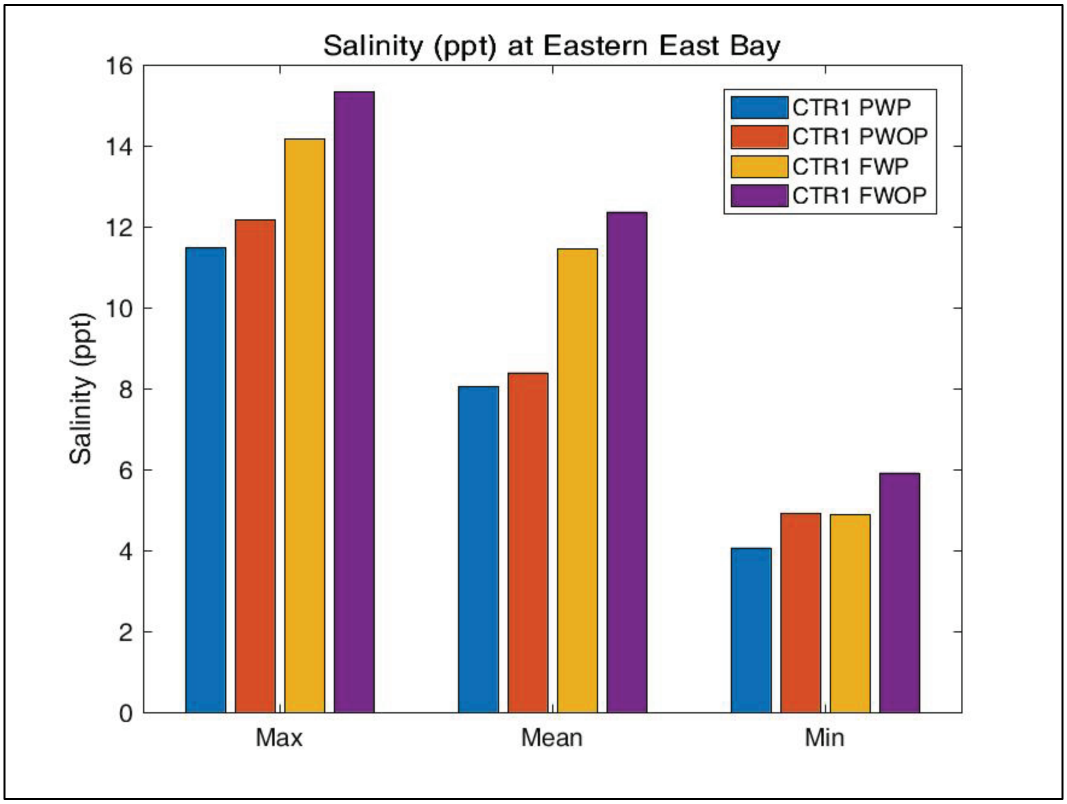

Mean Salinity Profiles at Mid Trinity Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Salinity (ppt)
4
5
6
7
8
9
10
11
12
13
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

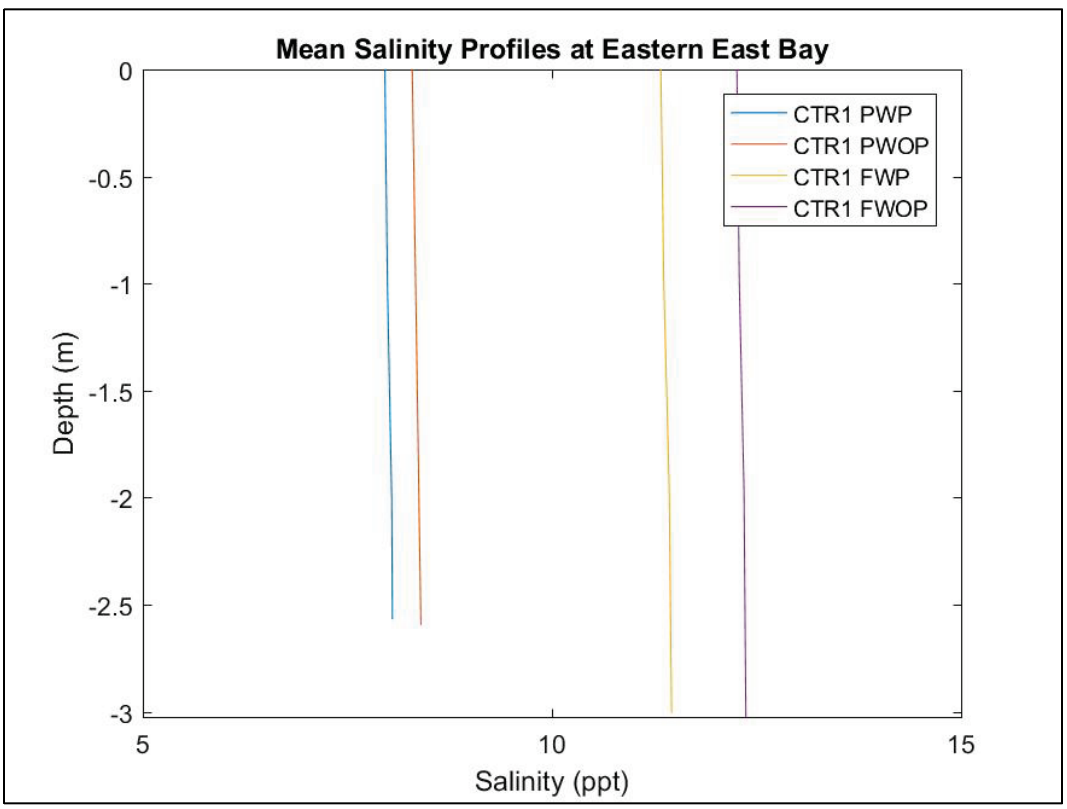

Salinity (ppt) at Upper Trinity Bay
Salinity (ppt)
9
8
7
6
5
4
3
2
1
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

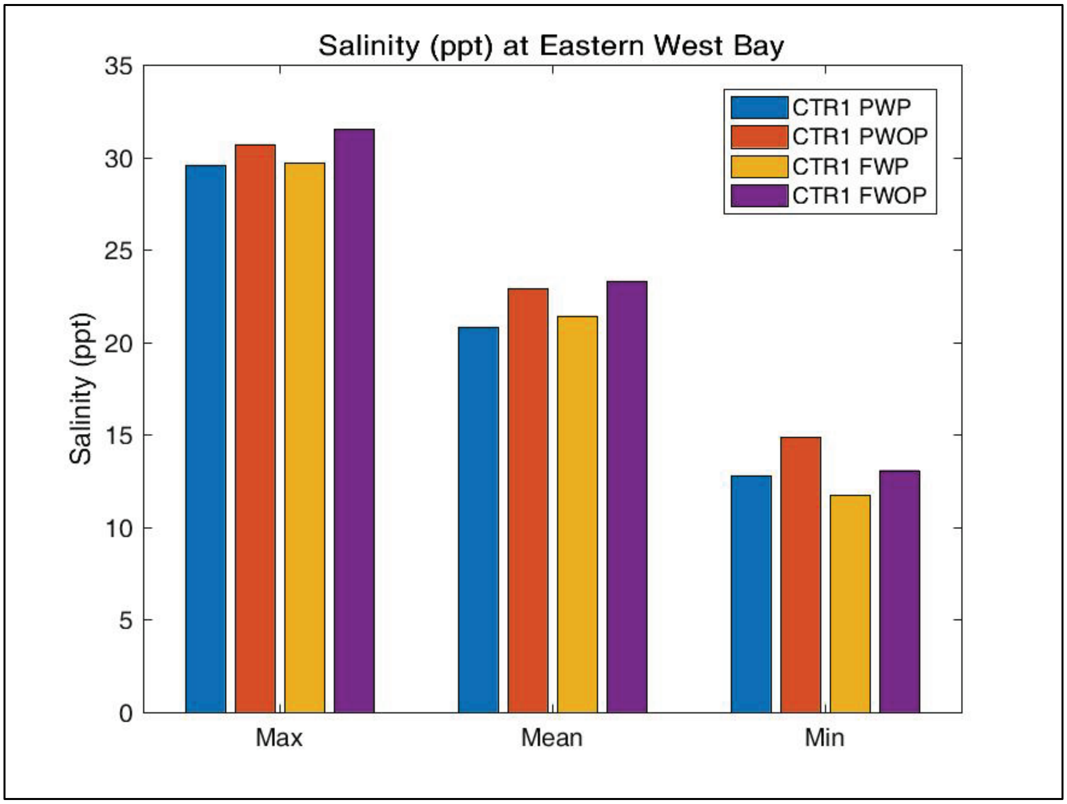

Mean Salinity Profiles at Upper Trinity Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-2
-1
0
1
2
3
4
5
6
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

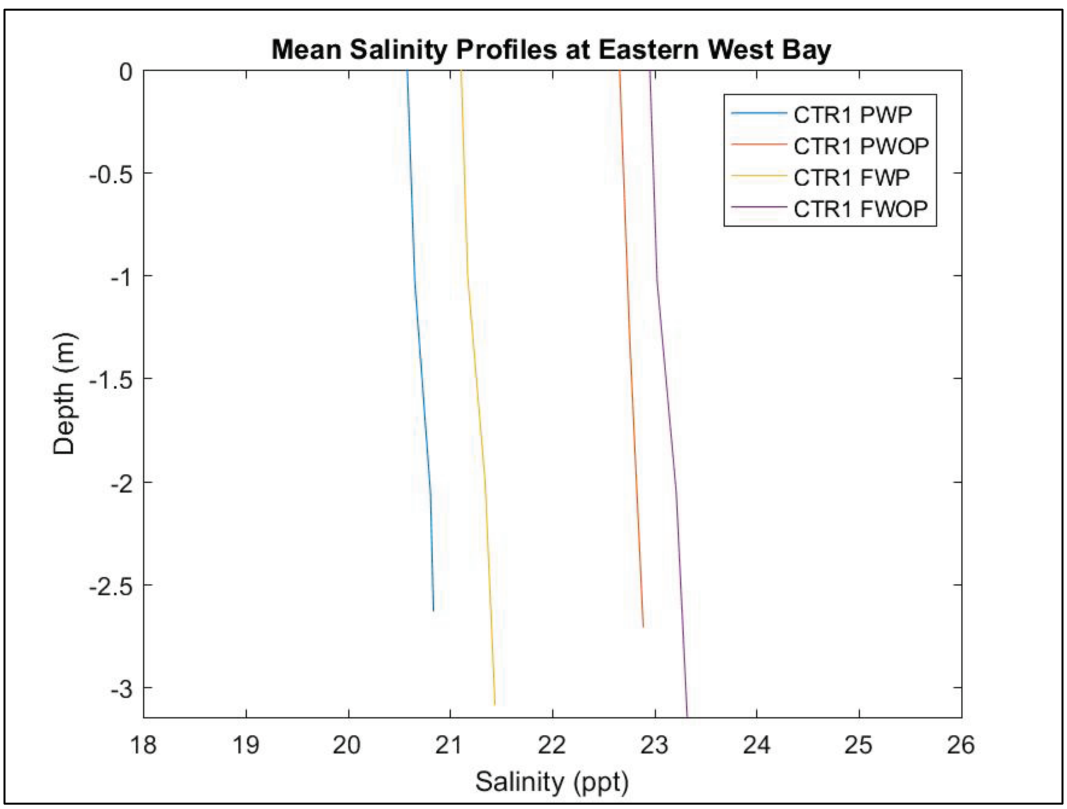

Salinity (ppt) at Western East Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

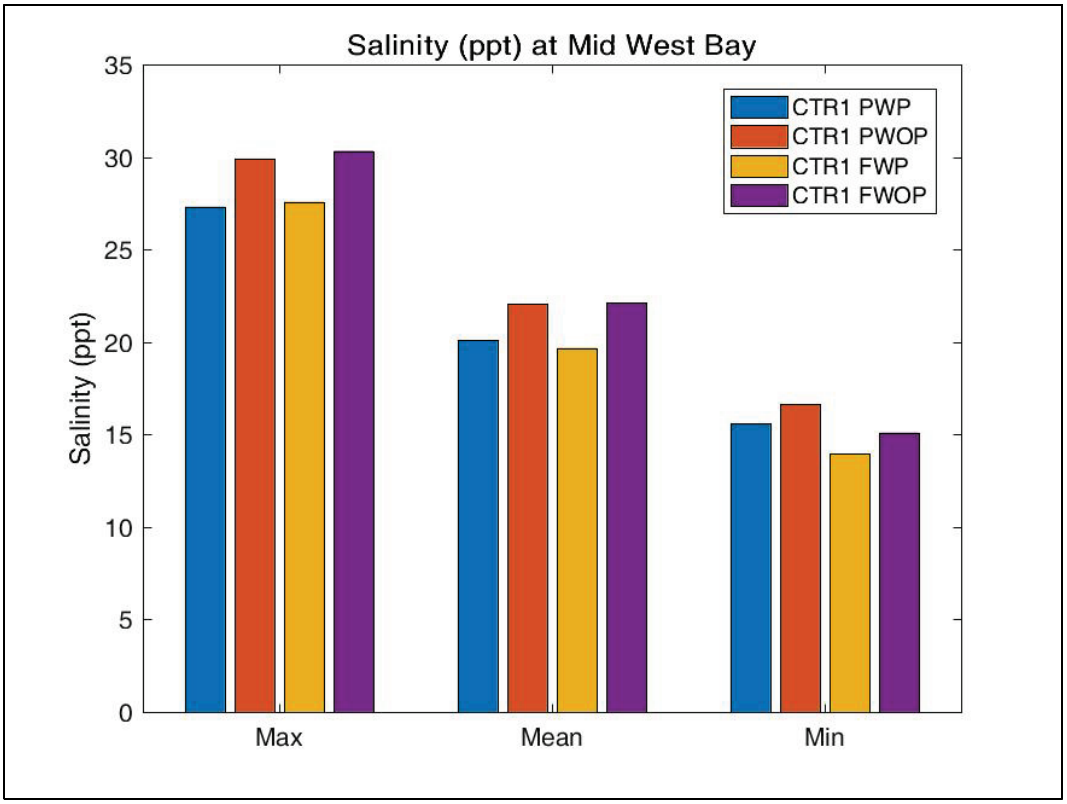

Mean Salinity Profiles at Western East Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
7
8
9
10
11
12
13
14
15
16
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

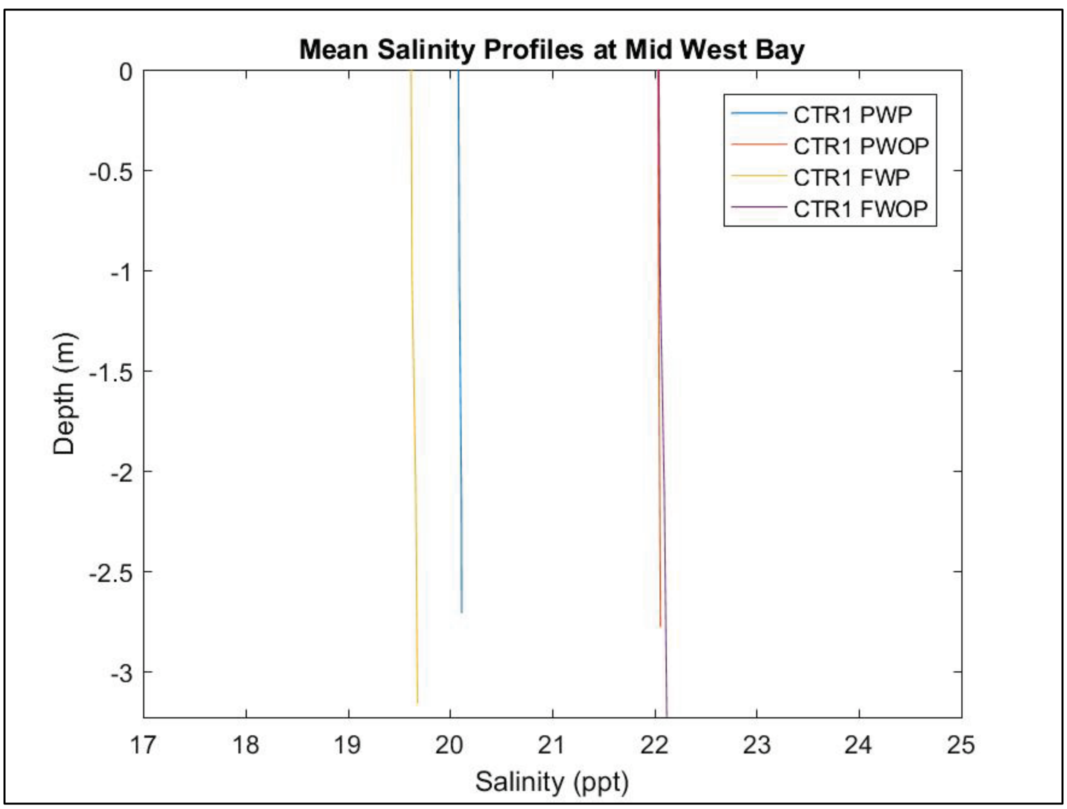

Salinity (ppt) at Eastern East Bay
Salinity (ppt)
16
14
12
10
8
6
4
2
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

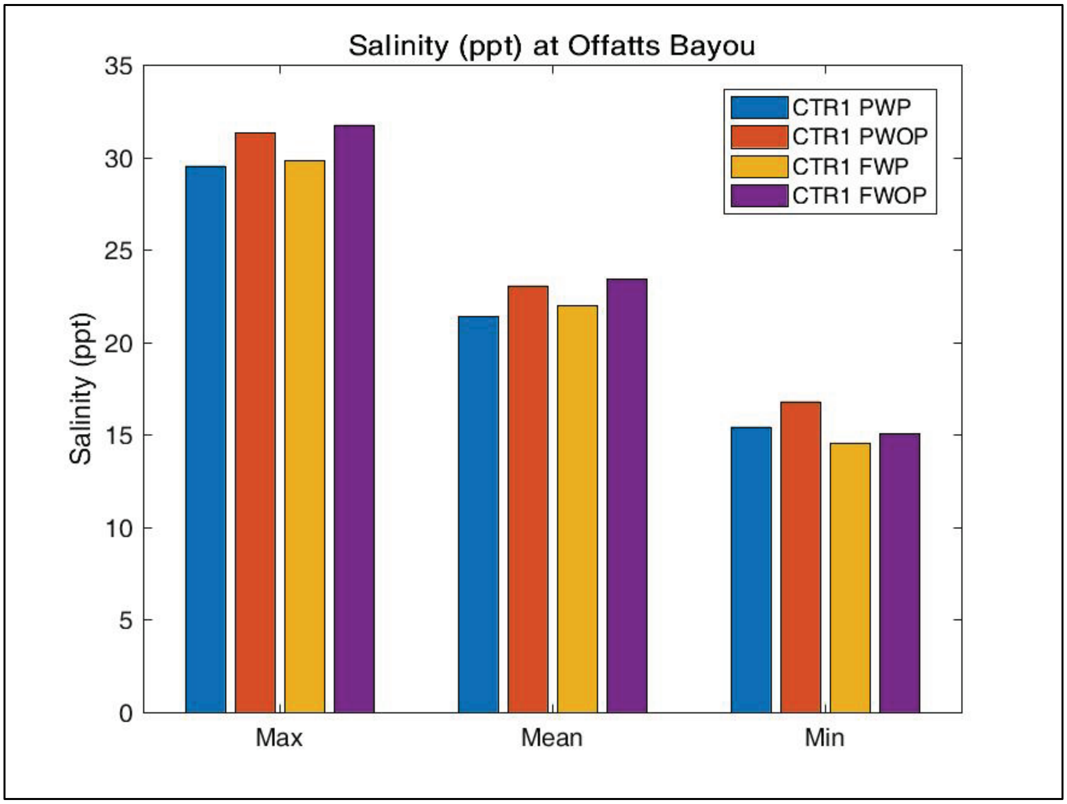

Mean Salinity Profiles at Eastern East Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
5
10
15
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

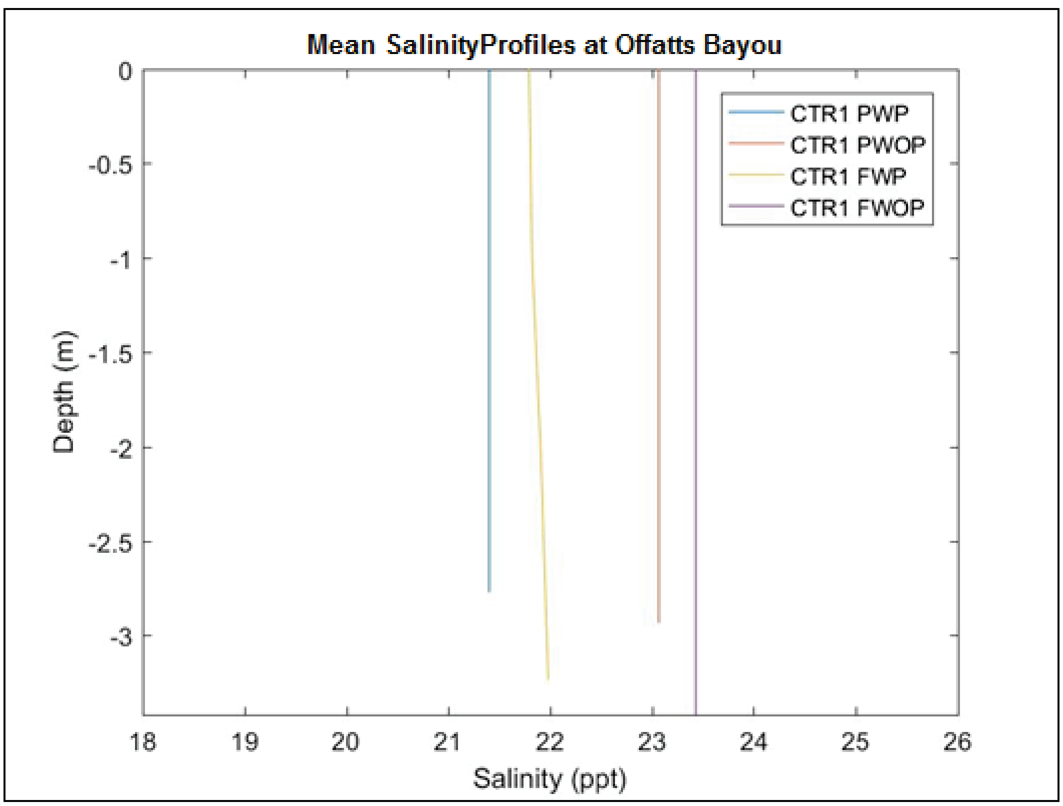

Salinity (ppt) at Eastern West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

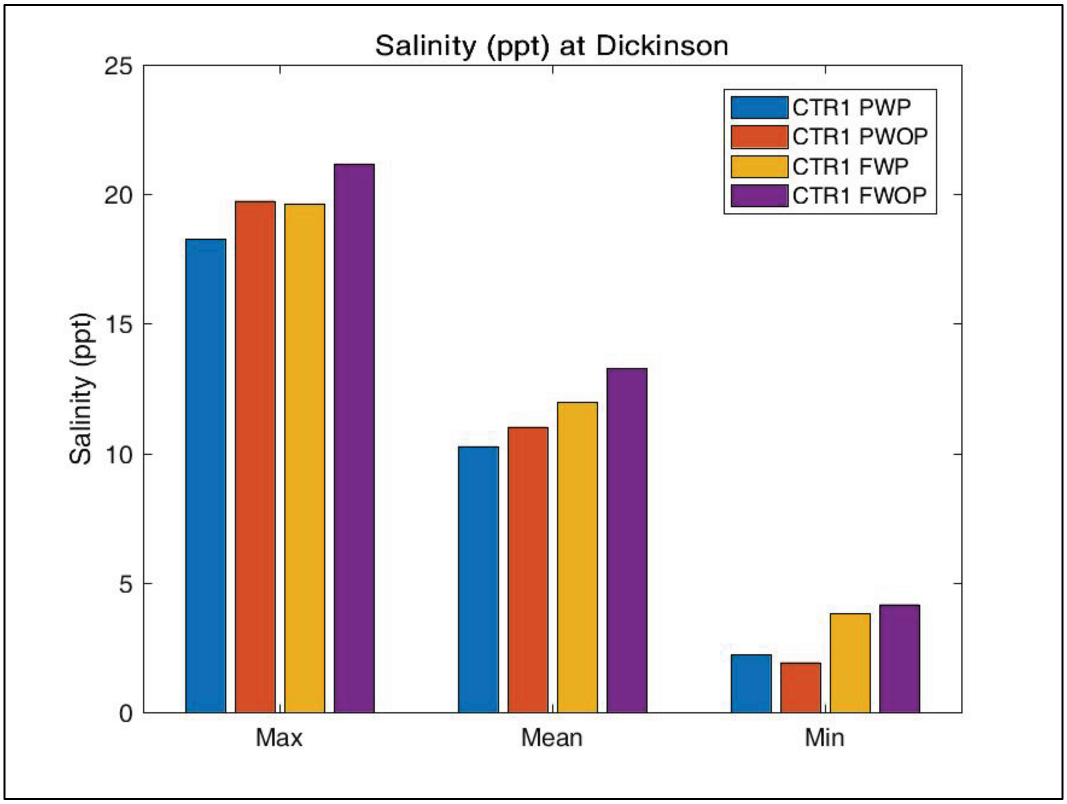

Mean Salinity Profiles at Eastern West Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
18
19
20
21
22
23
24
25
26
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Mid West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

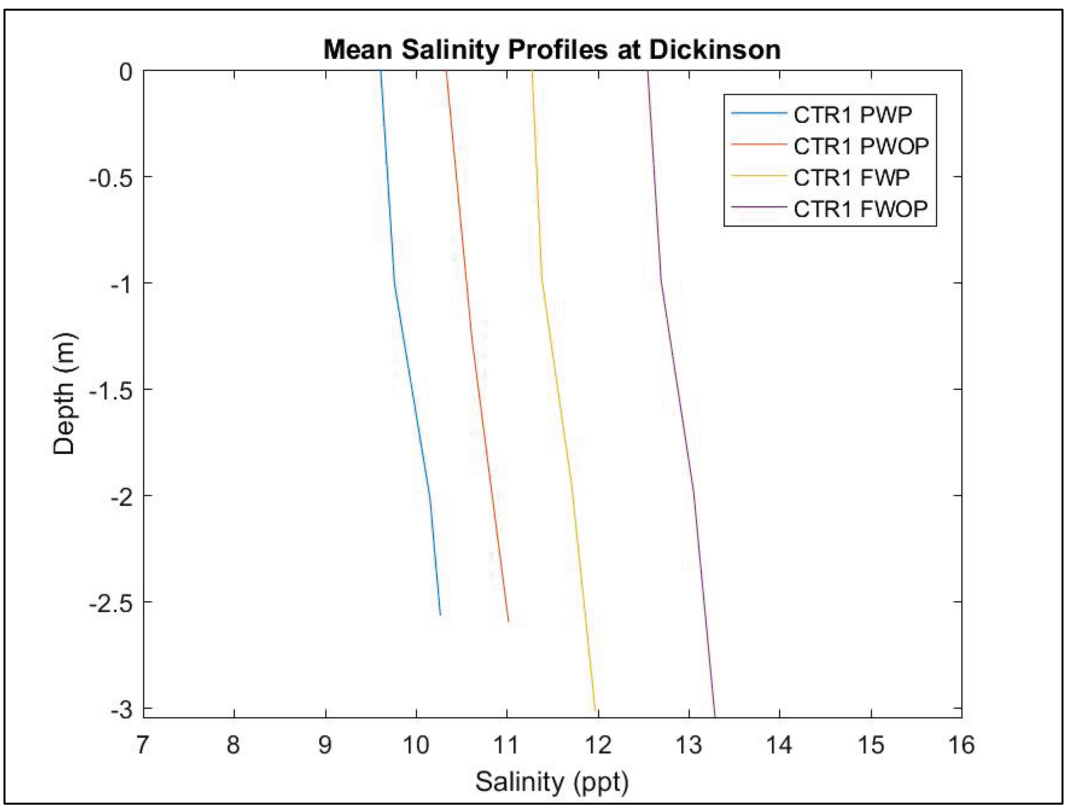

Mean Salinity Profiles at Mid West Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
17
18
19
20
21
22
23
24
25
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at Offatts Bayou
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

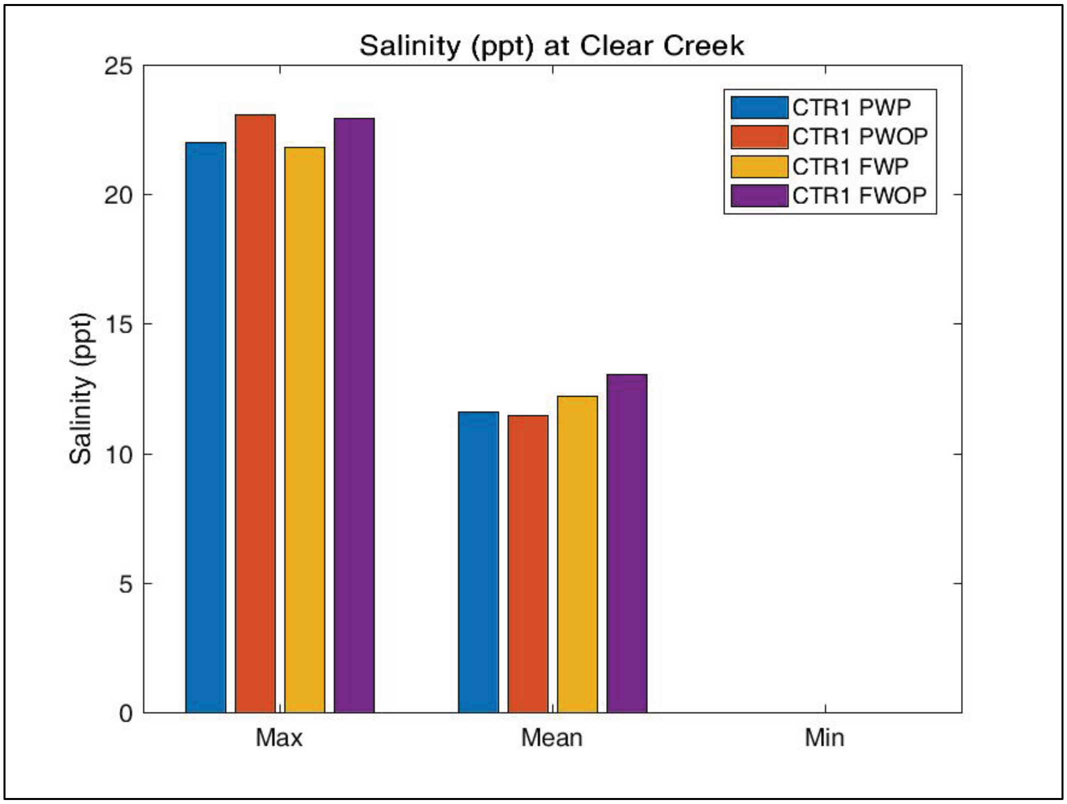

Mean SalinityProfiles at Offatts Bayou
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
18
19
20
21
22
23
24
25
26
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

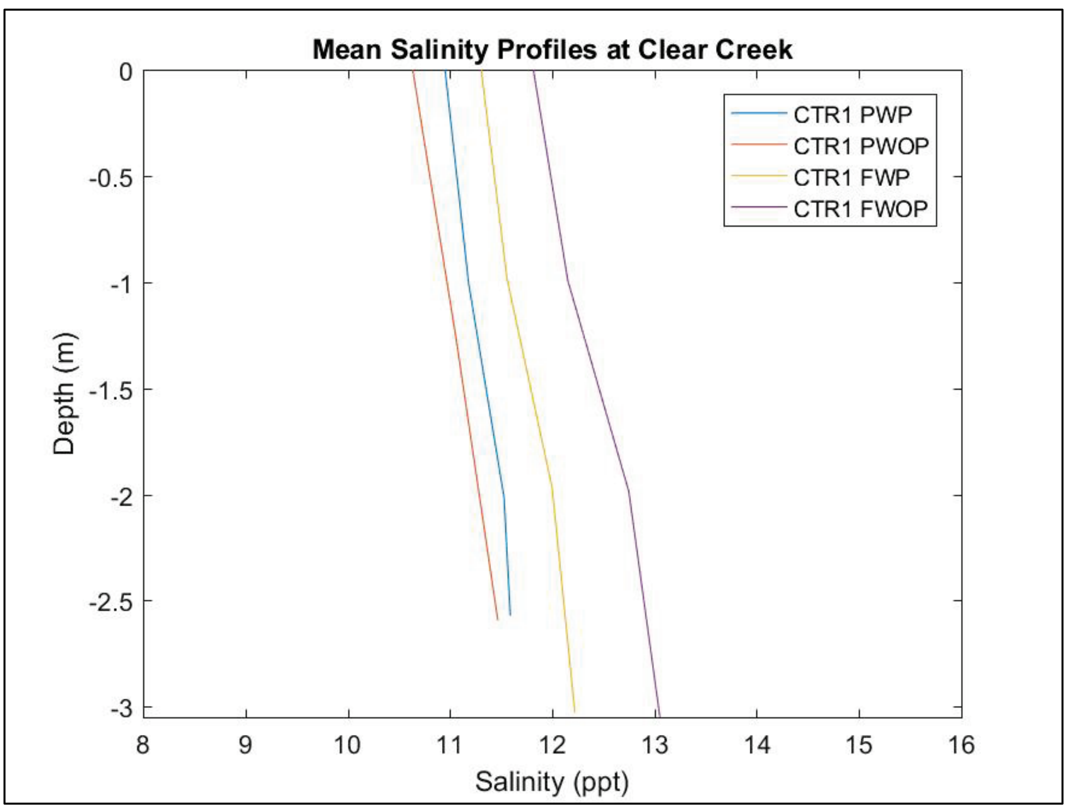


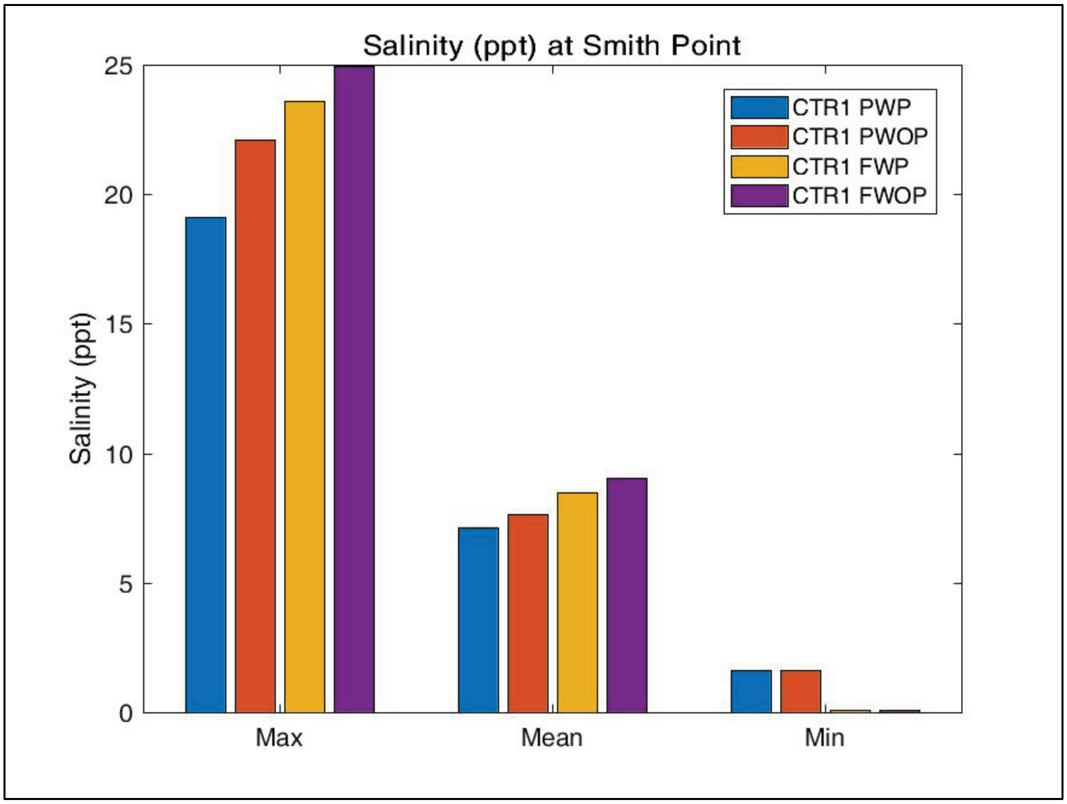
Salinity (ppt) at Dickinson
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

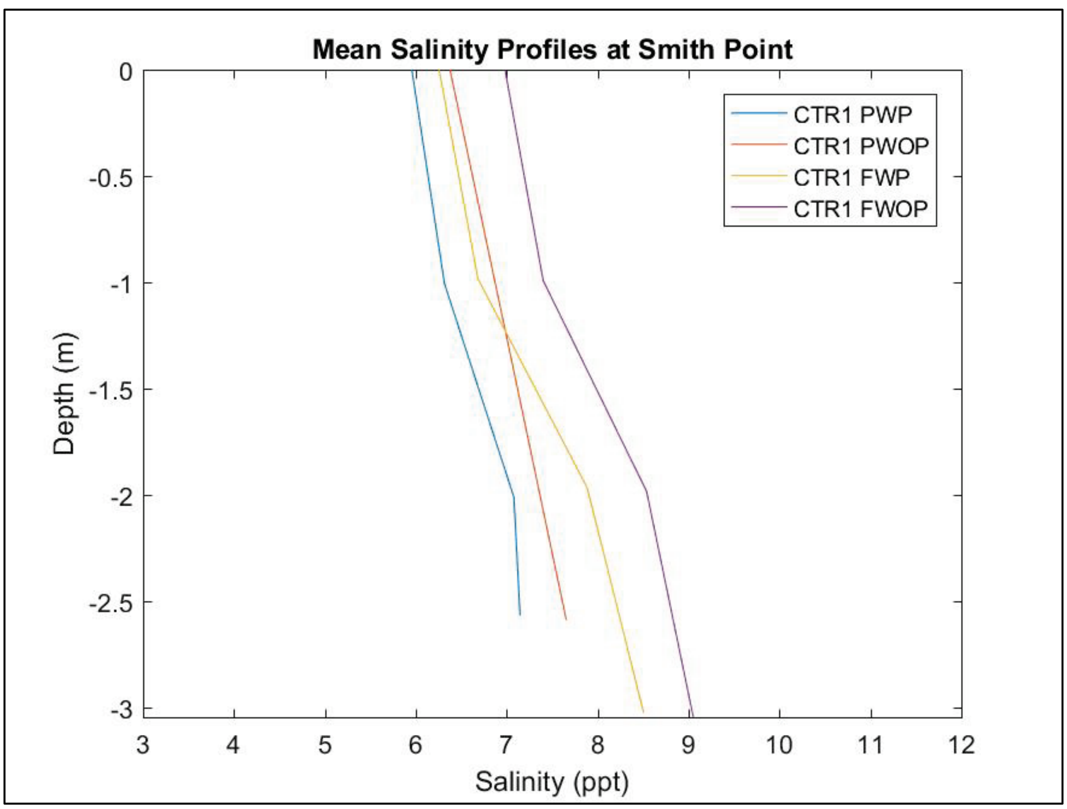


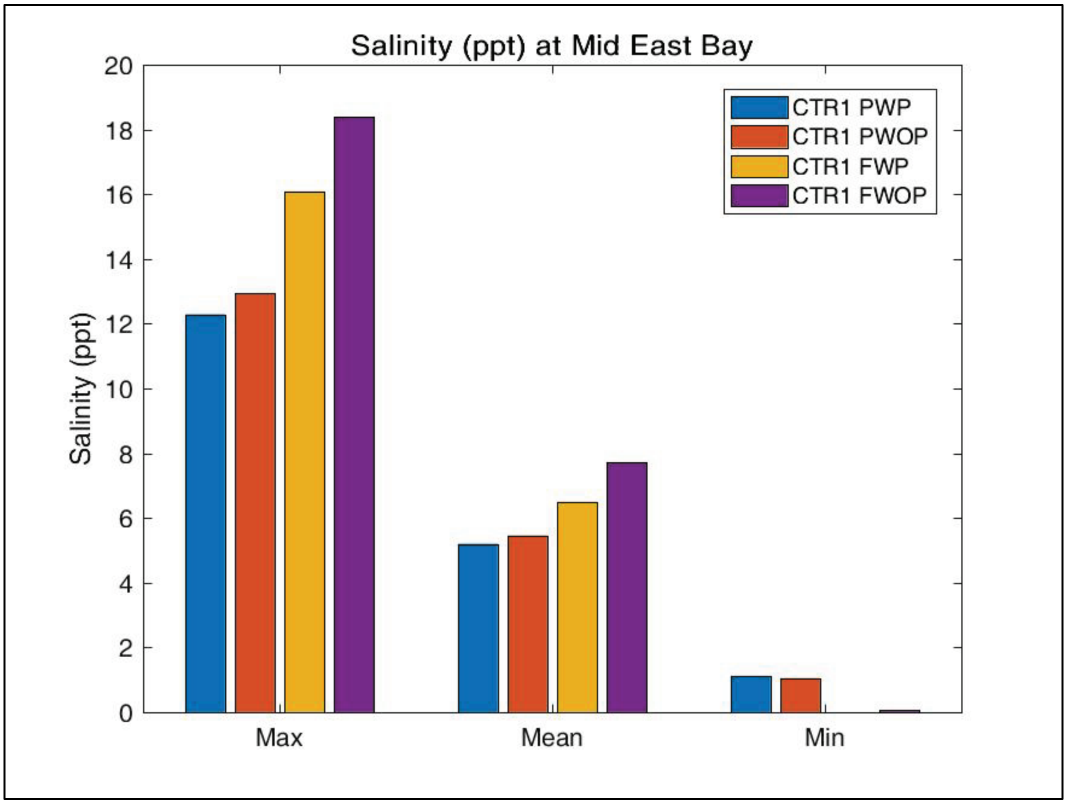
Mean Salinity Profiles at Dickinson
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
7
8
9
10
11
12
13
14
15
16
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

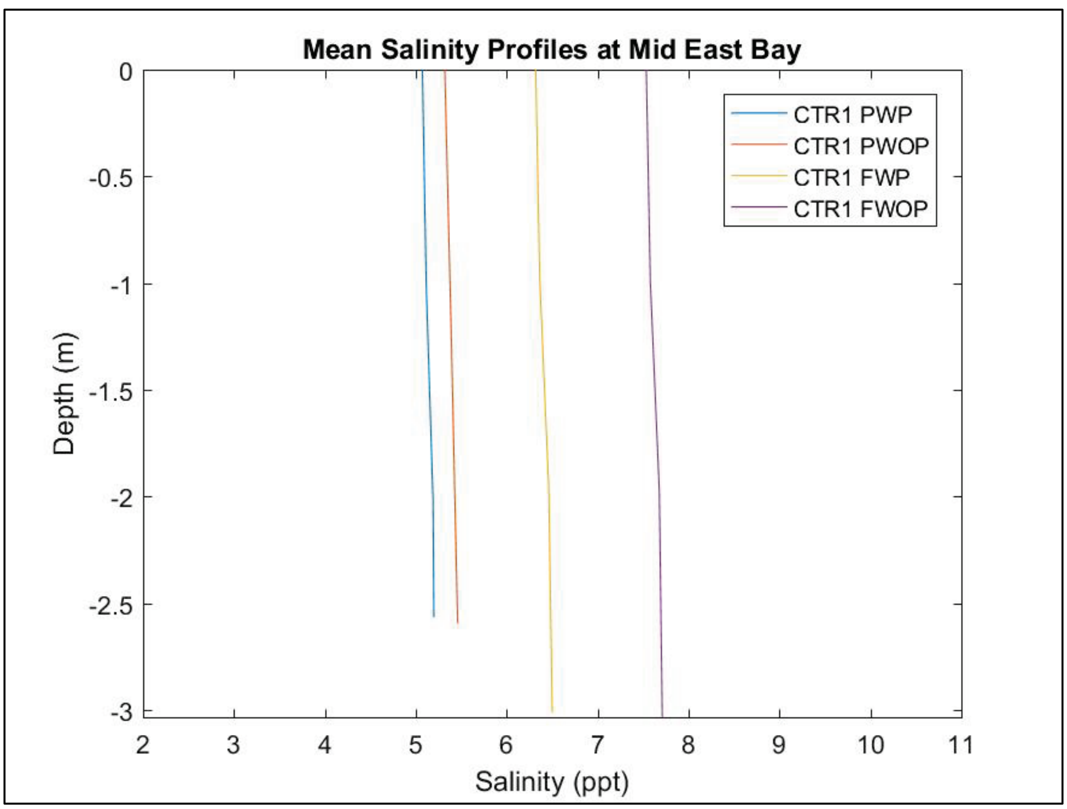

Salinity (ppt) at Clear Creek
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

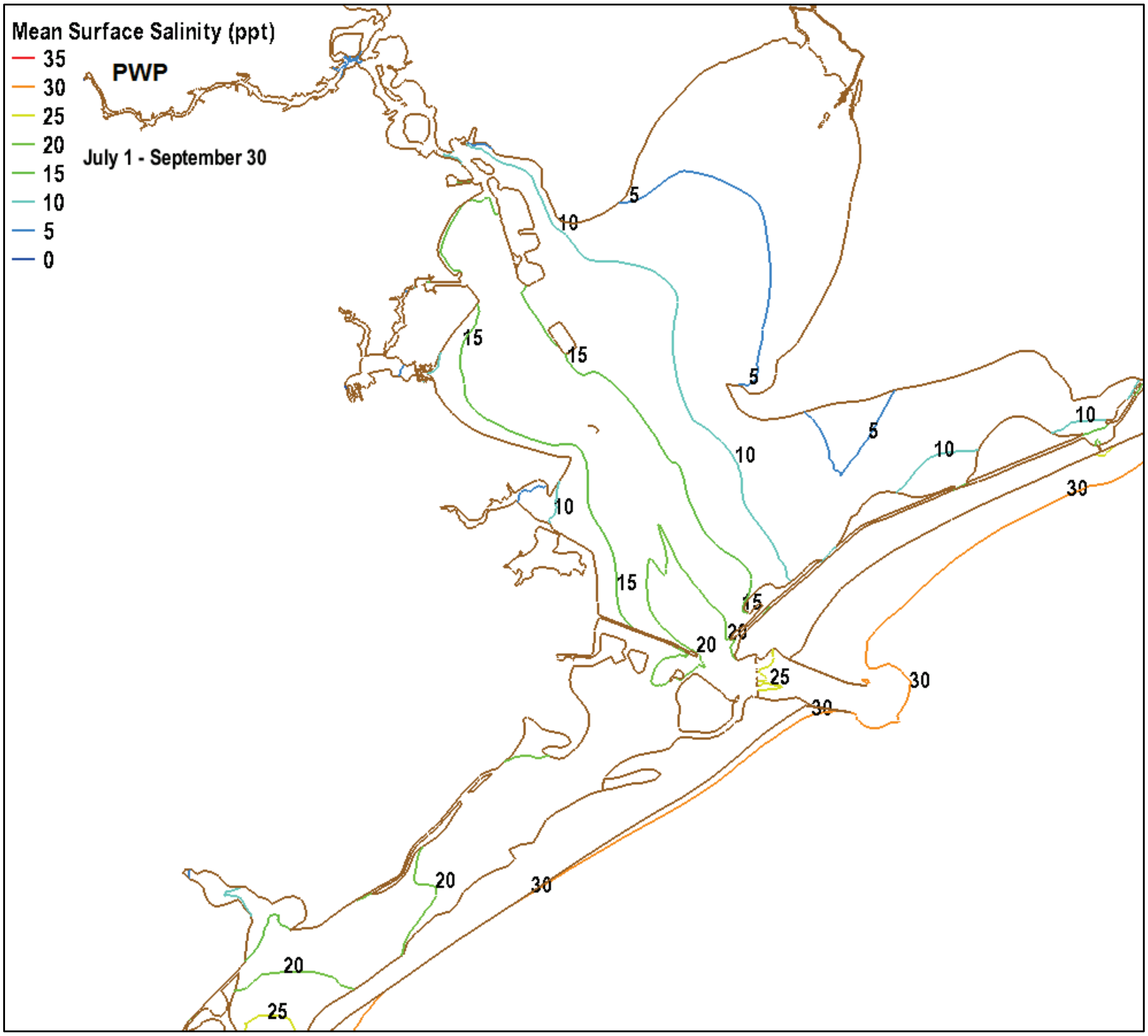

Mean Salinity Profiles at Clear Creek
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
8
9
10
11
12
13
14
15
16
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

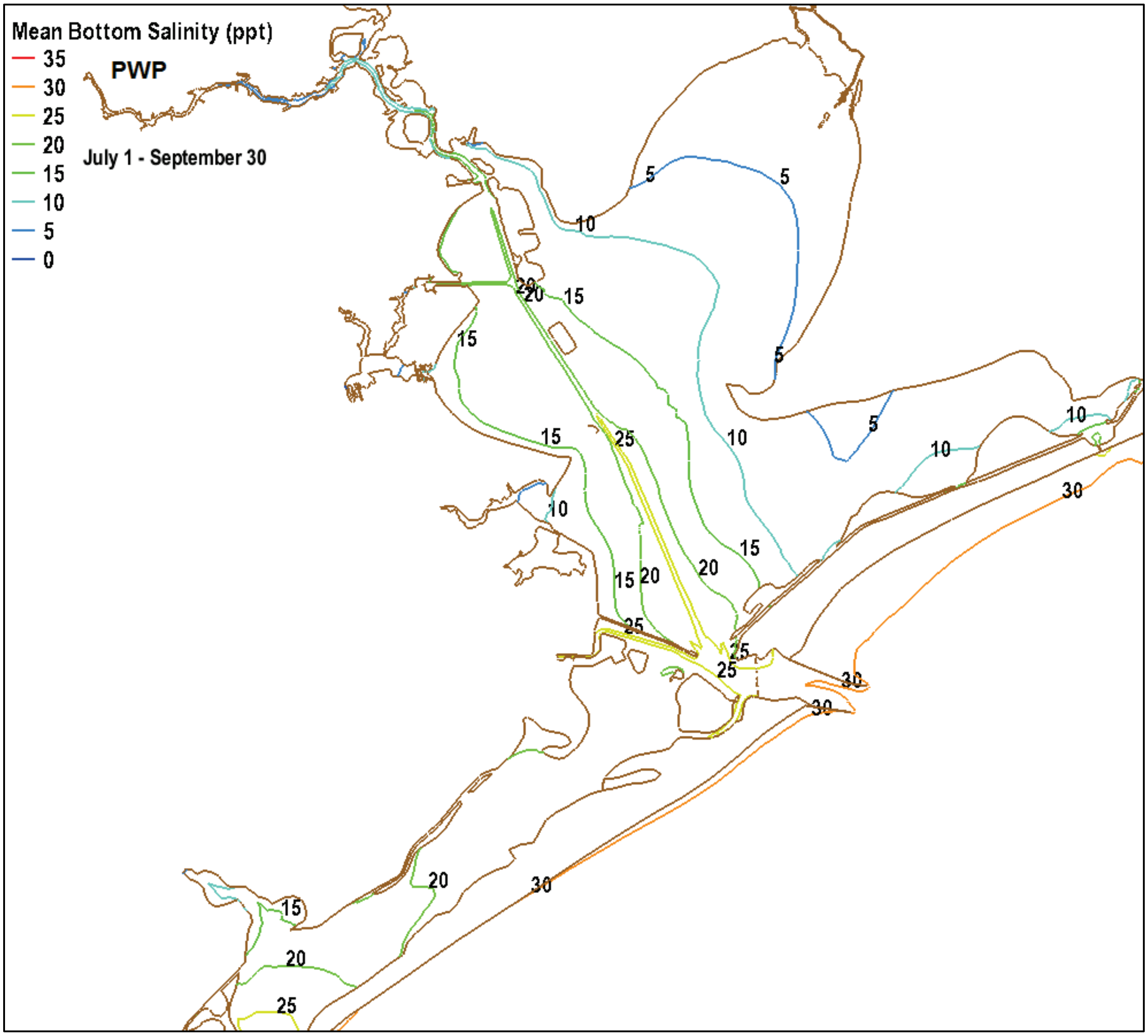

Salinity (ppt) at Smith Point
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

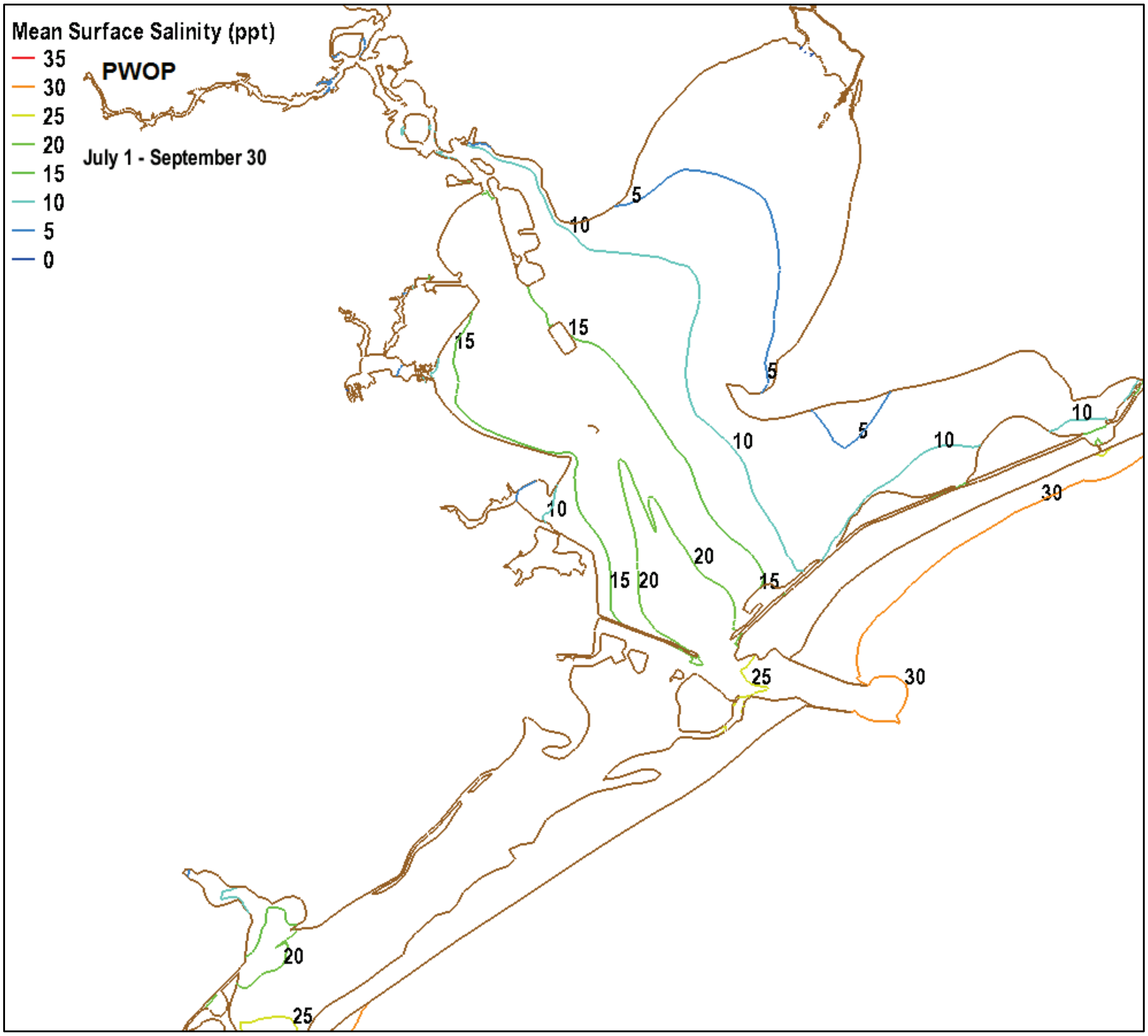

Mean Salinity Profiles at Smith Point
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
3
4
5
6
7
8
9
10
11
12
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

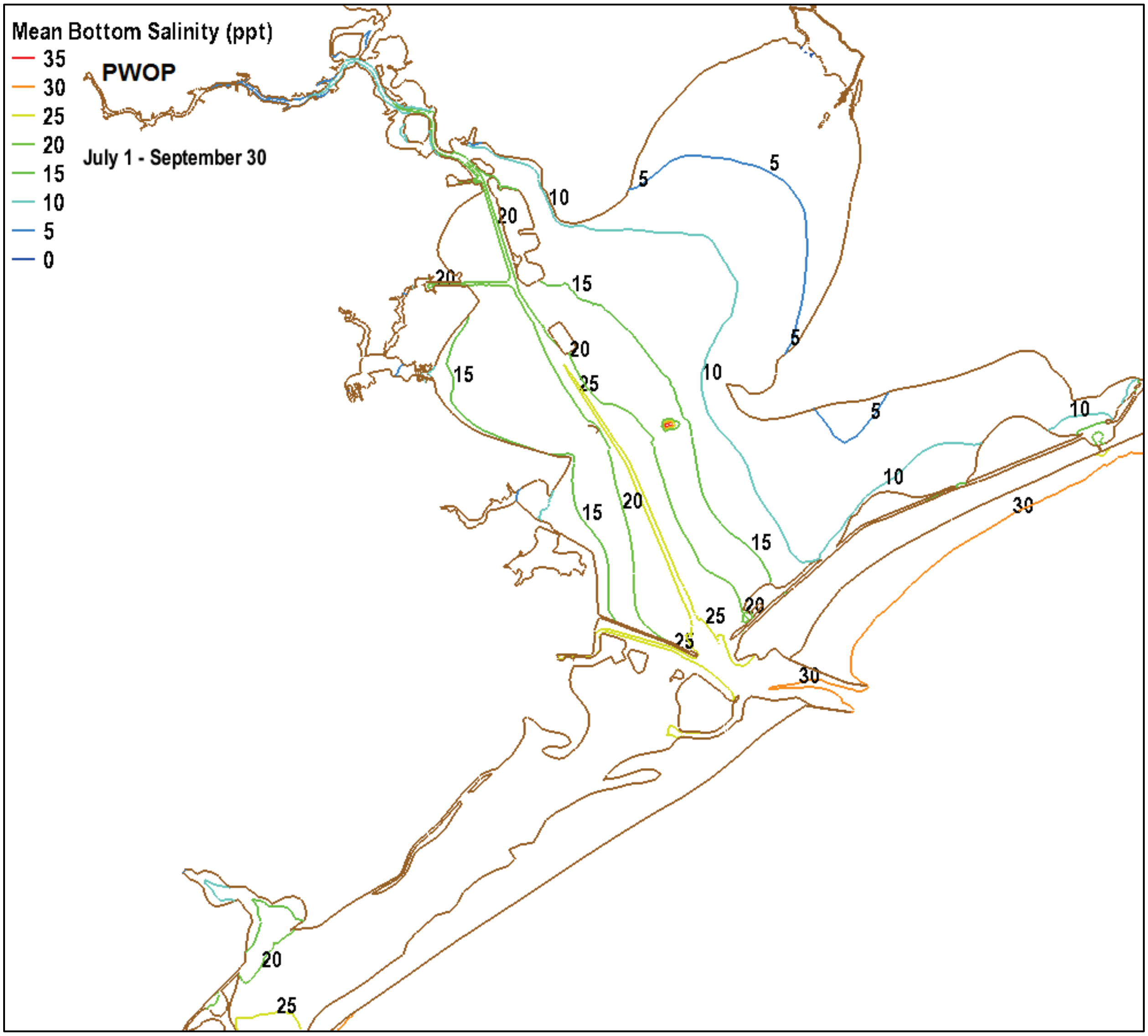

Salinity (ppt) at Mid East Bay
Salinity (ppt)
20
18
16
14
12
10
8
6
4
2
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

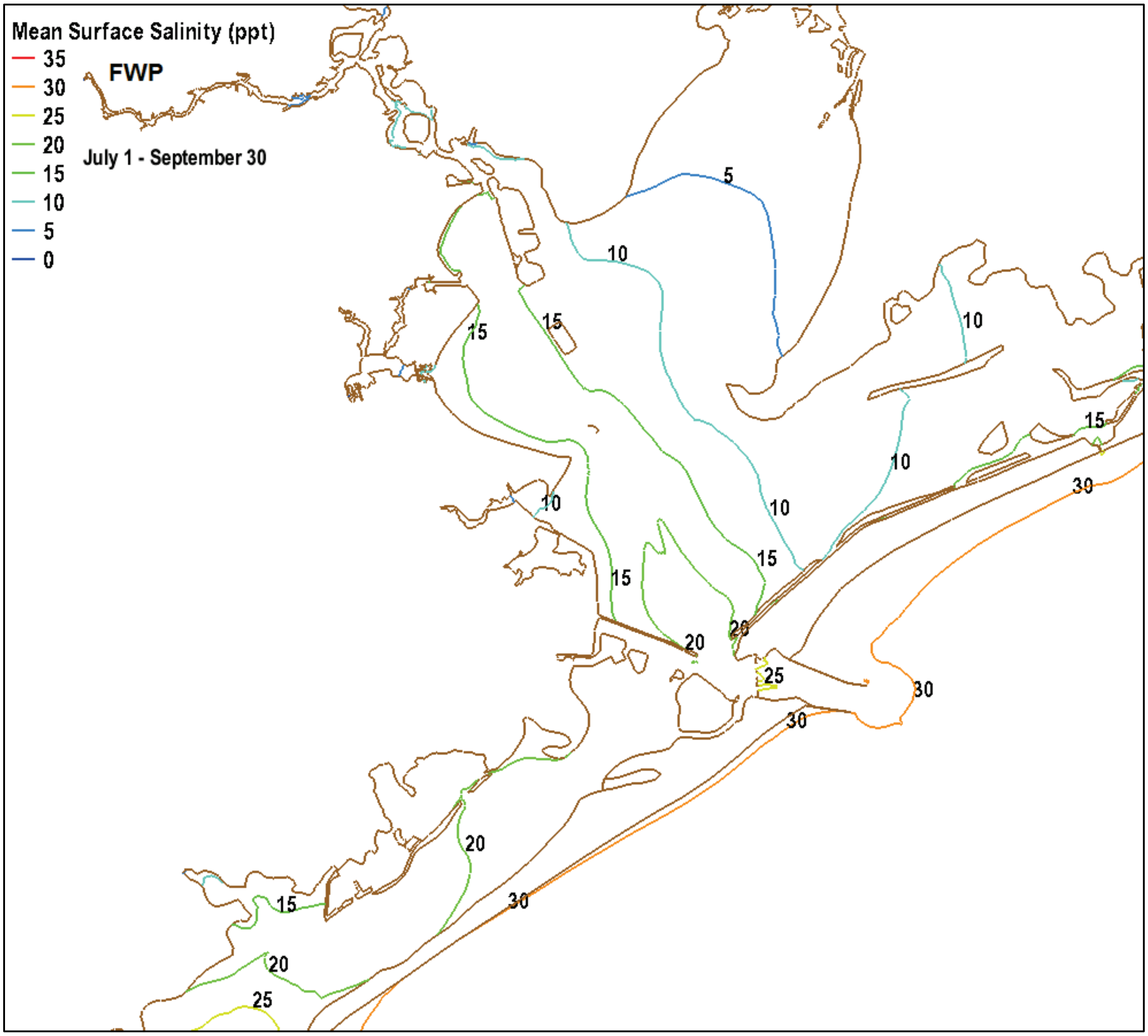

Mean Salinity Profiles at Mid East Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
2
3
4
5
6
7
8
9
10
11
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

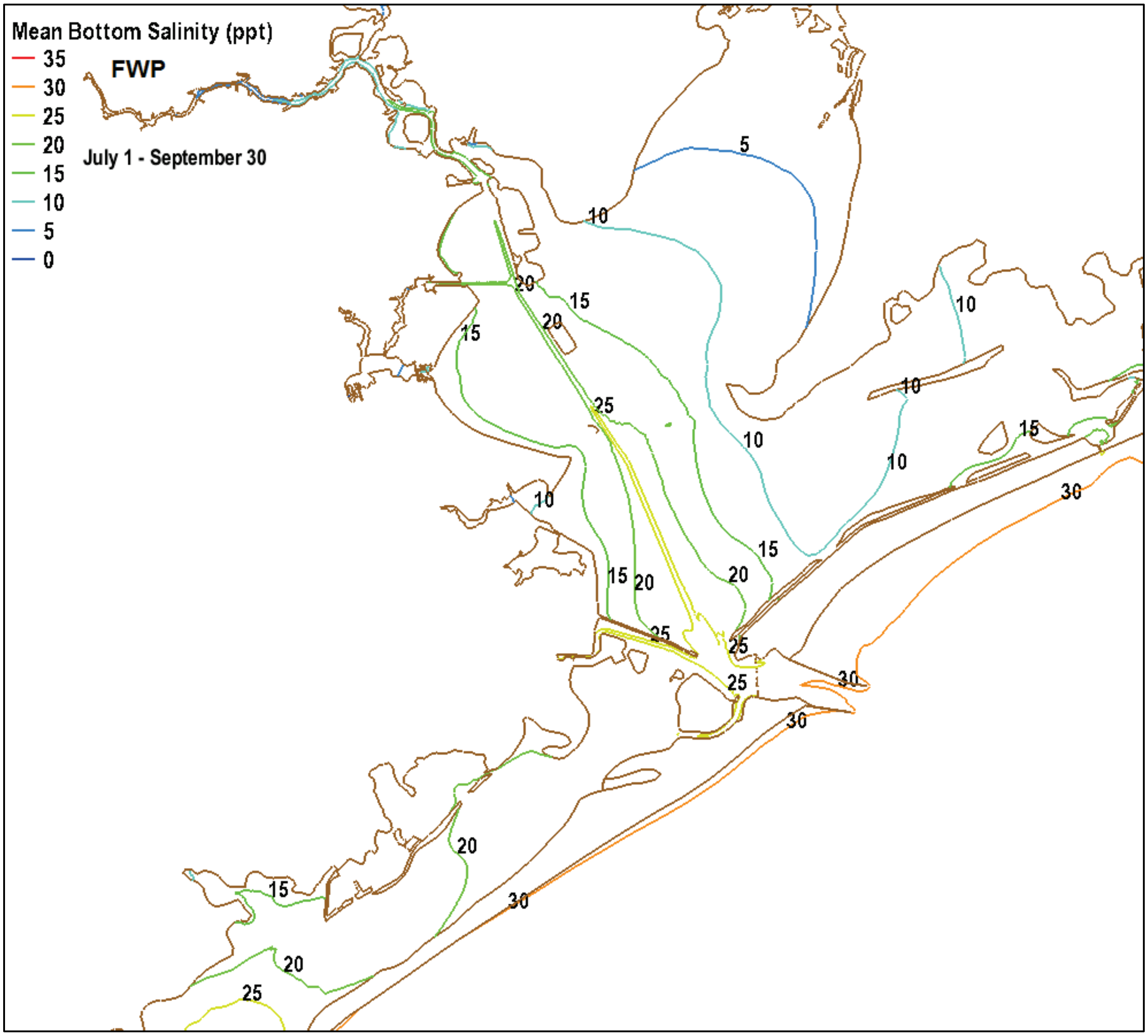

Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
PWP
July 1 - September 30
5
10
15
15
5
10
5
10
10
10
30
15
15
20
20
25
30
30
20
30
20
25

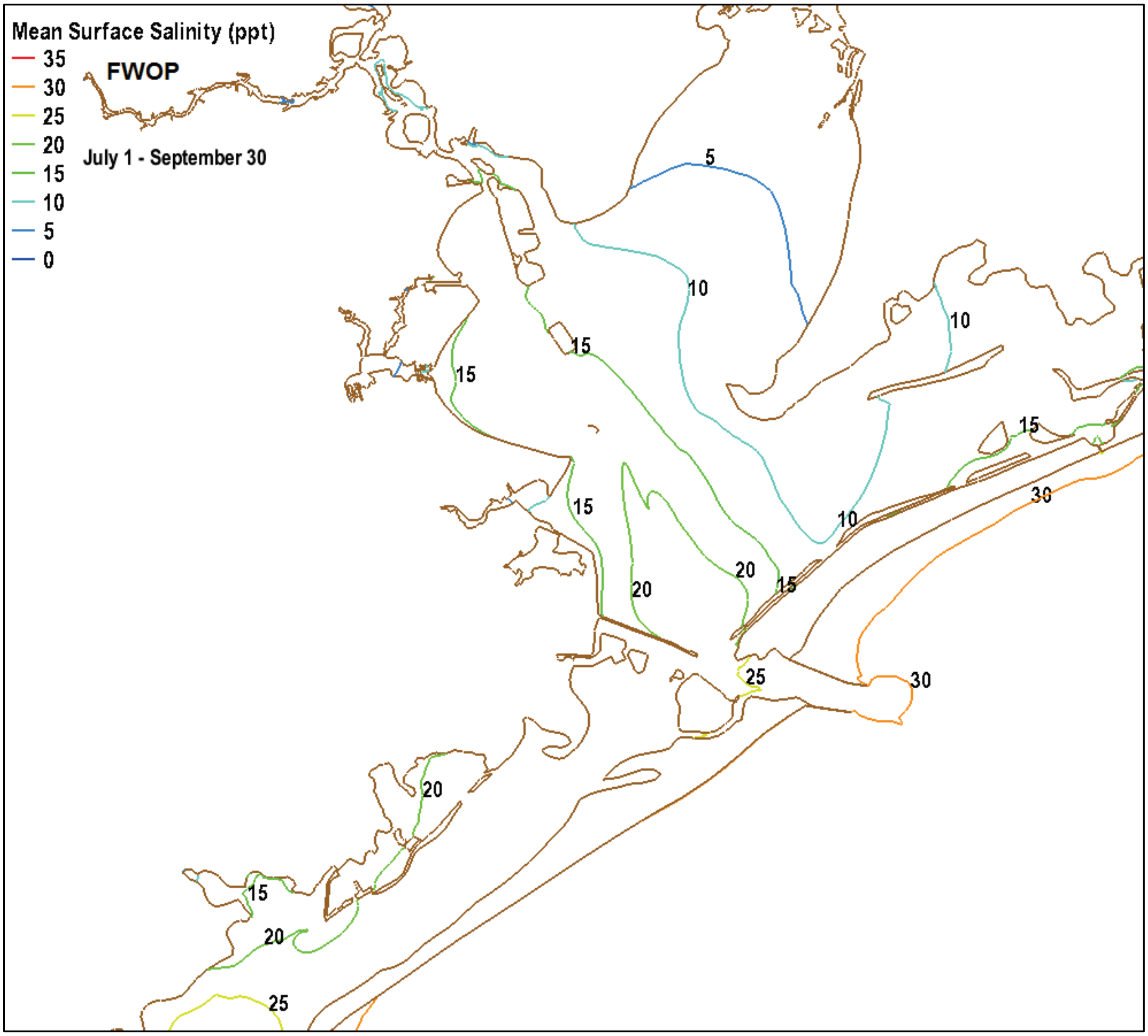

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
PWP
July 1 - September 30


Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
PWOP
July 1 - September 30
5
10
15
15
5
10
5
10
10
10
30
20
15
15 20
25
30
20
25

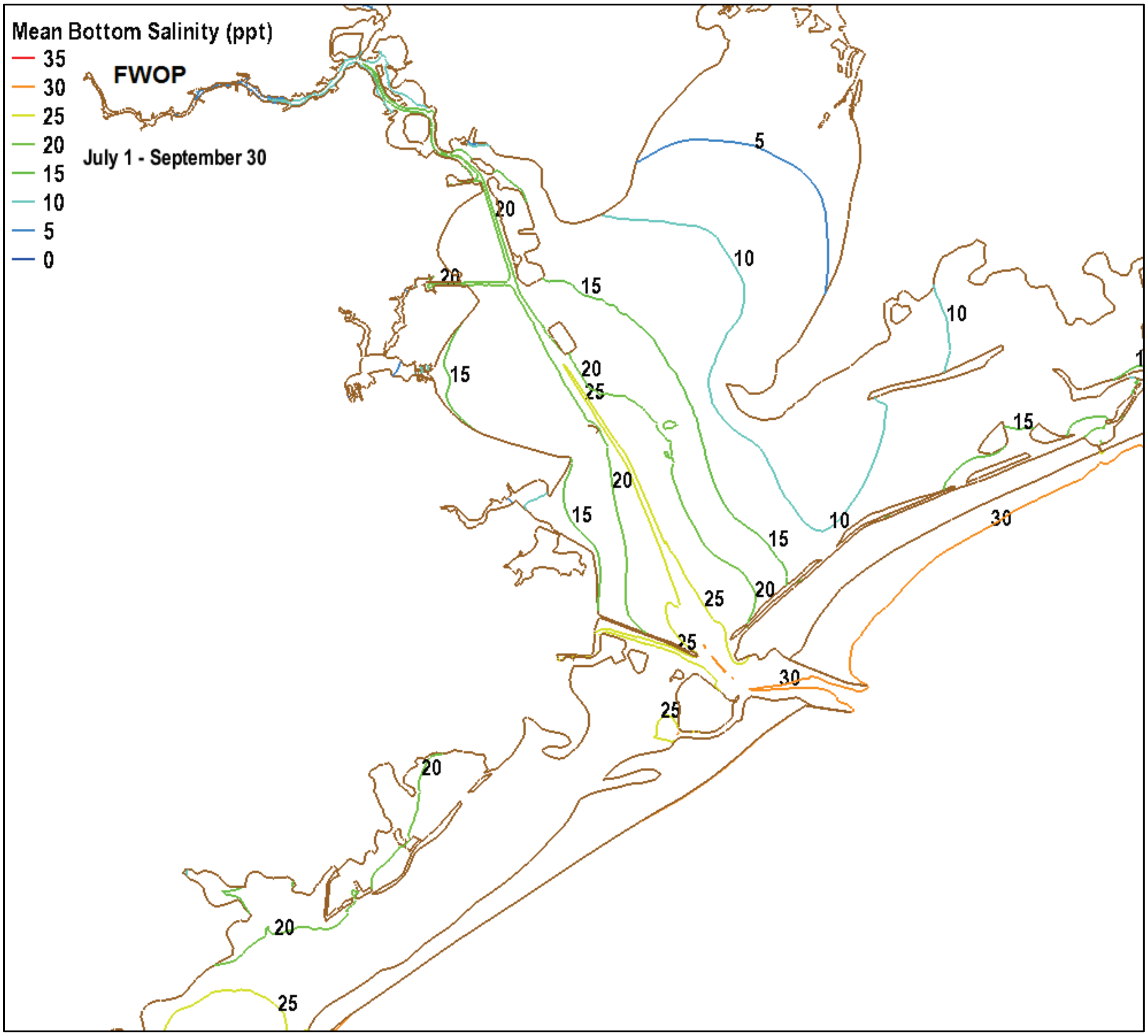

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
PWOP
July 1 - September 30
5
5
10
20
20
15
5
20
15
25
10
5
10
10
20
15
15
20
25
25
30
30
20
25


Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
FWP
July 1 - September 30
5
10
10
15
15
10
10
10
10
15
15
15
20
20
25
30
30
30
30
20
15
20
25

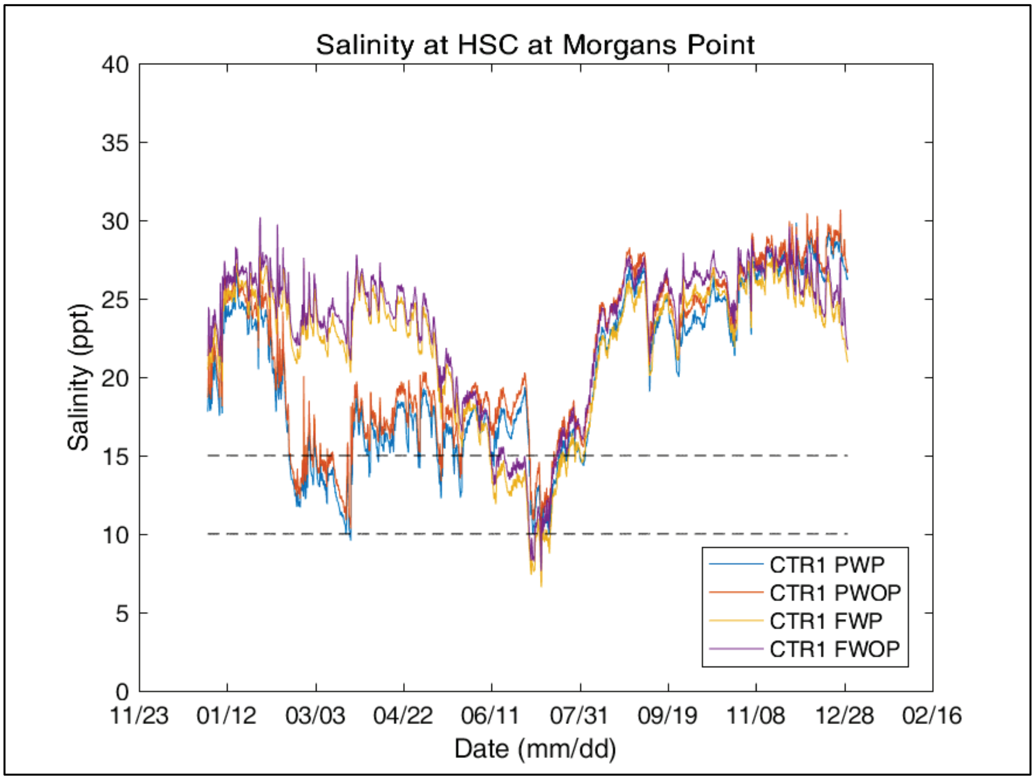

Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
FWP
July 1 - September 30
5
10
20
15
20
15
25
10
10
10
10
15
10
30
15
20
15
20
25
25
25
30
30
20
15
30
20
25

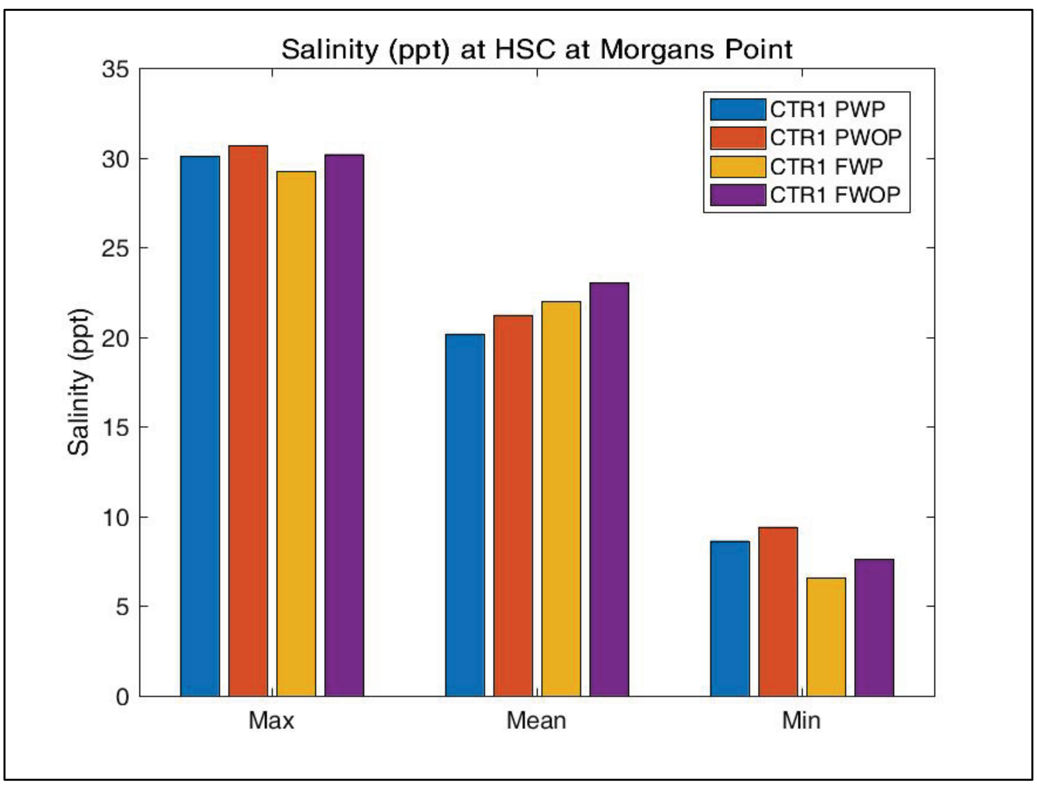


Mean Surface Salinity (ppt)
35
30
25
20
15
10
5
0
FWOP
July 1 - September 30
5
10
10
15
15
15
15
10
20
20
15
25
30
30
20
15
20
25


Mean Bottom Salinity (ppt)
35
30
25
20
15
10
5
0
FWOP
July 1 - September 30
5
10
15
20
25
30

Appendix B: Salinity Point Analysis

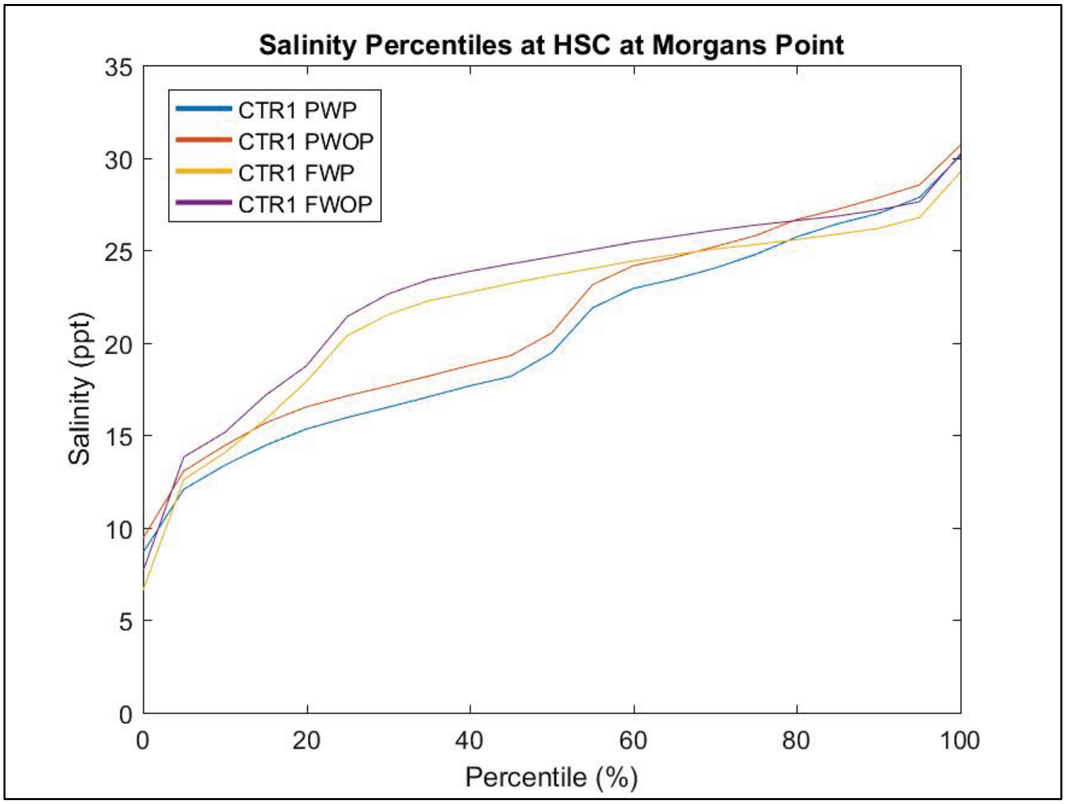


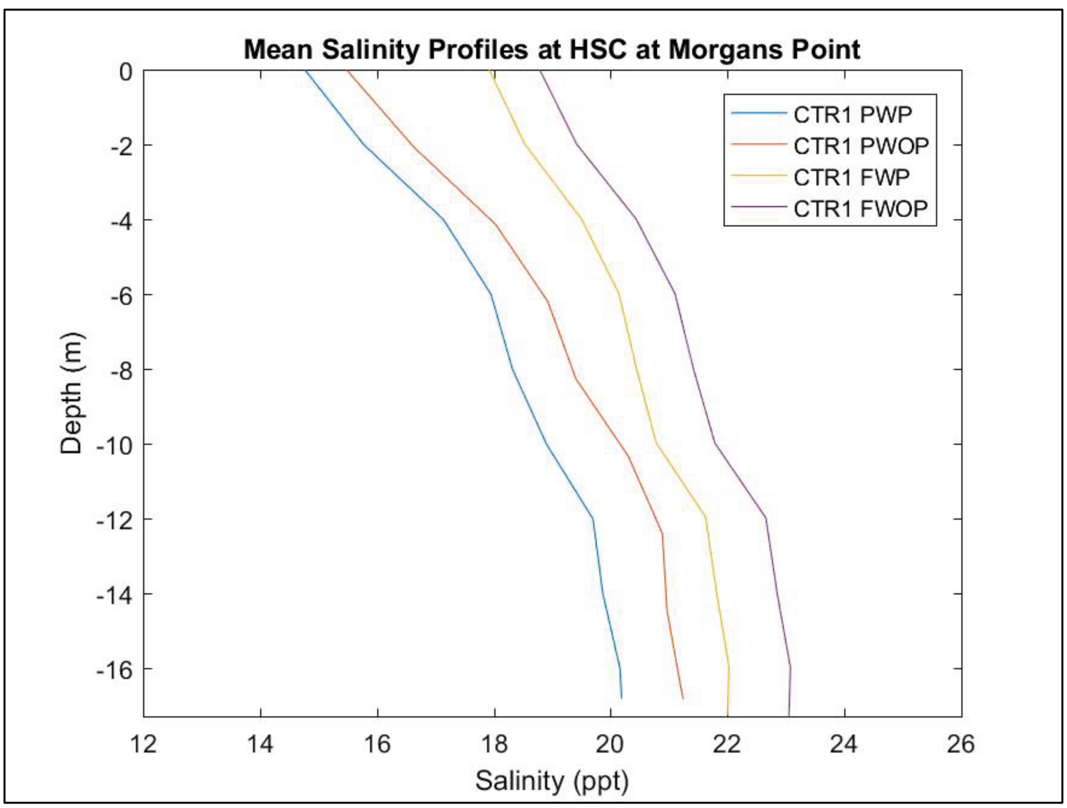


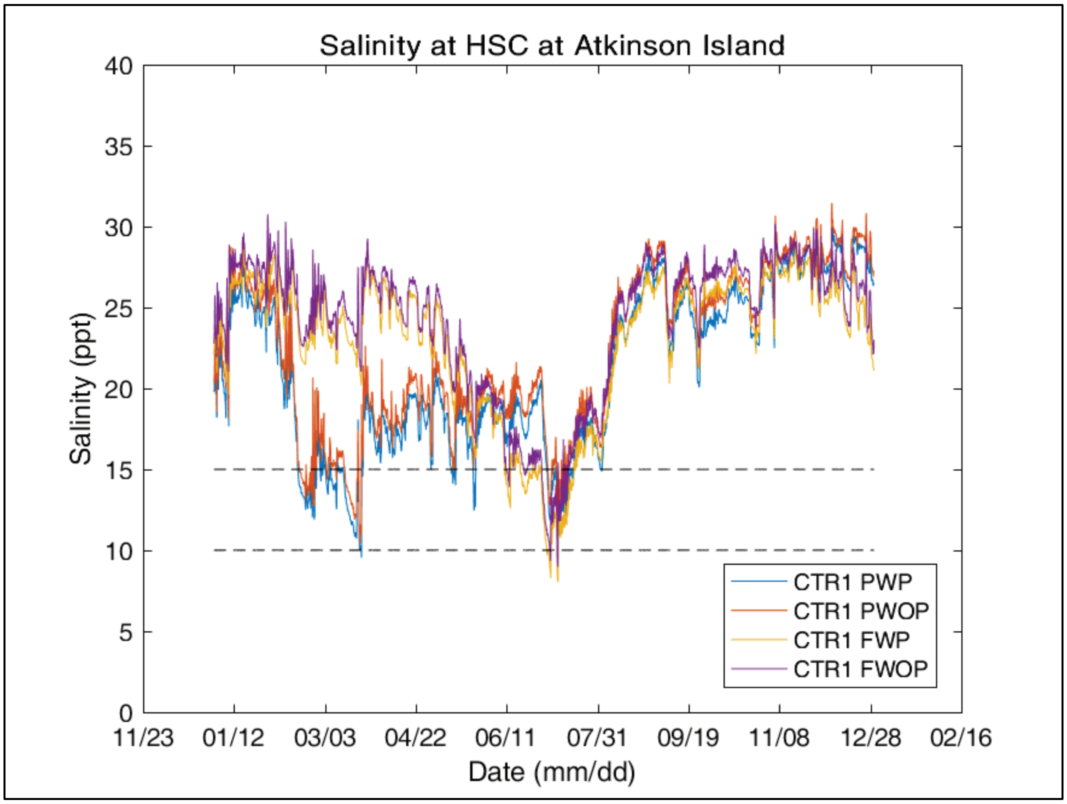
Greater Than 10 ppt for 14+ days - HSC at Morgan's Point			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 12:00	80.4
	3/23/2010 6:00	7/9/2010 0:00	107.8
	7/9/2010 15:00	12/30/2010 0:00	173.4
PWOP	1/1/2010 3:00	7/9/2010 0:00	188.9
	7/9/2010 12:00	12/30/2010 0:00	173.5
FWP	1/1/2010 3:00	7/2/2010 0:00	181.9
	7/14/2010 9:00	12/30/2010 0:00	168.6
FWOP	1/1/2010 3:00	7/2/2010 6:00	182.1
	7/9/2010 12:00	12/30/2010 0:00	173.5

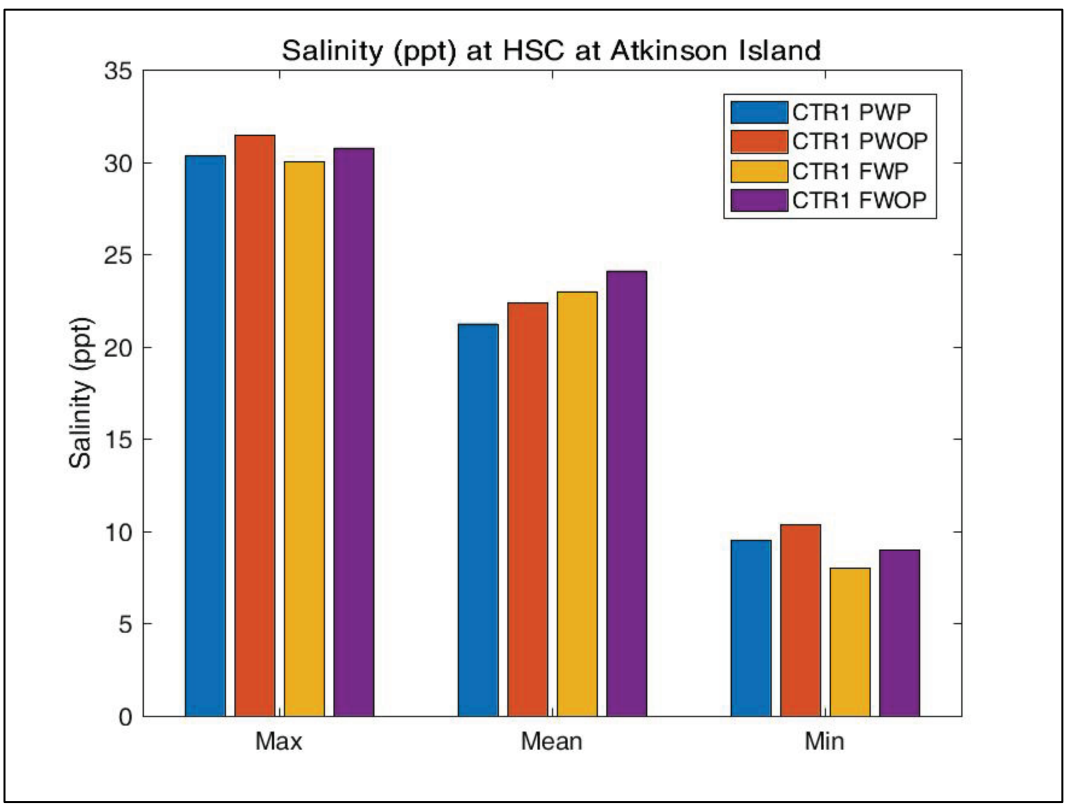
Greater Than 15 ppt for 14+ days - HSC at Morgan's Point			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 12:00	80.4
	3/23/2010 6:00	7/9/2010 0:00	107.8
	7/9/2010 15:00	12/30/2010 0:00	173.4
PWOP	1/1/2010 3:00	2/16/2010 12:00	46.4
	3/24/2010 3:00	5/12/2010 3:00	49.0
	5/25/2010 3:00	7/2/2010 9:00	38.3
	7/18/2010 0:00	12/30/2010 0:00	165.0
FWP	1/1/2010 3:00	6/10/2010 0:00	159.9
	8/2/2010 9:00	12/30/2010 0:00	149.6
FWOP	1/1/2010 3:00	6/10/2010 18:00	160.6
	7/18/2010 18:00	12/30/2010 0:00	164.3

Less Than 10 ppt for 14+ days - HSC at Morgan's Point			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Morgans Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Morgans Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-2
-4
-6
-8
-10
-12
-14
-16
12
14
16
18
20
22
24
26

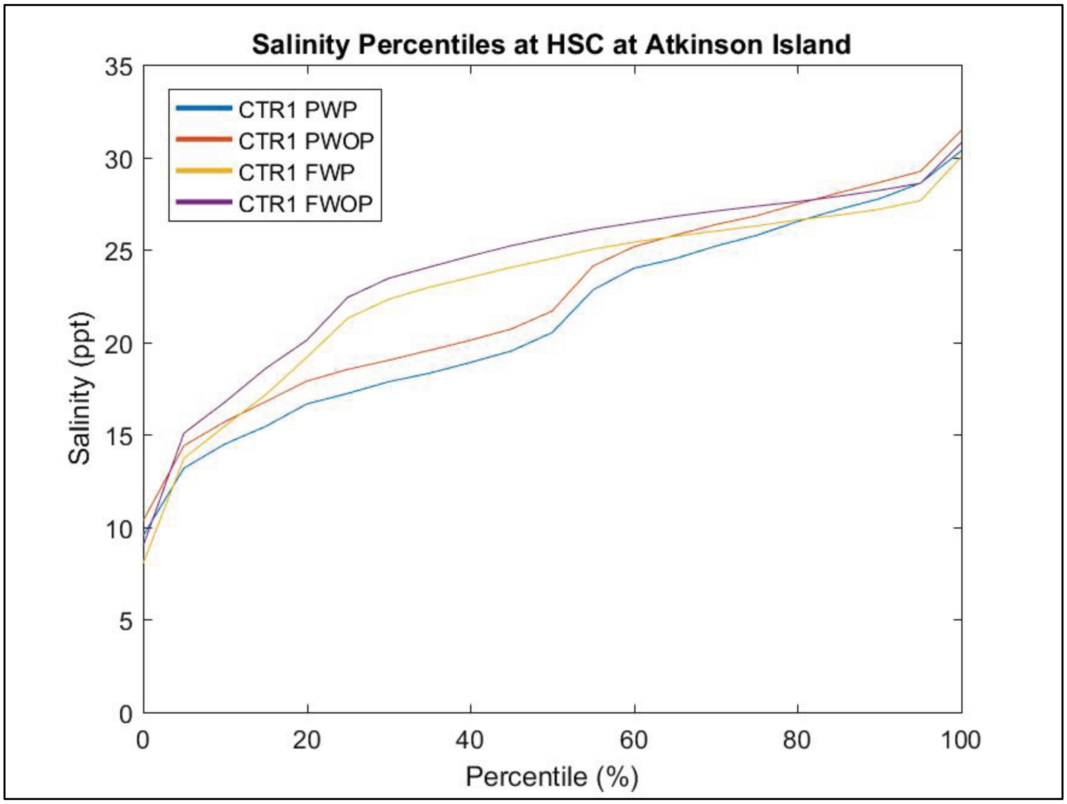

Salinity at HSC at Atkinson Island
Salinity (ppt)
Date (mm/dd)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

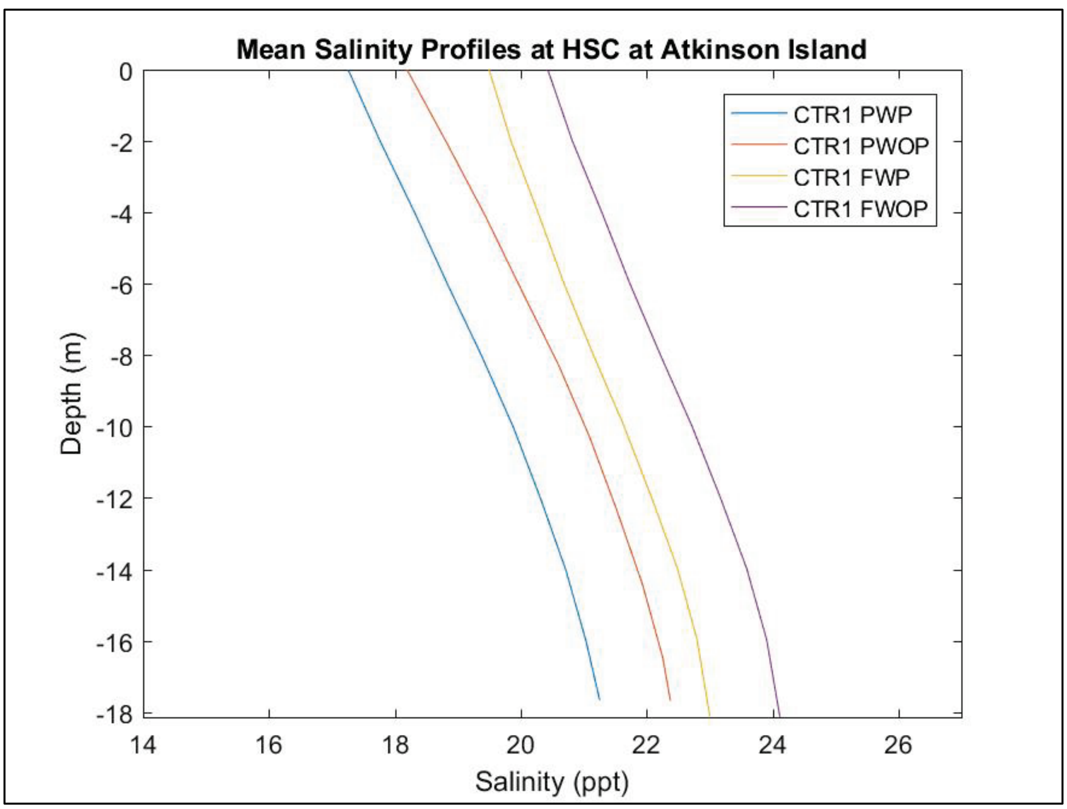

Salinity (ppt) at HSC at Atkinson Island
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

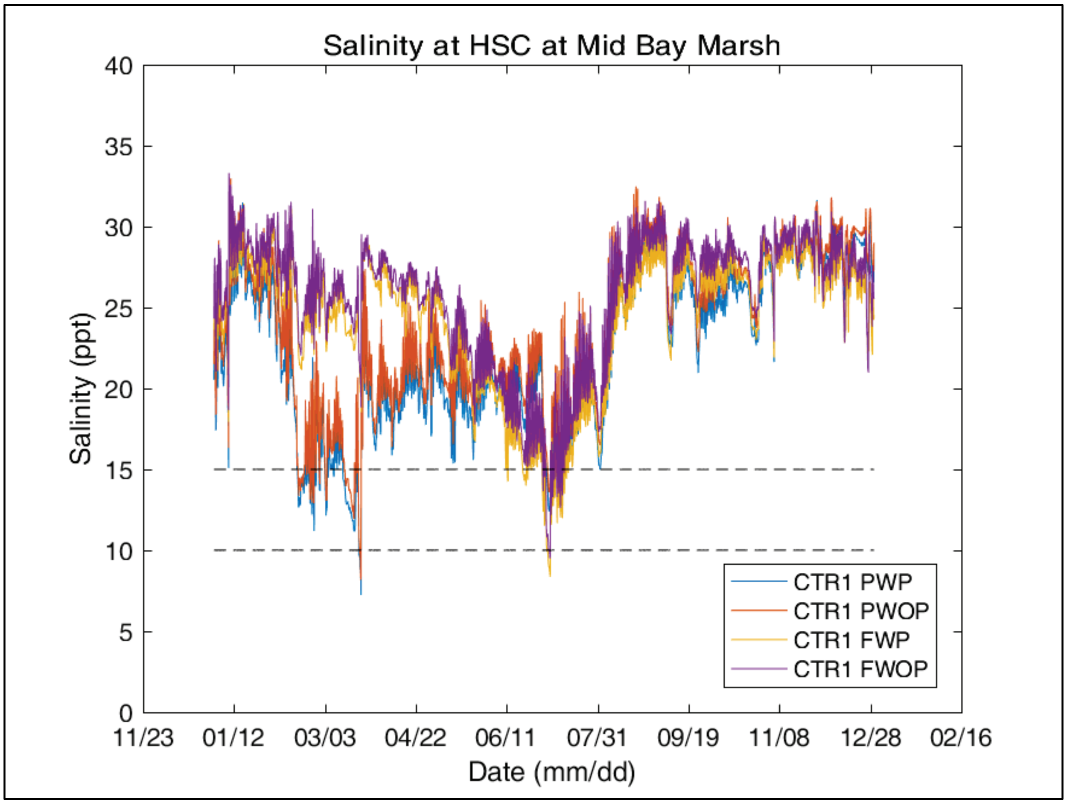
Greater Than 10 ppt for 14+ days - HSC at Atkinson Island			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 3:00	80.0
	3/23/2010 6:00	12/30/2010 0:00	282.0
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	7/3/2010 0:00	182.9
	7/9/2010 9:00	12/30/2010 0:00	173.6
FWOP	1/1/2010 3:00	7/4/2010 15:00	184.5
	7/9/2010 6:00	12/30/2010 0:00	173.8

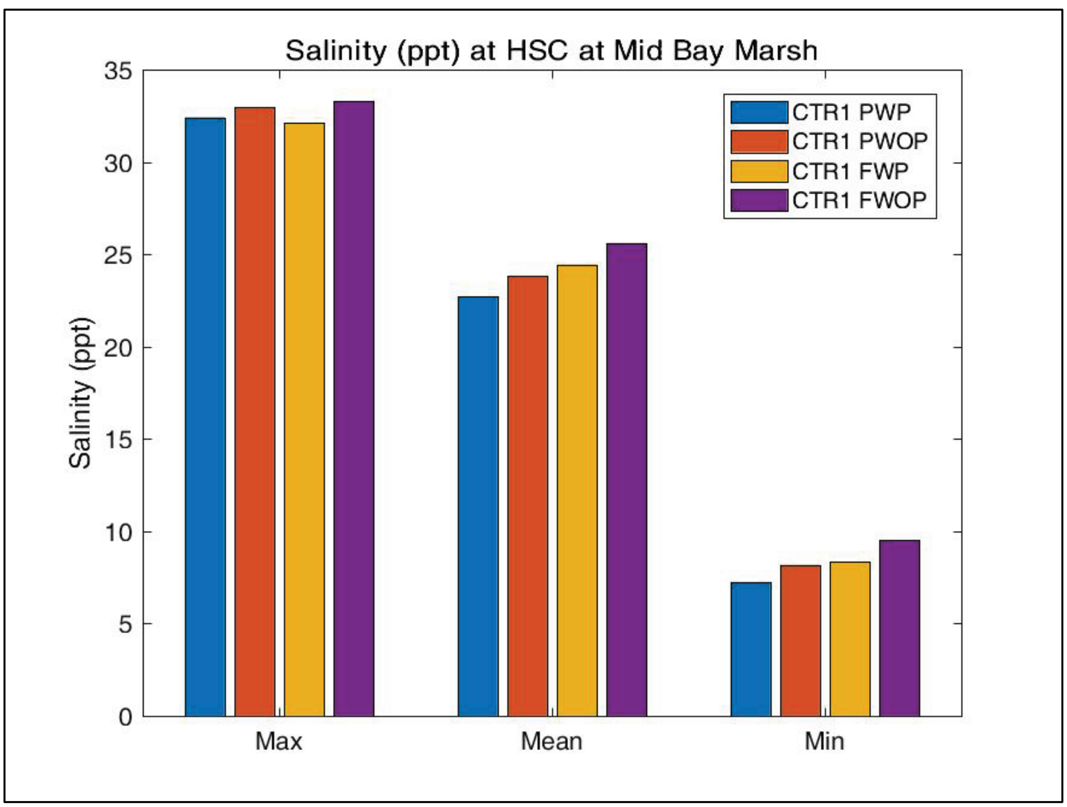
Greater Than 15 ppt for 14+ days - HSC at Atkinson Island			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/16/2010 0:00	45.9
	3/23/2010 21:00	4/30/2010 6:00	37.4
	5/25/2010 0:00	7/2/2010 21:00	38.9
	7/17/2010 18:00	8/1/2010 9:00	14.6
	8/2/2010 12:00	12/30/2010 0:00	150.0
PWOP	1/1/2010 3:00	2/16/2010 18:00	46.6
	3/23/2010 3:00	5/12/2010 6:00	50.1
	5/13/2010 12:00	7/3/2010 12:00	51.0
	7/14/2010 21:00	12/30/2010 0:00	168.1
FWP	1/1/2010 3:00	6/9/2010 15:00	159.5
	7/18/2010 18:00	12/30/2010 0:00	164.3
FWOP	1/1/2010 3:00	6/10/2010 12:00	160.4
	7/15/2010 3:00	12/30/2010 0:00	167.9

Less Than 10 ppt for 14+ days - HSC at Atkinson Island			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Atkinson Island
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Atkinson Island
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
14
16
18
20
22
24
26

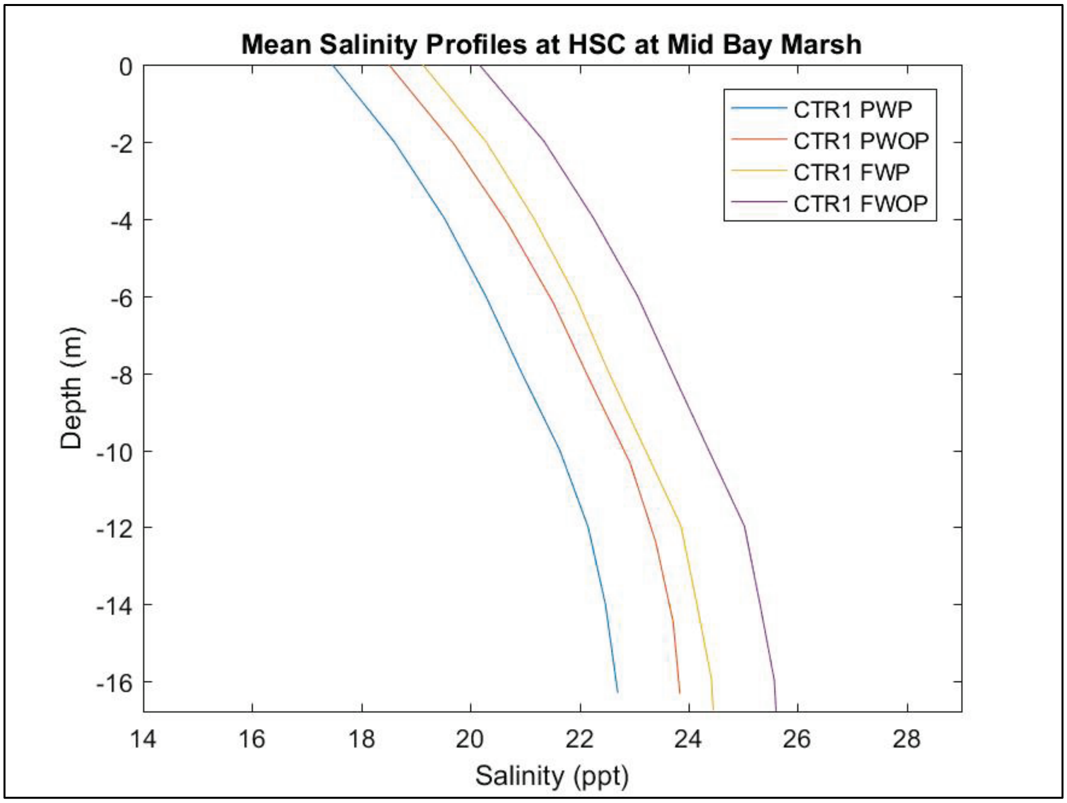

Salinity at HSC at Mid Bay Marsh
Salinity (ppt)
Date (mm/dd)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

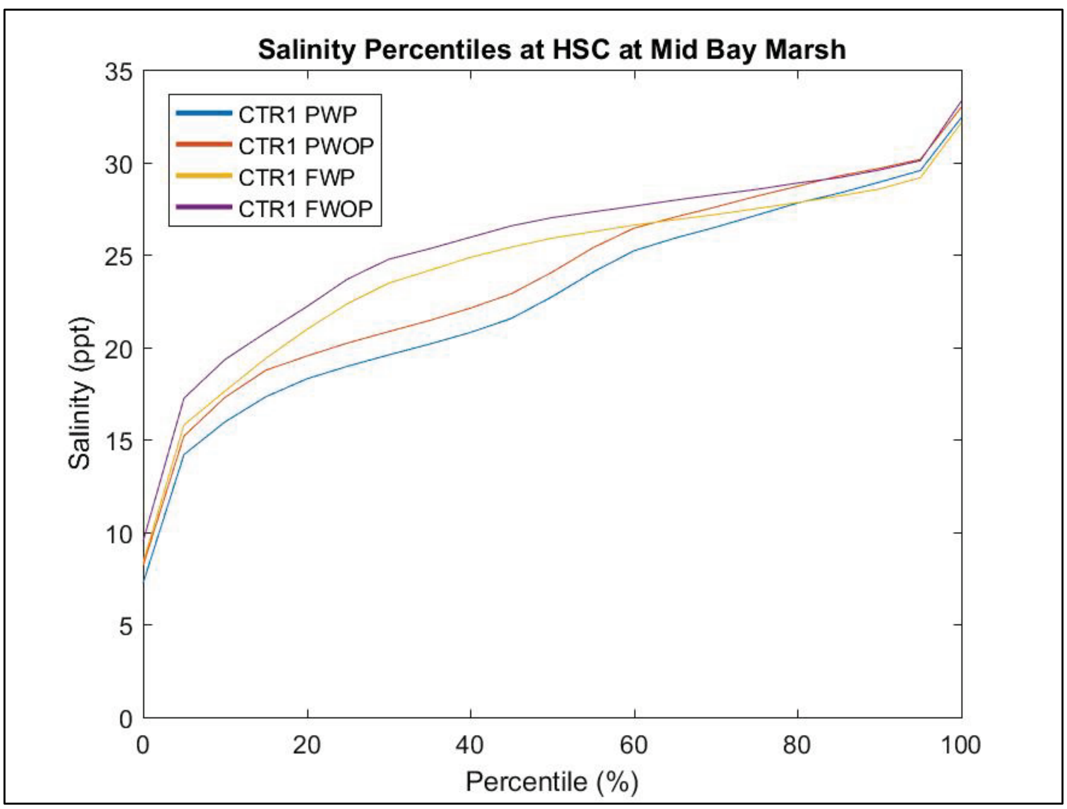

Salinity (ppt) at HSC at Mid Bay Marsh
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

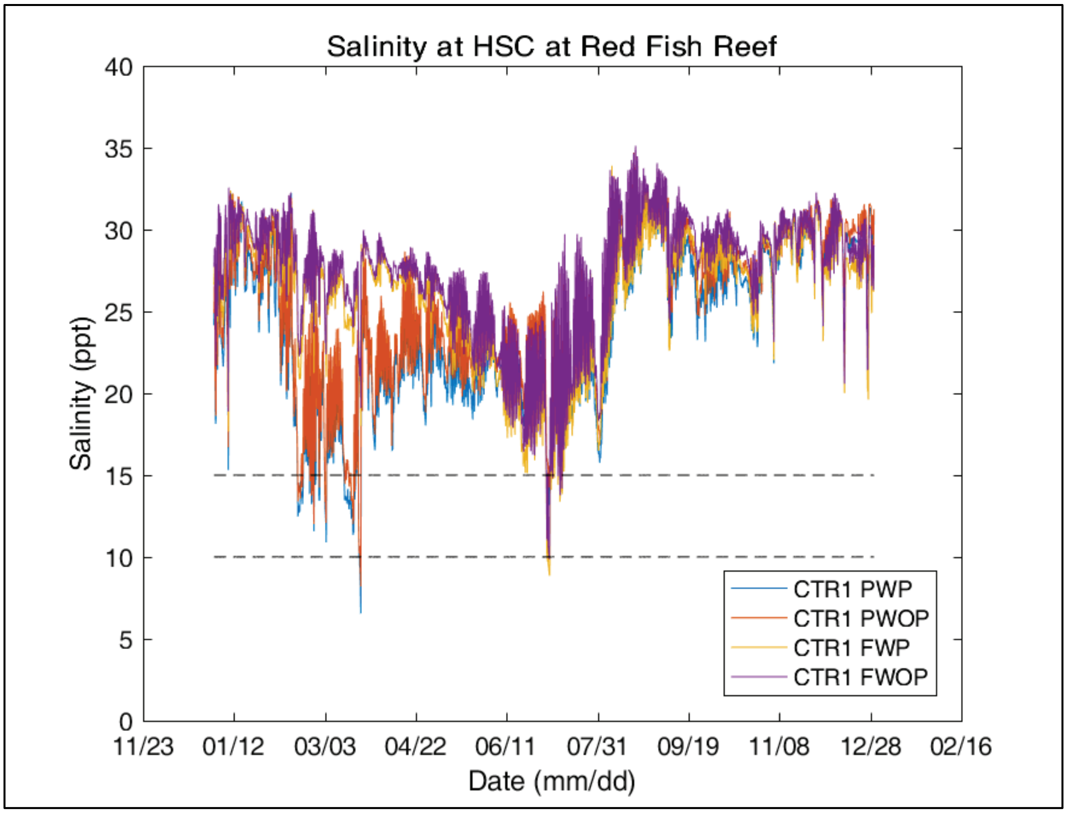
Greater Than 10 ppt for 14+ days - HSC at Mid Bay Marsh			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/21/2010 15:00	79.5
	3/23/2010 0:00	12/30/2010 0:00	282.0
PWOP	1/1/2010 3:00	3/22/2010 0:00	79.9
	3/23/2010 0:00	12/30/2010 0:00	282.0
FWP	1/1/2010 3:00	7/3/2010 0:00	182.9
	7/5/2010 0:00	12/30/2010 0:00	178.0
FWOP	1/1/2010 3:00	7/4/2010 3:00	184.0
	7/5/2010 0:00	12/30/2010 0:00	178.0

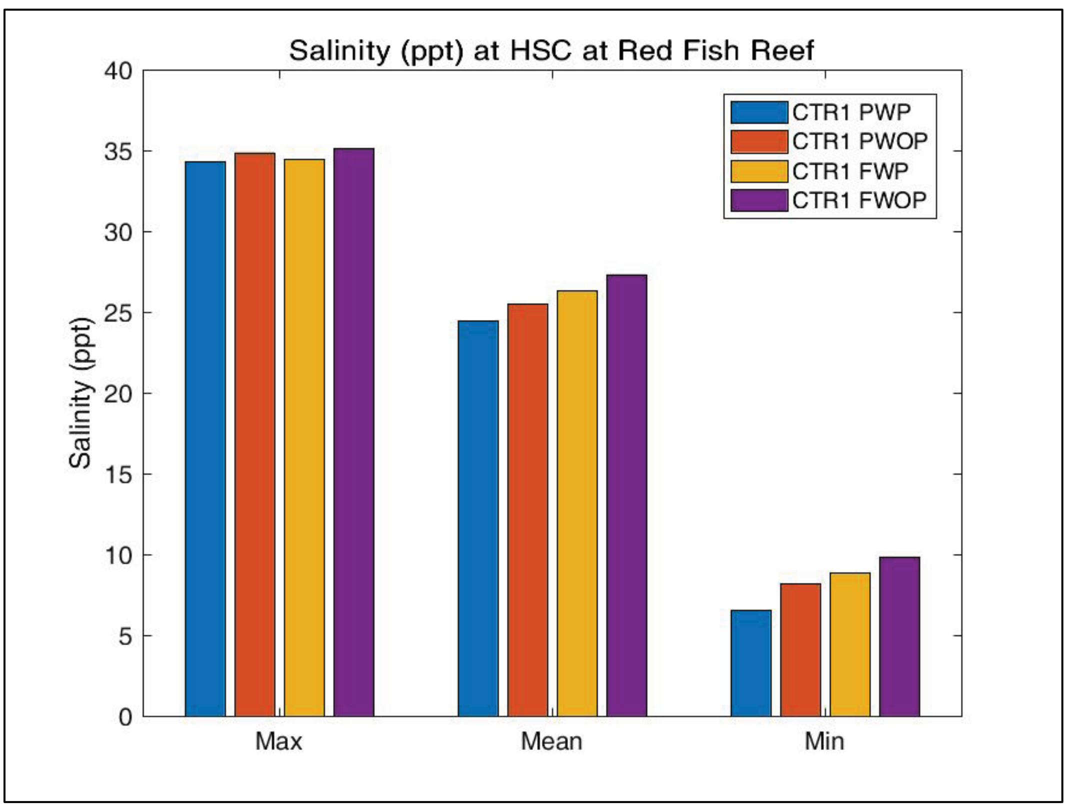
Greater Than 15 ppt for 14+ days - HSC at Mid Bay Marsh			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/15/2010 21:00	45.8
	3/23/2010 0:00	7/2/2010 18:00	101.8
	7/12/2010 21:00	8/1/2010 6:00	19.4
	8/1/2010 12:00	12/30/2010 0:00	150.5
PWOP	1/1/2010 3:00	2/16/2010 3:00	46.0
	3/23/2010 0:00	7/3/2010 9:00	102.4
	7/11/2010 18:00	12/30/2010 0:00	171.3
FWP	1/1/2010 3:00	6/10/2010 12:00	160.4
	7/14/2010 21:00	12/30/2010 0:00	168.1
FWOP	1/1/2010 3:00	6/30/2010 15:00	180.5
	7/12/2010 18:00	12/30/2010 0:00	170.3

Less Than 10 ppt for 14+ days - HSC at Mid Bay Marsh			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Mean Salinity Profiles at HSC at Mid Bay Marsh
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-2
-4
-6
-8
-10
-12
-14
-16
14
16
18
20
22
24
26
28


Salinity Percentiles at HSC at Mid Bay Marsh
Salinity (ppt)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
35
30
25
20
15
10
5
0
0
20
40
60
80
100

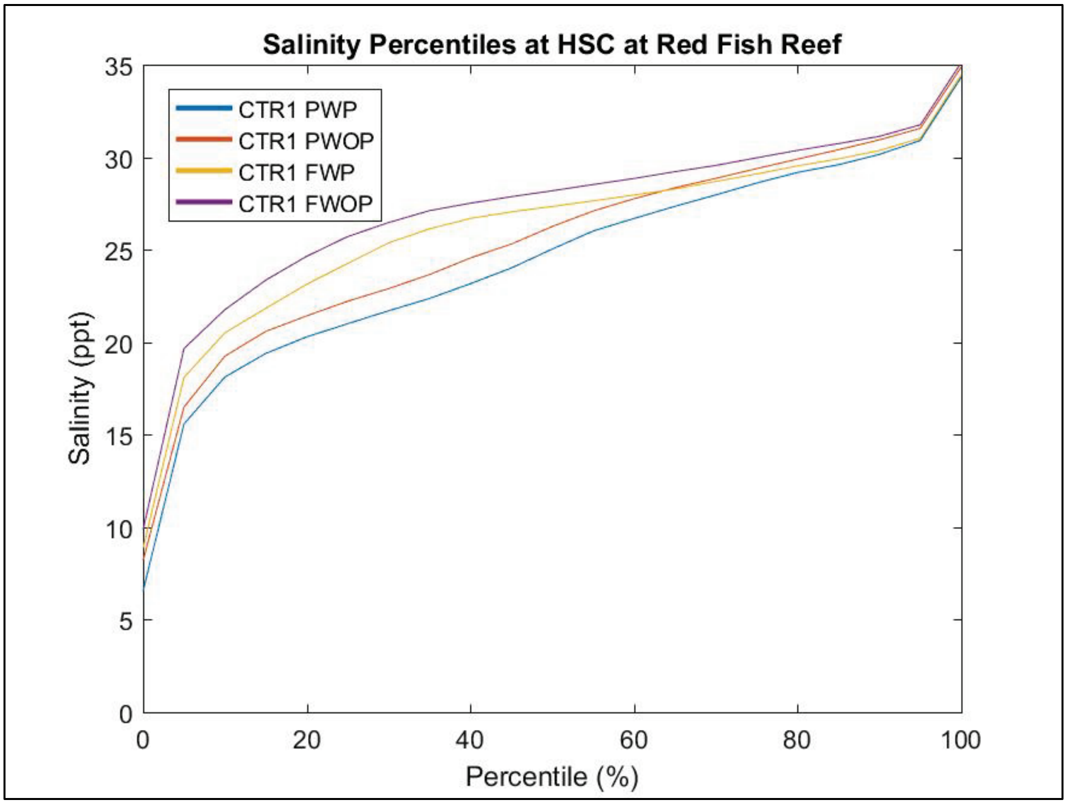

Salinity at HSC at Red Fish Reef
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

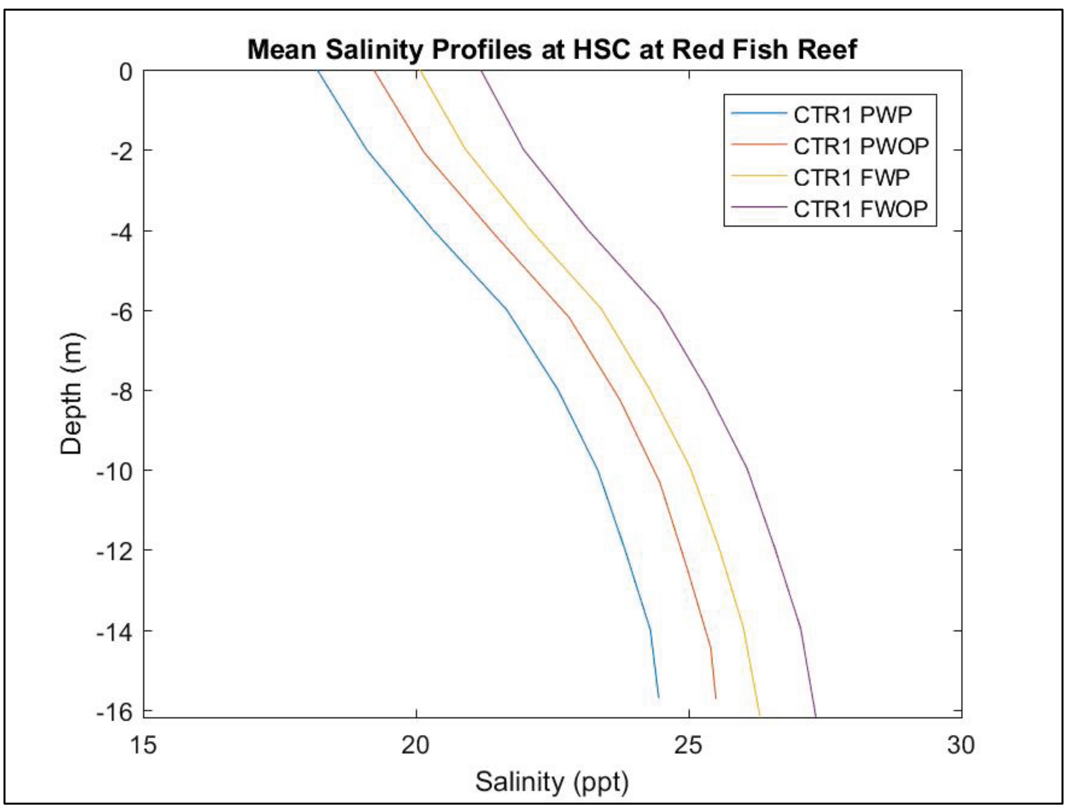

Salinity (ppt) at HSC at Red Fish Reef
Salinity (ppt)
0
5
10
15
20
25
30
35
40
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

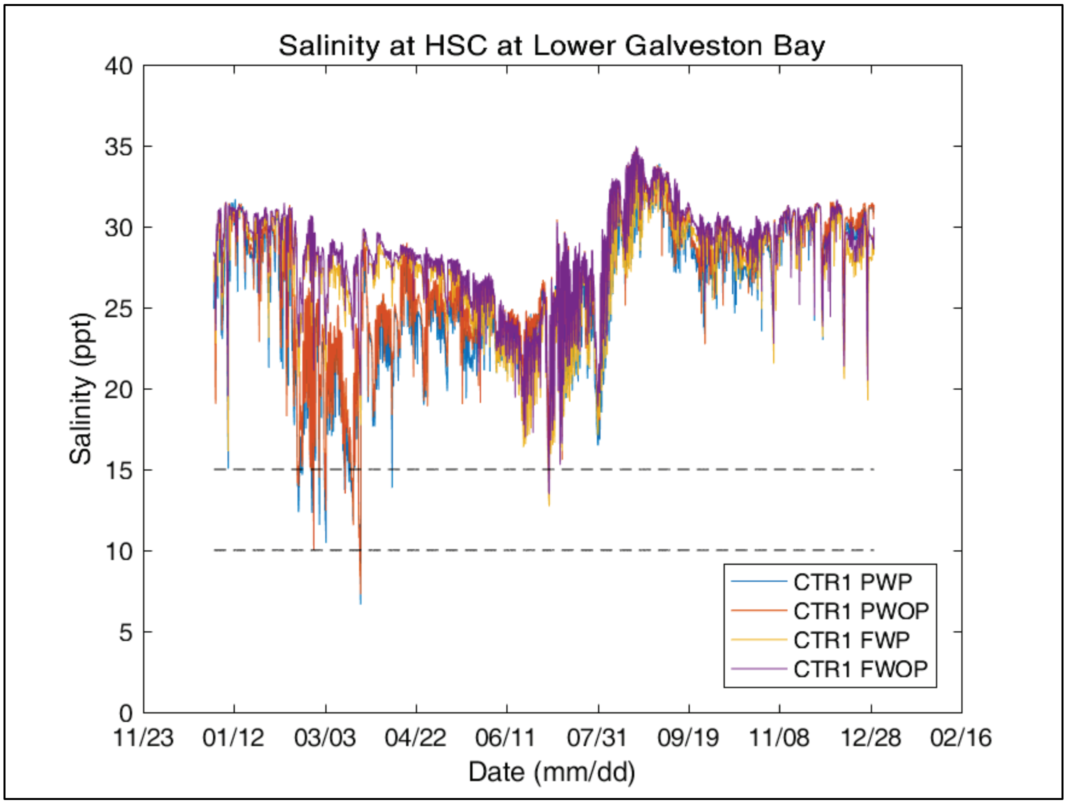
Greater Than 10 ppt for 14+ days - HSC at Red Fish Reef			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/21/2010 18:00	79.6
	3/22/2010 21:00	12/30/2010 0:00	282.1
PWOP	1/1/2010 3:00	3/22/2010 6:00	80.1
	3/22/2010 21:00	12/30/2010 0:00	282.1
FWP	1/1/2010 3:00	7/3/2010 6:00	183.1
	7/4/2010 18:00	12/30/2010 0:00	178.3
FWOP	1/1/2010 3:00	7/4/2010 6:00	184.1
	7/4/2010 15:00	12/30/2010 0:00	178.4

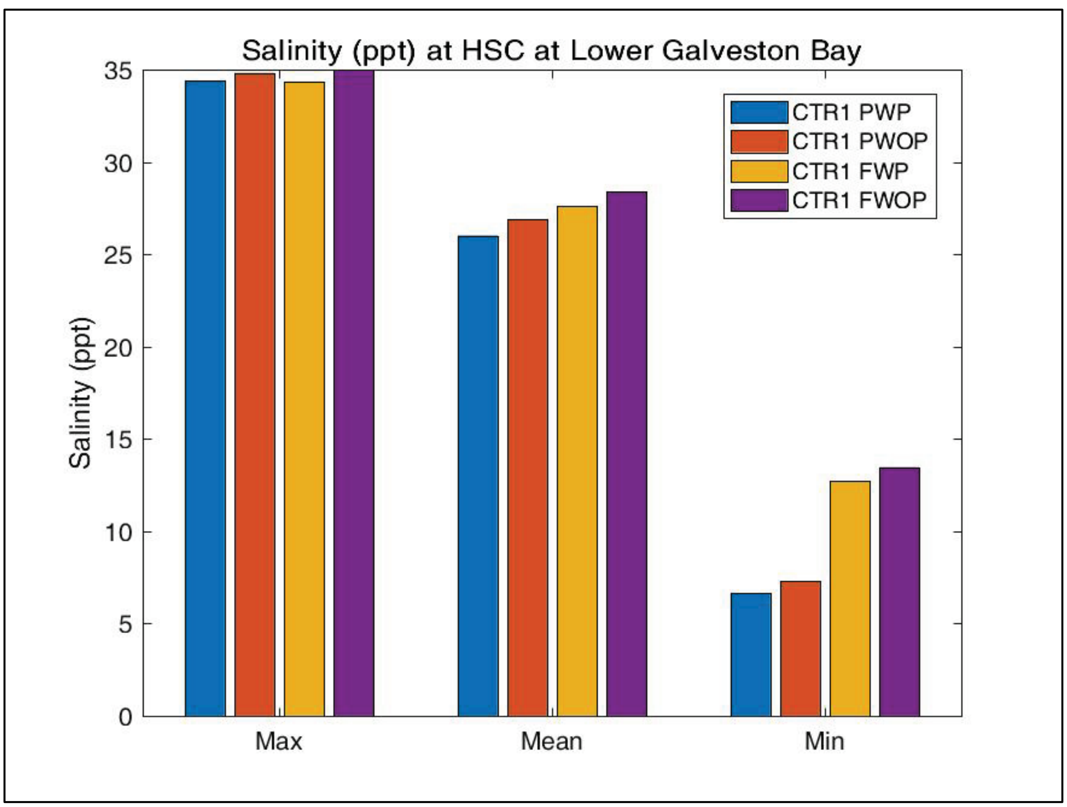
Greater Than 15 ppt for 14+ days - HSC at Red Fish Reef			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/15/2010 21:00	45.8
	3/22/2010 21:00	7/2/2010 21:00	102.0
	7/11/2010 12:00	12/30/2010 0:00	171.5
PWOP	1/1/2010 3:00	2/15/2010 21:00	45.8
	3/22/2010 21:00	7/3/2010 21:00	103.0
	7/11/2010 12:00	12/30/2010 0:00	172.0
FWP	1/1/2010 3:00	7/2/2010 15:00	182.5
	7/11/2010 15:00	12/30/2010 0:00	171.4
FWOP	1/1/2010 3:00	7/2/2010 18:00	182.6
	7/11/2010 12:00	12/30/2010 0:00	171.5

Less Than 10 ppt for 14+ days - HSC at Red Fish Reef			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-2
-4
-6
-8
-10
-12
-14
-16
15
20
25
30

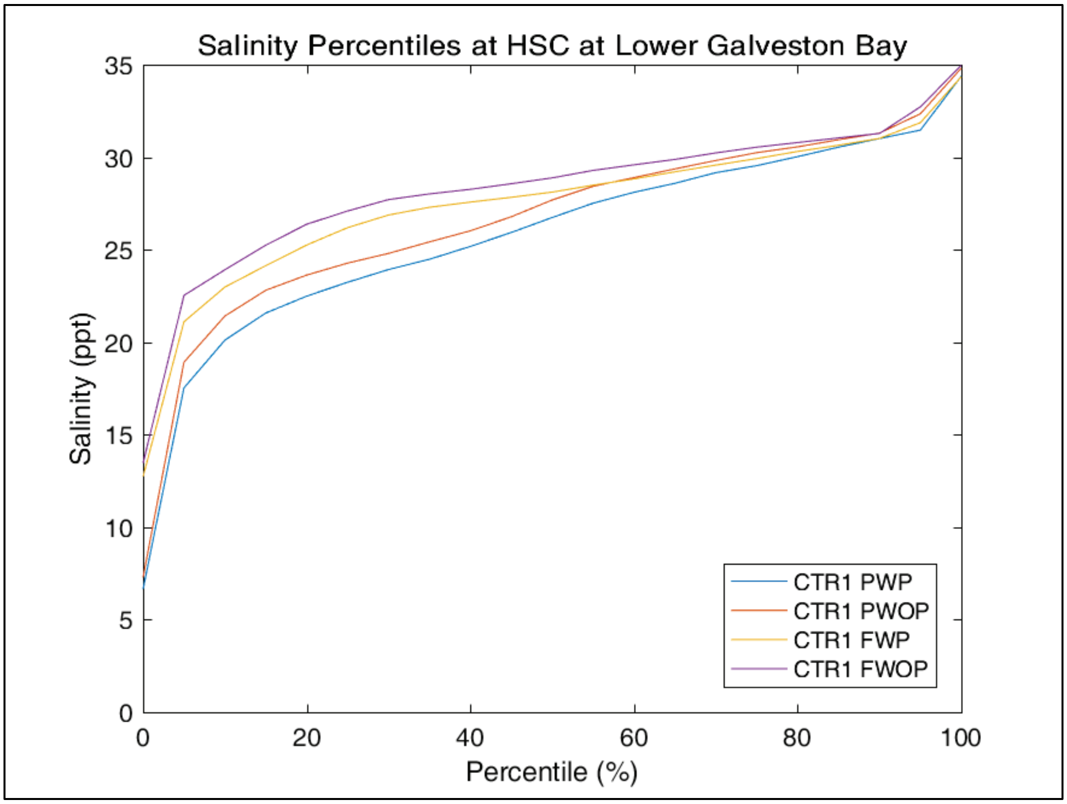

Salinity at HSC at Lower Galveston Bay
Salinity (ppt)
Date (mm/dd)
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Salinity (ppt) at HSC at Lower Galveston Bay
Salinity (ppt)
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

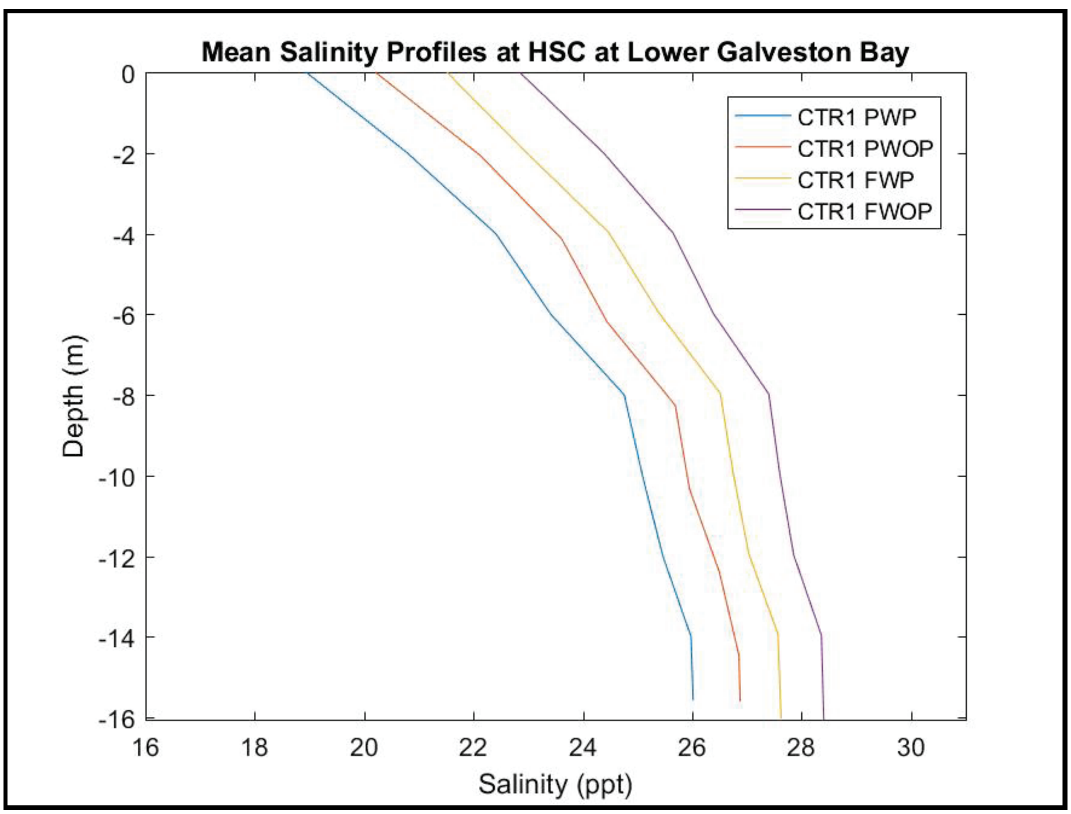
Greater Than 10 ppt for 14+ days - HSC at Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 0:00	79.9
	3/22/2010 21:00	12/30/2010 0:00	282.1
PWOP	1/1/2010 3:00	3/22/2010 3:00	80.0
	3/22/2010 18:00	12/30/2010 0:00	282.3
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

Greater Than 15 ppt for 14+ days - HSC at Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/15/2010 18:00	45.6
	3/22/2010 21:00	4/8/2010 21:00	17.0
	4/9/2010 3:00	7/3/2010 21:00	85.8
	7/4/2010 9:00	12/30/2010 0:00	178.6
PWOP	1/1/2010 3:00	2/15/2010 18:00	45.6
	3/22/2010 18:00	12/30/2010 0:00	282.3
FWP	1/1/2010 3:00	7/3/2010 18:00	183.6
	7/4/2010 12:00	12/30/2010 0:00	178.5
FWOP	1/1/2010 3:00	7/3/2010 21:00	183.8
	7/4/2010 12:00	12/30/2010 0:00	178.5

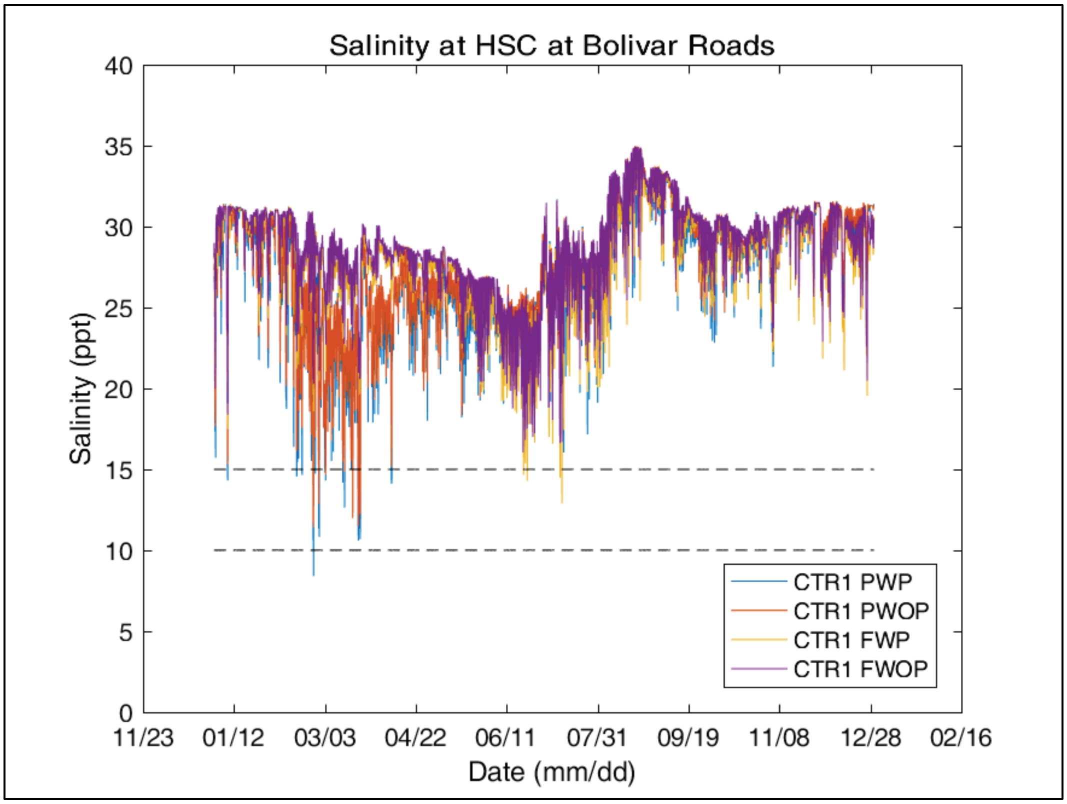
Less Than 10 ppt for 14+ days - HSC at Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA

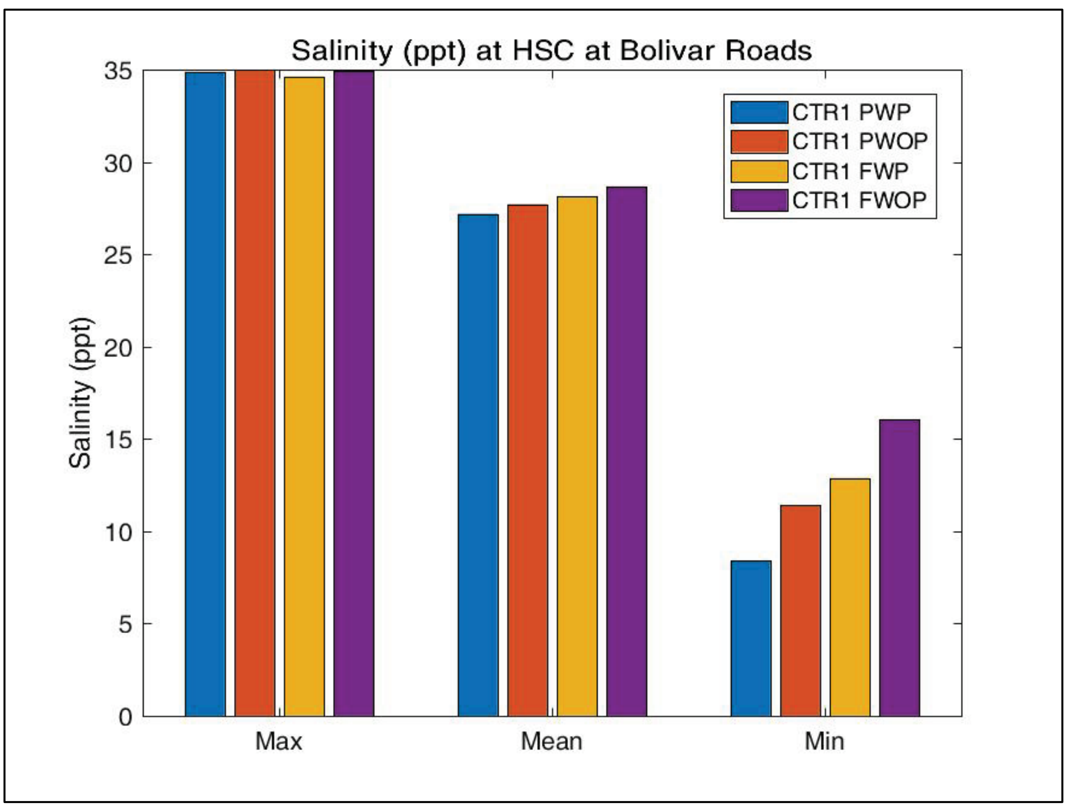


Salinity Percentiles at HSC at Lower Galveston Bay
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP



Mean Salinity Profiles at HSC at Lower Galveston Bay
Depth (m)
Salinity (ppt)
0
-2
-4
-6
-8
-10
-12
-14
-16
16
18
20
22
24
26
28
30
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

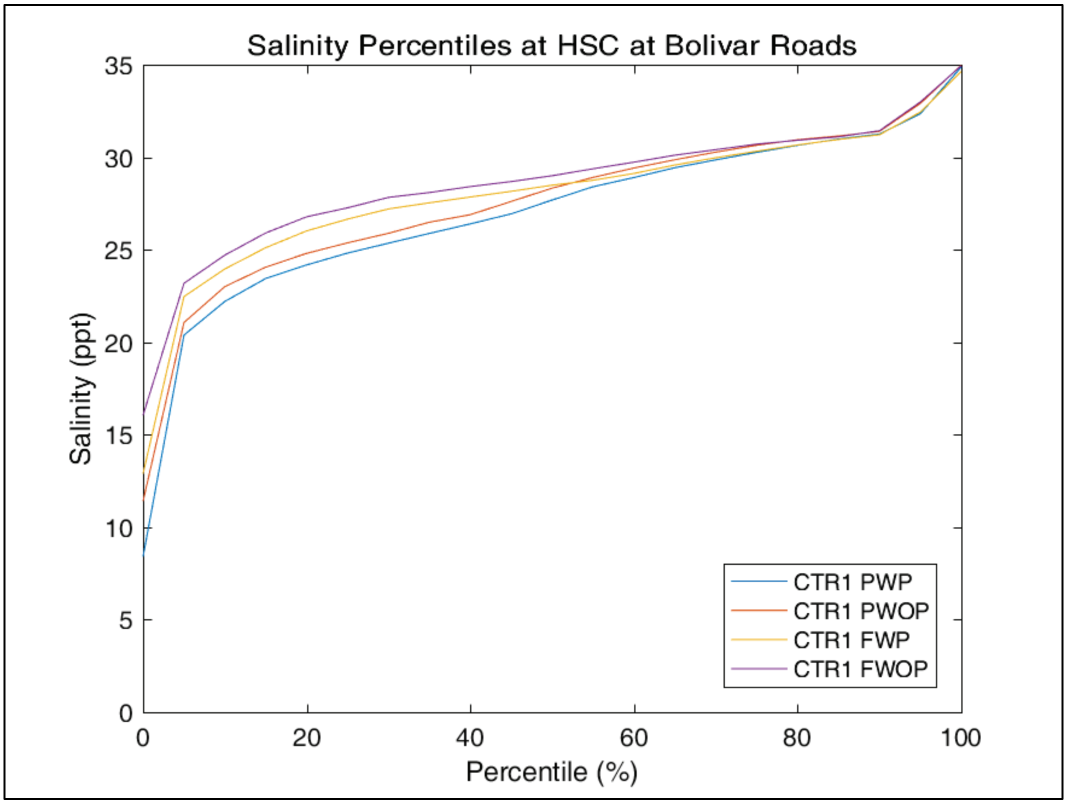

Salinity at HSC at Bolivar Roads
Salinity (ppt)
Date (mm/dd)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

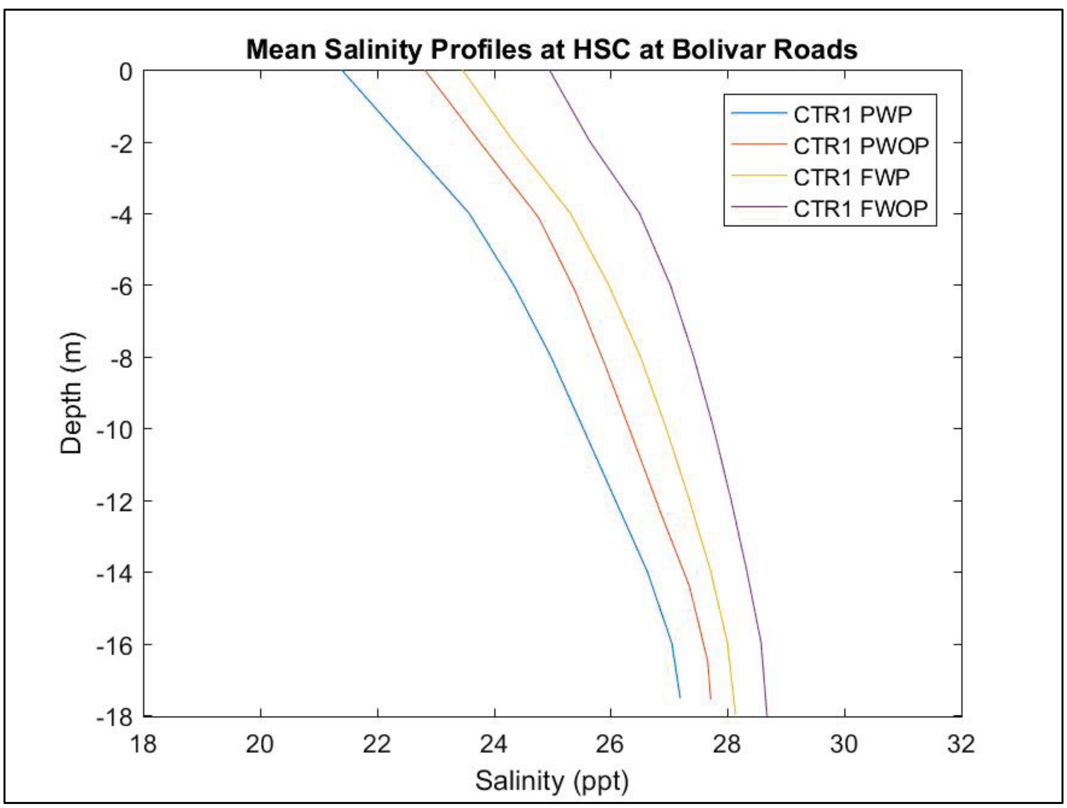

Salinity (ppt) at HSC at Bolivar Roads
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

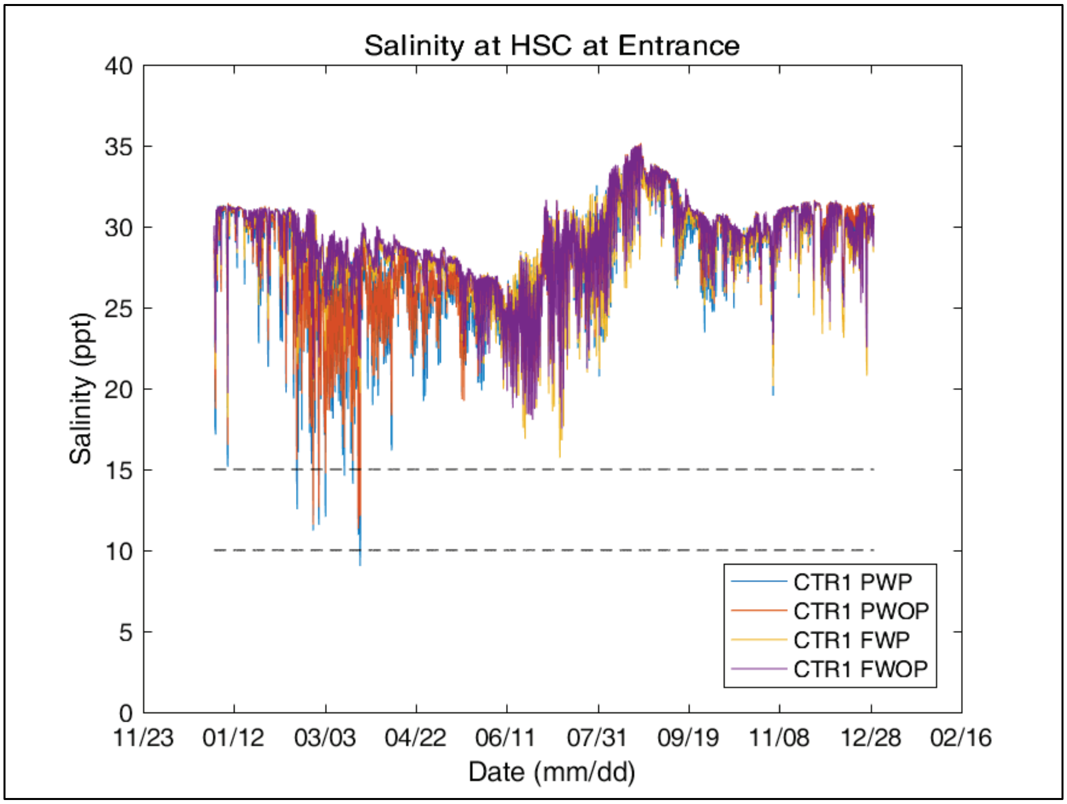
Greater Than 10 ppt for 14+ days - HSC at Bolivar Roads			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/24/2010 15:00	54.5
	2/24/2010 21:00	12/30/2010 0:00	308.1
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

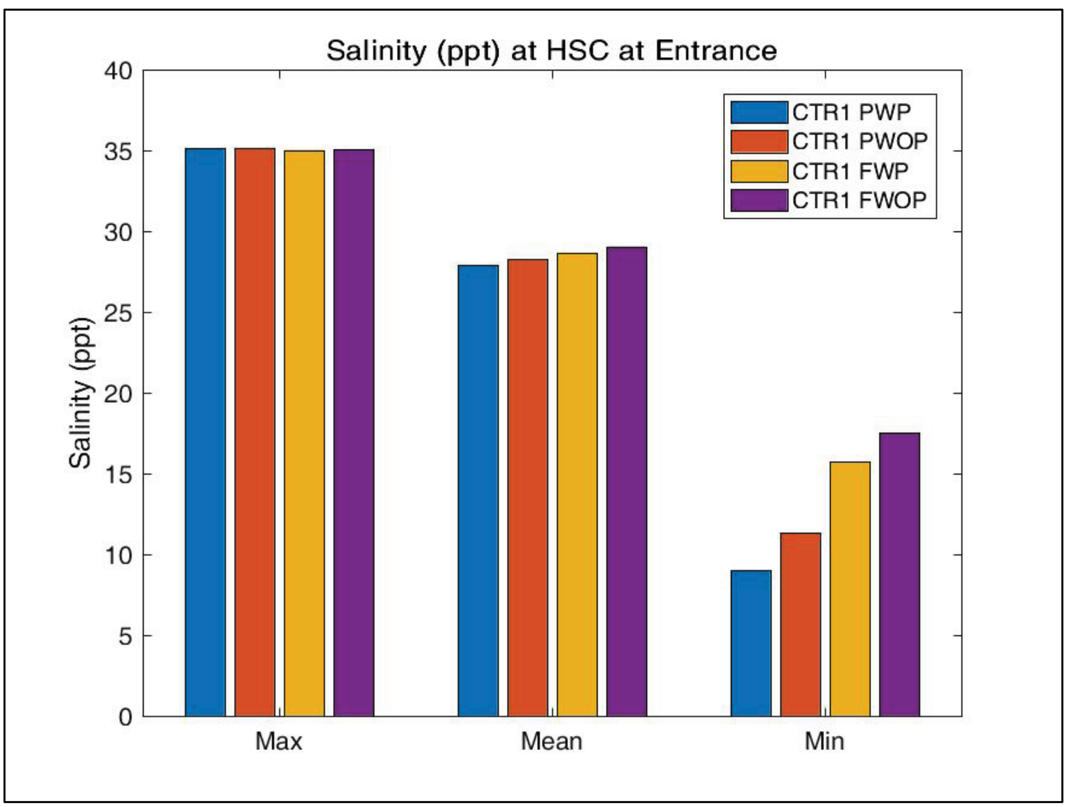
Greater Than 15 ppt for 14+ days - HSC at Bolivar Roads			
	Start	**Stop**	**Duration(days)**
PWP	1/8/2010 15:00	2/15/2010 9:00	37.8
	3/22/2010 15:00	4/8/2010 12:00	16.9
	4/8/2010 21:00	12/30/2010 0:00	265.1
PWOP	1/1/2010 3:00	2/24/2010 9:00	54.3
	3/22/2010 15:00	12/30/2010 0:00	282.0
FWP	1/1/2010 3:00	6/20/2010 3:00	170.0
	6/22/2010 9:00	7/10/2010 6:00	17.9
	7/11/2010 12:00	12/30/2010 0:00	171.5
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

Less Than 10 ppt for 14+ days - HSC at Bolivar Roads			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Bolivar Roads
Salinity (ppt)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Bolivar Roads
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
18
20
22
24
26
28
30
32

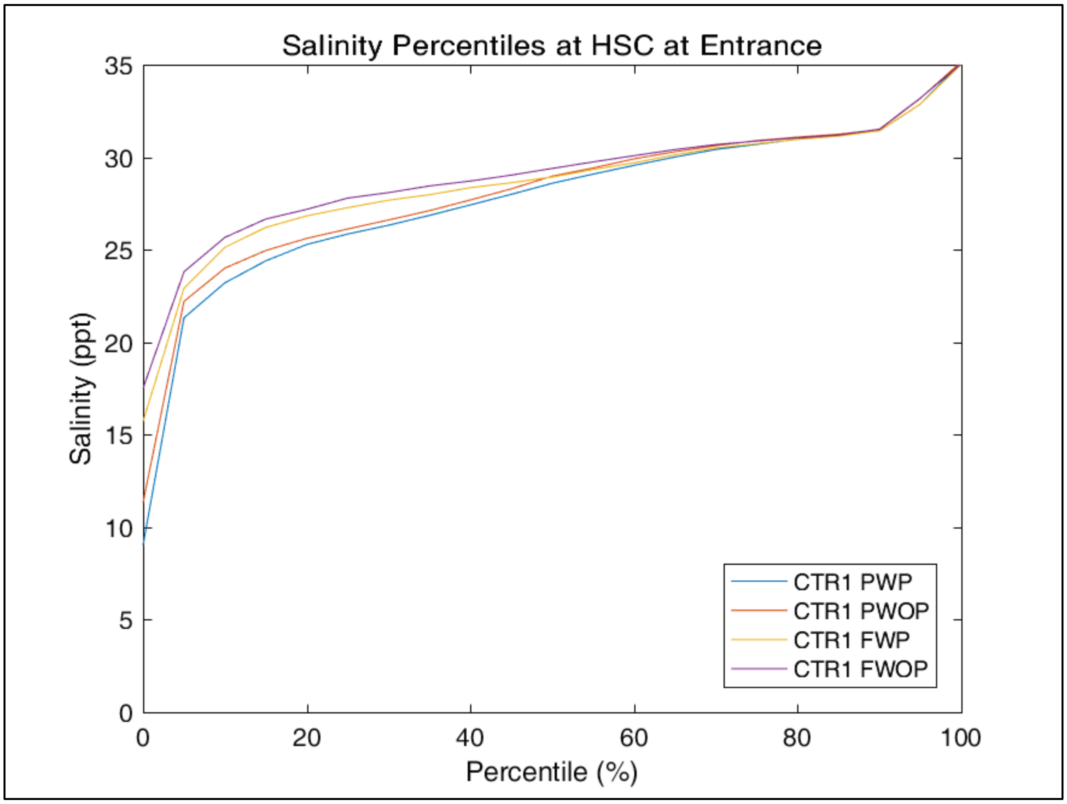

Salinity at HSC at Entrance
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

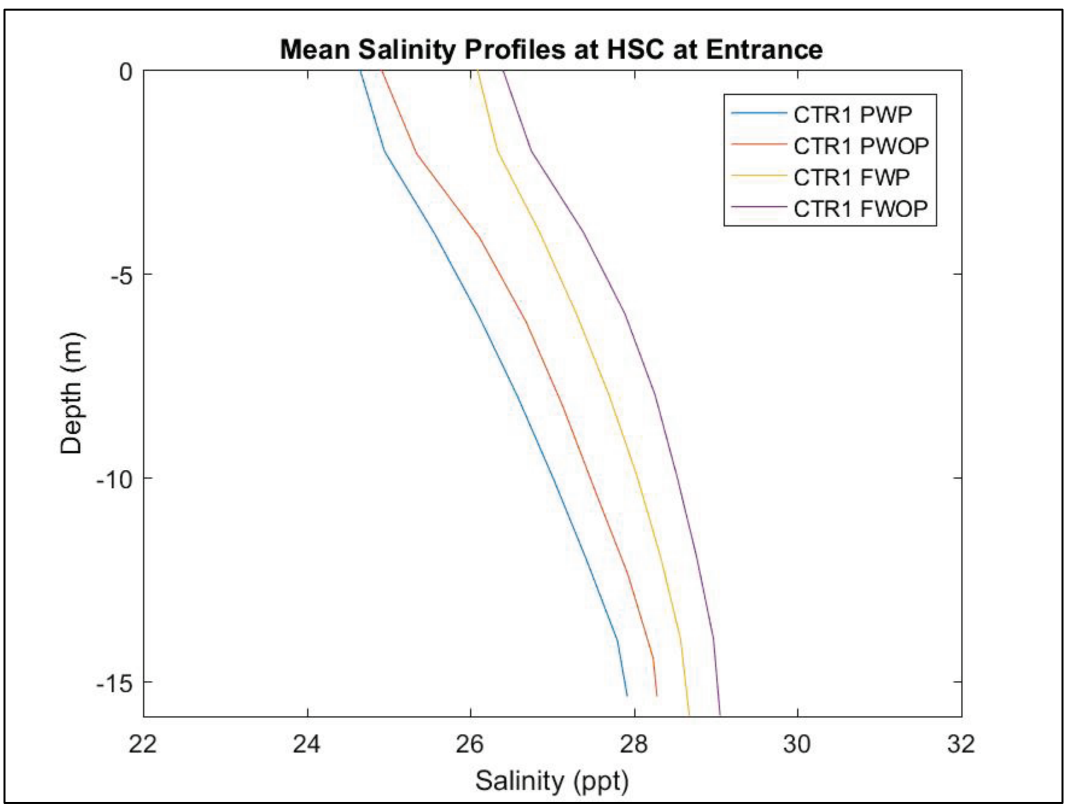

Salinity (ppt) at HSC at Entrance
Salinity (ppt)
0
5
10
15
20
25
30
35
40
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

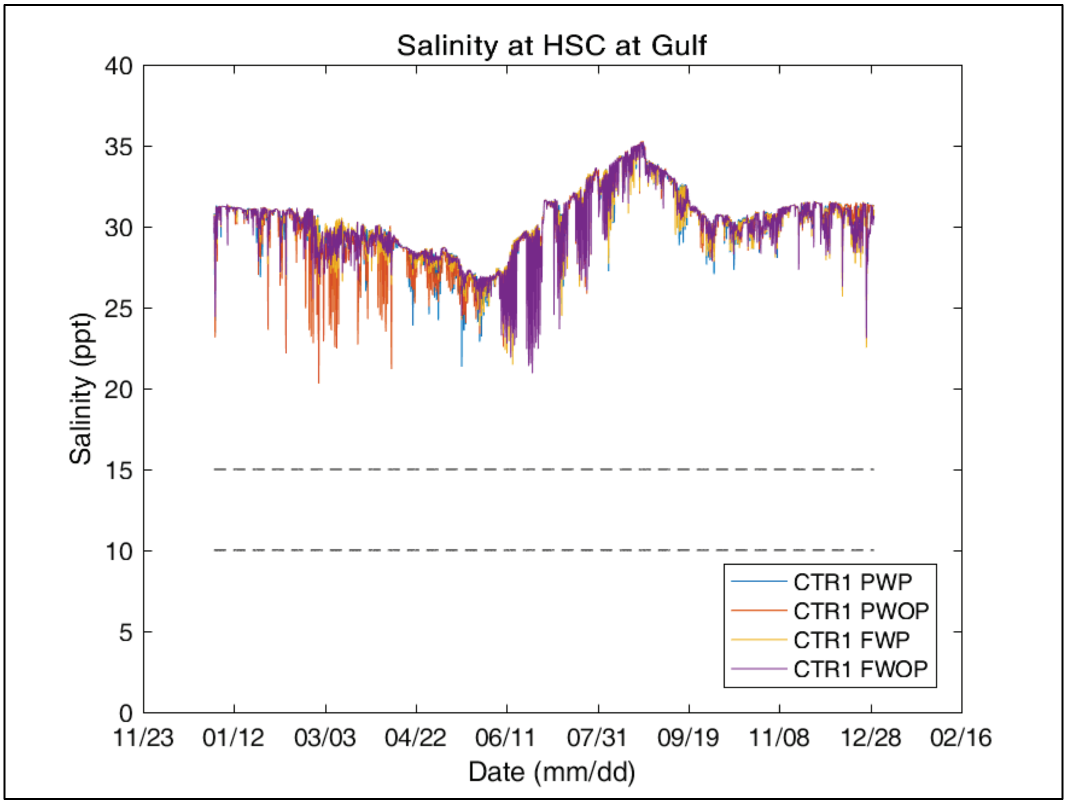
Greater Than 10 ppt for 14+ days - HSC at Entrance			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 6:00	80.1
	3/22/2010 12:00	12/30/2010 0:00	282.5
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

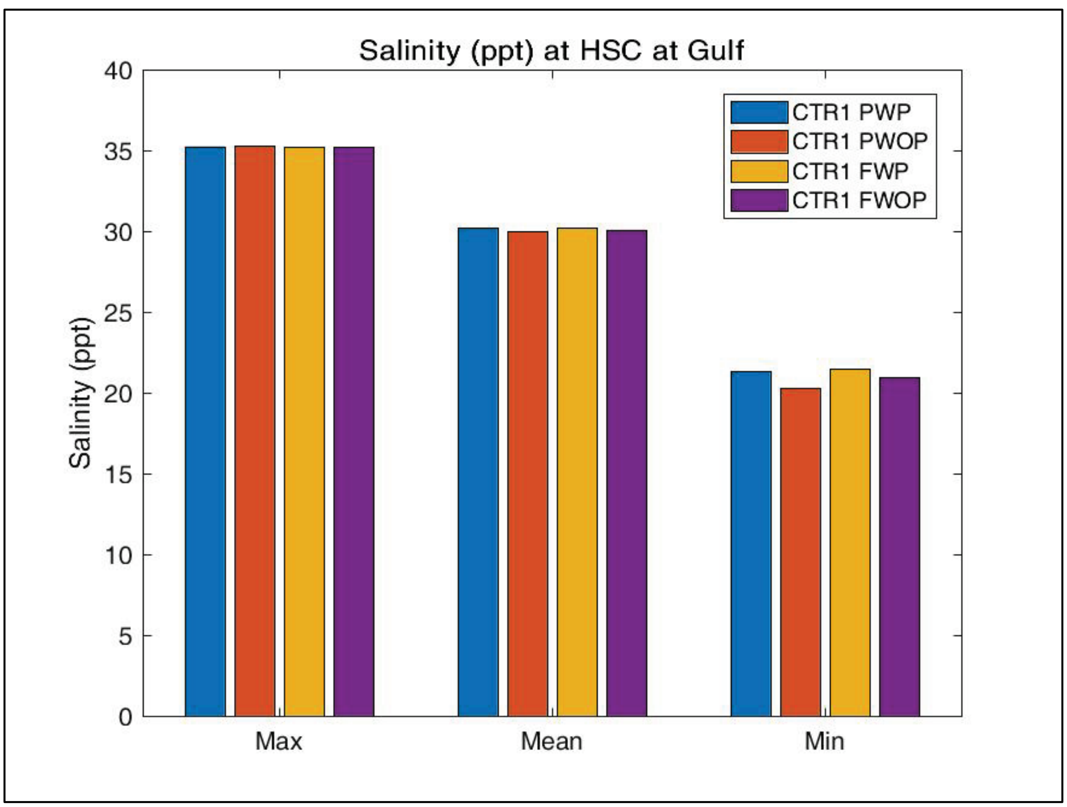
Greater Than 15 ppt for 14+ days - HSC at Entrance			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/15/2010 9:00	45.3
	3/22/2010 15:00	12/30/2010 0:00	282.4
PWOP	1/1/2010 3:00	2/24/2010 9:00	54.3
	3/3/2010 12:00	3/21/2010 3:00	17.6
	3/22/2010 15:00	12/30/2010 0:00	282.4
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

Less Than 10 ppt for 14+ days - HSC at Entrance			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Entrance
Salinity (ppt)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Entrance
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-5
-10
-15
22
24
26
28
30
32

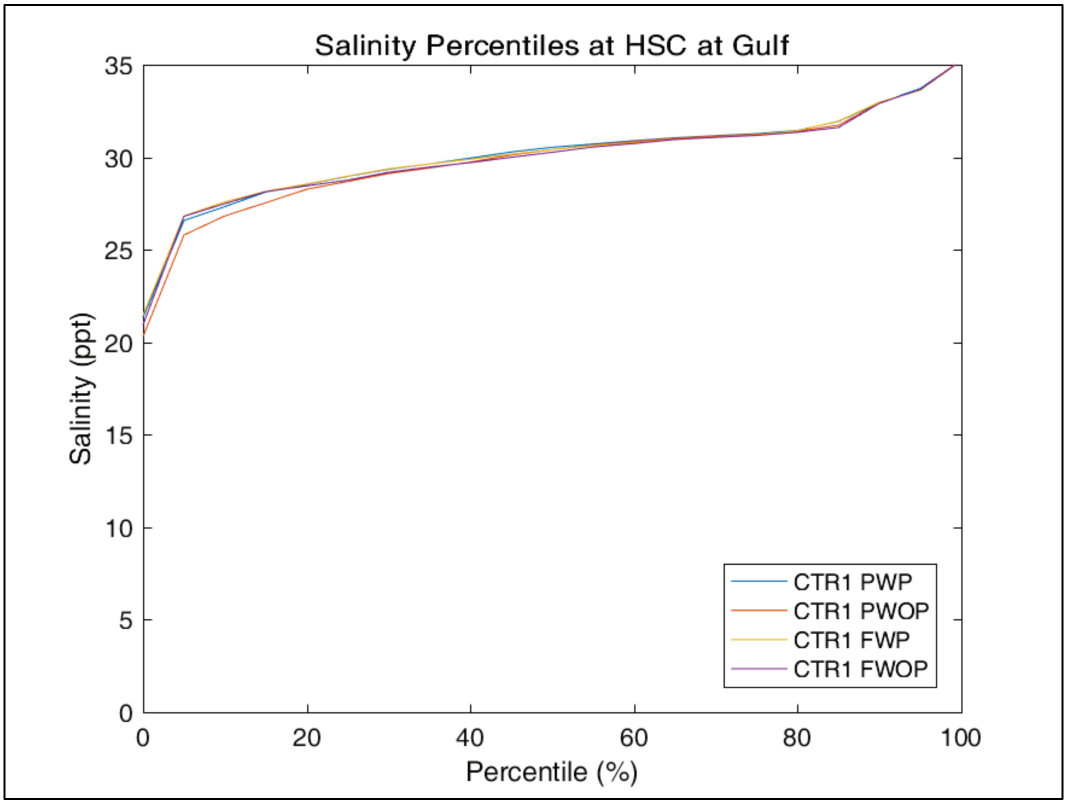

Salinity at HSC at Gulf
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

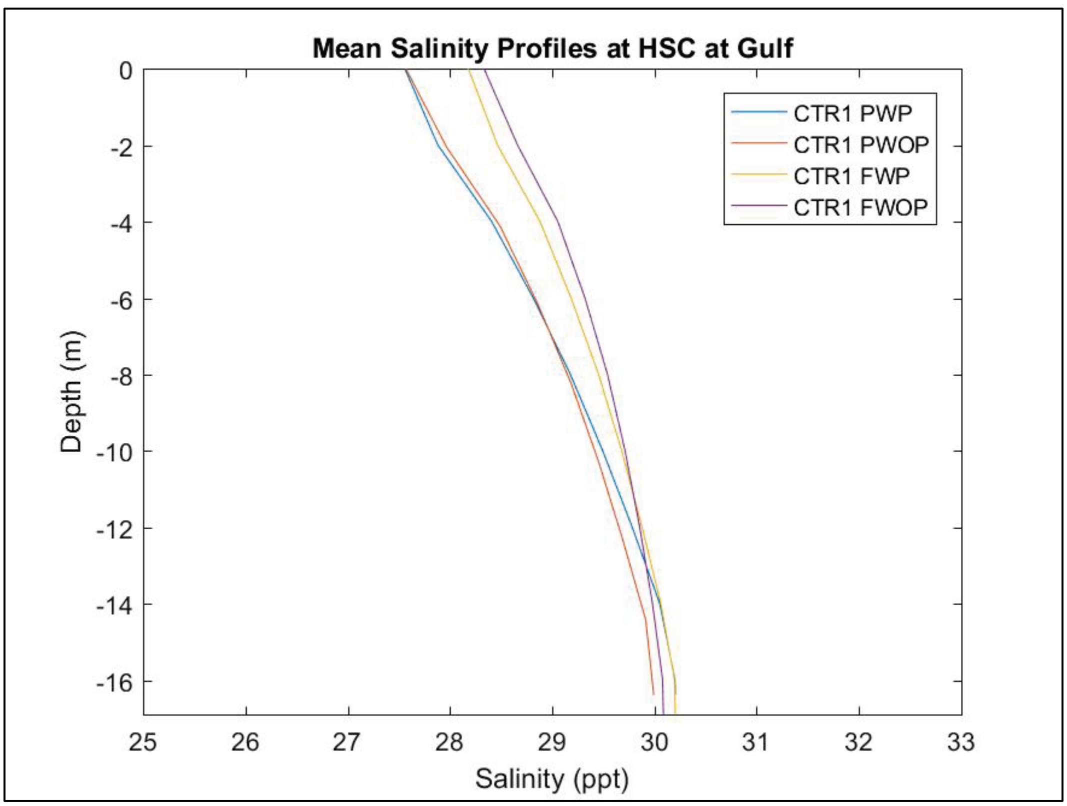

Salinity (ppt) at HSC at Gulf
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

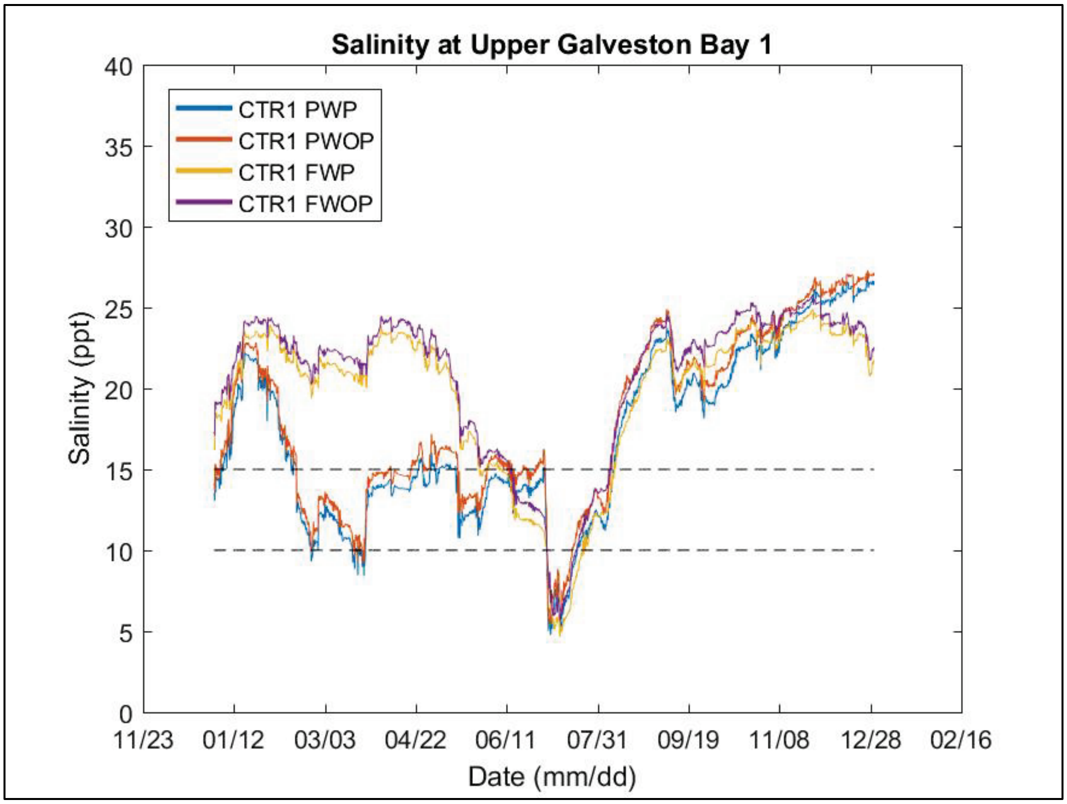
Greater Than 10 ppt for 14+ days - HSC at Gulf			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	12/30/2010 0:00	362.9
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

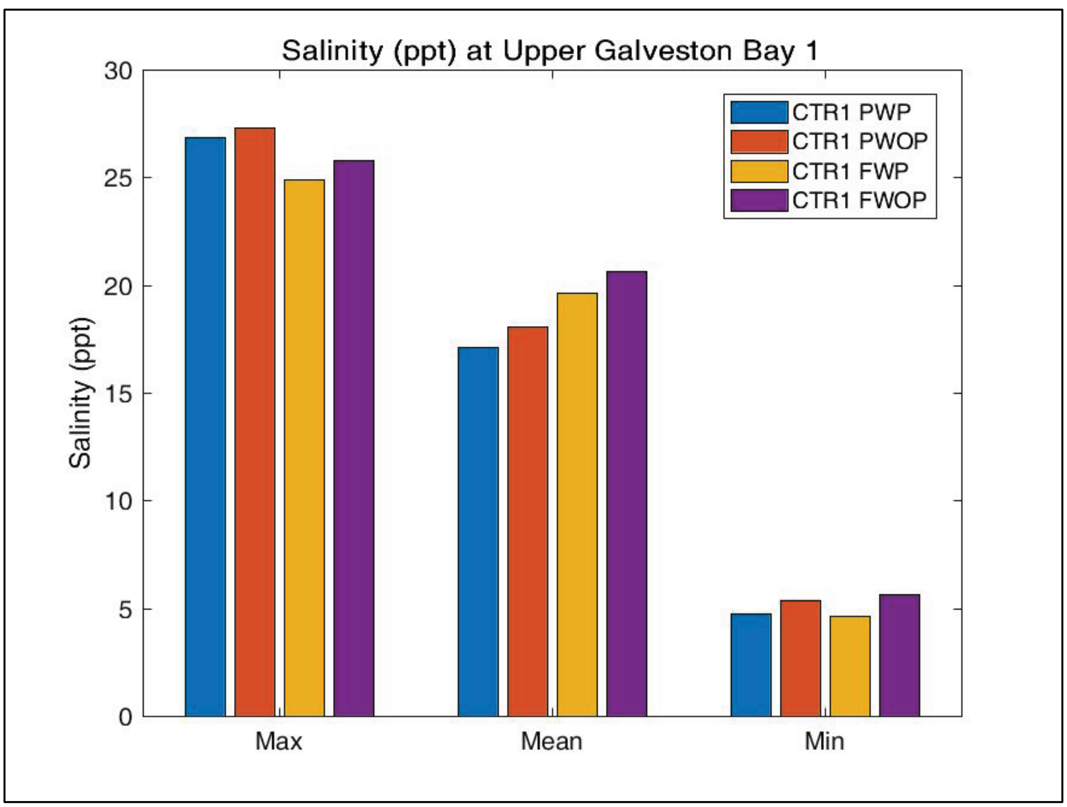
Greater Than 15 ppt for 14+ days - HSC at Gulf			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	12/30/2010 0:00	362.9
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

Less Than 10 ppt for 14+ days - HSC at Gulf			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at HSC at Gulf
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP


Mean Salinity Profiles at HSC at Gulf
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
25
26
27
28
29
30
31
32
33
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

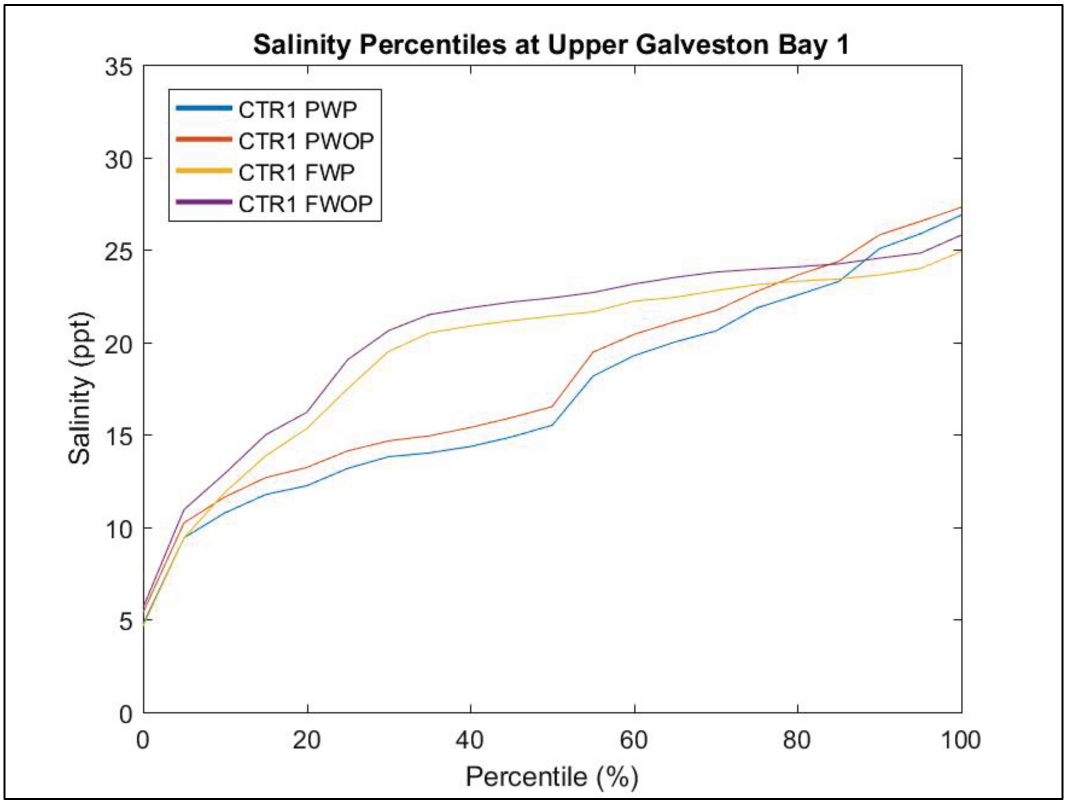

Salinity at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16

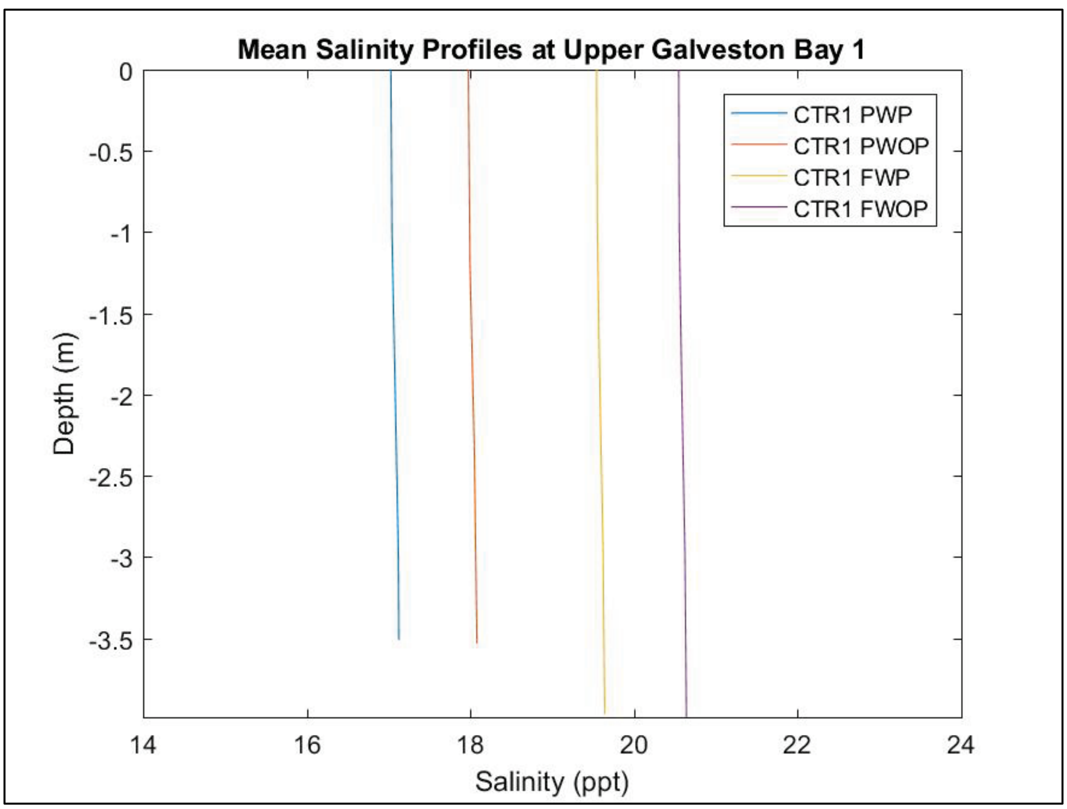

Salinity (ppt) at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

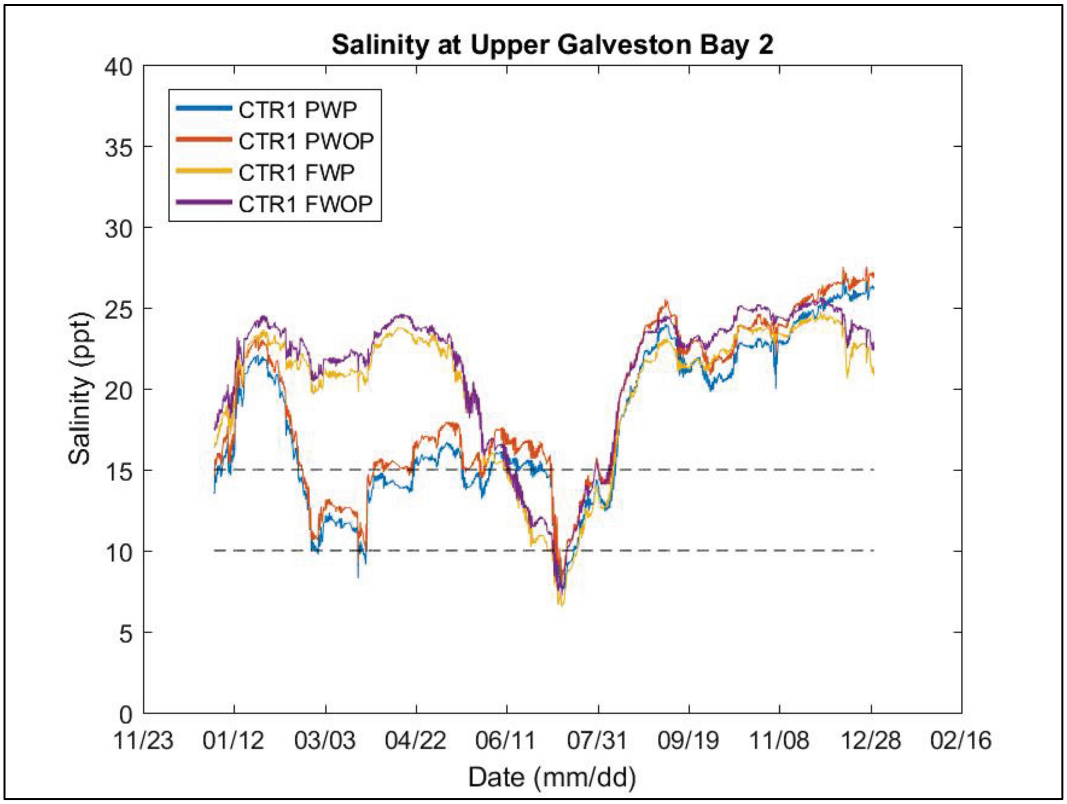
Greater Than 10 ppt for 14+ days - Upper Galveston Bay 1			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/23/2010 6:00	53.1
	2/24/2010 12:00	3/18/2010 3:00	21.6
	3/25/2010 9:00	7/3/2010 0:00	99.6
	7/19/2010 21:00	12/30/2010 0:00	163.1
PWOP	1/1/2010 3:00	2/23/2010 9:00	53.3
	2/23/2010 15:00	3/19/2010 6:00	23.6
	3/25/2010 3:00	7/3/2010 0:00	99.9
	7/17/2010 0:00	12/30/2010 0:00	166.0
FWP	1/1/2010 3:00	7/2/2010 21:00	182.8
	7/24/2010 9:00	12/30/2010 0:00	158.6
FWOP	1/1/2010 3:00	7/3/2010 3:00	183.0
	7/19/2010 15:00	12/30/2010 0:00	163.4

Greater Than 15 ppt for 14+ days - Upper Galveston Bay 1			
	Start	**Stop**	**Duration(days)**
PWP	1/6/2010 3:00	2/12/2010 12:00	37.4
	8/9/2010 0:00	12/30/2010 0:00	143.0
PWOP	1/5/2010 0:00	2/15/2010 6:00	41.3
	4/28/2010 21:00	5/15/2010 0:00	16.1
	8/7/2010 3:00	12/30/2010 0:00	144.9
FWP	1/1/2010 3:00	5/27/2010 0:00	145.9
	8/9/2010 3:00	12/30/2010 0:00	142.9
FWOP	1/1/2010 3:00	6/12/2010 21:00	162.8
	8/7/2010 0:00	12/30/2010 0:00	145.0

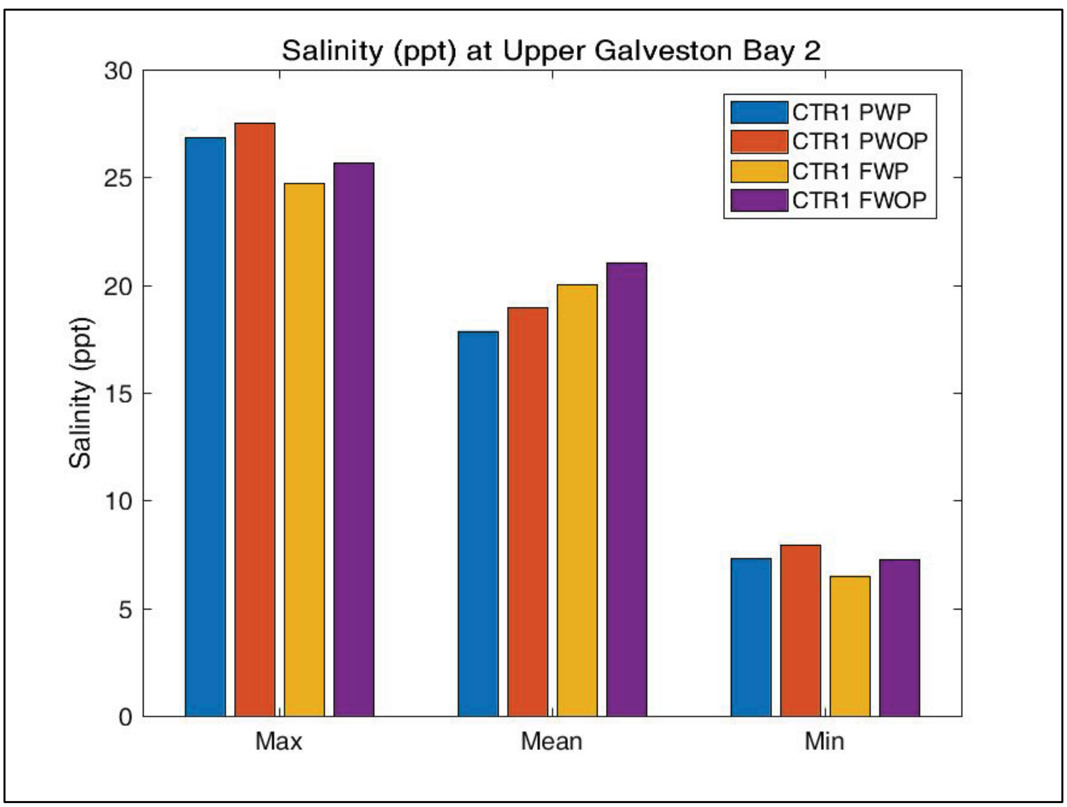
Less Than 10 ppt for 14+ days - Upper Galveston Bay 1			
	Start	**Stop**	**Duration(days)**
PWP	7/3/2010 3:00	7/19/2010 18:00	16.6
PWOP	NA	NA	NA
FWP	7/3/2010 0:00	7/22/2010 15:00	19.6
FWOP	7/3/2010 6:00	7/18/2010 21:00	15.6


Salinity Percentiles at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
14
16
18
20
22
24



Salinity at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16

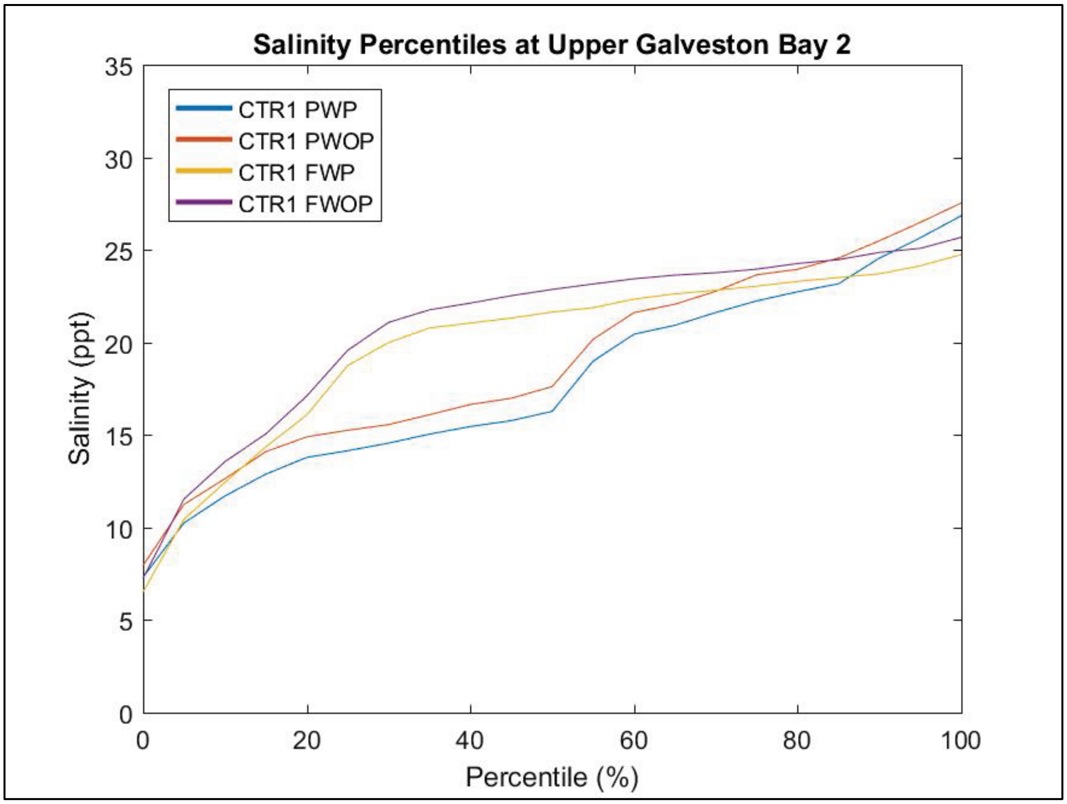


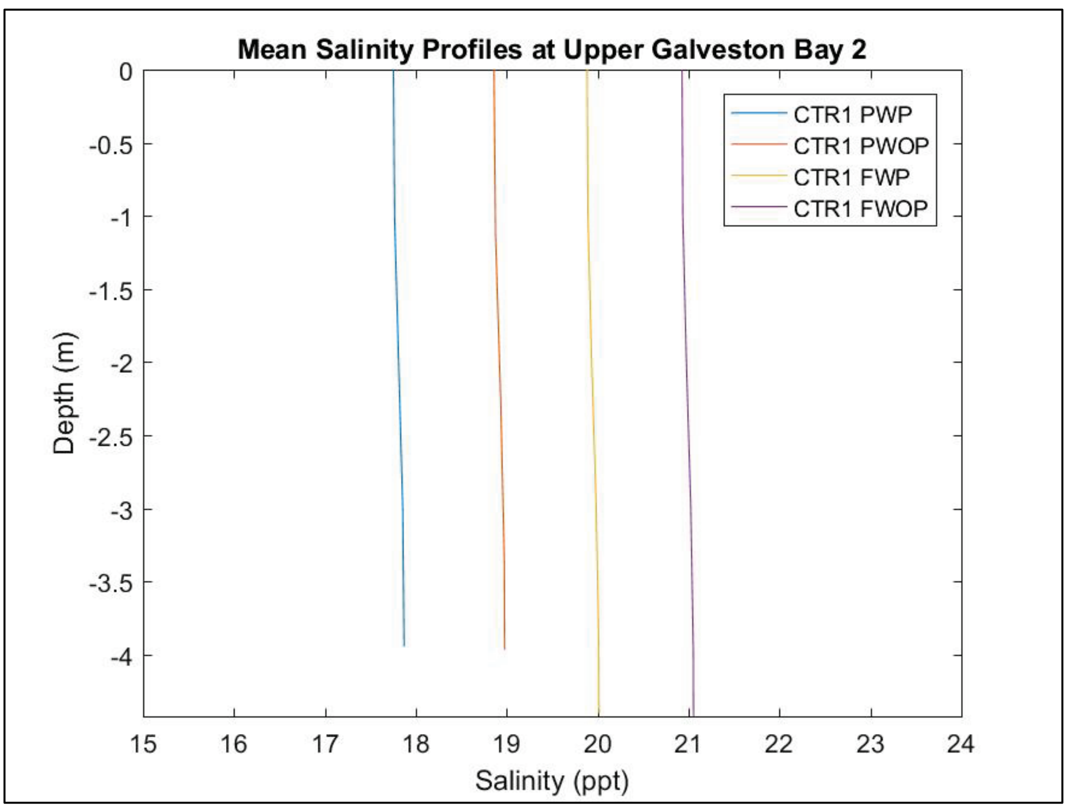
Salinity (ppt) at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

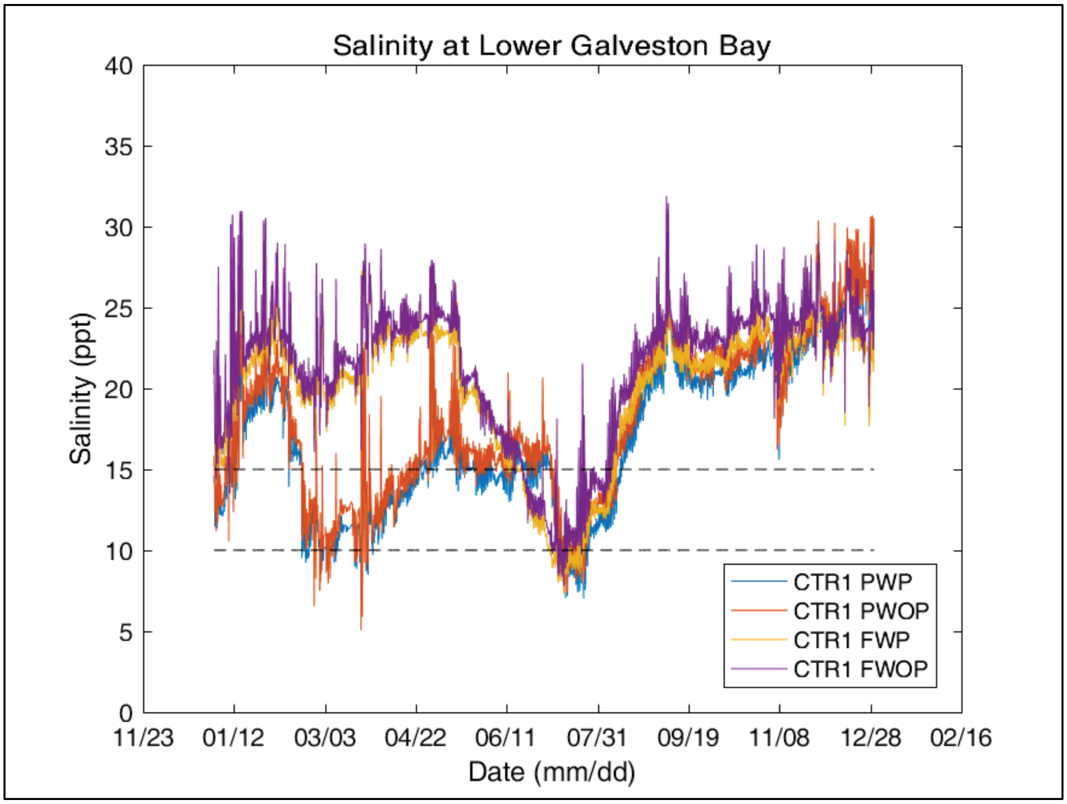
Greater Than 10 ppt for 14+ days - Upper Galveston Bay 2			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/23/2010 12:00	53.4
	2/27/2010 12:00	3/21/2010 0:00	21.5
	3/26/2010 3:00	7/7/2010 0:00	102.9
	7/18/2010 0:00	12/30/2010 0:00	165.0
PWOP	1/1/2010 3:00	3/21/2010 3:00	79.0
	3/25/2010 12:00	7/7/2010 0:00	103.5
	7/14/2010 0:00	12/30/2010 0:00	169.0
FWP	1/1/2010 3:00	7/3/2010 9:00	183.3
	7/20/2010 0:00	12/30/2010 0:00	163.0
FWOP	1/1/2010 3:00	7/6/2010 0:00	185.9
	7/14/2010 0:00	12/30/2010 0:00	169.0

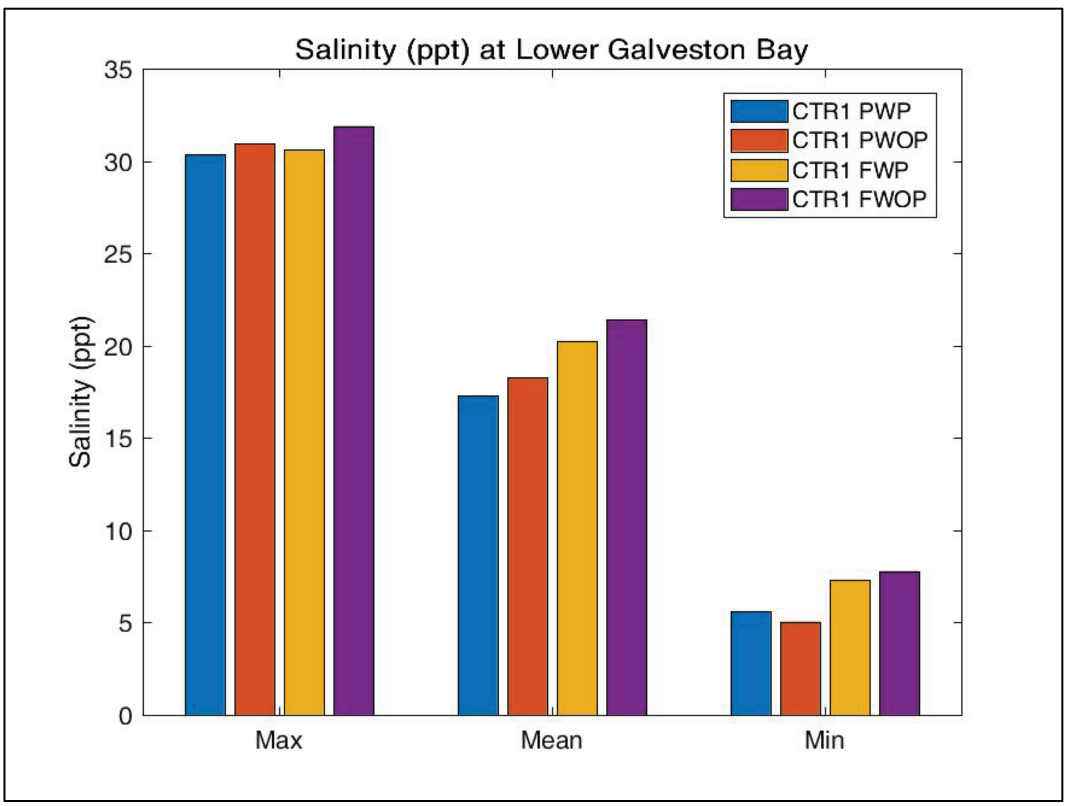
Greater Than 15 ppt for 14+ days - Upper Galveston Bay 2			
	Start	**Stop**	**Duration(days)**
PWP	1/10/2010 9:00	2/16/2010 6:00	36.9
	4/21/2010 6:00	5/17/2010 3:00	25.9
	6/2/2010 6:00	6/16/2010 6:00	14.0
	8/9/2010 21:00	12/30/2010 0:00	142.1
PWOP	1/1/2010 12:00	2/18/2010 9:00	47.9
	4/20/2010 3:00	5/18/2010 3:00	28.0
	5/30/2010 3:00	7/5/2010 0:00	35.9
	8/7/2010 21:00	12/30/2010 0:00	144.1
FWP	1/1/2010 3:00	6/9/2010 3:00	159.0
	8/9/2010 0:00	12/30/2010 0:00	143.0
FWOP	1/1/2010 3:00	6/11/2010 0:00	160.9
	8/6/2010 21:00	12/30/2010 0:00	145.1

Less Than 10 ppt for 14+ days - Upper Galveston Bay 2			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
15
16
17
18
19
20
21
22
23
24

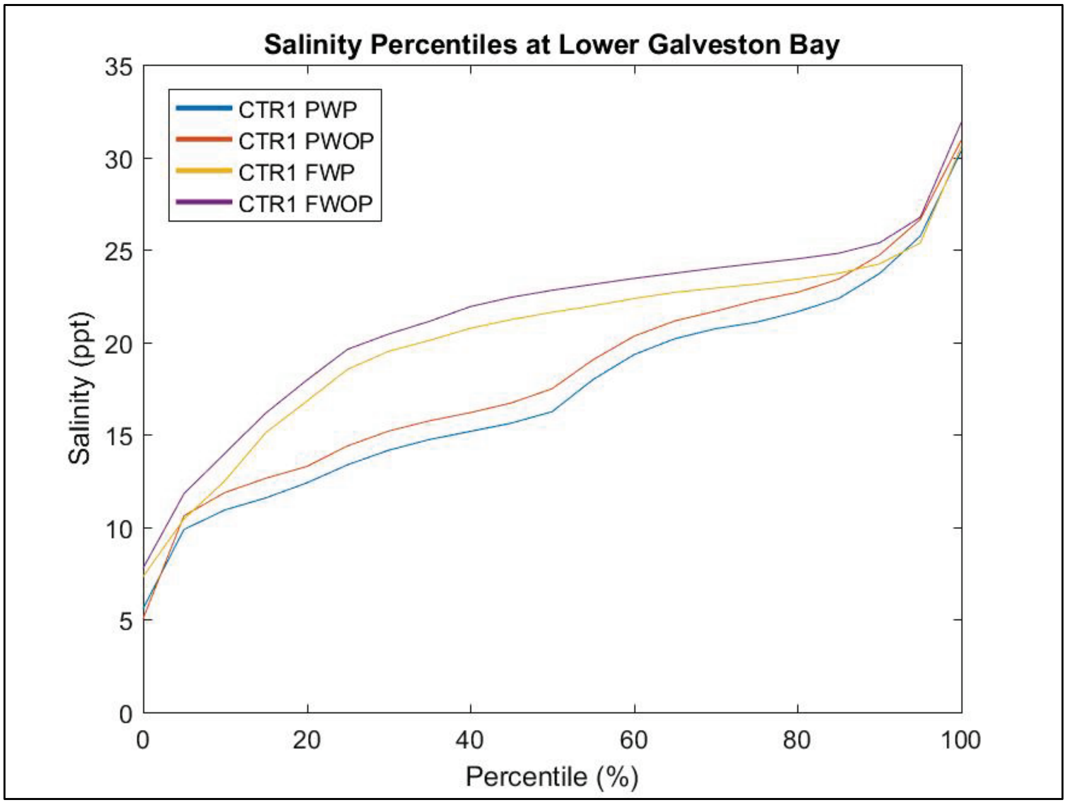

Salinity at Lower Galveston Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

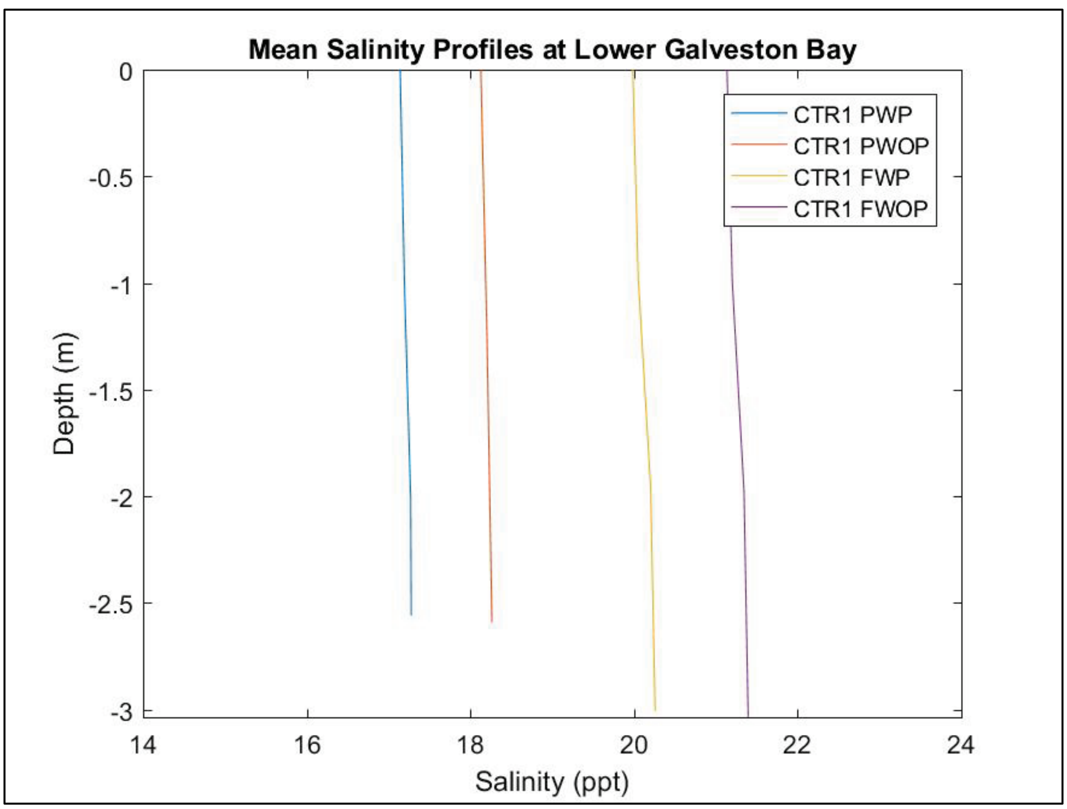

Salinity (ppt) at Lower Galveston Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

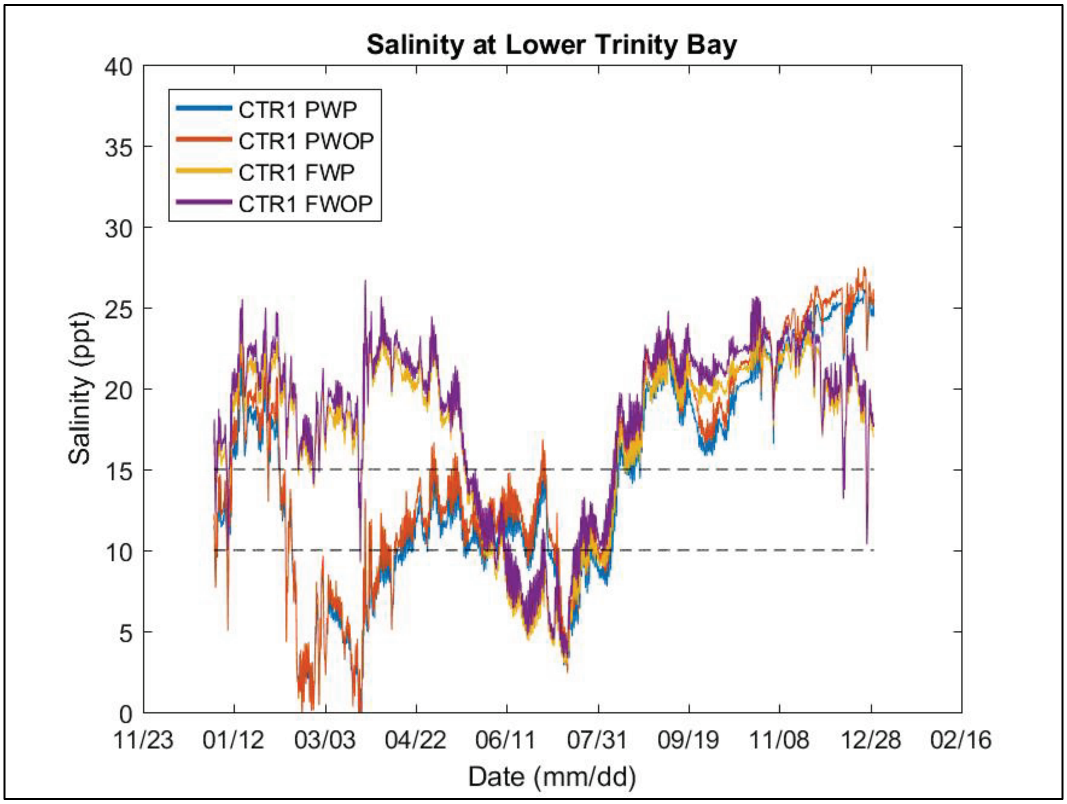
Greater Than 10 ppt for 14+ days - Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	3/22/2010 0:00	79.9
	3/22/2010 21:00	12/30/2010 0:00	282.1
PWOP	1/1/2010 3:00	2/20/2010 6:00	50.1
	3/26/2010 21:00	7/9/2010 0:00	104.1
	7/24/2010 12:00	12/30/2010 0:00	158.5
FWP	1/1/2010 3:00	7/3/2010 18:00	183.6
	7/23/2010 9:00	12/30/2010 0:00	159.6
FWOP	1/1/2010 3:00	7/5/2010 18:00	185.6
	7/22/2010 9:00	12/30/2010 0:00	160.6

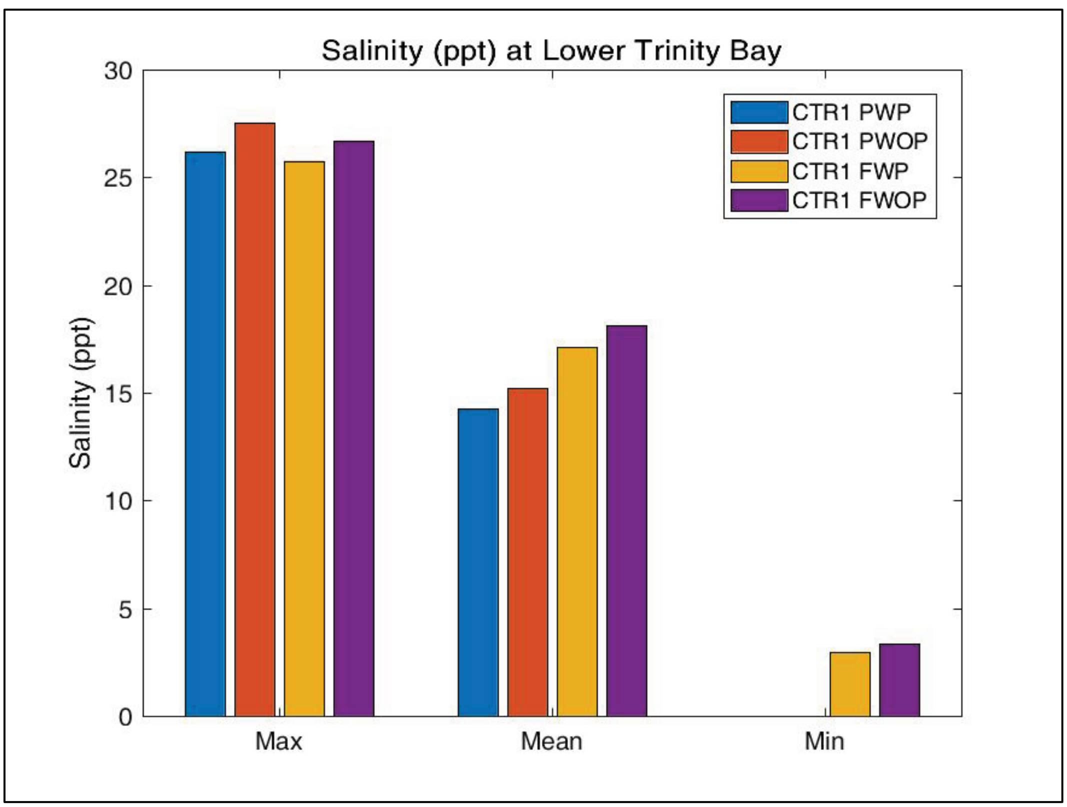
Greater Than 15 ppt for 14+ days - Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/15/2010 18:00	45.6
	3/22/2010 21:00	4/8/2010 21:00	17.0
	4/9/2010 3:00	7/3/2010 21:00	85.8
	7/4/2010 9:00	12/30/2010 0:00	178.6
PWOP	1/13/2010 21:00	2/11/2010 6:00	28.4
	4/29/2010 15:00	5/14/2010 3:00	14.5
	8/10/2010 12:00	12/30/2010 0:00	141.5
FWP	1/2/2010 9:00	6/11/2010 12:00	160.1
	8/10/2010 12:00	12/30/2010 0:00	141.5
FWOP	1/9/2010 9:00	6/14/2010 15:00	156.3
	8/7/2010 9:00	12/30/2010 0:00	144.6

Less Than 10 ppt for 14+ days - Lower Galveston Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
14
16
18
20
22
24

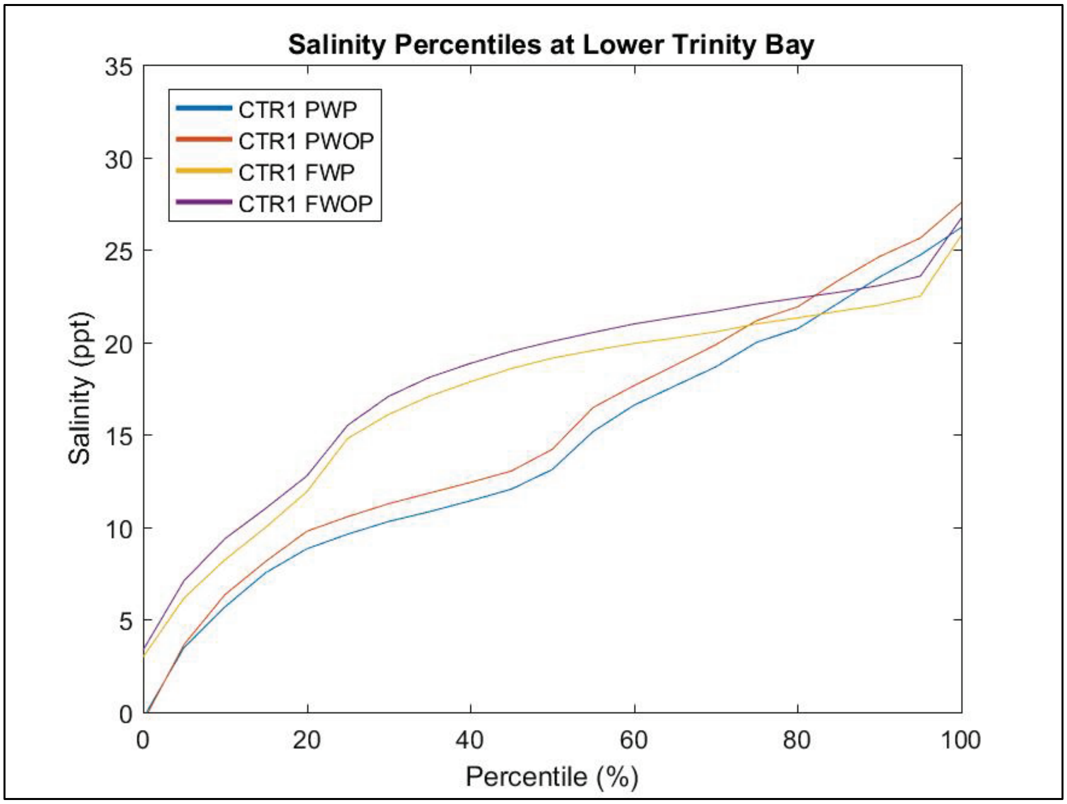

Salinity at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

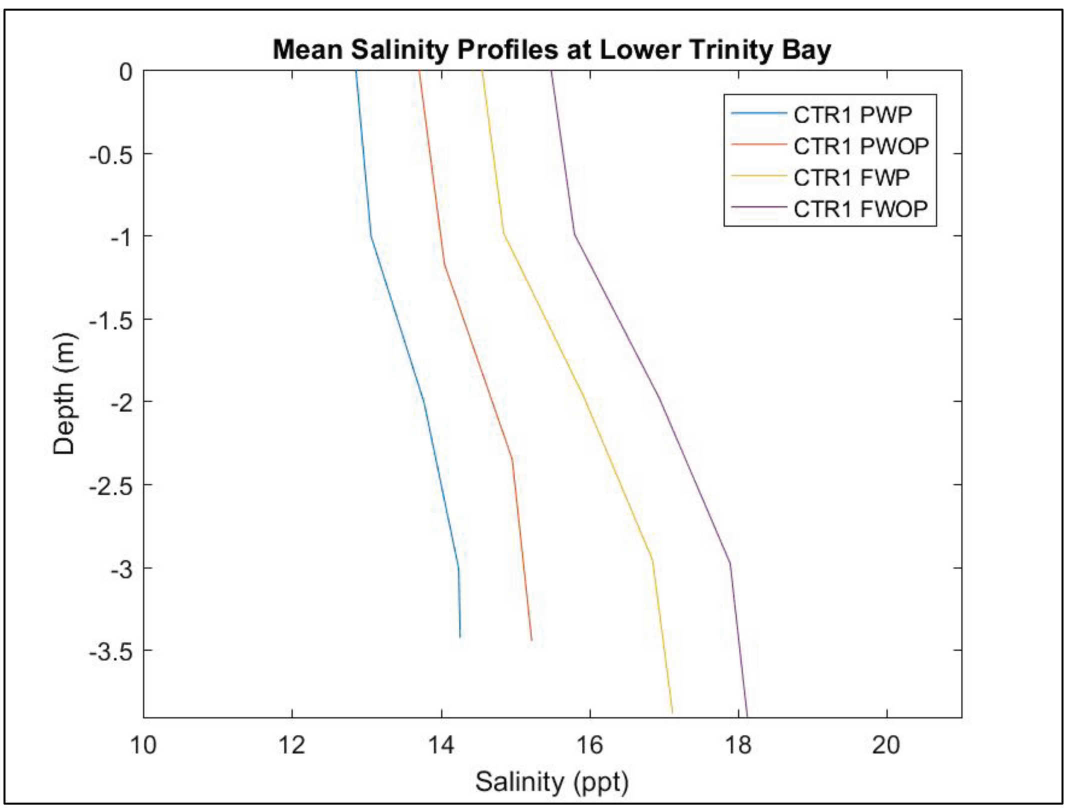

Salinity (ppt) at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

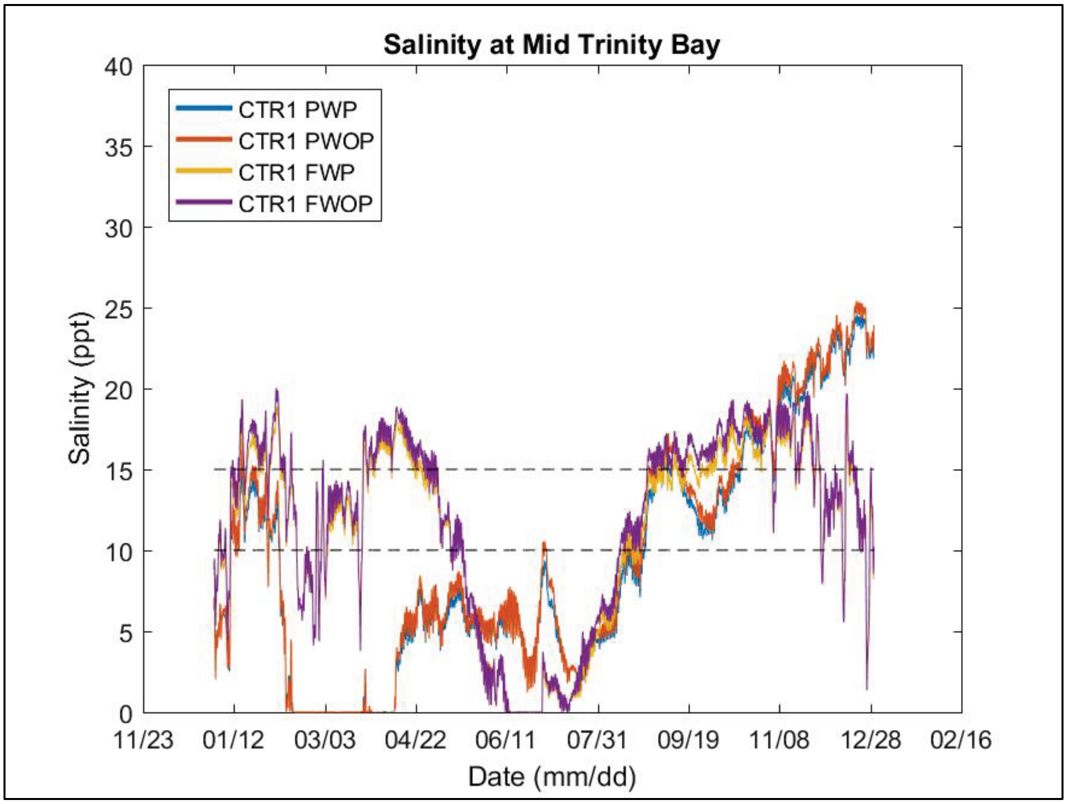
Greater Than 10 ppt for 14+ days - Lower Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/9/2010 3:00	2/9/2010 9:00	31.3
	4/28/2010 12:00	5/18/2010 6:00	19.8
	8/8/2010 9:00	12/30/2010 0:00	143.6
PWOP	1/9/2010 3:00	2/9/2010 9:00	31.3
	4/14/2010 9:00	5/28/2010 3:00	43.8
	5/30/2010 12:00	6/22/2010 0:00	22.5
	8/7/2010 9:00	12/30/2010 0:00	144.6
FWP	1/1/2010 3:00	3/22/2010 6:00	80.1
	3/22/2010 18:00	5/29/2010 6:00	67.5
	8/6/2010 9:00	12/30/2010 0:00	145.6
FWOP	1/8/2010 18:00	3/22/2010 9:00	72.6
	3/22/2010 15:00	5/29/2010 6:00	67.6
	8/4/2010 6:00	12/30/2010 0:00	147.8

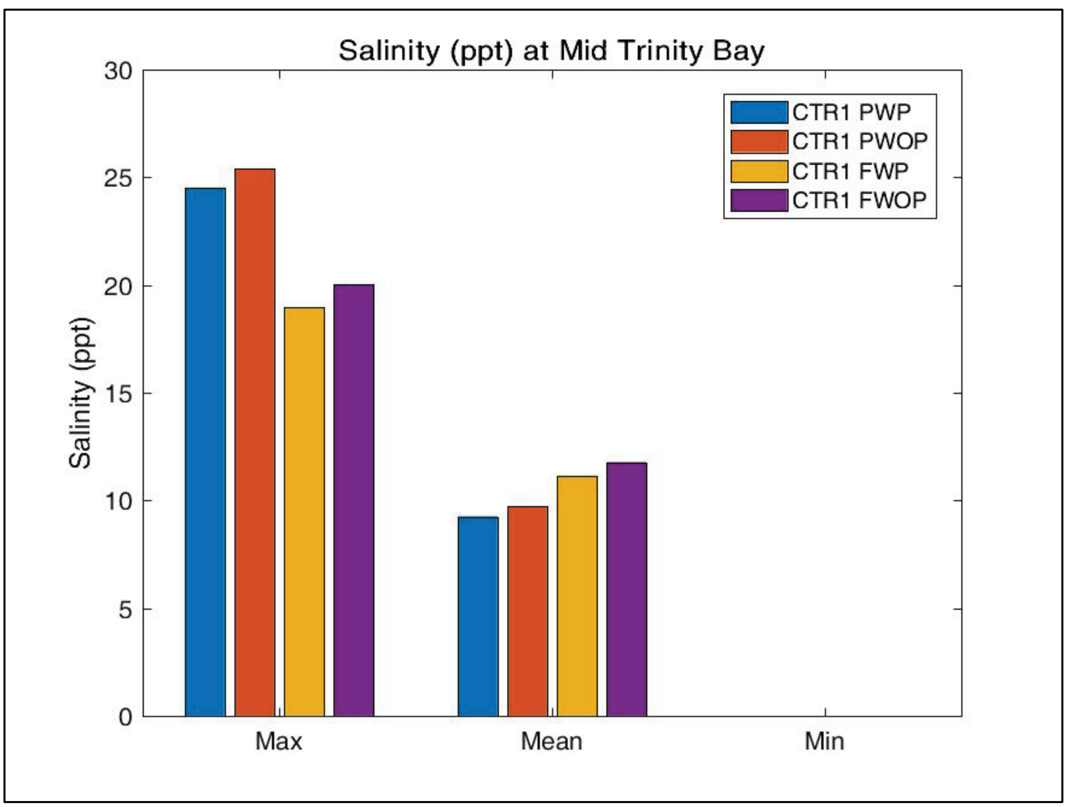
Greater Than 15 ppt for 14+ days - Lower Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/10/2010 21:00	1/30/2010 15:00	19.8
	8/23/2010 12:00	12/30/2010 0:00	128.5
PWOP	1/10/2010 21:00	1/30/2010 15:00	19.8
	8/10/2010 15:00	12/30/2010 0:00	141.4
FWP	1/10/2010 3:00	2/16/2010 6:00	37.1
	2/28/2010 0:00	3/21/2010 9:00	21.4
	3/24/2010 0:00	5/18/2010 9:00	55.4
	8/17/2010 6:00	12/12/2010 21:00	117.6
FWOP	1/9/2010 12:00	2/16/2010 9:00	37.9
	2/28/2010 0:00	3/21/2010 9:00	21.4
	3/23/2010 15:00	5/19/2010 9:00	56.8
	8/10/2010 12:00	12/12/2010 21:00	124.4

Less Than 10 ppt for 14+ days - Lower Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	2/13/2010 0:00	3/25/2010 0:00	40.0
PWOP	2/13/2010 3:00	3/24/2010 21:00	39.8
FWP	6/10/2010 0:00	7/21/2010 12:00	41.5
FWOP	6/13/2010 0:00	6/30/2010 0:00	17.0


Salinity Percentiles at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
10
12
14
16
18
20

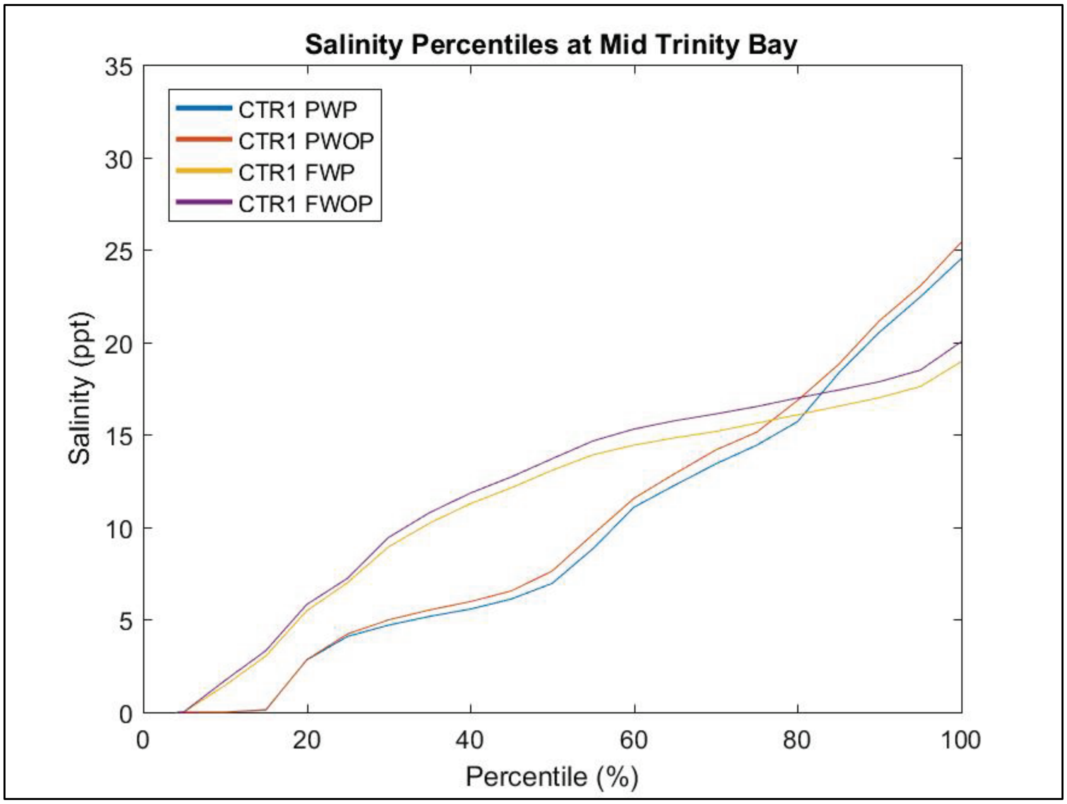

Salinity at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

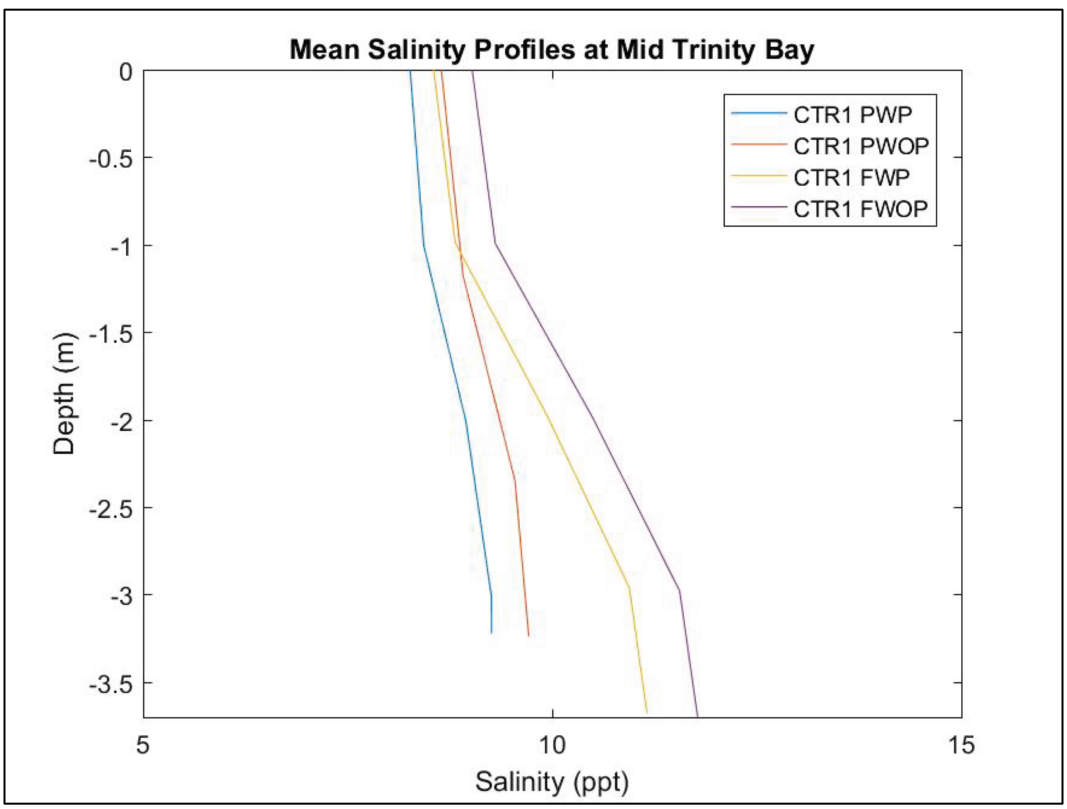

Salinity (ppt) at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

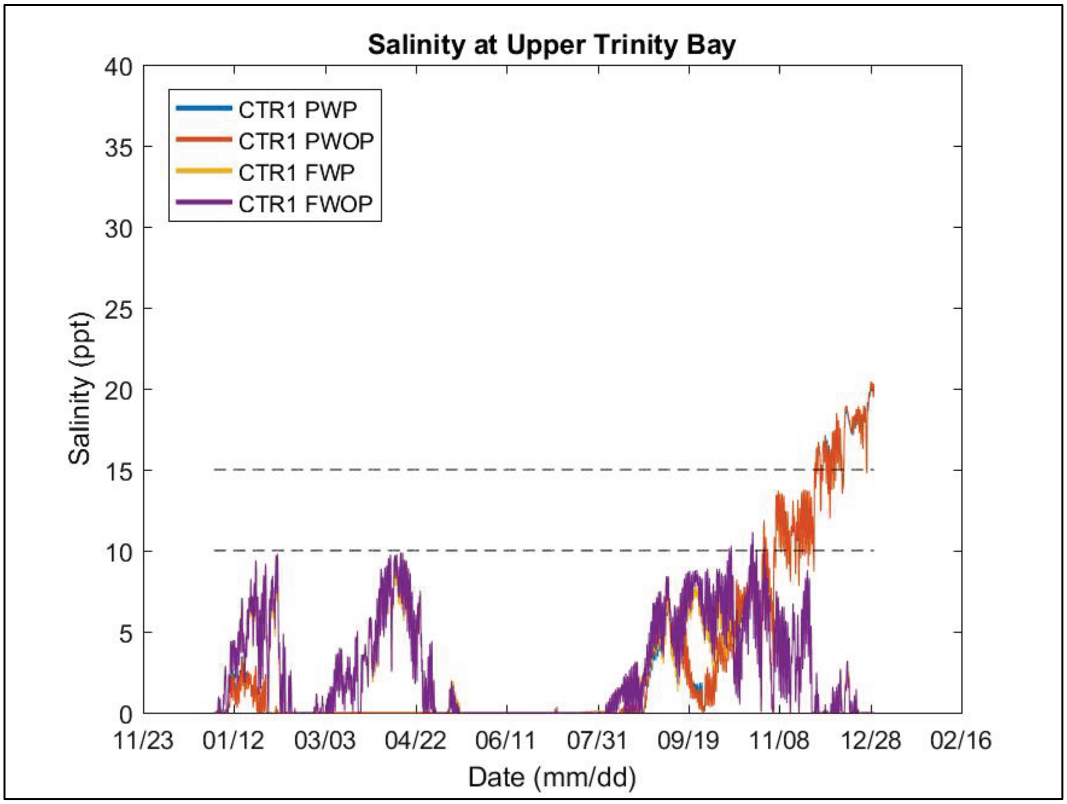
Greater Than 10 ppt for 14+ days - Mid Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/15/2010 0:00	1/30/2010 9:00	15.4
	8/26/2010 0:00	12/30/2010 0:00	126.0
PWOP	1/14/2010 0:00	1/30/2010 12:00	16.5
	8/24/2010 15:00	12/30/2010 0:00	127.4
FWP	1/10/2010 0:00	2/15/2010 9:00	36.4
	3/4/2010 15:00	3/21/2010 6:00	16.6
	3/23/2010 9:00	5/11/2010 0:00	48.6
	8/23/2010 15:00	11/30/2010 21:00	99.3
FWOP	1/10/2010 0:00	2/15/2010 9:00	36.4
	3/4/2010 0:00	3/21/2010 6:00	17.3
	3/23/2010 12:00	5/11/2010 0:00	48.5
	8/23/2010 12:00	11/30/2010 21:00	99.4

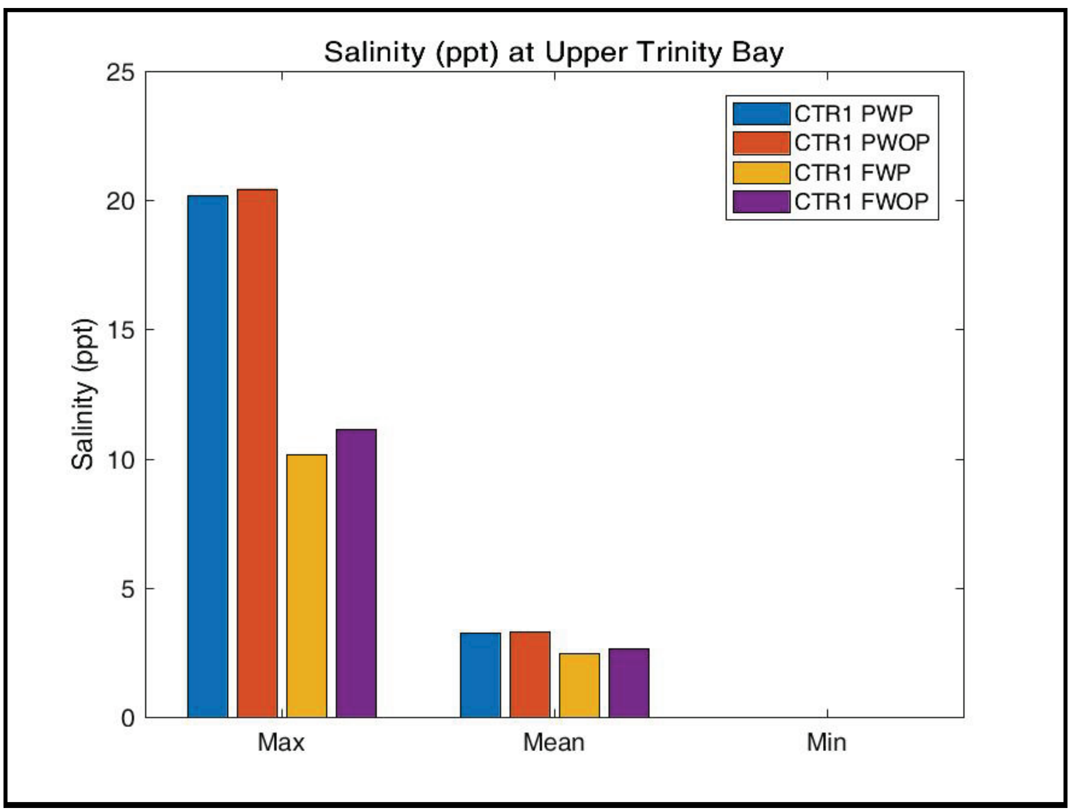
Greater Than 15 ppt for 14+ days - Mid Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	11/5/2010 21:00	12/30/2010 0:00	54.1
PWOP	10/17/2010 9:00	11/4/2010 9:00	18.0
	11/5/2010 21:00	12/30/2010 0:00	54.1
FWP	10/9/2010 0:00	10/28/2010 18:00	19.8
FWOP	4/8/2010 21:00	4/26/2010 3:00	17.3
	9/25/2010 0:00	11/4/2010 3:00	40.1

Less Than 10 ppt for 14+ days - Mid Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	2/5/2010 21:00	8/16/2010 9:00	191.5
PWOP	2/6/2010 6:00	6/30/2010 18:00	144.5
	7/2/2010 21:00	8/14/2010 0:00	42.1
FWP	5/18/2010 6:00	8/14/2010 3:00	87.9
FWOP	5/18/2010 6:00	8/12/2010 0:00	85.8


Salinity Percentiles at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Percentile (%)
0
20
40
60
80
100


Mean Salinity Profiles at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Salinity (ppt)
5
10
15

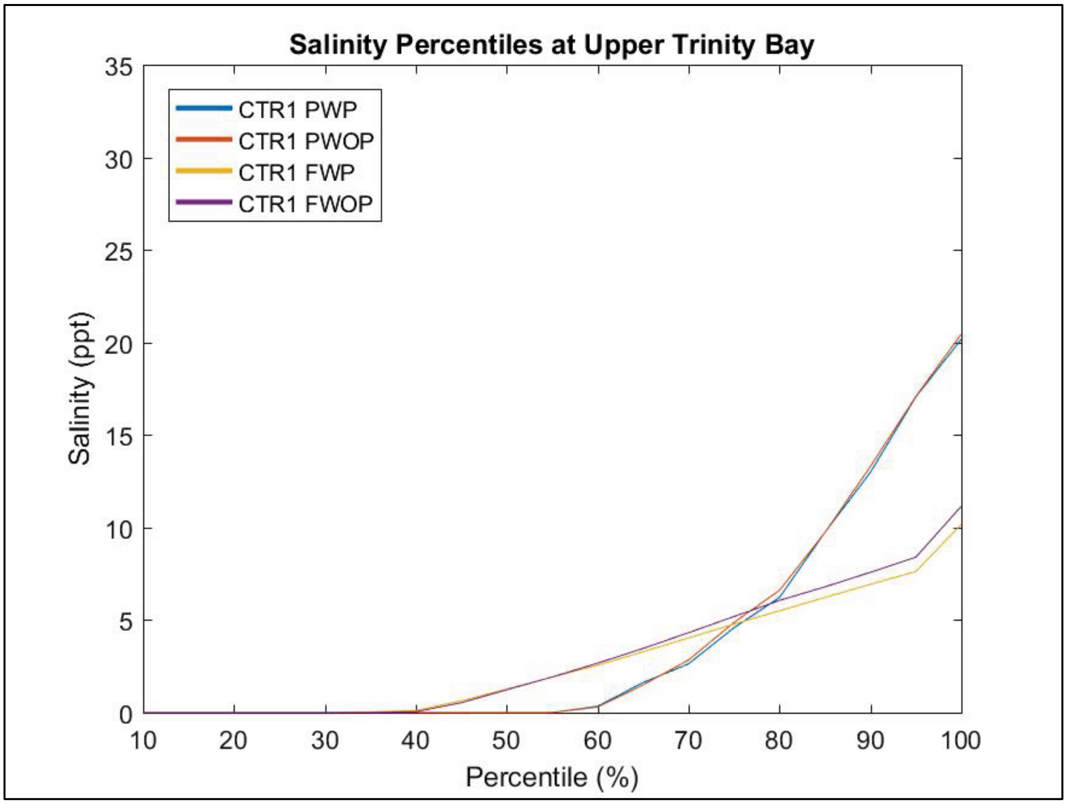

Salinity at Upper Trinity Bay
Salinity (ppt)
Date (mm/dd)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16


Salinity (ppt) at Upper Trinity Bay
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
5
10
15
20
25
Max
Mean
Min

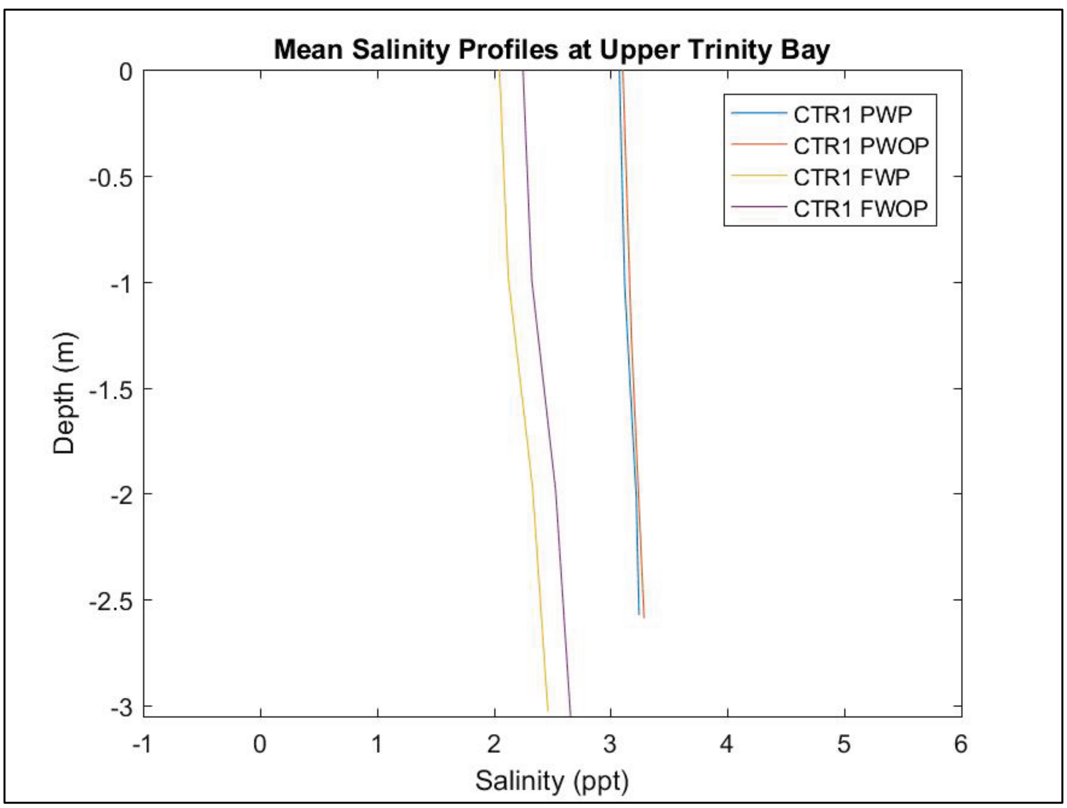
Greater Than 10 ppt for 14+ days - Upper Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	11/27/2010 3:00	12/30/2010 0:00	32.9
PWOP	11/27/2010 3:00	12/30/2010 0:00	32.9
FWP	NA	NA	NA
FWOP	NA	NA	NA

Greater Than 15 ppt for 14+ days - Upper Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	12/13/2010 9:00	12/30/2010 0:00	16.6
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA

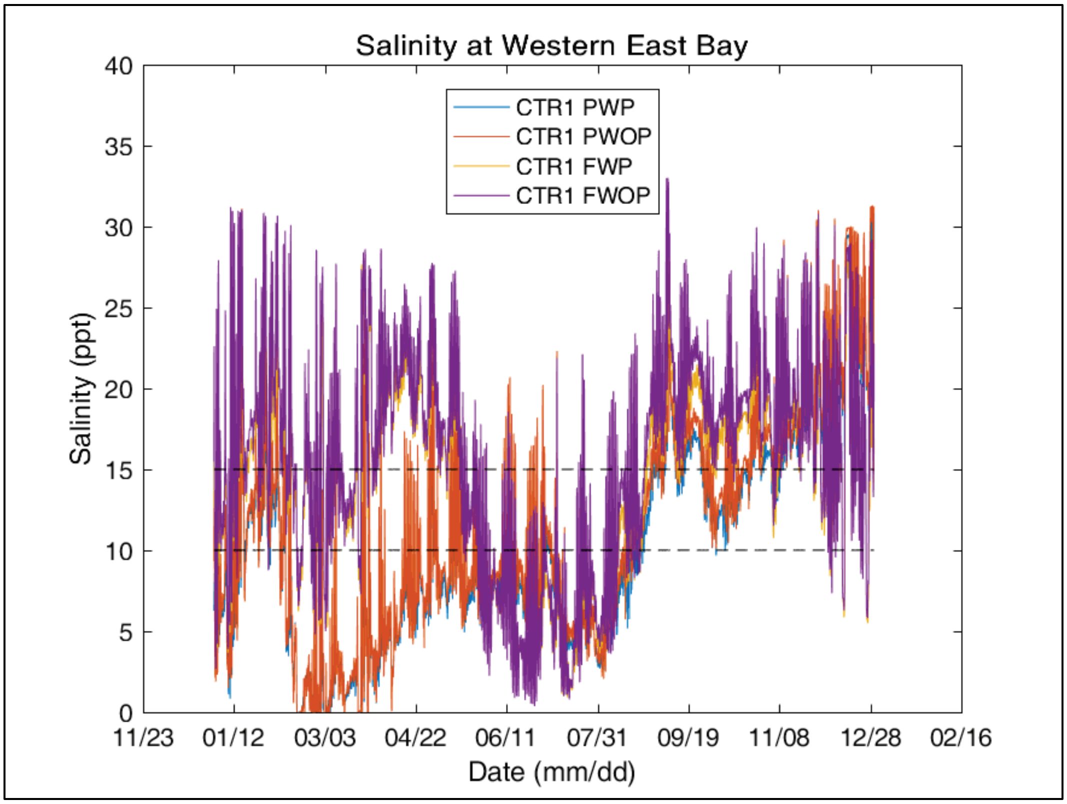
Less Than 10 ppt for 14+ days - Upper Trinity Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	10/30/2010 3:00	302.0
PWOP	1/1/2010 3:00	10/30/2010 3:00	302.0
FWP	1/1/2010 3:00	10/24/2010 3:00	296.0
	10/24/2010 12:00	12/30/2010 0:00	66.5
FWOP	1/1/2010 3:00	10/11/2010 9:00	283.3
	10/30/2010 15:00	12/30/2010 0:00	60.4

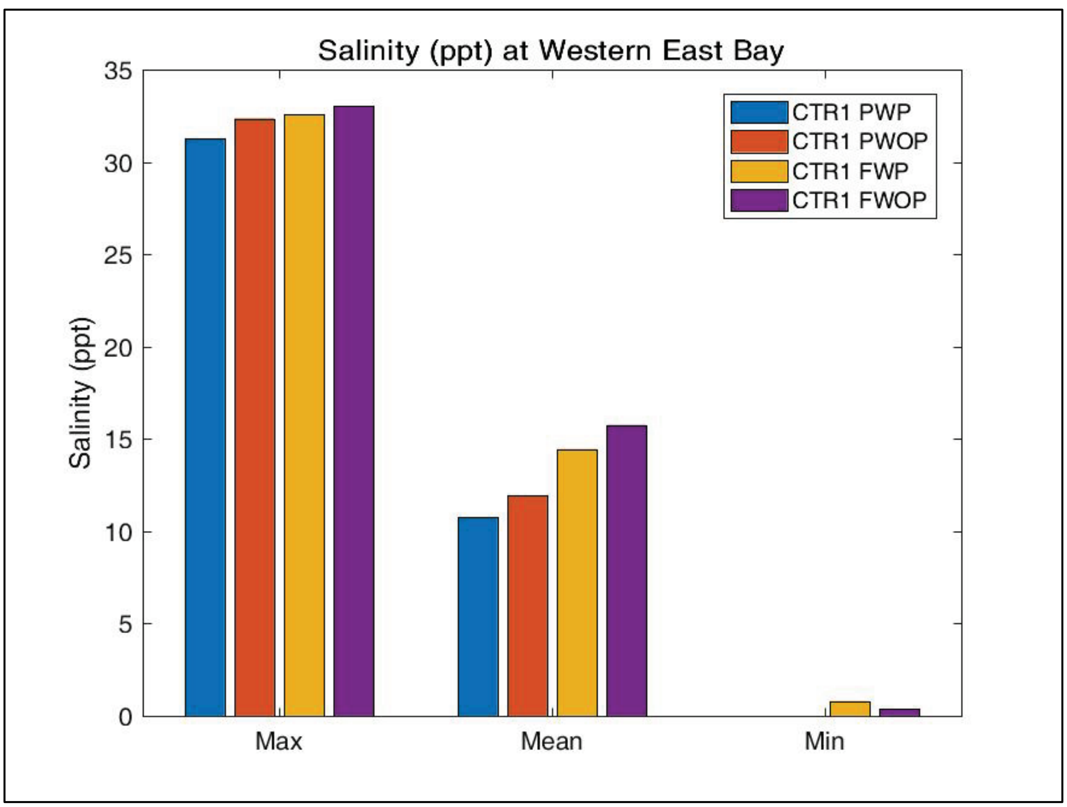


Salinity Percentiles at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
10
20
30
40
50
60
70
80
90
100



Mean Salinity Profiles at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
-1
0
1
2
3
4
5
6

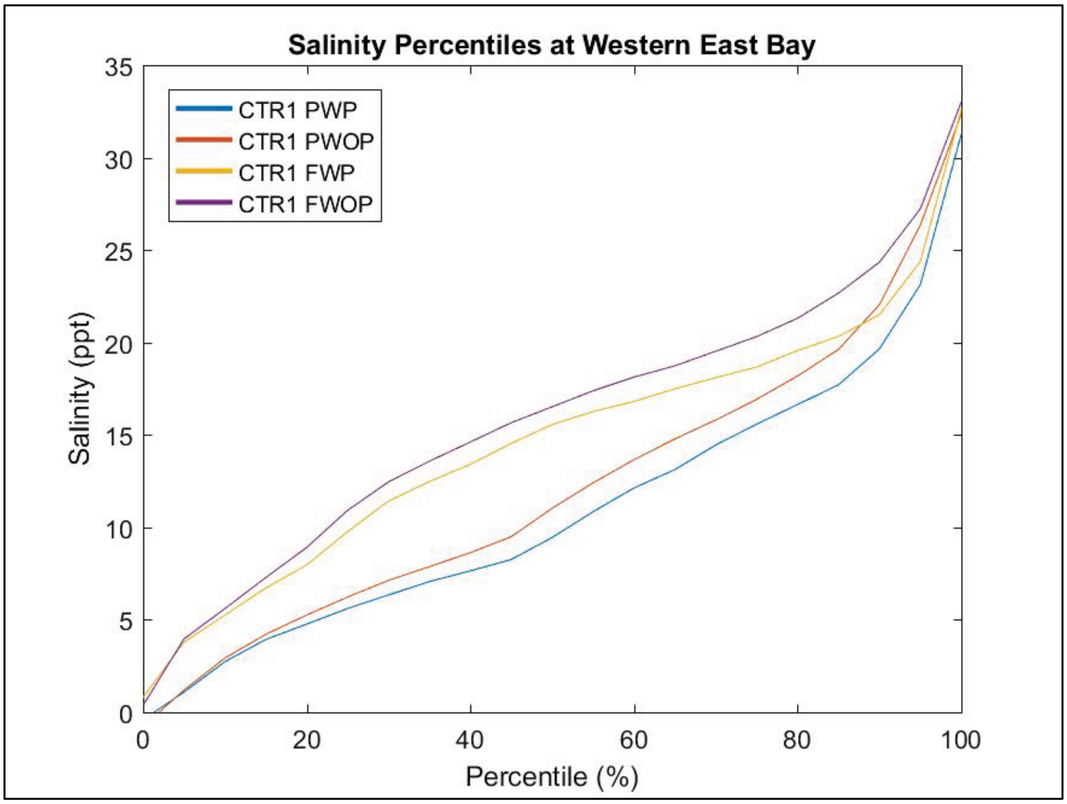

Salinity at Western East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

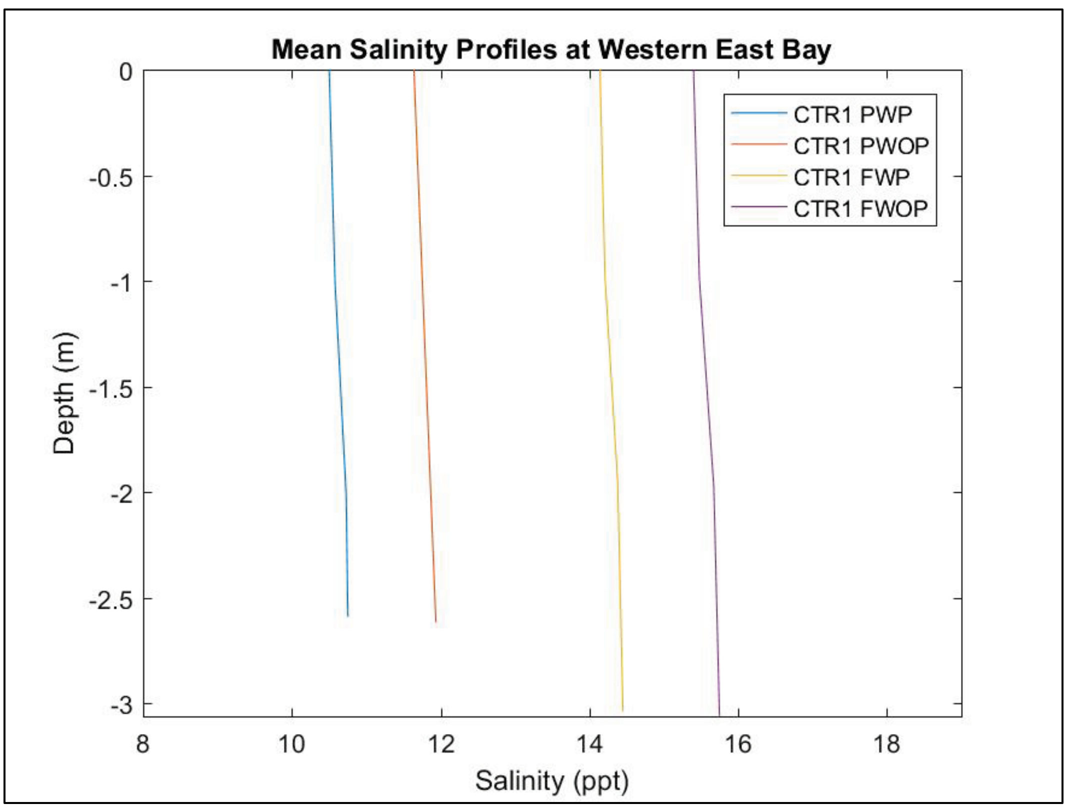

Salinity (ppt) at Western East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min

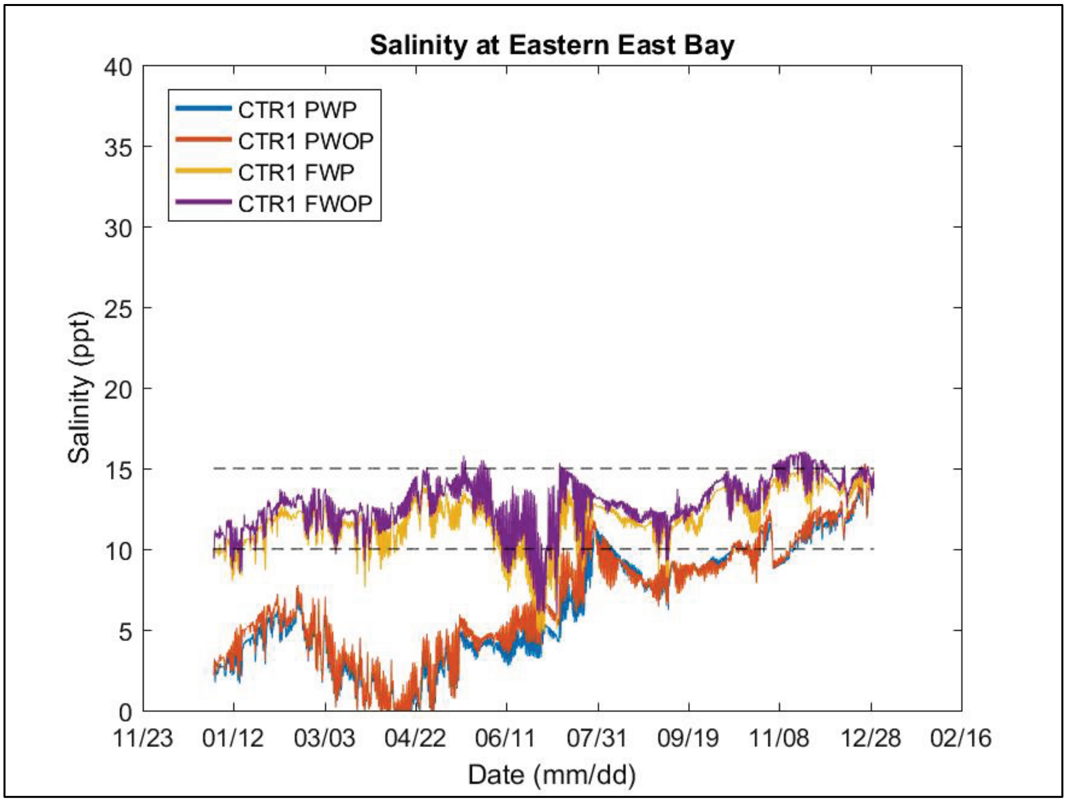
Greater Than 10 ppt for 14+ days - Western Eastern Bay			
	Start	**Stop**	**Duration(days)**
PWP	8/25/2010 15:00	10/4/2010 0:00	39.4
	10/9/2010 6:00	12/30/2010 0:00	81.8
PWOP	8/22/2010 18:00	12/30/2010 0:00	129.3
FWP	1/13/2010 21:00	2/15/2010 12:00	32.6
	3/6/2010 15:00	3/21/2010 6:00	14.6
	3/22/2010 21:00	5/18/2010 9:00	56.5
	8/24/2010 12:00	12/5/2010 12:00	103.0
FWOP	1/14/2010 0:00	1/30/2010 18:00	16.8
	1/31/2010 0:00	2/15/2010 12:00	15.5
	3/6/2010 18:00	3/21/2010 6:00	14.5
	3/22/2010 21:00	5/18/2010 6:00	56.4
	8/23/2010 12:00	12/4/2010 15:00	103.1

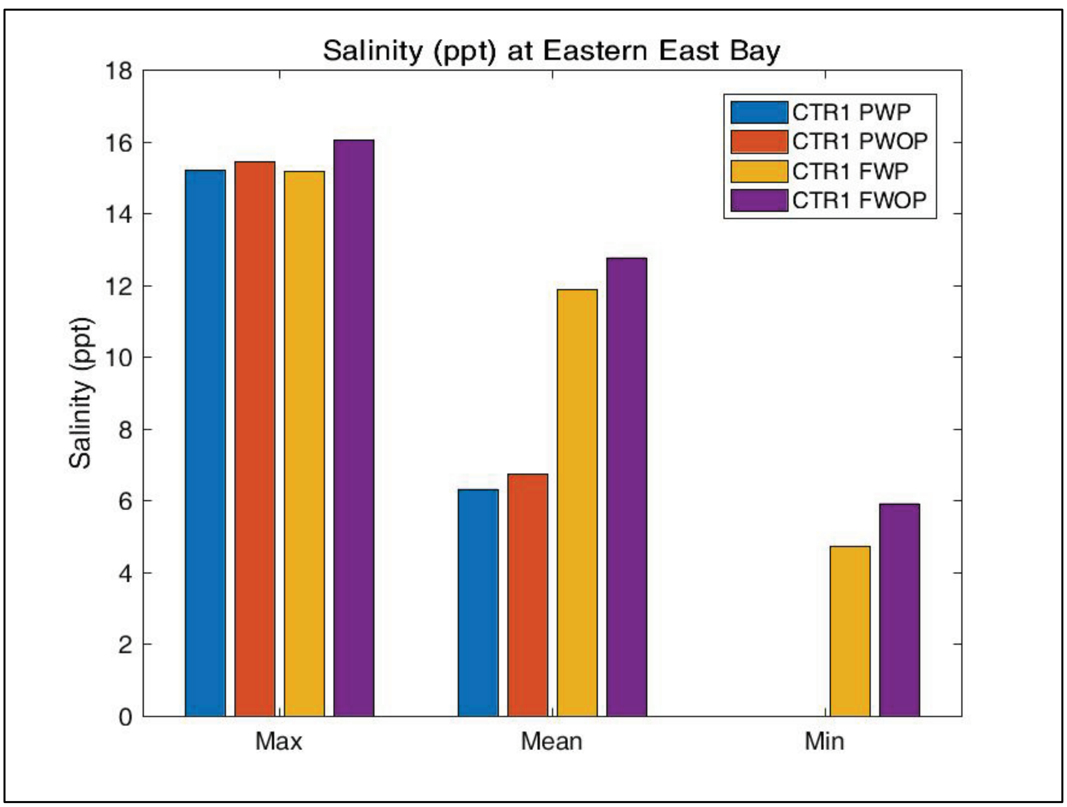
Greater Than 15 ppt for 14+ days -Western Eastern Bay			
	Start	**Stop**	**Duration(days)**
PWP	11/10/2010 0:00	11/27/2010 6:00	17.3
	11/27/2010 12:00	12/30/2010 0:00	32.5
PWOP	11/8/2010 3:00	12/30/2010 0:00	51.9
FWP	3/31/2010 12:00	5/4/2010 9:00	33.9
	8/27/2010 3:00	9/12/2010 18:00	16.6
	9/14/2010 6:00	10/1/2010 21:00	17.6
	10/15/2010 6:00	11/3/2010 15:00	19.4
FWOP	4/1/2010 12:00	5/5/2010 9:00	33.9
	8/25/2010 15:00	9/13/2010 21:00	19.3
	9/14/2010 3:00	10/4/2010 3:00	20.0
	10/14/2010 6:00	11/4/2010 0:00	20.8

Less Than 10 ppt for 14+ days - Western Eastern Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	6/12/2010 21:00	7/1/2010 15:00	18.8
FWOP	NA	NA	NA


Salinity Percentiles at Western East Bay
Salinity (ppt)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Western East Bay
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-0.5
-1
-1.5
-2
-2.5
-3
8
10
12
14
16
18

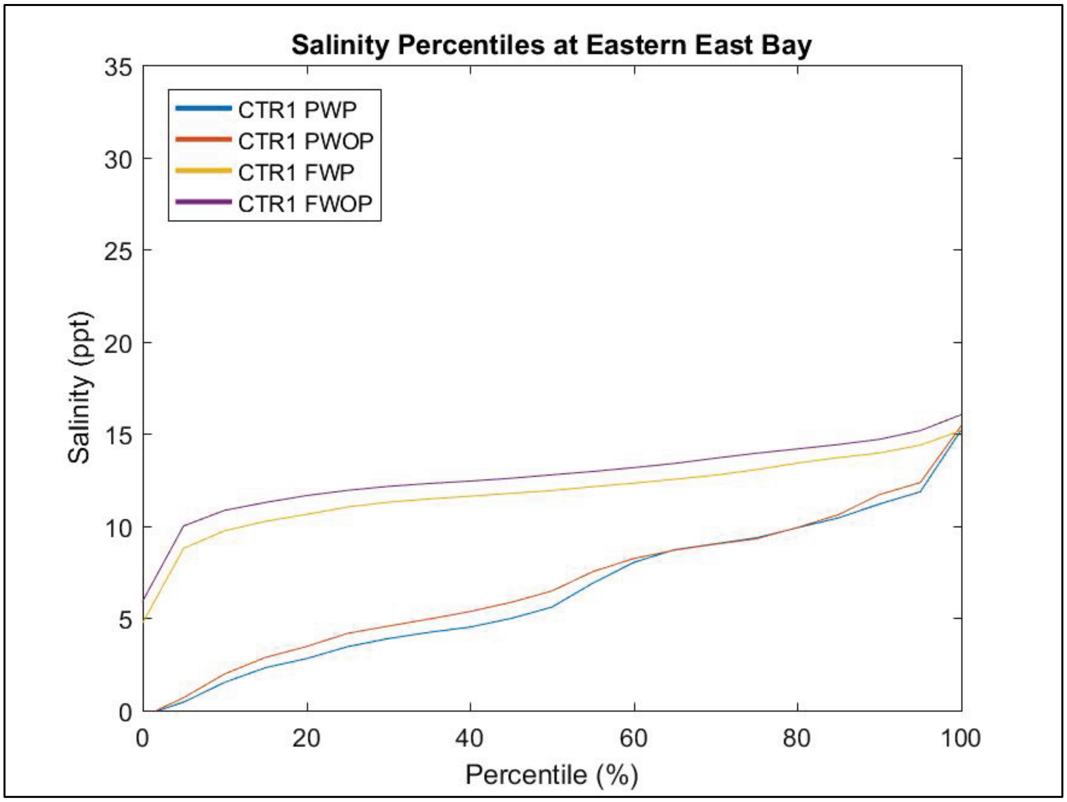

Salinity at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

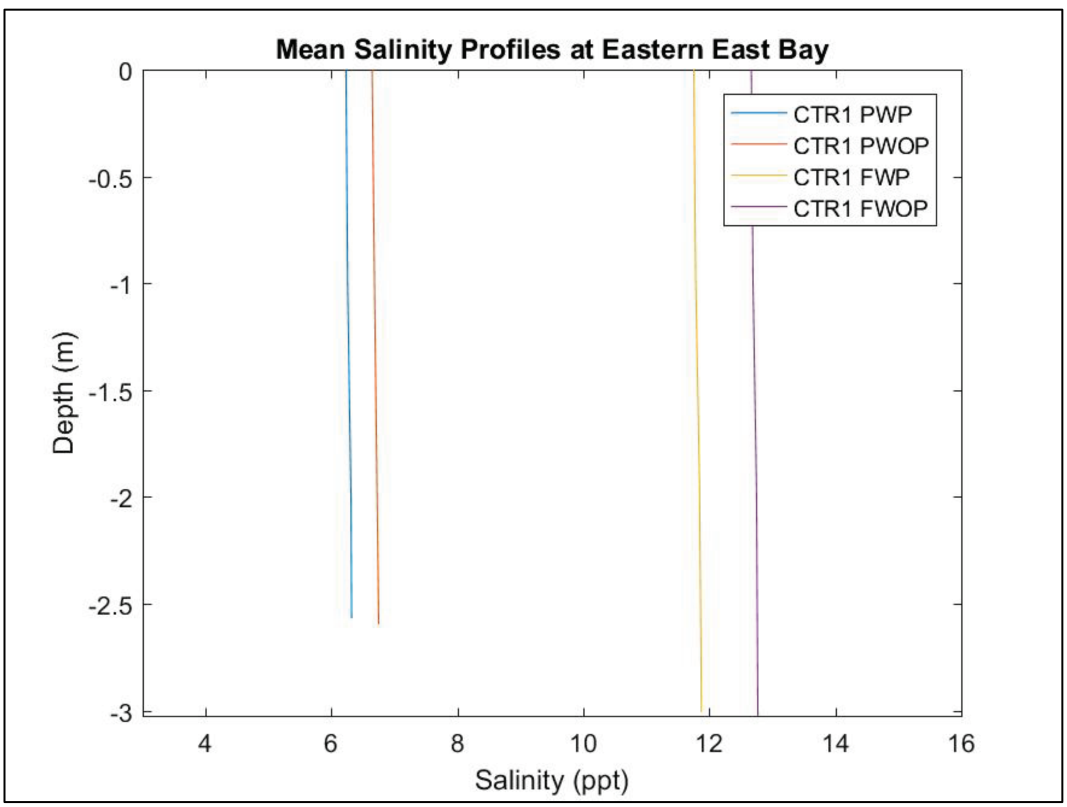

Salinity (ppt) at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
2
4
6
8
10
12
14
16
18
Max
Mean
Min

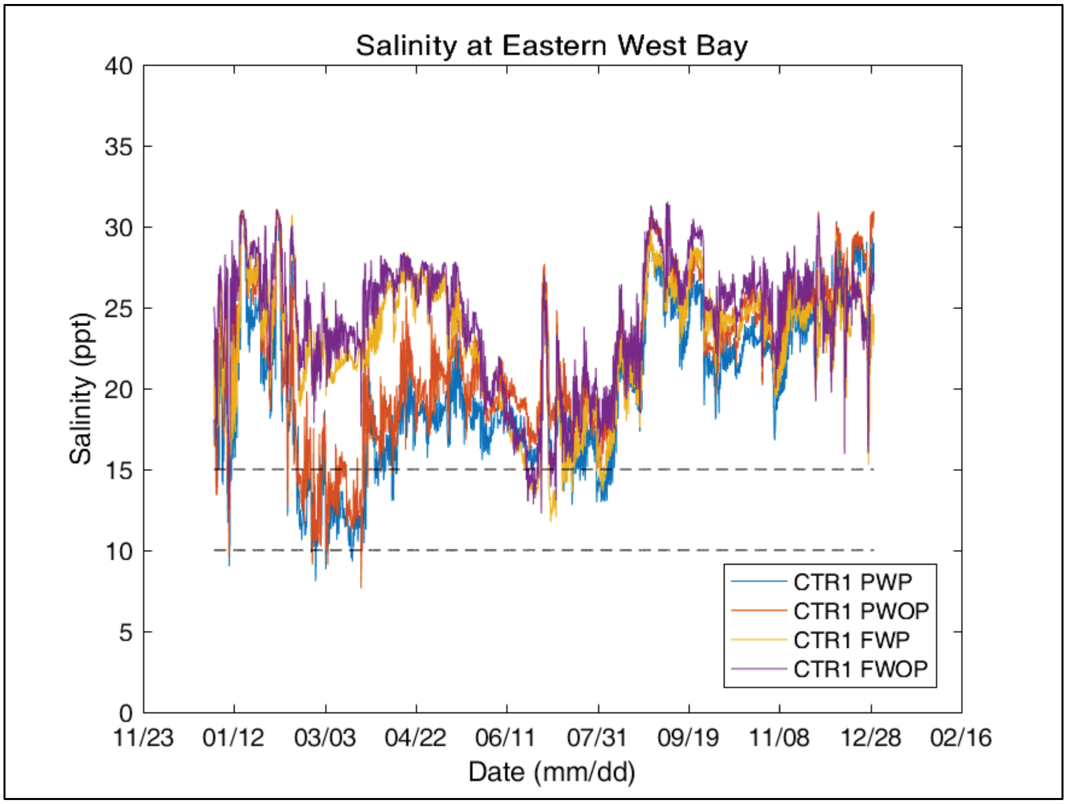
Greater Than 10 ppt for 14+ days - Eastern East Bay			
	Start	**Stop**	**Duration(days)**
PWP	11/16/2010 12:00	12/30/2010 0:00	43.5
PWOP	11/13/2010 18:00	12/30/2010 0:00	46.3
FWP	1/29/2010 18:00	3/9/2010 0:00	38.3
	4/11/2010 15:00	6/3/2010 21:00	53.3
	7/23/2010 21:00	9/1/2010 9:00	39.5
	9/8/2010 18:00	12/30/2010 0:00	112.3
FWOP	1/24/2010 3:00	3/9/2010 0:00	43.9
	3/9/2010 9:00	3/24/2010 21:00	15.5
	3/25/2010 12:00	6/8/2010 9:00	74.9
	7/23/2010 21:00	9/2/2010 12:00	40.6
	9/8/2010 3:00	12/30/2010 0:00	112.9

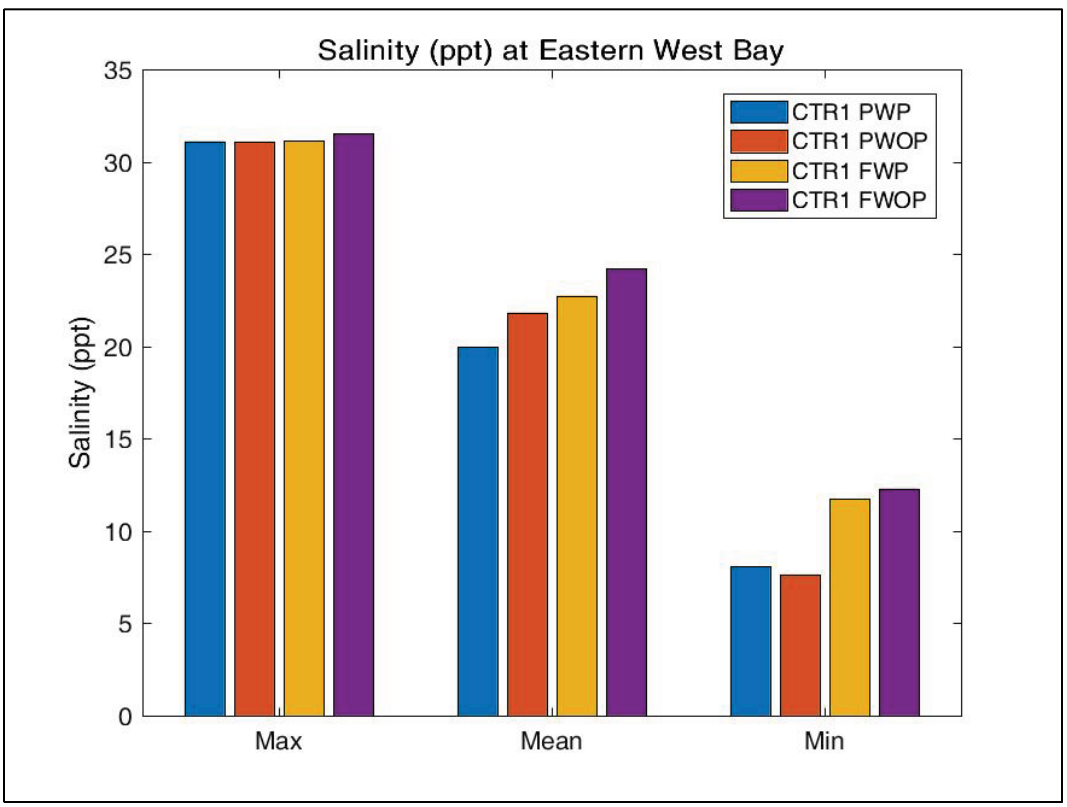
Greater Than 15 ppt for 14+ days - Eastern East Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA

Less Than 10 ppt for 14+ days - Eastern East Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	7/25/2010 3:00	205.0
	8/9/2010 0:00	10/12/2010 15:00	64.6
PWOP	1/1/2010 3:00	7/12/2010 3:00	192.0
	8/7/2010 21:00	10/12/2010 15:00	65.8
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
4
6
8
10
12
14
16

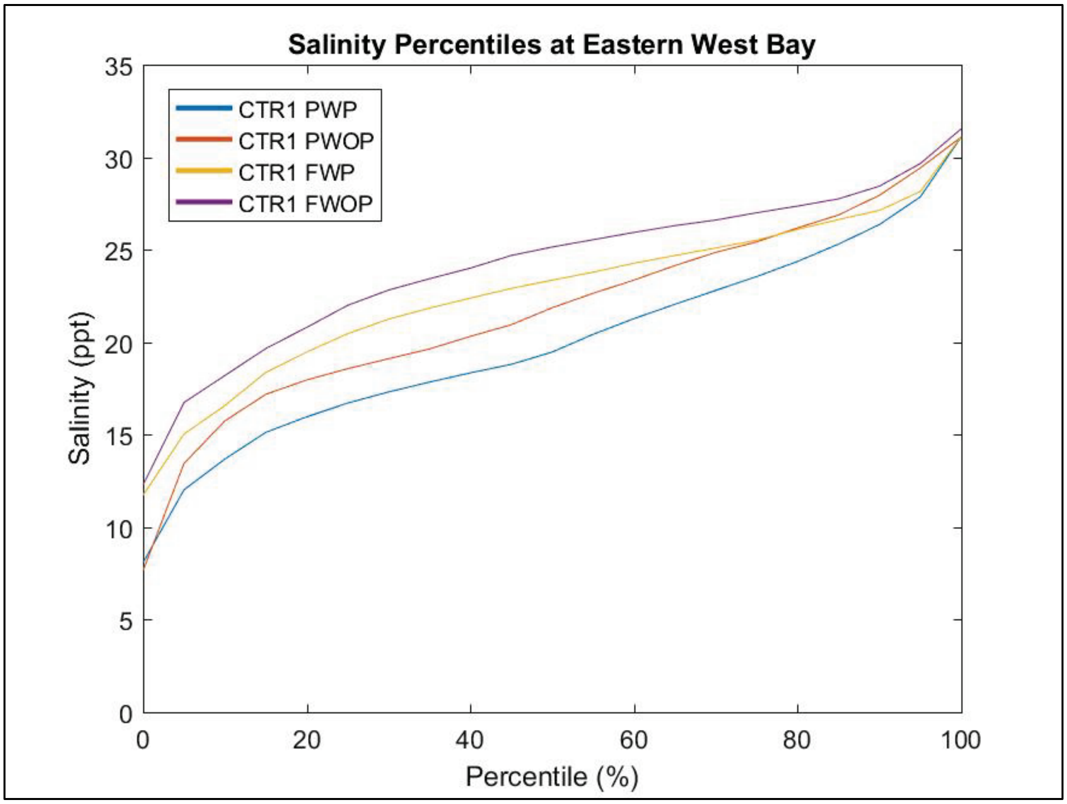

Salinity at Eastern West Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

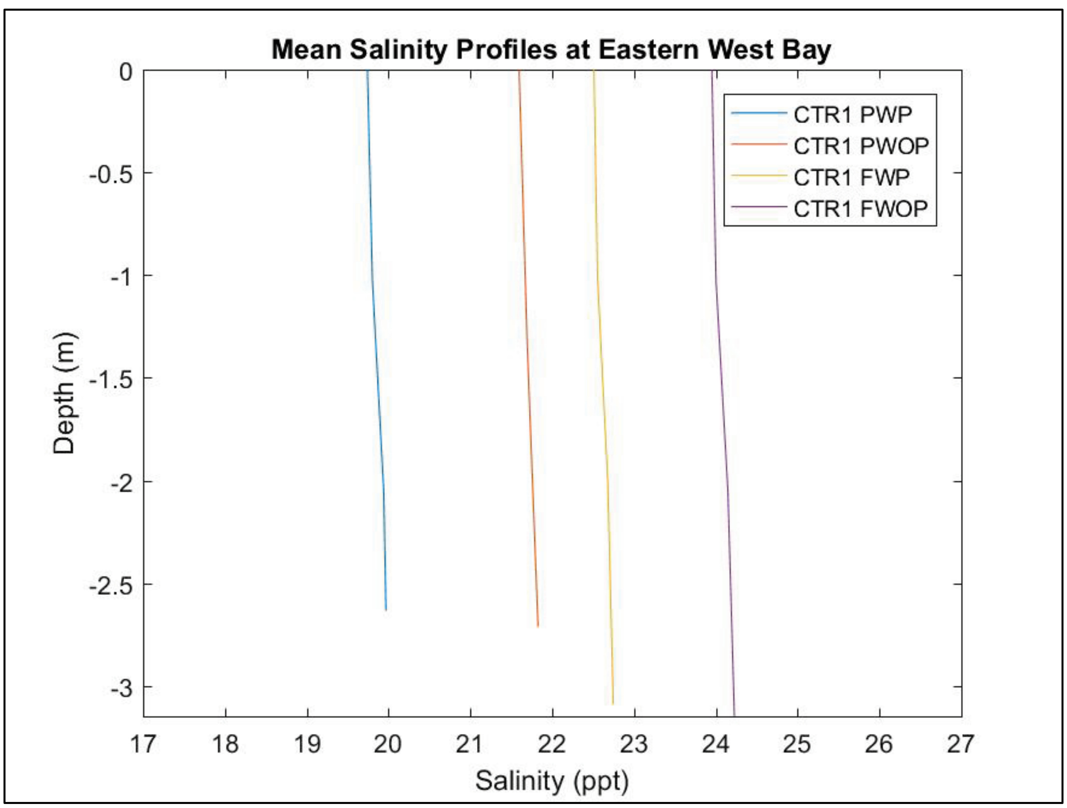

Salinity (ppt) at Eastern West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

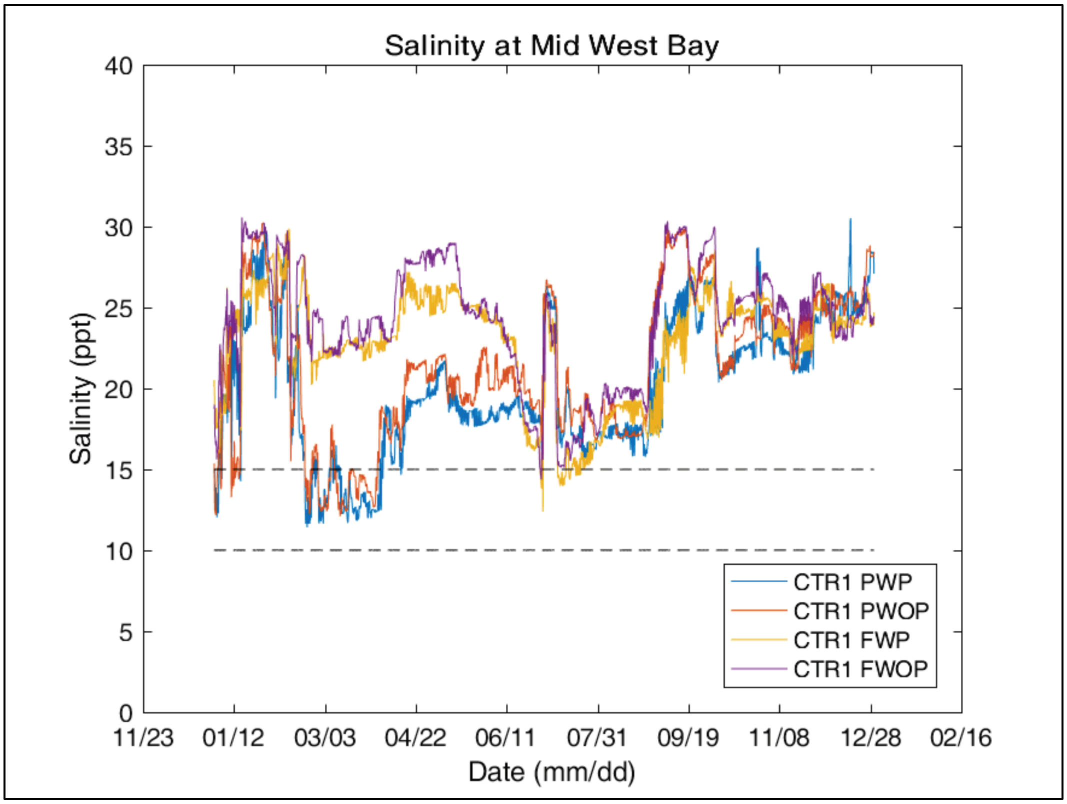
Greater Than 10 ppt for 14+ days - Eastern West Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/9/2010 15:00	2/23/2010 12:00	44.9
	3/18/2010 9:00	12/30/2010 0:00	286.6
PWOP	1/9/2010 12:00	2/23/2010 21:00	45.4
	3/4/2010 15:00	3/22/2010 18:00	18.1
	3/23/2010 18:00	12/30/2010 0:00	281.0
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

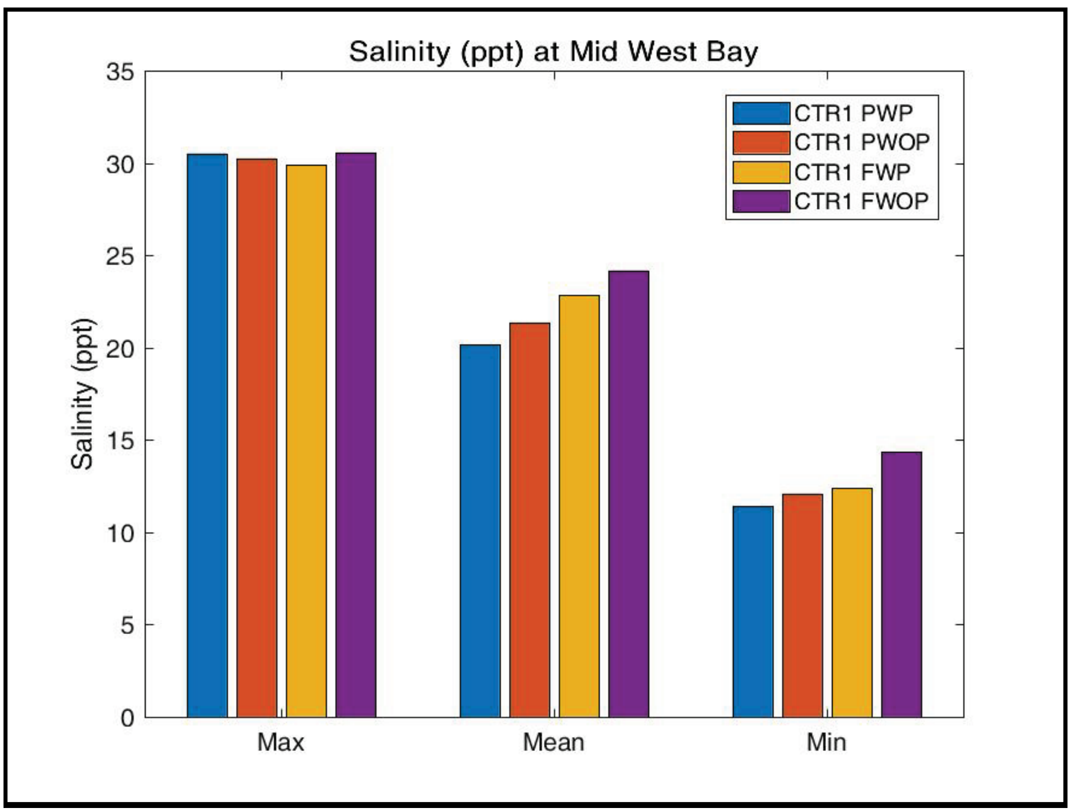
Greater Than 15 ppt for 14+ days - Eastern West Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/10/2010 18:00	2/10/2010 6:00	30.5
	4/11/2010 18:00	7/5/2010 0:00	84.3
	8/8/2010 6:00	12/30/2010 0:00	143.8
PWOP	1/9/2010 21:00	2/10/2010 6:00	31.4
	4/9/2010 0:00	8/1/2010 21:00	114.9
	8/2/2010 3:00	12/30/2010 0:00	149.9
FWP	1/9/2010 21:00	6/21/2010 9:00	162.5
	8/4/2010 6:00	12/30/2010 0:00	147.8
FWOP	1/9/2010 18:00	6/21/2010 15:00	162.9
	7/8/2010 6:00	12/30/2010 0:00	174.8

Less Than 10 ppt for 14+ days - Eastern West Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
17
18
19
20
21
22
23
24
25
26
27

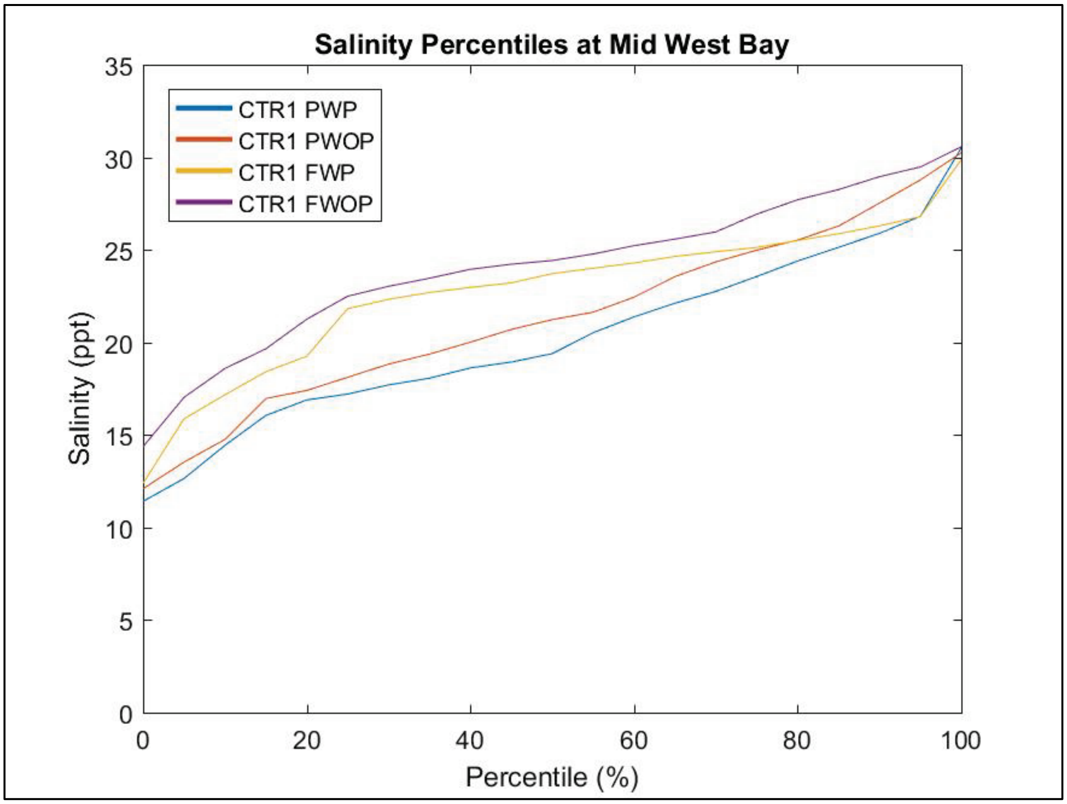

Salinity at Mid West Bay
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

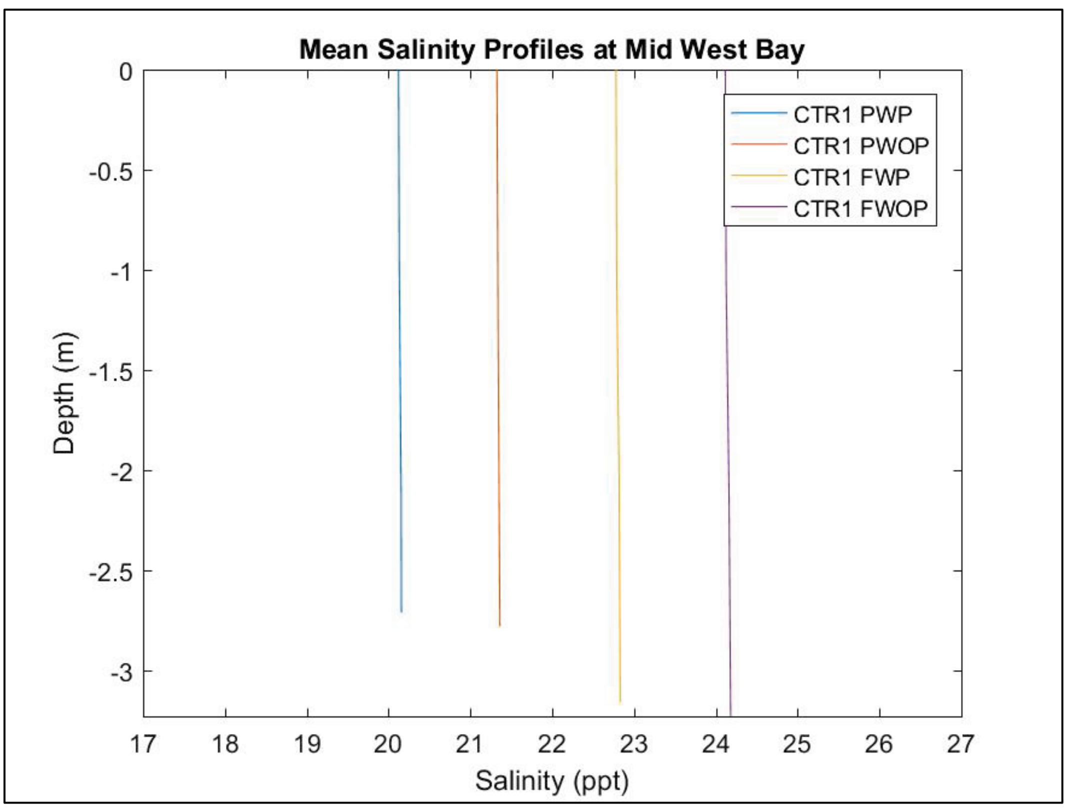

Salinity (ppt) at Mid West Bay
Salinity (ppt)
0
5
10
15
20
25
30
35
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

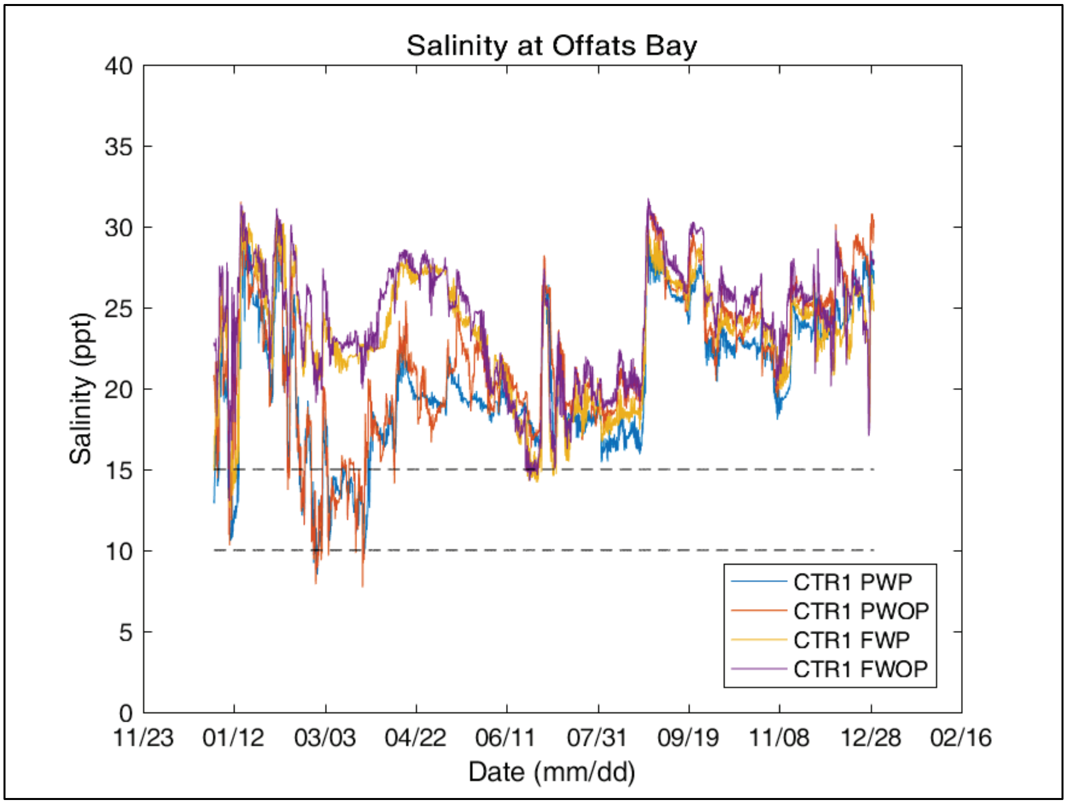
Greater Than 10 ppt for 14+ days - Mid West Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	12/30/2010 0:00	362.9
PWOP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

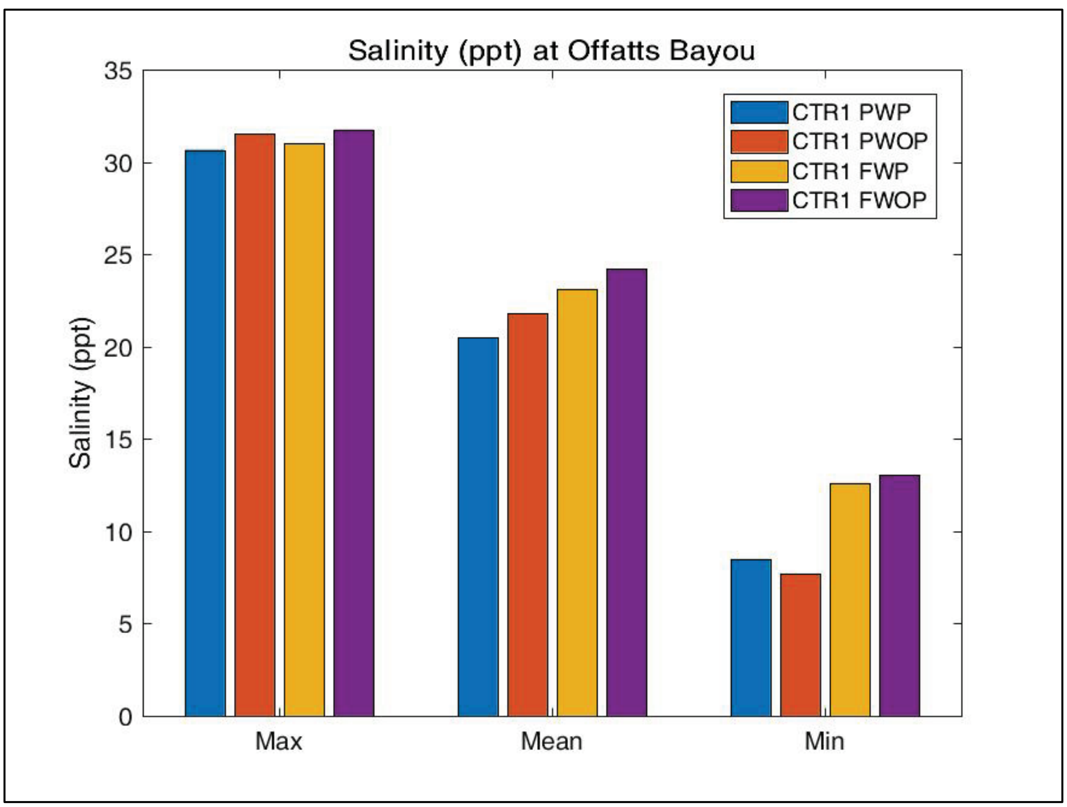
Greater Than 15 ppt for 14+ days - Mid West Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/15/2010 21:00	2/19/2010 21:00	35.0
	4/14/2010 3:00	12/30/2010 0:00	259.9
PWOP	1/15/2010 12:00	2/19/2010 21:00	35.4
	4/1/2010 0:00	12/30/2010 0:00	273.0
FWP	1/1/2010 3:00	6/29/2010 6:00	179.1
	7/21/2010 21:00	12/30/2010 0:00	161.1
FWOP	1/1/2010 3:00	6/29/2010 9:00	179.3
	6/30/2010 3:00	12/30/2010 0:00	182.9

Less Than 10 ppt for 14+ days - Mid West Bay			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Mid West Bay
Salinity (ppt)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
35
30
25
20
15
10
5
0
0
20
40
60
80
100


Mean Salinity Profiles at Mid West Bay
Depth (m)
Salinity (ppt)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
-0.5
-1
-1.5
-2
-2.5
-3
17
18
19
20
21
22
23
24
25
26
27

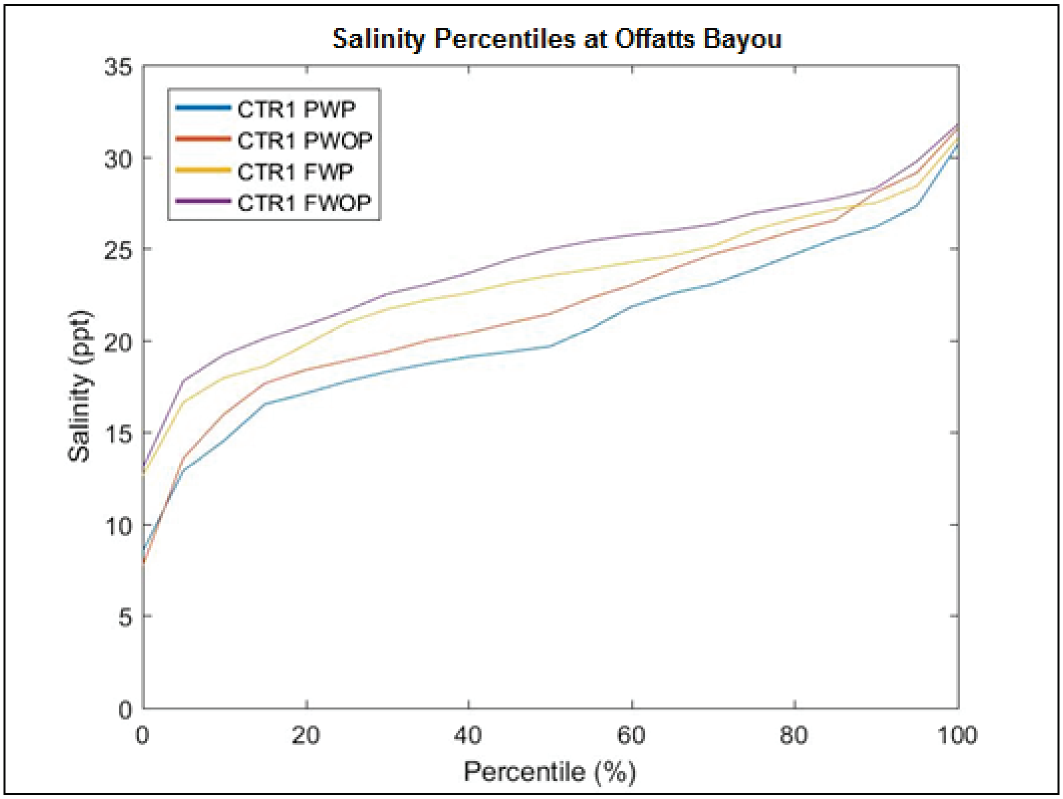

Salinity at Offats Bay
Salinity (ppt)
Date (mm/dd)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

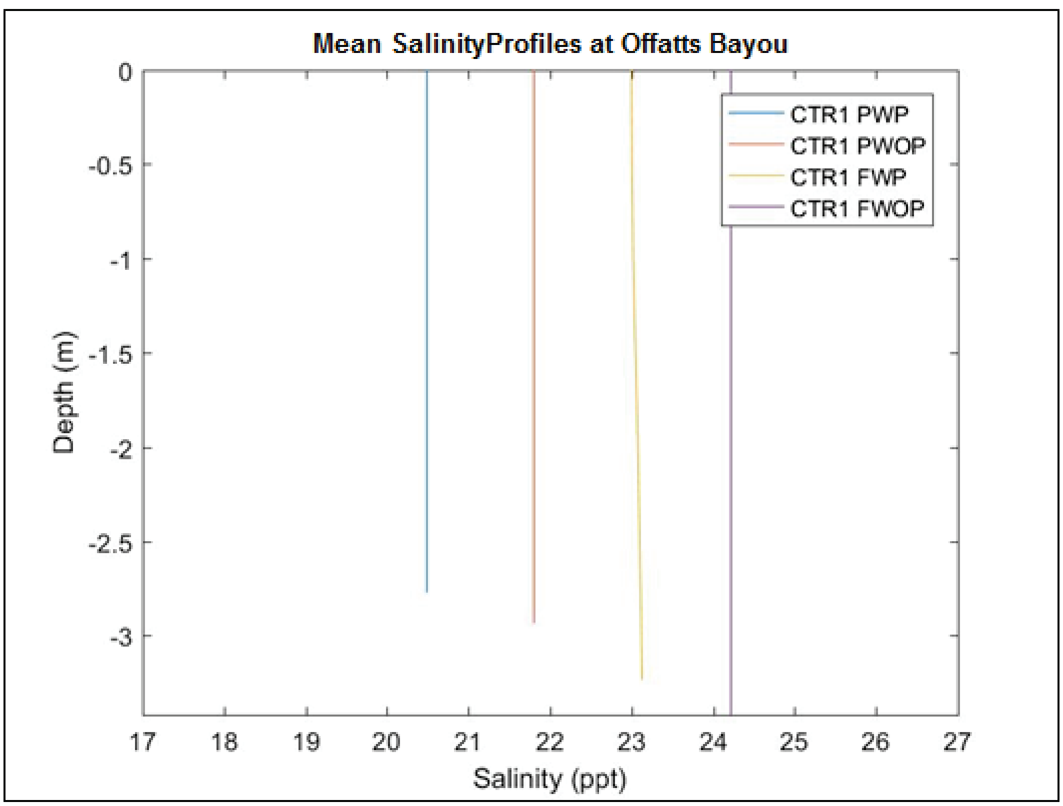

Salinity (ppt) at Offatts Bayou
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

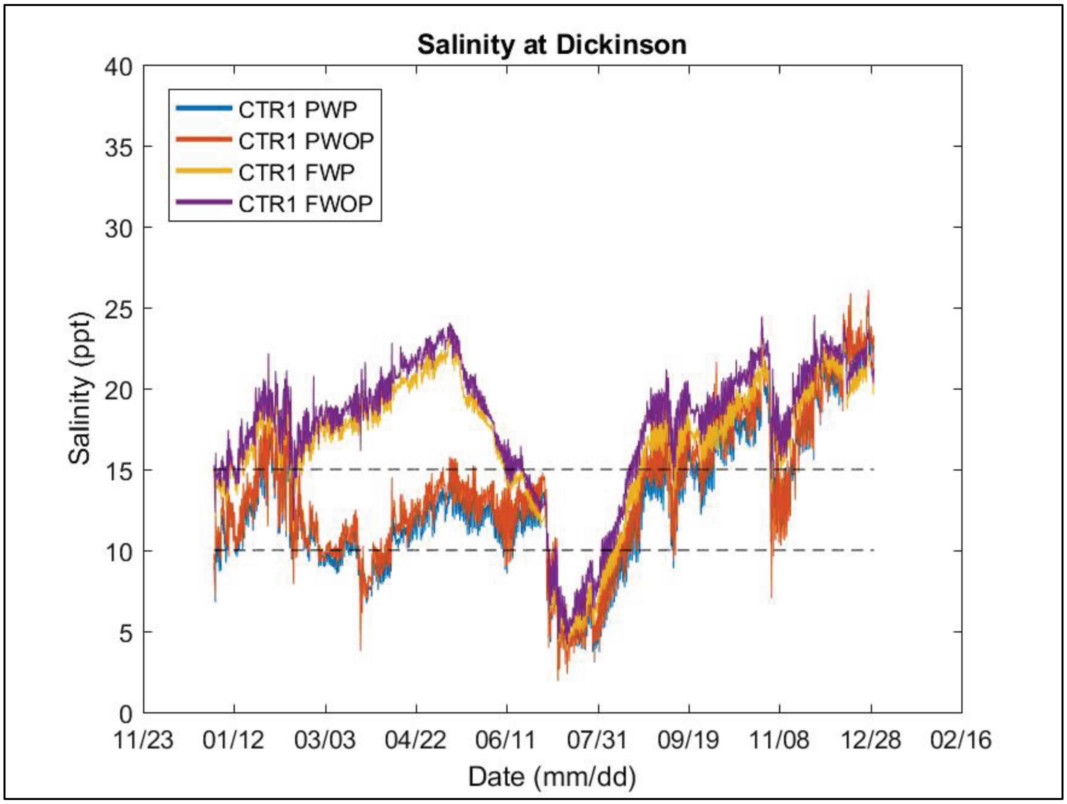
Greater Than 10 ppt for 14+ days - Offatts Bayou			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	2/24/2010 15:00	54.5
	2/27/2010 12:00	3/24/2010 12:00	25.0
	3/24/2010 21:00	12/30/2010 0:00	280.1
PWOP	1/1/2010 3:00	2/24/2010 15:00	54.5
	3/5/2010 3:00	3/19/2010 21:00	14.8
	3/24/2010 15:00	12/30/2010 0:00	280.4
FWP	1/1/2010 3:00	12/30/2010 0:00	362.9
FWOP	1/1/2010 3:00	12/30/2010 0:00	362.9

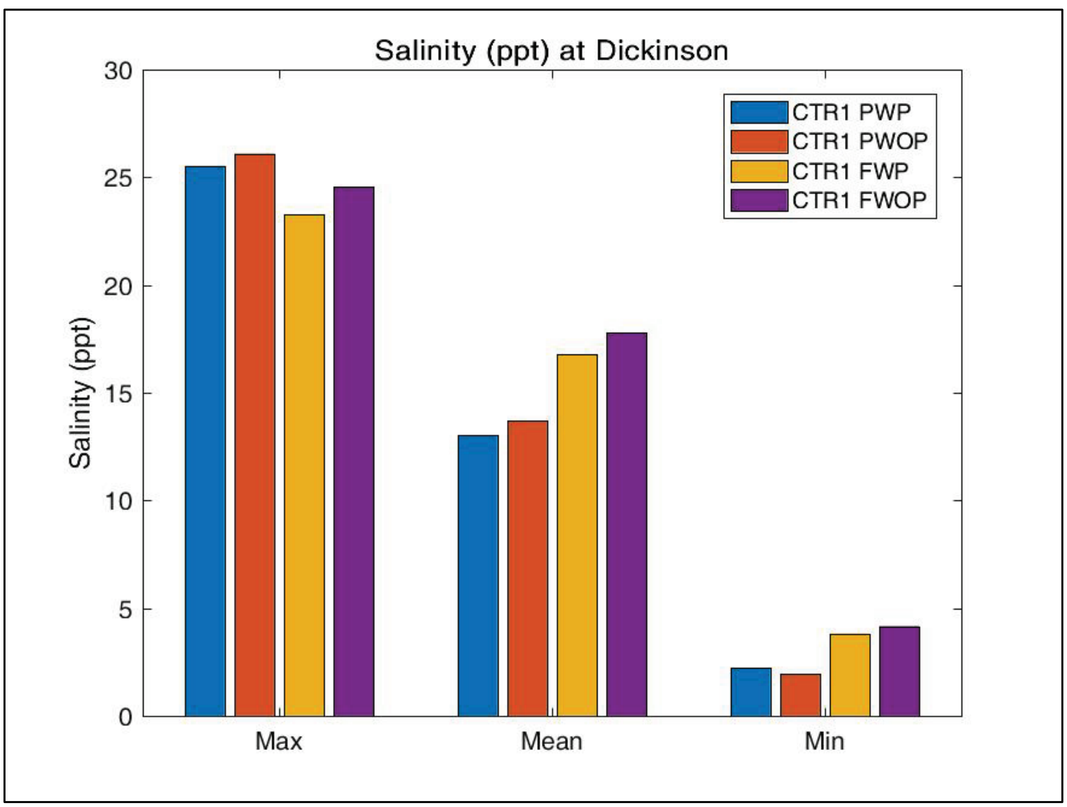
Greater Than 15 ppt for 14+ days - Offatts Bayou			
	Start	**Stop**	**Duration(days)**
PWP	1/14/2010 18:00	2/16/2010 21:00	33.1
	3/27/2010 21:00	12/30/2010 0:00	277.0
PWOP	1/12/2010 21:00	2/10/2010 6:00	28.4
	3/25/2010 18:00	4/10/2010 0:00	15.3
	4/10/2010 9:00	12/30/2010 0:00	263.6
FWP	1/13/2010 6:00	6/22/2010 6:00	160.0
	7/8/2010 6:00	12/30/2010 0:00	174.8
FWOP	1/9/2010 18:00	6/21/2010 9:00	162.6
	6/28/2010 0:00	12/30/2010 0:00	185.0

Less Than 10 ppt for 14+ days - Offatts Bayou			
	Start	**Stop**	**Duration(days)**
PWP	NA	NA	NA
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA


Salinity Percentiles at Offatts Bayou
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean SalinityProfiles at Offatts Bayou
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
17
18
19
20
21
22
23
24
25
26
27

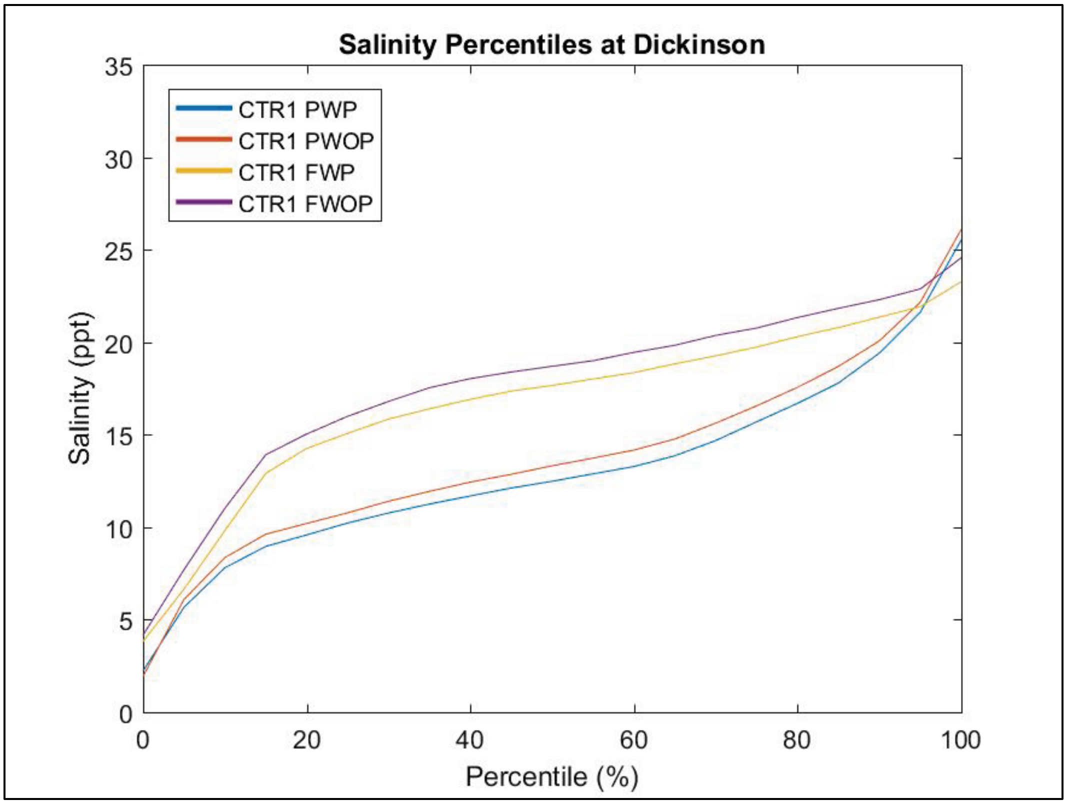

Salinity at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16

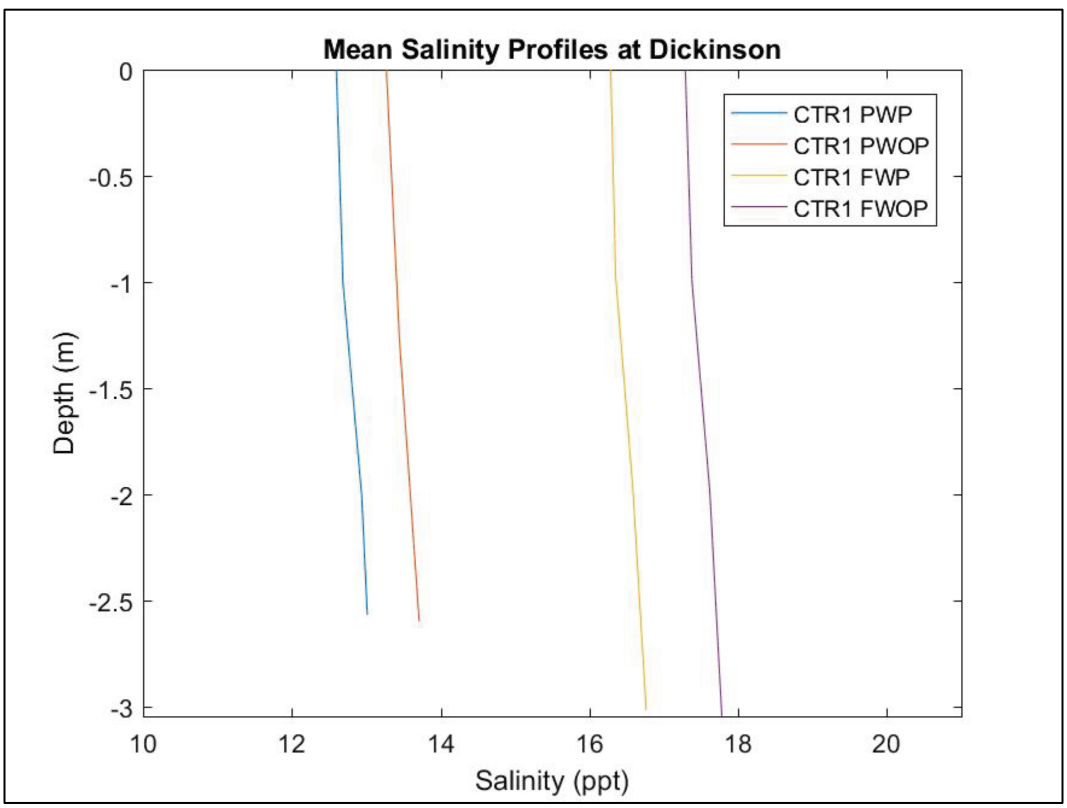

Salinity (ppt) at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

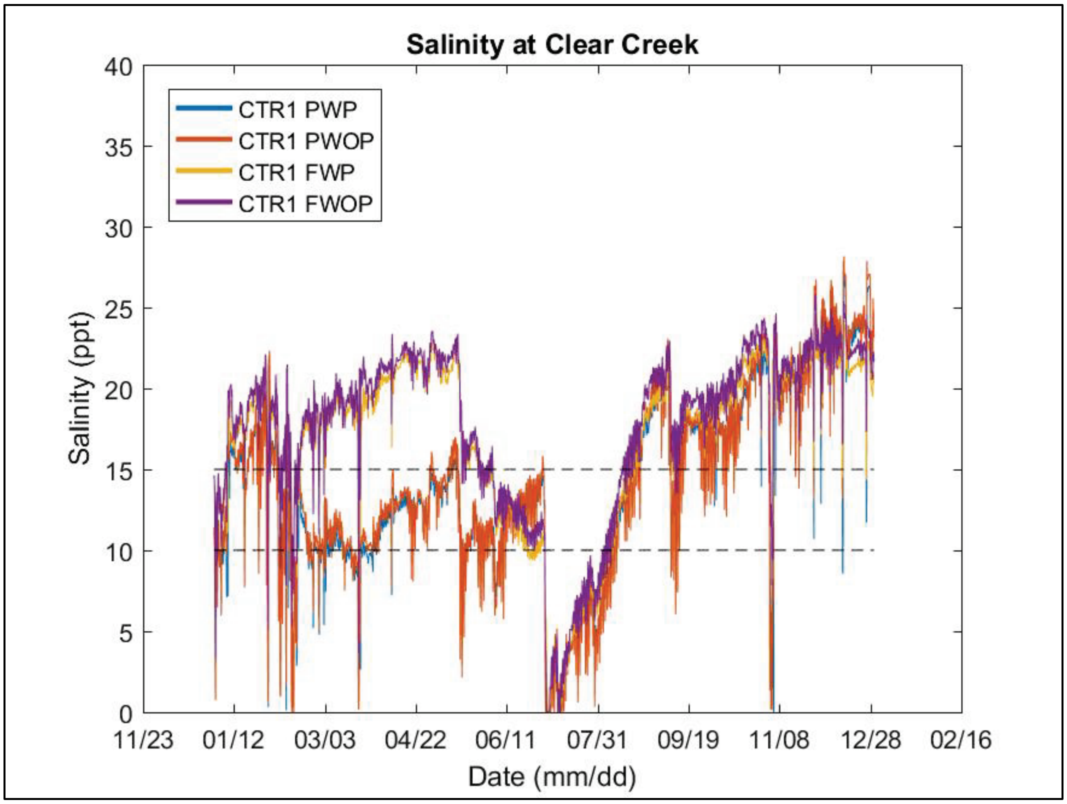
Greater Than 10 ppt for 14+ days - Dickinson			
	Start	**Stop**	**Duration(days)**
PWP	1/14/2010 0:00	2/12/2010 12:00	29.5
	4/8/2010 15:00	6/9/2010 0:00	61.4
	6/14/2010 12:00	7/2/2010 21:00	18.4
	8/23/2010 6:00	9/9/2010 18:00	17.5
	9/11/2010 21:00	11/3/2010 12:00	52.6
	11/3/2010 18:00	12/30/2010 0:00	56.3
PWOP	1/12/2010 21:00	2/12/2010 12:00	30.6
	4/8/2010 15:00	6/10/2010 0:00	62.4
	6/14/2010 9:00	7/2/2010 21:00	18.5
	8/21/2010 6:00	9/10/2010 15:00	20.4
	9/11/2010 21:00	11/3/2010 12:00	52.6
	11/4/2010 18:00	12/30/2010 0:00	55.3
FWP	1/1/2010 3:00	7/3/2010 3:00	183.0
	8/11/2010 15:00	12/30/2010 0:00	140.4
FWOP	1/1/2010 3:00	7/3/2010 18:00	183.6
	8/8/2010 6:00	12/30/2010 0:00	143.8

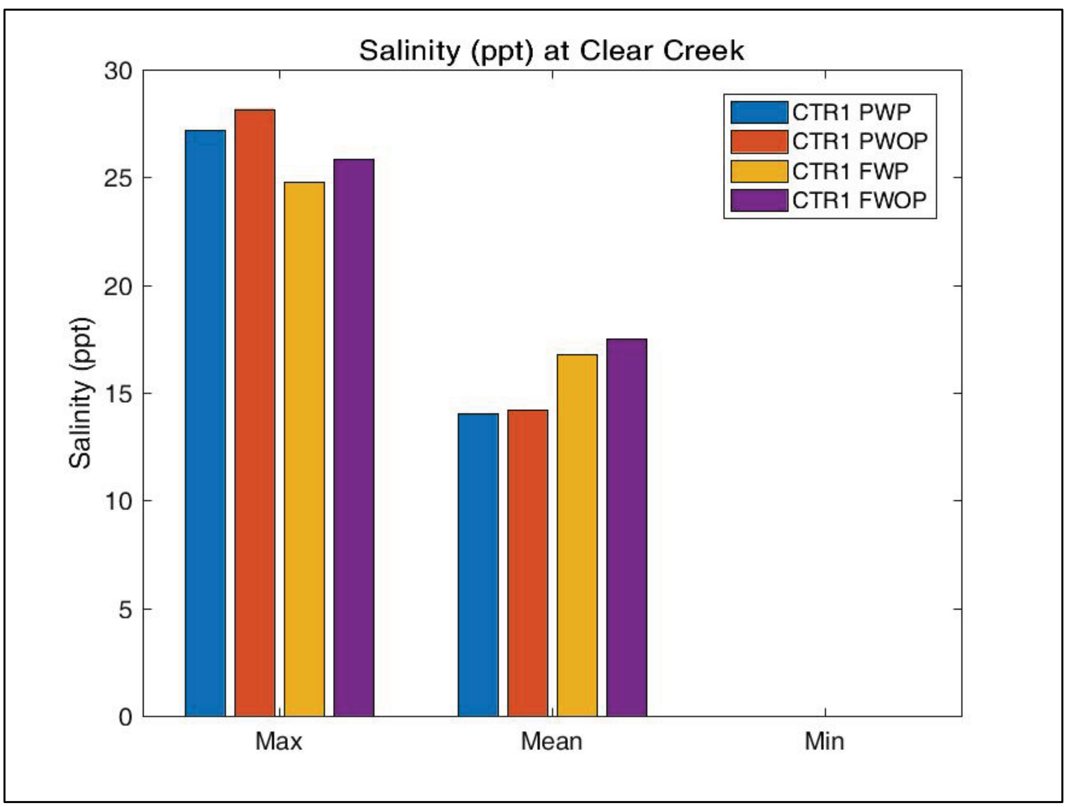
Greater Than 15 ppt for 14+ days - Dickinson			
	Start	**Stop**	**Duration(days)**
PWP	10/3/2010 3:00	11/2/2010 21:00	30.8
	11/18/2010 15:00	12/30/2010 0:00	41.4
PWOP	10/2/2010 0:00	11/3/2010 0:00	32.0
	11/18/2010 15:00	12/30/2010 0:00	41.4
FWP	1/17/2010 21:00	2/6/2010 3:00	19.3
	2/18/2010 12:00	6/9/2010 21:00	111.4
	8/25/2010 12:00	9/9/2010 18:00	15.3
	9/26/2010 0:00	11/3/2010 9:00	38.4
	11/9/2010 0:00	12/30/2010 0:00	51.0
FWOP	1/15/2010 0:00	2/11/2010 15:00	27.6
	2/15/2010 15:00	6/10/2010 0:00	114.4
	8/22/2010 6:00	9/10/2010 15:00	19.4
	9/10/2010 21:00	11/3/2010 12:00	53.6
	11/3/2010 18:00	12/30/2010 0:00	56.3

Less Than 10 ppt for 14+ days - Dickinson			
	Start	**Stop**	**Duration(days)**
PWP	3/21/2010 6:00	4/6/2010 18:00	16.5
	7/7/2010 18:00	8/14/2010 3:00	37.4
PWOP	7/8/2010 18:00	8/10/2010 15:00	32.9
FWP	7/3/2010 21:00	8/6/2010 12:00	33.6
FWOP	7/8/2010 21:00	8/2/2010 6:00	24.4


Salinity Percentiles at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
10
12
14
16
18
20


Salinity at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

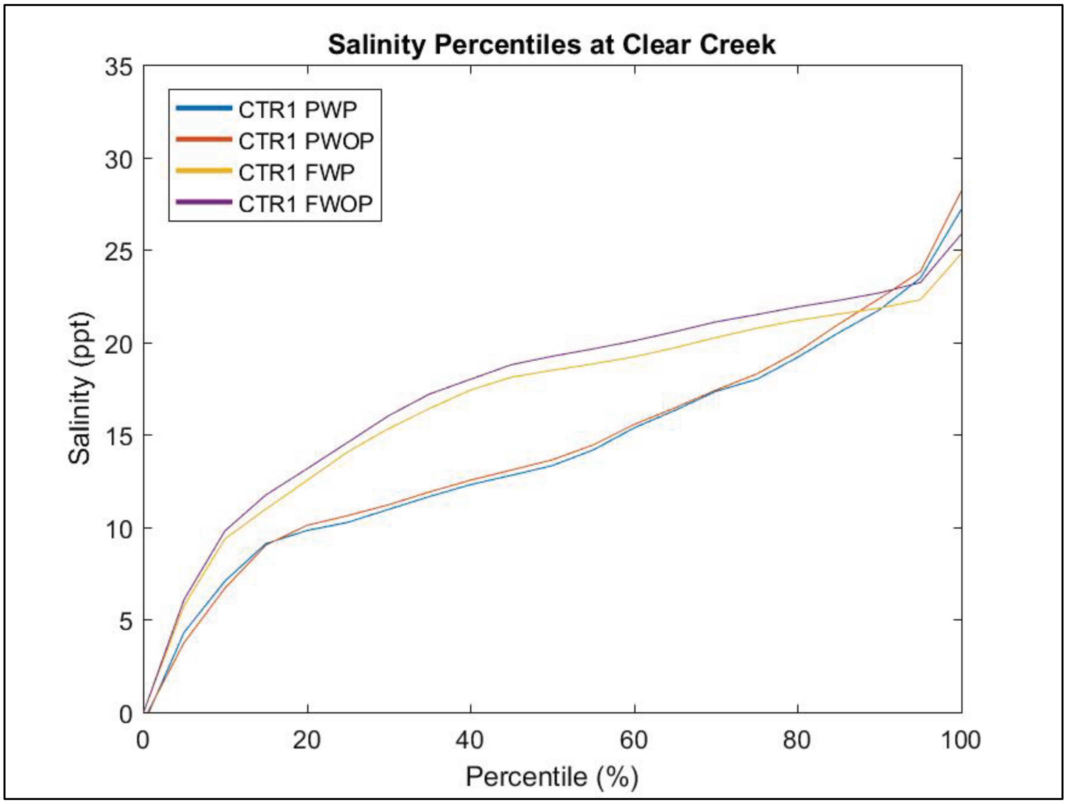

Salinity (ppt) at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

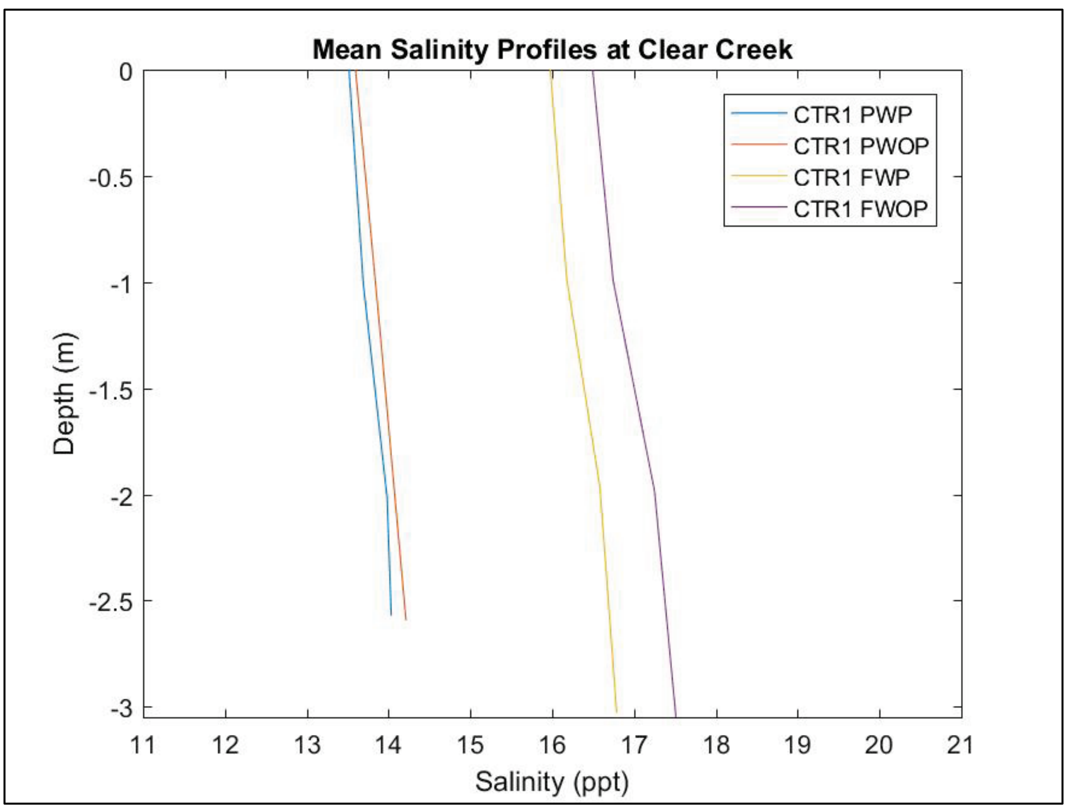
Greater Than 10 ppt for 14+ days - Clear Creek			
	Start	**Stop**	**Duration(days)**
PWP	1/8/2010 18:00	1/30/2010 6:00	21.5
	4/8/2010 21:00	5/16/2010 6:00	37.4
	6/10/2010 9:00	7/2/2010 0:00	21.6
	8/10/2010 12:00	9/9/2010 18:00	30.3
	9/13/2010 3:00	11/2/2010 15:00	50.5
	11/4/2010 21:00	12/12/2010 15:00	37.8
	12/13/2010 0:00	12/30/2010 0:00	17.0
PWOP	4/20/2010 18:00	5/16/2010 6:00	25.5
	6/10/2010 9:00	7/1/2010 21:00	21.5
	8/10/2010 12:00	9/9/2010 6:00	29.8
	9/13/2010 3:00	11/2/2010 12:00	50.4
	11/4/2010 21:00	12/30/2010 0:00	55.1
FWP	1/2/2010 3:00	1/30/2010 15:00	28.5
	2/16/2010 0:00	3/21/2010 9:00	33.4
	3/21/2010 21:00	6/22/2010 3:00	92.3
	8/8/2010 9:00	11/3/2010 15:00	87.3
	11/4/2010 12:00	12/30/2010 0:00	55.5
FWOP	1/3/2010 0:00	1/30/2010 15:00	27.6
	2/15/2010 18:00	3/21/2010 6:00	33.5
	3/21/2010 18:00	7/1/2010 21:00	102.1
	8/7/2010 9:00	11/3/2010 15:00	88.3
	11/4/2010 12:00	12/30/2010 0:00	55.5

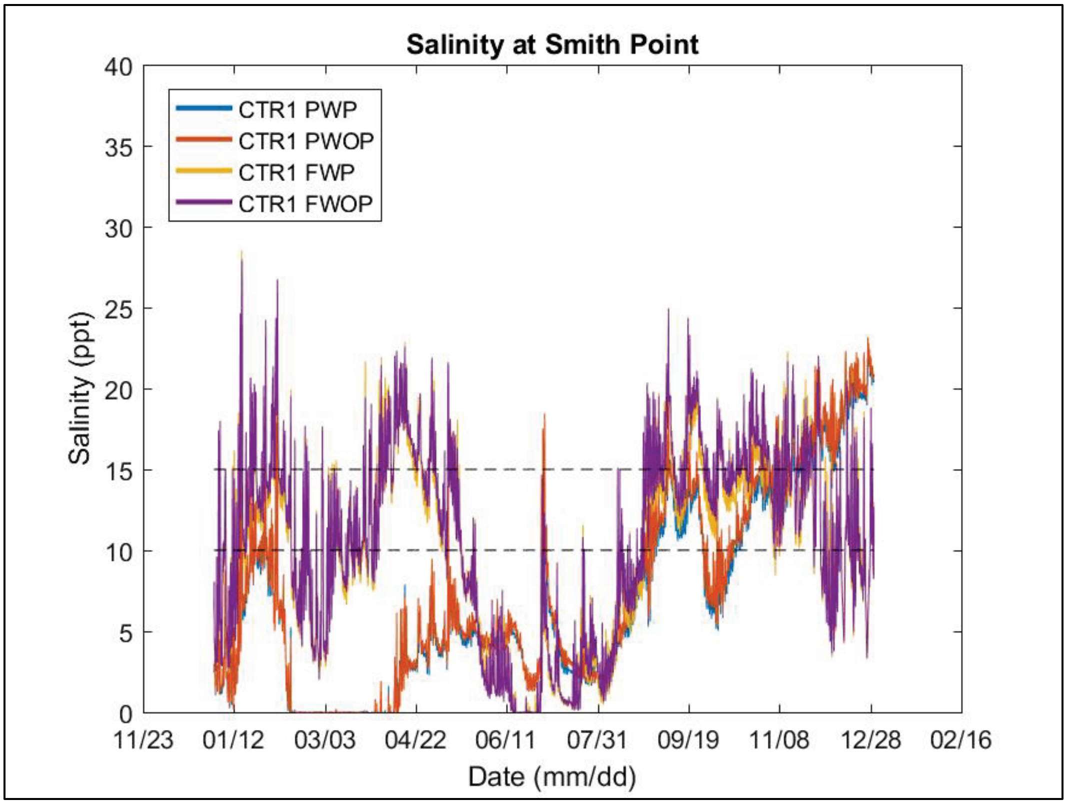
Greater Than 15 ppt for 14+ days - Clear Creek			
	Start	**Stop**	**Duration(days)**
PWP	8/23/2010 12:00	9/9/2010 3:00	16.6
	10/4/2010 9:00	10/28/2010 21:00	24.5
PWOP	8/23/2010 12:00	9/8/2010 18:00	16.3
	10/14/2010 6:00	11/2/2010 3:00	18.9
	11/27/2010 0:00	12/12/2010 12:00	15.5
	12/12/2010 21:00	12/30/2010 0:00	17.1

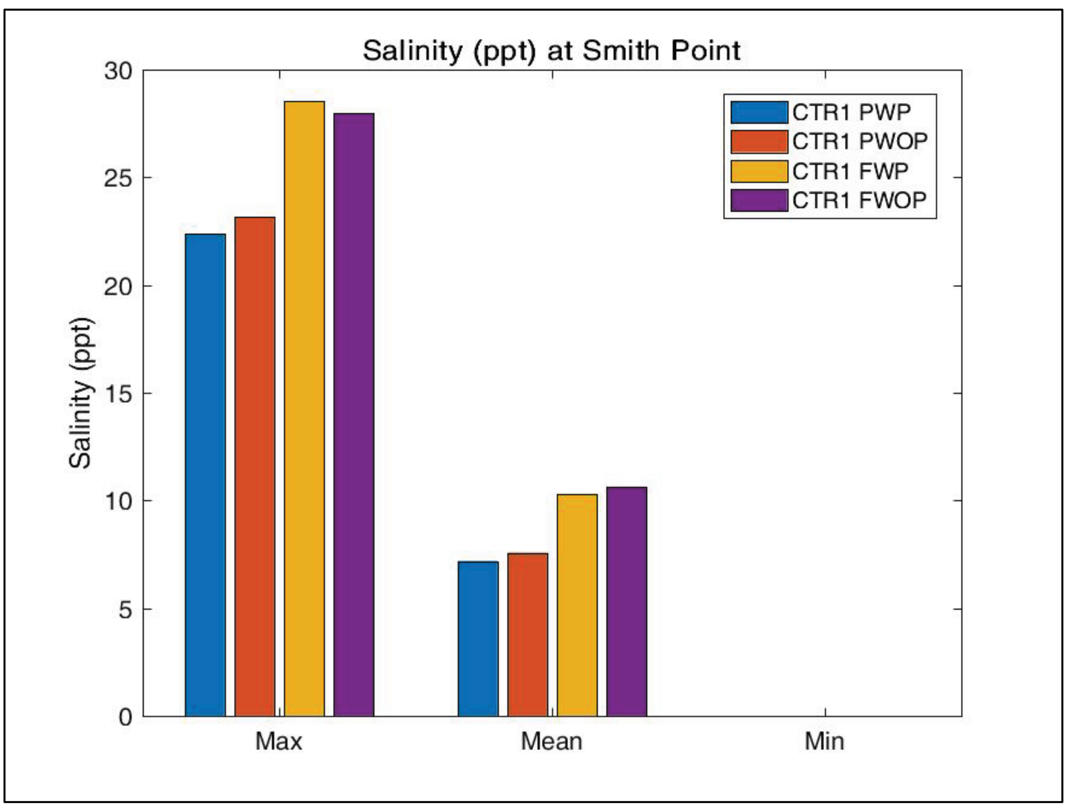
FWP	1/8/2010 15:00	1/30/2010 6:00	21.6
	3/2/2010 18:00	3/21/2010 6:00	18.5
	3/22/2010 18:00	5/17/2010 9:00	55.6
	8/20/2010 9:00	9/9/2010 18:00	20.4
	9/13/2010 3:00	11/3/2010 0:00	50.9
	11/4/2010 21:00	12/12/2010 15:00	37.8
FWOP	3/2/2010 15:00	3/21/2010 3:00	18.5
	3/22/2010 15:00	5/17/2010 6:00	55.6
	8/19/2010 9:00	9/10/2010 18:00	22.4
	9/13/2010 3:00	11/2/2010 15:00	50.5
	11/4/2010 18:00	12/30/2010 0:00	55.3

Less Than 10 ppt for 14+ days - Clear Creek			
	Start	**Stop**	**Duration(days)**
PWP	7/2/2010 3:00	8/6/2010 12:00	35.4
PWOP	7/2/2010 0:00	8/5/2010 12:00	34.5
FWP	7/2/2010 0:00	8/5/2010 12:00	34.5
FWOP	7/2/2010 0:00	8/2/2010 12:00	31.5


Salinity Percentiles at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)


Mean Salinity Profiles at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
11
12
13
14
15
16
17
18
19
20
21
Salinity (ppt)


Salinity at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

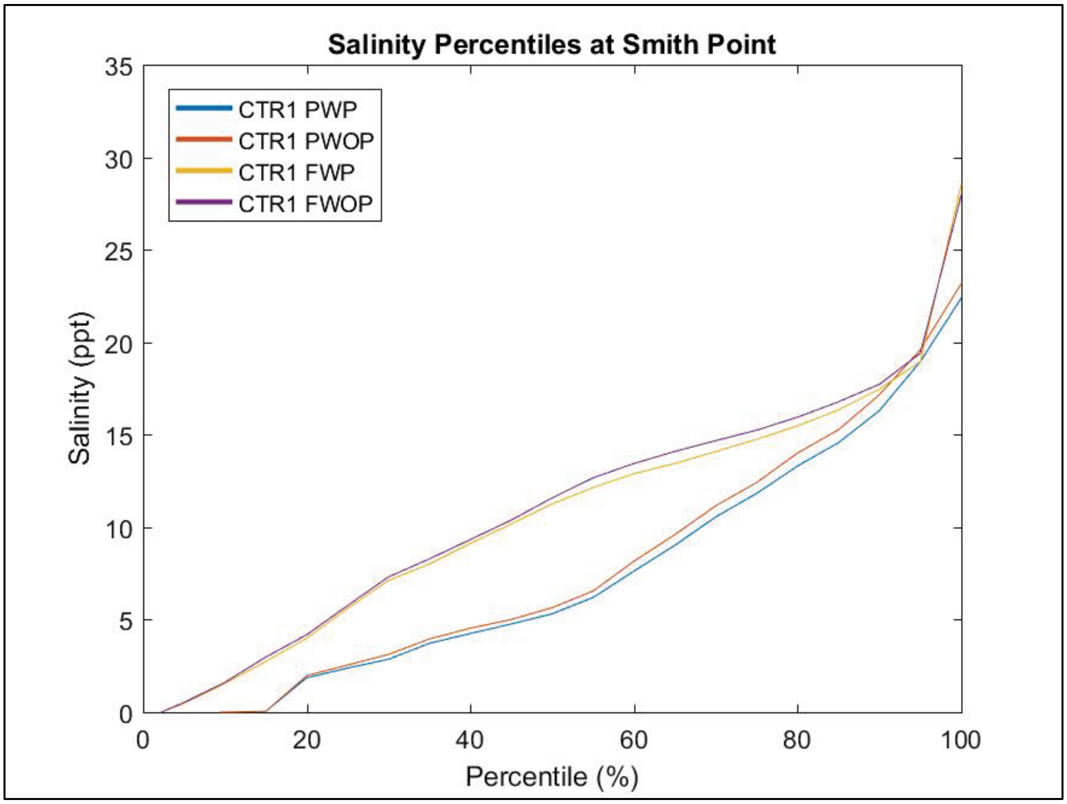

Salinity (ppt) at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

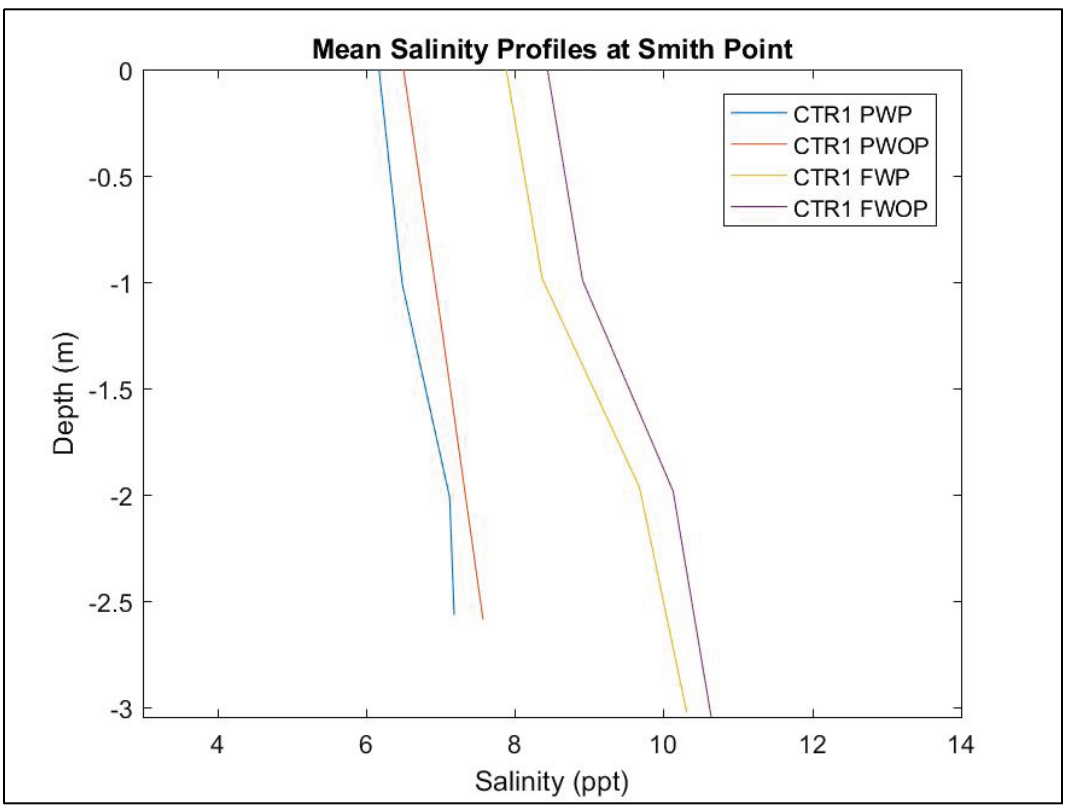
Greater Than 10 ppt for 14+ days - Smith Point			
	Start	Stop	Duration(days)
PWP	9/1/2010 9:00	9/26/2010 18:00	25.4
	10/17/2010 12:00	11/5/2010 15:00	19.1
	11/5/2010 21:00	12/30/2010 0:00	54.1
PWOP	8/31/2010 9:00	9/26/2010 18:00	26.4
	10/13/2010 18:00	11/5/2010 15:00	22.9
	11/5/2010 21:00	12/30/2010 0:00	54.1
FWP	1/19/2010 0:00	2/12/2010 9:00	24.4
	4/1/2010 15:00	5/6/2010 9:00	34.8
	8/28/2010 0:00	11/4/2010 15:00	68.6
	11/8/2010 3:00	11/26/2010 18:00	18.6
FWOP	1/18/2010 21:00	2/12/2010 12:00	24.6
	4/1/2010 15:00	5/8/2010 0:00	36.4
	8/25/2010 12:00	11/5/2010 15:00	72.1
	11/5/2010 21:00	11/26/2010 18:00	20.9

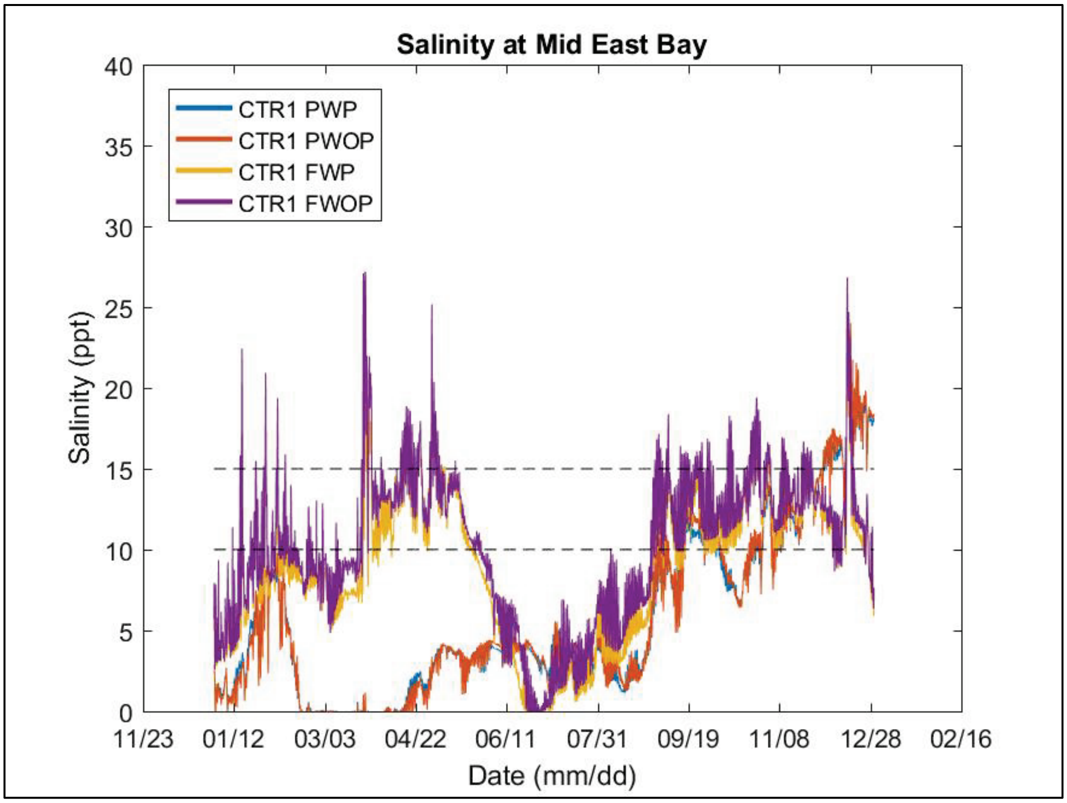
Greater Than 15 ppt for 14+ days - Smith Point			
	Start	Stop	Duration(days)
PWP	12/8/2010 18:00	12/30/2010 0:00	21.3
PWOP	11/18/2010 0:00	12/6/2010 15:00	18.6
	12/7/2010 0:00	12/30/2010 0:00	23.0
FWP	NA	NA	NA
FWOP	NA	NA	NA

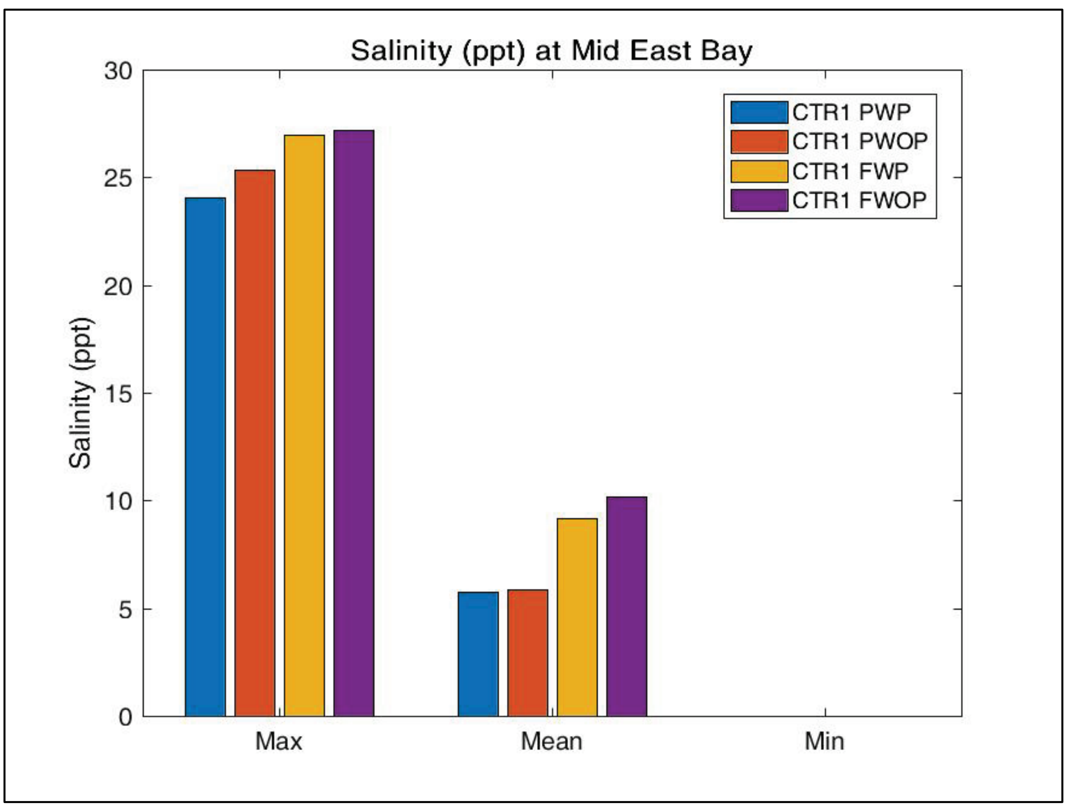
Less Than 10 ppt for 14+ days - Smith Point			
	Start	Stop	Duration(days)
PWP	1/1/2010 3:00	1/15/2010 6:00	14.1
	2/5/2010 3:00	5/9/2010 18:00	93.6
	5/10/2010 0:00	6/30/2010 0:00	51.0
	7/3/2010 0:00	8/26/2010 21:00	54.9
PWOP	1/1/2010 3:00	1/15/2010 6:00	14.1
	2/5/2010 3:00	5/9/2010 15:00	93.5
	5/10/2010 3:00	6/29/2010 21:00	50.8
	7/3/2010 0:00	8/24/2010 21:00	52.9

FWP	5/24/2010 18:00	6/30/2010 15:00	36.9
	7/2/2010 0:00	7/22/2010 15:00	20.6
	7/23/2010 0:00	8/10/2010 21:00	18.9
FWOP	5/24/2010 18:00	6/30/2010 15:00	36.9
	7/2/2010 0:00	7/22/2010 15:00	20.6
	7/23/2010 18:00	8/10/2010 21:00	18.1


Salinity Percentiles at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
4
6
8
10
12
14

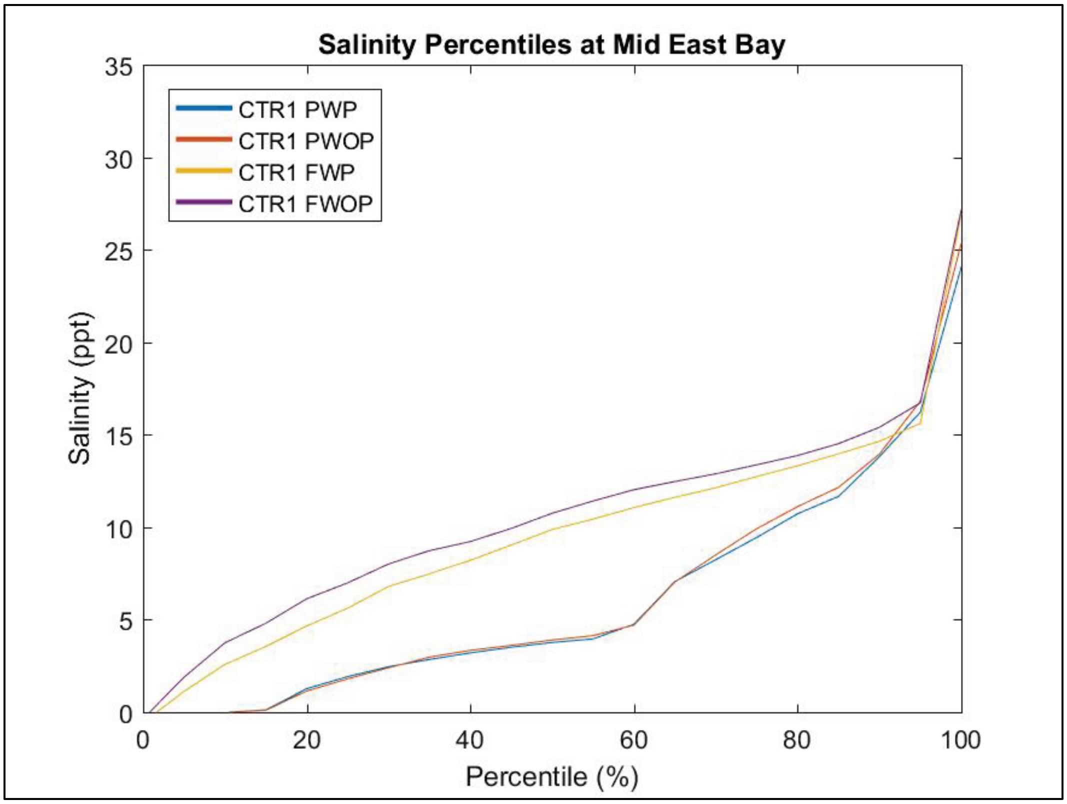

Salinity at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

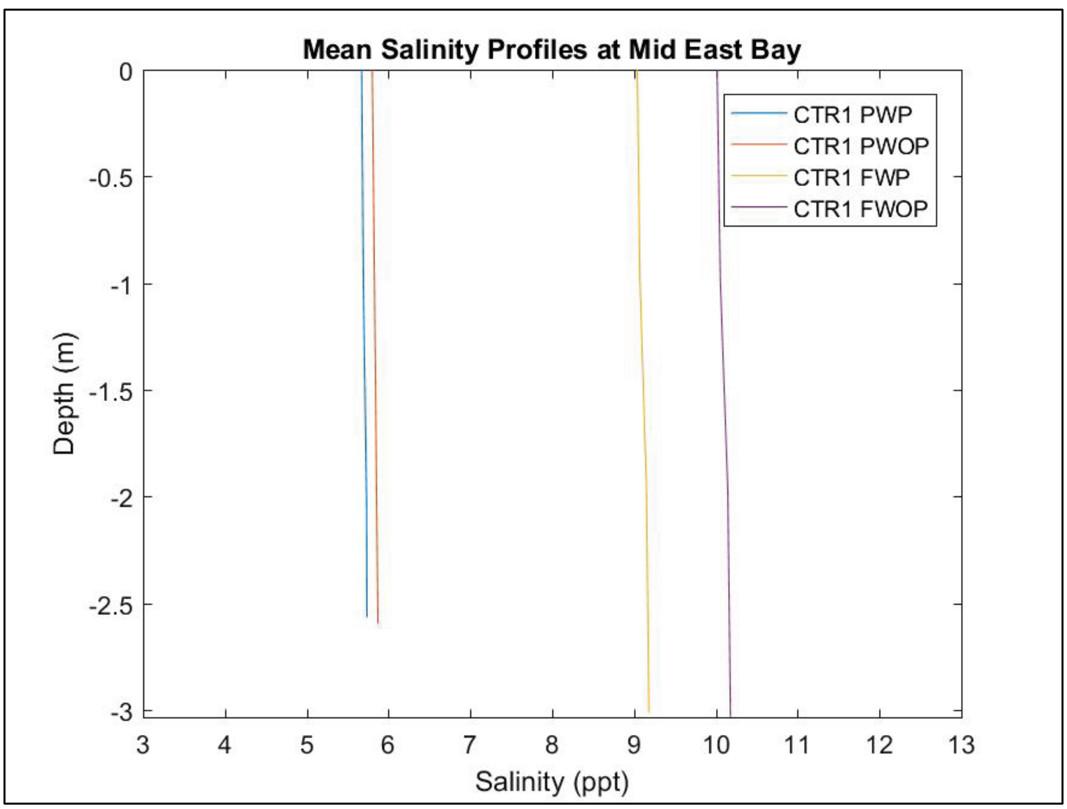

Salinity (ppt) at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

Greater Than 10 ppt for 14+ days - Mid East Bay			
	Start	**Stop**	**Duration(days)**
PWP	11/9/2010 0:00	12/30/2010 0:00	51.0
PWOP	11/9/2010 0:00	12/30/2010 0:00	51.0
FWP	4/9/2010 0:00	4/28/2010 3:00	19.1
	4/28/2010 9:00	5/21/2010 9:00	23.0
	10/11/2010 3:00	11/5/2010 12:00	25.4
	11/5/2010 18:00	12/8/2010 6:00	32.5
FWOP	3/26/2010 18:00	5/24/2010 12:00	58.8
	9/16/2010 6:00	12/7/2010 6:00	82.0

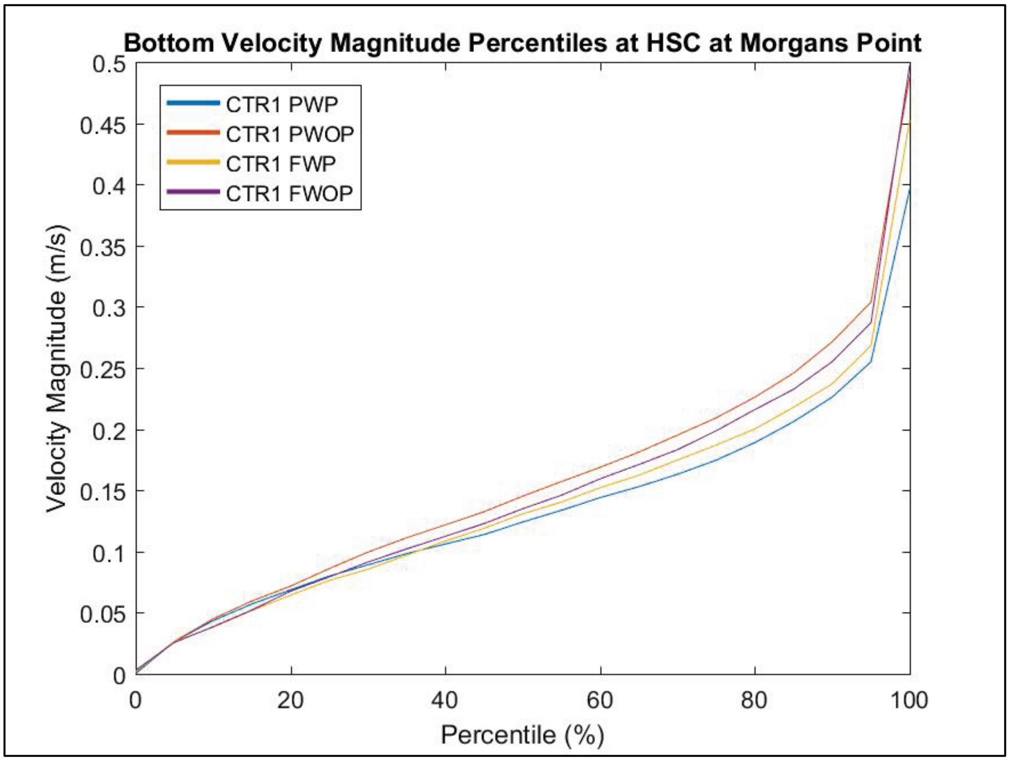
Greater Than 15 ppt for 14+ days - Mid East Bay			
	Start	**Stop**	**Duration(days)**
PWP	12/14/2010 21:00	12/30/2010 0:00	15.1
PWOP	NA	NA	NA
FWP	NA	NA	NA
FWOP	NA	NA	NA

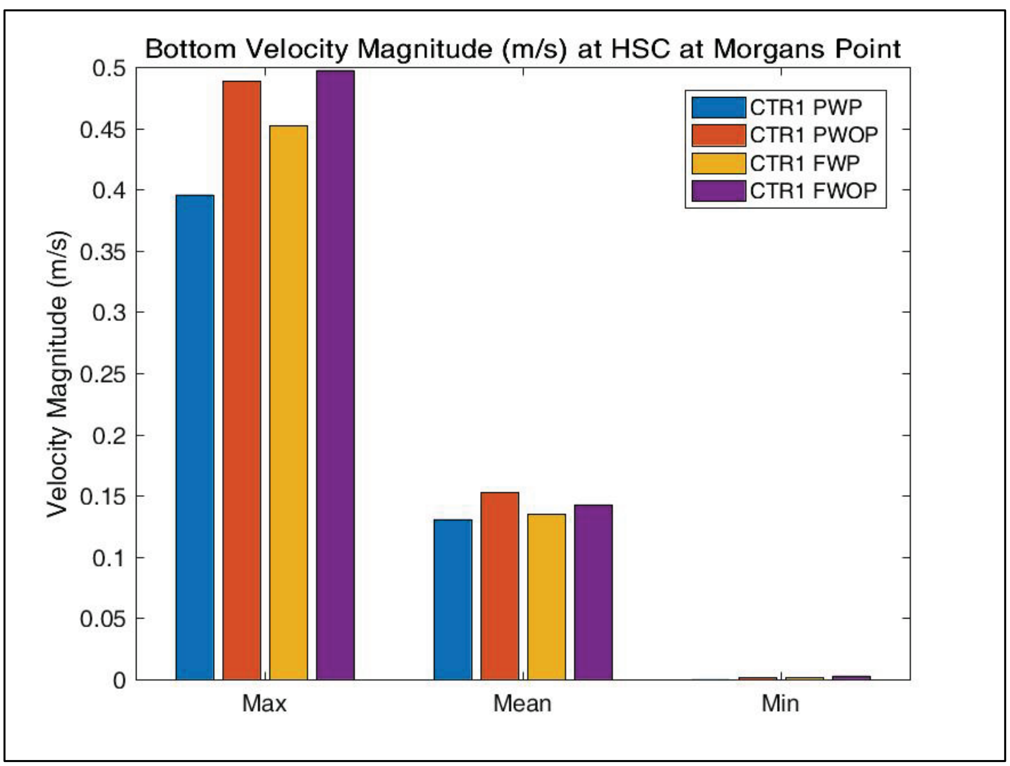
Less Than 10 ppt for 14+ days - Mid East Bay			
	Start	**Stop**	**Duration(days)**
PWP	1/1/2010 3:00	9/2/2010 9:00	244.3
	10/5/2010 21:00	10/23/2010 0:00	17.1
PWOP	1/1/2010 3:00	9/1/2010 6:00	243.1
	10/7/2010 21:00	10/22/2010 0:00	14.1
FWP	1/1/2010 3:00	1/15/2010 6:00	14.1
	5/24/2010 12:00	8/29/2010 9:00	96.9
FWOP	5/28/2010 0:00	8/7/2010 3:00	71.1
	8/7/2010 9:00	8/29/2010 3:00	21.8

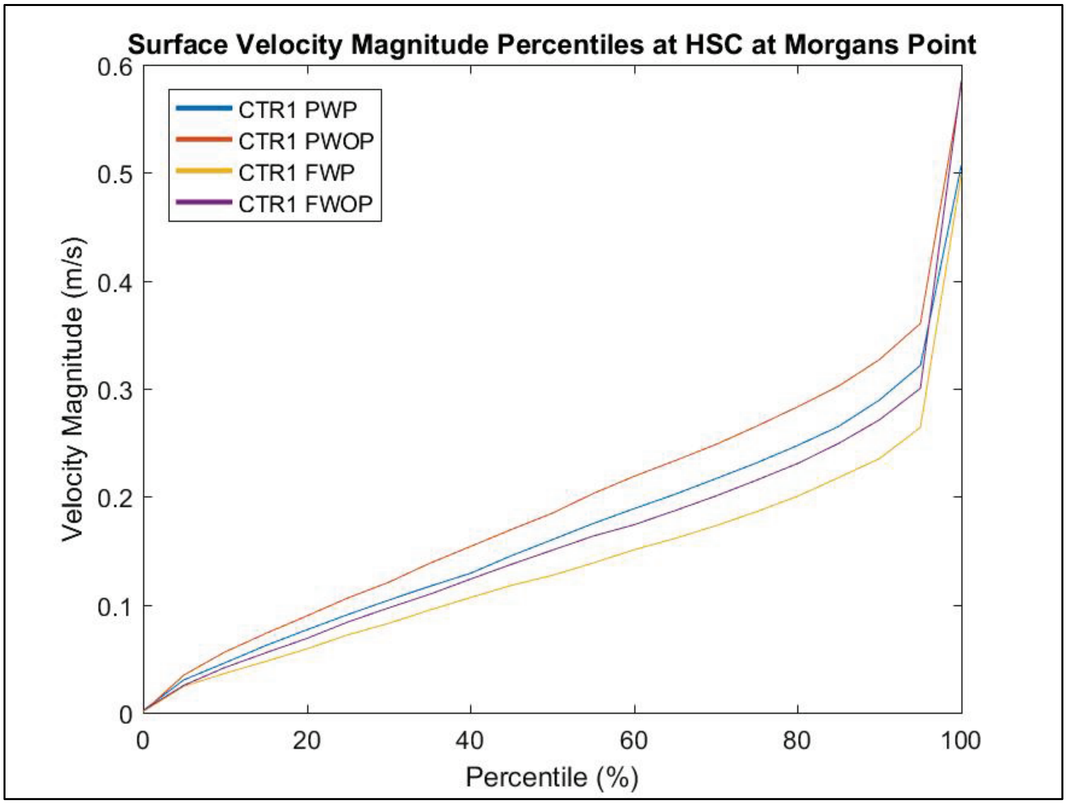

Salinity Percentiles at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100

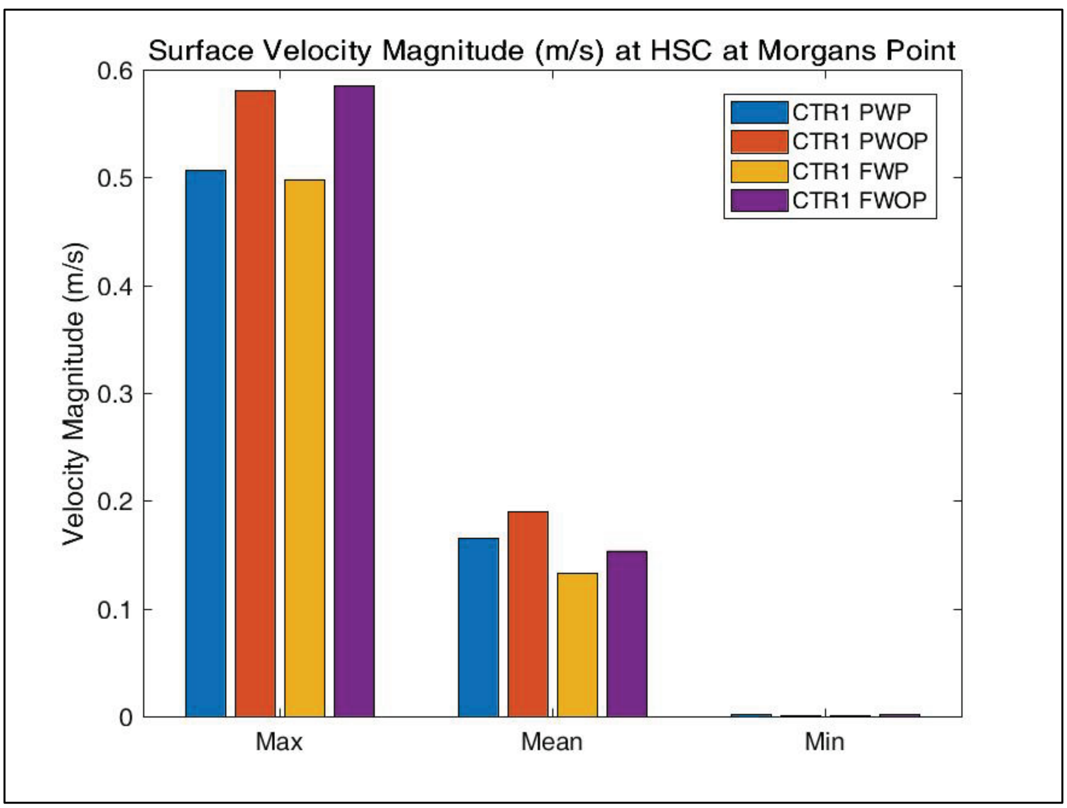

Mean Salinity Profiles at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
3
4
5
6
7
8
9
10
11
12
13

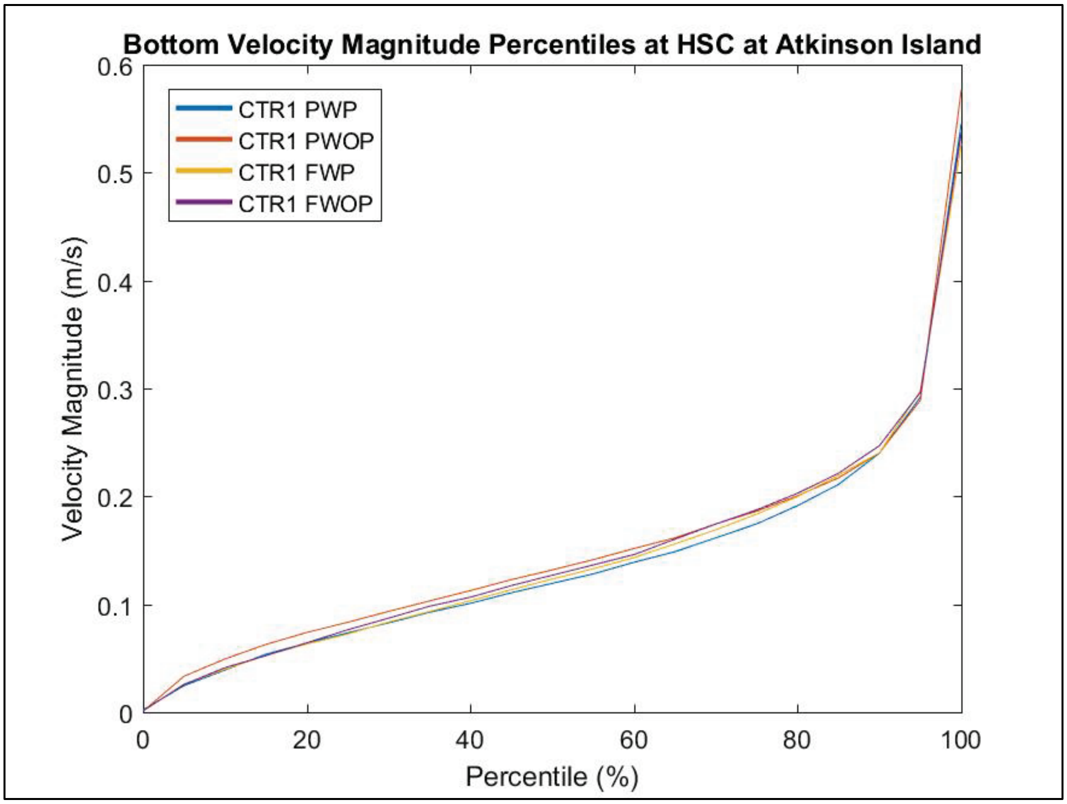
Appendix C: Velocity Magnitude Point Analysis

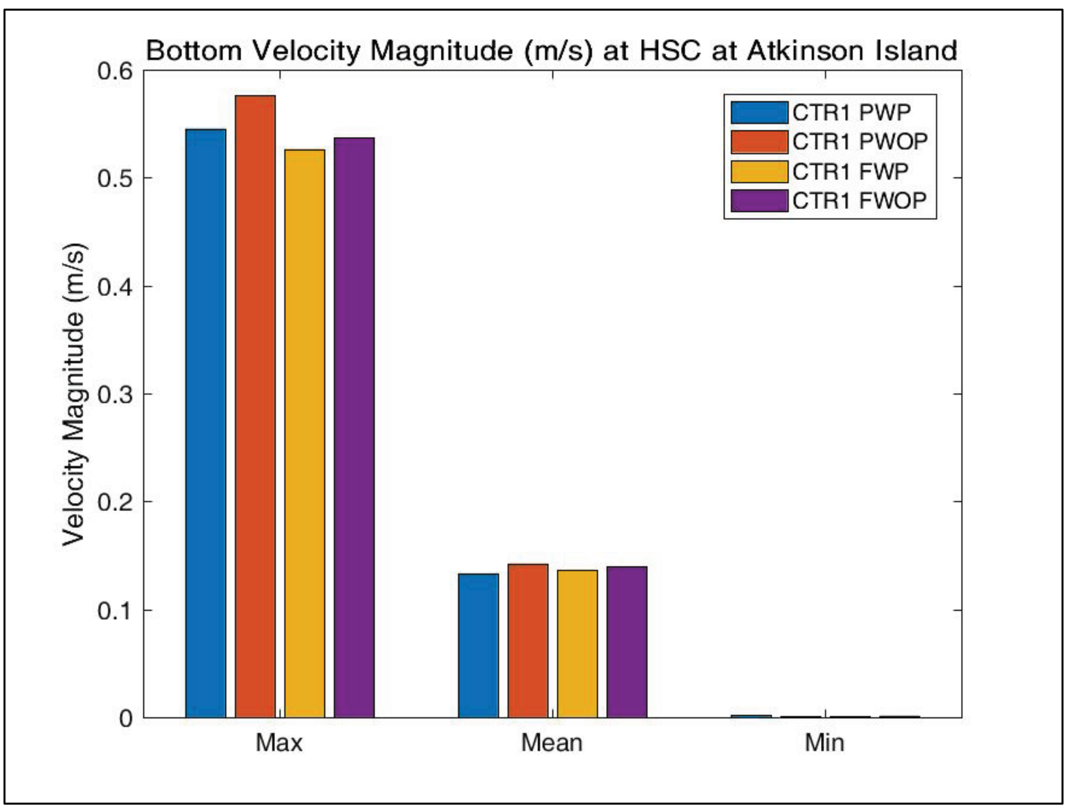


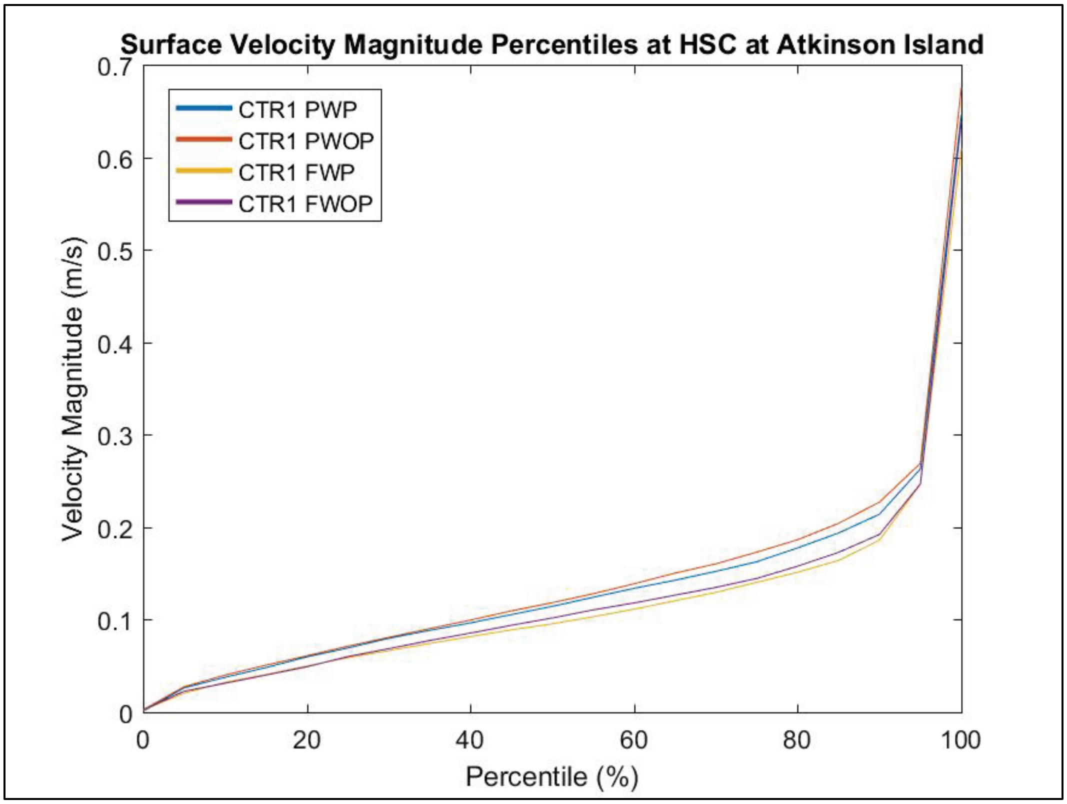


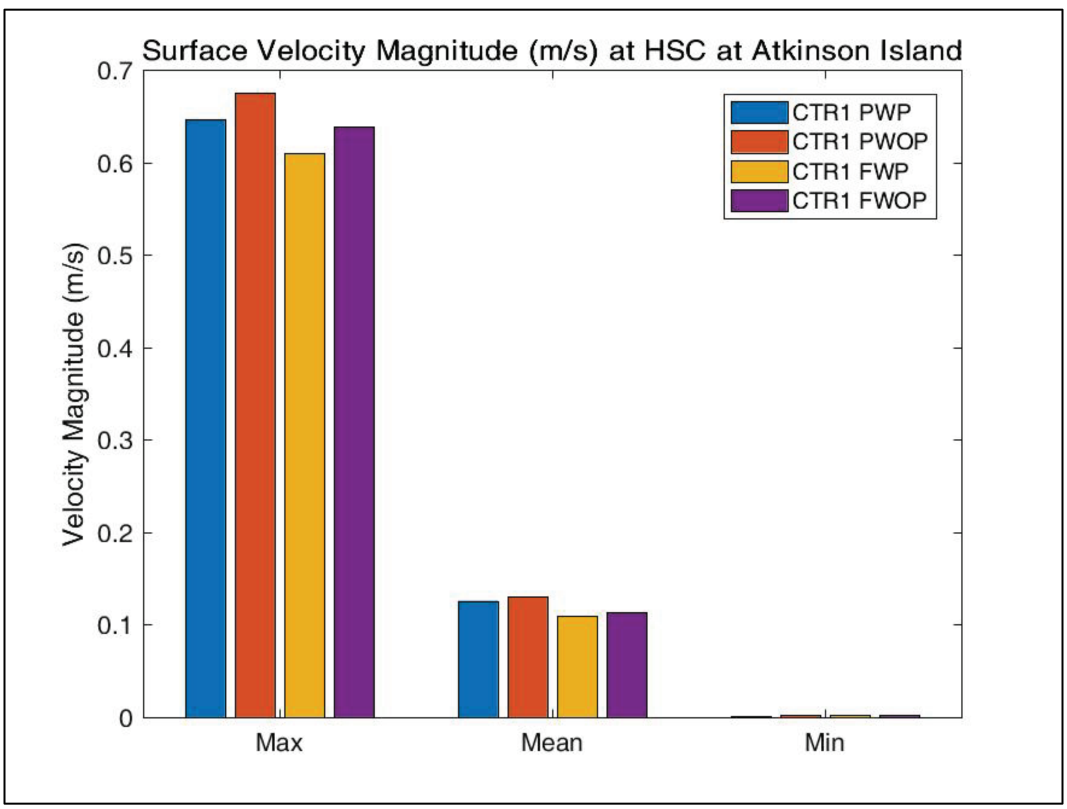

Surface Velocity Magnitude Percentiles at HSC at Morgans Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100
Percentile (%)

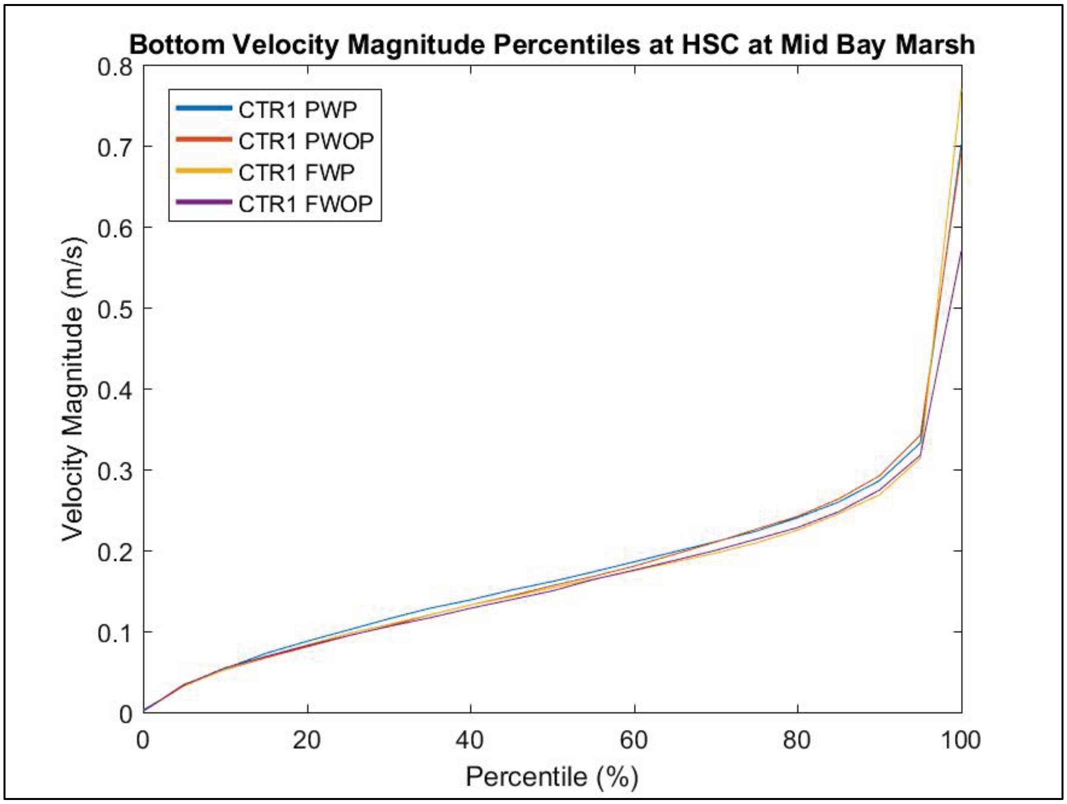

Surface Velocity Magnitude (m/s) at HSC at Morgans Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
Max
Mean
Min

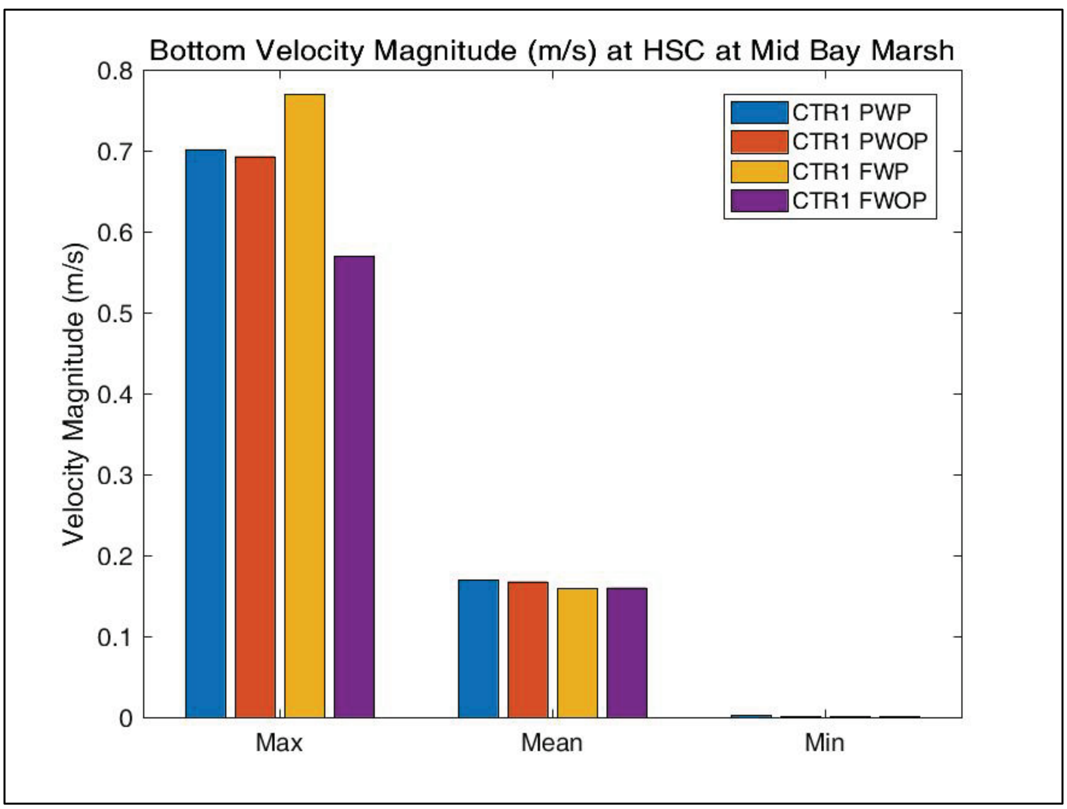

Bottom Velocity Magnitude Percentiles at HSC at Atkinson Island
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

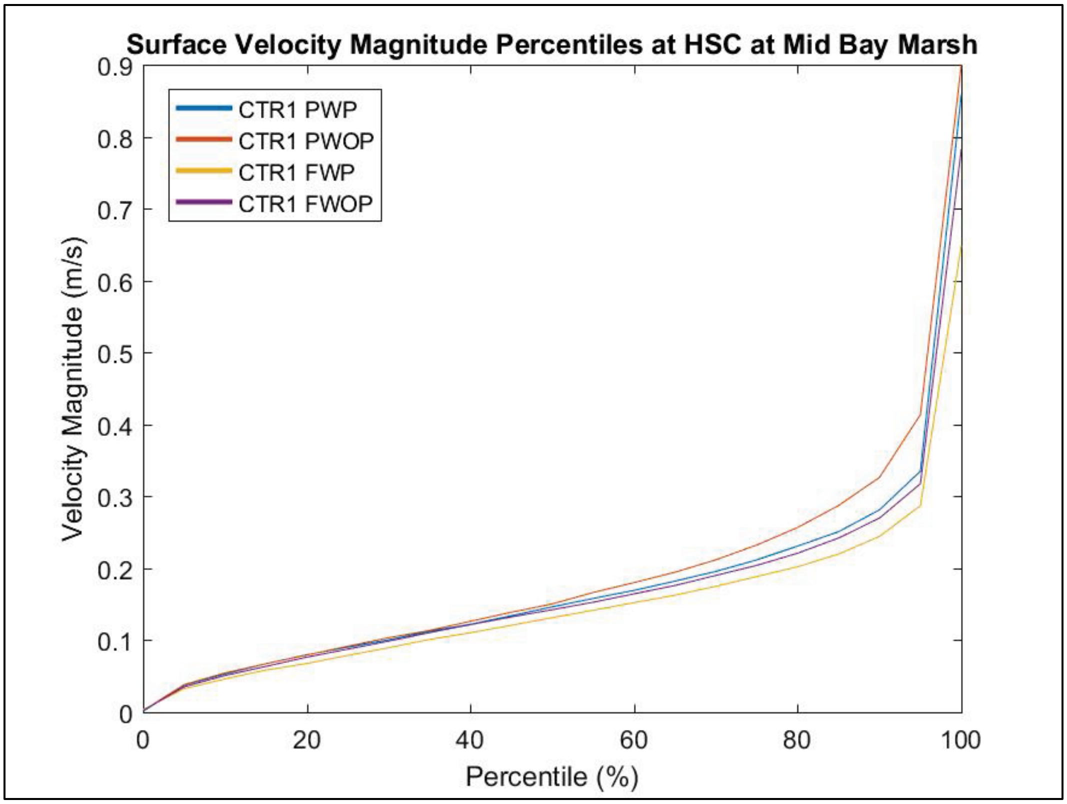

Bottom Velocity Magnitude (m/s) at HSC at Atkinson Island
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
Max
Mean
Min

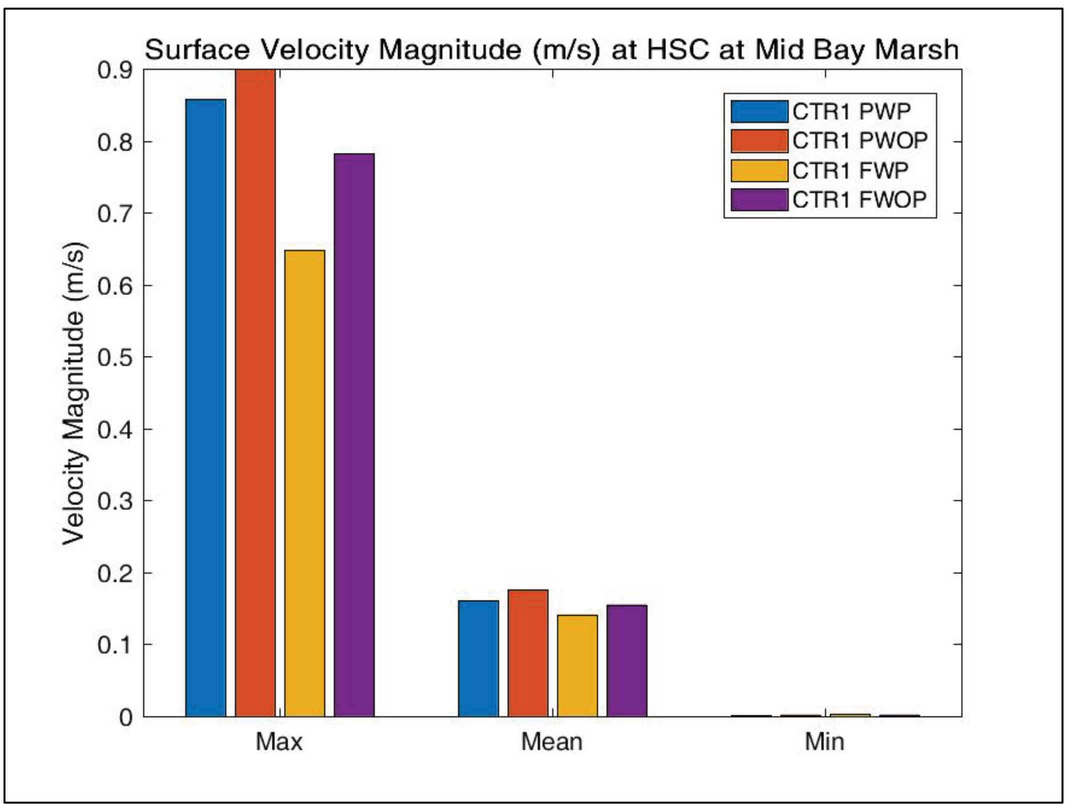

Surface Velocity Magnitude Percentiles at HSC at Atkinson Island
Velocity Magnitude (m/s)
Percentile (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
20
40
60
80
100
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

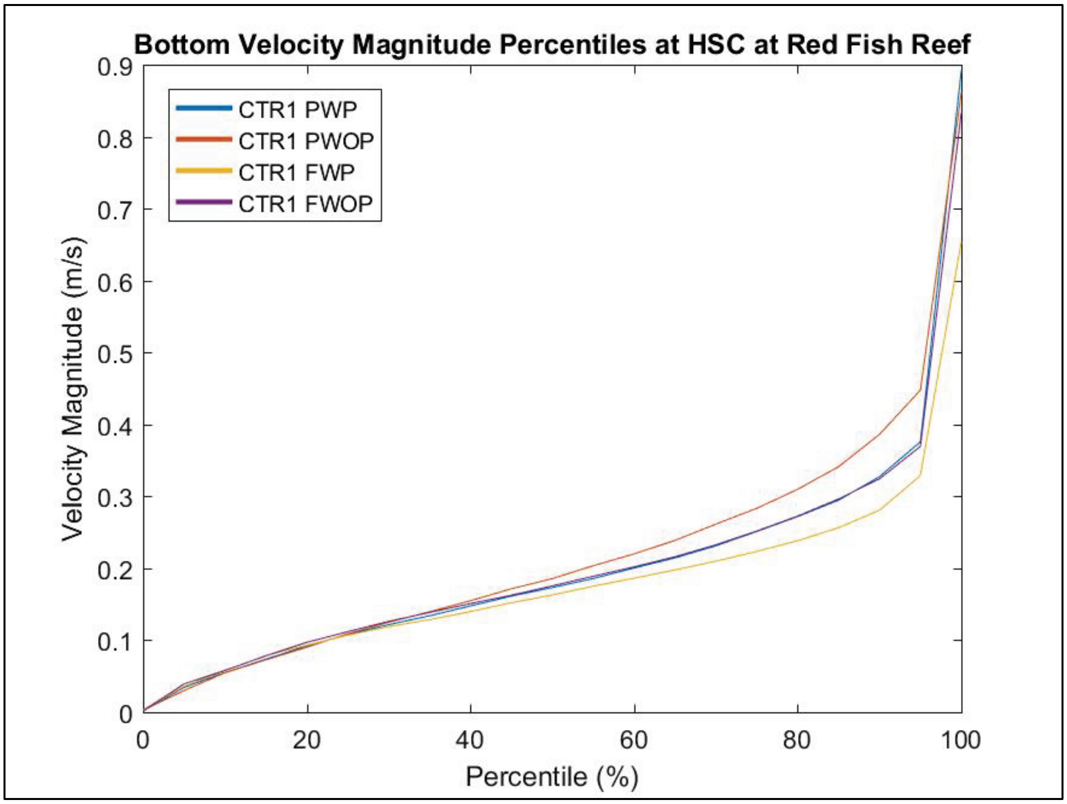

Surface Velocity Magnitude (m/s) at HSC at Atkinson Island
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Max
Mean
Min
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP

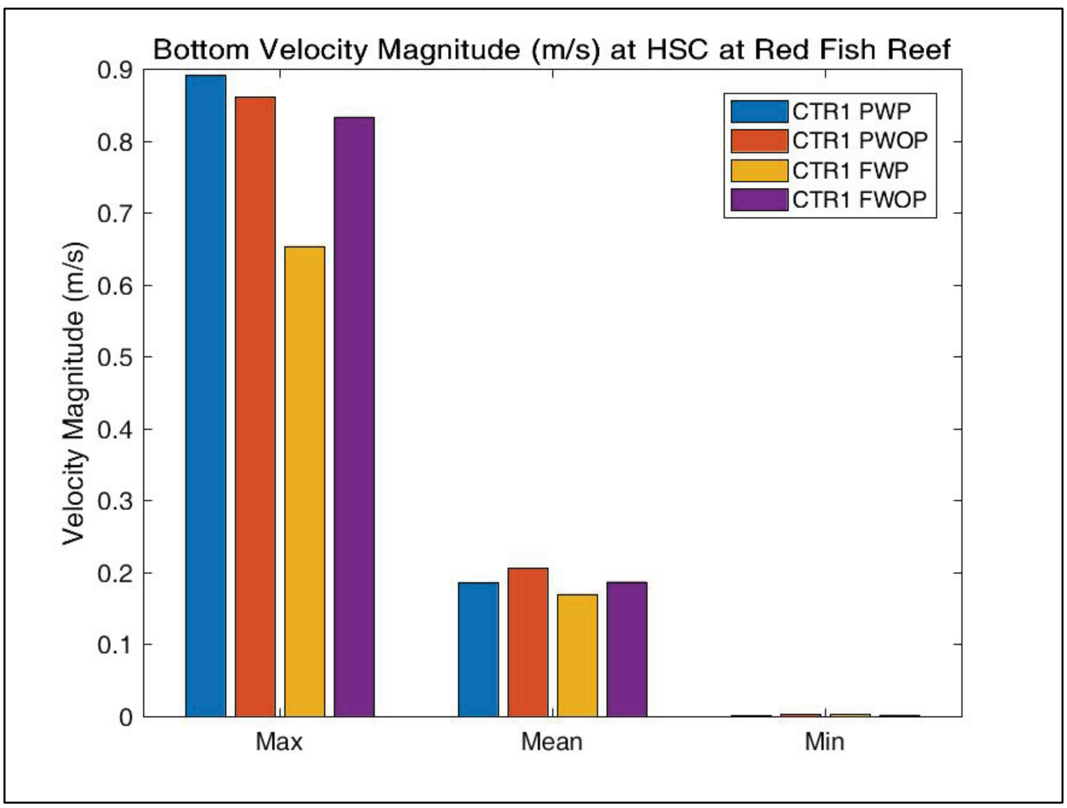

Bottom Velocity Magnitude Percentiles at HSC at Mid Bay Marsh
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100

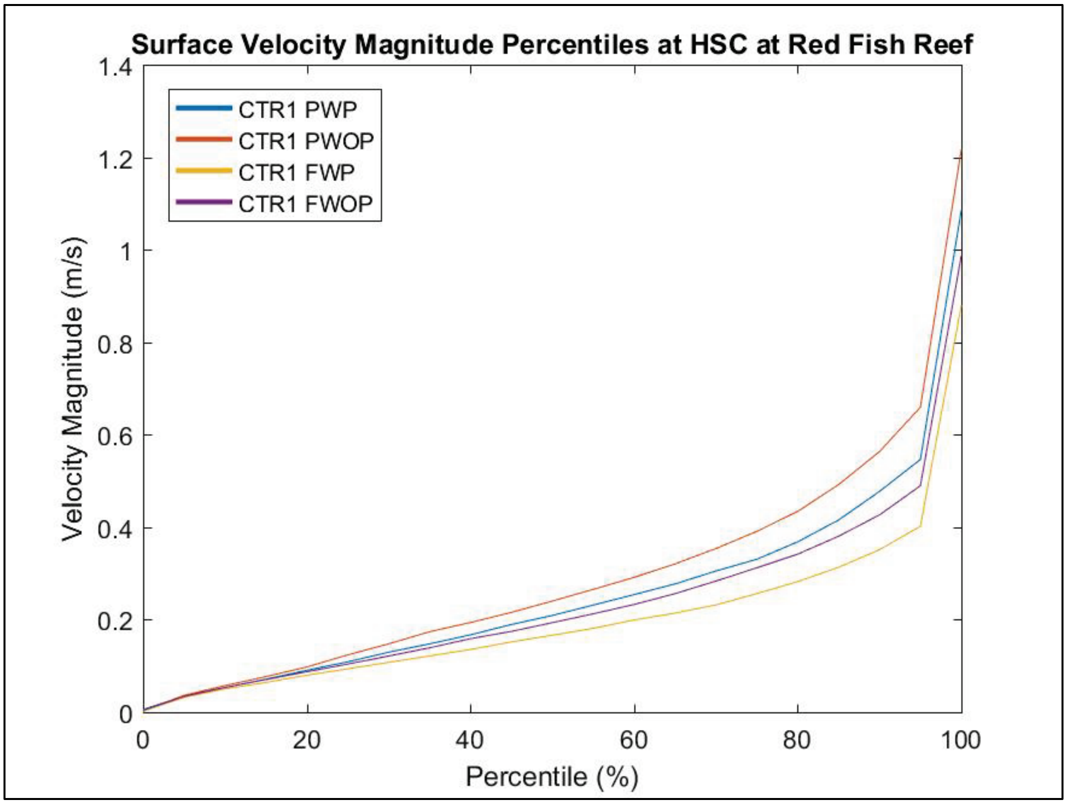

Bottom Velocity Magnitude (m/s) at HSC at Mid Bay Marsh
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Max
Mean
Min

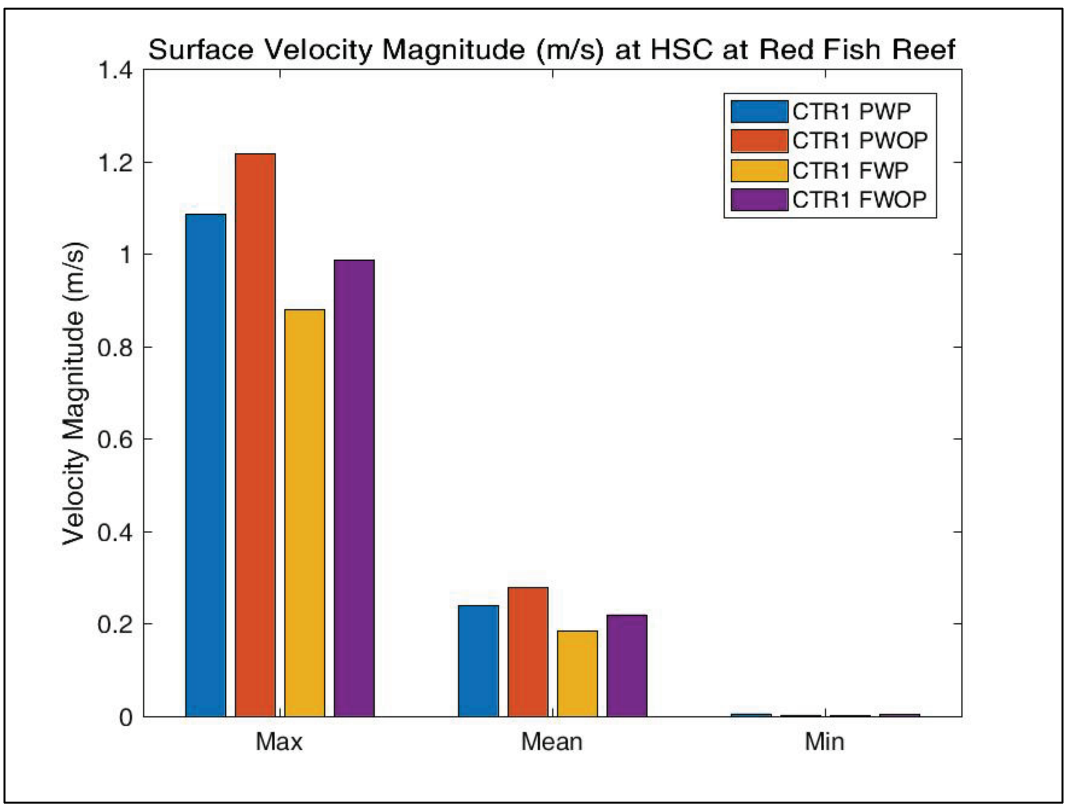

Surface Velocity Magnitude Percentiles at HSC at Mid Bay Marsh
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
20
40
60
80
100

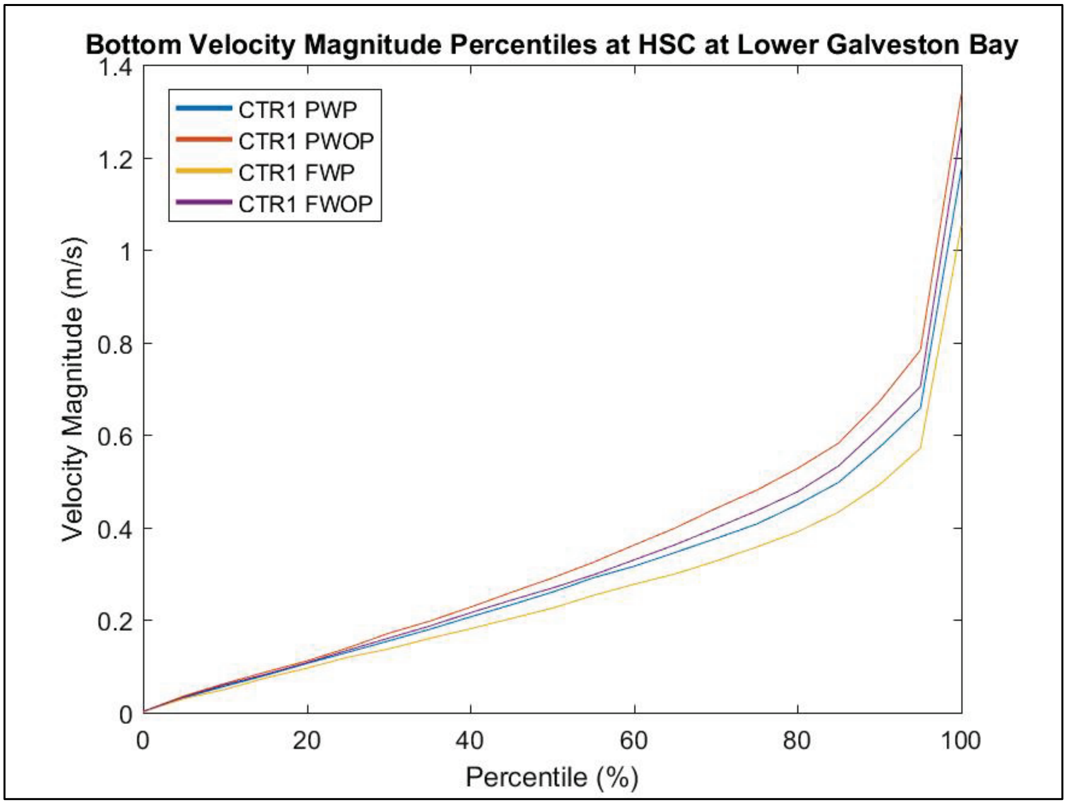

Surface Velocity Magnitude (m/s) at HSC at Mid Bay Marsh
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Max
Mean
Min

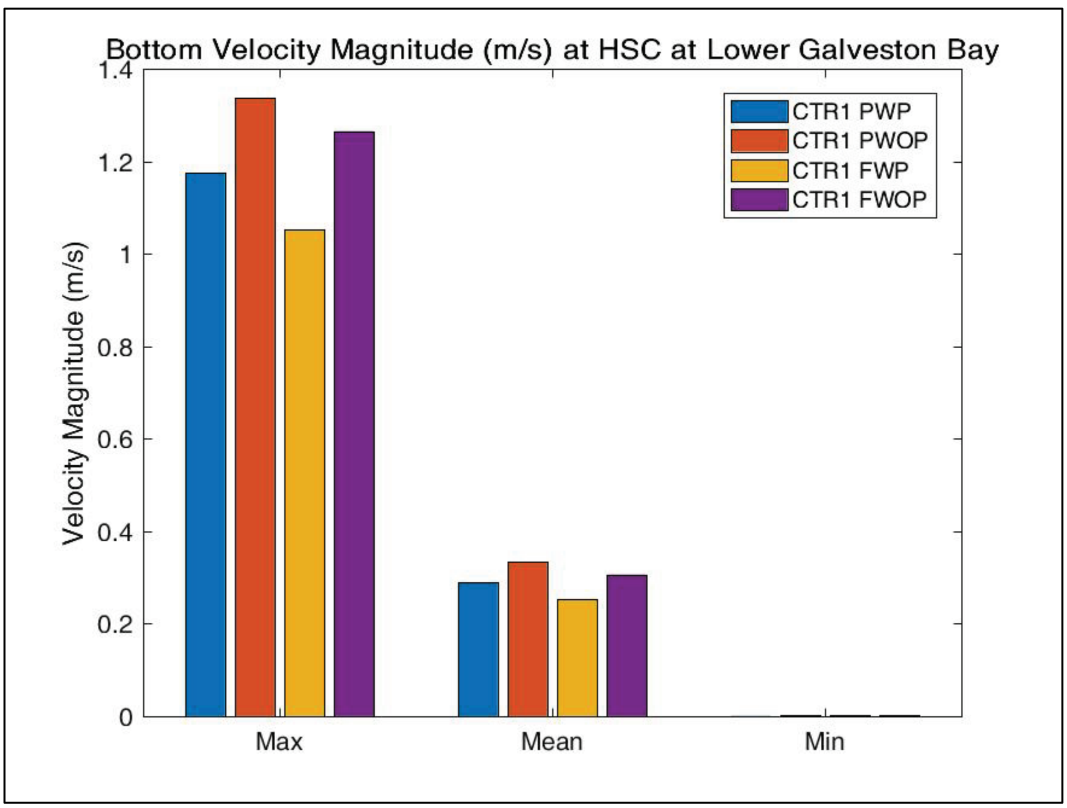

Bottom Velocity Magnitude Percentiles at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
20
40
60
80
100
Percentile (%)

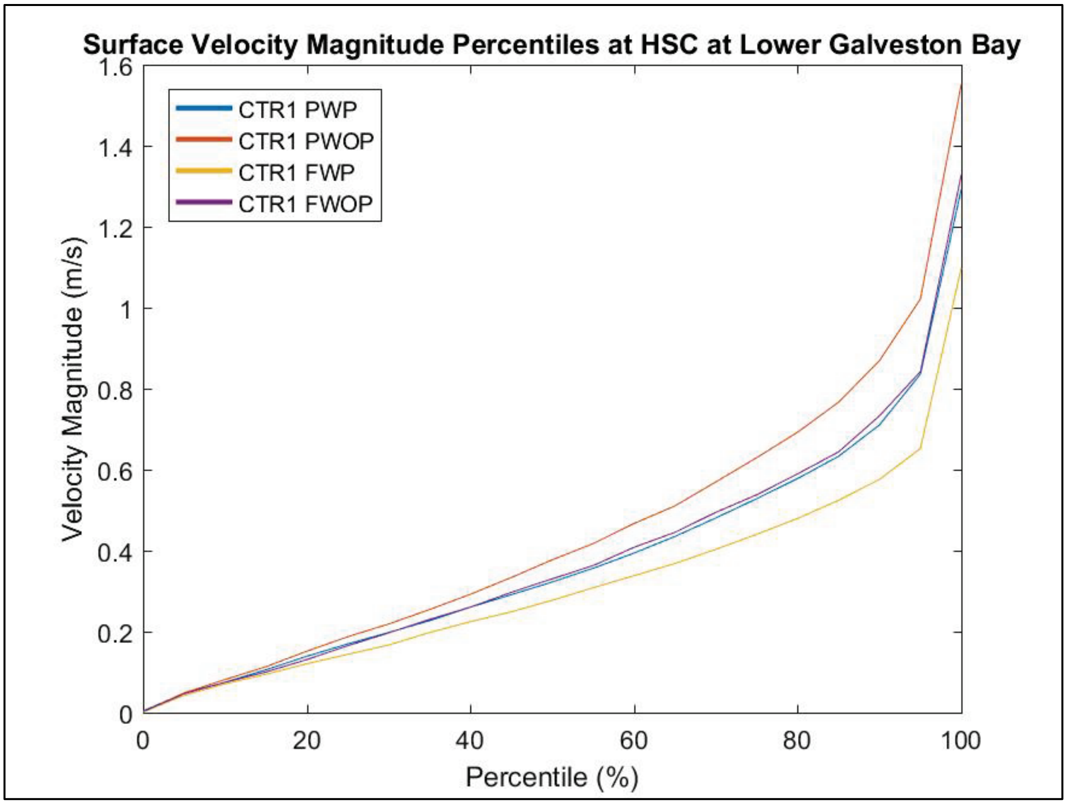

Bottom Velocity Magnitude (m/s) at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Max
Mean
Min

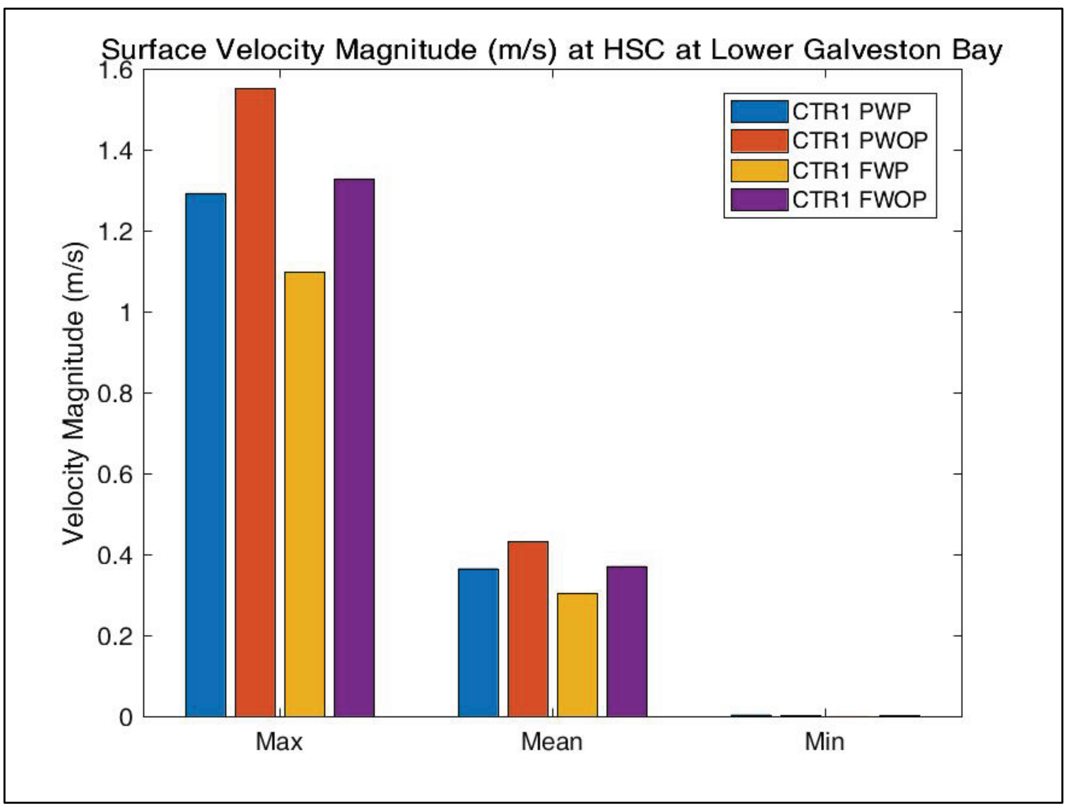

Surface Velocity Magnitude Percentiles at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100
Percentile (%)

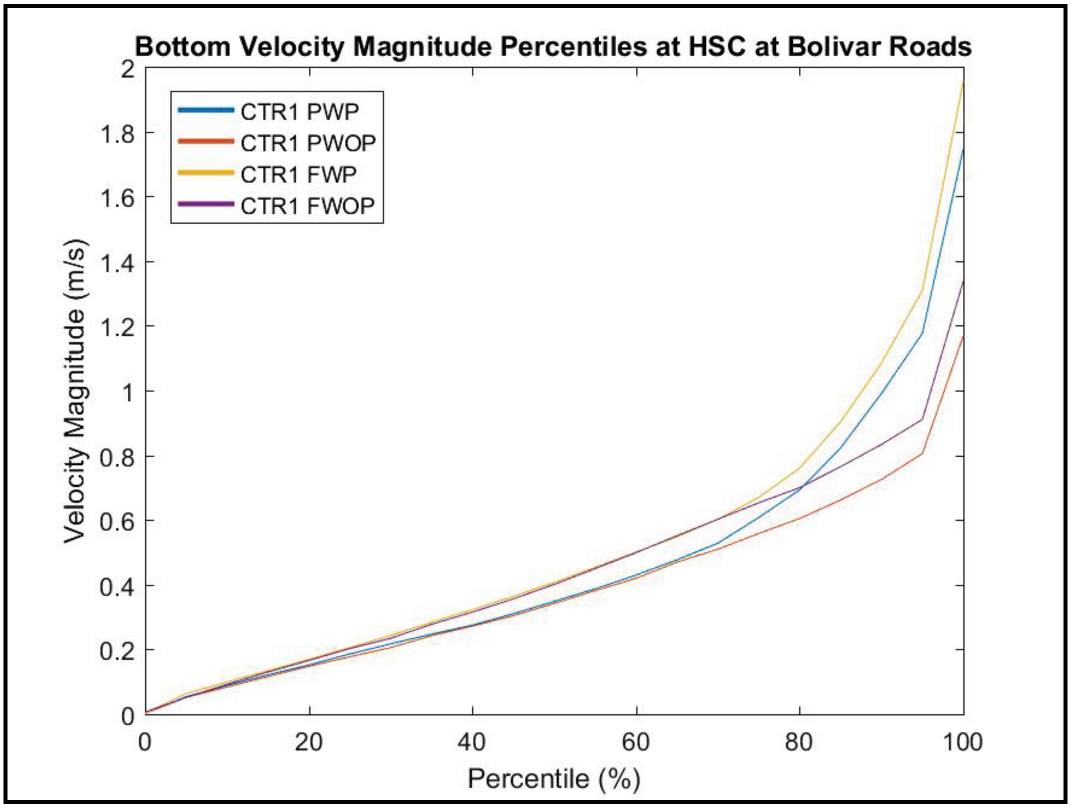

Surface Velocity Magnitude (m/s) at HSC at Red Fish Reef
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Max
Mean
Min

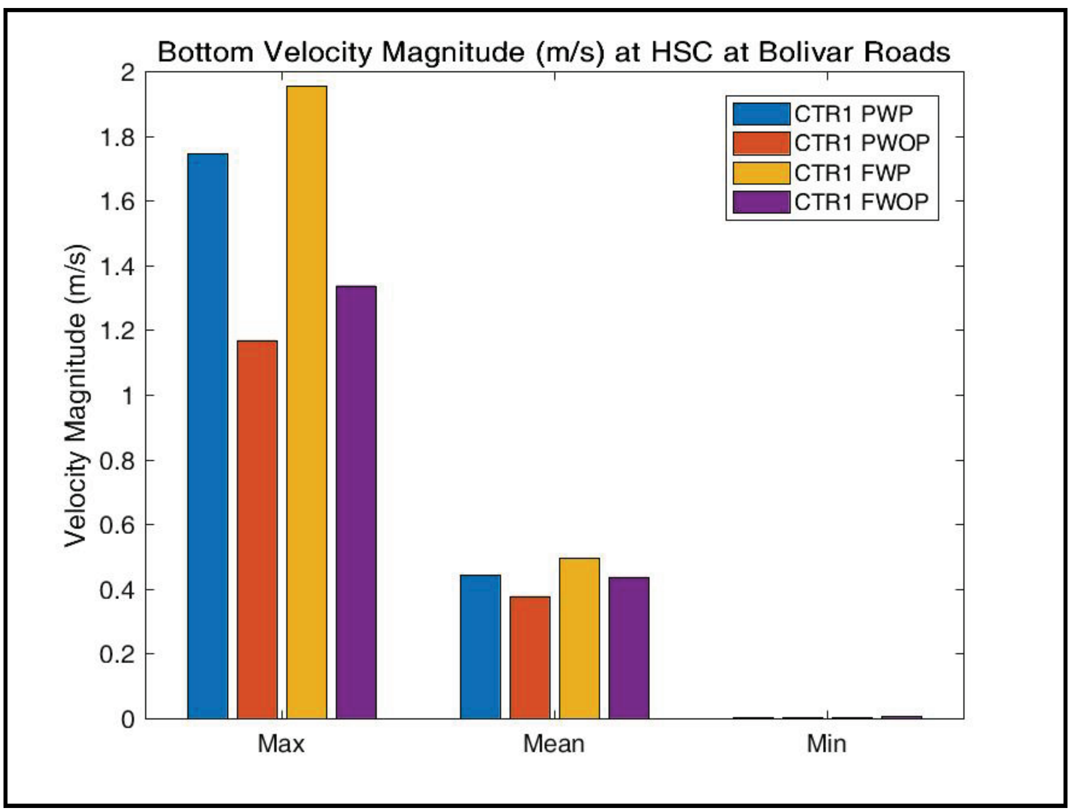

Bottom Velocity Magnitude Percentiles at HSC at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100

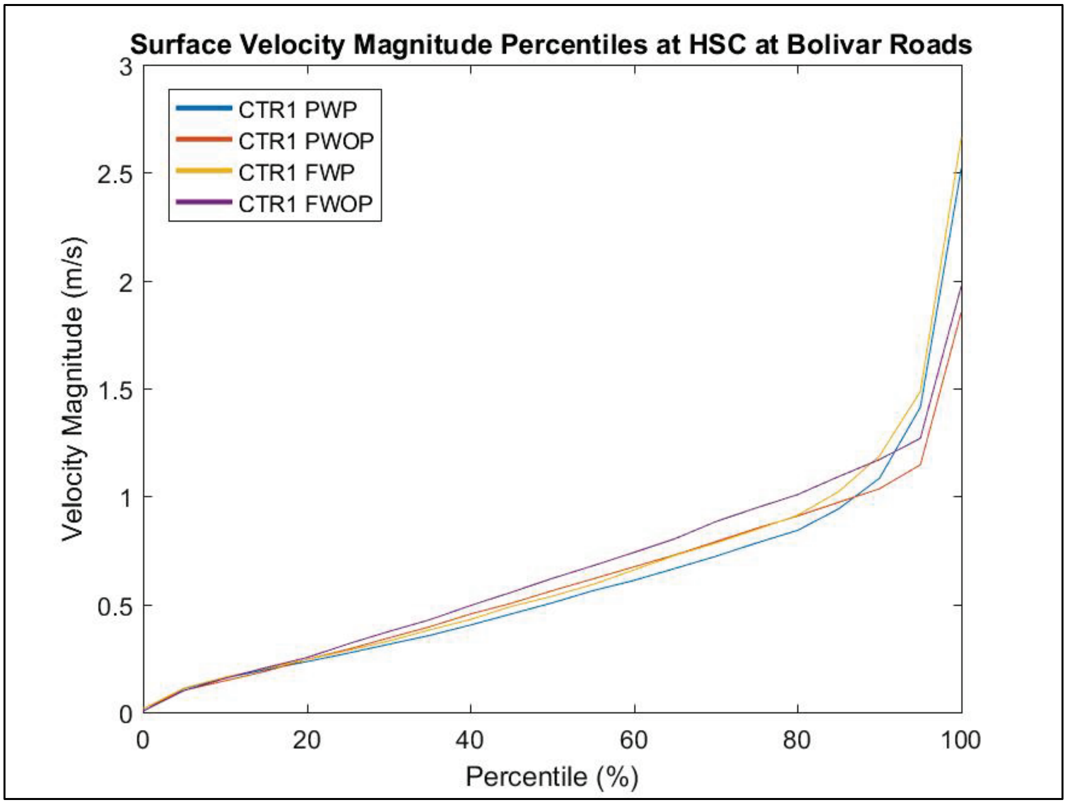

Bottom Velocity Magnitude (m/s) at HSC at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Max
Mean
Min

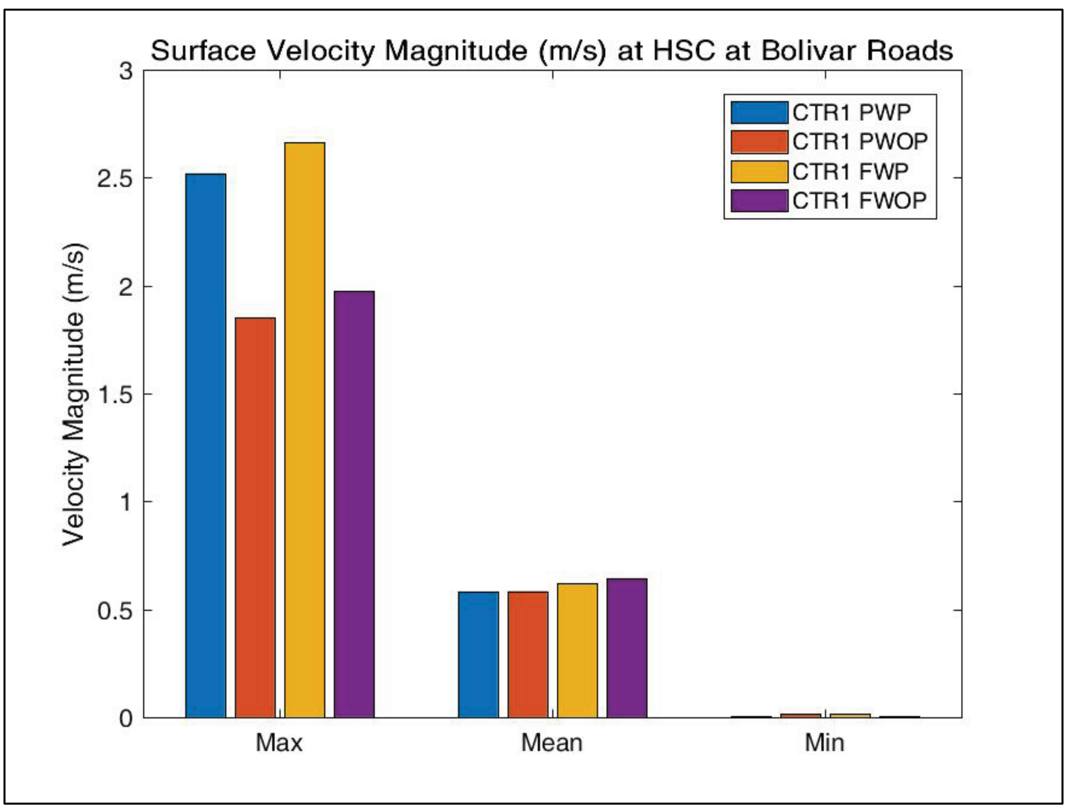

Surface Velocity Magnitude Percentiles at HSC at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
20
40
60
80
100

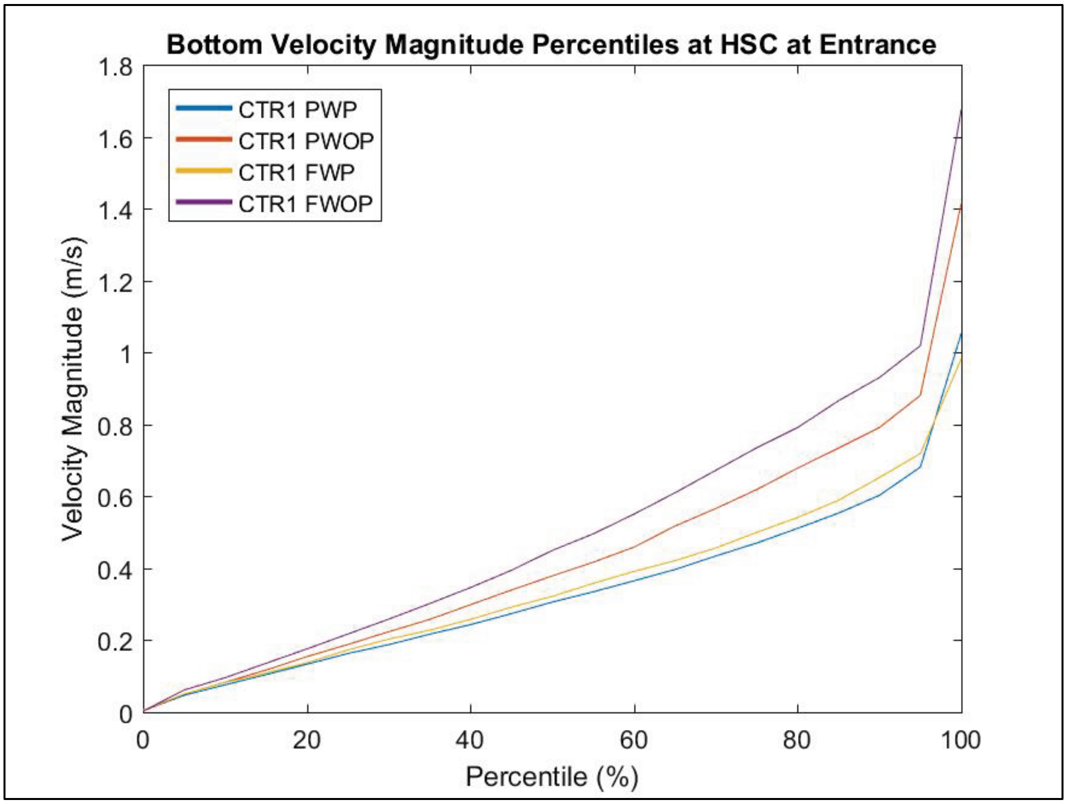

Surface Velocity Magnitude (m/s) at HSC at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Max
Mean
Min

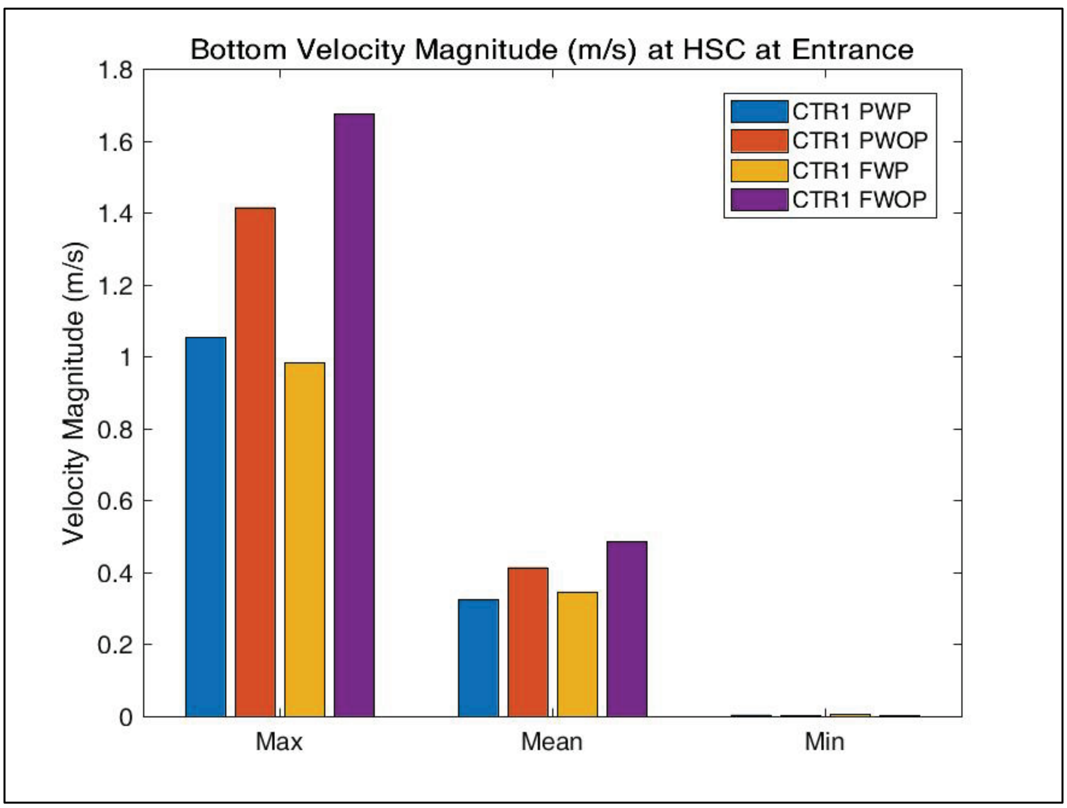

Bottom Velocity Magnitude Percentiles at HSC at Bolivar Roads
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
20
40
60
80
100

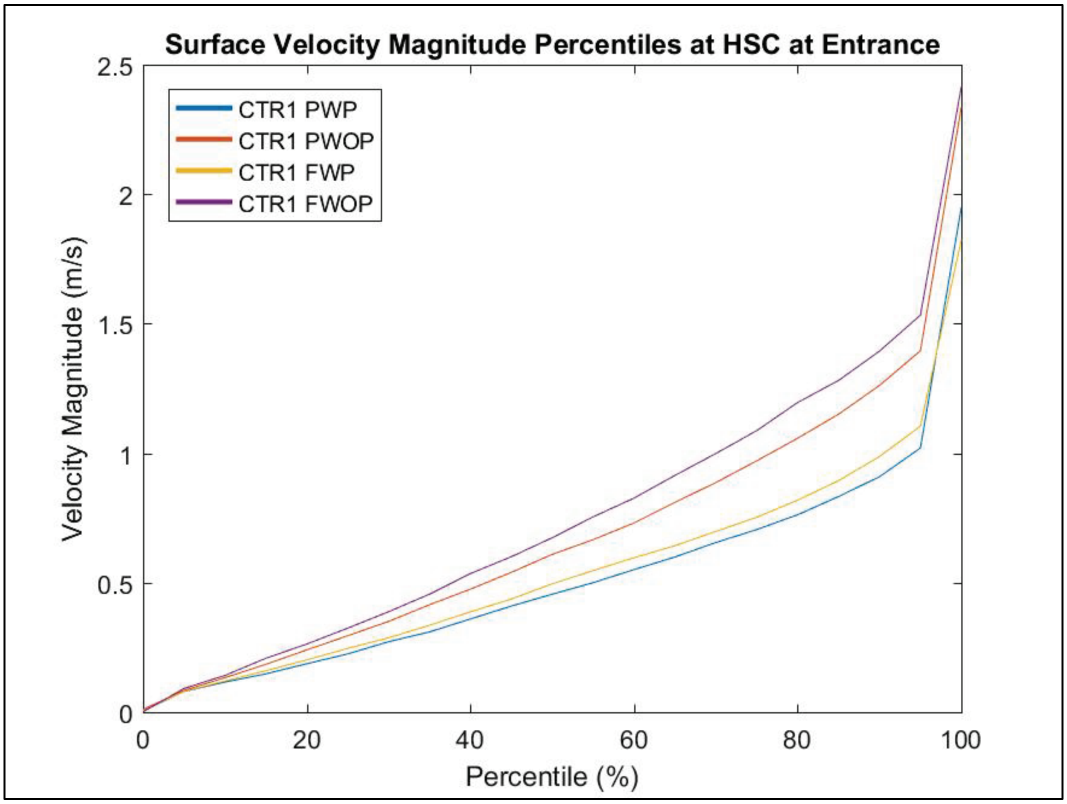

Bottom Velocity Magnitude (m/s) at HSC at Bolivar Roads
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Max
Mean
Min

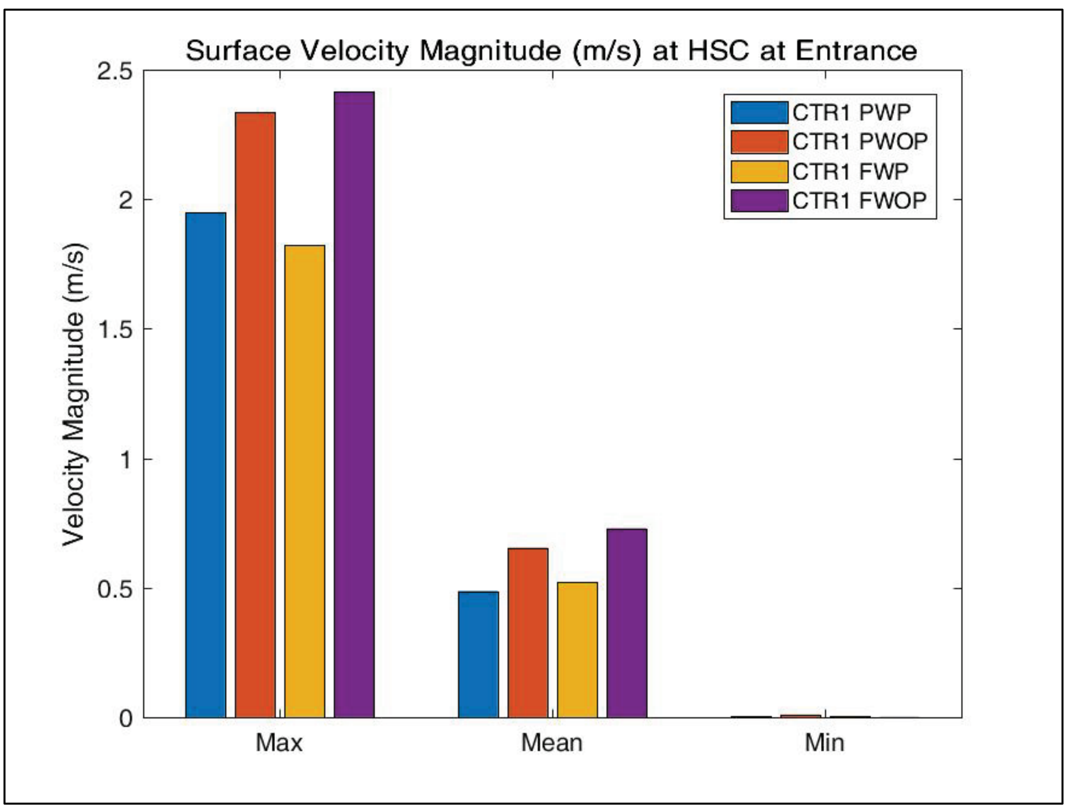

Surface Velocity Magnitude Percentiles at HSC at Bolivar Roads
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.5
1
1.5
2
2.5
3
20
40
60
80
100

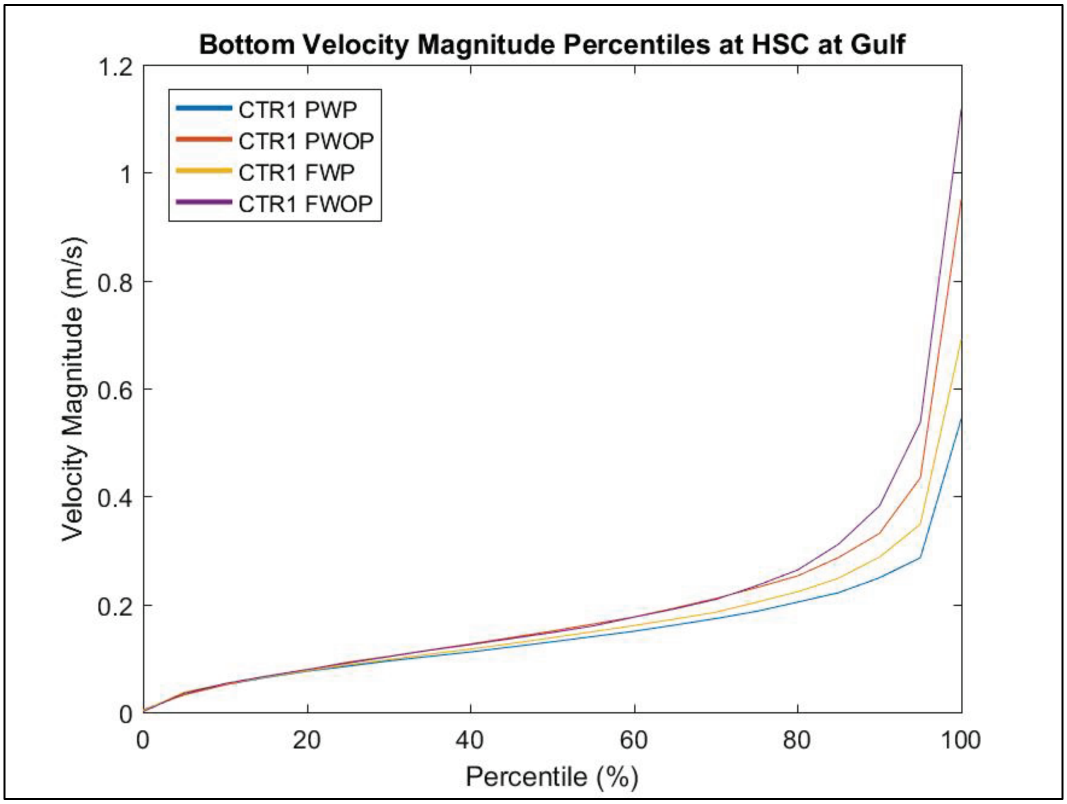

Surface Velocity Magnitude (m/s) at HSC at Bolivar Roads
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.5
1
1.5
2
2.5
3
Max
Mean
Min

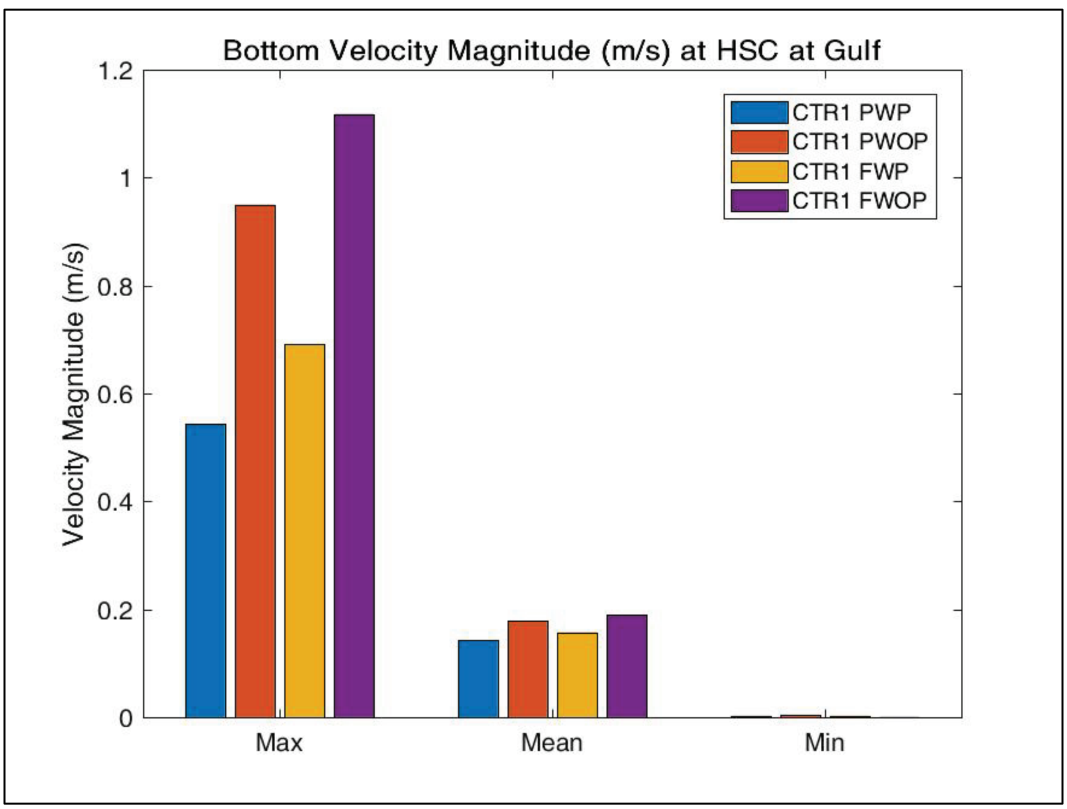

Bottom Velocity Magnitude Percentiles at HSC at Entrance
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
20
40
60
80
100

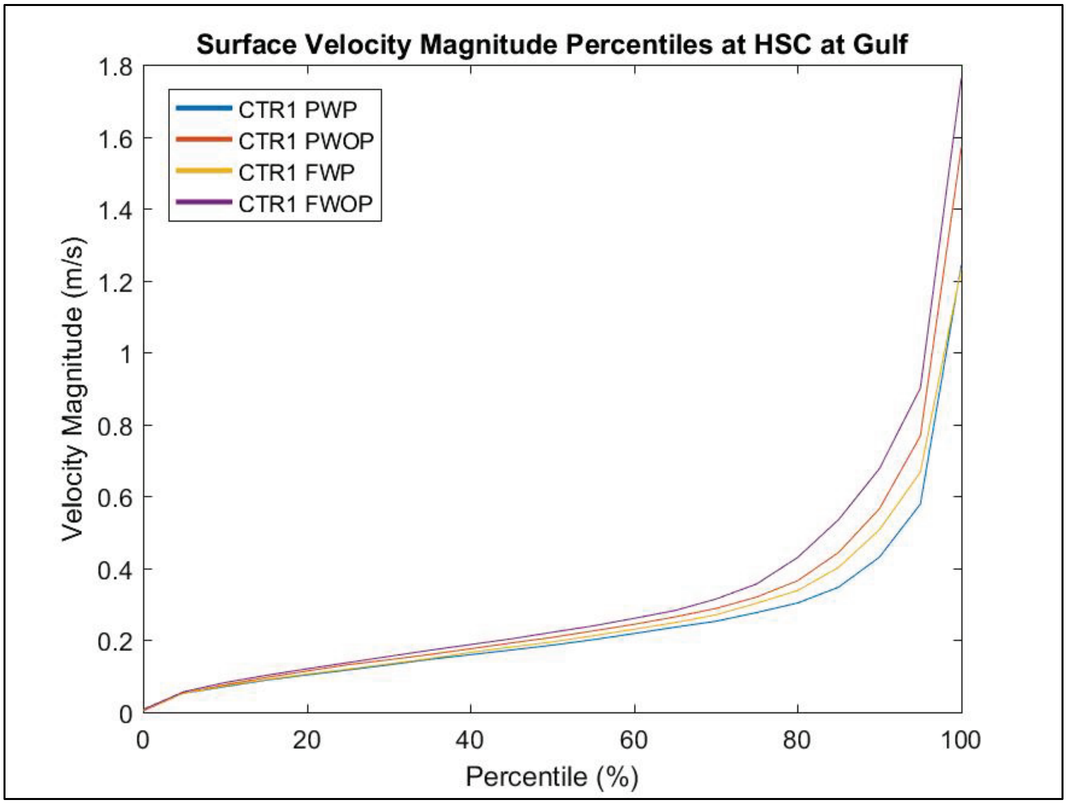

Bottom Velocity Magnitude (m/s) at HSC at Entrance
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Max
Mean
Min

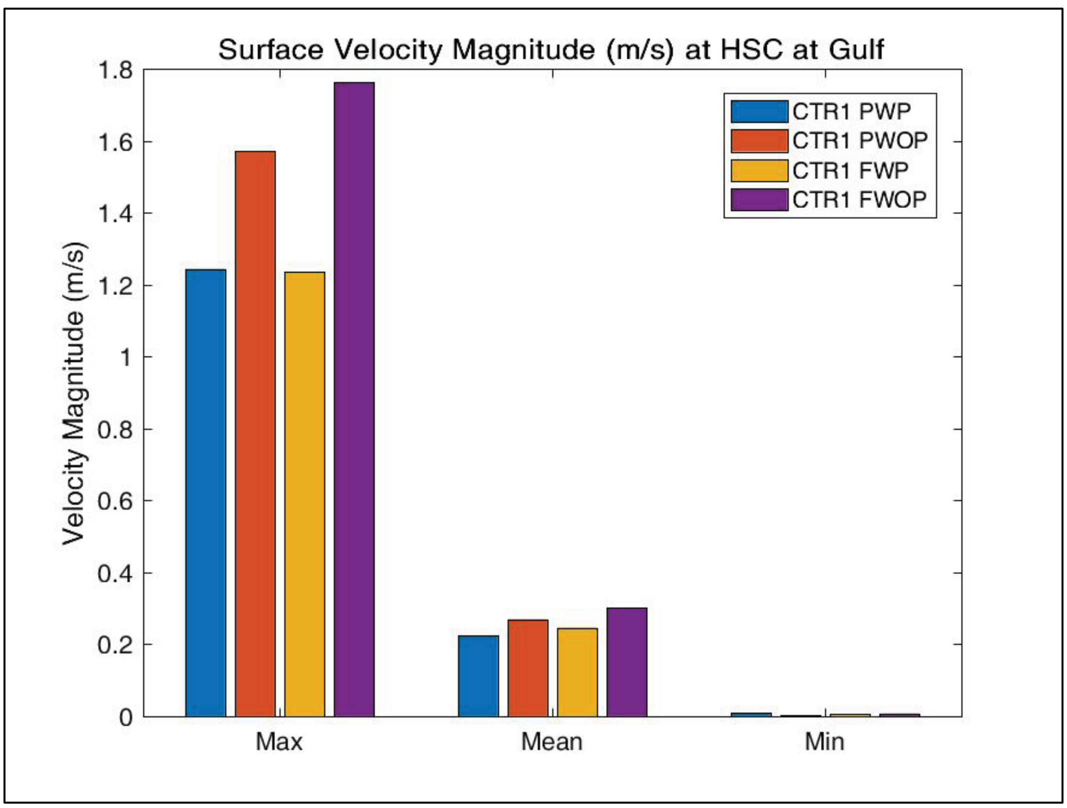

Surface Velocity Magnitude Percentiles at HSC at Entrance
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.5
1
1.5
2
2.5
0
20
40
60
80
100

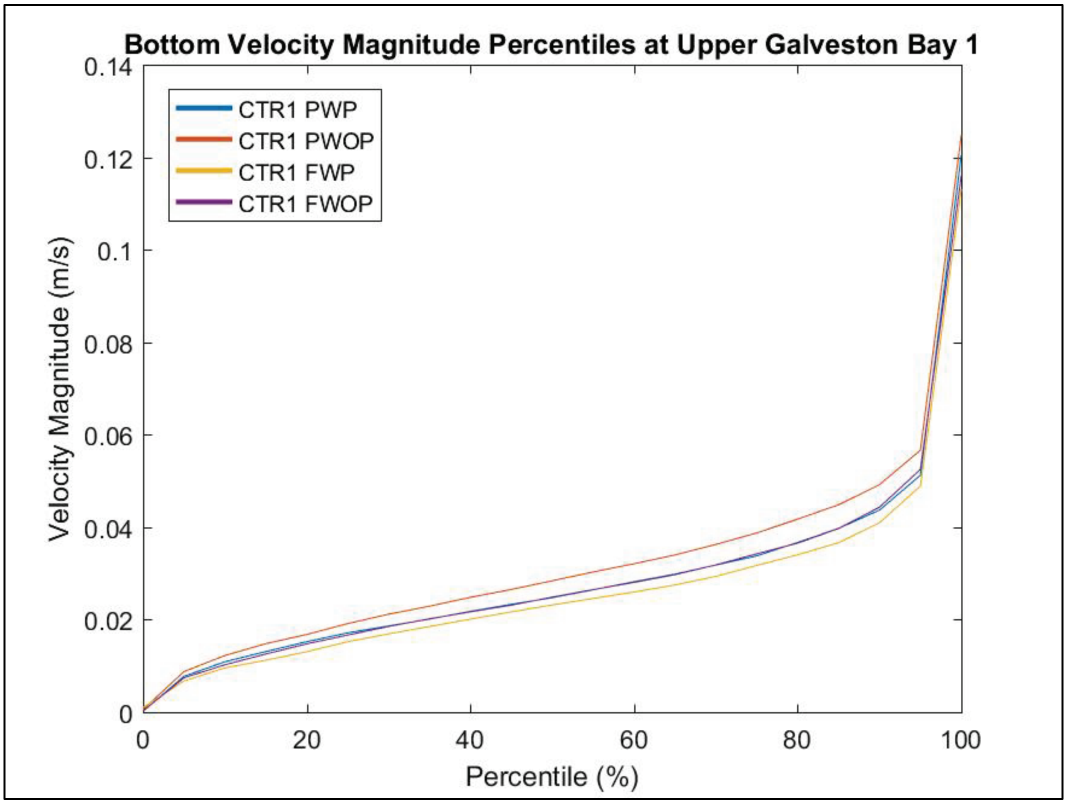

Surface Velocity Magnitude (m/s) at HSC at Entrance
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.5
1
1.5
2
2.5
Max
Mean
Min

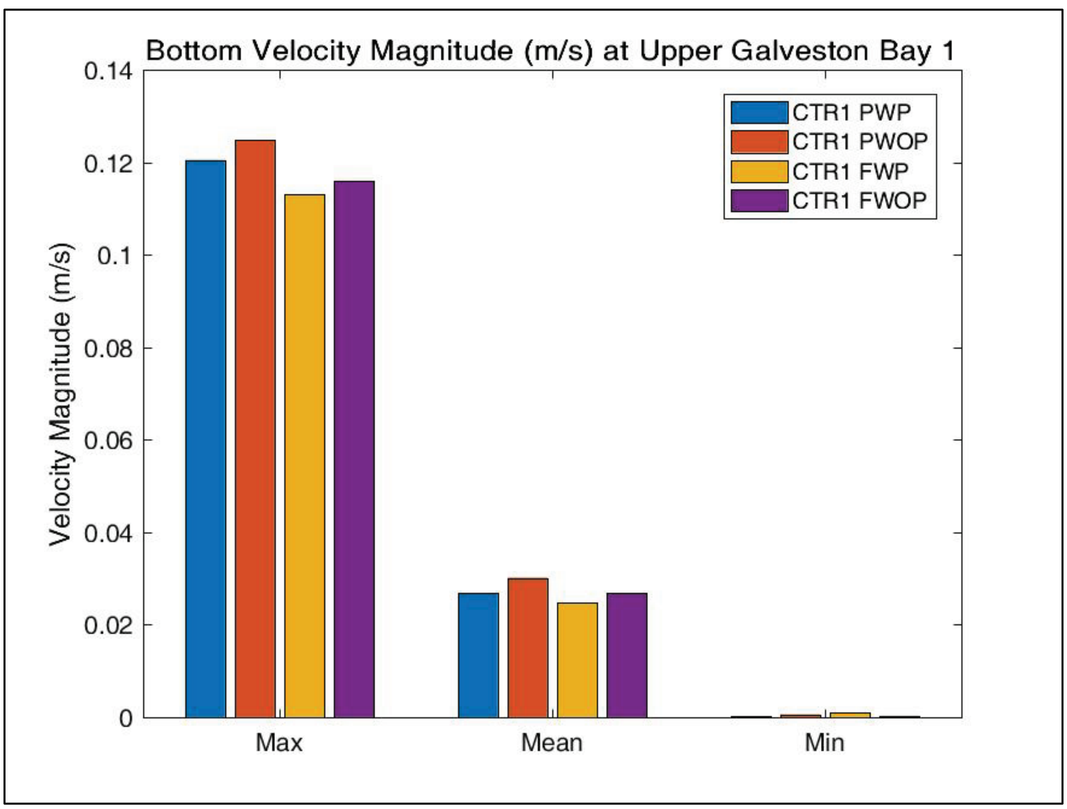

Bottom Velocity Magnitude Percentiles at HSC at Gulf
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.2
0.4
0.6
0.8
1
1.2
20
40
60
80
100

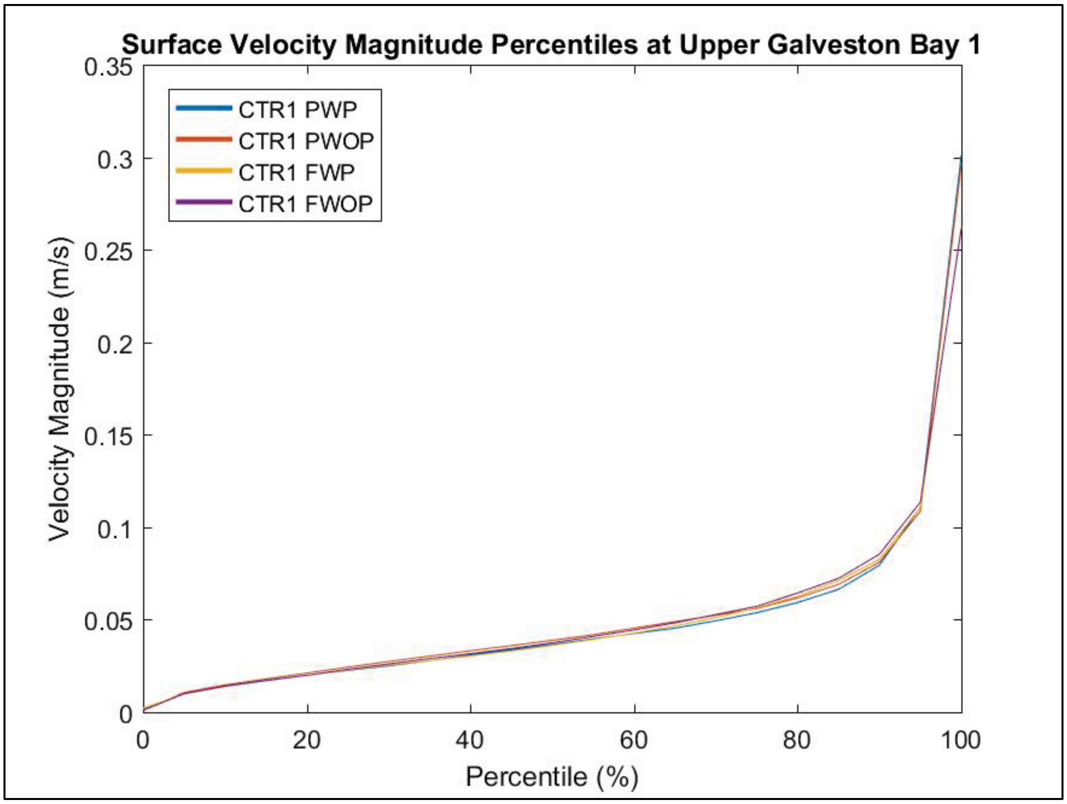

Bottom Velocity Magnitude (m/s) at HSC at Gulf
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
Max
Mean
Min

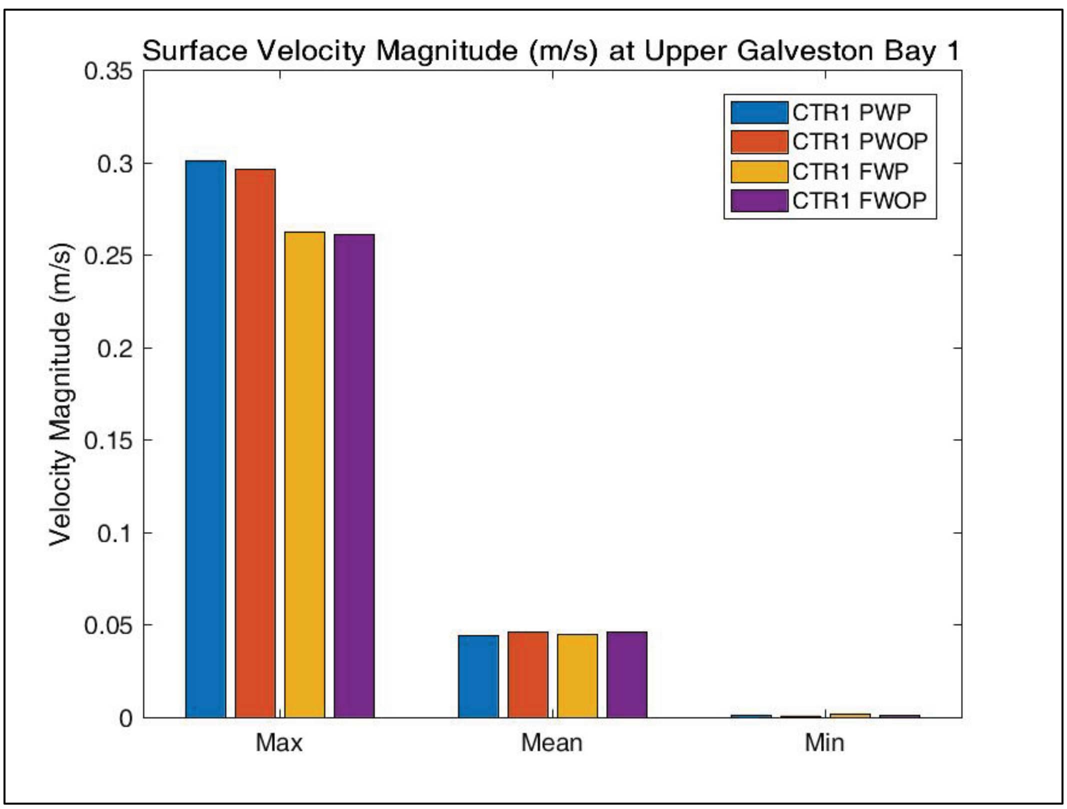

Surface Velocity Magnitude Percentiles at HSC at Gulf
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
20
40
60
80
100

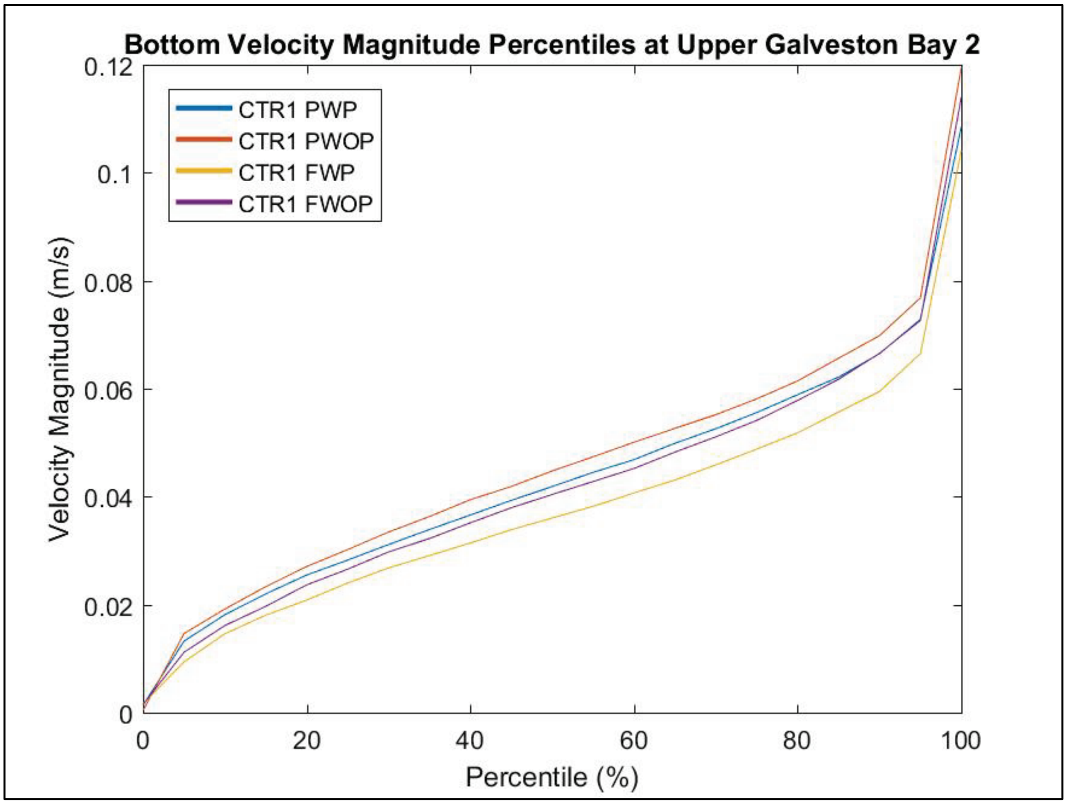

Surface Velocity Magnitude (m/s) at HSC at Gulf
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Max
Mean
Min

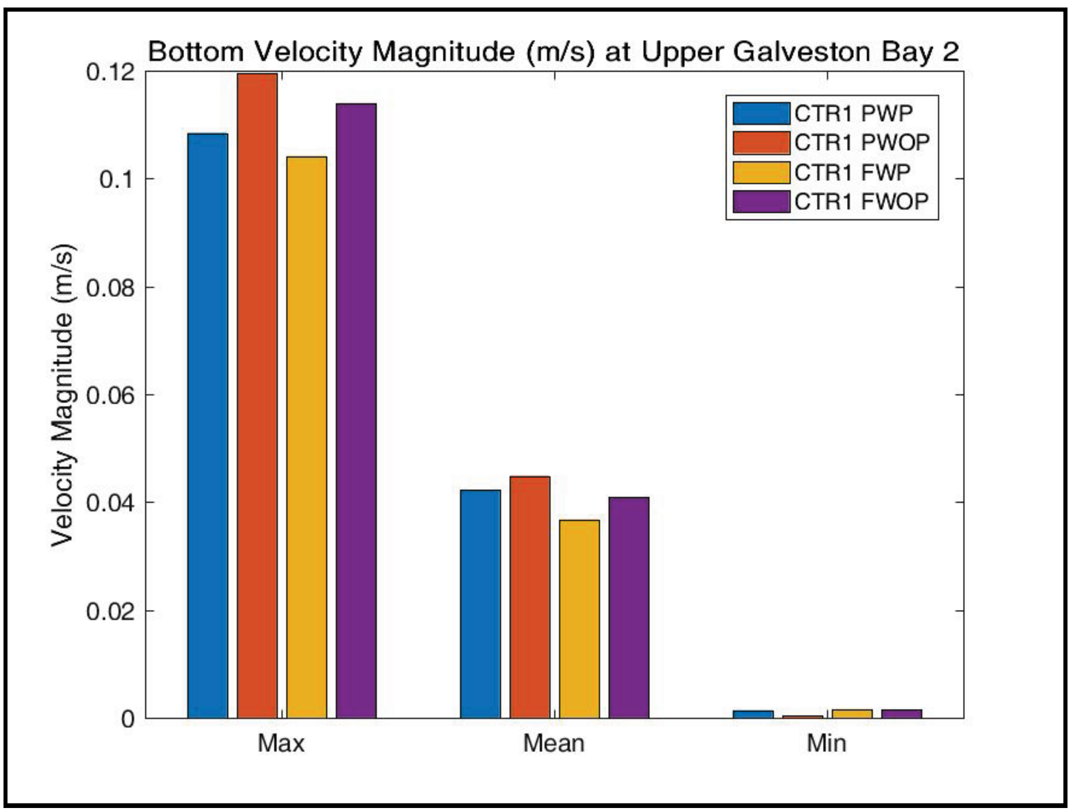

Bottom Velocity Magnitude Percentiles at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Percentile (%)
0
20
40
60
80
100

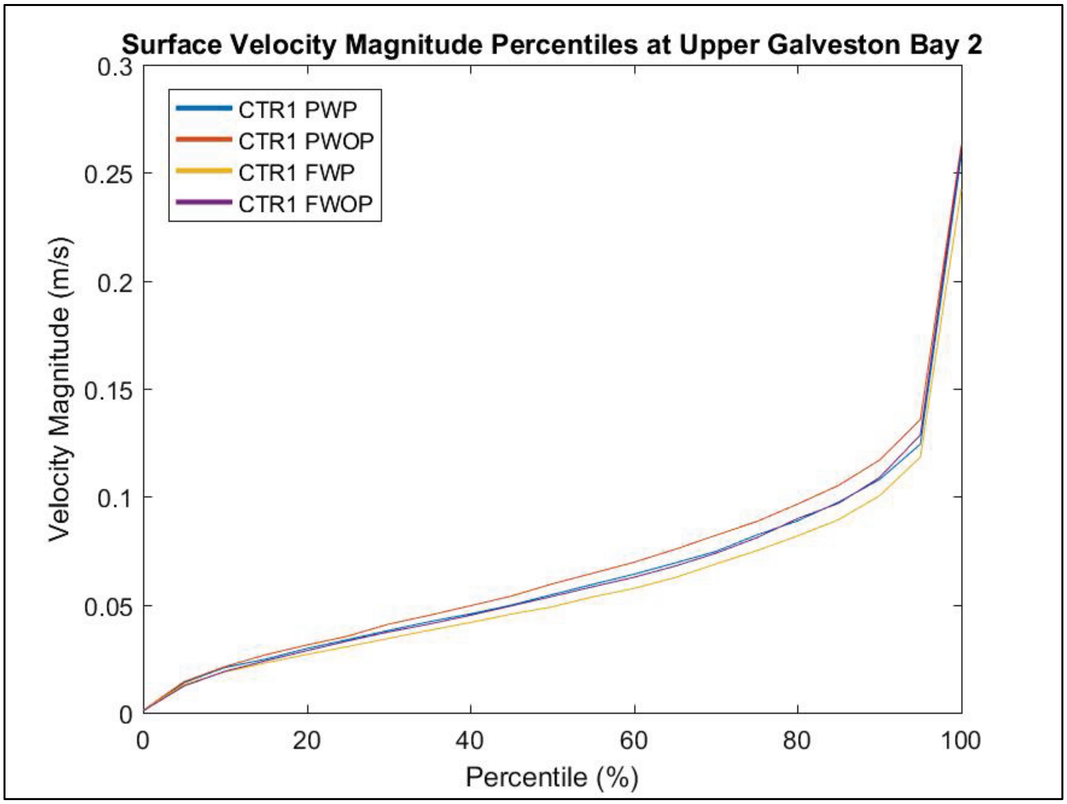

Bottom Velocity Magnitude (m/s) at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Max
Mean
Min

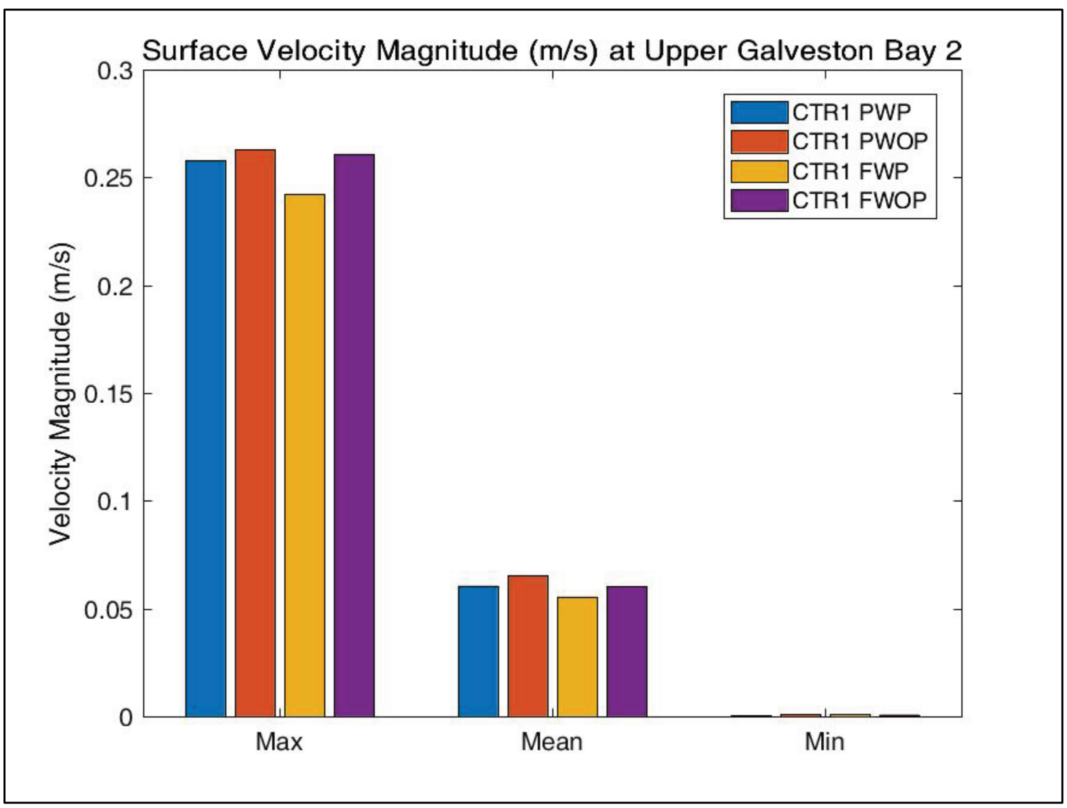

Surface Velocity Magnitude Percentiles at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
20
40
60
80
100

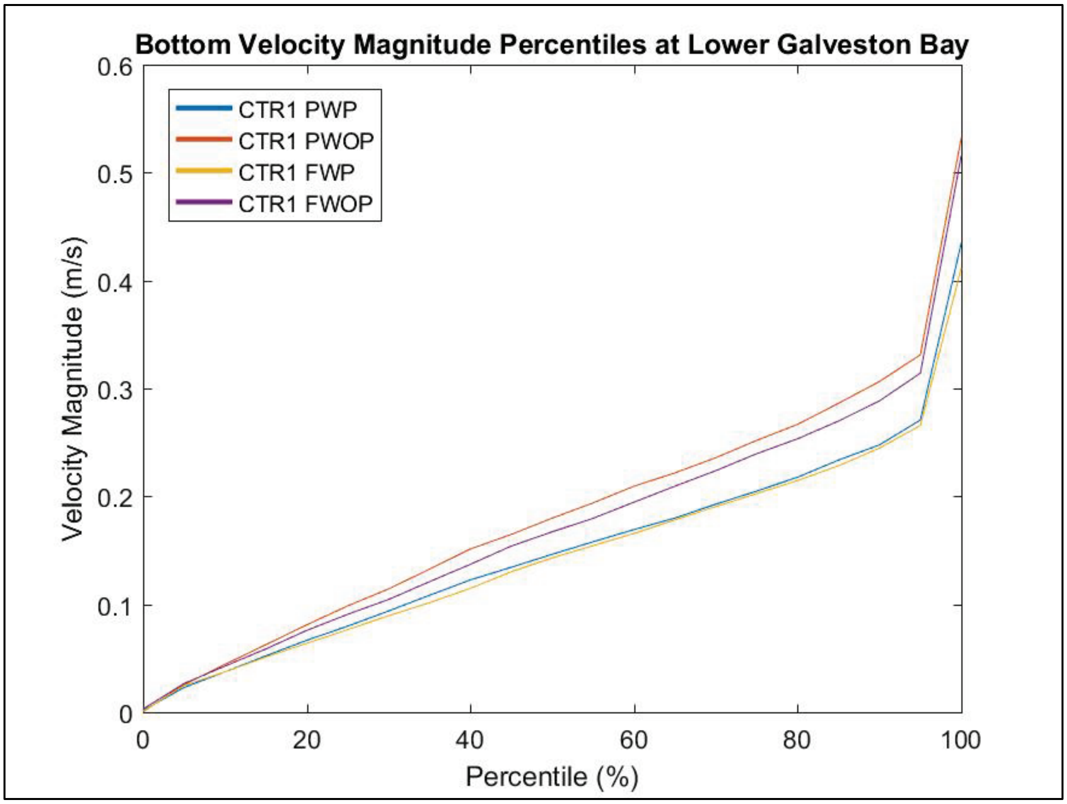

Surface Velocity Magnitude (m/s) at Upper Galveston Bay 1
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Max
Mean
Min

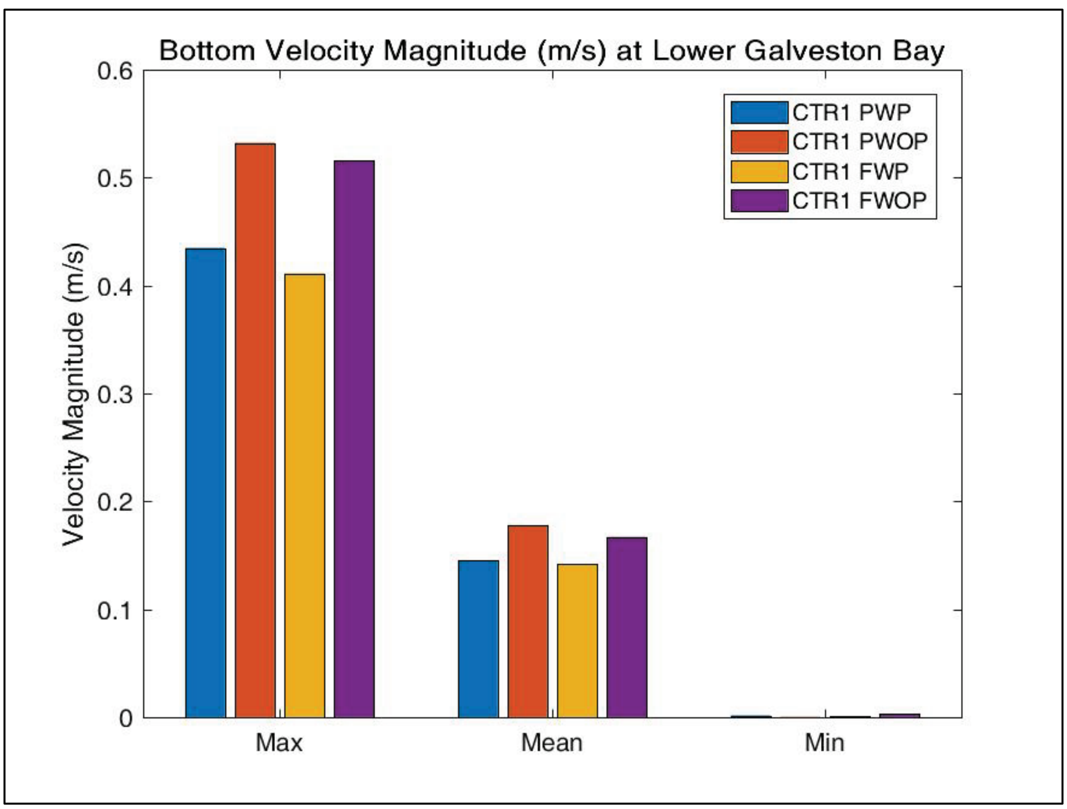

Bottom Velocity Magnitude Percentiles at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.02
0.04
0.06
0.08
0.1
0.12
0
20
40
60
80
100

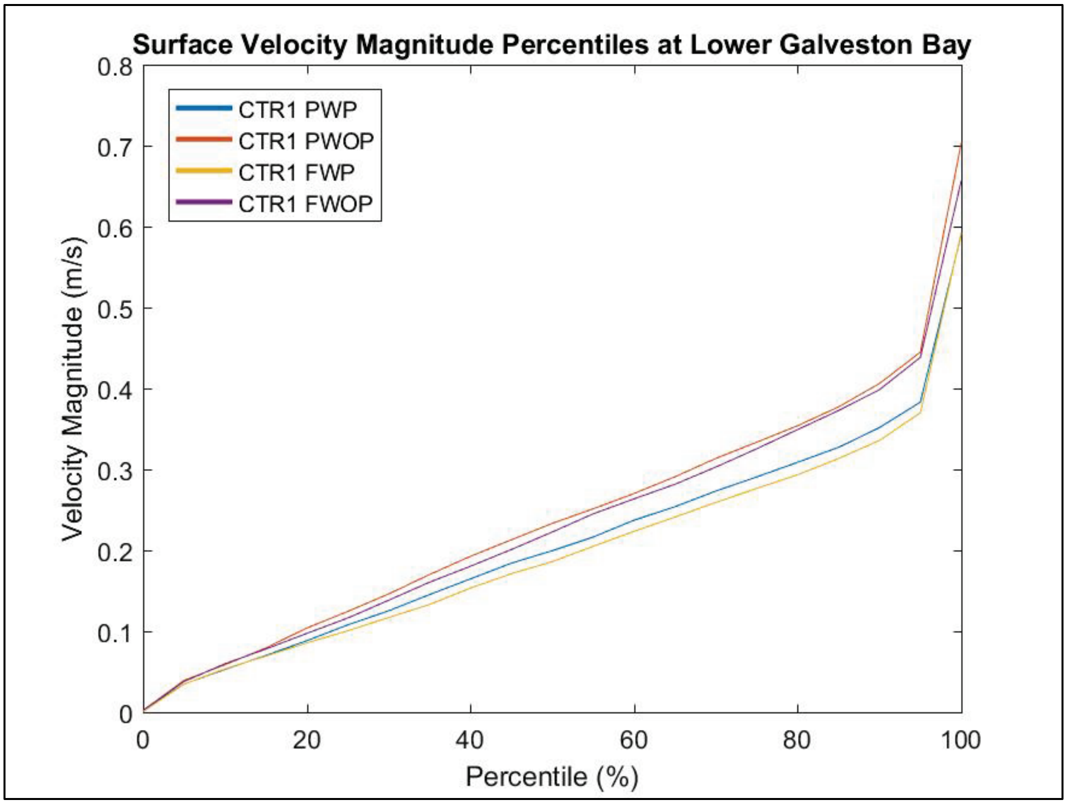

Bottom Velocity Magnitude (m/s) at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
Max
Mean
Min

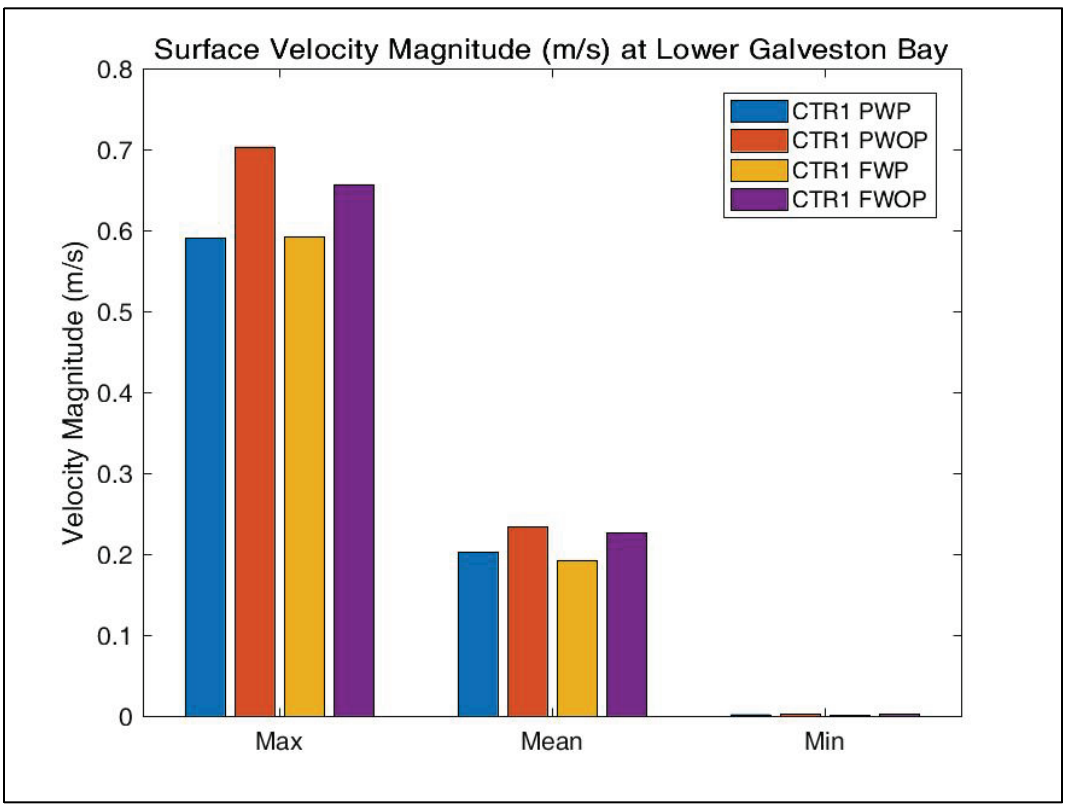

Surface Velocity Magnitude Percentiles at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100
Percentile (%)

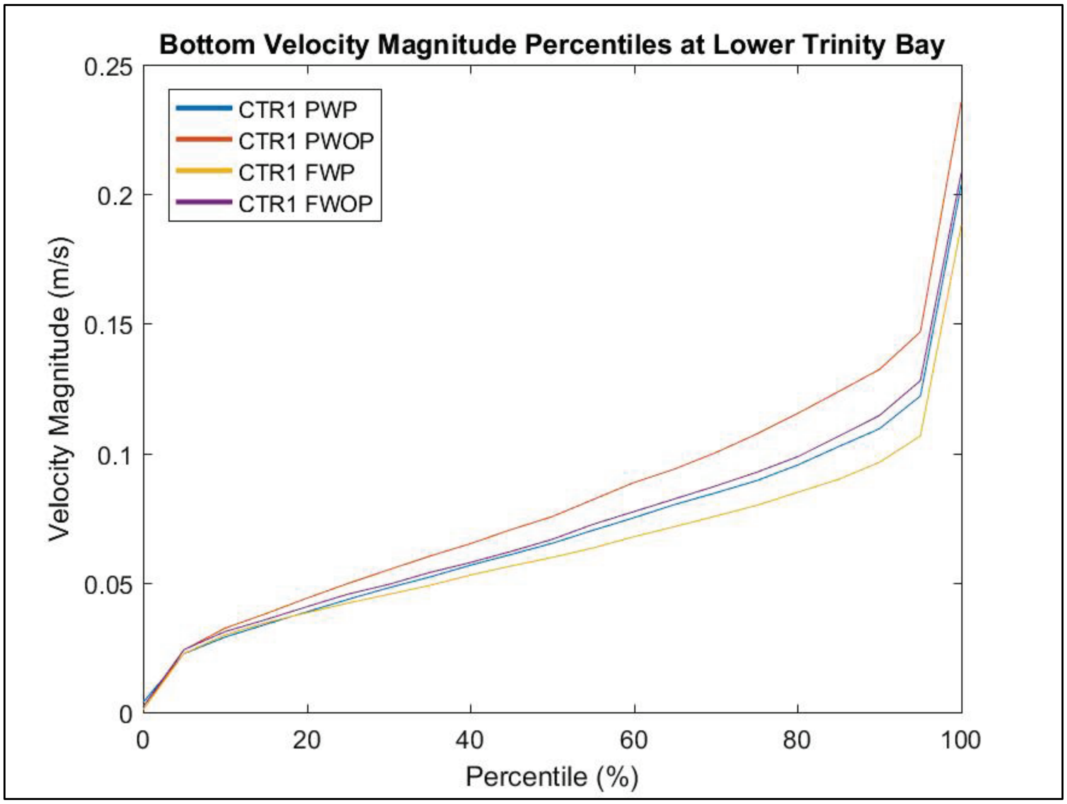

Surface Velocity Magnitude (m/s) at Upper Galveston Bay 2
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Max
Mean
Min

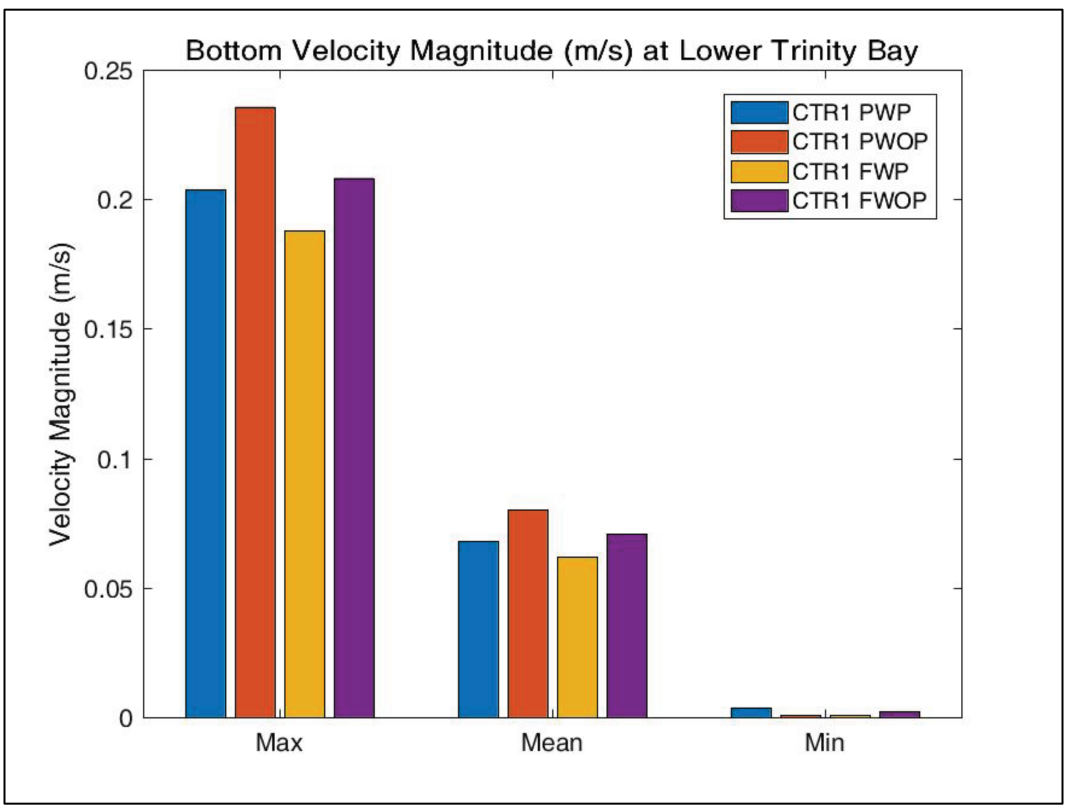

Bottom Velocity Magnitude Percentiles at Lower Galveston Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

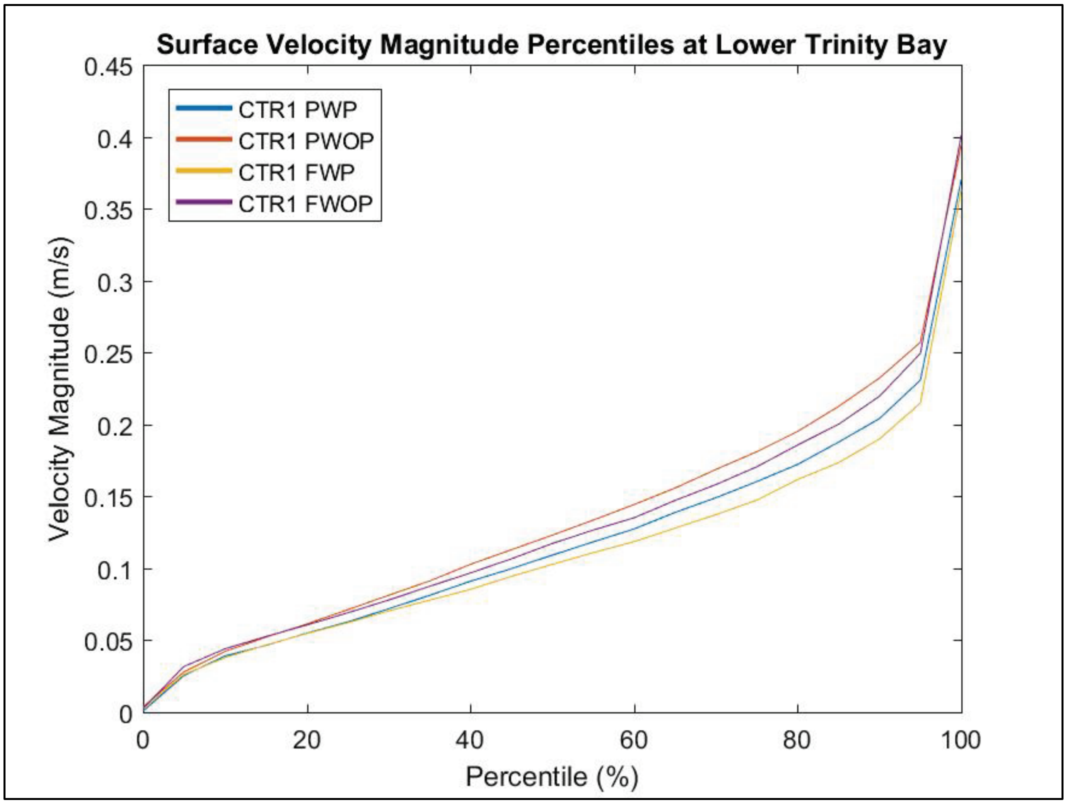

Bottom Velocity Magnitude (m/s) at Lower Galveston Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.1
0.2
0.3
0.4
0.5
0.6
Max
Mean
Min

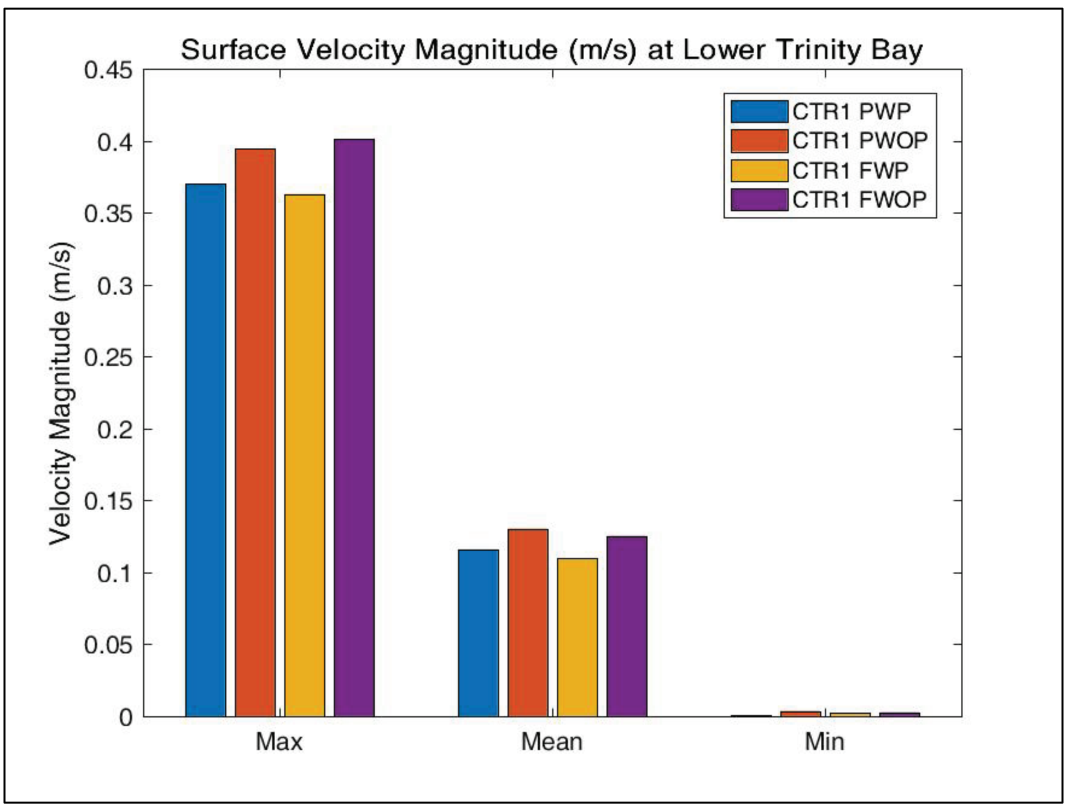

Surface Velocity Magnitude Percentiles at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100

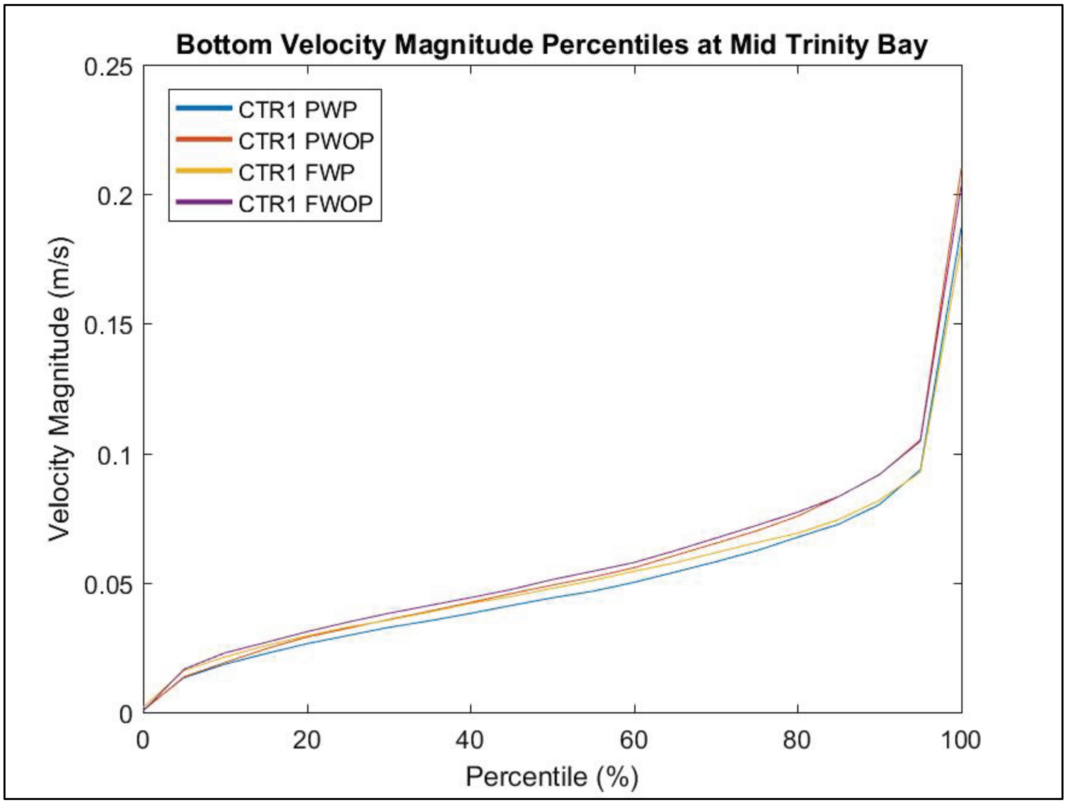

Surface Velocity Magnitude (m/s) at Lower Galveston Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Max
Mean
Min

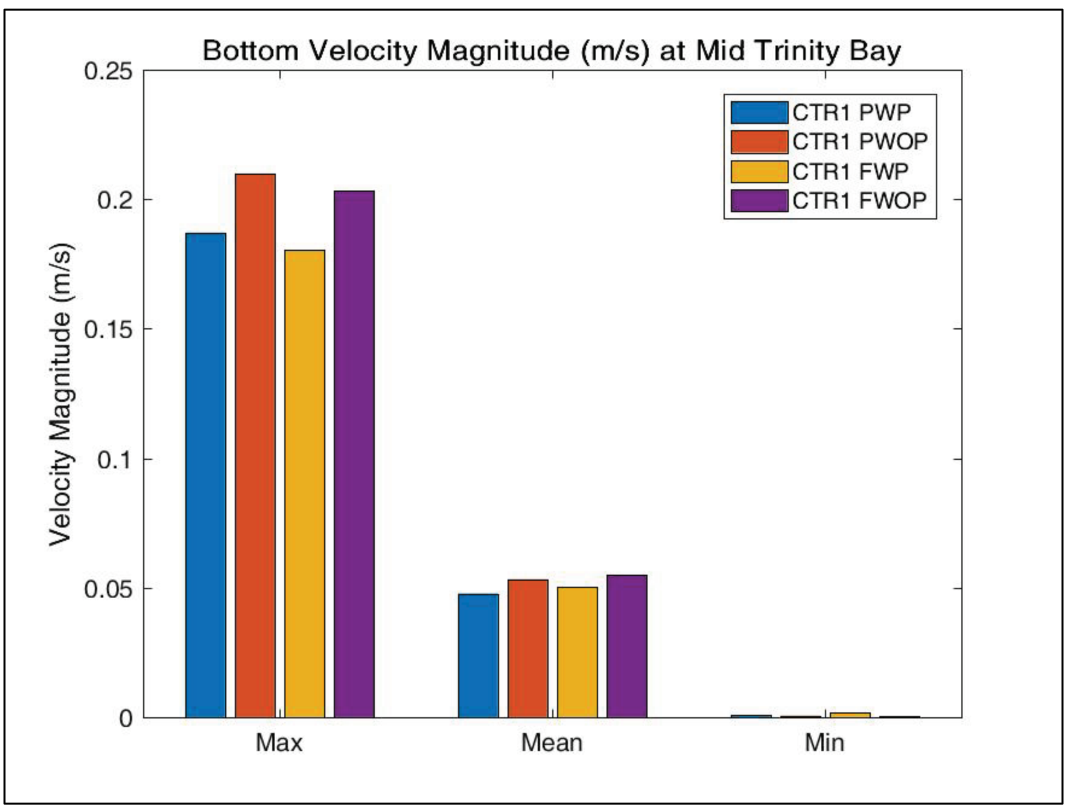

Bottom Velocity Magnitude Percentiles at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Percentile (%)

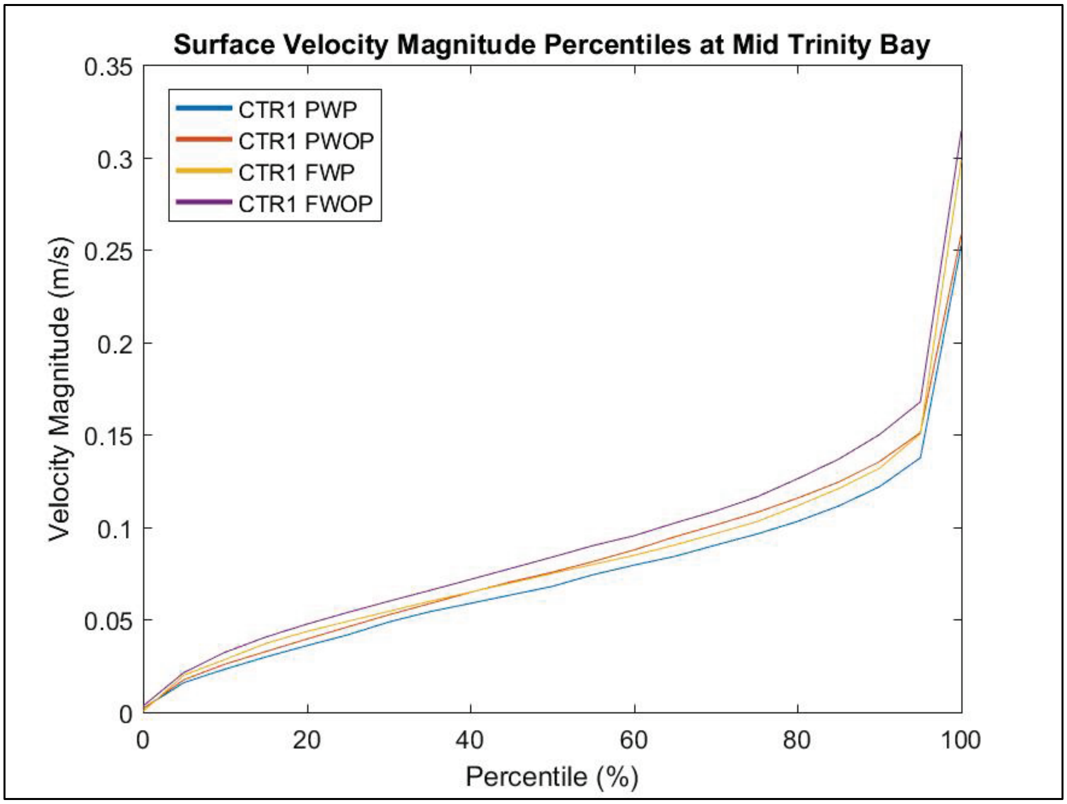

Bottom Velocity Magnitude (m/s) at Lower Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

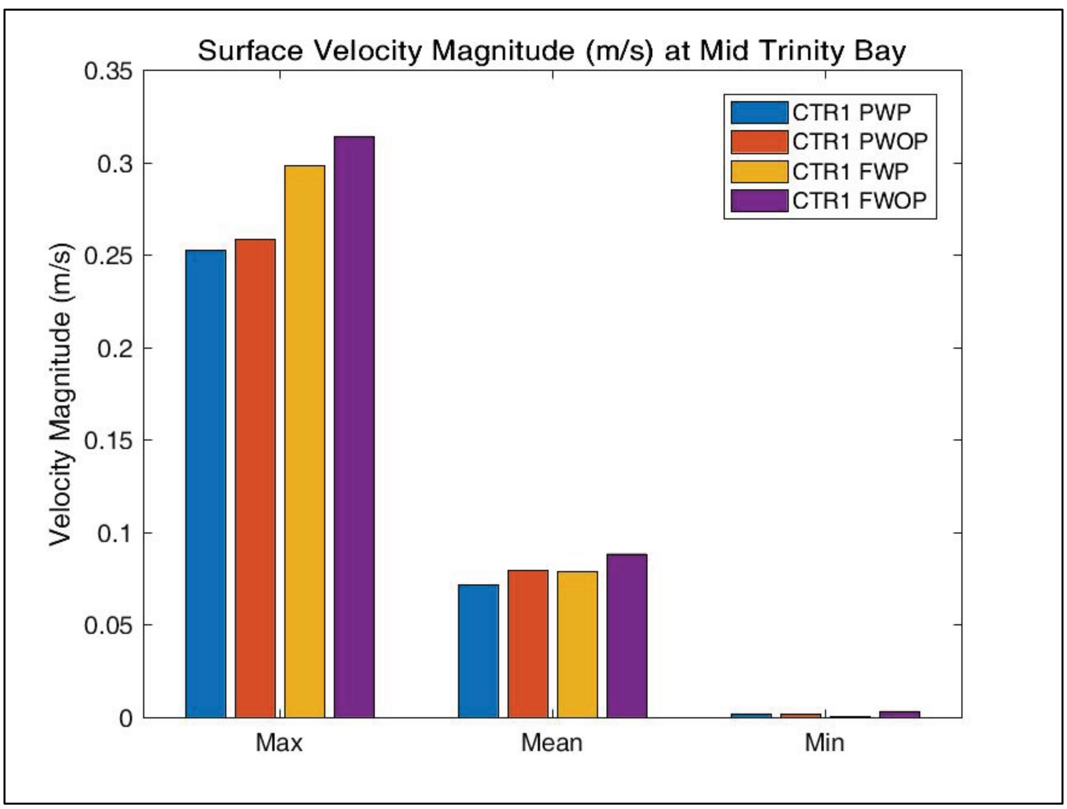

Surface Velocity Magnitude Percentiles at Lower Trinity Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0
20
40
60
80
100

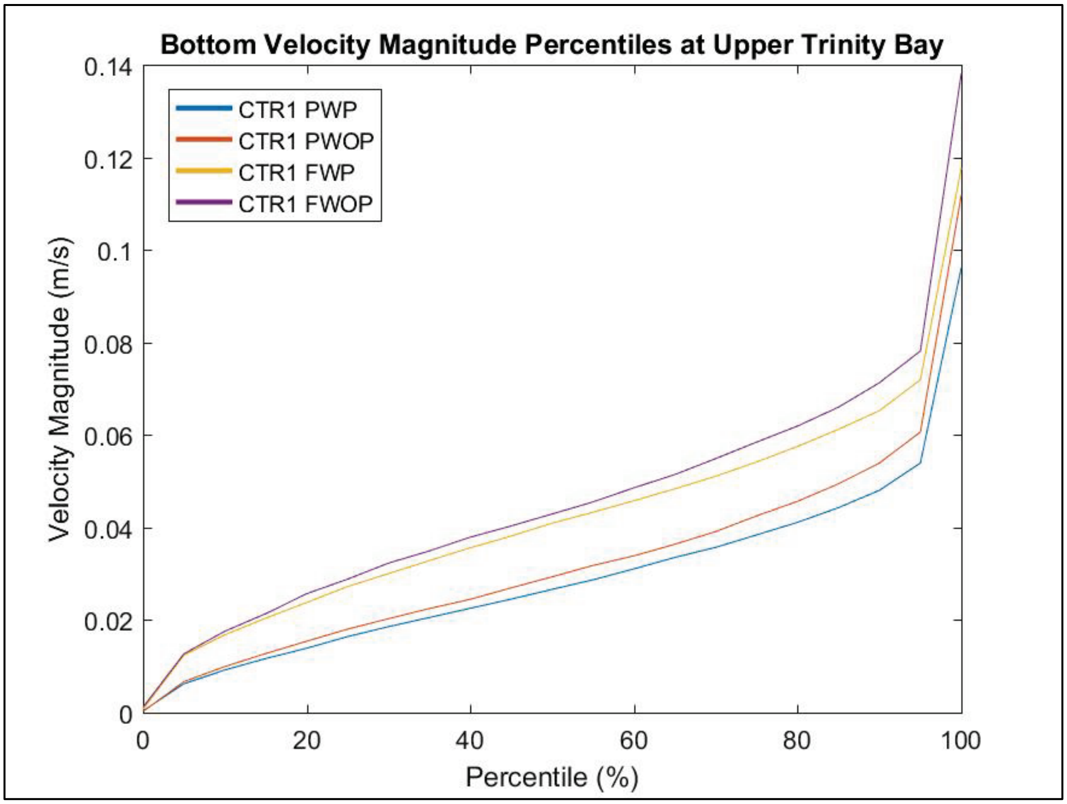

Surface Velocity Magnitude (m/s) at Lower Trinity Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Max
Mean
Min

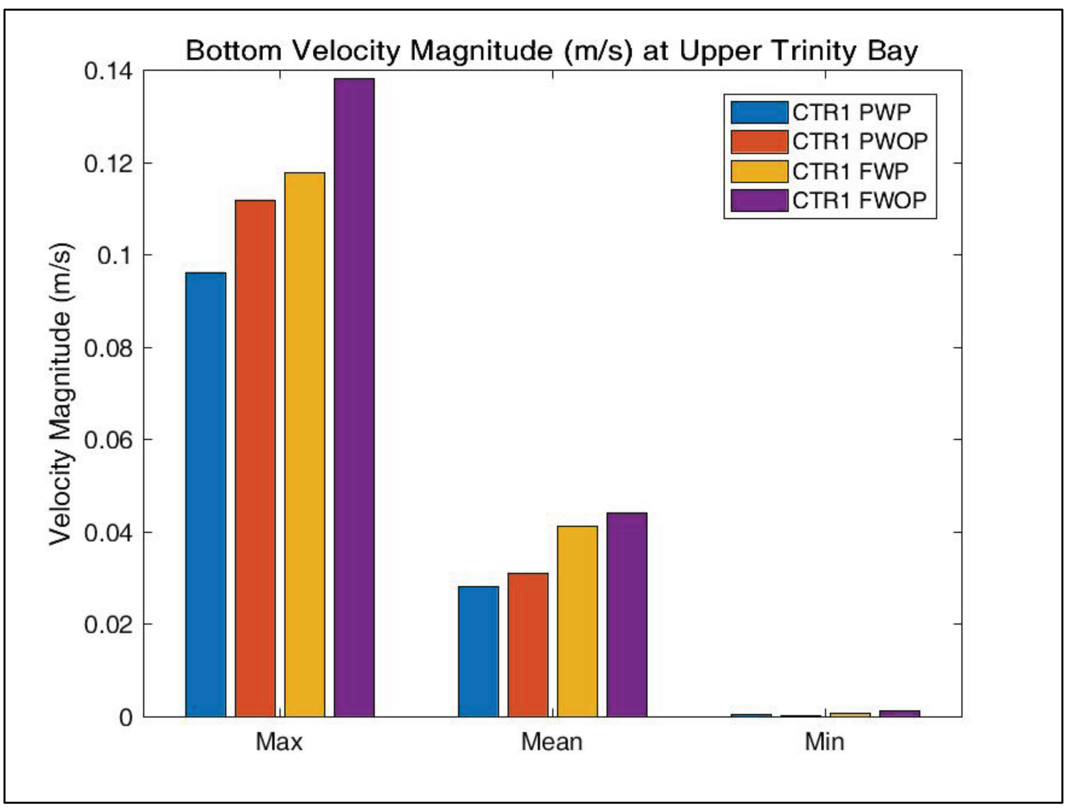

Bottom Velocity Magnitude Percentiles at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Percentile (%)

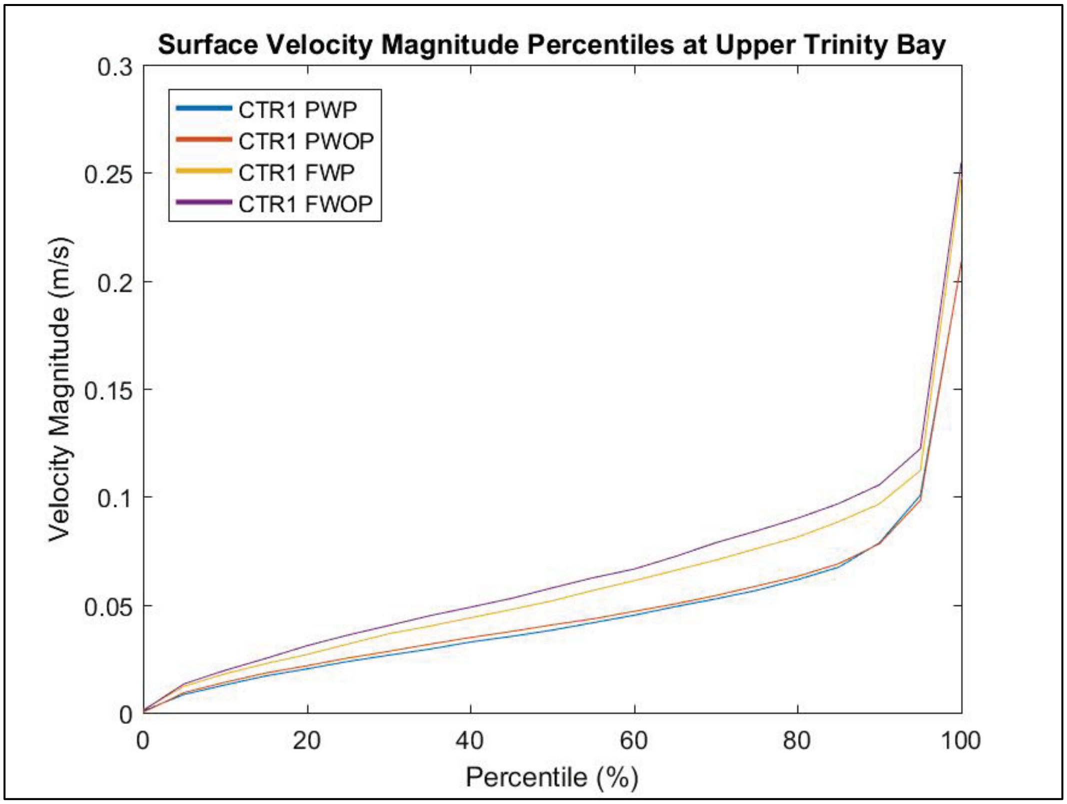

Bottom Velocity Magnitude (m/s) at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

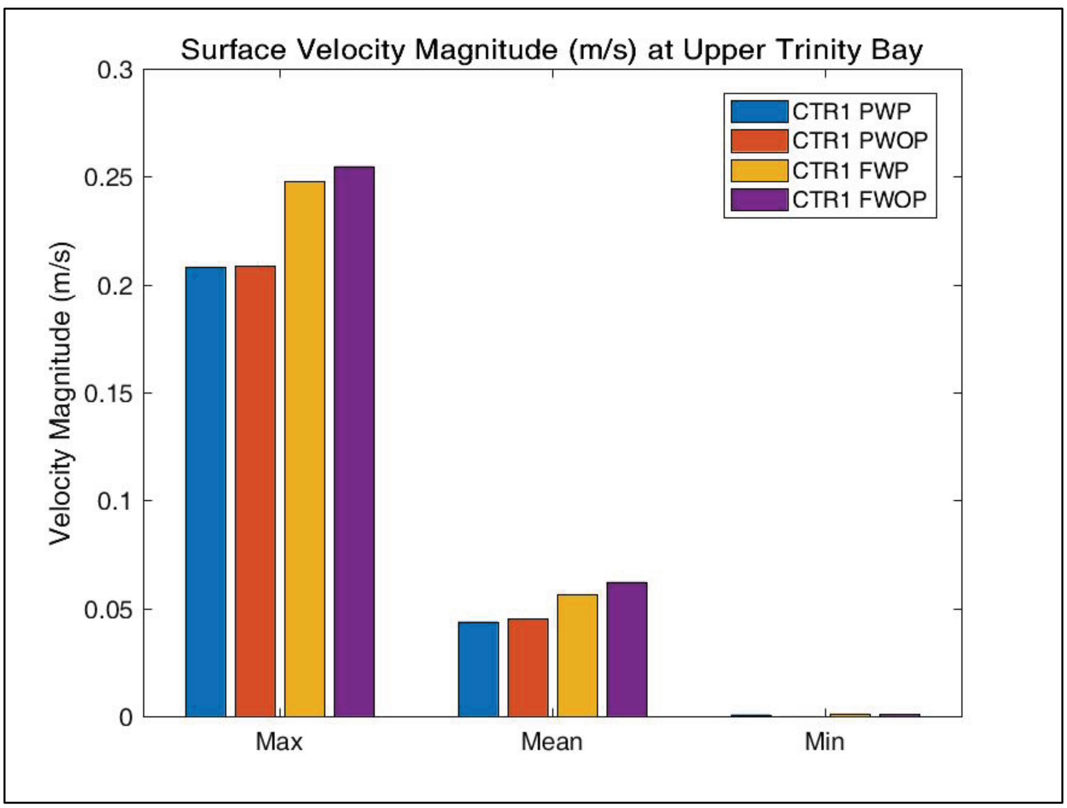

Surface Velocity Magnitude Percentiles at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
20
40
60
80
100

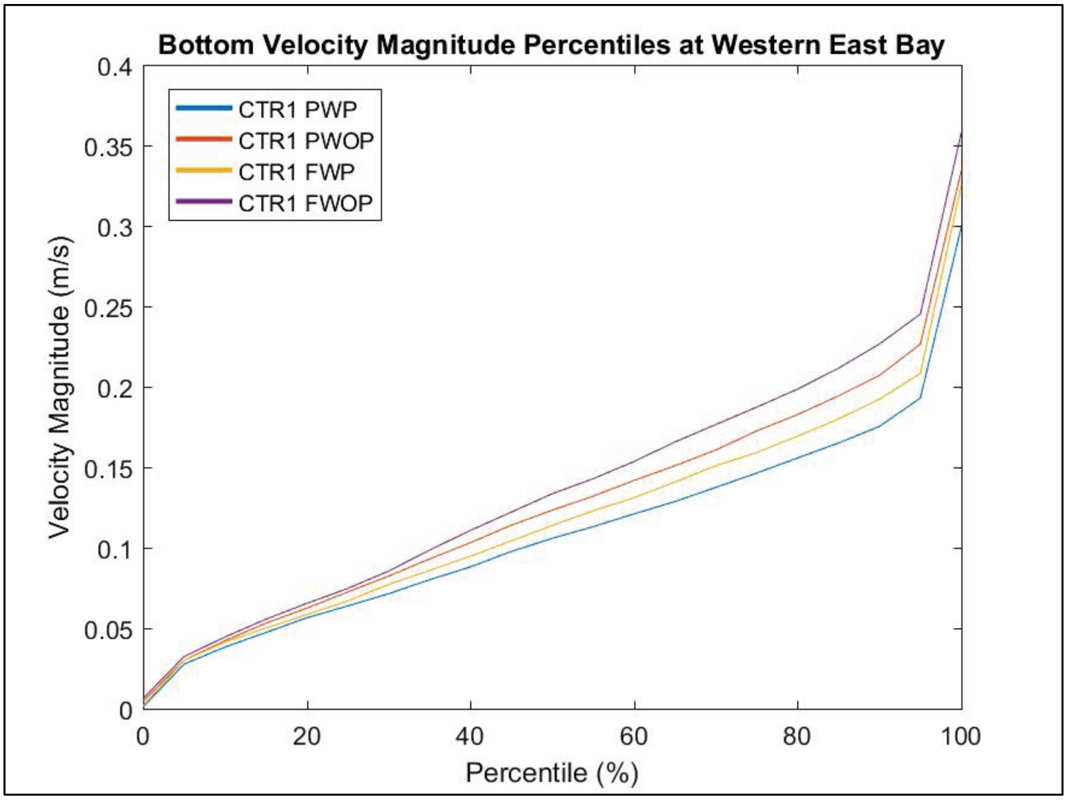

Surface Velocity Magnitude (m/s) at Mid Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

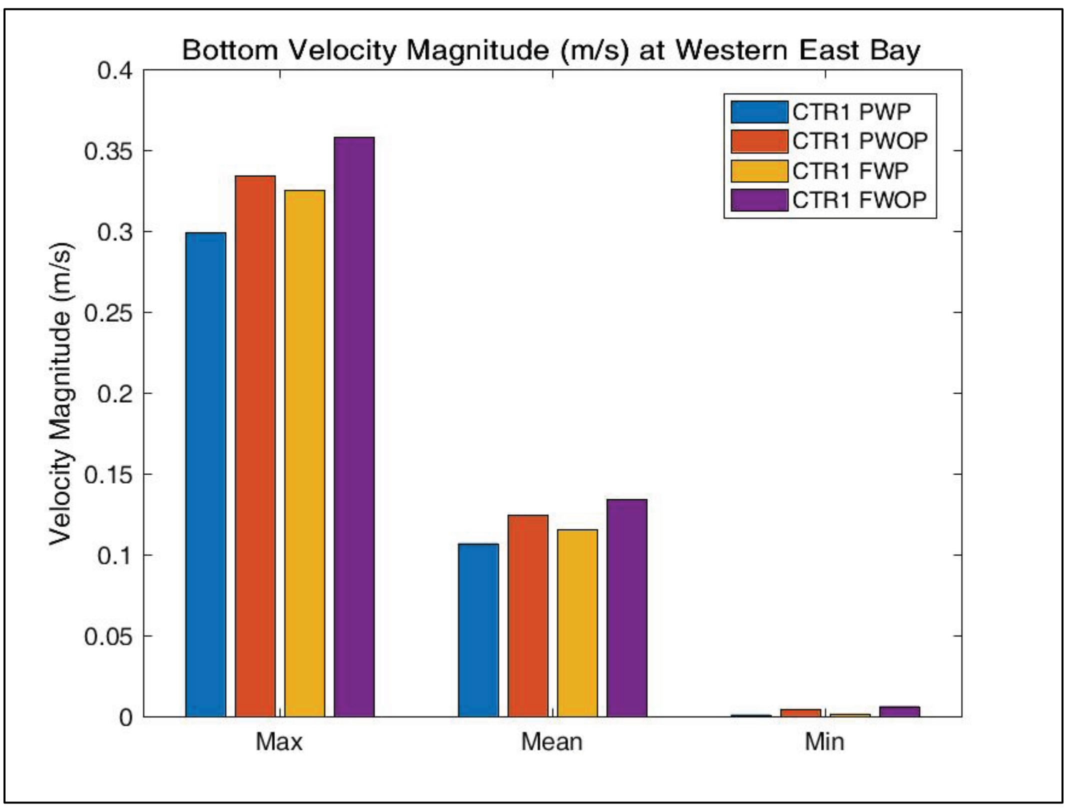

Bottom Velocity Magnitude Percentiles at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0
20
40
60
80
100

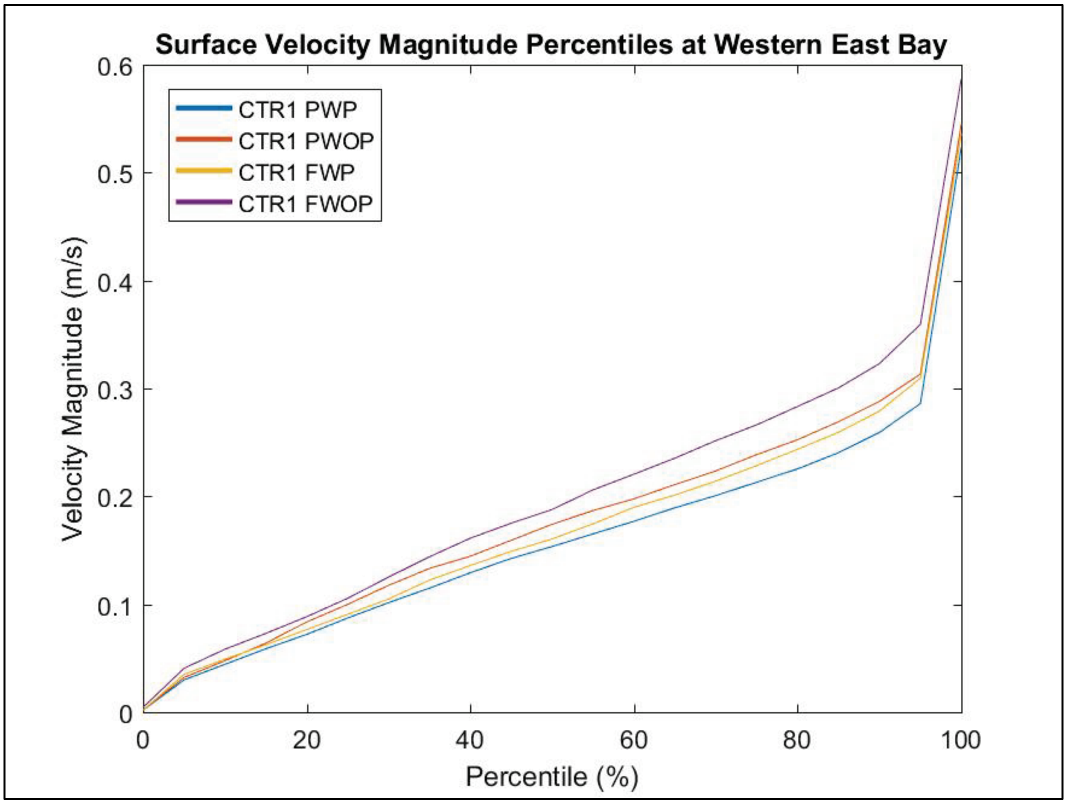

Bottom Velocity Magnitude (m/s) at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Max
Mean
Min

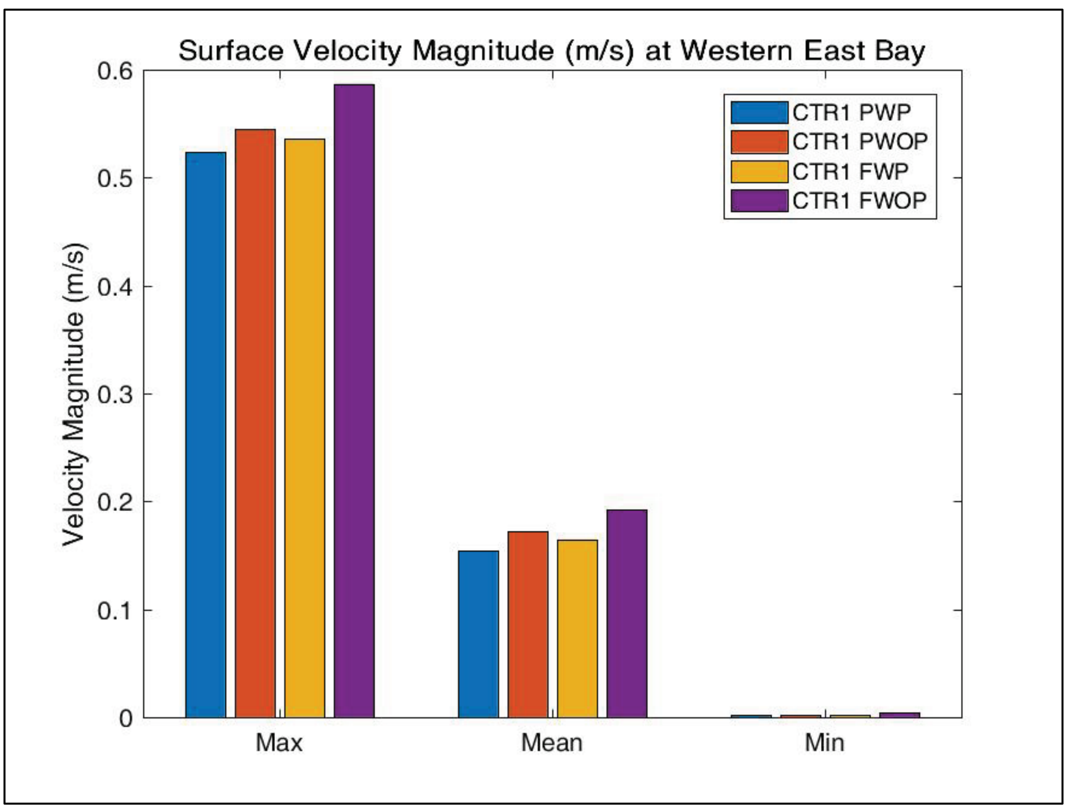

Surface Velocity Magnitude Percentiles at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100
Percentile (%)

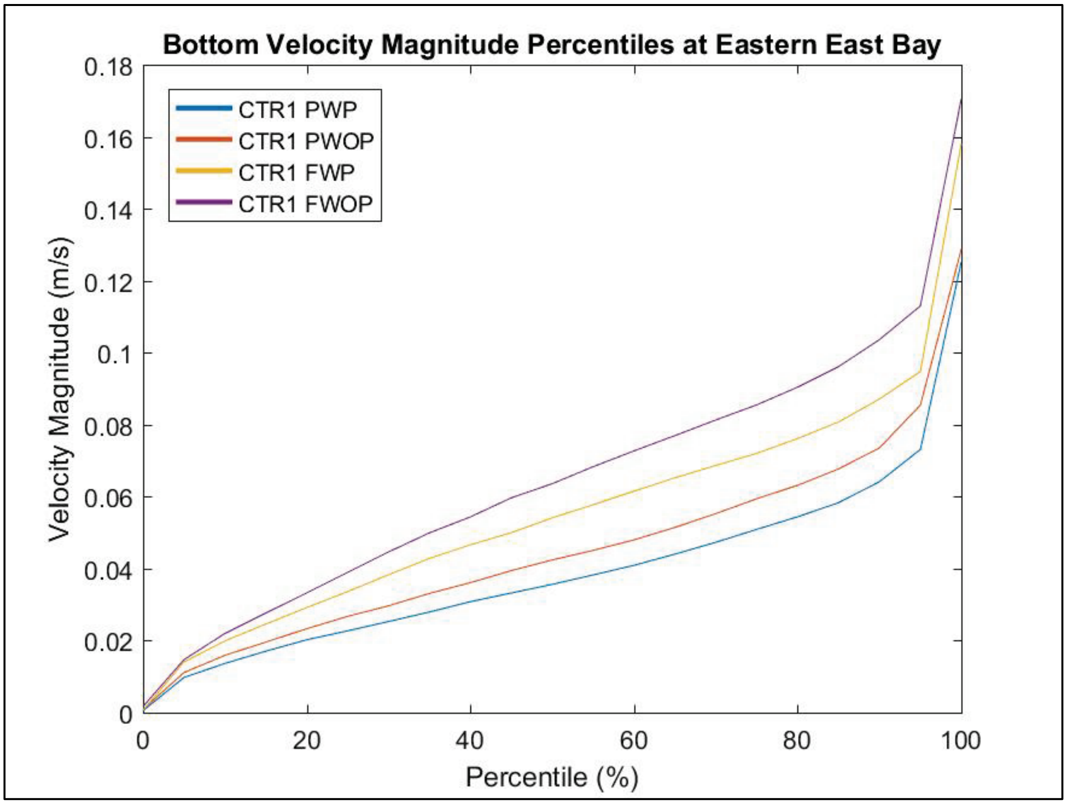

Surface Velocity Magnitude (m/s) at Upper Trinity Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Max
Mean
Min

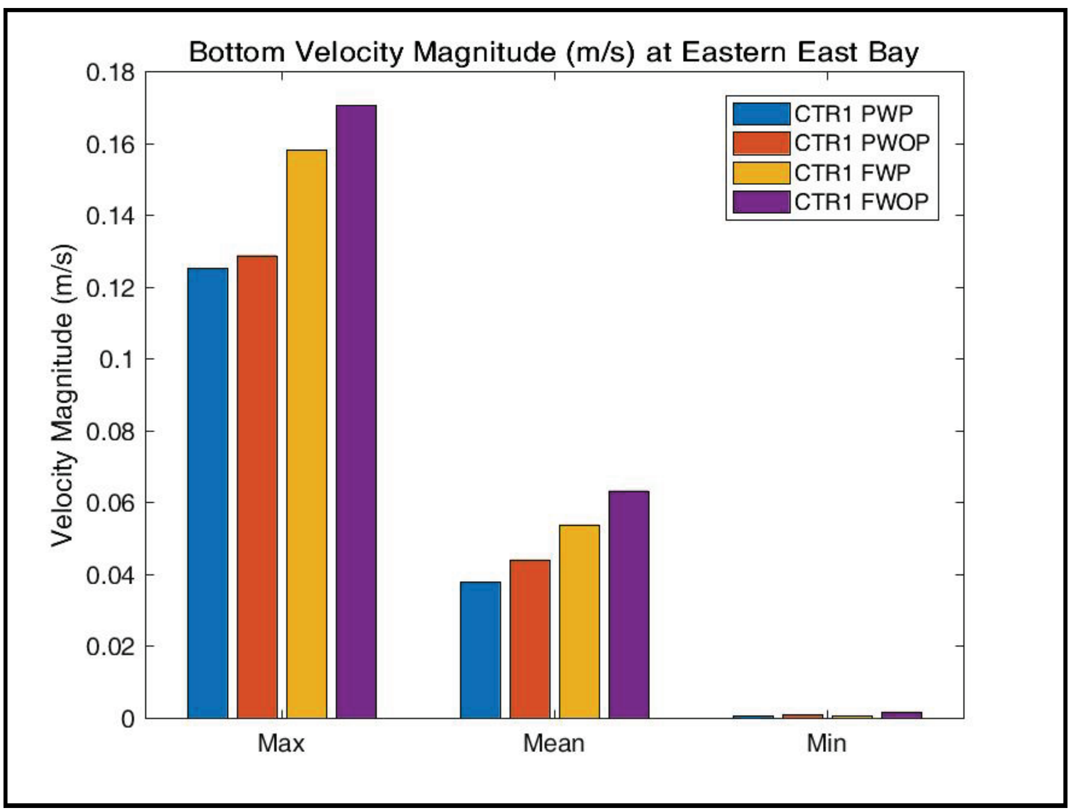

Bottom Velocity Magnitude Percentiles at Western East Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
20
40
60
80
100

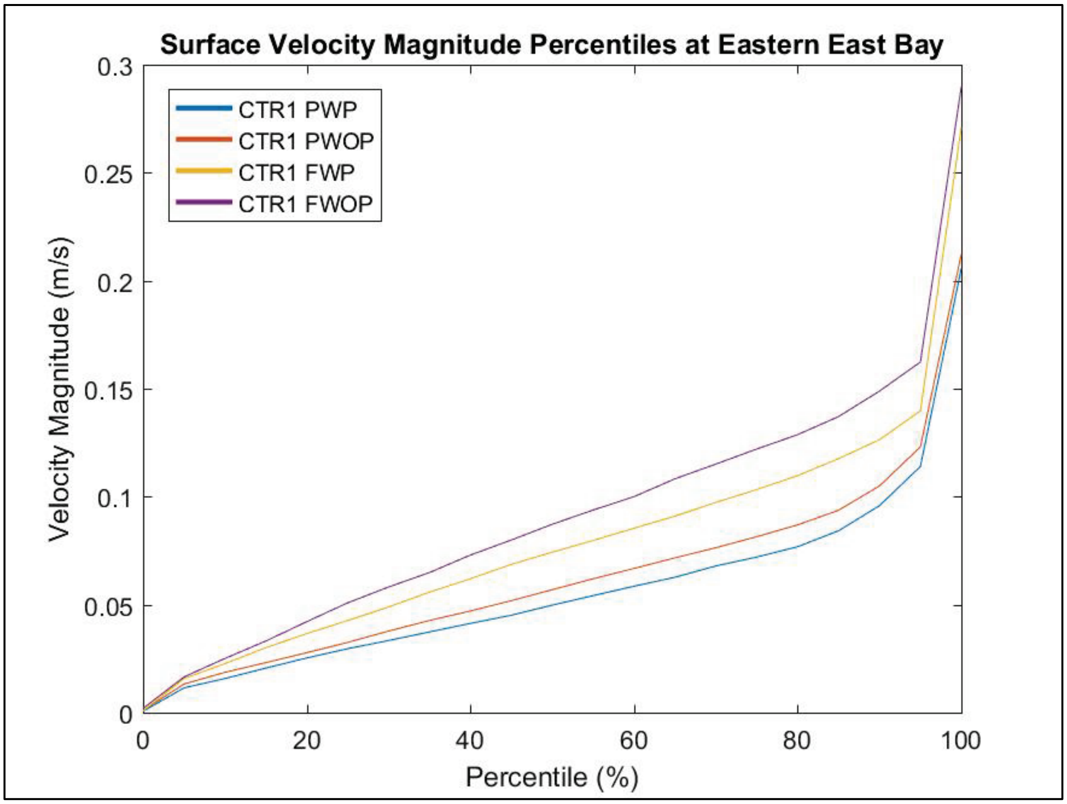

Bottom Velocity Magnitude (m/s) at Western East Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Max
Mean
Min

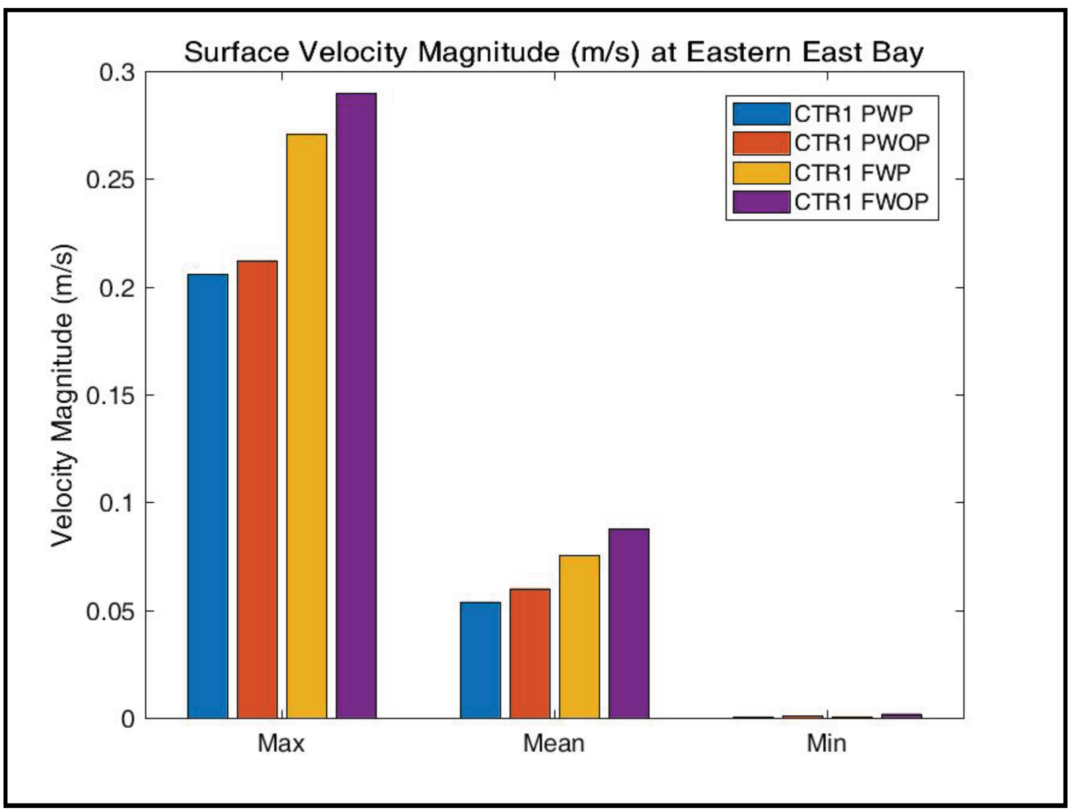

Surface Velocity Magnitude Percentiles at Western East Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100

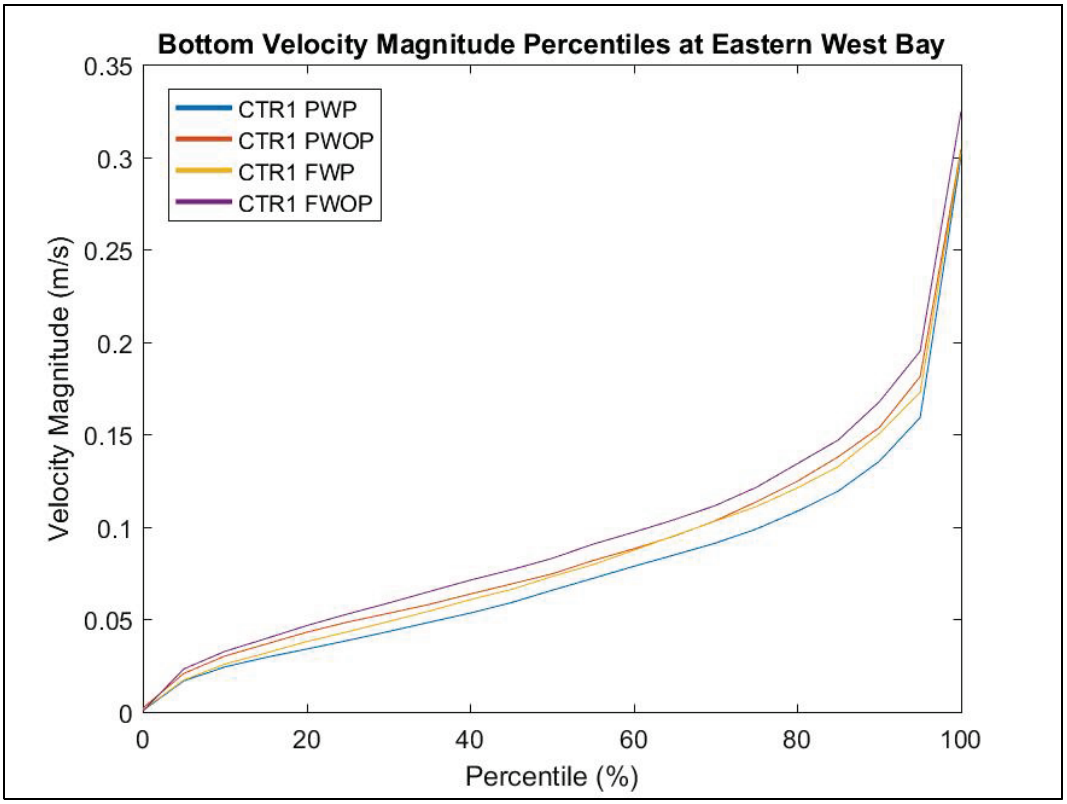

Surface Velocity Magnitude (m/s) at Western East Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.6
0.5
0.4
0.3
0.2
0.1
0
Max
Mean
Min

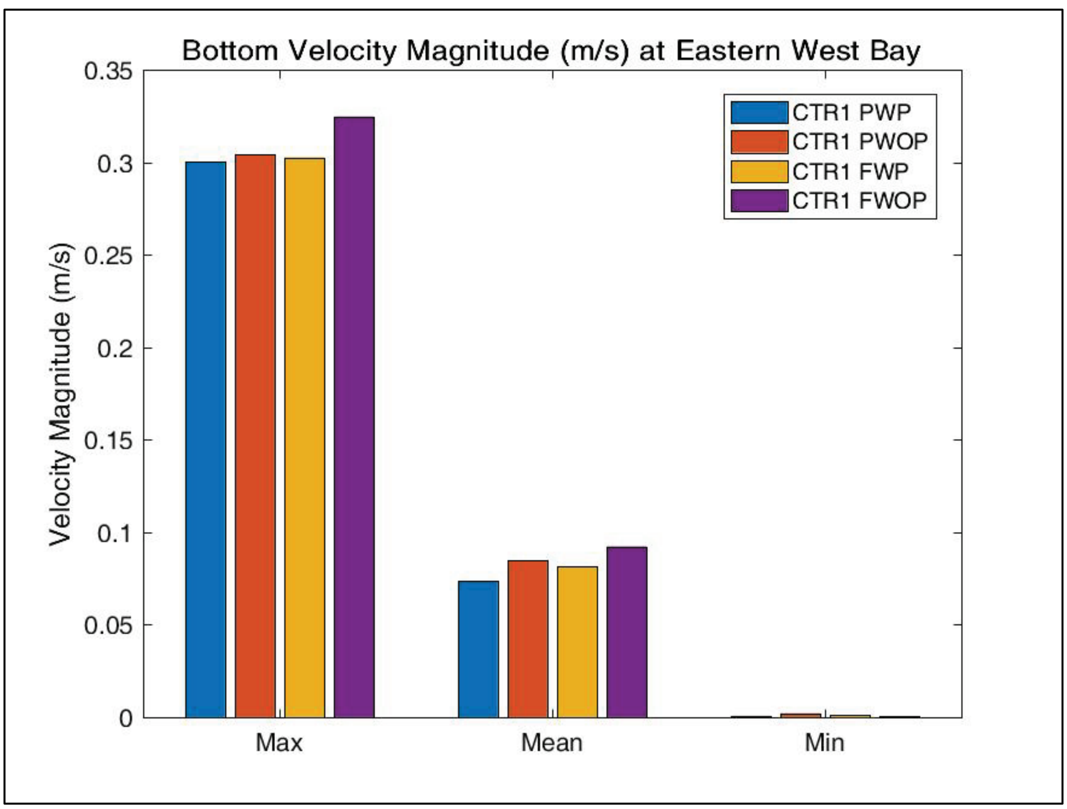

Bottom Velocity Magnitude Percentiles at Eastern East Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
20
40
60
80
100

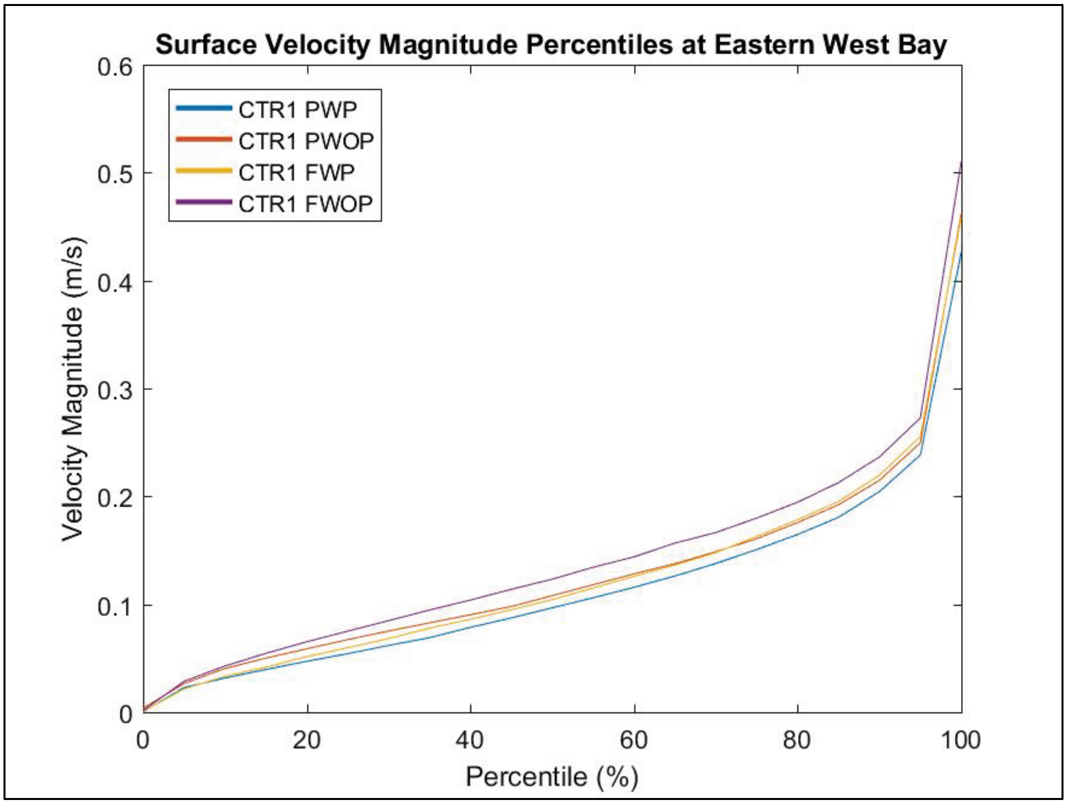

Bottom Velocity Magnitude (m/s) at Eastern East Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Max
Mean
Min

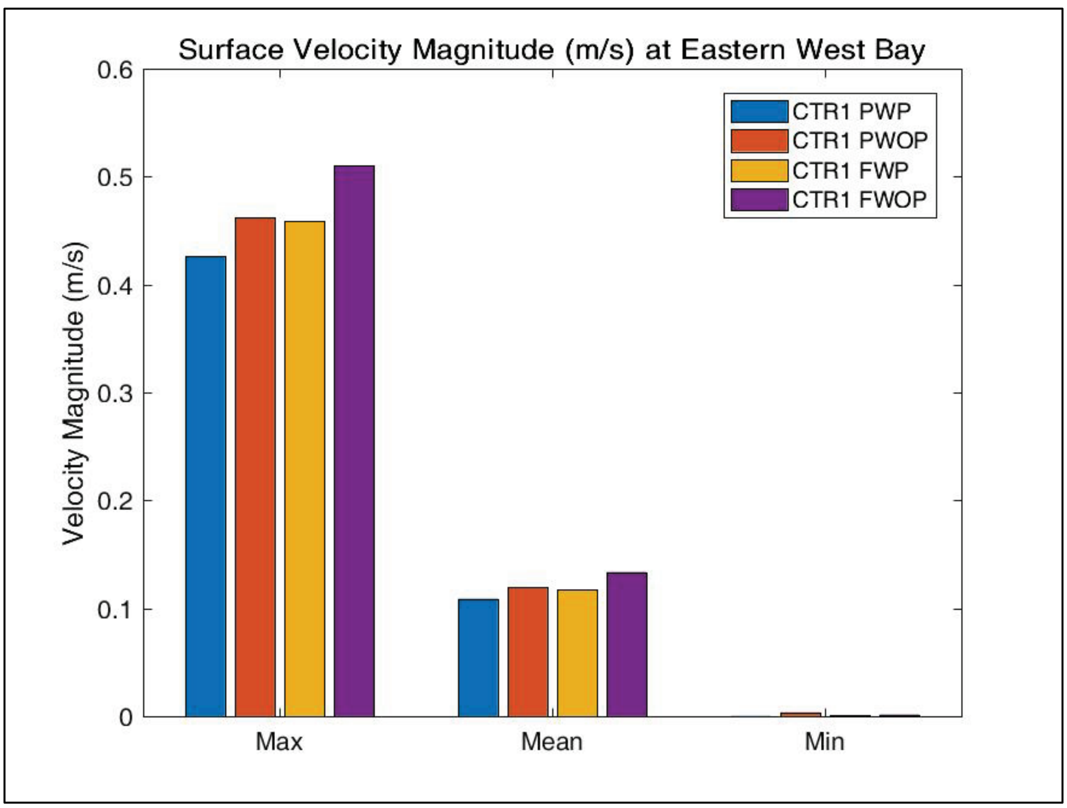

Surface Velocity Magnitude Percentiles at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100
Percentile (%)

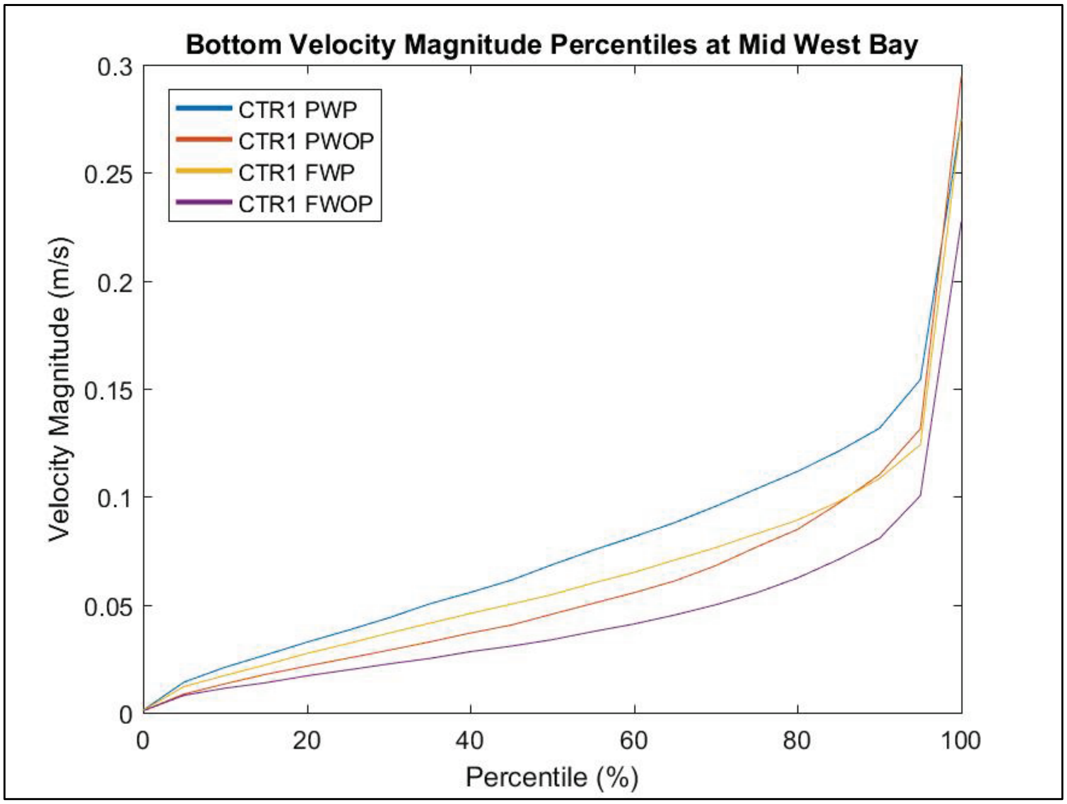

Surface Velocity Magnitude (m/s) at Eastern East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Max
Mean
Min

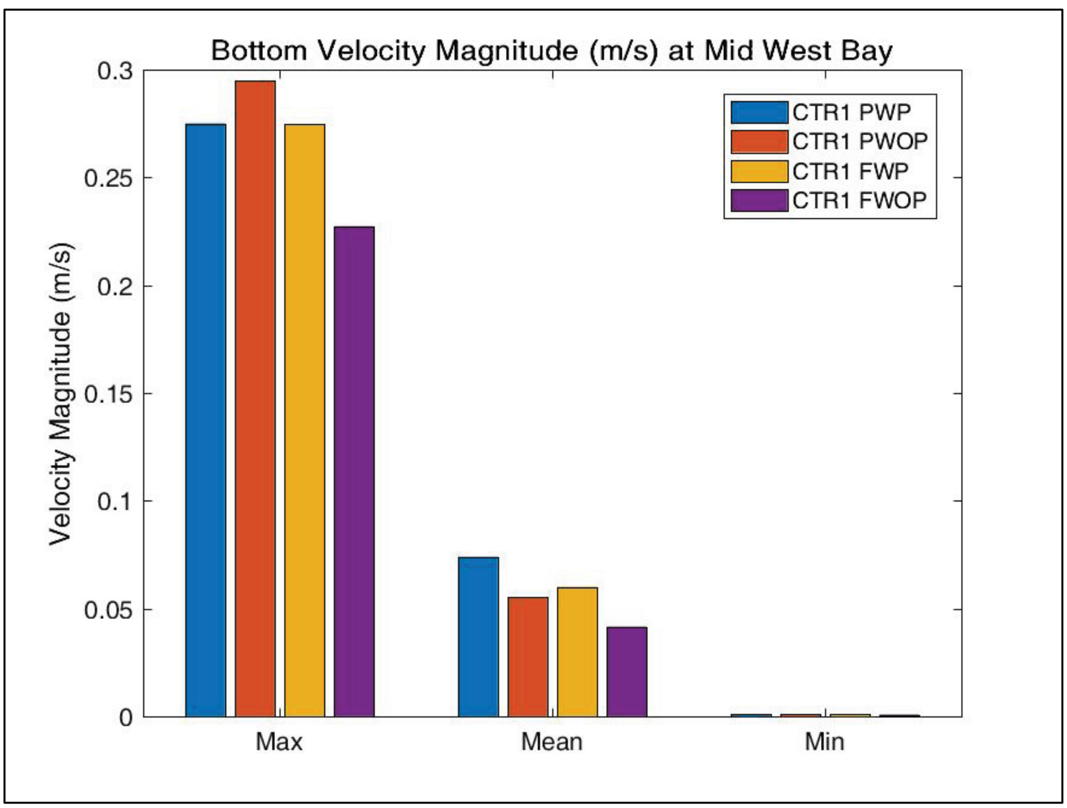

Bottom Velocity Magnitude Percentiles at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
20
40
60
80
100
Percentile (%)

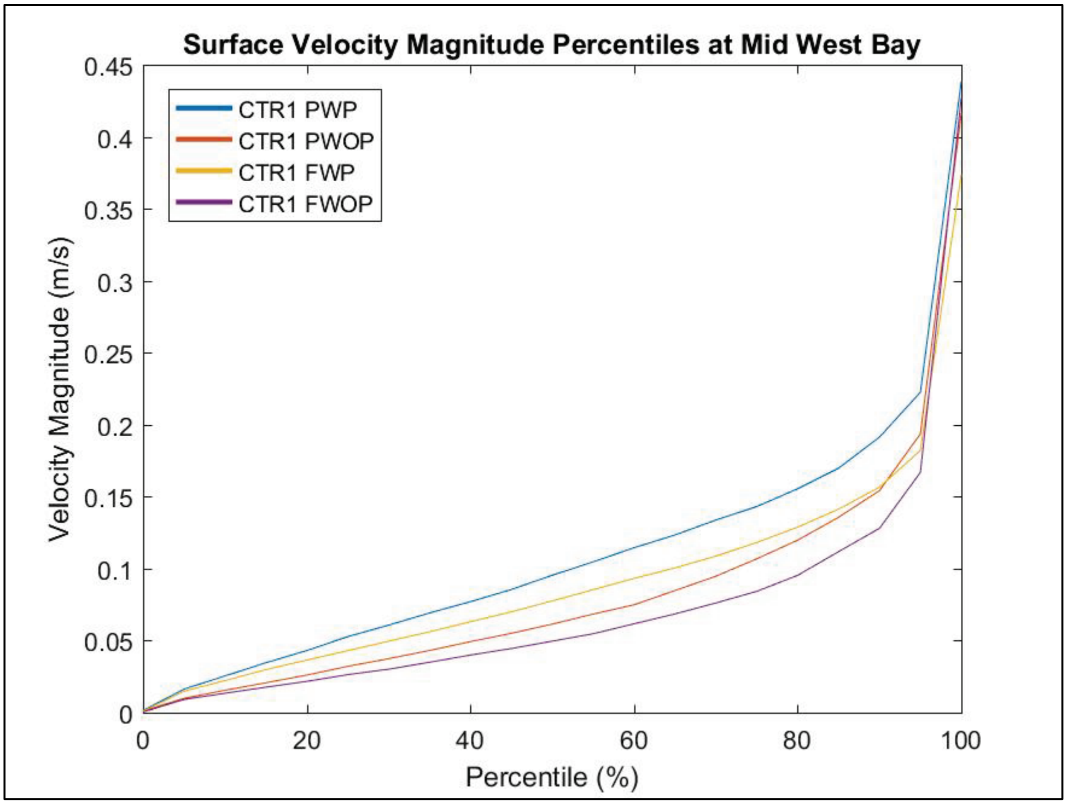

Bottom Velocity Magnitude (m/s) at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Max
Mean
Min

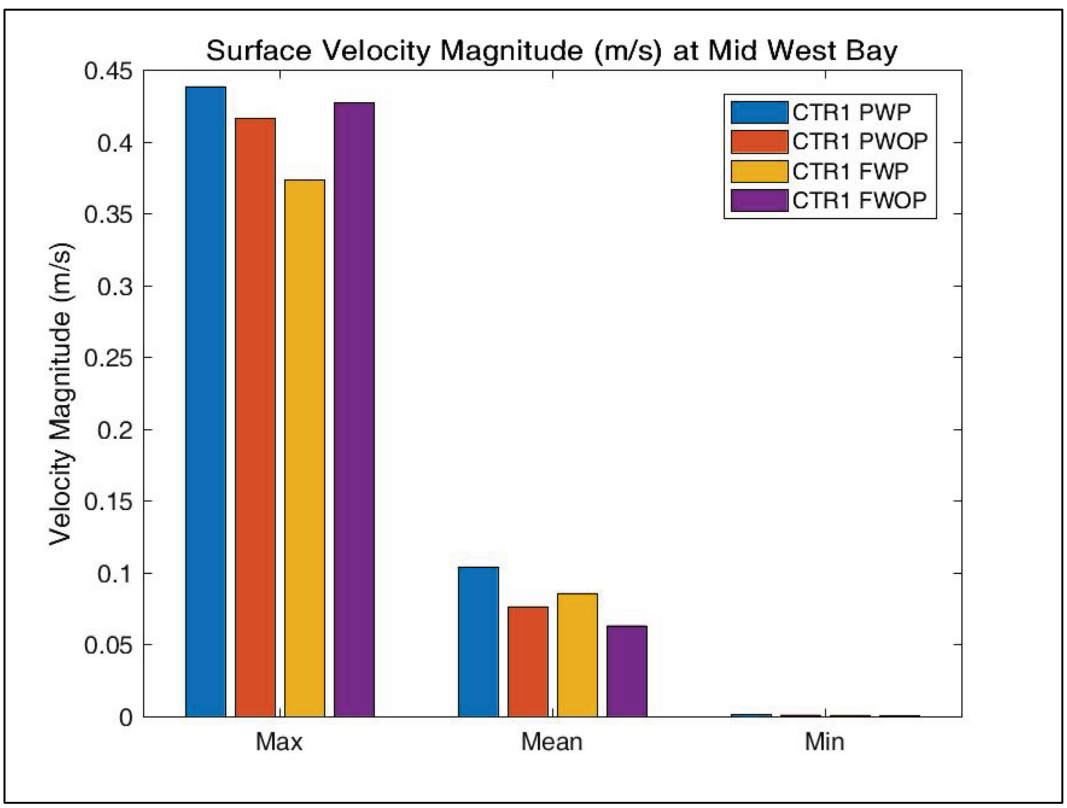

Surface Velocity Magnitude Percentiles at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

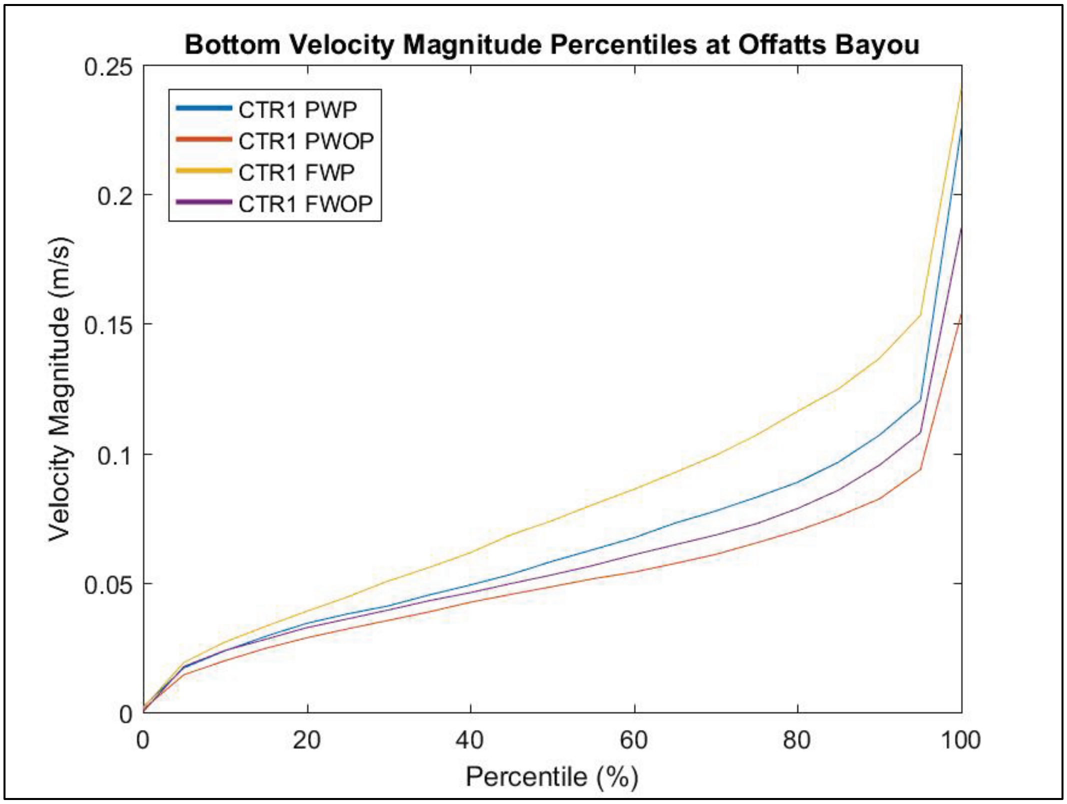

Surface Velocity Magnitude (m/s) at Eastern West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
Max
Mean
Min

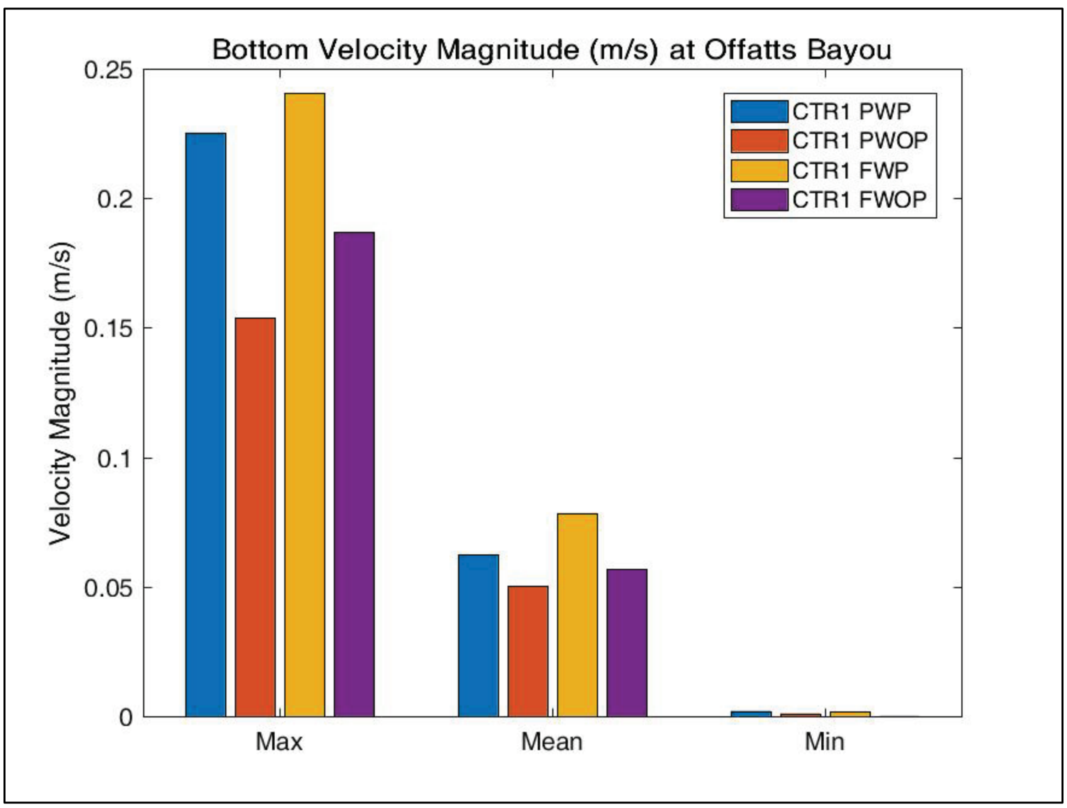

Bottom Velocity Magnitude Percentiles at Mid West Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100

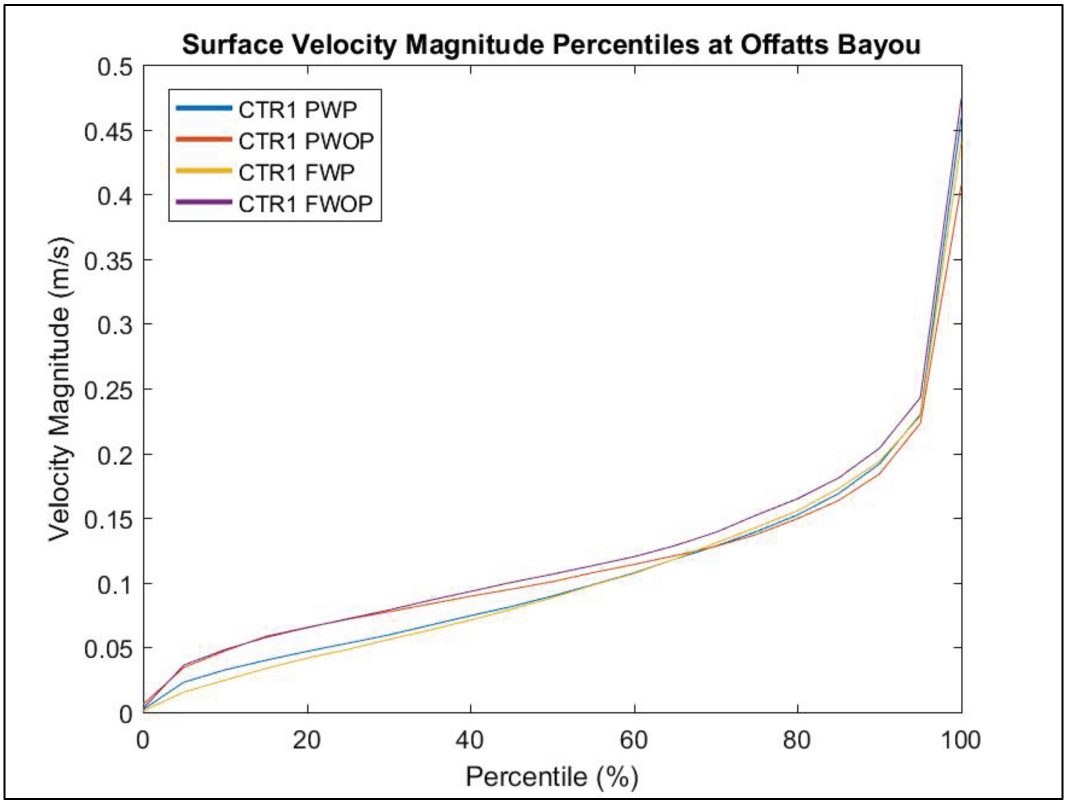

Bottom Velocity Magnitude (m/s) at Mid West Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0
0.05
0.1
0.15
0.2
0.25
0.3
Max
Mean
Min

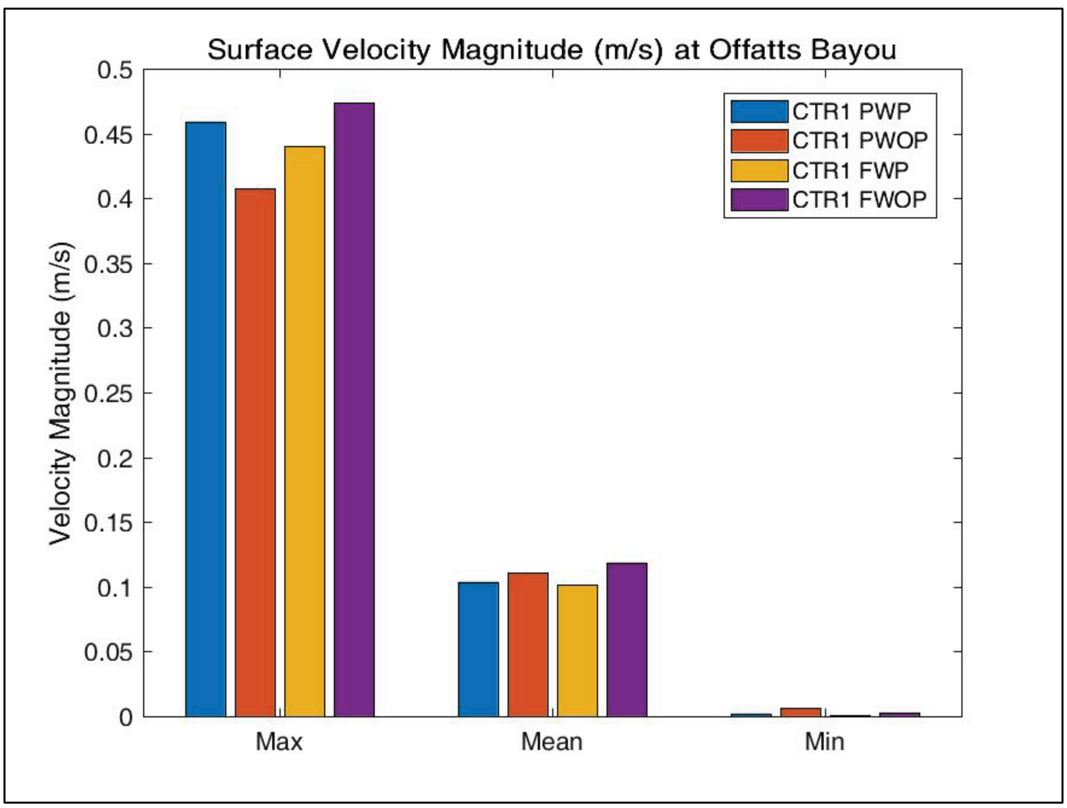

Surface Velocity Magnitude Percentiles at Mid West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Percentile (%)

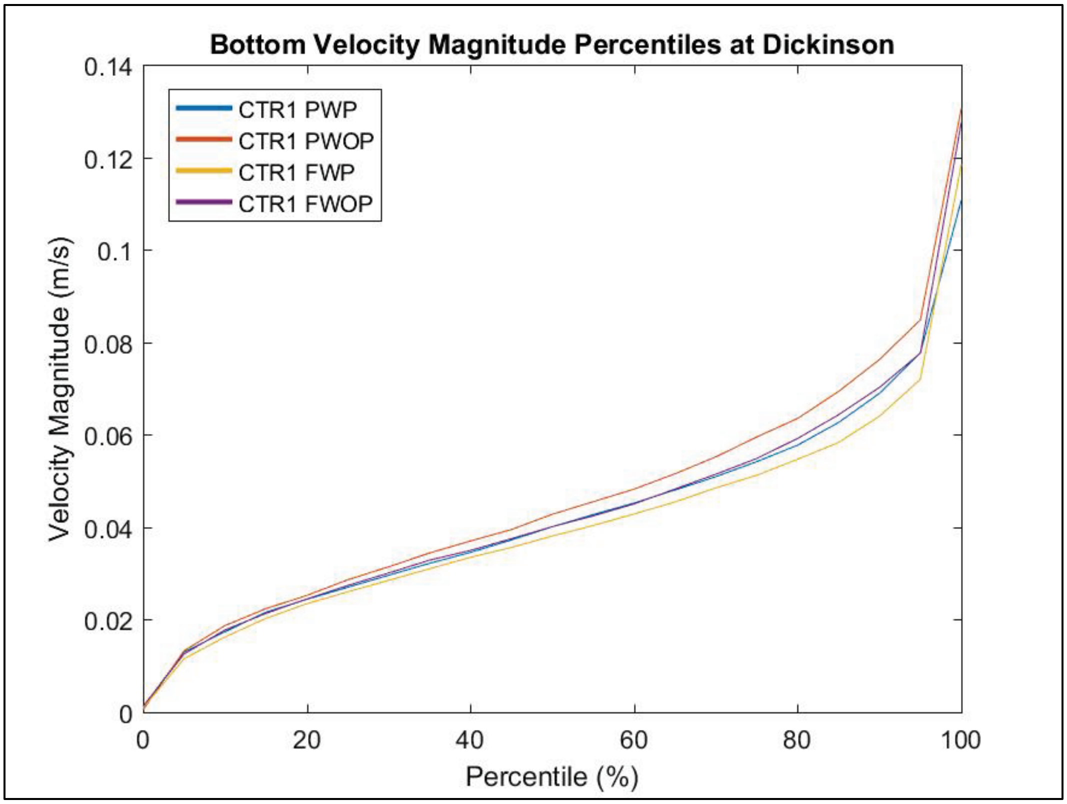

Surface Velocity Magnitude (m/s) at Mid West Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

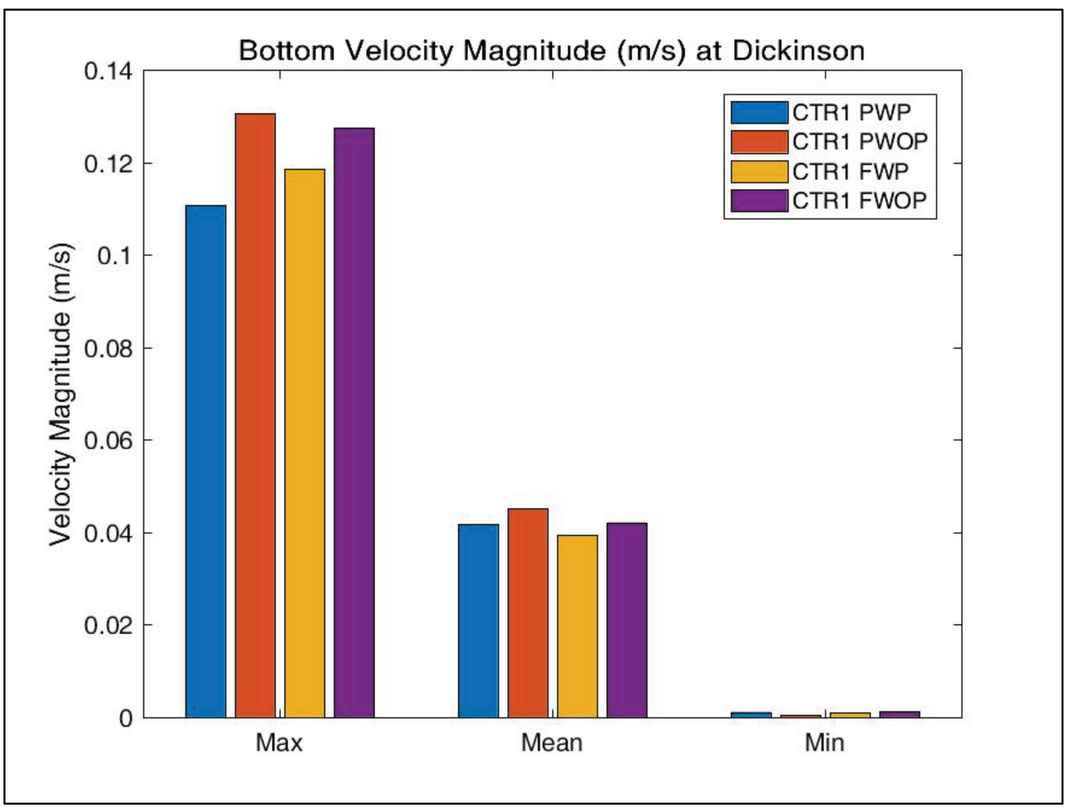

Bottom Velocity Magnitude Percentiles at Offatts Bayou
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100

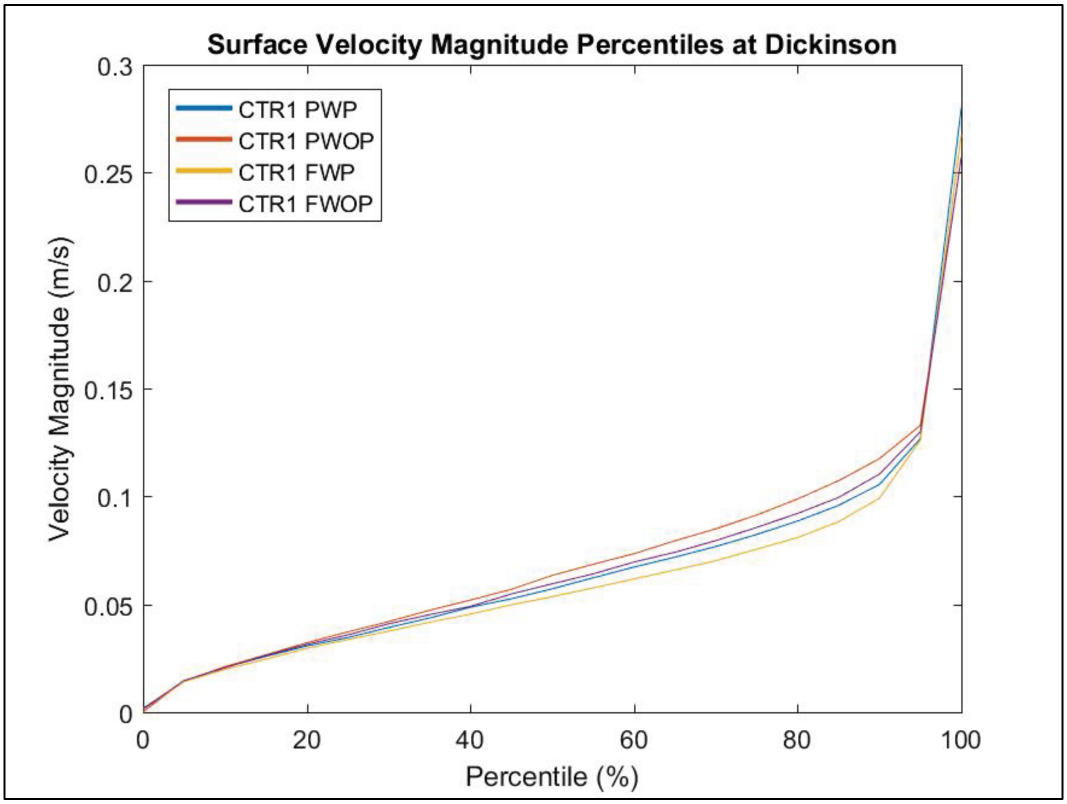

Bottom Velocity Magnitude (m/s) at Offatts Bayou
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

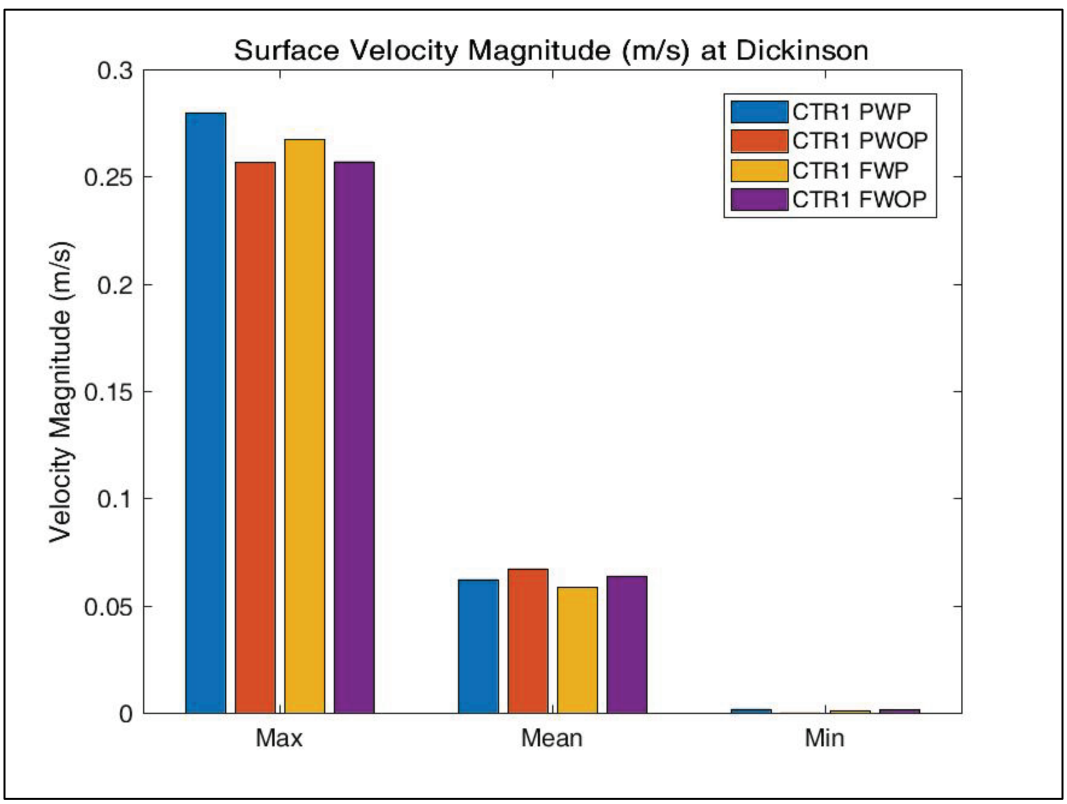

Surface Velocity Magnitude Percentiles at Offatts Bayou
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100

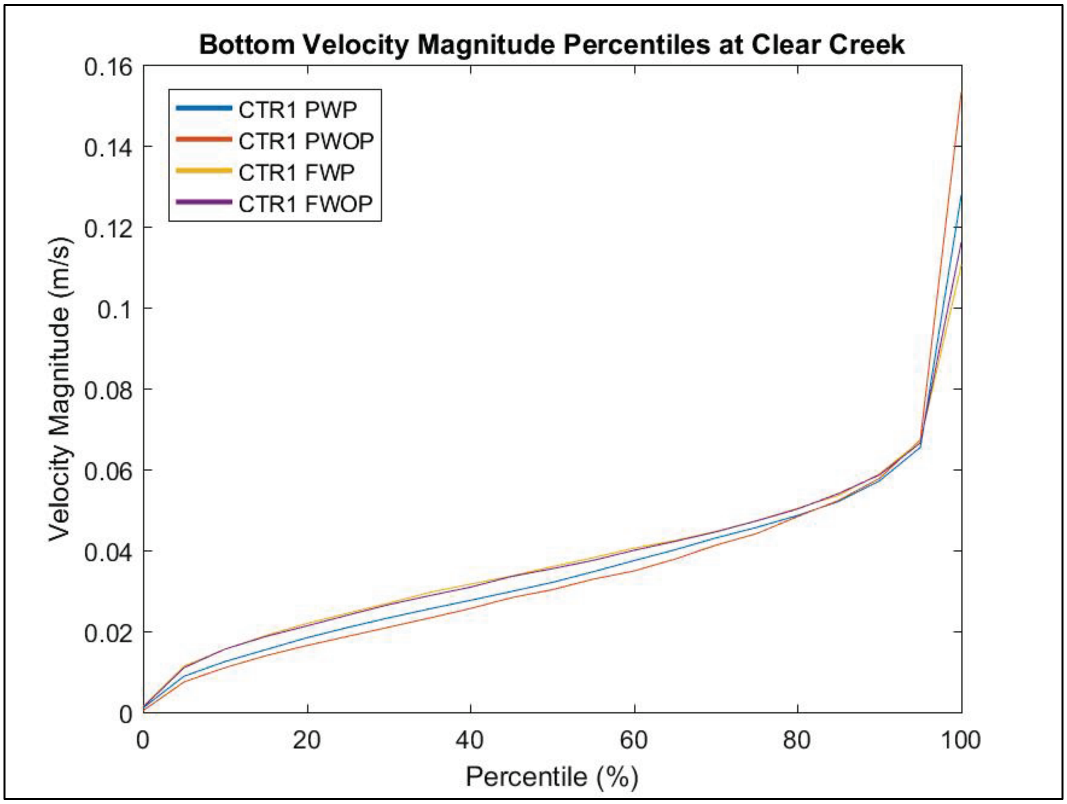

Surface Velocity Magnitude (m/s) at Offatts Bayou
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

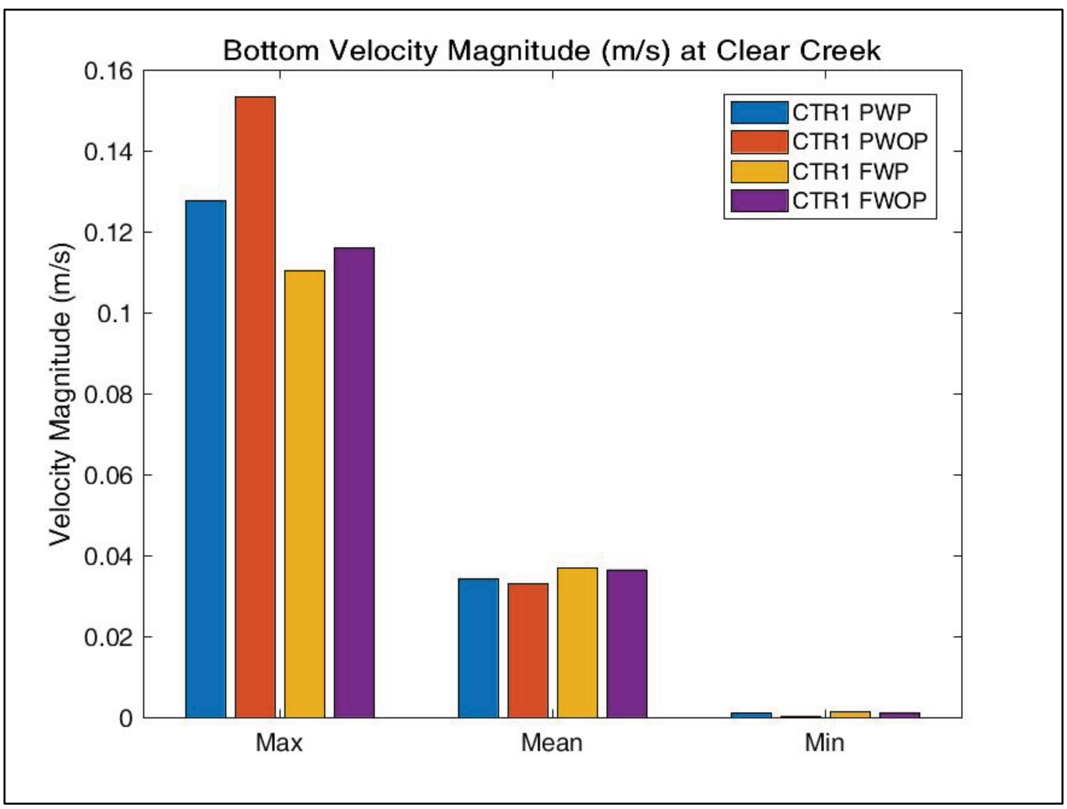

Bottom Velocity Magnitude Percentiles at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Percentile (%)
0
20
40
60
80
100

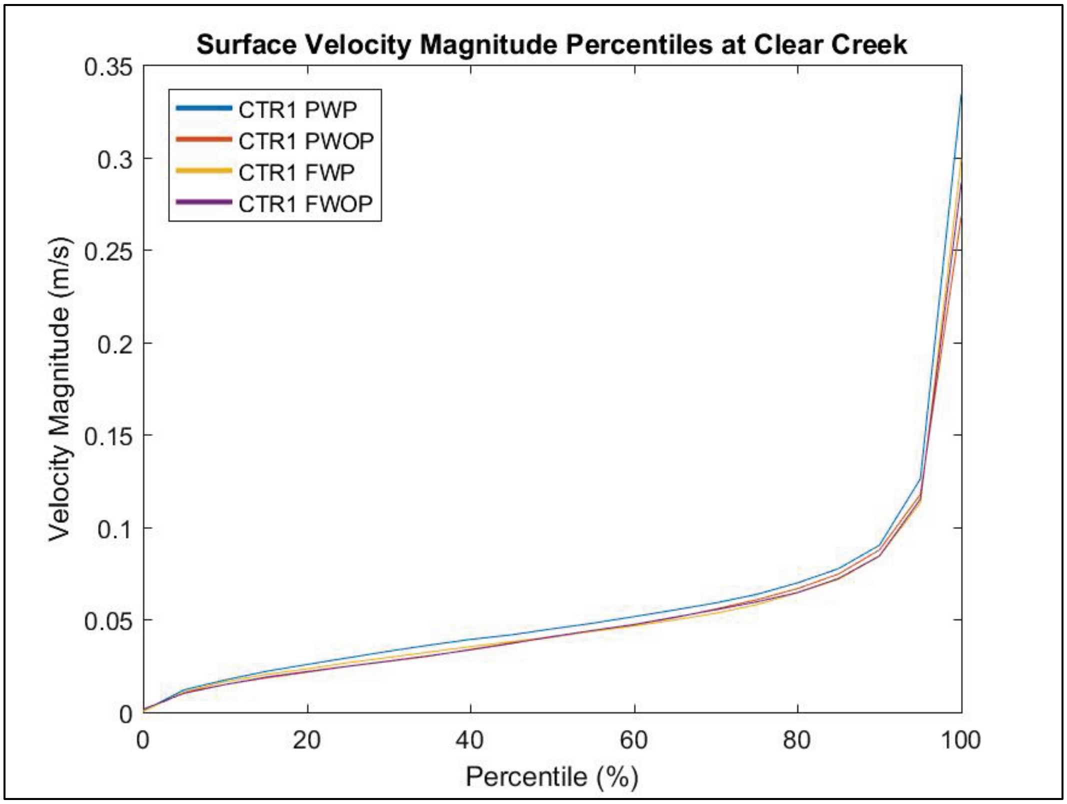

Bottom Velocity Magnitude (m/s) at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Max
Mean
Min

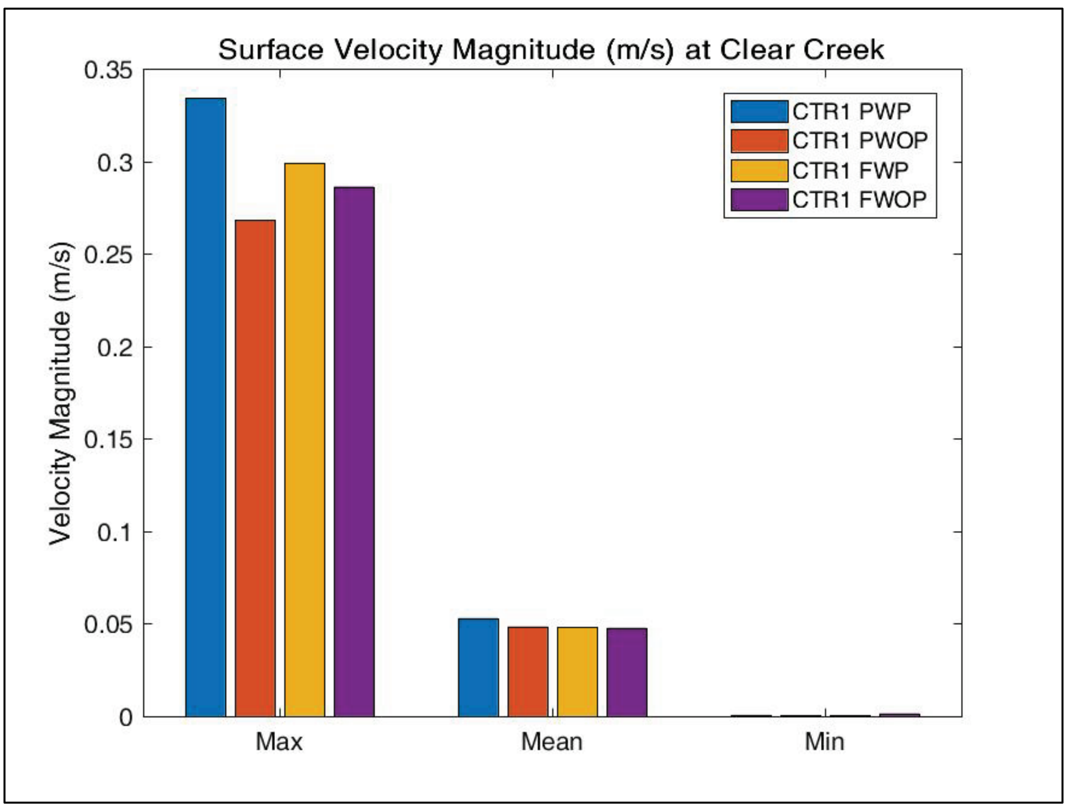

Surface Velocity Magnitude Percentiles at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100
Percentile (%)

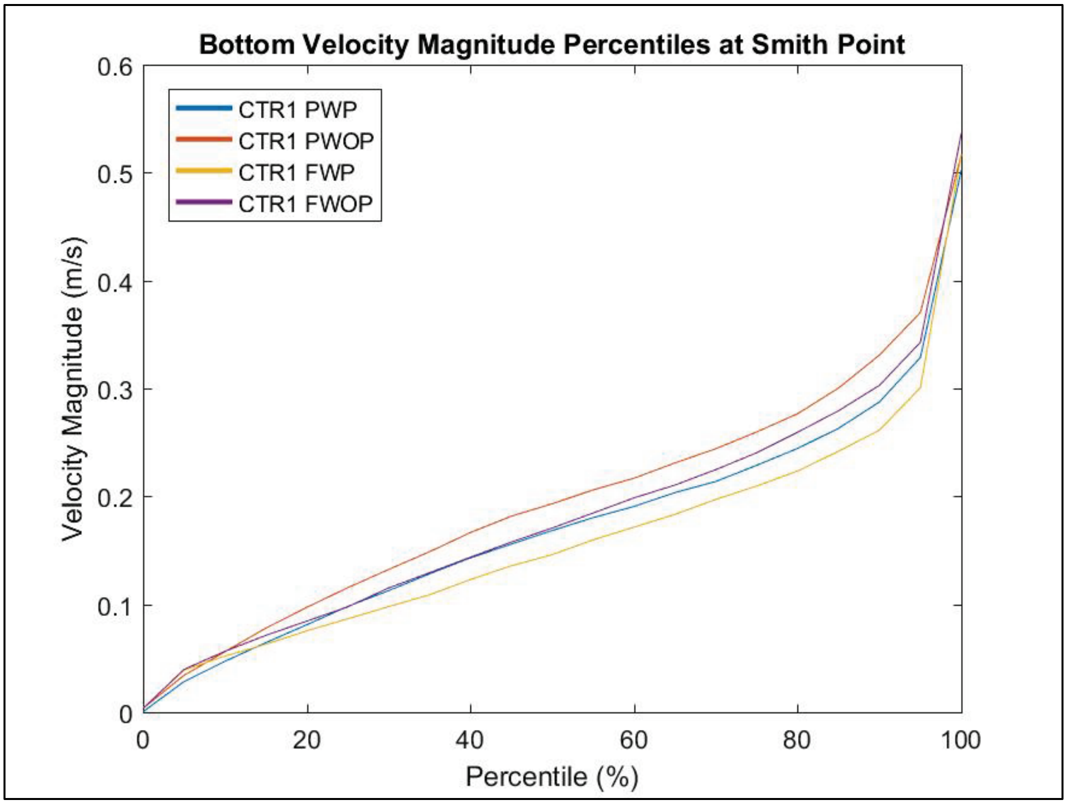

Surface Velocity Magnitude (m/s) at Dickinson
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Max
Mean
Min

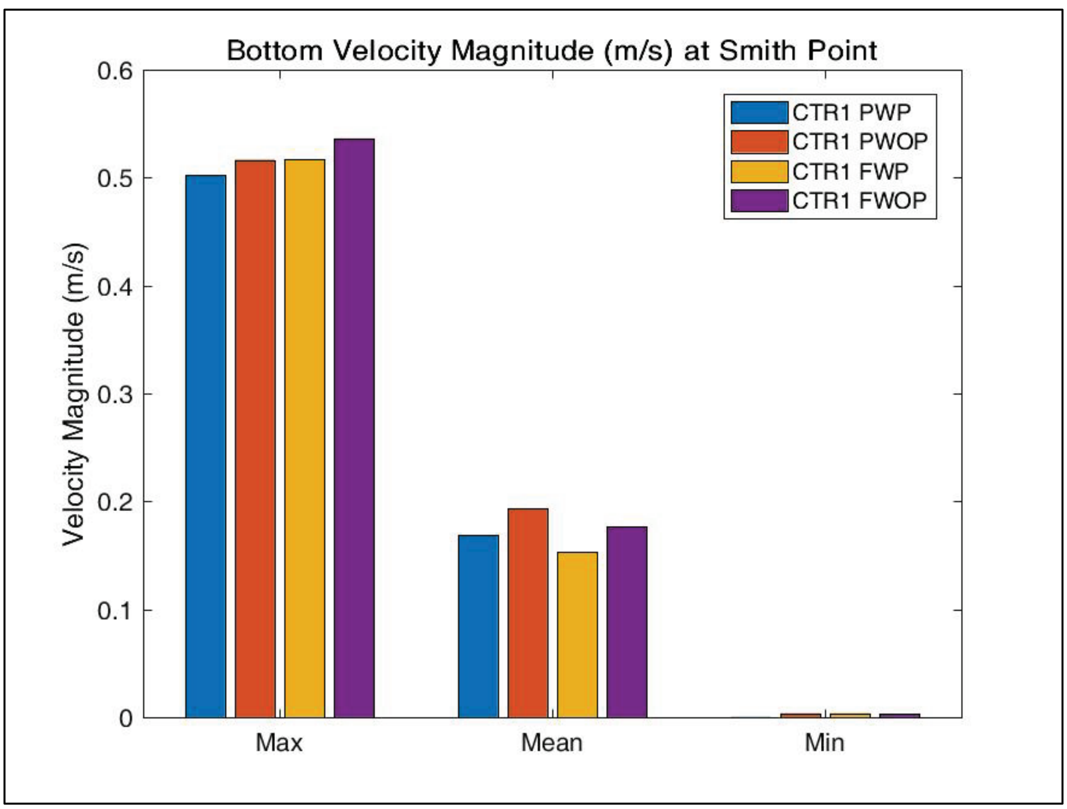

Bottom Velocity Magnitude Percentiles at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
20
40
60
80
100
Percentile (%)

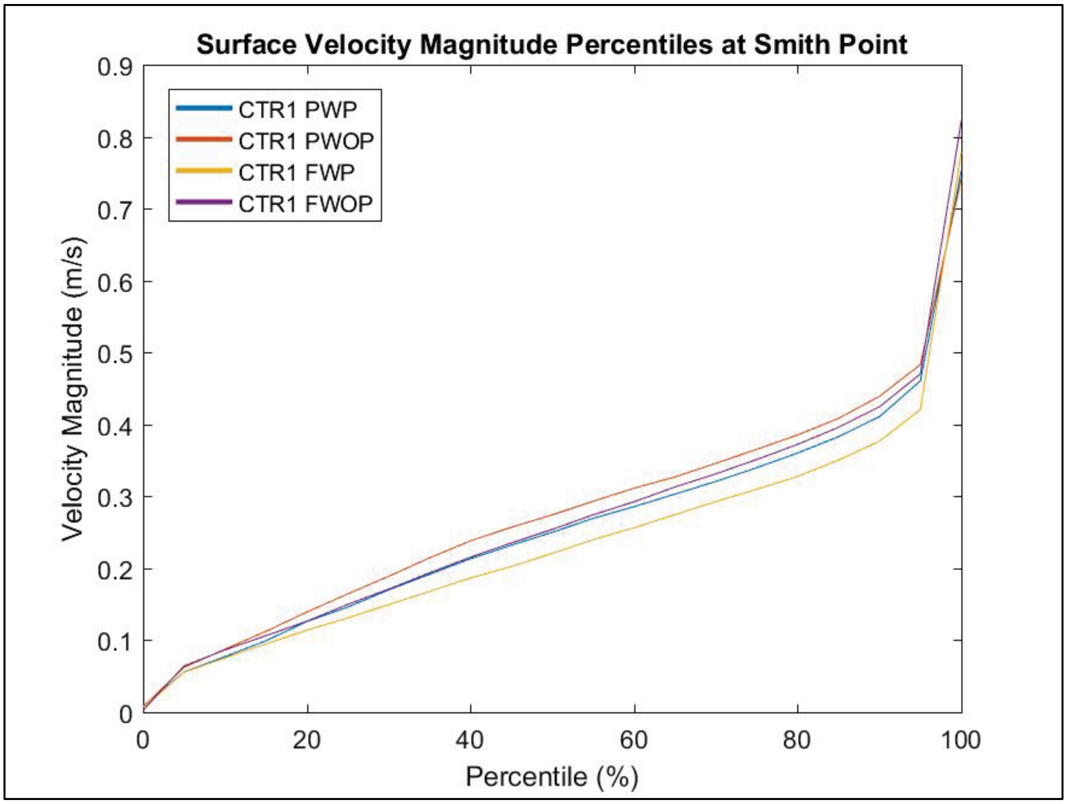

Bottom Velocity Magnitude (m/s) at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Max
Mean
Min

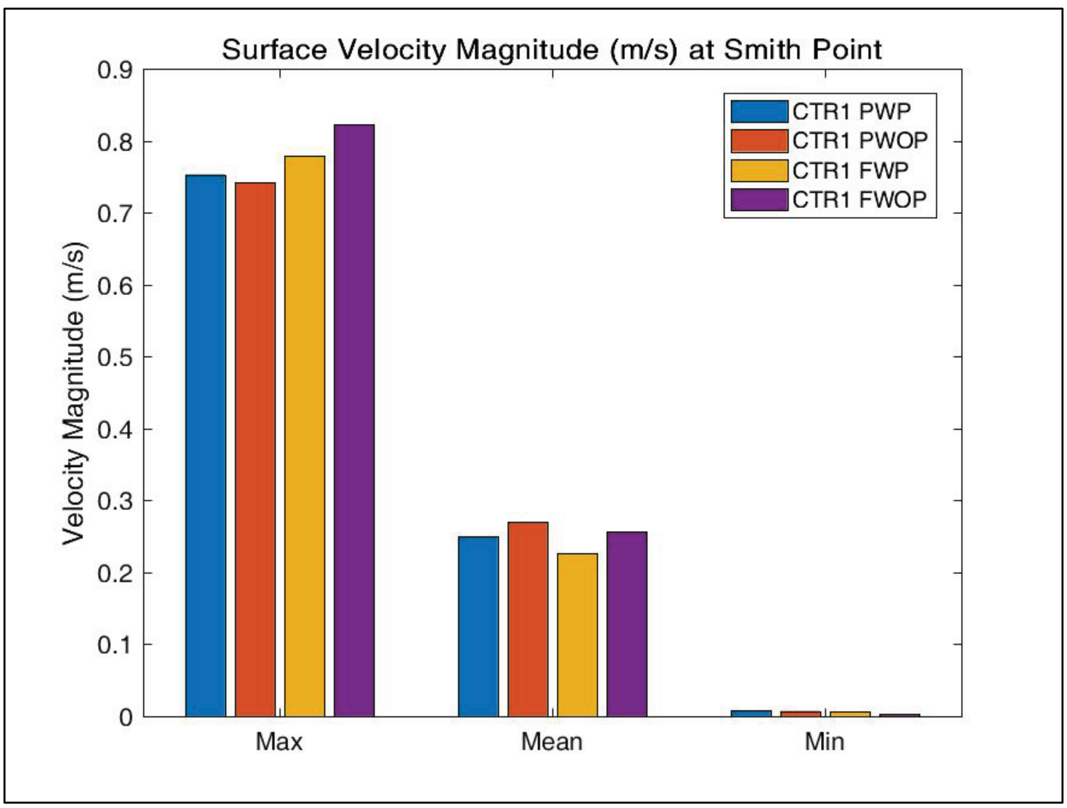

Surface Velocity Magnitude Percentiles at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Percentile (%)

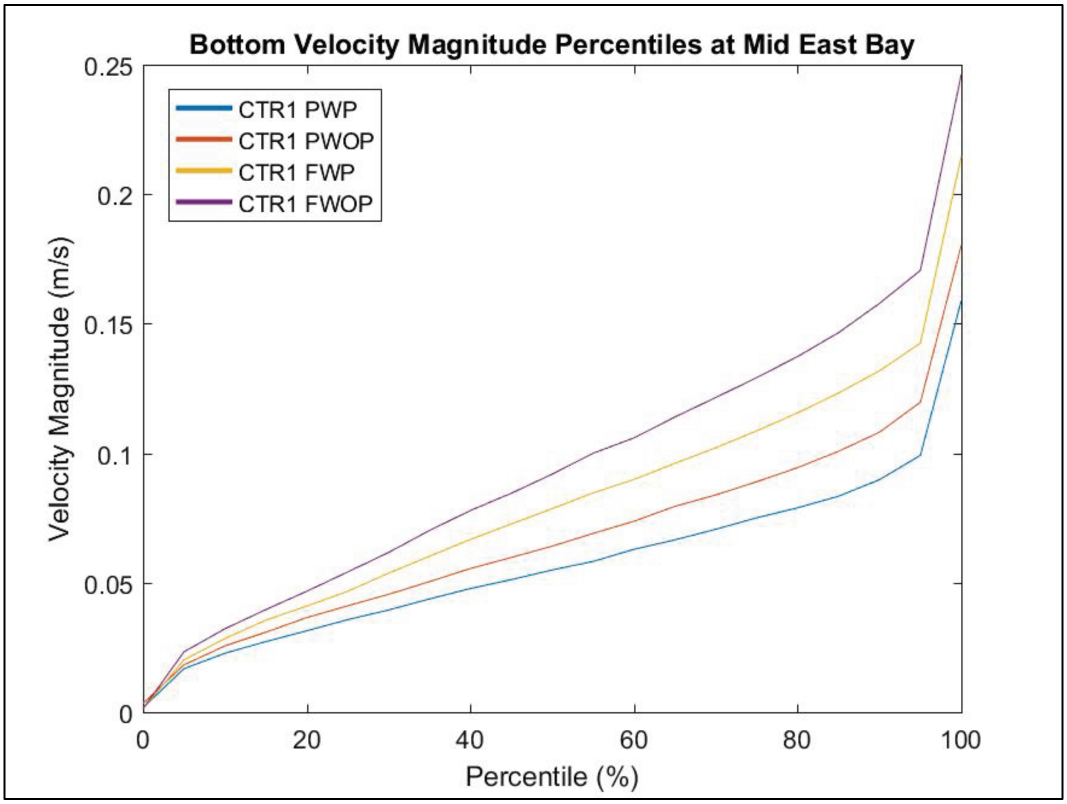

Surface Velocity Magnitude (m/s) at Clear Creek
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

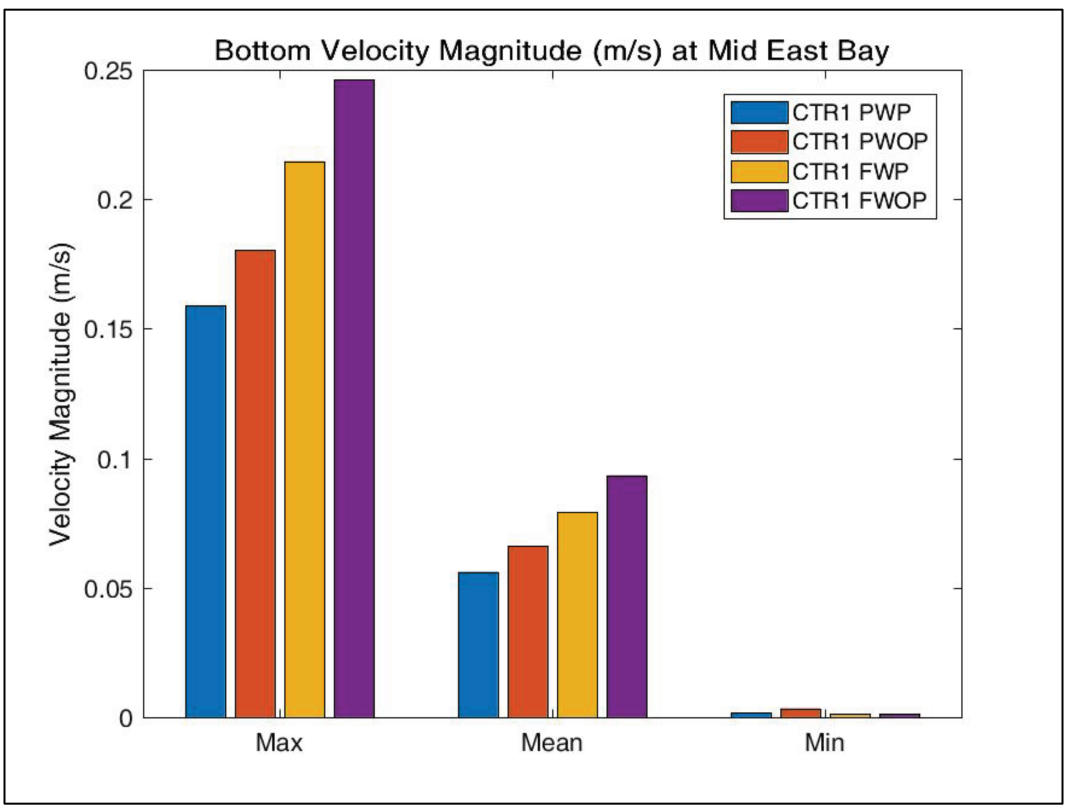

Bottom Velocity Magnitude Percentiles at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

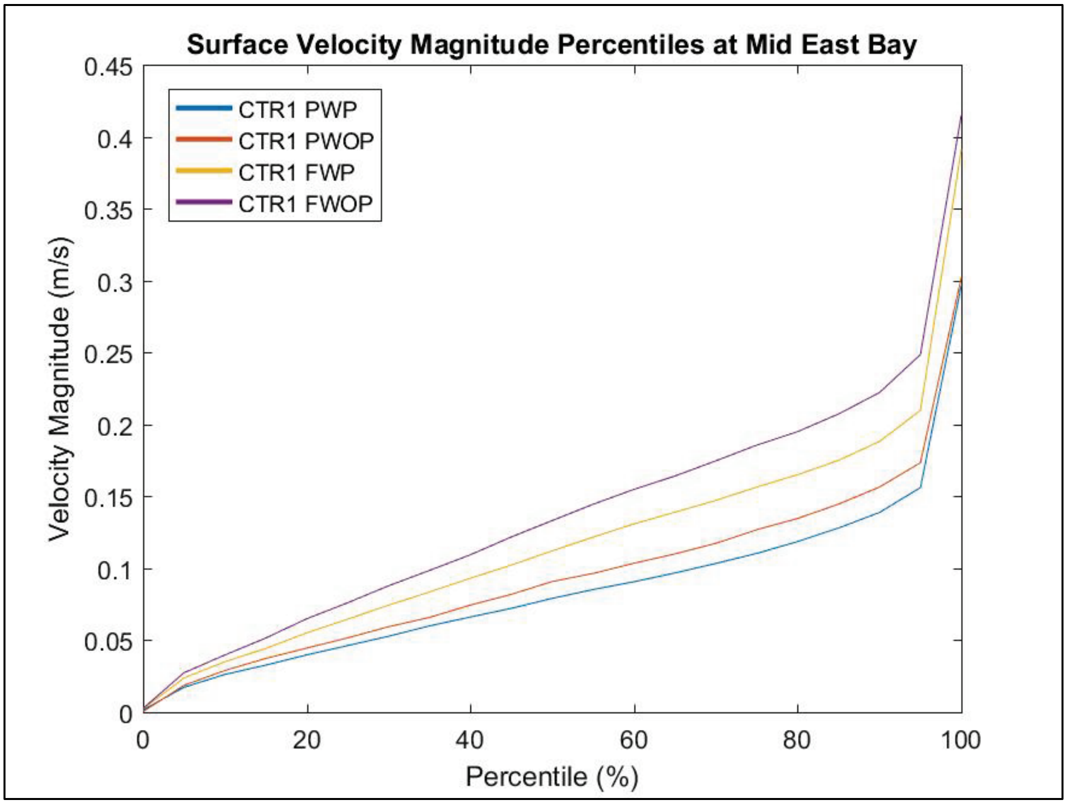

Bottom Velocity Magnitude (m/s) at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
Max
Mean
Min

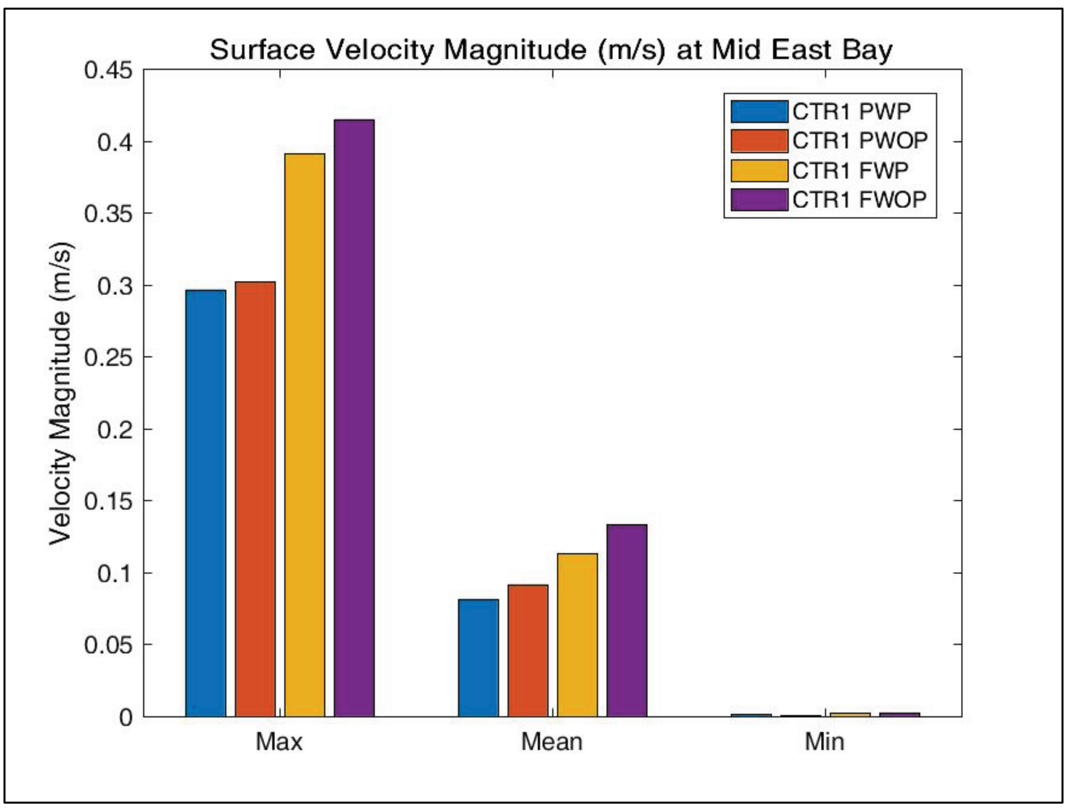

Surface Velocity Magnitude Percentiles at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
20
40
60
80
100
Percentile (%)


Surface Velocity Magnitude (m/s) at Smith Point
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Max
Mean
Min


Bottom Velocity Magnitude Percentiles at Mid East Bay
Velocity Magnitude (m/s)
Percentile (%)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100


Bottom Velocity Magnitude (m/s) at Mid East Bay
Velocity Magnitude (m/s)
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min


Surface Velocity Magnitude Percentiles at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
Percentile (%)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100

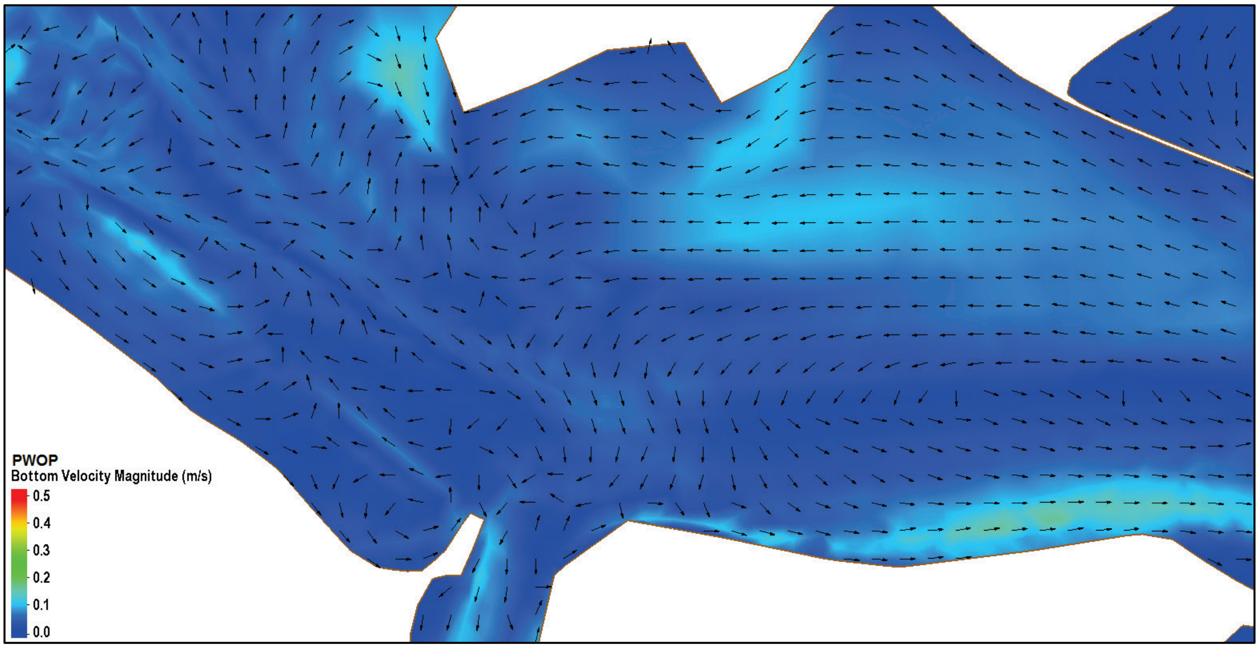

Surface Velocity Magnitude (m/s) at Mid East Bay
CTR1 PWP
CTR1 PWOP
CTR1 FWP
CTR1 FWOP
Velocity Magnitude (m/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Max
Mean
Min

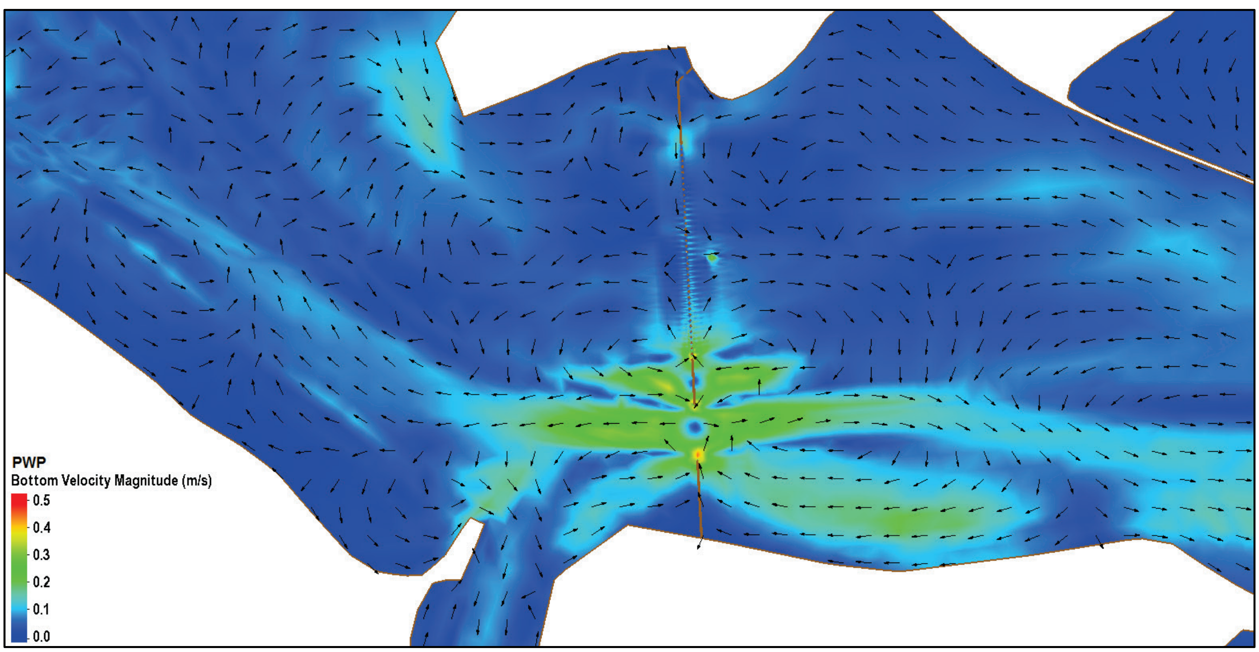
Appendix D: Residual Velocity at Structure Locations

The surface and bottom velocity comparisons for with project and without project are shown below. The first two sets of images show with and without project residual velocity magnitudes (contoured) and directions (vectors) for bottom and surface. The third set of images shows the residual velocity comparisons. The red vectors indicate the direction of the with project residual velocity and the black vectors, the without project. The contours represent the difference in the velocity magnitudes – with project minus without project such that positive values (reds/yellows) indicate the with project residual velocity magnitude is greater and negative values (blues) indicate that the without project residual velocity magnitude is greater. These results are only provided for present conditions. The overall impact will be similar for future conditions.

Bottom average residual velocity magnitude and direction for present conditions at Bolivar Roads.

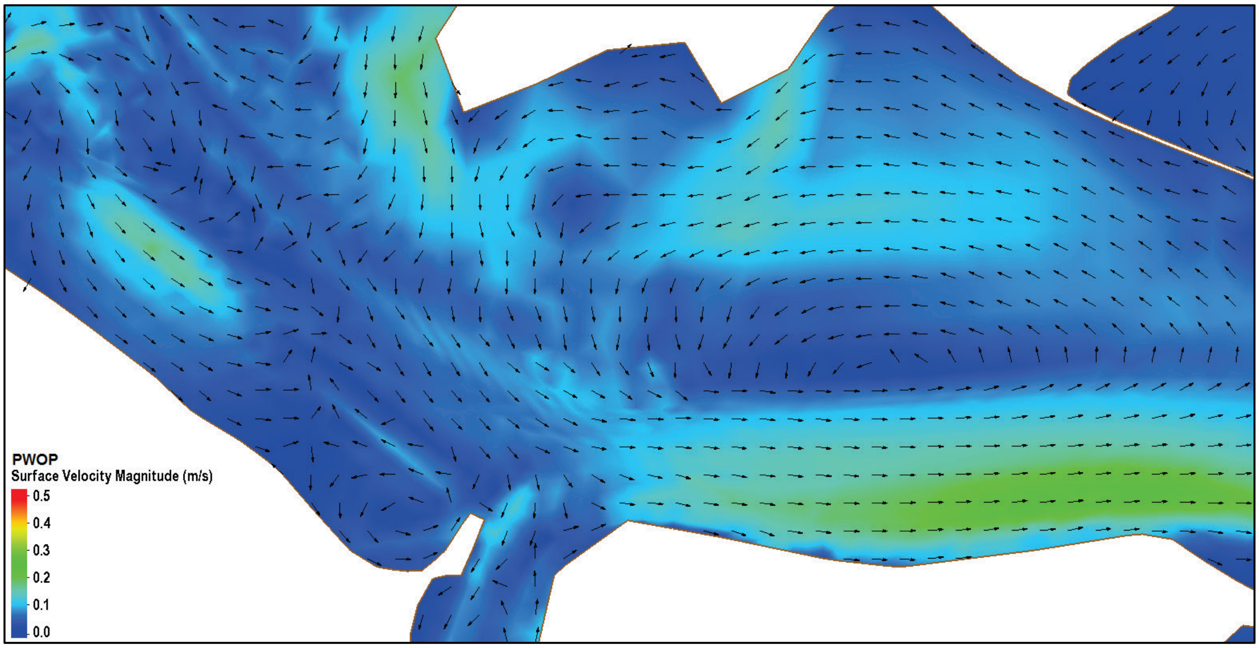
(top – without project, bottom – with project)

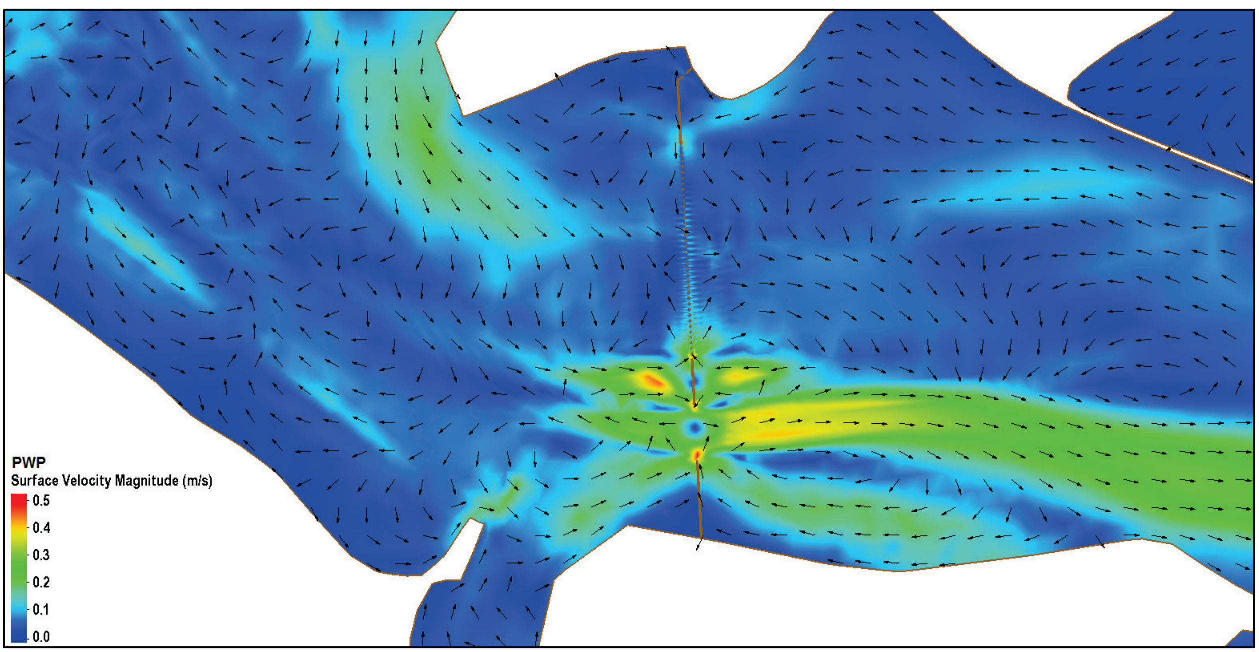




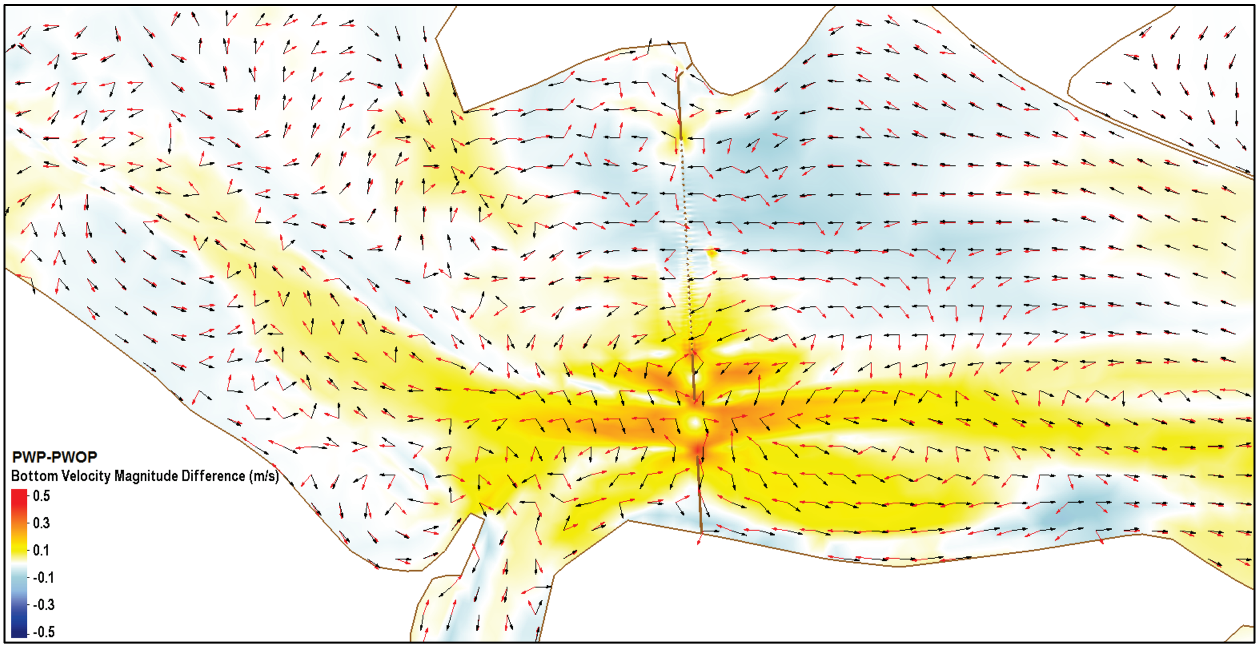
Surface average residual velocity magnitude and direction for present conditions at Bolivar Roads.

(top – without project, bottom – with project)

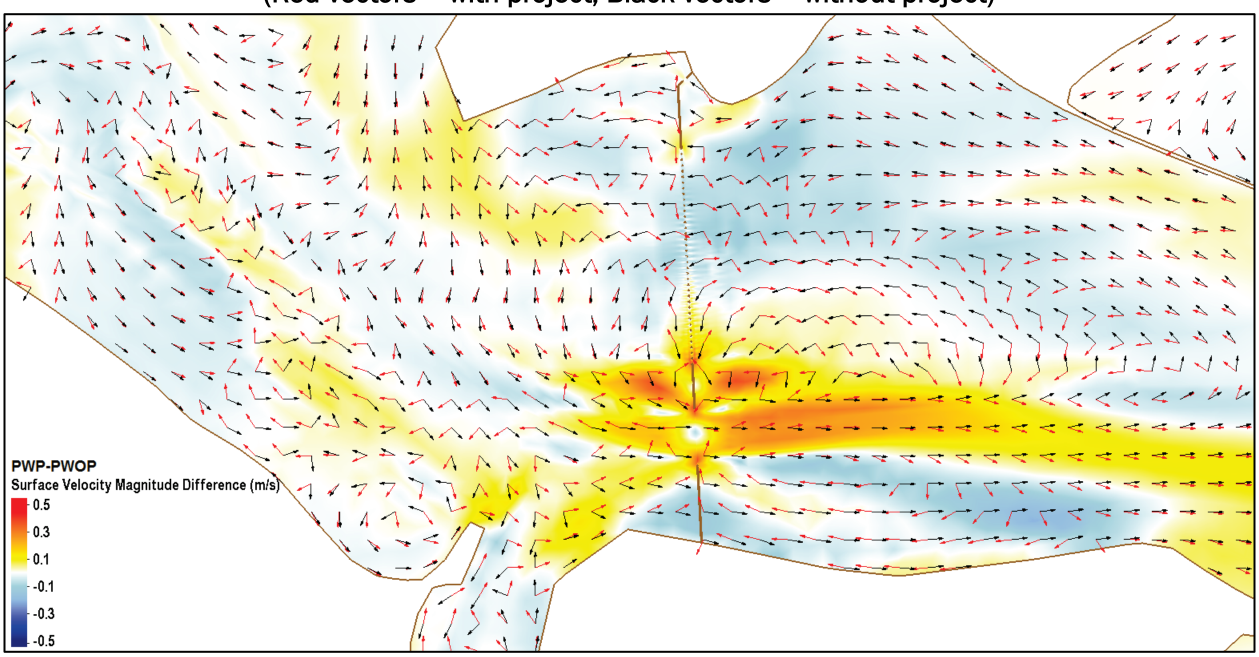




Bottom average residual velocity comparison for present conditions at Bolivar Roads.
(Red vectors – with project, Black vectors – without project)

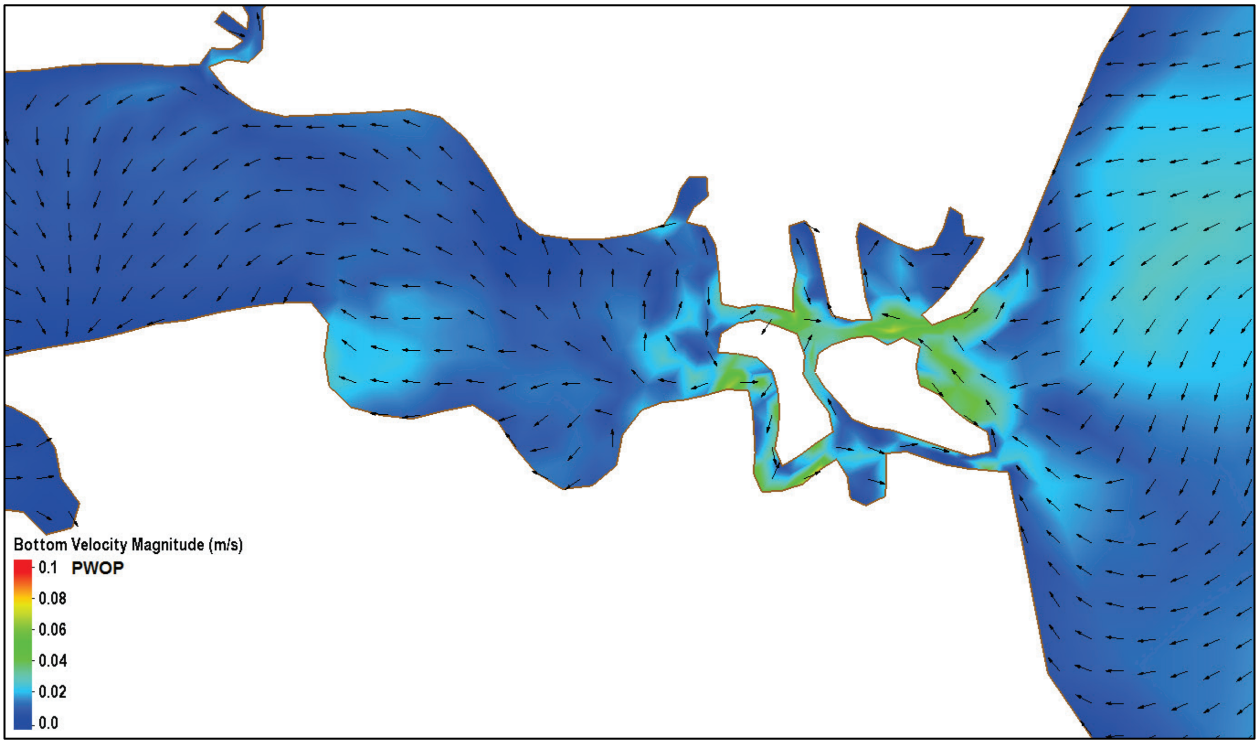


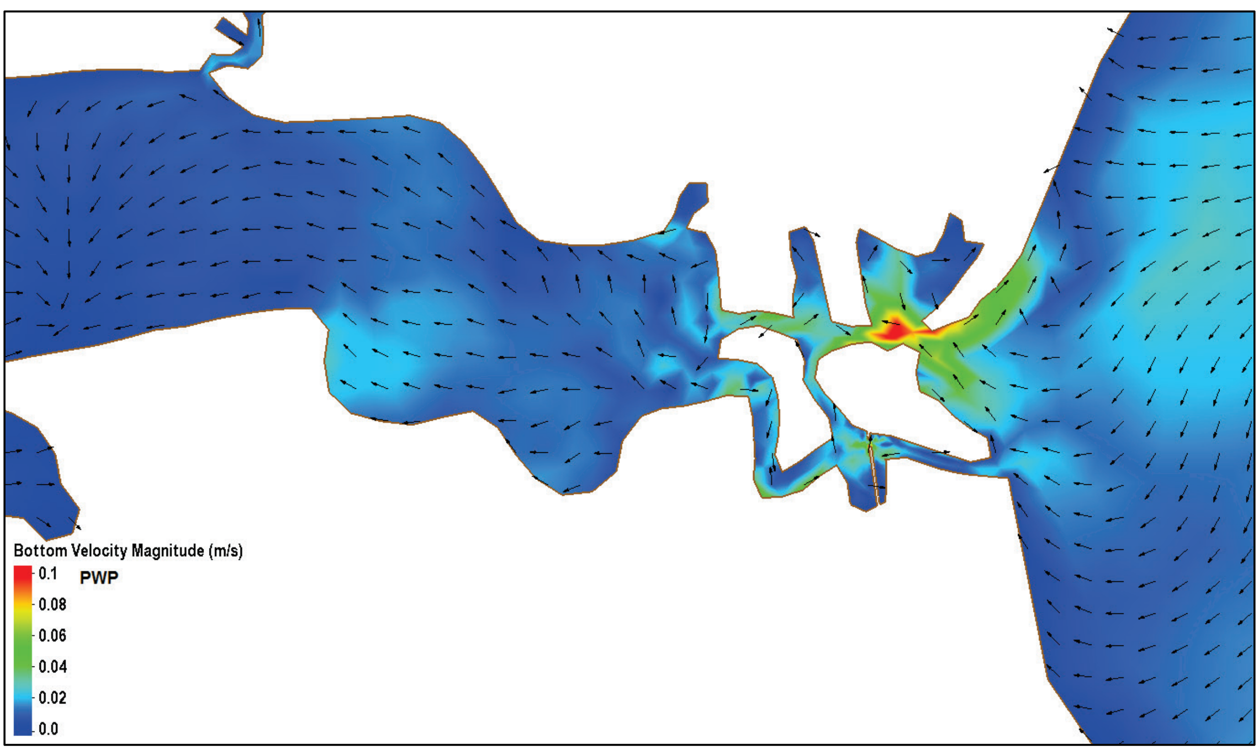
Surface average residual velocity comparison for present conditions at Bolivar Roads.
(Red vectors – with project, Black vectors – without project)



Bottom average residual velocity magnitude and direction for present conditions at Clear Creek.

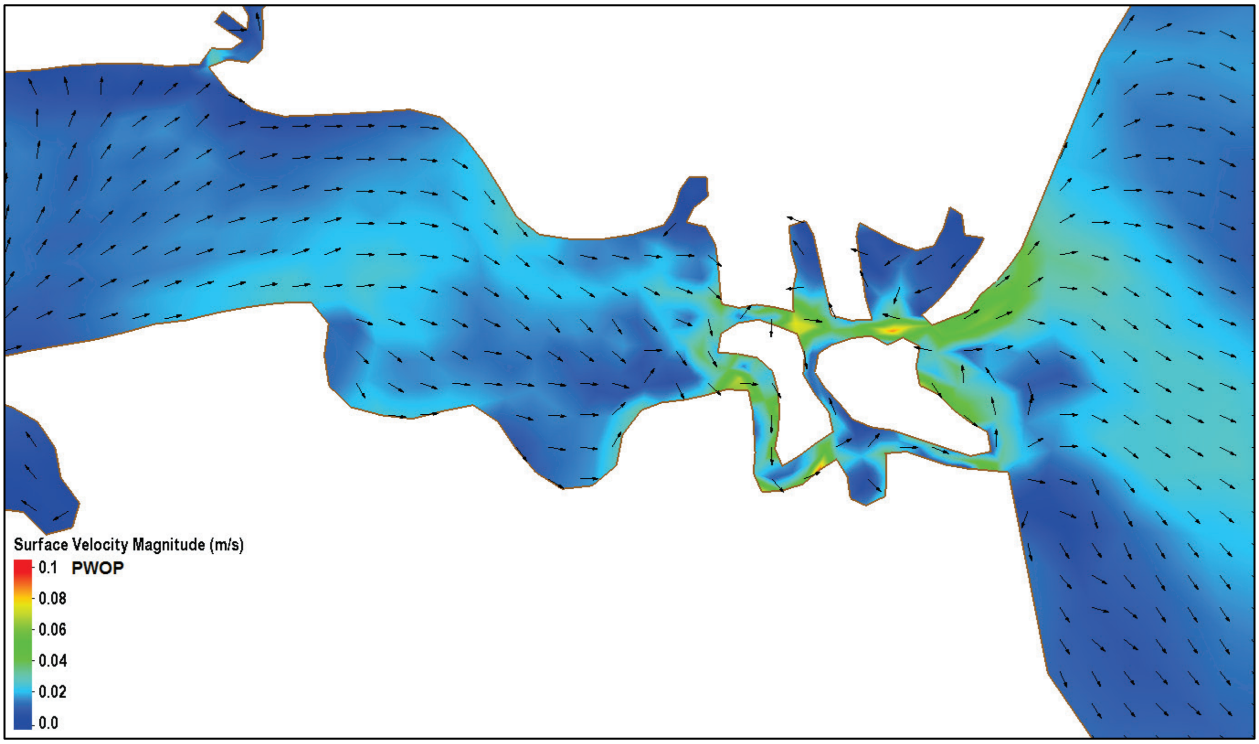
(top – without project, bottom – with project)

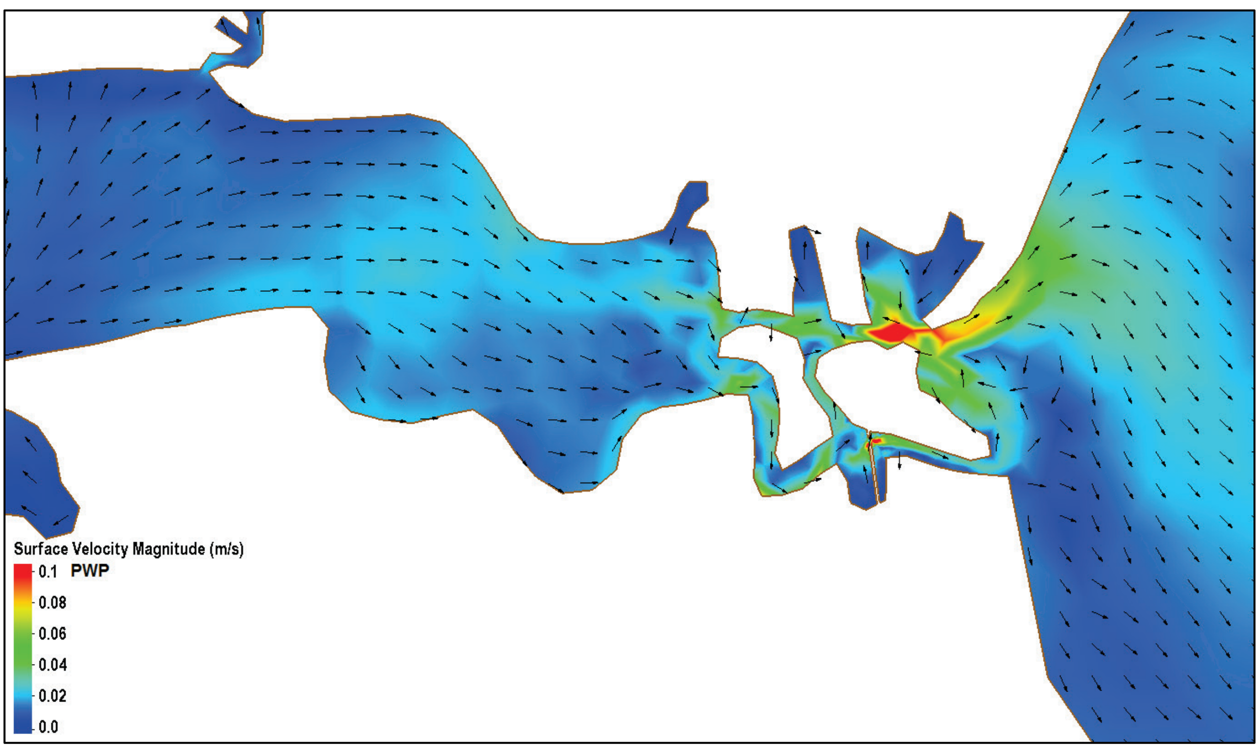




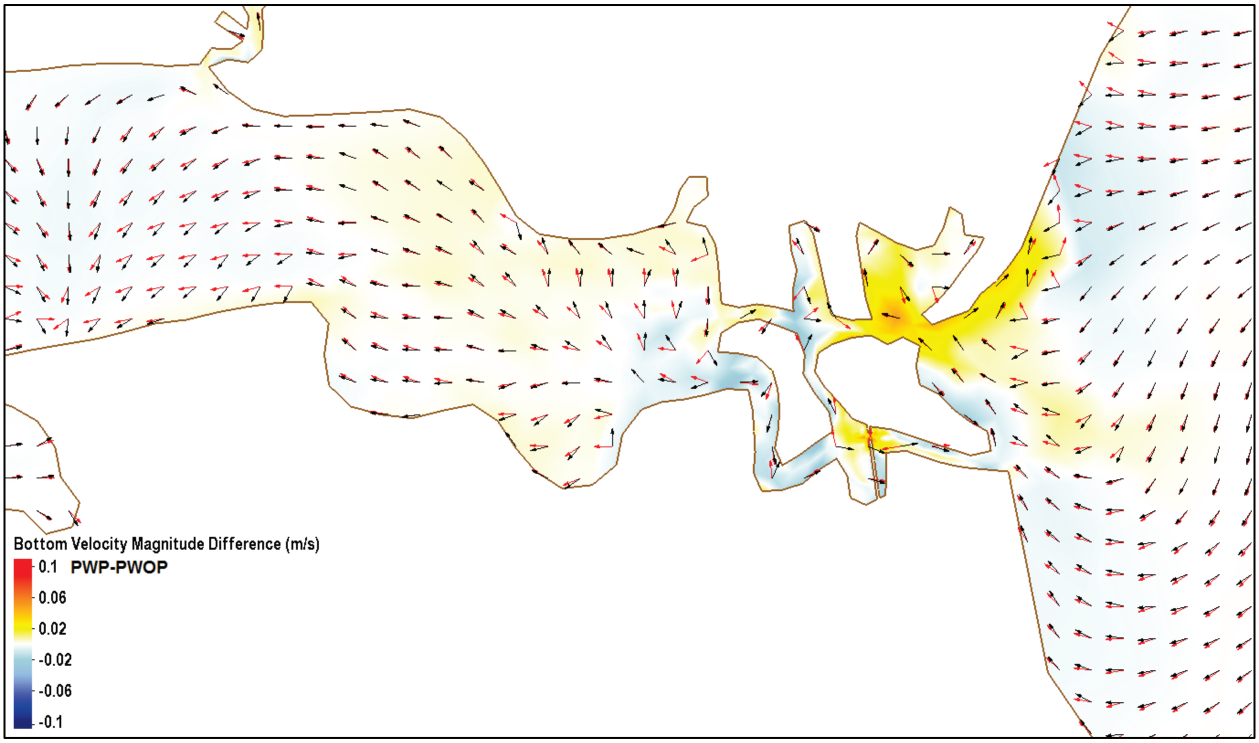
Surface average residual velocity magnitude and direction for present conditions at Clear Creek.

(top – without project, bottom – with project)

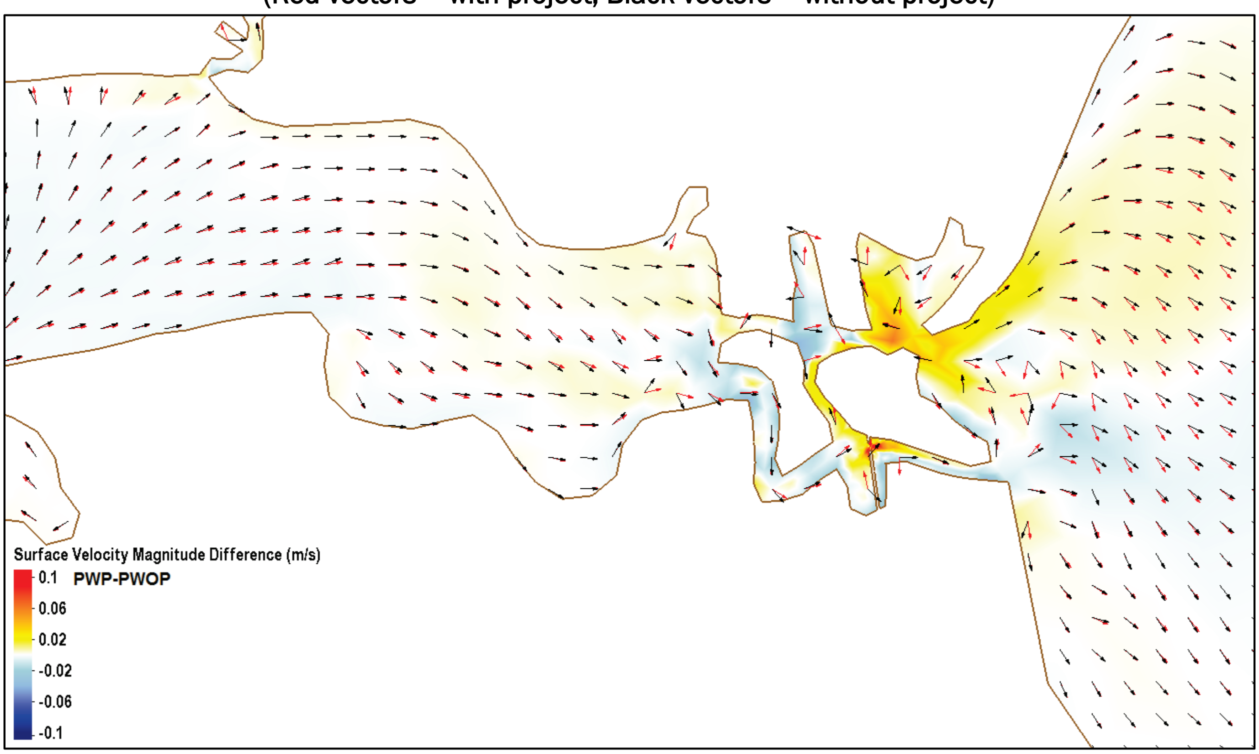




Bottom average residual velocity comparison for present conditions at Clear Creek.
(Red vectors – with project, Black vectors – without project)

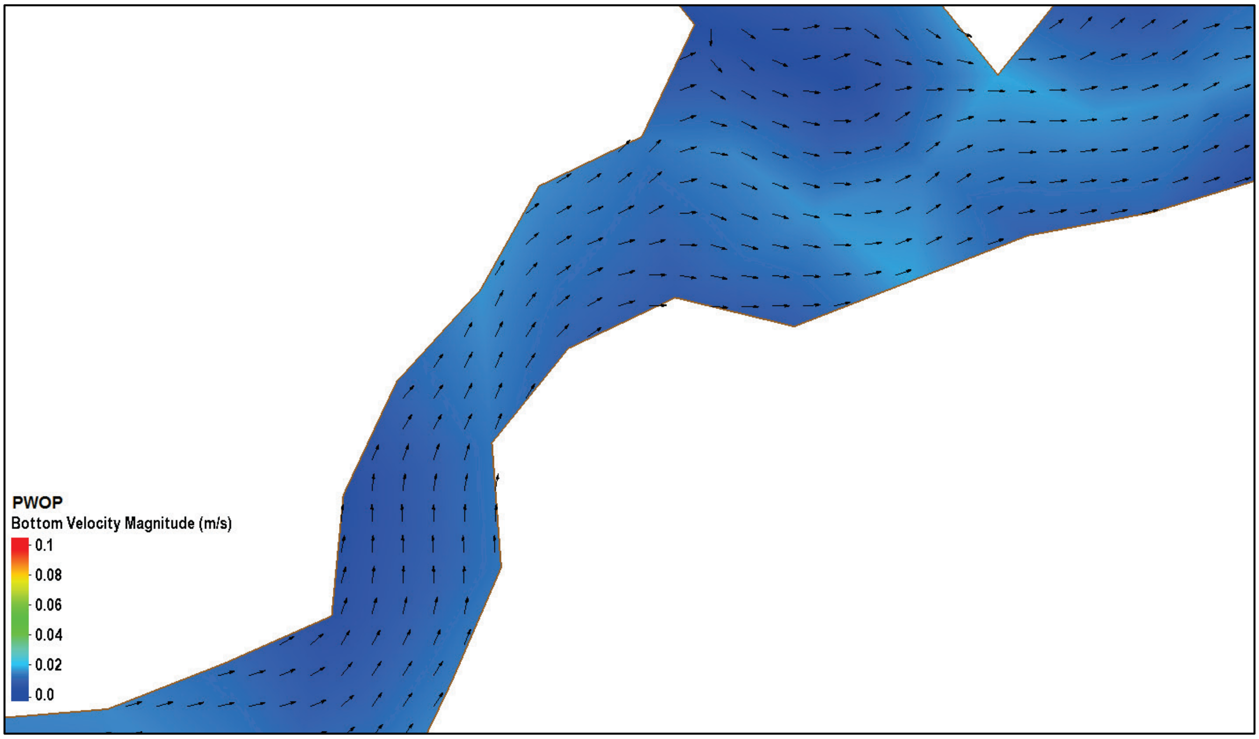


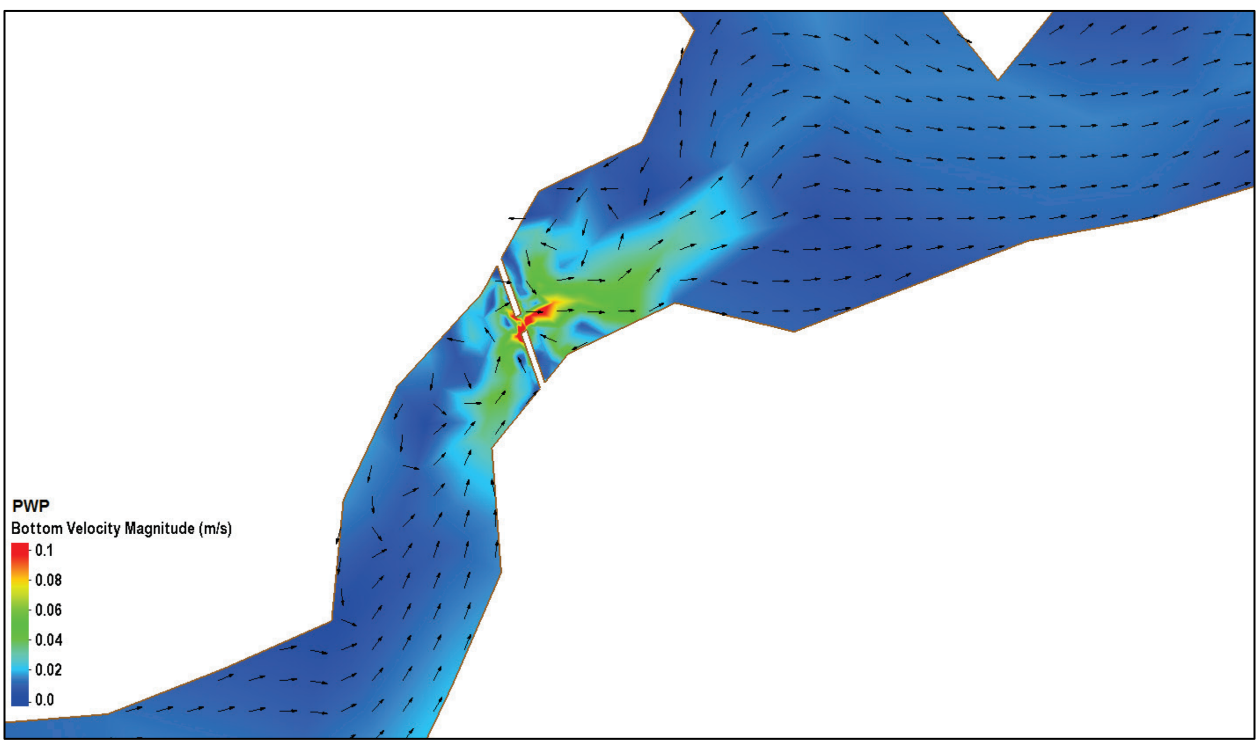
Surface average residual velocity comparison for present conditions at Clear Creek.
(Red vectors – with project, Black vectors – without project)



Bottom average residual velocity magnitude and direction for present conditions at Dickinson Bayou.

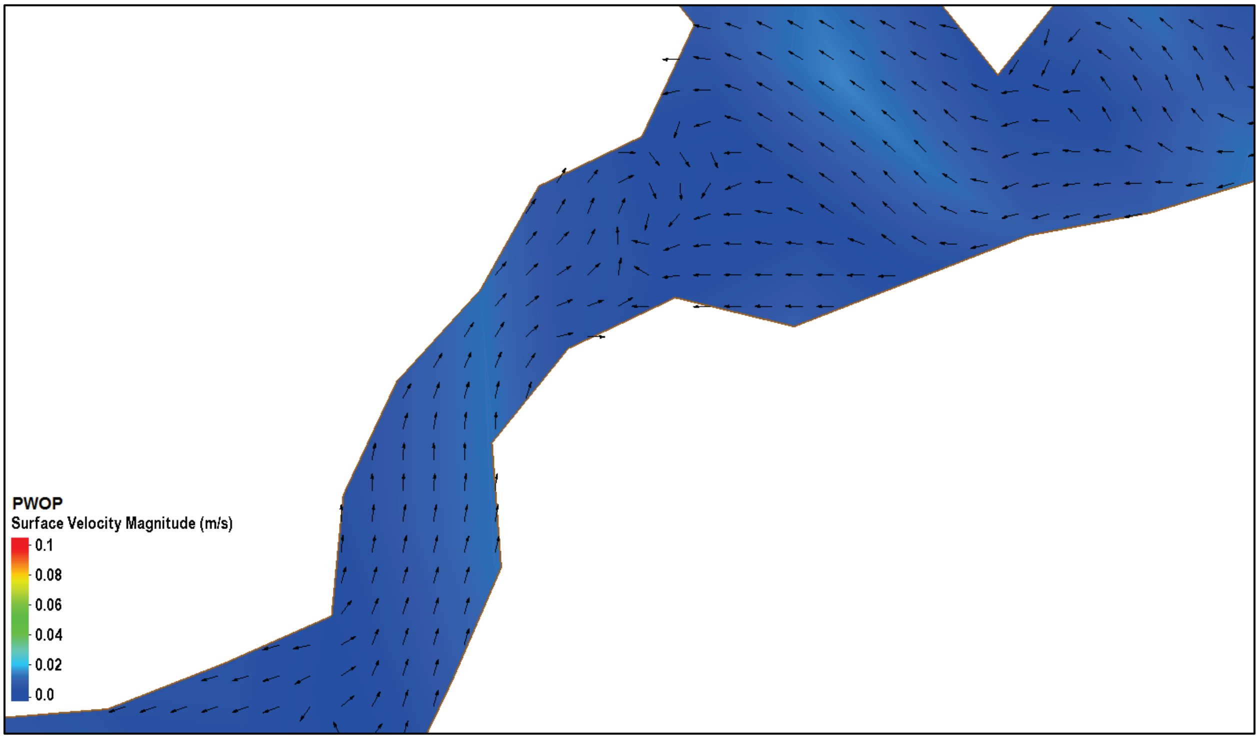
(top – without project, bottom – with project)

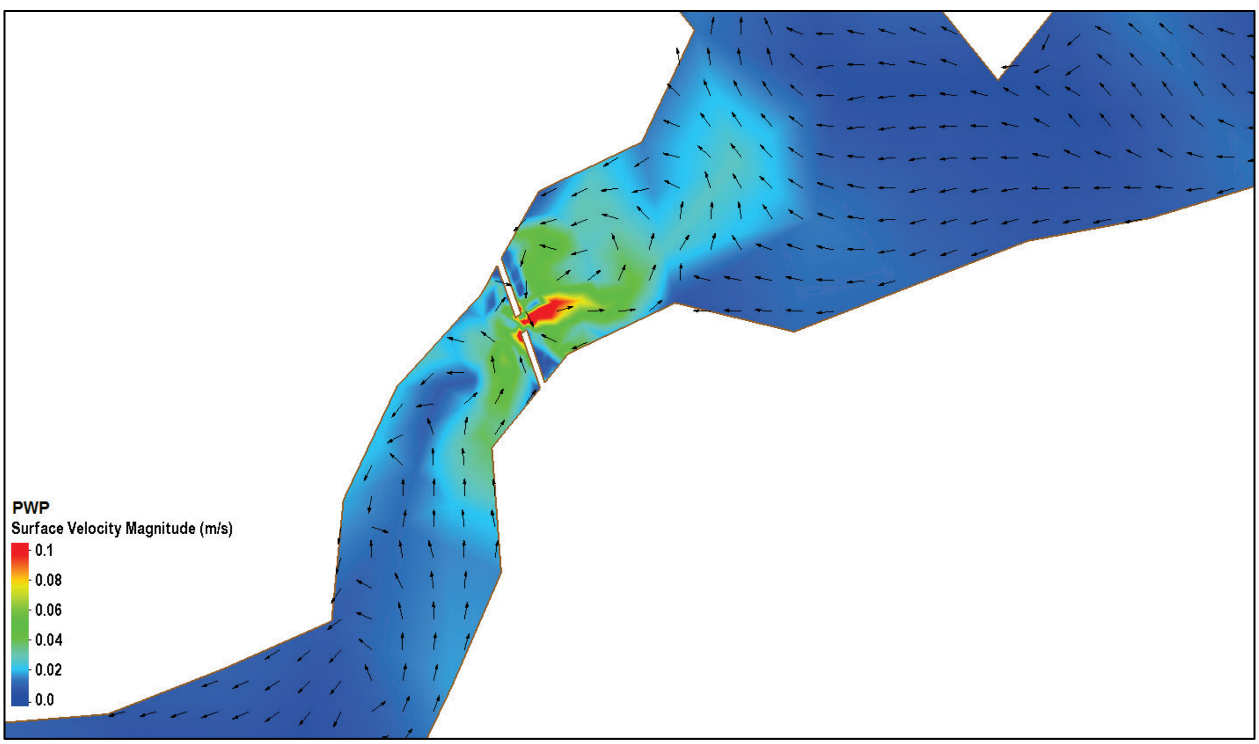




Surface average residual velocity magnitude and direction for present conditions at Dickinson Bayou.

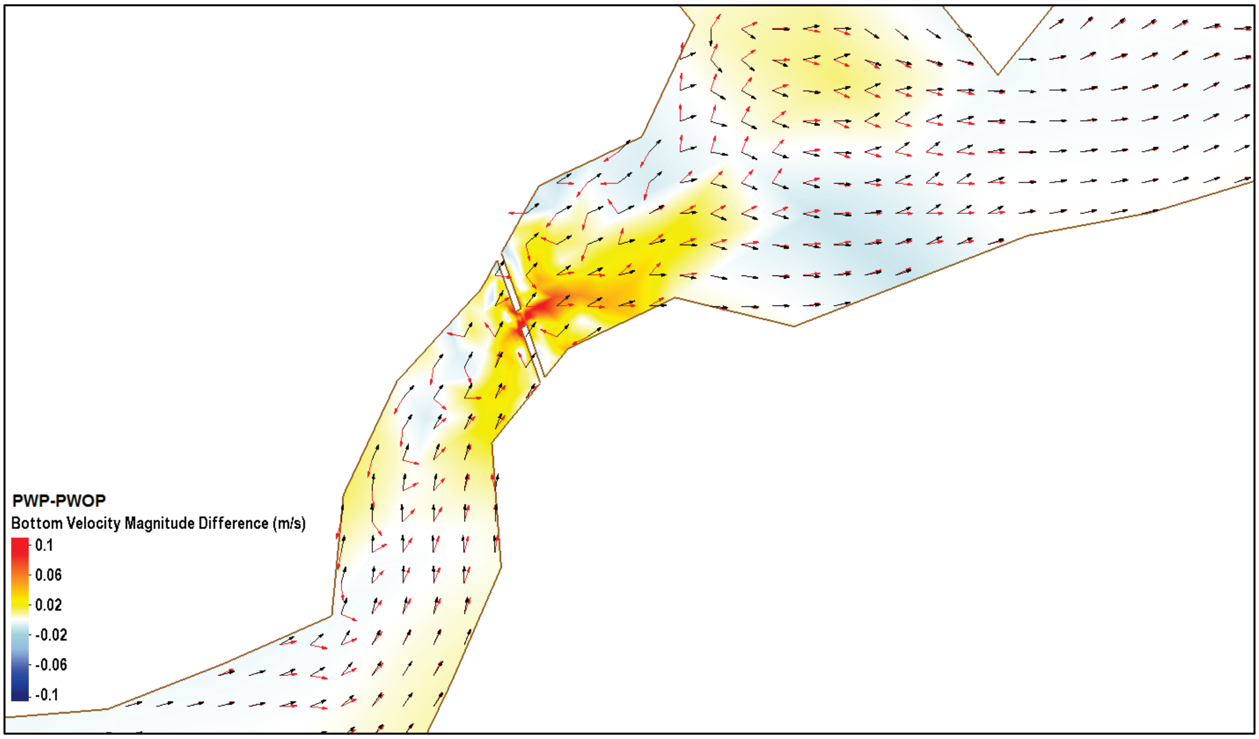
(top – without project, bottom – with project)





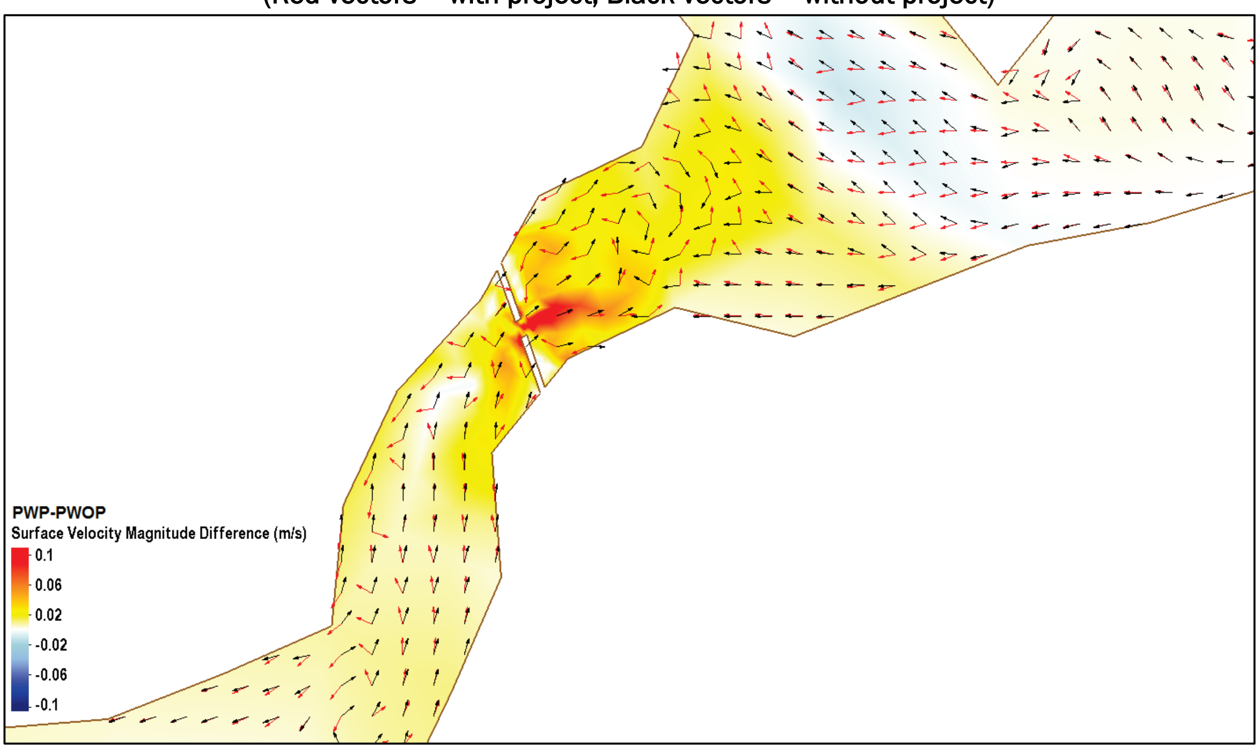
Bottom average residual velocity comparison for present conditions at Dickinson Bayou.

(Red vectors – with project, Black vectors – without project)



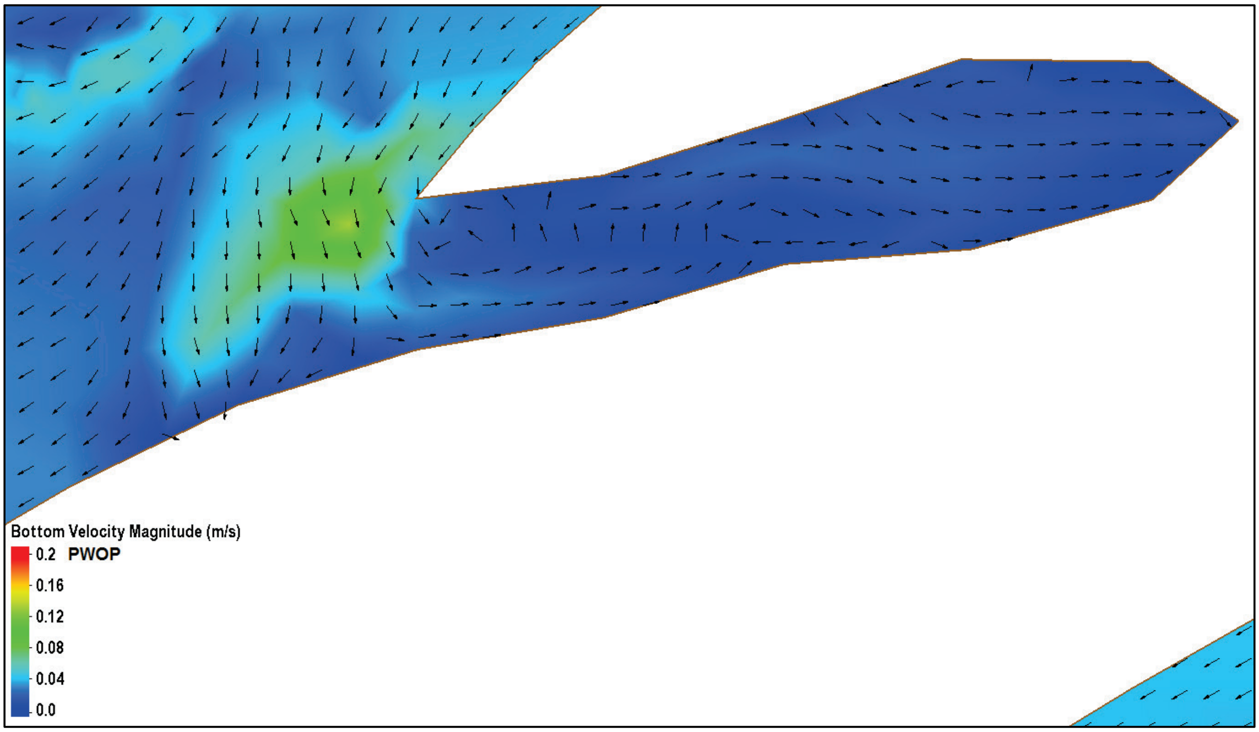
Surface average residual velocity comparison for present conditions at Dickinson Bayou.

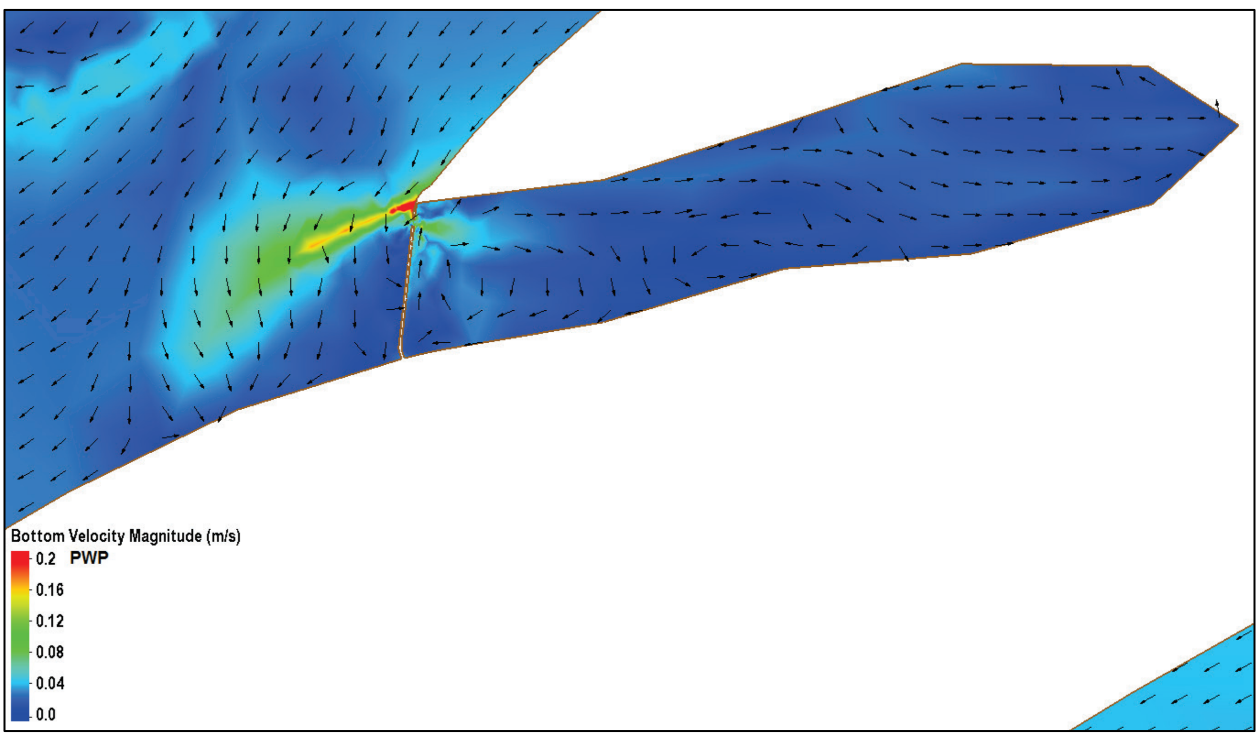
(Red vectors – with project, Black vectors – without project)



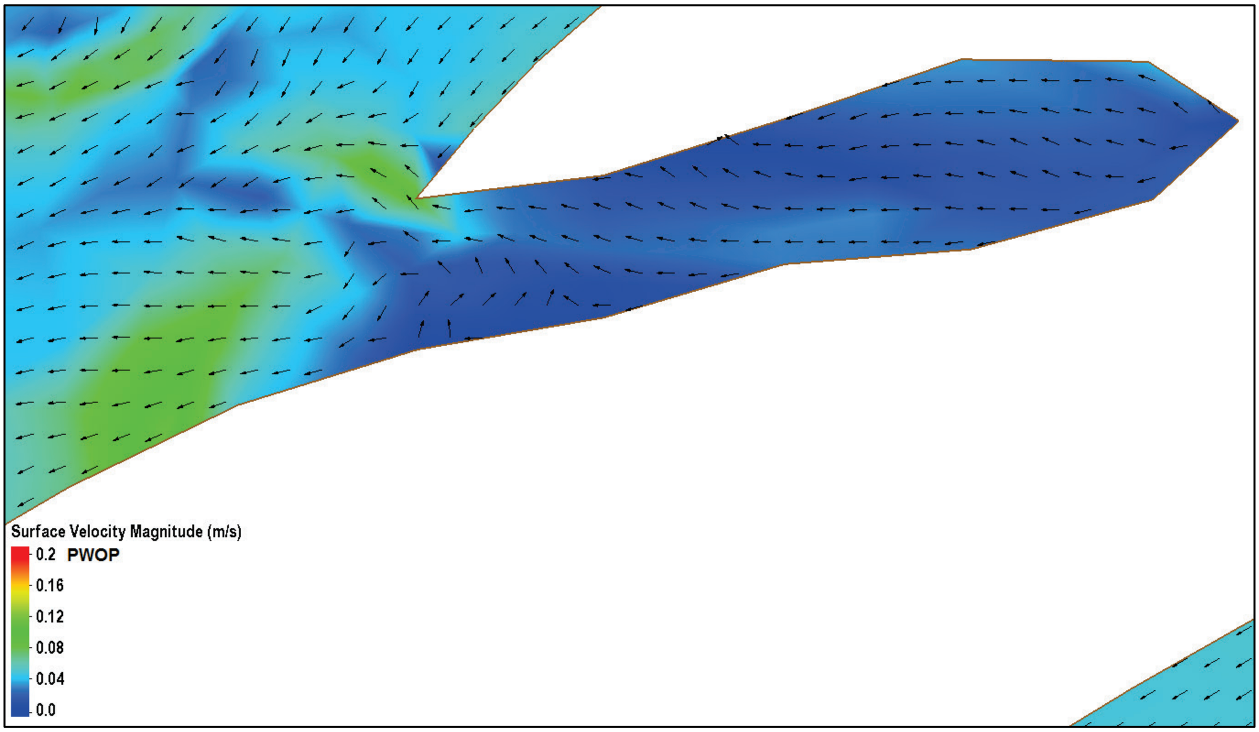
Bottom average residual velocity magnitude and direction for present conditions at Offatts Bayou.

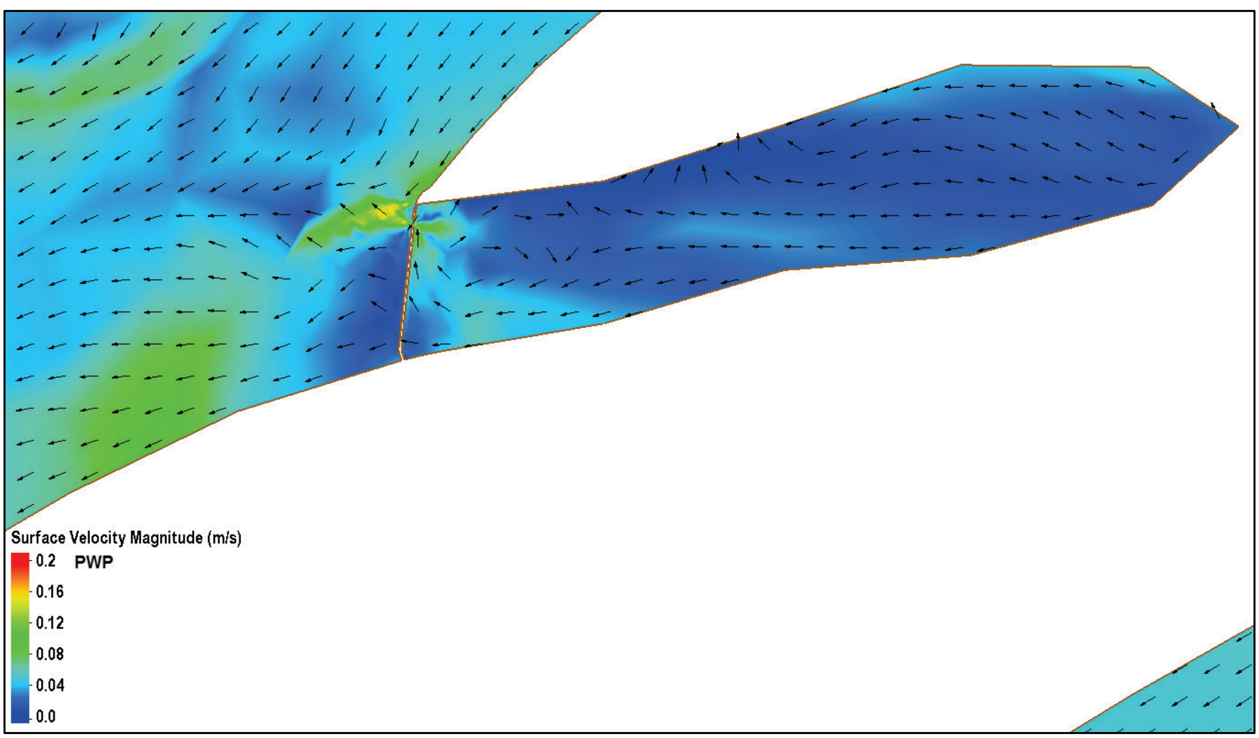
(top – without project, bottom – with project)



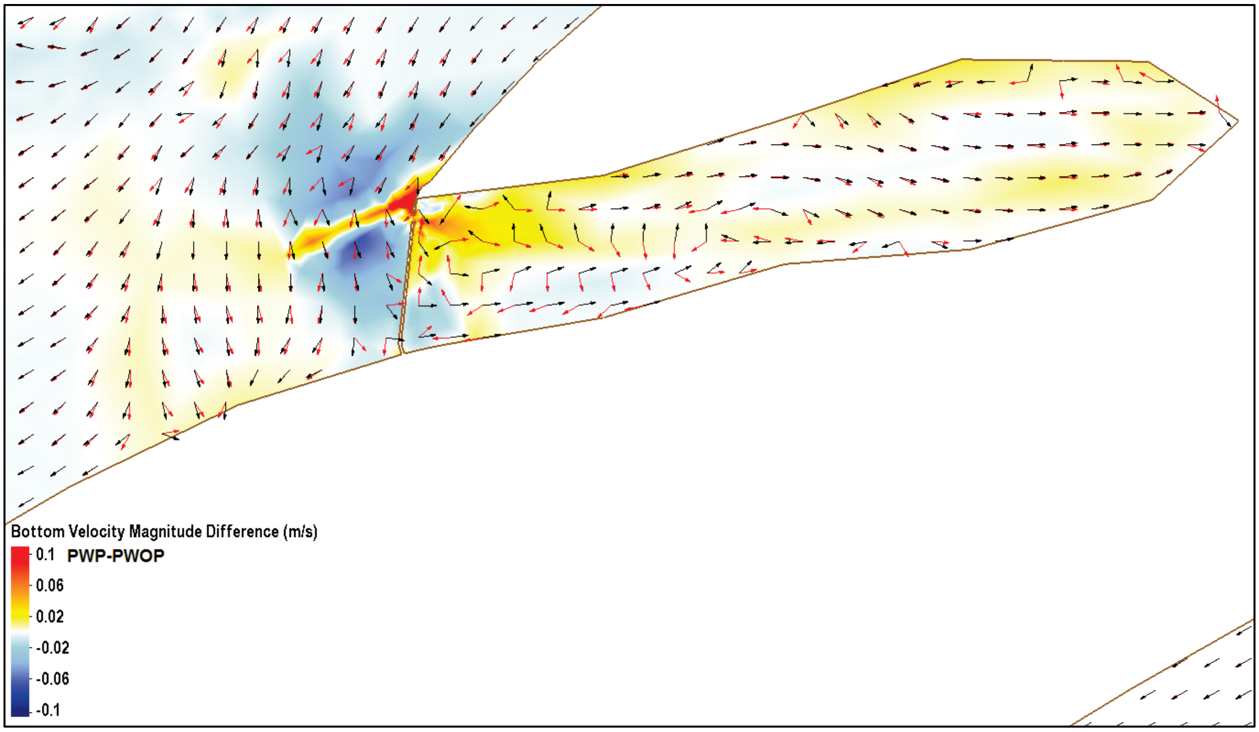


Surface average residual velocity magnitude and direction for present conditions at Offatts Bayou.
(top – without project, bottom – with project)

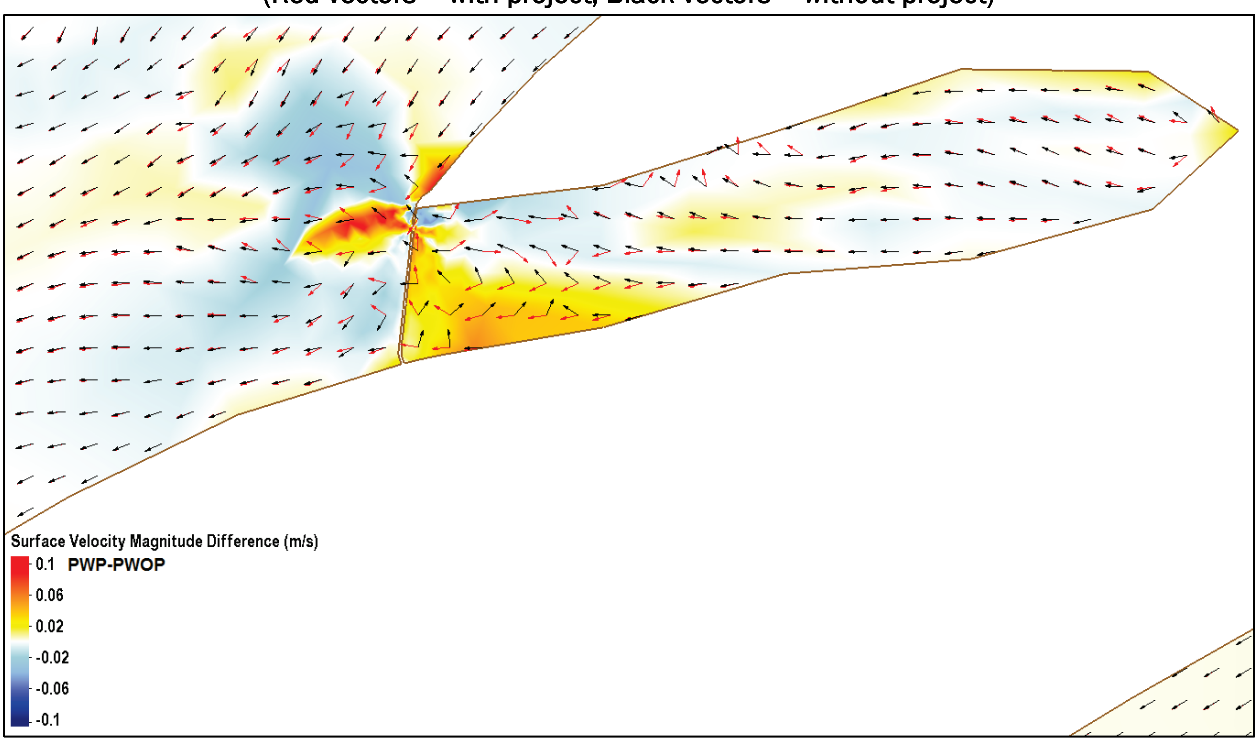




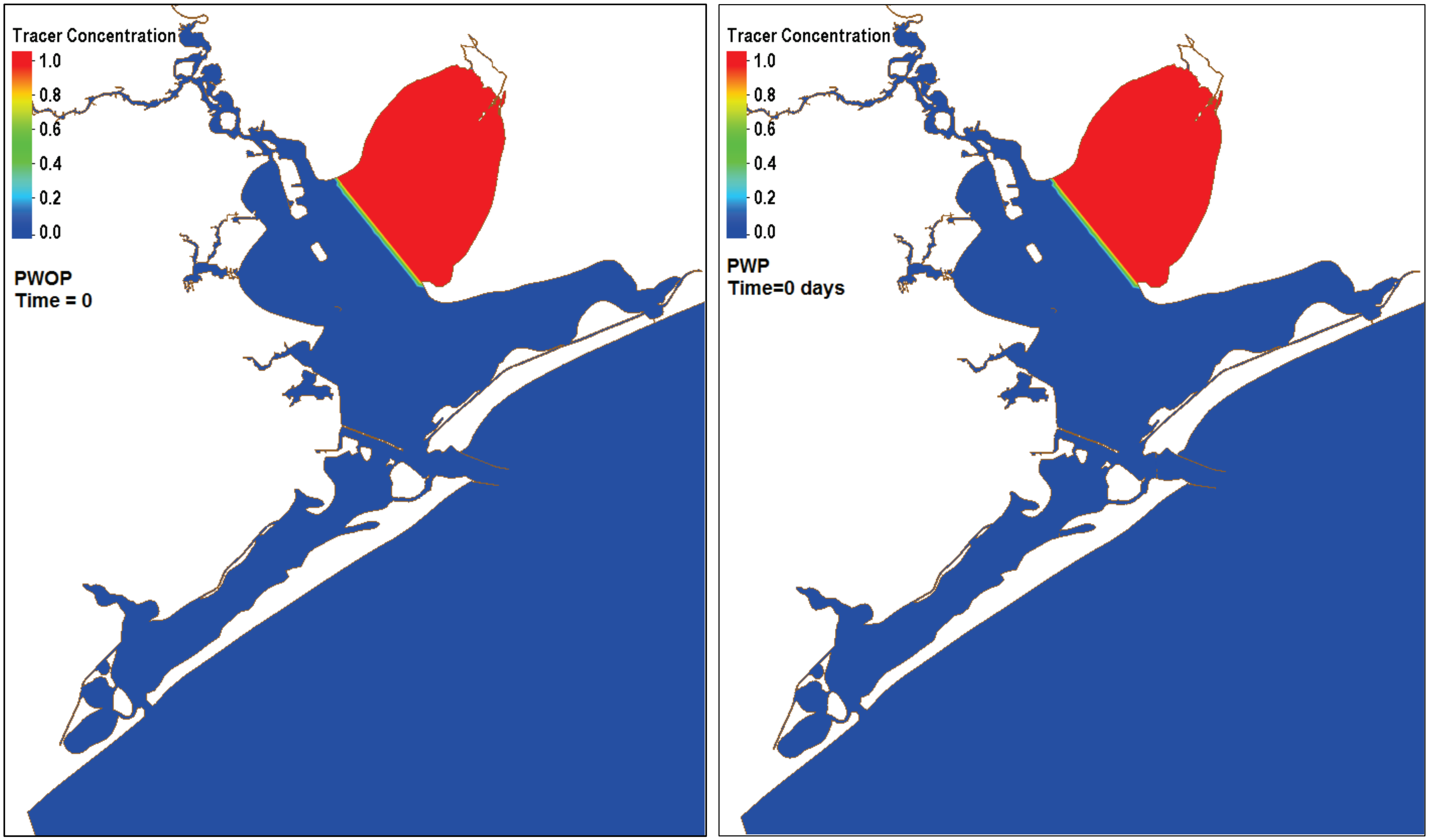
Bottom average residual velocity comparison for present conditions at Offatts Bayou.
(Red vectors – with project, Black vectors – without project)

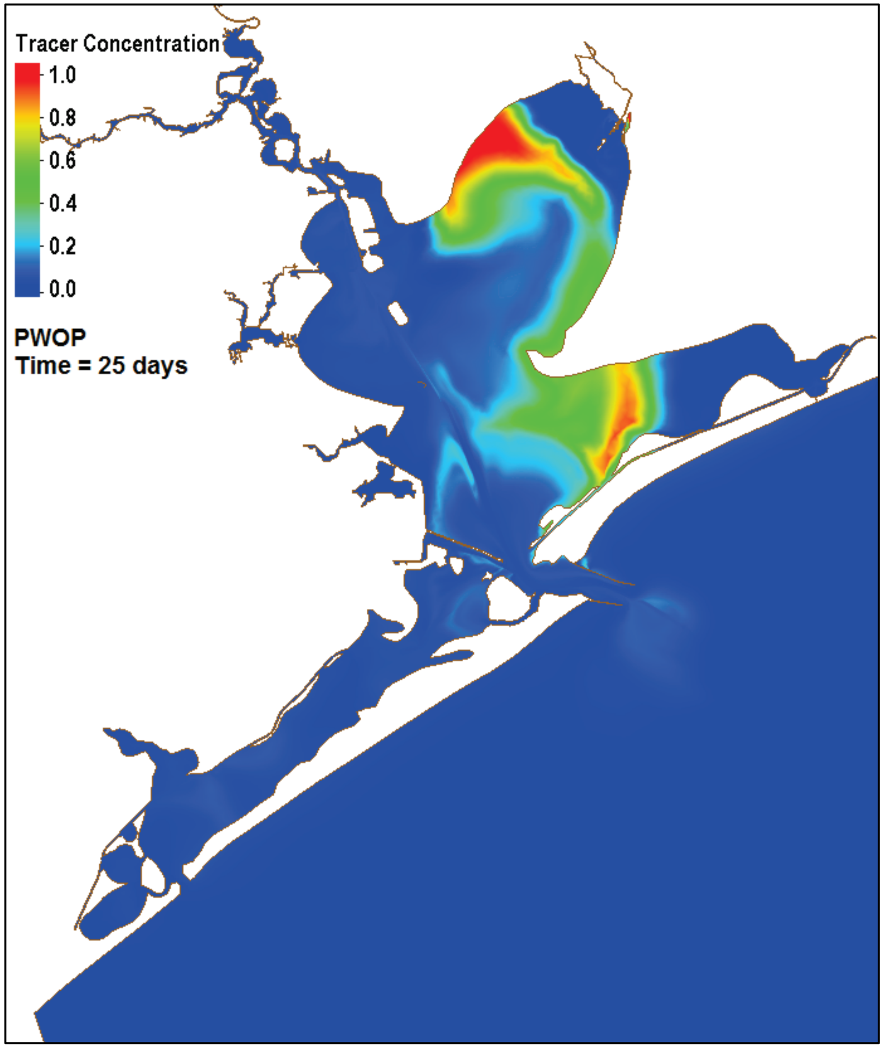


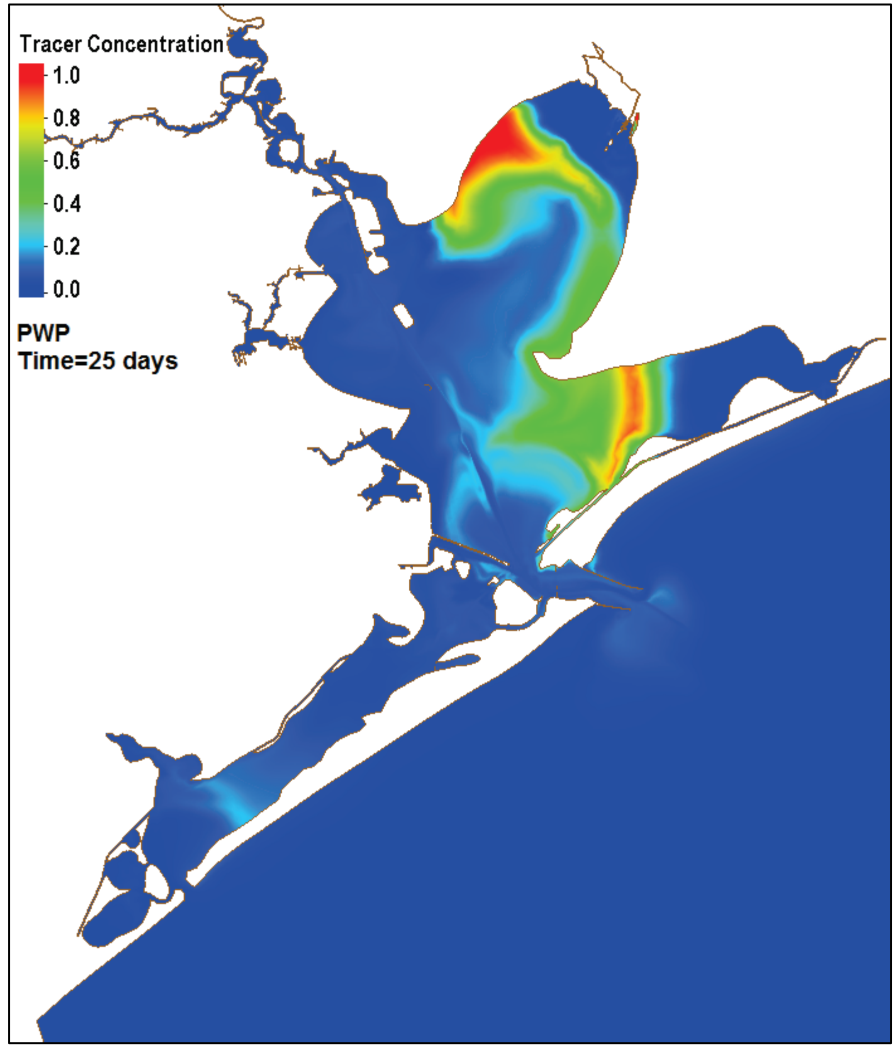
Surface average residual velocity comparison for present conditions at Offatts Bayou.
(Red vectors – with project, Black vectors – without project)

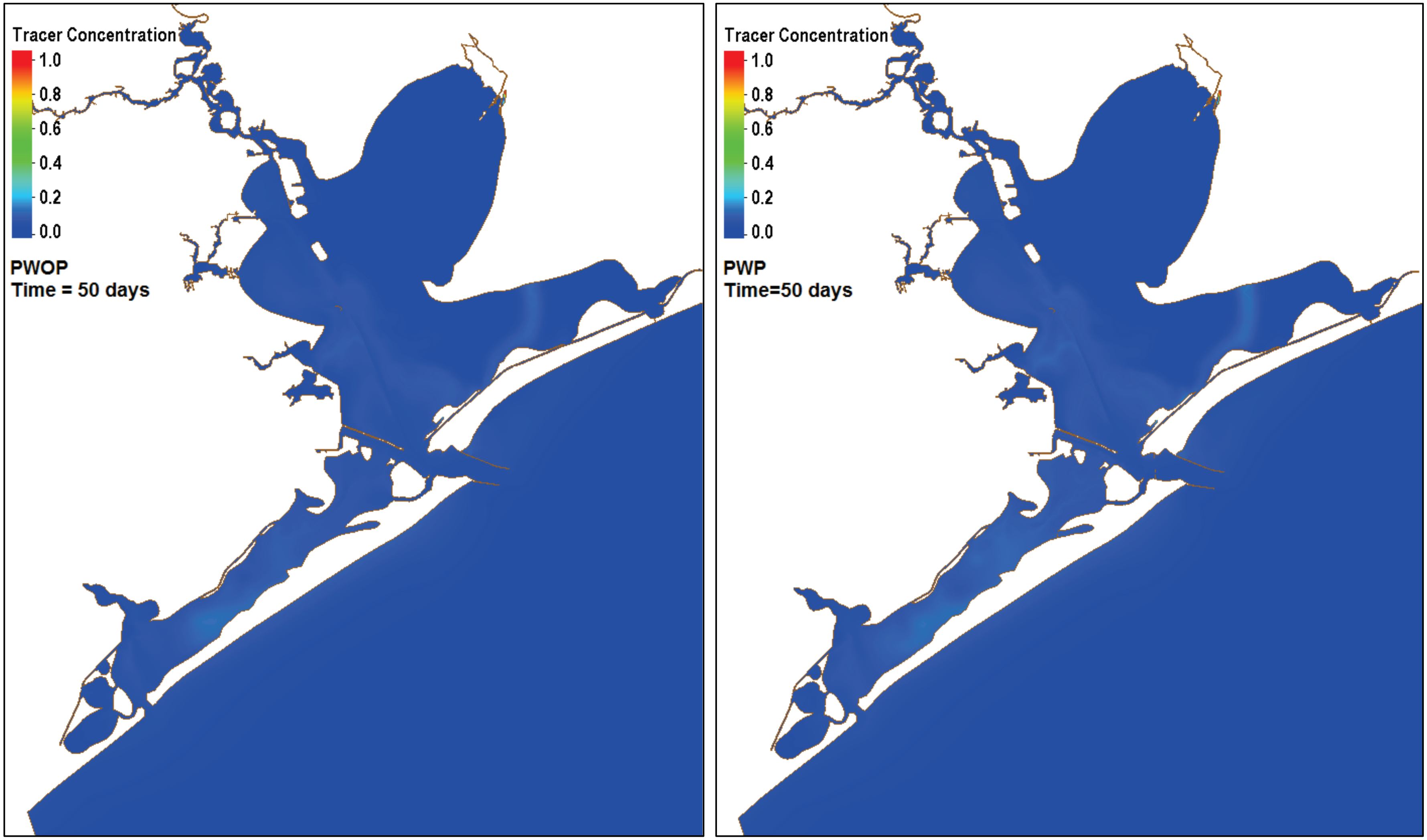


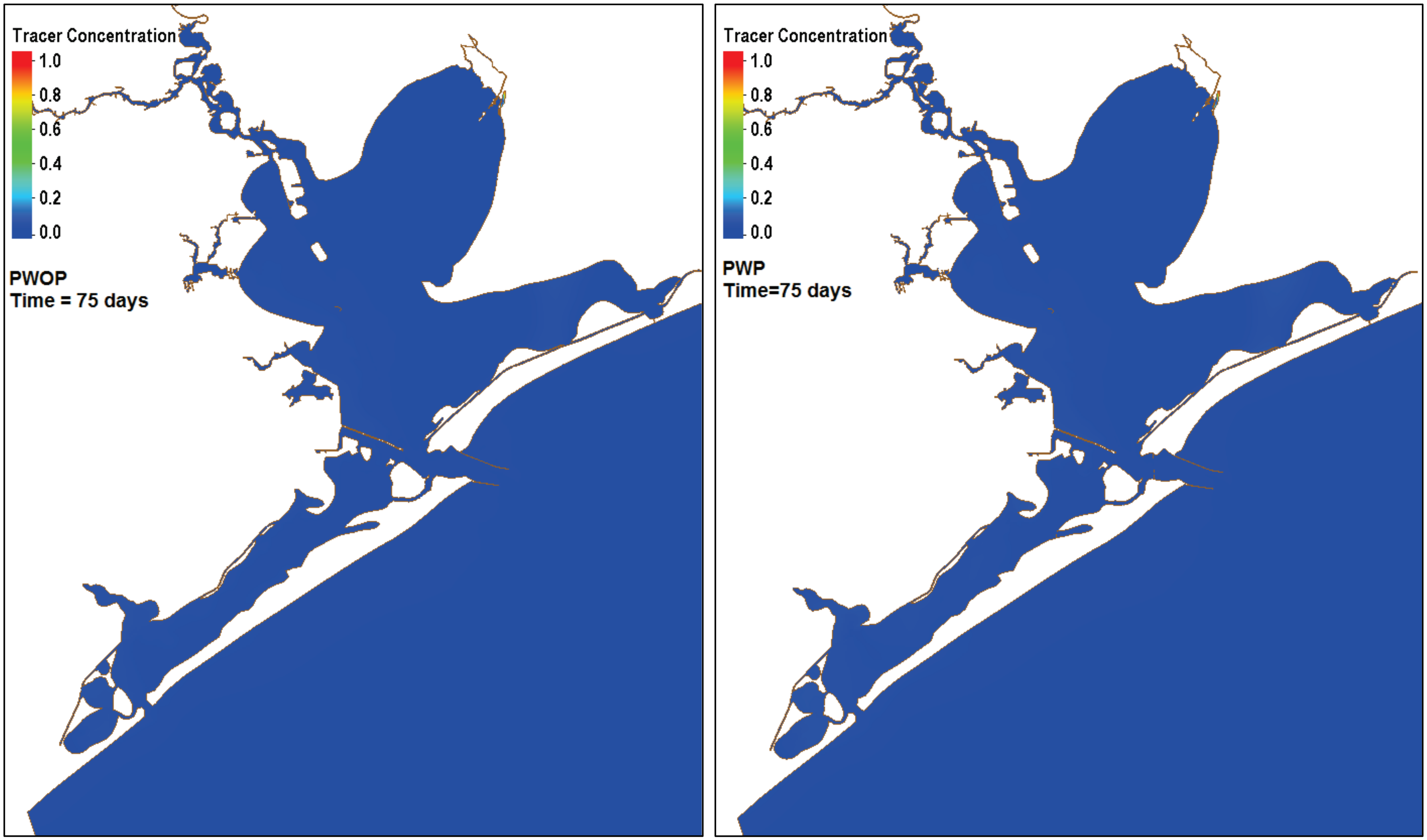
Appendix E: Tracer Analysis over Full Domain

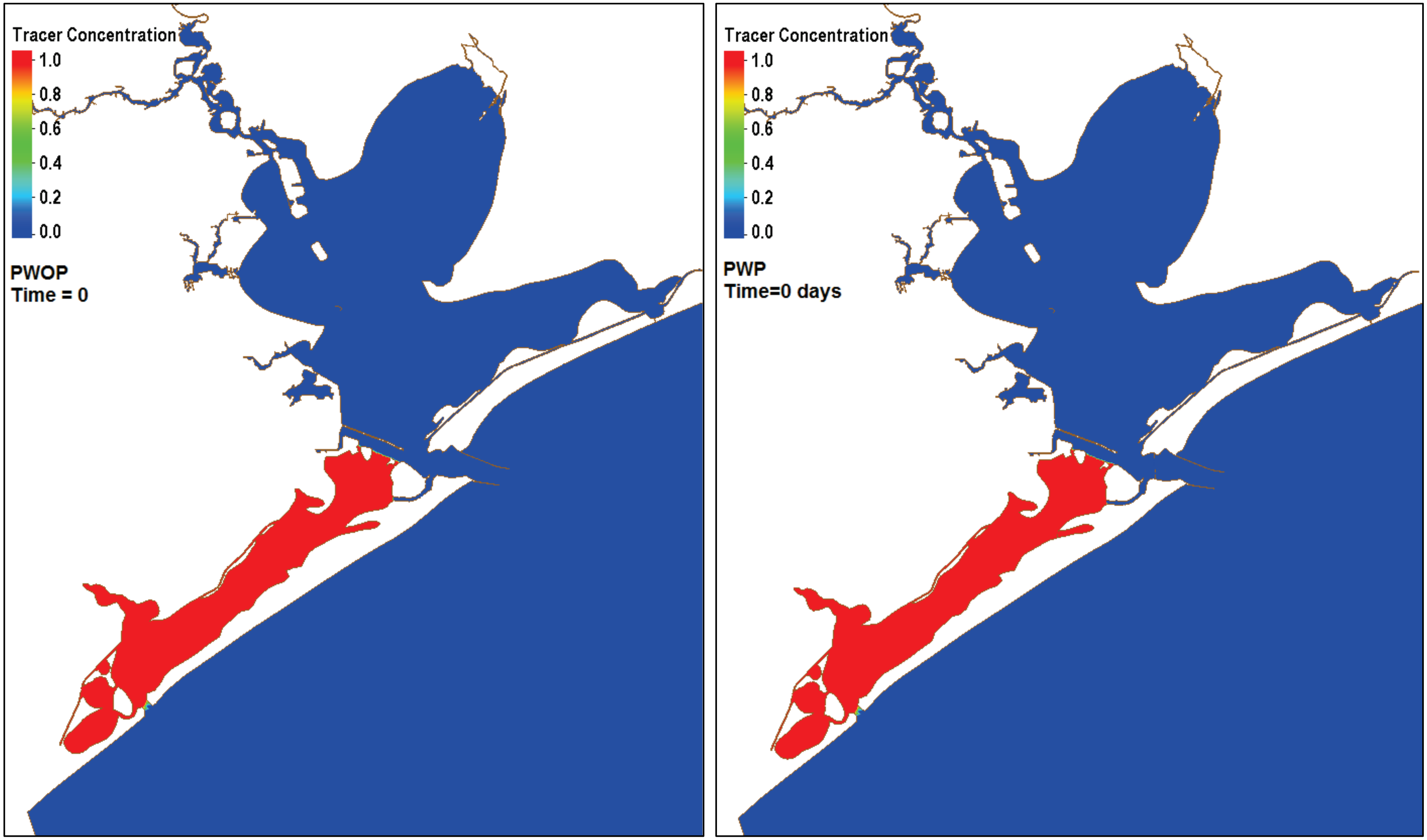

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 0
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=0 days

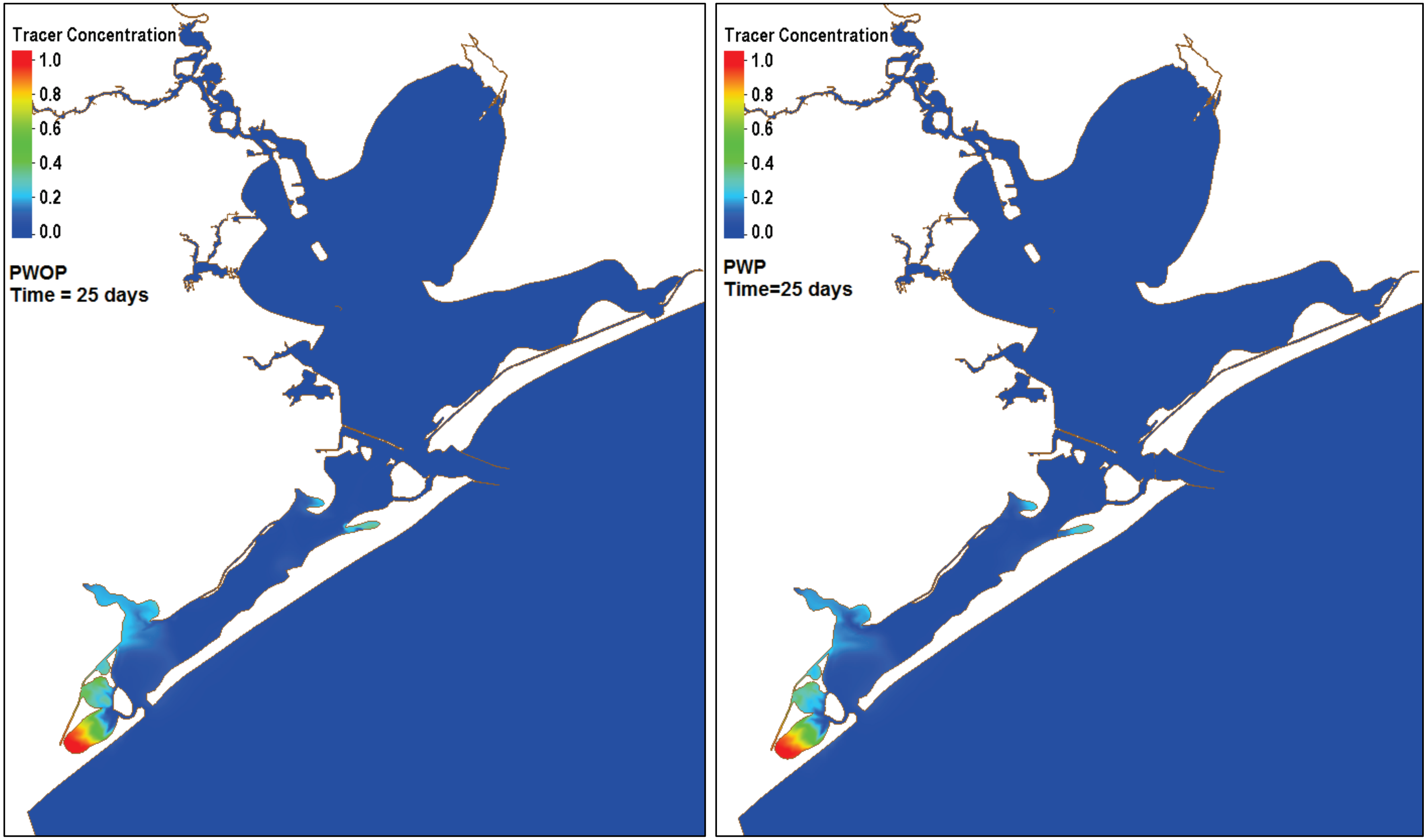

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 25 days

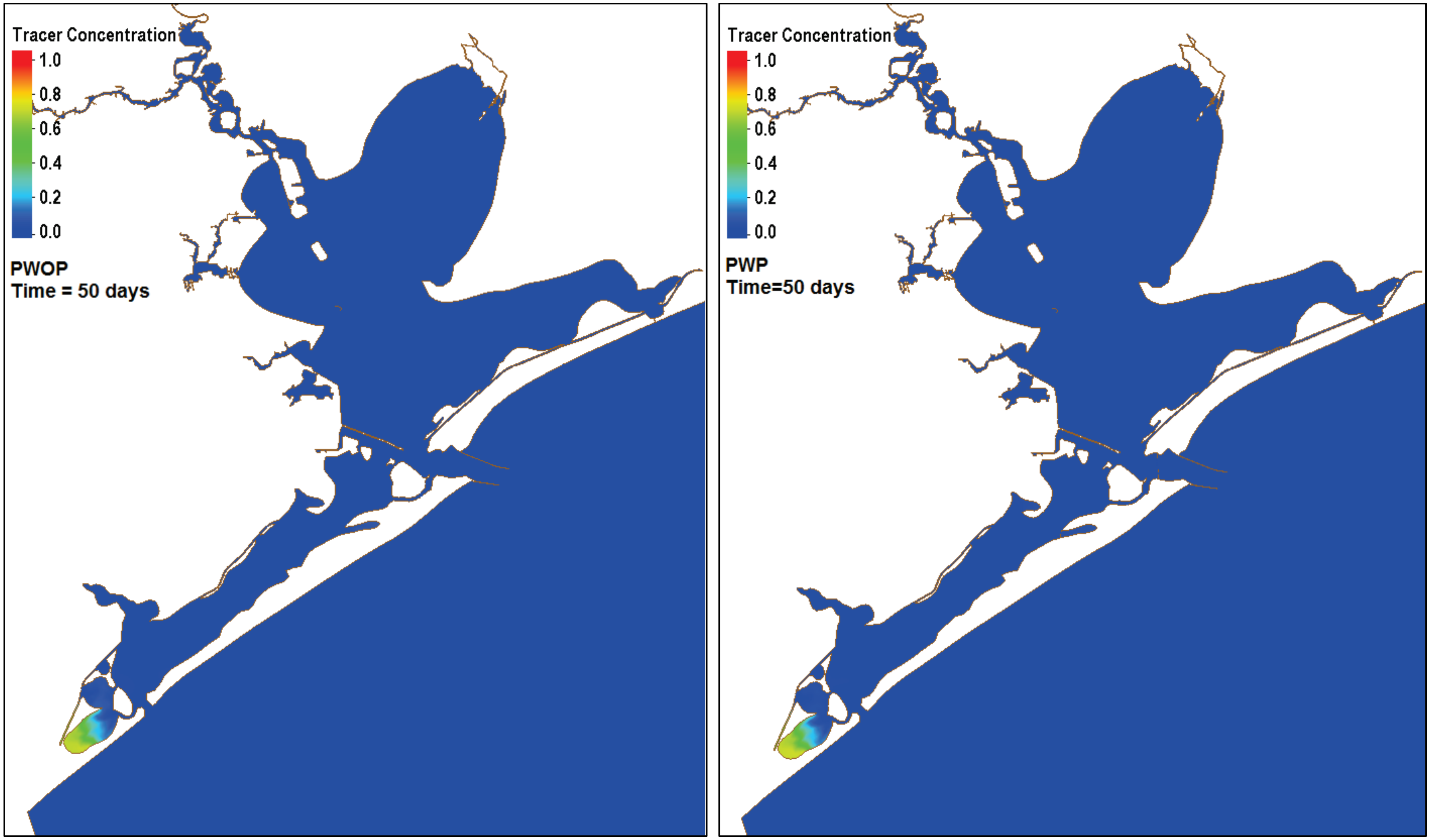

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=25 days

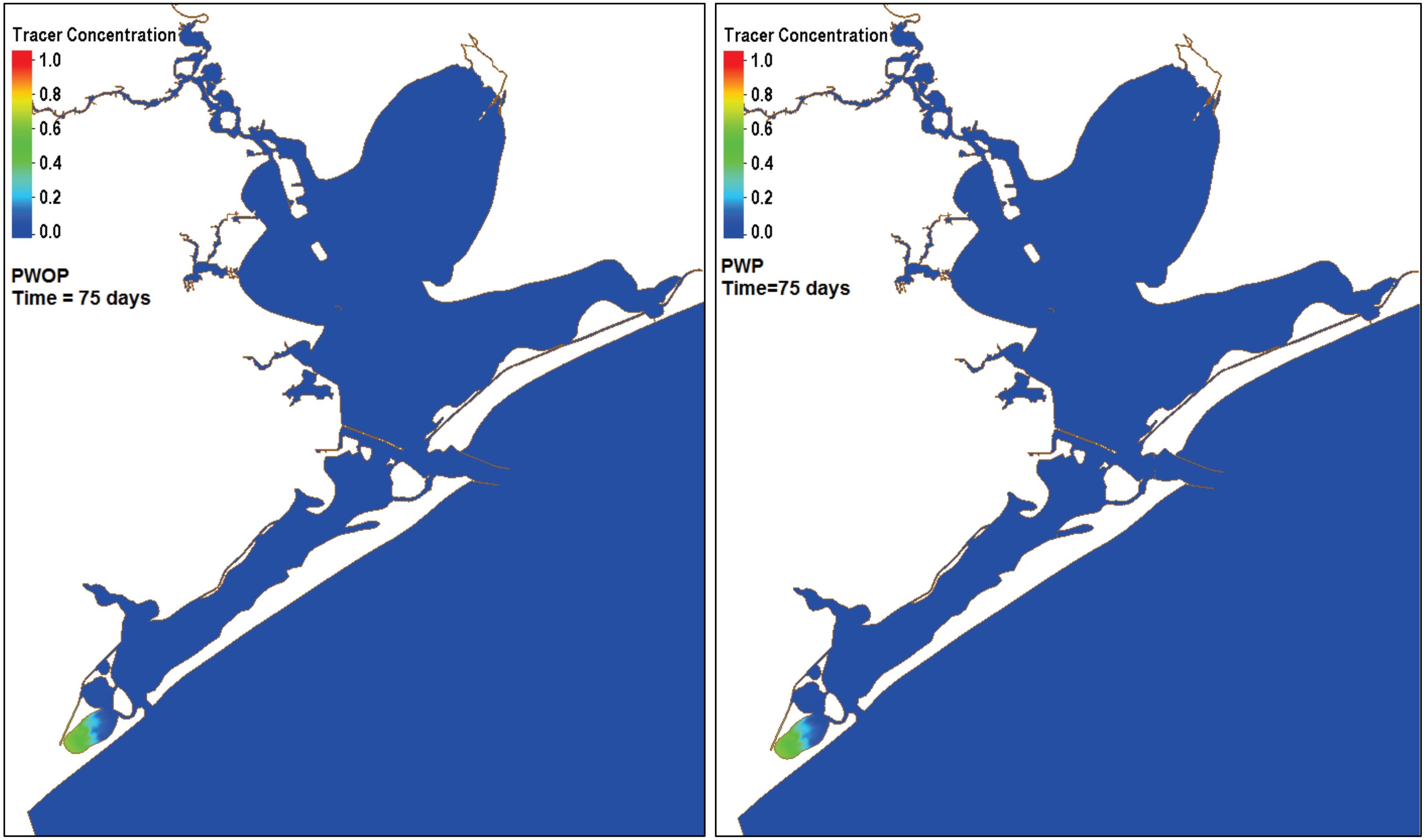

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 50 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=50 days

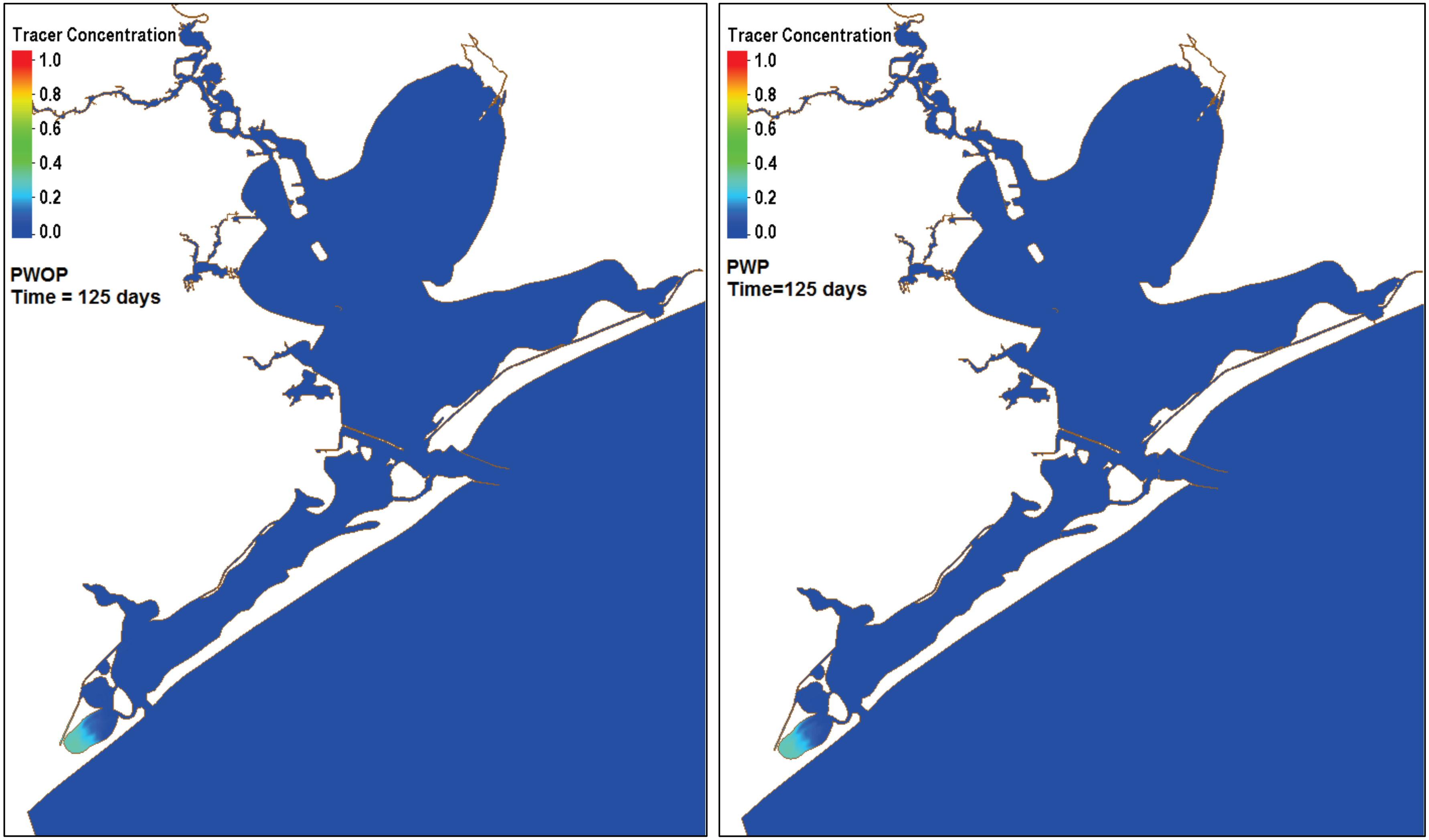

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 75 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=75 days

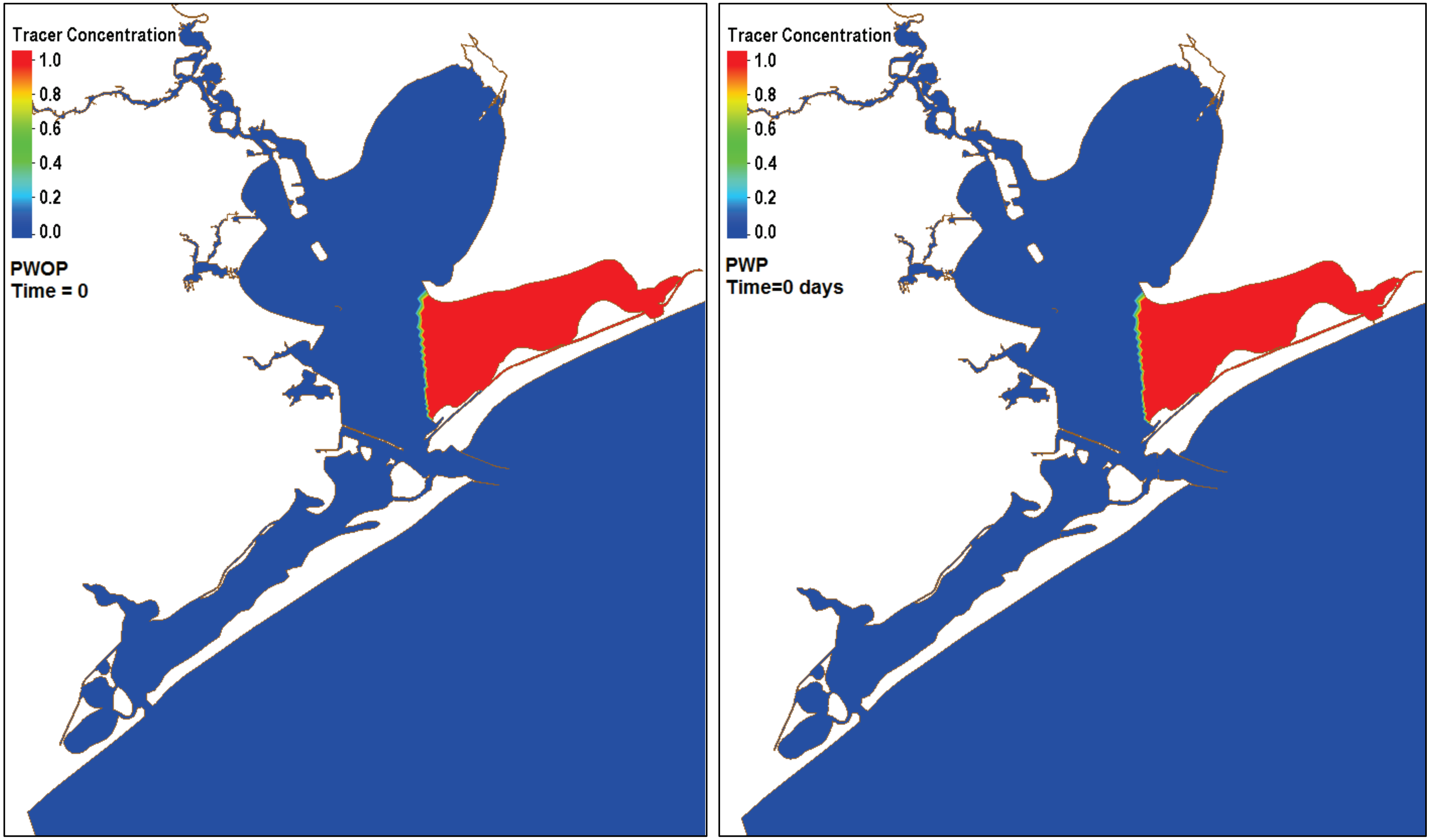

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 0
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=0 days

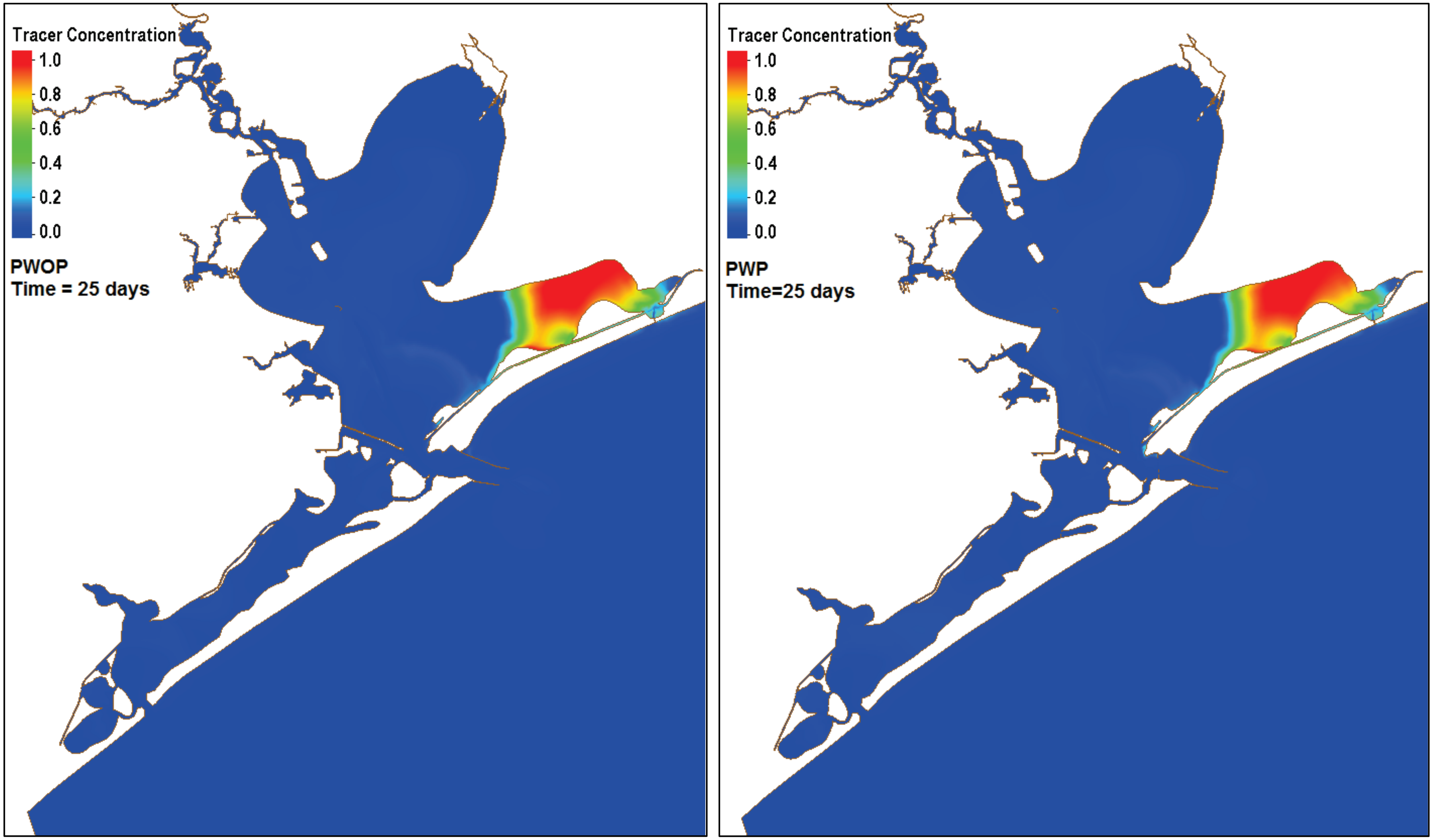

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 25 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=25 days

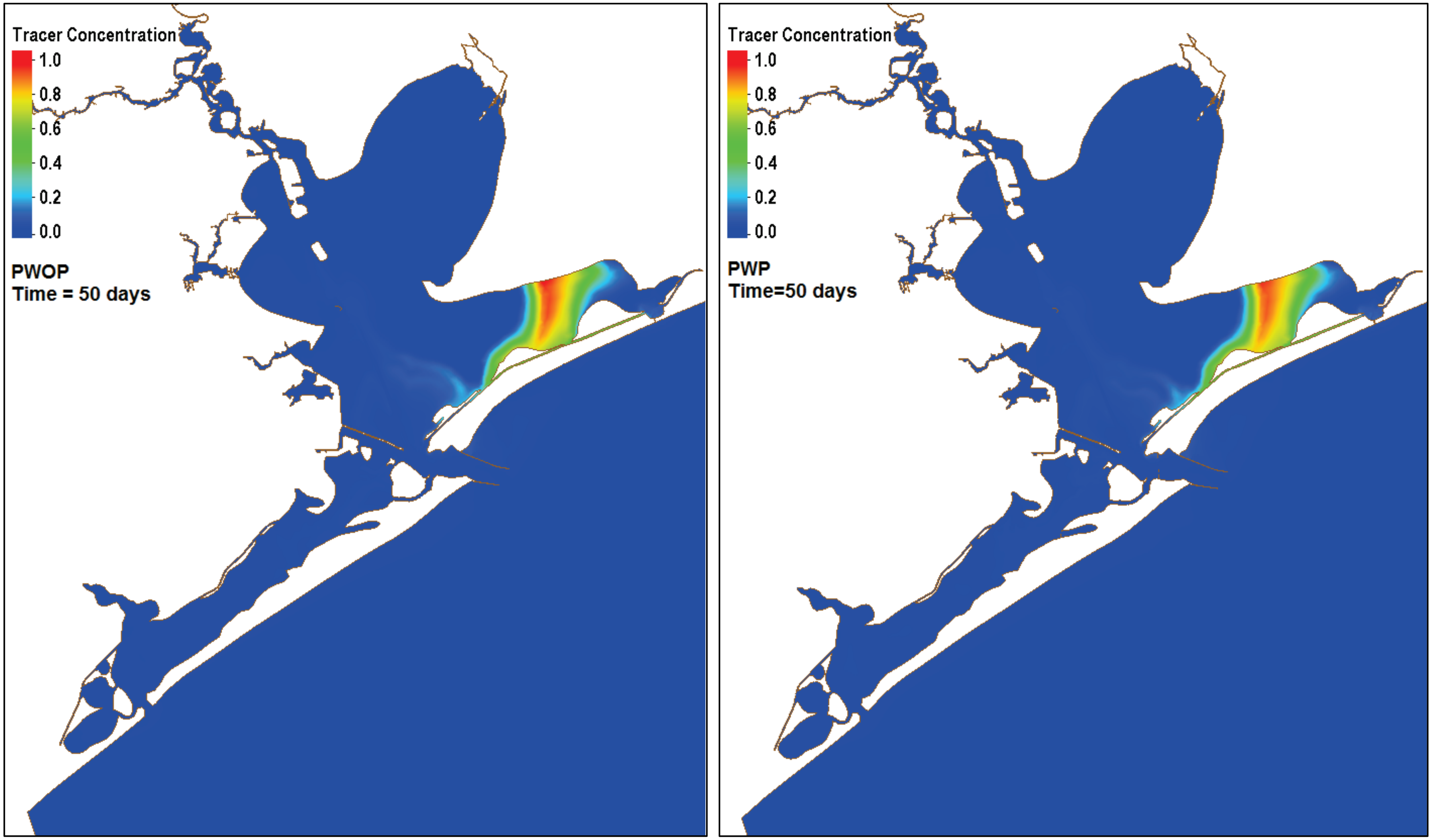

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 50 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=50 days

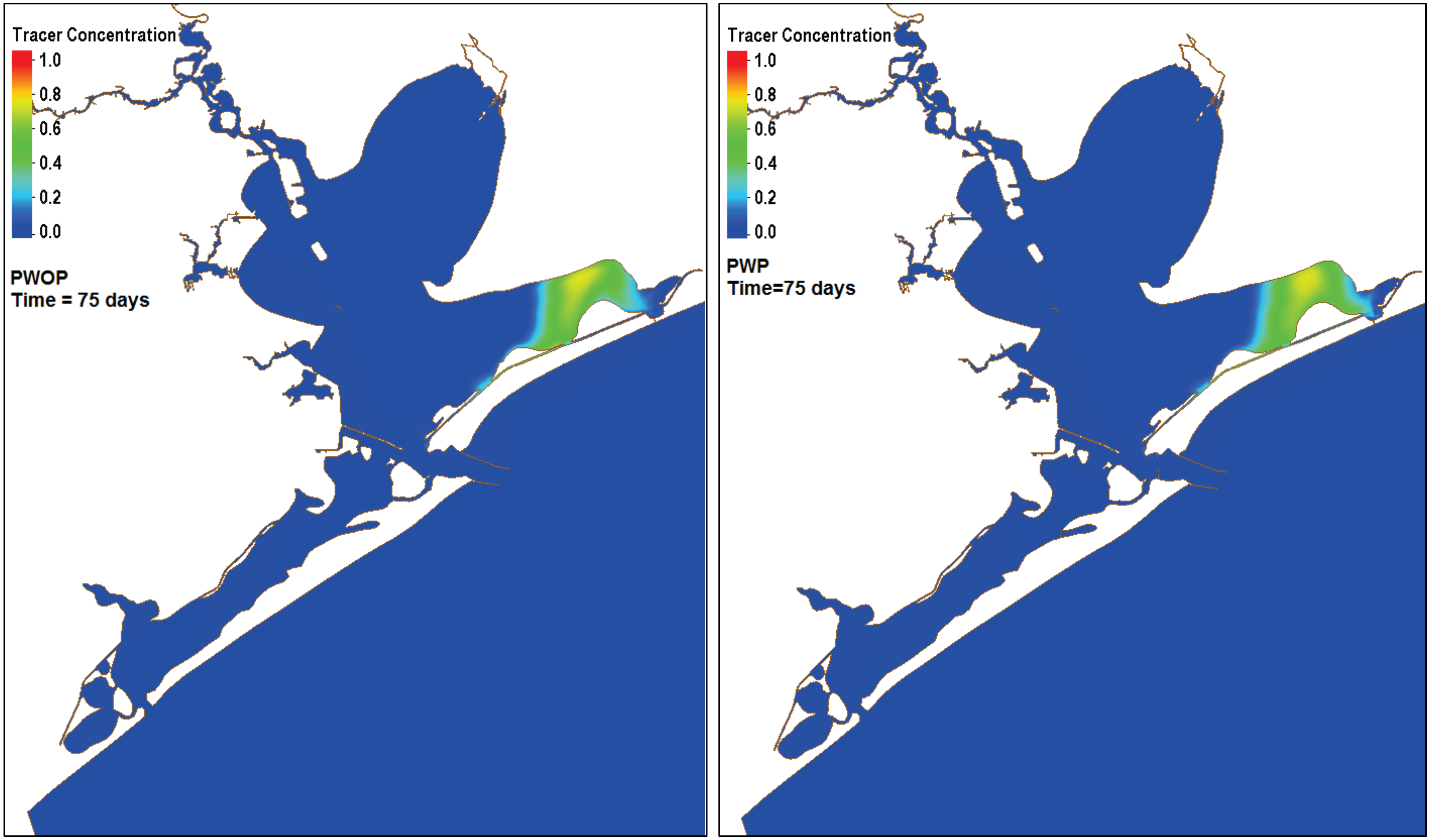

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 75 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=75 days

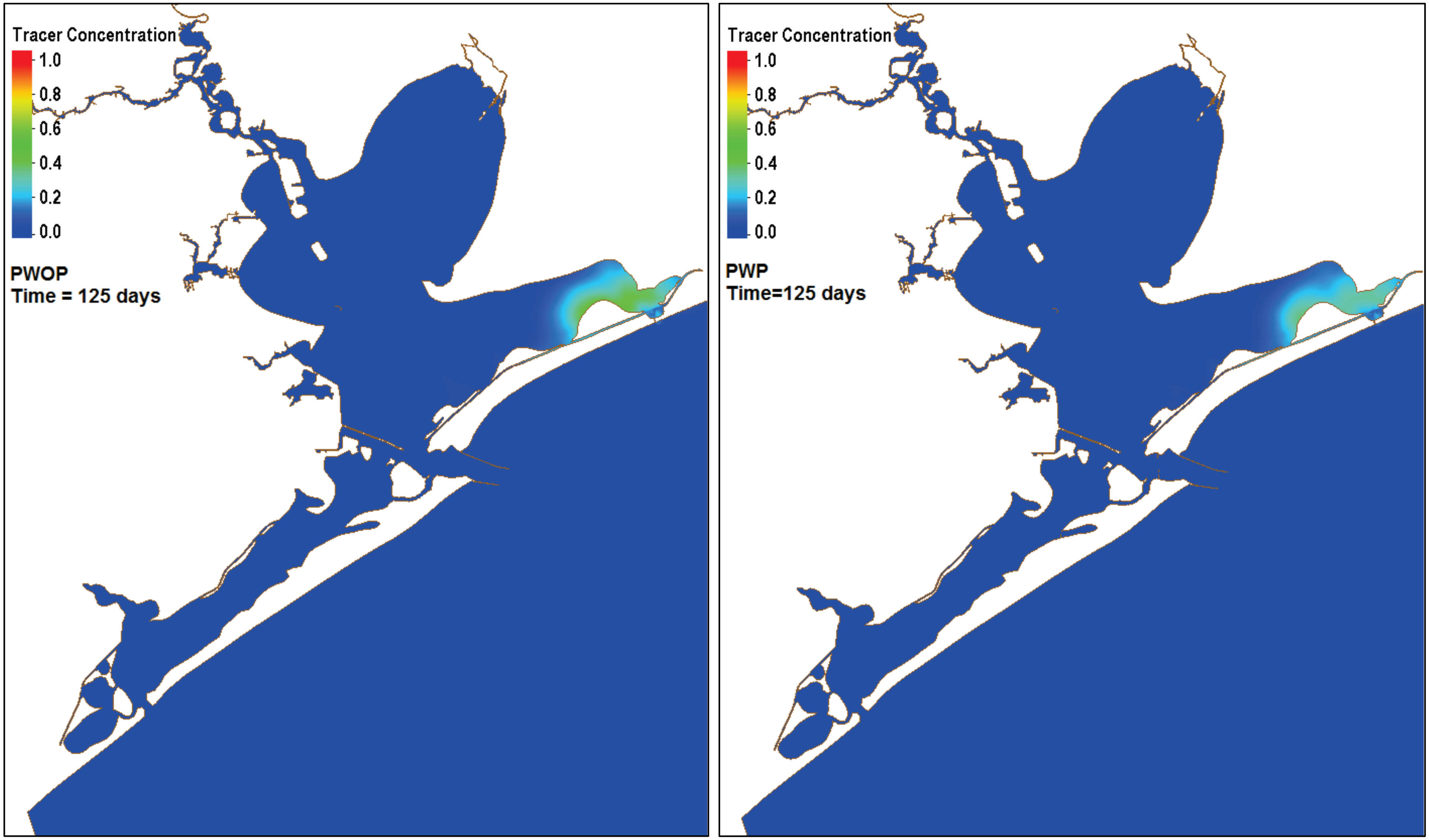

Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 125 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=125 days


Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 0
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=0 days


Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 25 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=25 days


Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 50 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=50 days


Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 75 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=75 days


Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWOP
Time = 125 days
Tracer Concentration
1.0
0.8
0.6
0.4
0.2
0.0
PWP
Time=125 days

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic feet per second	0.02831685	cubic meters per second
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	0.0254	meters
knots	0.5144444	meters per second
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

List of Abbreviations

HSC	Houston Ship Channel
AdH	Adaptive Hydraulics
CTR1	Coastal Texas Region 1
ERDC-CHL	Engineer Research and Development Center, Coastal and Hydraulics Laboratory
FWP	Future With Project
FWOP	Future Without Project
MLLW	Mean Lower Low Water
NOAA	National Oceanic and Atmospheric Administration
PWP	Present With Project
PWOP	Present Without Project
SLR	Sea Level Rise
SWG	U.S. Army Engineer District, Galveston
TSP	Tentatively selected plan
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
WIS	Wave Information Studies
3D	Three-dimensional

List of Unit Abbreviations

ft	feet
m	meters
m^3	cubic meters
cms	cubic meters per second
m/s	meters per second
mg/l	milligrams per liter
ppt	parts per thousand

REPORT DOCUMENTATION PAGE

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14. ABSTRACT
The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate vessels even in the event of providing storm surge protection. The U.S. Army Engineer District, Galveston, requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, to perform hydrodynamic and salinity modeling of proposed storm surge protection measures at the Houston Ship Channel entrance to the Gulf of Mexico. The modeling results are necessary to provide data for environmental analysis. The model setup and validation are presented as well as the results of project year zero (2035) and project year 50 (2085) with and without project results.

15. SUBJECT TERMS
Coastal engineering—Numerical analysis, Flood control, Houston Ship Channel (Tex.), Hydrodynamics, Inland navigation, Salinity, Seawalls, Storm surges

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