ENVIRONMENTAL APPENDIX C

ATTACHMENT C-1

AQUATIC RESOURCES ASSESSMENTS

ENVIRONMENTAL MONITORING OF MOBILE BAY AQUATIC RESOURCES AND POTENTIAL IMPACTS OF THE MOBILE HARBOR GENERAL REEVALUATION REPORT

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Abstract

The following report assesses potential impacts to aquatic resources resulting from proposed navigation channel expansion activities within Mobile Bay, Alabama. The report was conducted for the U.S. Army Corps of Engineers (USACE) – Mobile District, supporting development of a supplemental Environmental Impact Statement. Specifically, changes in water quality and hydrodynamics are evaluated for potential impacts to benthic macroinvertebrates, wetlands, submerged aquatic vegetation, oysters, and fish. The assessment includes extensive characterization of baseline conditions, followed by evaluation of estimated post project conditions related to aquatic resource habitat (e.g., changes in salinity, dissolved oxygen). Additionally, an analysis of potential impacts related to a 0.5m sea level rise scenario are evaluated. Results suggest that no substantial impacts in aquatic resources within the study area are anticipated due to project implementation, as the area of greatest potential changes to environmental conditions are already adapted to natural shifts in salinity (and other factors) as well as conditions resulting from the existing navigation channel. Further, although sea level rise has the potential to alter aquatic resource habitats with Mobile Bay, additional impacts related to project implementation remain negligible under the 0.5 m sea level rise scenario. The sections below provide detailed information regarding the study design, execution, and results.

Executive summary

The U.S. Army Corps of Engineers (USACE) – Mobile District is evaluating potential expansion of the Mobile Bay navigation channel, including deepening and widening activities. These structural modifications to the navigation channel can potentially alter circulation and transport within Mobile Bay, which has the potential to impact aquatic resources. In response an assessment of aquatic resources was conducted to evaluate potential changes in habitat related to five aquatic resource categories identified by an interagency team including: benthic macroinvertebrates, wetlands, submerged aquatic vegetation (SAV), oysters, and fish. The assessment describes baseline characterization and distribution of existing resources, followed by analysis of projected post-project conditions (e.g., salinity, dissolved oxygen) with the potential to impact the presence and productivity of each target aquatic resource. A 0.5 m sea level rise scenario is also evaluated in accordance with current USACE guidance.

The benthic macroinvertebrate assessment results indicate that benthic macrofaunal assemblages transition from polychaete-rich assemblages in the estuary to being dominated by insects in freshwater habitat. Expected post project conditions suggest mean bottom salinity increases 1 -3 psu. The greatest salinity increases are projected to occur within the transitional and estuarine zones where benthic macrofaunal assemblages are dominated by polychaete worms that are well adapted to experiencing salinity fluctuations that occur during tidal exchanges. Impacts of harbor deepening on benthic macrofauna due to salinity intrusion are predicted to be negligible, with no effects on higher trophic levels, such as fish, because prey availability and distributions are unlikely to be affected.

The wetland assessment identified >40 habitat types occurring across a wide range of salinity regimes. Projected changes in water quality will not exceed wetland plant community mortality or productivity thresholds within the study area, suggesting that impacts to wetlands are not expected. While the 0.5 m sea level rise scenario will result in increased wetland inundation within portions of Mobile Bay, implementation of the project is expected to have limited additional impacts on wetlands.

The SAV assessments identified > 600 acres of sea grasses encompassing 55 community types. Expected post project conditions suggest that > 93% of SAV communities will not experience substantial salinity increases. Where potential salinity thresholds may be exceeded, affected species are dominated by invasive species (Eurasian watermilfoil) or occur during short duration (<7 day) events. Dissolved oxygen levels remain within SAV tolerance limits across all scenarios examined.

Simulated oyster larvae movement through integrated hydrodynamic, water quality, and larval tracking modeling was successfully implemented. Dissolved oxygen levels stay well above the minimum oyster tolerance threshold for simulated scenarios with and without SLR. Similarly, salinity stays within oyster tolerance survival threshold for all scenarios. Importantly, the oyster model results do not project an increase in larvae flushing out of Mobile Bay due to project implementation.

For the fisheries assessment, a total of 2,097,836 individuals representing 162 species were recorded and used in the analysis, which include five salinity tolerance guilds ranging from freshwater to marine habitat conditions. The freshwater entering estuary salinity guild is likely the most susceptible to changes in salinity due to project construction, but the range they occupy suggests that differences between baseline and project alternative with and without sea level rise would have to much greater than the physical model suggests. Given these relationships, impacts to the Mobile Bay fishery are not expected.

List of Tables – Full list pending professional formatting

Table 2.1. Total abundances of benthic macroinvertebrates collected in Estuarine, Transitional, and Freshwater areas during Fall (October 2016) sampling (30 stations per area). .

Table 2.2. Average abundances of benthic macroinvertebrates in each location within the Estuarine, Transitional, and Freshwater zones in October 2016.

Table 2.3. Benthic macroinvertebrate mean abundances of taxa that contributed at least 5% to dissimilarities between freshwater stations downstream from C10 and upstream from C9 (SIMPER).

Table 2.4. Total abundances of benthic macroinvertebrates collected in each area during (May 2017) sampling (30 stations per area).

Table 2.5. Average abundances of benthic macroinvertebrates in each location within the Estuarine, Transitional, and Freshwater zones in May 2017.

List of Figures – Full list pending professional formatting

Figure 2.1. Benthic station locations in estuarine habitat in upper Mobile Bay.

Figure 2.2. Benthic stations locations in the transition zone.

Figure 2.3. Benthic stations locations in the western portion of freshwater zone.

Figure 2.4. Benthic stations locations in the eastern portion of freshwater zone.

Figure 2.5. Mean (+ standard error) salinity, dissolved oxygen, and depth at stations in the estuarine, transitional, and freshwater zones during fall (October 2016) sampling.

Figure 2.6. Sediment grain size distributions and % TOC in the estuarine, transitional, and freshwater zones during the fall 2016 sampling period.

Figure 2.7. Mean fall biomass (+ standard error) of Annelids, Arthropods and Molluscs in each sampling area.

Figure 2.8. Non-metric multidimensional scaling plot of samples collected during fall sampling (October 2016) in the estuarine (blue symbols), transitional (red symbols), and freshwater (green symbols) zones.

Figure 2.9. Non-metric multidimensional scaling plot of samples collected during fall sampling (October 2016) in the transitional (red symbols) and freshwater (green symbols) zones.

Figure 2.10. Mean (+ standard error) salinity, dissolved oxygen, and depth at stations in the estuarine, transitional, and freshwater zones during spring (May 2017) sampling.

Figure 2.11. Sediment grain size distributions and % TOC in the estuarine, transitional, and freshwater zones during the spring 2017 sampling period.

Figure 2.12. Mean spring biomass (+ standard error) of Annelids, Arthropods and Molluscs in each sampling area.

Figure 2.13. Non-metric multidimensional scaling plot of samples collected during spring sampling (May 2017) in the estuarine (blue symbols), transitional (red symbols), and freshwater (green symbols) zones.

Figure 2.14. Non-metric multidimensional scaling plot of samples collected during spring sampling (May 2017) in the transitional (red symbols) and freshwater (green symbols) zones.

Chapter 1: Project purpose and overview

Chapter 1: Introduction

1.1 Purpose.

The purpose of this study is to document the a wide array of aquatic resources within Mobile Bay and investigate potential changes in natural resource habitat and productivity associated with proposed deepening and widening of the Mobile navigation channel. Aquatic resources evaluated will include benthic macroinvertebrates, wetlands, submerged aquatic vegetation (SAVs), oysters, and fish.

1.2 Background

The study site occupies Mobile Bay, Alabama which is formed by the Fort Morgan Peninsula to the east and Dauphin Island, a barrier island on the west. Mobile Bay is 413 square miles (1,070 km2) in area. It is 31 miles (50 km) long with a maximum width of 24 miles (39 km). The deepest (75 feet, 23 m) areas of the Bay are located within the federal navigation channel, which serves Alabama's only port for ocean-going vessels, but the average depth of the bay is around 10 feet (3 m). The Mobile Bay watershed is the sixth largest river basin in the United States and the fourth largest in terms of streamflow. It drains water from three-fourths of Alabama as well as portions of Georgia, Tennessee and Mississippi into Mobile Bay. Both the Mobile River and Tensaw River empty into the northern end of the Bay. Several smaller rivers: Dog River, Deer River, and Fowl River, on the western side of the Bay and the Fish River on the eastern side also empty into the Bay, making it an estuary. A feature of all estuaries is a transition zone, where the freshwater from the rivers mixes with the tidally-influenced salt water of the Gulf of Mexico.

The principal navigation problem is that vessels are experiencing delays leaving and arriving at the port facilities and their cargo capacities are limited. This problem is a result of the increasing number and size of vessels entering and departing the port. In the last five years, the Alabama State Port Authority (ASPA) has added two new facilities at the lower end of the Mobile River (at the upper portion of Mobile Bay). One is the Choctaw Point container terminal and the other is the Pinto Island Terminal. Both facilities have increased the amount of traffic into the port. The existing channel depths and widths limit vessel cargo capability and also restrict many vessels to one-way traffic and light loading. Therefore, evaluating deepening and widening of the Bar and Bay channels up to their fully authorized dimensions is being proposed to alleviate harbor delays and improve cargo capacity. These structural modifications to the navigation channels can potentially alter circulation and transport within Mobile Bay, which has the potential to impact aquatic resources. Potential impacts include changes in salinity, sediment transport, and water quality parameters related to aquatic resources in the region.

As part of an investigation of potential environmental effects of widening and deepening of the federal navigation channel, the U.S. Army Corps of Engineers Mobile District requests the assistance of the U. S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) to assess potential impacts to aquatic resources in locations potentially impacted by saltwater intrusion and other factors. Characterizations of baseline aquatic resources in estuarine, transitional, and freshwater environments are important to establish prior to channel deepening and potential impacts from saltwater intrusion. A key component of the current study is to document changes to aquatic resources along the salinity continuum moving upriver and estimates how far upriver changes may occur after the navigation channel is widened and depended to its new authorized depth. Elevated salinities upriver and in adjacent marshes have raised concerns among resource managers because of potentially undesirable impacts to the marshes and their biological resources. Benthic invertebrates, SAV, oysters, fish, and wetlands are a critical part of both estuarine and riverine food webs, providing habitat and forage for economically and ecologically important finfish and shellfish species, which are identified as an important indicator of potential effects, and are routinely monitored as part of environmental assessments. A range of species utilize wetlands as rearing habitats including seasonally flooded bottomland hardwood forests, estuarine environments and tidal marshes. Some examples of commercially or recreationally important fish species that rely on aquatic resources include: Atlantic Croaker, Southern Kingfish or Ground Mullet, Spot, and Hardhead Catfish. Many other fish species located in the Mobile estuary feed primarily on epifauna, crustaceans and mollusks, include crabs, crayfish, snails, clams, etc. Additionally, the Alabama Shad is a freshwater species that feeds almost exclusively on benthic invertebrates.

The ERDC-EL has completed numerous aquatic resource assessments, including evaluations of potential impacts associated with navigation projects and alternatives analysis (Figure 1.1; Berkowitz et al. 2016). These studies have been successfully executed through a combination of 1) direct measurements of aquatic resources and 2) modeling approaches. Mobile Bay contains a variety of natural resources. An interagency team identified the following resources for evaluation of potential project impacts: wetlands, submerged aquatic vegetation (SAVs), oysters, benthic invertebrates and fish (GRR meeting Mobile, AL 03/31/16). Due to the variety of aquatic resources being evaluated, specific examples of resource assessments are provided in the chapters below. The general approach for all aquatic resource assessments will include 1) assessment of existing resources and 2) analysis of potential impacts based upon water quality and sediment modeling outputs (Bunch, 2016).

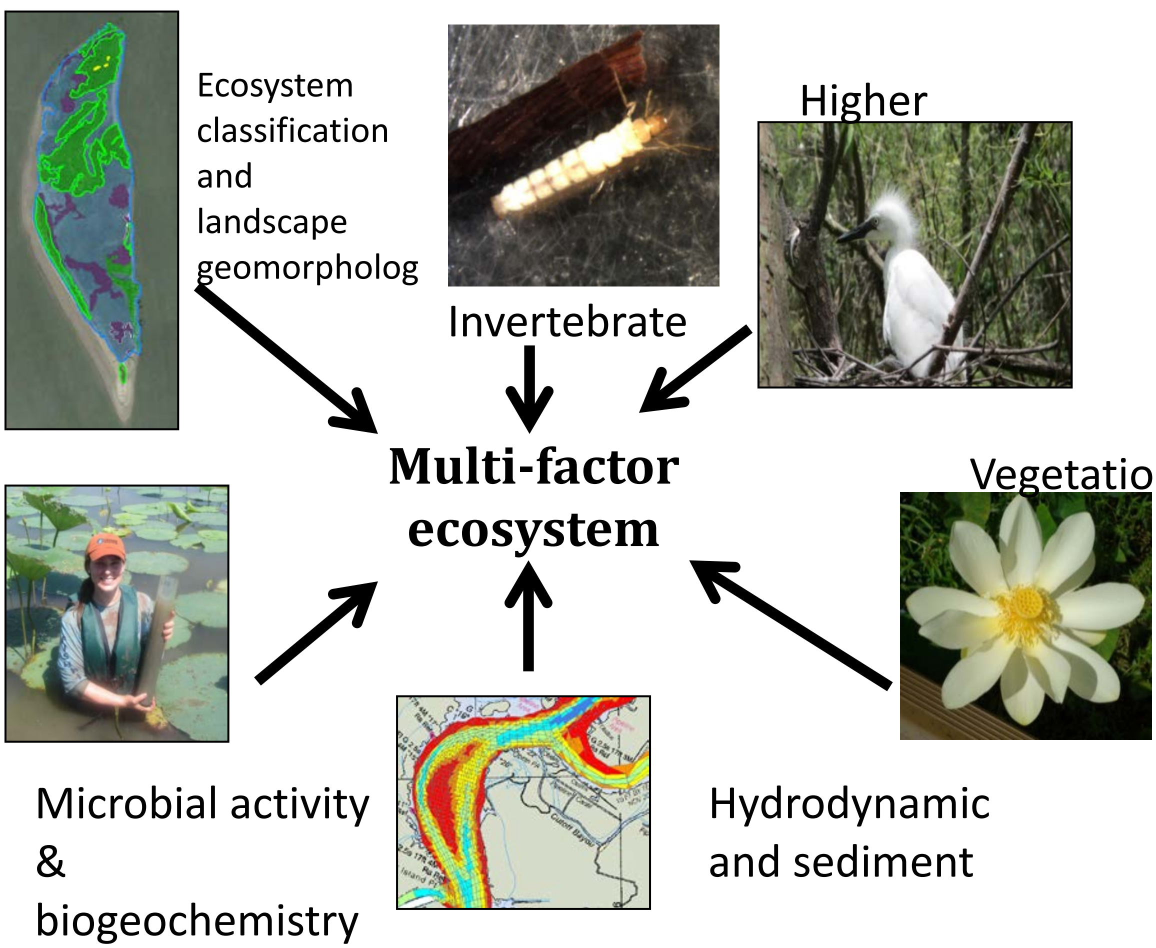

Figure 1.1. Conceptual model of the multi-factor assessment approach applied at Horseshoe Bend Island (Berkowitz et al. 2016).

1.3 Approach

Mobile Bay contains a variety of natural resources. As a result, an interagency team identified the following resources for evaluation of potential project impacts: wetlands, submerged aquatic vegetation (SAVs), oysters, benthic invertebrates and fish (GRR meeting Mobile, AL 03/31/16). Due to the variety of aquatic resources being evaluated, specific approaches for each resource assessment is provided in the chapters below. The general approach for all aquatic resource assessments will include 1) assessment of existing resources, 2) analysis of potential impacts based upon water quality modeling outputs (Bunch, 2016), and 3) evaluation of potential sea level rise implications. All hydrodynamic and water quality data was generated using a combination of approaches including the Geophysical Scale Multi-Block (GSMB) system, the Curvilinear Hydrodynamic in three-dimension Waterways Experiment Station (CH3D-WES) approach, and the CE-QUAL-ICM water quality component developed and maintained by the US Army Corps of Engineers Engineer Research and Development Center (Cerco and Cole 1995, others). Model outputs allowed for analysis of a variety of water quality parameters including salinity (Figure 1.2). Detailed model parameterization and implementation information is provided in other documentation associated with the supplemental Environmental Impact Statement and is not reproduced herein. The model documentation includes a discussion of the selected model dataset, verification, validation and other factors.

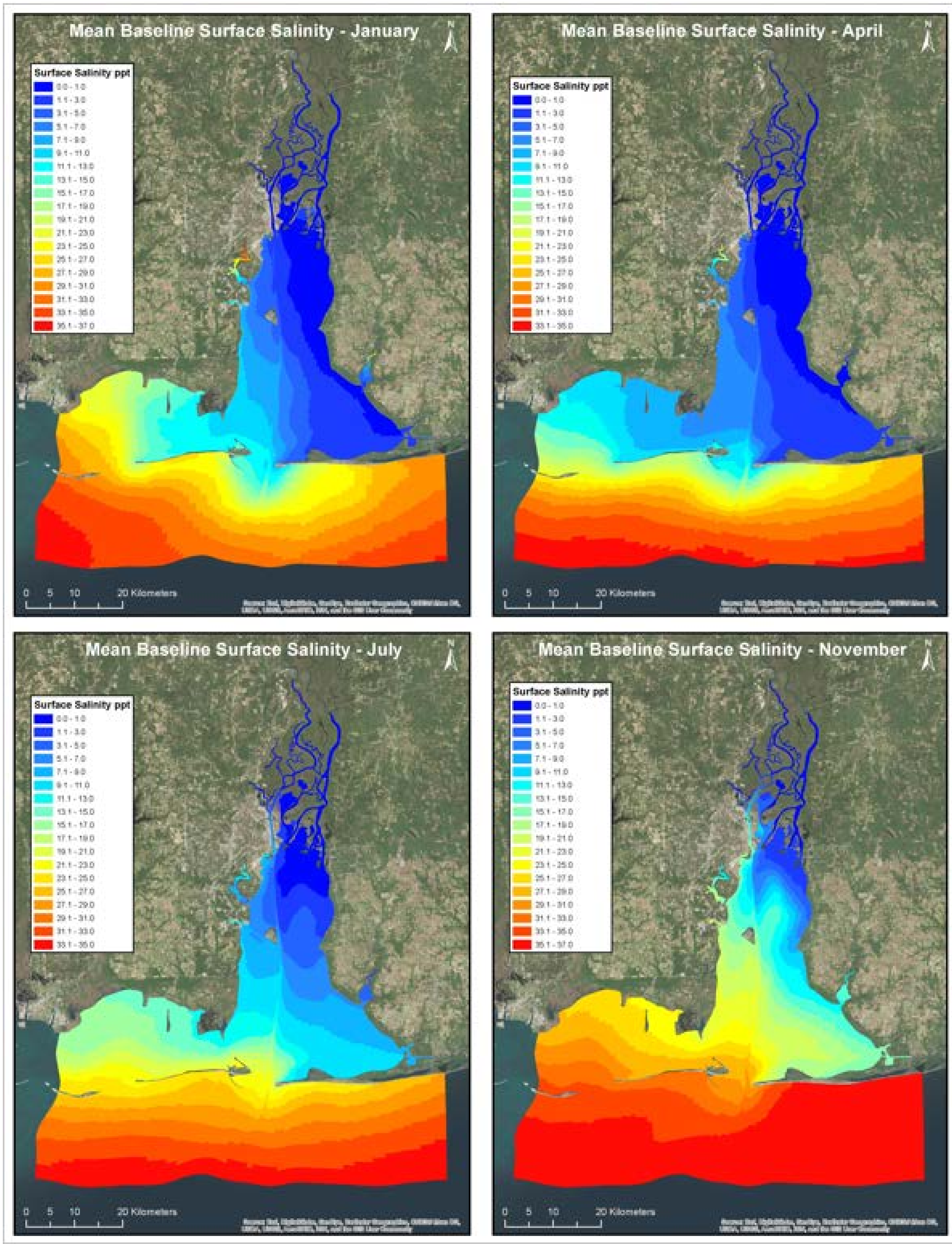

Figure 1.2. Example of surface water quality model outputs for the study area. Baseline (i.e., pre-project) salinity values are presented for winter, spring, summer, and fall (clockwise from top left).

Chapter 2: Benthic invertebrates

Summary

Potential impacts of the harbor deepening project on biological resources in Mobile Bay are a concern to natural resource managers because changes to saltwater – freshwater exchanges in the estuary could affect the distribution of biotic communities, including benthic macroinvertebrates and the fish that feed on them. In this chapter, benthic macroinvertebrates in Mobile Bay and upstream river habitat are examined. Results indicate that benthic macrofaunal assemblages transition from polychaete-rich assemblages in the estuary to being dominated by insects in freshwater habitat. In the fall, a gradual decline in salinity occurred as sampling occurred upstream in the Mobile River declining from 23 to 5 ppt. Benthic community composition remained consistent with estuarine assemblages within this zone, with a numerical dominance of capitellid, pilargiid, and spionid polychaetes. A sharp decline in salinity to freshwater conditions occurred near Bucks, Alabama, which corresponded to a significant change in the composition of benthic macroinvertebrates, i.e., polychaete abundances declined and insect (primarily, Ephemeridae and Chironomidae) abundances increased at this location and stations upstream.

Spring sampling occurred during a freshet, when low salinities were recorded throughout the study area. Benthic macroinvertebrates assemblages in the transitional and freshwater zones were similar to each other, with relatively high insect abundances, whereas estuarine assemblages had higher polychaete abundances. As with the fall sampling, biomass was dominated by bivalve molluscs, especially in the estuarine habitat.

Water quality modeling indicated that mean bottom salinity increases of approximately 1 ppt are expected following harbor deepening and maximum increases of approximately 3 ppt may occur. The greatest salinity increases are projected to occur within the transitional and estuarine zones where benthic macrofaunal assemblages are dominated by polychaete worms that are well adapted to experiencing salinity fluctuations that occur during tidal exchanges. The change to an insect dominated benthic community occurs where freshwater habitat is encountered, which

during fall sampling was well upstream from predicted project impacts. Impacts of harbor deepening on benthic macrofauna due to salinity intrusion are predicted to be negligible, with no effects on higher trophic levels, such as fish, because prey availability and distributions are unlikely to be affected.

2.1 Introduction

General context: The balance between freshwater inflow and saltwater tidal exchanges is an important driver establishing salinity-zone habitats in estuaries (Van Diggelen and Montagna 2016) and salinity strongly influences benthic macroinvertebrate distributions (Telesh and Khlebovich 2010). Changes to this freshwater/saltwater relationship are associated with wetland loss on the northern Gulf of Mexico via altered riverine input of freshwater and sediment (Day et al. 2000) and salt water intrusion via canal dredging (Turner 1997). Channel dredging can affect this relationship, for instance, saltwater intrusion increased in the Pearl River estuary (Yuan and Zhu 2015), Tampa Bay (Zhu et al. 2014), and Lake Pontchartrain (Junot et al. 1983) following dredging. Other factors affect habitat quality and the salinity balance within an estuary, including severe storms, sediment changes, and development; therefore, understanding the influence of a single factor, such as channel dredging, is difficult. Alterations to inputs of freshwater (e.g., droughts, floods, flood control levees) or saltwater (e.g., channel deepening), can affect biotic communities that are adapted to particular salinity zones by changing their taxonomic composition and distributions. Important estuarine biota includes benthic invertebrates, which are relatively stationary, living within bottom sediments. Their abundances and distributions, therefore, can serve as an indicator of environmental conditions in an area. It is expected that saltwater intrusion will facilitate landward migration of estuarine benthic macroinvertebrate assemblages (Little et al. 2017). For instance, upstream migrations of estuarine and marine benthic invertebrates occurred following a drought event that caused salt water incursion (Attrill and Power 2000). Salinity, however, is not the only factor affecting the distributions of benthic invertebrates, which also respond to sediment composition, competition, and predator-prey relationships (Little et al. 2017).

Problem statement: Because benthic invertebrates are important prey items for bottom feeding fishes and crustaceans, changes to invertebrate distributions and abundances could affect these higher trophic organisms. The widening and deepening of the Mobile Bay Federal Navigation Channel is an environmental concern because the possible influx of saltwater into upstream habitats may affect benthic invertebrates and their fish predators. Salinity in Mobile Bay is affected by river inflow, wind, and tides. Periodic breaches to barrier islands such as "Katrina Cut," which was filled in 2010 (Park et al. 2014), also affect salinity patterns in the Bay. Commercially and recreationally important estuarine fish that feed on benthic invertebrates in these estuarine and freshwater habitats include Atlantic croaker, southern kingfish, spot, and hardhead catfish. The freshwater Alabama shad feeds almost exclusively on benthic invertebrates.

Model purpose: This chapter characterizes baseline benthic infaunal communities in estuarine, transitional, and freshwater habitats in the Mobile Bay watershed. Changes in benthic community composition among these habitat types are documented along the salinity gradient and are used to estimate how far upriver changes may occur following channel deepening.

Model summary: Empirical data were collected to document the distribution and abundance of benthic macroinvertebrates within the potential zone of influence of the harbor deepening project. Multivariate statistical techniques were used to determine the location(s) where the taxonomic composition of these benthic assemblages changed relative to bottom salinity concentrations. Water quality model results were assessed near benthic stations to determine whether projected salinity increases affected macroinvertebrate distributions.

2.2 Methods – Model Development Process

Study Site

Mobile Bay, Alabama is formed by the Fort Morgan Peninsula to the east and Dauphin Island, a barrier island on the west. Mobile Bay is 413 square miles (1,070 km2) in area. It is 31 miles (50 km) long with a maximum width of 24 miles (39 km). The deepest (75 feet, 23 m) areas of the Bay are located within the federal navigation channel, which serves Alabama's only port for ocean-going vessels, but the average depth of the bay is around 10 feet (3 m). Throughout this shallow estuary, low wind speeds can contribute to stratification and the occurrence of hypoxic events (Turner et al. 1987). Water masses with low dissolved oxygen can be forced onshore, depositing moribund demersal fish and crustaceans in phenomena termed “jubilees” (May 1973). The Mobile Bay watershed is the sixth largest river basin in the United States and the fourth largest in terms of streamflow. It drains water from three-fourths of Alabama as well as portions of Georgia, Tennessee and Mississippi. The Mobile River and Tensaw River empty into the northern end of the Bay. Several smaller rivers: Dog River, Deer River, and Fowl River, on the western side of the Bay and the Fish River on the eastern side also empty into the Bay. River discharge is seasonal with high flows in the late winter and early spring and lowest flows in the summer. Estuarine habitat receives seawater during tidal exchanges, transitional zones have lower salinities and occur upstream in rivers and tributaries, and freshwater zones typically are upstream from the tidal reach of seawater.

Benthic macrofauna in Mobile Bay are dominated by polychaetes and macrofaunal abundances are relatively low in this area compared to other Gulf of Mexico estuaries (HX5, 2016). An examination of the Environmental Monitoring and Assessment Program (EMAP) benthic data set collected by the U.S. Environmental Protection Agency from (1991-1994) to assess the potential foraging value for Gulf sturgeon revealed the macrofaunal densities in Mobile Bay were greatest at water depths of 1.5 to 2.5m, with decreasing densities at greater depths.

Sampling protocol – Process followed

Benthic macroinvertebrates

Benthic macroinvertebrates were sampled in October 2016 and May 2017. A total of 240 benthic samples were collected, 120 samples in each season. Samples were collected at 40 stations within each zone (Freshwater, Brackish and Estuarine (upper bay) by ponar grab (Figures 1-4). Successful samples reached a minimum penetration depth of 10 cm into bottom sediments. Samples were sieved in the field using a 0.5 mm mesh to remove excess sediment, placed in individual fabric bags, and preserved in 10% buffered formalin. All samples were collected by ERDC personnel with the assistance of personnel from the USACE: Mobile District (boat and operator). Species were enumerated by LPIL (lowest practical identification level) taxa. Wet-weight biomass was determined after combining LPIL taxa into higher-order taxa (Annelids, Arthropoda, Mollusca, Echinodermata and Miscellaneous).

Statistical Approach – Process followed

Quantification: One-factor Analysis of Variance (ANOVA) tests were used to examine potential differences in water quality parameters among station types. A one-factor ANOVA was used to test for habitat type differences in Annelid biomass and non-parametric Kruskal-Wallis tests similarly were used to test for potential differences in Arthropod and Molluscan biomass.

Analysis of Similarity (ANOSIM) tests were used to examine potential differences in benthic macrofaunal assemblages among habitat types. ANOSIM results are distinguished on a scale of $R = 0$ (groups were indistinguishable) to $R = 1$ (no similarity among groups; Clarke et al., 2014; Clarke and Gorley, 2015). Nonmetric multidimensional scaling (nMDS) ordinations were plotted with each symbol representing a station coded by habitat type. In these plots, stations with similar assemblages are grouped close together and stations with dissimilar assemblage composition are farther apart. In cases where benthic macrafaunal assemblages differed between habitat types, Similarity Percentages (SIMPER) were conducted to identify the taxa contributing at least 5% to the dissimilarities among groups.

Evaluation: Multivariate statistics were conducted using PRIMER 7 (Plymouth Routines In Multivariate Ecological Research), which is ideal for analyzing arrays of species-by-samples data for environmental assessments (Clarke et al. 2014). The non-parametric multivariate model makes few assumptions about the form of the data, using non-metric ordination and permutation tests that are robust and applicable to macroinvertebrate abundance data. PRIMER is a proven, effective statistical tool that has been used to identify macroinvertebrate assemblages associated with salinity zones related to management of freshwater inflows (Palmer et al. 2015).

2.3 Results - Application

Fall 2016

Fall 2016

Environmental Conditions

During the fall (October 2016), water quality parameters were recorded within expected ranges in each zone. Salinities differed significantly among habitat types ($F = 57.4$, $p < 0.001$), declining from averaging 18 ppt in the estuarine zone to 4 ppt in the freshwater zone (Figure 5), with several stations less than 1 ppt. Dissolved oxygen concentrations were above hypoxic concentrations, which are defined as DO concentrations below 2-3 mg/L (Dauer et al. 1992; Diaz and Rosenberg, 1995). Dissolved oxygen concentrations did not differ significantly among habitat types ($F = 1.4$, $p > 0.2$), with highest concentrations in the freshwater zone (Figure 5). Sampling depths were significantly greater in the freshwater habitat ($F = 5.9$, $p = 0.004$), averaging 3.7 m compared to 2.2 m in the transitional and estuarine zones. Bottom water temperatures averaged 25oC in all locations. Sediments in estuarine habitat were comprised of more fine grain sizes, e.g., silts and clays, compared to the sandier transitional and freshwater habitats (Figure 6). Total organic content was significantly lower in the freshwater ($F = 5.75$, $p = 0.005$) than the estuarine and transitional habitats (Figure 6).

Benthic Macrofauna

A total of 1,789 individual benthic macrofauna from 54 taxa were collected during baseline (October 2016) sampling, with the highest number of taxa and individuals collected in freshwater habitat (Table 1). The distribution and abundance of many species changed along the salinity gradient sampled. For example, the dwarf surf clam Mulinia lateralis, amphipod Grandidierella bonnieroides, and polychaetes Glycinde solitaria, Laeonereis cuveri, and Paraprionospio pinnata, were abundant in the estuary, but not common in the transitional and freshwater zones. In contrast, seven insect taxa were collected in freshwater benthic habitat, one insect taxon in the transitional zone, and none within the estuary (Table 1). Likewise, tubificid oligochaetes were more abundant in the freshwater zone. Several polychaetes were more widely distributed, occurring in all habitat types throughout the study area, including, Mediomastus (LPIL), Parandalia americana, and Streblospio benedicti.

Fall benthic biomass was dominated by bivalve molluscs in the estuarine habitat (Kruskal-Wallis test statistic = 19.6, $p < 0.001$; Figure 7). Bivalves were present in only four of 30 samples in the transitional zone, and were uncommon in the freshwater zone. Arthropod (insects) biomass was highest in the freshwater zone (Kruskal-Wallis test statistic = 26.6, $p < 0.001$; Figure 7), whereas Annelid (primarily polychaetes) biomass was relatively even across the salinity zones ($F = 2.8$, $p > 0.05$; Figure 7).

Benthic Assemblages

The taxonomic composition of benthic macroinvertebrate assemblages overlapped considerably between the estuarine and transitional zones, with more distinct assemblages in freshwater habitat (Figure 8). Within the freshwater zone, samples collected in the Mobile River were similar to estuarine and transitional assemblages and distinct from assemblages collected in the Tombigbee and Alabama Rivers. A diverse array of polychaetes was collected in the Mobile River (Table 2), which accounts for this location's similarity to estuarine and transitional assemblages. When comparing benthic assemblages between only the transitional and freshwater zones (Figure 9), it is more apparent that stations in the lower Mobile River (stations C1-C9) overlapped in composition with assemblages collected downstream in the transitional zone. Therefore, a distinct break in benthic communities is apparent between stations C9 and C10 (Figure 10) in the fall, which is an approximate 4 km stretch of river with several changes in sinuosity between the stations (Figure 3). Stations upstream C9 included tubificid oligochaetes and insects that were not collected downstream, whereas polychaetes were in higher abundances at stations C1-C9 and were uncommon at the upstream stations (Table 3).

Within the transitional zone, Tensaw River assemblages differed from all other locations because the benthic macrofauna were comprised entirely of nemerteans, tubificid oligochaetes, and polychaetes (Table 2). Benthic macrofauna in the Alabama River were the most diverse of any other location and included 14 taxa, with more bivalves and insects than collected in other locations.

Spring 2017

Environmental Conditions

During the spring (May 2017), sampling occurred during a period of high freshwater runoff (a freshet), therefore salinities were very low in all areas, averaging less than 4 ppt in the estuarine and less than 1 ppt in the transitional and freshwater zones (Figure 11). Estuarine salinities were significantly greater in the estuarine area ($F = 52.5$, $p < 0.001$). Dissolved oxygen concentrations were high, well above levels associated with hypoxic conditions (Figure 11). Similar to fall sampling, freshwater stations were significantly deeper ($F = 20.8$, $p < 0.001$) than those in the transitional and estuarine zones. Fine-grained sediments (silts and clay) were prevalent in the estuarine and transitional zones, with a greater composition of coarser grain sizes (sands and some gravel) in the freshwater environment (Figure 12). Total organic content was higher in the estuarine than the transitional and freshwater zones (Figure 12) although this difference is not significant ($F = 2.3$; $p > 0.1$). Spring temperatures averaged approximately 23oC at all stations.

Benthic Macrofauna –

A total of 2,165 individual benthic macrofauna from 44 taxa were collected during spring (May 2017) sampling, with the highest number of individuals collected in estuarine habitat (Table 4). A major difference between the fall and spring benthic assemblages is the presence of insects in the estuarine zone and much higher insect abundances in the transitional and freshwater zones. Taxa richness was relatively even among habitat types.

Spring benthic biomass was strongly dominated by molluscs in the estuary (Kruskal-Wallis test statistic = 39.6, $p < 0.001$; Figure 13). Annelid biomass differed significantly among habitat types ($F = 4.1$, $p = 0.02$), with lowest biomass in freshwater habitat. Arthropod (primarily crustaceans) biomass was significantly higher in transitional habitat (Kruskal-Wallis test statistic = 12.9, $p = 0.002$; Figure 13).

Benthic Assemblages –

In the spring, there was less overlap in the taxonomic composition of macrofaunal assemblages among the different habitat types. For instance each pairwise comparison (ANOSIM) between areas differed significantly (Figure 14). The biggest difference occurred between the estuarine and freshwater assemblages ($R = 0.72$, $p = 0.001$), with smaller differences between estuarine and transitional ($R = 0.28$, $p = 0.001$) and transitional and freshwater ($R = 0.30$, $p = 0.001$) zones. Locations of where benthic assemblages changed between the transitional and freshwater zones were less obvious than fall assemblages (Figure 15), with freshwater invertebrates occurring downriver in the transitional zone (Figure 10).

2.4 Discussion

Potential impacts of the harbor deepening project on biological resources in Mobile Bay are a concern to natural resource managers because the navigation channel has big influence on water circulation, estuarine mixing, and sedimentation patterns in the Bay (Osterman and Smith 2012).

The completion of the navigation channel in the 1950s restricted tidal flushing and increased the input of terrestrial organic matter (Osterman and Smith 2012). In addition, hypoxic events are associated with low flow conditions, rather than nutrient loading (Cowan et al. 1995; Park et al. 2007), therefore if channel deepening alters flow conditions, biota in the estuary and watershed could be affected. This examination of benthic macroinvertebrates has established how benthic communities transition from estuarine to freshwater habitat, which largely reflected a change from relatively high abundances of polychaetes to insects, respectively. A similar transition in benthic community composition was reported for Lavaca Bay and Matagorda Bay, Texas, in which polychaetes and crustaceans were indicator taxa for brackish and marine habitats and insect larvae occurred in freshwater areas (Pollack et al. 2009). Likewise,

In the fall, when salinities were relatively high, the extent of influence of salt water on benthic macroinvertebrates was evident as far upstream as station C9, which is located south of Bucks, Alabama. At this location, immediately upstream from C9, the Mobile River takes two sharp 90 degree bends, first east, then north, which may contribute to the abrupt salinity decline between stations C9 (5 ppt) and C10 (<1 ppt) if tidal forces were weaker than the opposing conditions created by flow and river sinuosity. These results indicate that under the environmental conditions present in the fall of 2016, a clear break in the upstream influence of estuarine waters occurred near Bucks, Alabama. Downstream from this location, fall benthic macroinvertebrate assemblages were similar through the transitional habitat and into the estuary.

In the spring, salinities were less than one ppt throughout all transitional and freshwater stations, therefore, a clear break in benthic macroinvertebrate composition related to salinity change was not evident.

Application of Water Quality Modelling Results

Salinity

Model results were used for the bottom three strata to characterize projected salinities following harbor deepening. Projected salinities for cells within a 100m of each benthic station were evaluated for the mean project salinity. To evaluate a worst case scenario, the maximum difference in salinity projected by the model under harbor deepening conditions also was considered for each month for cells within the aforementioned buffer. In the fall, maximum projected differences in salinity ranged from 1.9 to 3.6 ppt and the greatest changes in salinity were projected for the estuarine habitat where benthic macrofauna are well adapted to salinity fluctuations of this magnitude. In the winter, maximum changes to salinity ranged from 2.5 to 3.2 ppt. In the spring, maximum salinity changes were projected to be 2.2 to 3.2 ppt, whereas summer maximum changes ranged from 1.6 to 2.9 ppt. These most extreme projected changes in salinity occurred within the transitional and estuarine zones where benthic macrofaunal assemblages are dominated by polychaete worms that experience greater salinity fluctuations during tidal exchanges. Differences in benthic macrofaunal assemblages occur where freshwater habitat begins, which in the fall, was further upstream than the water quality grid extended. There is no indication that the location of the freshwater transition point will be affected by the harbor deepening project. Impacts to higher trophic levels, such as fish, will be negligible because prey availability and distributions are unlikely to be affected.

Sea Level Rise

Maximum potential salinity changes projected by the water quality model under a scenario of sea level rise did not predict conditions that were more extreme than reported above. For instance, fall maximum salinity changes could be as small as 1.2 ppt instead of 1.9 ppt, whereas spring maximum salinity predictions were as low as 0 ppt. Based on these model predictions, there is no indication that sea level rise will substantially affect benthic macrofaunal assemblage distributions.

Dissolved Oxygen

Estuarine organisms respond to decreasing dissolved oxygen in variable ways depending on their life stage and mobility. In general, however, a consistent pattern of response occurs at very low dissolved oxygen concentrations, i.e., below 2 mg/L. Mobile fish and crustaceans avoid benthic a habitat with oxygen concentrations below 2 mg/L. Less mobile benthic invertebrates, such as burrowing species, exhibit stress behaviors (e.g., emerging from sediments) at oxygen concentrations from 1.5-1 mg/L, with mortality occurring if durations of low dissolved oxygen concentrations are extensive (Rabalais et al., 2001).

A worst case scenario of harbor deepening project impacts on dissolved oxygen concentrations was evaluated by determining the minimum concentrations predicted under project conditions in the summer. High temperatures combine with low dissolved oxygen concentrations to create the most deleterious biological impacts. Minimum summer (June – September) dissolved oxygen concentrations ranged from 6.7 -7.1 mg/L, which is a concentration well above hypoxic levels that would induce stress responses or mortality in benthic macrocinvertebrates.

Model limitations:

Predictions of potential impacts to benthic macroinvertebrates are dependent upon the accuracy of the water quality model and its projected changes to salinity.

Benthic macroinvertebrates were sampled only during two seasons (fall and spring), therefore summer distributions and abundances are inferred, but not documented.

Spring macroinvertebrate sampling occurred during a period of extremely high freshwater inflows, therefore spring invertebrate distributions during less extreme environmental conditions were not documented.

2.5 References

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Table 2.1. Total abundances of benthic macroinvertebrates collected in each area during Fall (October 2016) sampling (30 stations per area).						
Class	Family	LPIL	Estuarine	Transitional	Freshwater	Total
Arachnida	Araneae	Arachnida (LPIL)	0	0	3	3
		Hydracarina (LPIL)	0	0	1	1
Bivalvia	Bivalvia	Bivalve (LPIL)	0	0	2	2
	Mactridae	*Mulinia lateralis*	71	2	1	74
		Rangia cuneata	0	1	0	1
	Mytilidae	*Ischadium recurvum*	0	0	2	2
	Sphaeriidae	Sphaeriidae (LPIL)	0	0	4	4
	Tellinidae	*Macoma mitchelli*	0	1	0	1
	Unionidae	Unionidae (LPIL)	0	0	1	1
Crustacea	Ampeliscidae	Ampelisca (LPIL)	0	1	0	1
	Aoridae	*Grandidierella bonnieroides*	10	2	1	13
	Corophiidae	Corophiidae (LPIL)	0	0	2	2
		Monocorophium insidiosum	0	0	2	2
	Decapoda	Crab Megalops (LPILL)	0	0	1	1
	Harpacticoida	Harpacticoida (LPIL)	0	0	2	2
	Idoteidae	*Edotia triloba*	4	6	2	12
	Mysidacea	Mysidacea (LPIL)	0	2	0	2
	Mysidae	*Americamysis bahia*	0	9	0	9
		Bowmaniella (LPIL)	1	0	0	1
	Oedicerotidae	Ameroculodes (LPIL)	0	1	0	1
	Ogyrididiae	*Ogyrides alphaerostris*	2	2	0	4
	Palaemonidae	*Palaemon pugio*	0	0	1	1

	Portunidae	*Callinectes sapidus*	0	0	1	1
Insecta	Ceratopoginidae	Ceratopoginidae (LPIL)	0	0	7	7
	Chaoberidae	Chaoborus (LPIL)	0	0	2	2
	Chironomidae	Chironomidae Pupa (LPIL)	0	0	5	5
		Chironomini (LPIL)	0	0	42	42
		Tanypodinae (LPIL)	0	44	47	91
	Ephemeridae	Hexagenia (LPIL)	0	0	86	86
	Trichoptera	Trichoptera (LPIL)	0	0	1	1
Nematoda	Nematoda	Nematoda (LPIL)	1	1	13	15
Nemertea	Nemertea	Nemertea 1 (LPIL)	62	18	5	85
		Nemertea 2 (LPIL)	5	0	0	5
Oligochaeta	Tubificidae	Tubificidae (LPIL)	6	3	194	203
Polychaeta	Ampharetidae	*Hobsonia florida*	6	3	4	13
	Archiannelida	Archiannelida (LPIL)	0	0	1	1
	Capitellidae	Capitella (LPIL)	40	27	0	67
		Mediomastus (LPIL)	106	125	54	285
	Chaetopteridae	*Spiochaetopterus oculatus*	1	0	0	1
Polychaeta	Gonianidae	*Glycinde solitaria*	48	3	0	51
	Nereidae	*Alitta succinea*	2	3	6	11
		Laeonereis cuveri	16	0	0	16
	Nereididae	Nereidae (LPIL)	11	5	0	16
	Onuphidae	*Diopatra cuprea*	1	0	0	1
	Pectinariidae	*Pectinaria gouldii*	1	0	0	1

	Pilargiidae	*Parandalia americana*	125	72	79	276
		Sigambra (LPIL)	0	1	0	1
		Sigambra tentaculata	4	0	0	4
	Sabellidae	Sabellidae (LPIL)	0	0	1	1
	Spionidae	*Marenzellaria viridis*	0	0	6	6
		Paraprionospio pinnata	34	1	7	42
		Polydora (LPIL)	0	1	0	1
		Streblospio benedicti	31	211	70	312
Total Taxa Richness			23	25	35	54
Total Abundance			588	545	656	1,789

Table 2.2. Average abundances of benthic macroinvertebrates in each location within the Estuarine, Transitional, and Freshwater zones in October 2016.

		Estuarine	Transitional					Freshwater		
Class	Family	Estuarine	Raft River	Tensaw River	Chac. Bay	Apalachee River	Grand Bay	Mobile River	Tom. River	Alabama River
Arachnida	Araneae	0	0	0	0	0	0	0	0	0.33
Bivalvia	Mactridae	2.45	0	0	0	1	0	0	0	0
	Mysidae	0	0.21	0	0	0	0	0	0	0
	Sphaeriidae	0	0	0	0	0	0	0	0	0.44
	Unionidae	0	0	0	0	0	0	0	0	0.11
Crustacea	Corophiidae	0	0	0	0	0	0	0	0	0.22
	Harpacticoida	0	0	0	0	0	0	0	0.25	0
	Idoteidae	0.14	0.29	0	0	1	0	0.15	0	0
	Ogyridiae	0.07	0	0	0	0	0	0	0	0
Insecta	Ceratopoginidae	0	0	0	0	0	0	0	0.63	0.22
	Chaoberidae	0	0	0	0	0	0	0	0	0.22
	Chironomidae	0	0.29	0	4.67	0	6.5	0.38	4.25	5
	Ephemeridae	0	0	0	0	0	0	1.69	5	2.7
	Trichoptera	0	0	0	0	0	0	0	0	0.11
Nematoda	Nematoda	0	0	0	0	0	0	0	0	1.22
Nemertea	Nemertea	2.31	0.64	0.29	0.67	1	0	0.38	0	0
Oligochaeta	Tubificidae	0.21	0.21	0	0	0	0	1.23	6.63	1F
Polychaeta	Ampharetidae	0.21	0	0.29	0	0	0	0.31	0	0
	Archiannelida	0	0	0	0	0	0	0	0	0.11
	Capitellidae	5.03	3.86	10.14	1.33	3	4.25	3.92	0	0.22
	Gonianidae	1.66	0.21	0	0	0	0	0	0	0
	Nereidae	0.62	0.14	0	0	0	0	0.46	0	0
	Nereididae	0.38	0	0.29	0	0	0	0	0	0
	Pilargiidae	4.45	4.07	2	0	0	0	6.08	0	0
	Spionidae	2.24	3.29	22.71	0	0	1.25	6.08	0	0

Table 2.3. Benthic macroinvertebrate mean abundances of taxa that contributed at least 5% to dissimilarities between freshwater stations downstream from C10 and upstream from C9 (SIMPER).

	Taxa	Downstream	Upstream
Oligochaeta	Tubificidae	0	9.2
Polychaeta	Pilargiidae	8.8	0
	Spionidae	8.6	0.3
	Capitellidae	5.6	0.2
Insecta	Ephemeridae	0	4.1
	Tanypodinae	0	2.2
	Chironomidae	0.1	2.2

Table 2.4. Total abundances of benthic macroinvertebrates collected in each area during (May 2017) sampling (30 stations per area).						
Class	Family	LPIL	Estuarine	Transitional	Freshwater	Total
Arachnida	Araneae	Hydracarina (LPIL)	0	0	2	2
Bivalvia	Mactridae	*Mulinia lateralis*	114	11	13	138
	Mytilidae	*Ischadium recurvum*	0	0	1	1
	Sphaeriidae	Pisidium (LPIL)	0	0	2	2
		Sphaeriidae (LPIL)	0	0	2	2
	Tellinidae	*Macoma mitchelli*	45	10	0	55
Crustacea	Alpheidae	Alpheidae (LPIL)	1	0	0	1
	Aoridae	*Grandidierella bonnieroides*	0	4	5	9
	Corophiidae	Corophiidae (LPIL)	0	0	1	1
		Monocorophium insidiosum	0	12	91	103
	Cumacea	Cumacea (LPIL)	3	0	0	3
	Gammaridae	*Gammarus mucronatus*	1	2	3	6
	Harpacticoida	Harpacticoida (LPIL)	0	3	0	3
	Haustoriidae	Lepidactylus (LPIL)	0	4	0	4
	Idoteidae	*Edotia triloba*	7	1	0	8
	Melitidae	*Melita nitida*	0	1	0	1
	Mysidacea	Mysidacea (LPIL)	0	5	0	5
	Oedicerotidae	Ameroculodes (LPIL)	12	0	0	12
	Xanthidae	Xanthidae (LPIL)	1	0	0	1
Gastropoda	Cyclichnidae	*Acetocina canaliculata*	1	0	0	1
	Gastropoda	Gastropoda (LPIL)	0	0	1	1
Insecta	Chaoberidae	Chaoborus (LPIL)	0	5	1	6

		Chironomidae Pupa (LPIL)	0	0	10	10
		Chironomini (LPIL)	13	116	192	321
	Chironomidae	Tanypodinae (LPIL)	6	70	16	92
	Coleoptera	Coleoptera larva	0	0	17	17
	Ephemeridae	Hexagenia (LPIL)	0	24	44	68
Nematoda	Nematoda	Nematoda (LPIL)	1	2	54	57
		Nemertea 1 (LPIL)	9	22	35	66
Nemertea	Nemertea	Nemertea 2 (LPIL)	18	0	0	18
		Tubificidae (LPIL)	7	5	109	121
Oligochaeta	Tubificidae	Tubificoides (LPIL)	19	39	0	58
	Ampharetidae	*Hobsonia florida*	77	18	10	105
		Capitella (LPIL)	39	1	1	41
		Heteromastus filiformis	2	0	0	2
Polychaeta	Capitellidae	Mediomastus (LPIL)	341	155	3	499
	Gonianidae	*Glycinde solitaria*	1	0	0	1
	Nereidae	Nereidae (LPIL)	4	3	0	7
	Orbiniidae	Leitoscoloplos (LPIL)	1	0	0	1
		Parandalia americana	88	113	17	218
	Pilargiidae	*Sigambra tentaculata*	5	0	0	5
		Marenzellaria viridis	0	3	43	46
		Polydora (LPIL)	0	0	2	2
Polychaeta	Spionidae	*Streblospio benedicti*	35	10	0	46
Total Taxa Richness			26	25	25	44

Total Abundance	851	639	675	2,165

Table 2.5. Average abundances of benthic macroinvertebrates in each location within the Estuarine, Transitional, and Freshwater zones in May 2017.

		Estuarine	Transitional					Freshwater		
Class	Family	Estuarine	Raft River	Tensaw River	Chac. Bay	Apalachee River	Grand Bay	Mobile River	Tom. River	Alabama River
Arachnida	Araneae	0	0	0	0	0	0	0	0.17	0.13
Bivalvia	Mactridae	3.80	0.57	0.29	0	0.50	0	0.92	0.17	0
	Mytilidae	0	0	0	0	0	0	0.08	0	0
	Sphaeriidae	0	0	0	0	0	0	0.23	0	0.13
	Tellinidae	1.5	0.29	0	0.33	0.50	1.00	0	0	0
Crustacea	Alpheidae	0.03	0	0	0	0	0	0	0	0
	Aoridae	0	0.14	0	0	1.00	0	0.38	0	0
	Corophiidae	0	0	0.29	0	5.00	0	6.92	0.17	0.13
	Cumacea	0.1	0	0	0	0	0	0	0	0
	Gammaridae	0.03	0.07	0	0	0.50	0	0.23	0	0
	Harpacticoida	0	0.14	0.14	0	0	0	0	0	0
	Haustoriidae	0	0.07	0.43	0	0	0	0	0	0
	Idoteidae	0.23	0	0	0	0.50	0	0	0	0
	Melitidae	0	0.07	0	0	0	0	0	0	0
	Mysidacea	0	0	0	1.00	0.50	0.25	0	0	0
	Oedicerotidae	0.4	0	0	0	0	0	0	0	0
	Xanthidae	0.03	0	0	0	0	0	0	0	0
Gastropoda	Cyclichnidae	0.03	0	0	0	0	0	0	0	0
	Gastropoda	0	0	0	0	0	0	0.08	0	0
Insecta	Chaoberidae	0	0.36	0	0	0	0	0	0	0.13
	Chironomidae	0.63	5.29	1.71	21.33	4.50	6.75	4.00	4.00	17.75
	Coleoptera	0	0	0	0	0	0	0.08	0	2.00
	Ephemeridae	0	0	0.14	0	11.50	0	0.62	2.67	2.50
Nematoda	Nematoda	0.03	0.07	0	0	0	0.25	0.38	0.17	6.00
Nemertea	Nemertea	0.9	0.57	0.86	1.67	0	0.75	0.23	0	4.00

Oligochaeta	Tubificidae	0.87	2.14	1.29	0.67	0.50	0.50	2.00	9.00	3.63
Polychaeta	Ampharetidae	2.57	0.64	0	0.33	1.50	1.25	0.77	0	0
	Capitellidae	12.73	5.29	1.14	4.00	3.50	13.75	0.23	0.17	0
	Gonianidae	0.03	0	0	0	0	0	0	0	0
	Nereidae	0.13	0	0	0.67	0.50	0	0	0	0
	Orbiniidae	0.03	0	0	0	0	0	0	0	0
	Pilargiidae	3.10	6.36	1.00	0	3.00	2.75	1.31	0	0
	Spionidae	1.17	0.29	0.29	0.33	0	1.50	1.23	4.83	0

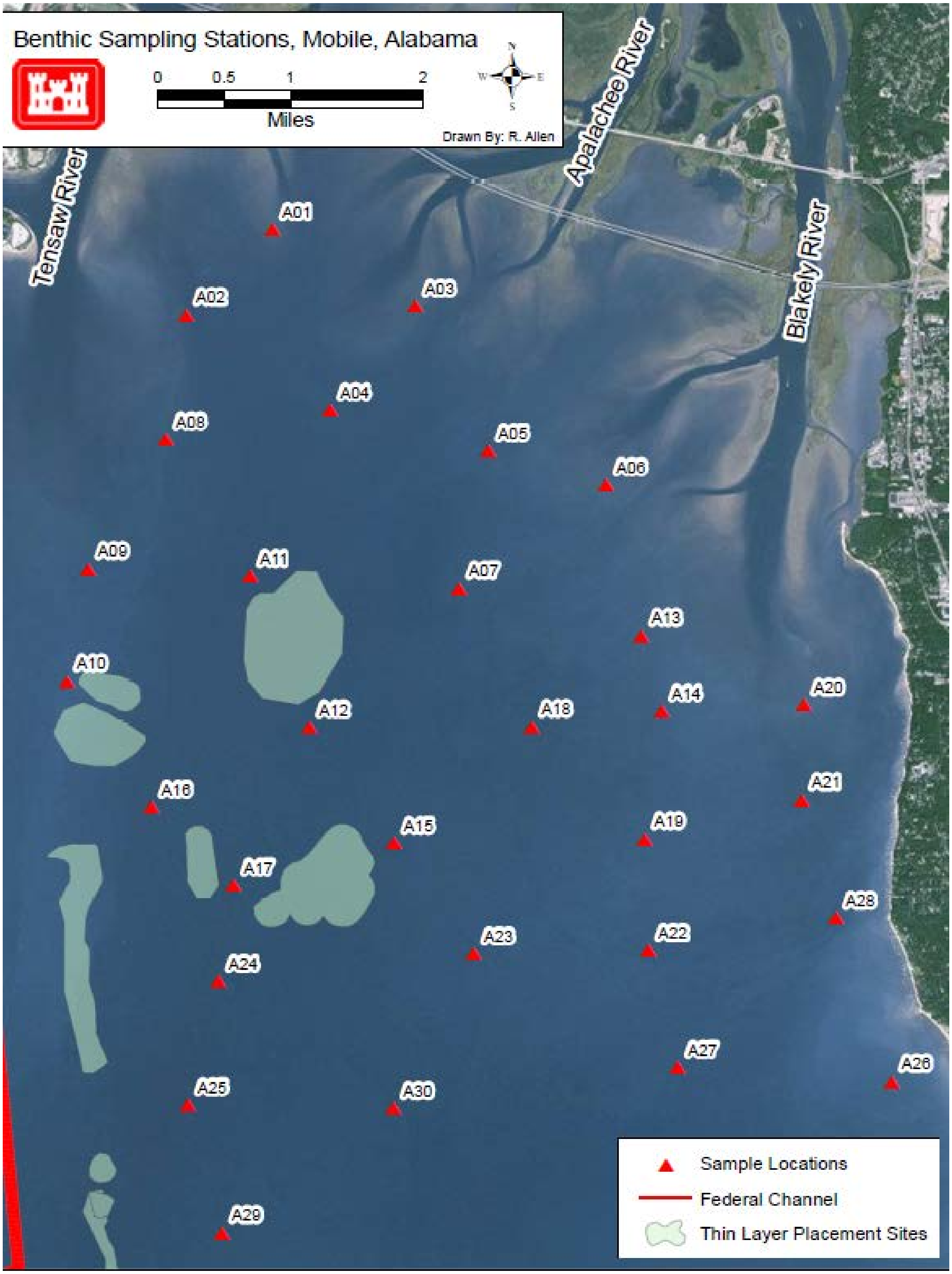


Figure 2.1. Benthic station locations for estuarine habitat in upper Mobile Bay.

Figure 2.2. Benthic stations locations in the transition zone.

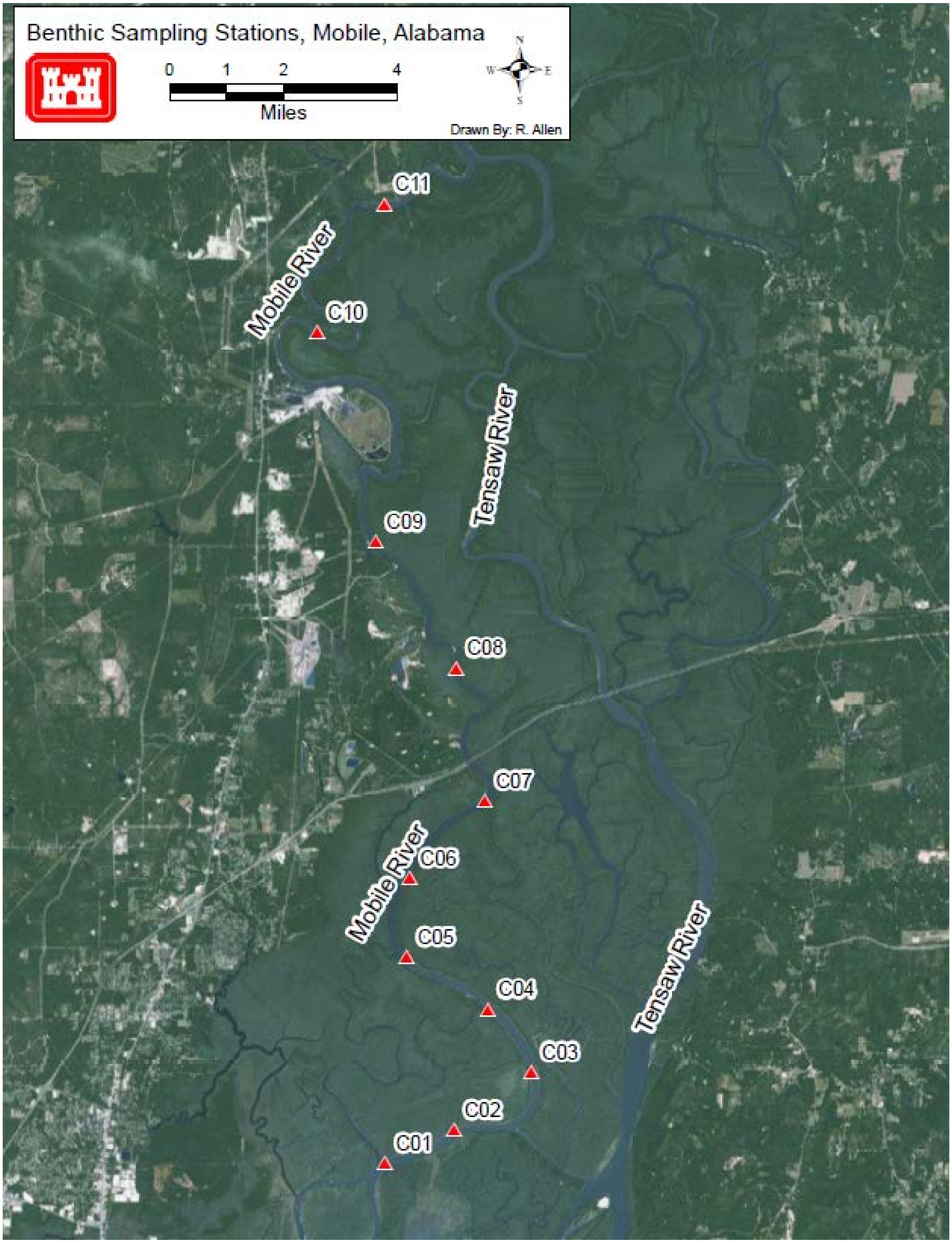


Figure 2.3. Benthic stations locations in the western portion of freshwater zone.

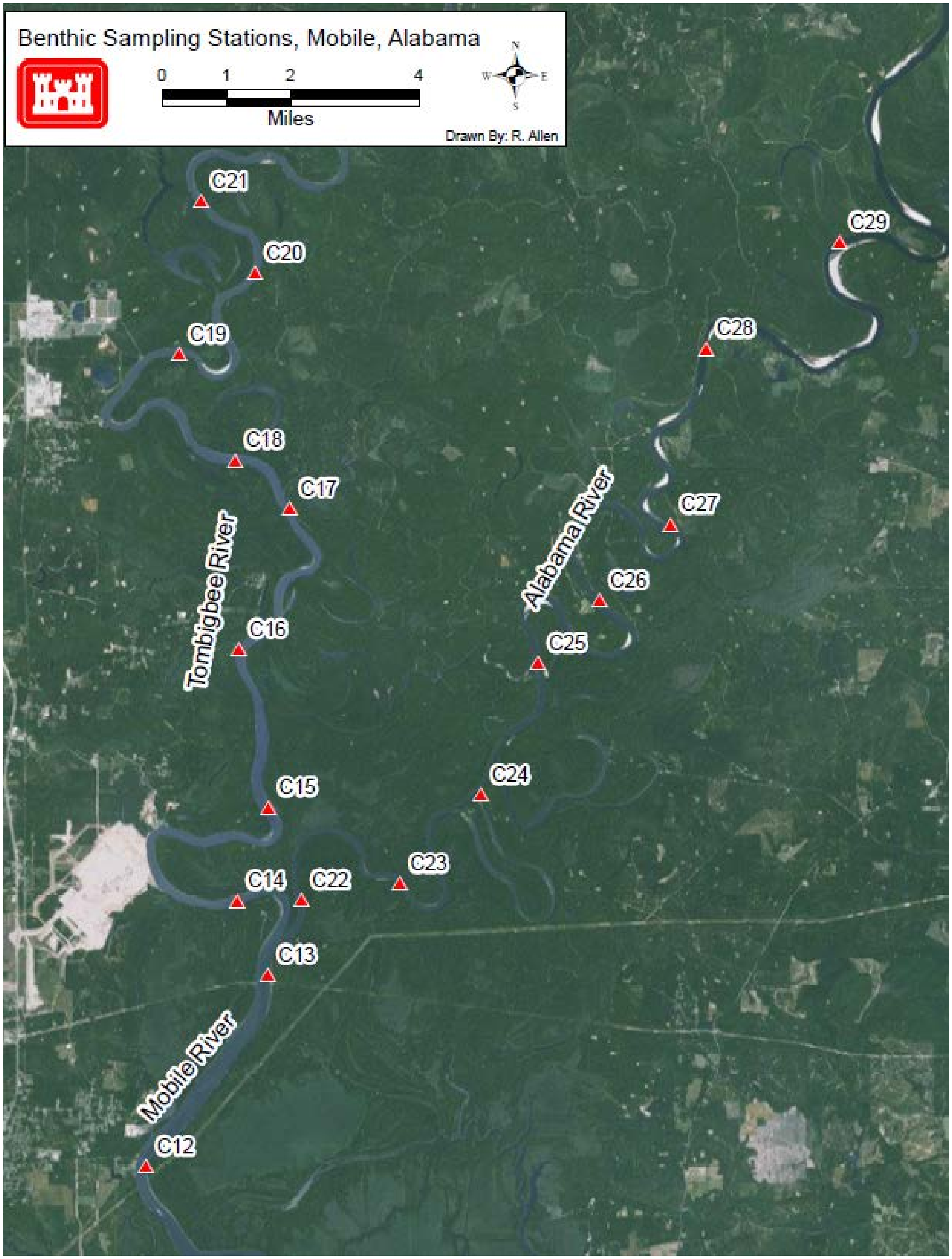


Figure 2.4. Benthic stations locations in the eastern portion of freshwater zone.

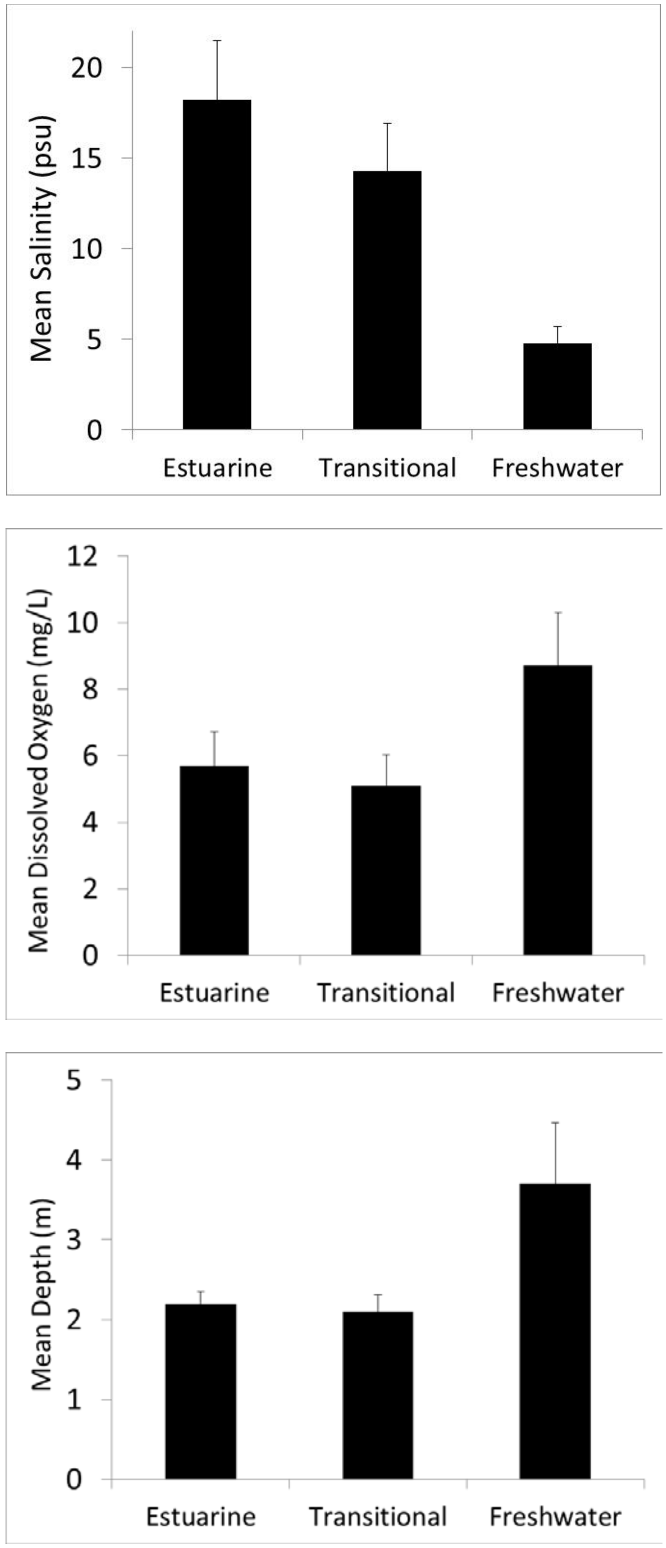
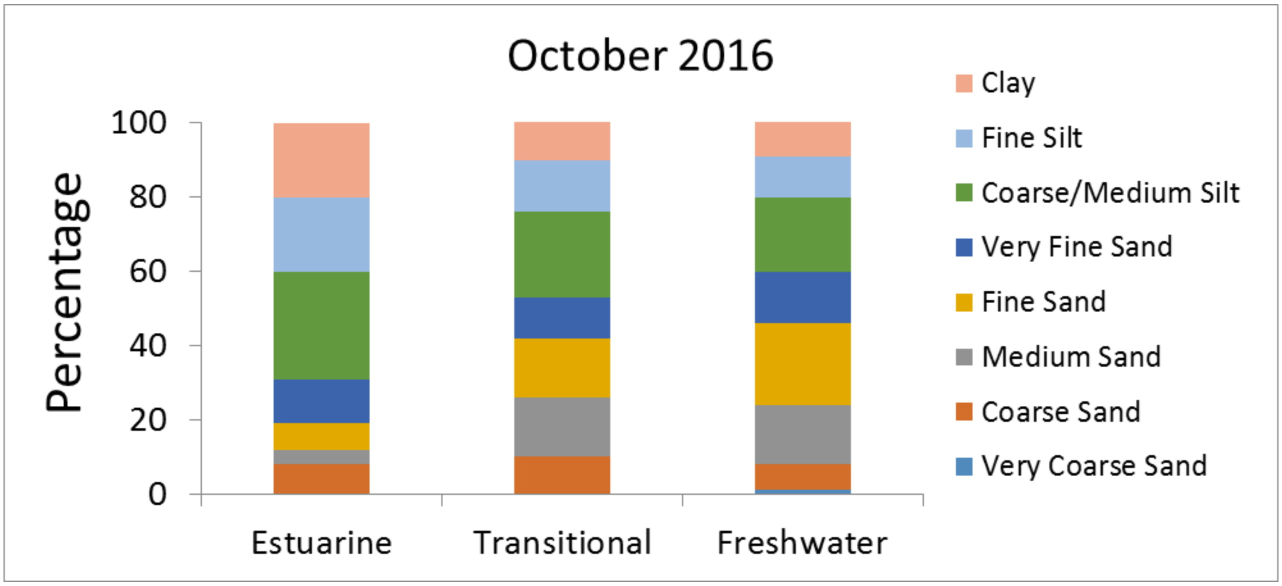


Figure 2.5. Mean (+ standard error) salinity, dissolved oxygen, and depth at stations in the estuarine, transitional, and freshwater zones during fall (October 2016) sampling.



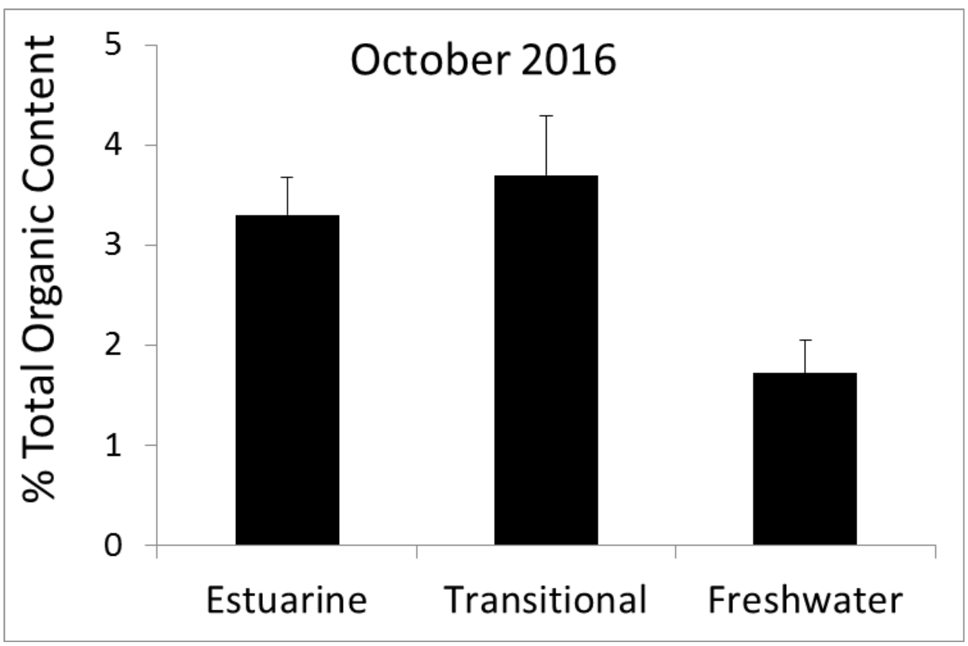


Figure 2.6. Sediment grain size distributions and % TOC in the estuarine, transitional, and freshwater zones during the fall 2016 sampling period.

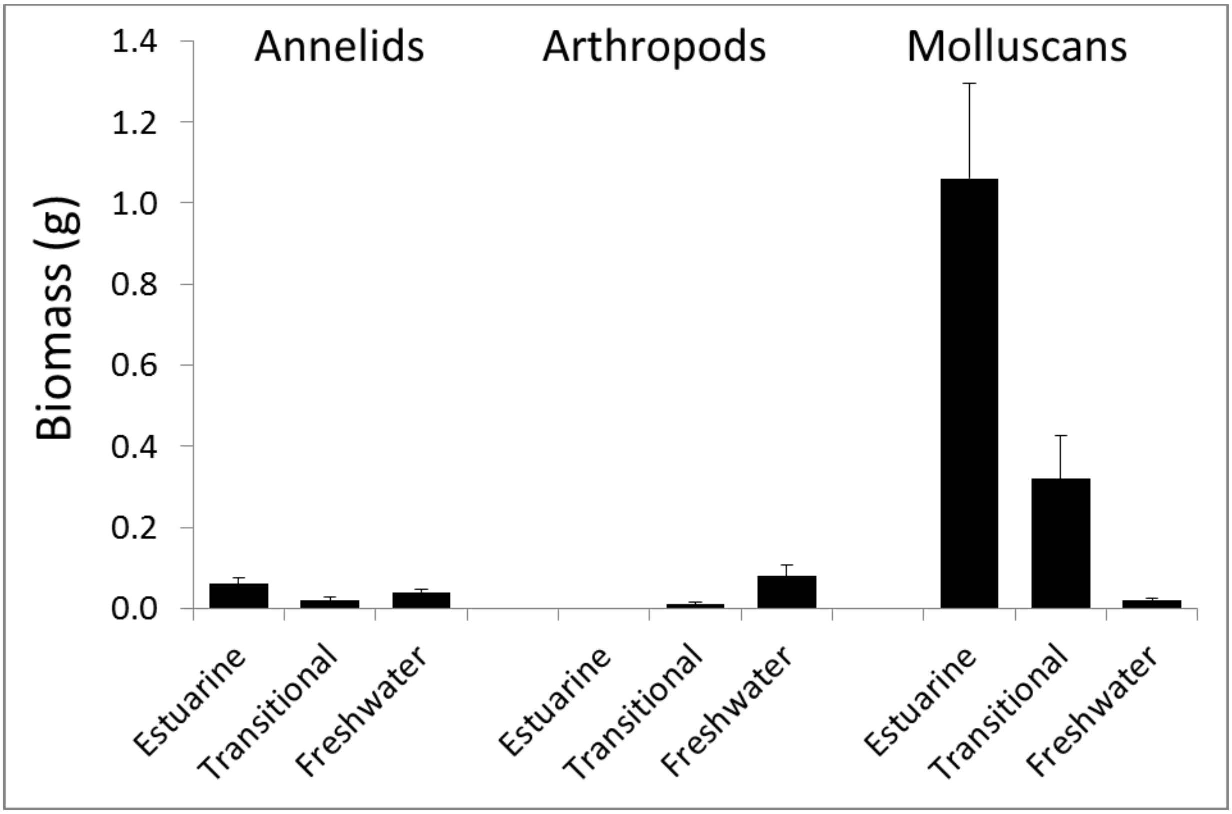


Figure 2.7. Mean fall biomass (+ standard error) of Annelids, Arthropods and Molluscs in each sampling area.

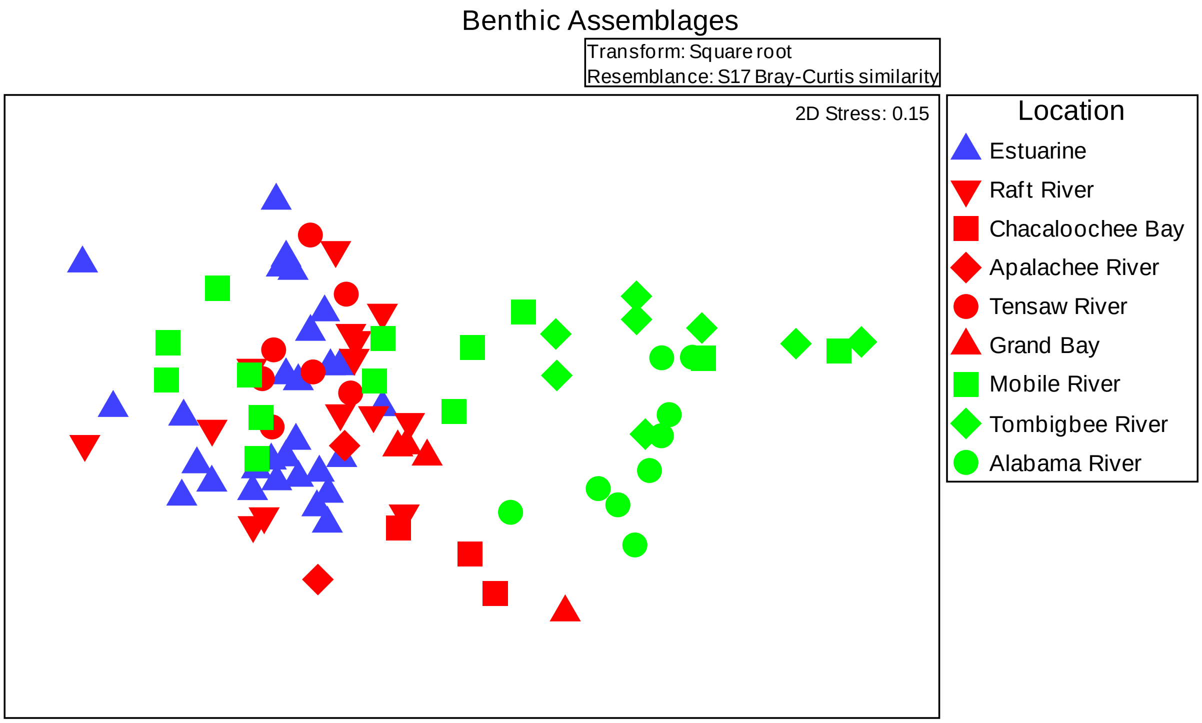


Figure 2.8. Non-metric multidimensional scaling plot of samples collected during fall sampling (October 2016) in the estuarine (blue symbols), transitional (red symbols), and freshwater (green symbols) zones.

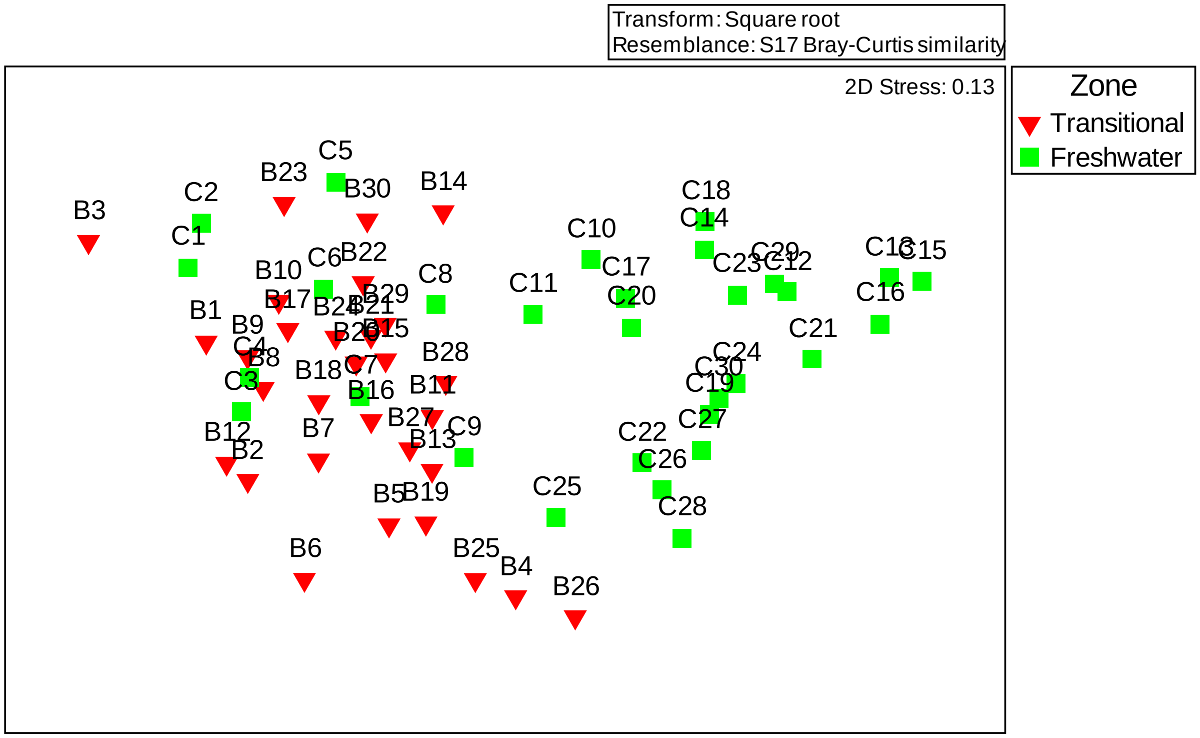


Figure 2.9. Non-metric multidimensional scaling plot of samples collected during fall sampling (October 2016) in the transitional (red symbols) and freshwater (green symbols) zones.

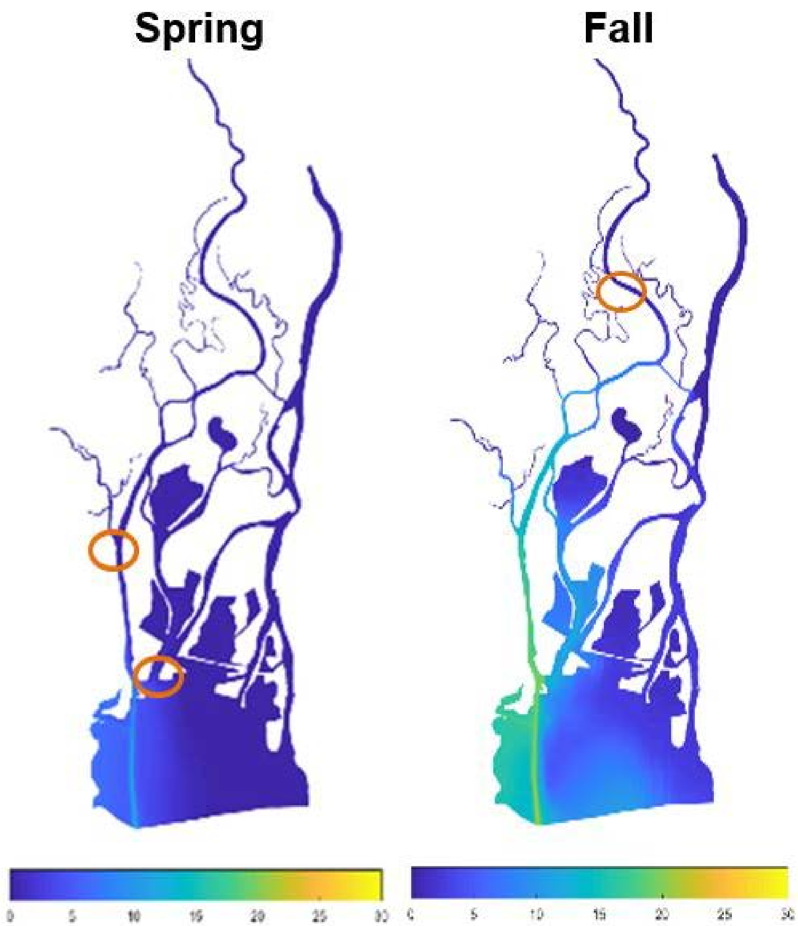


Figure 2.10. Location (orange ovals) of transitions between estuarine and freshwater benthic invertebrate communities.

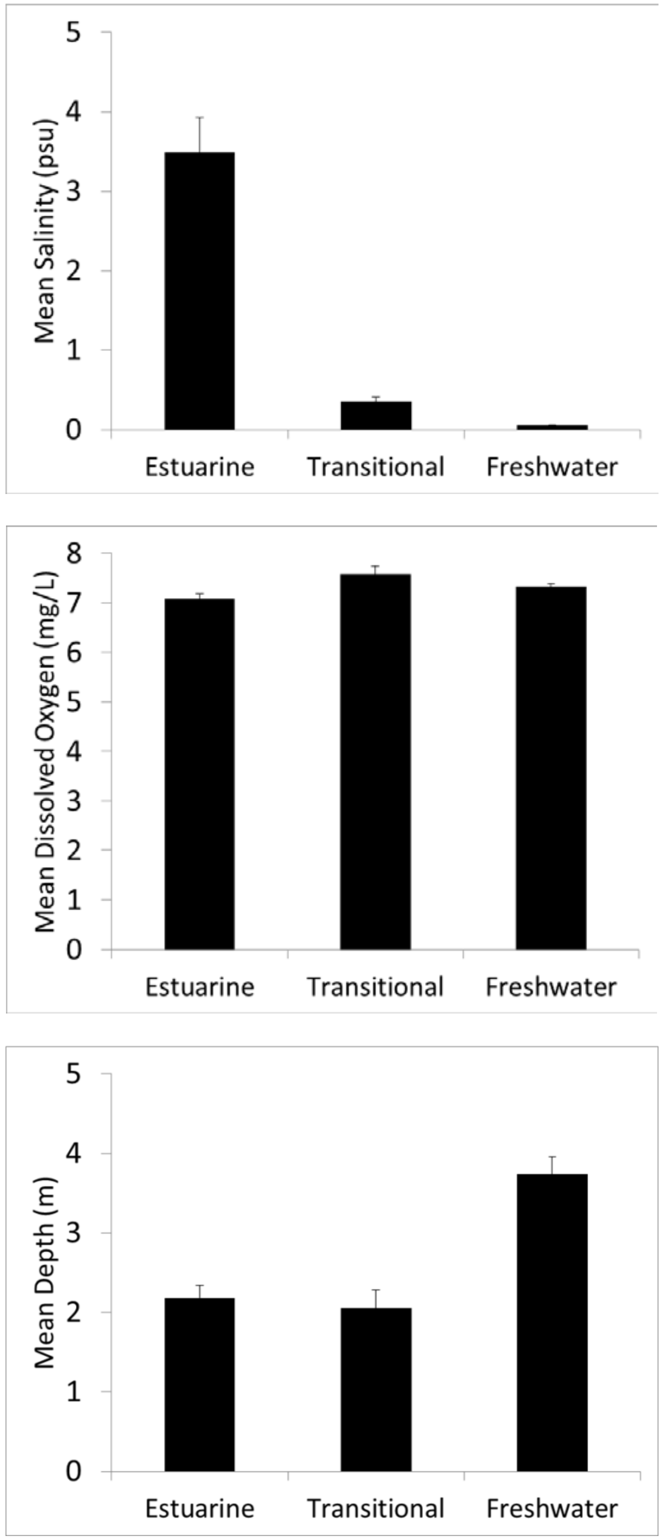
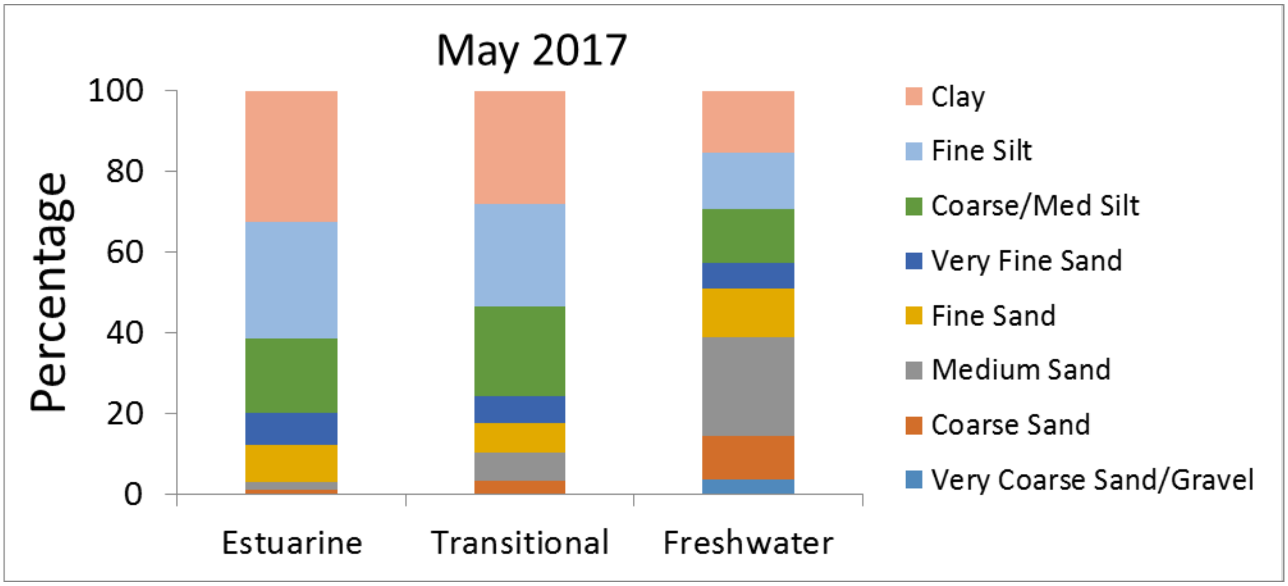


Figure 2.11. Mean (+ standard error) salinity, dissolved oxygen, and depth at stations in the estuarine, transitional, and freshwater zones during spring (May 2017) sampling.



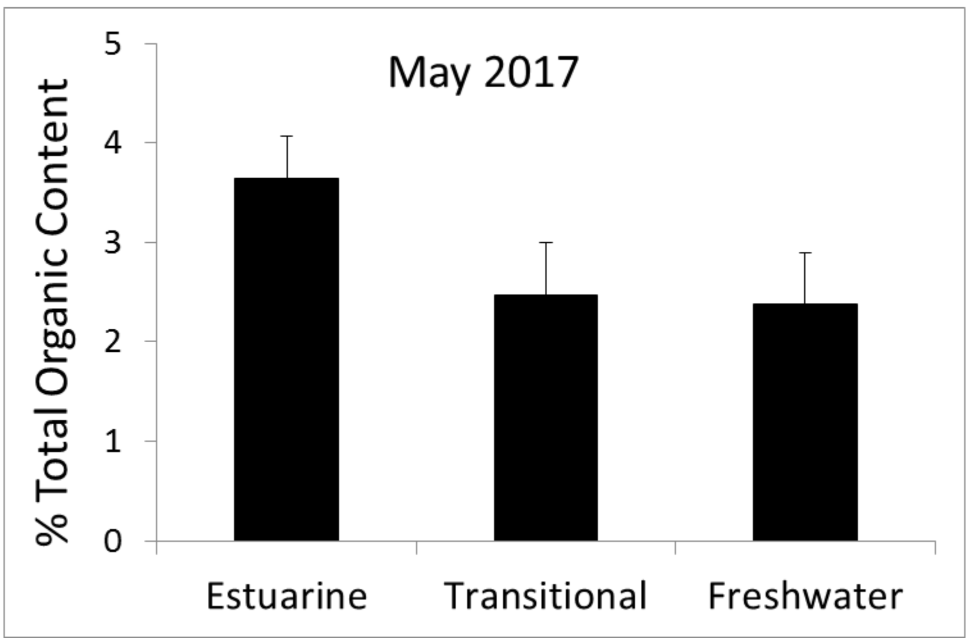


Figure 2.12. Sediment grain size distributions and % TOC in the estuarine, transitional, and freshwater zones during the spring 2017 sampling period.

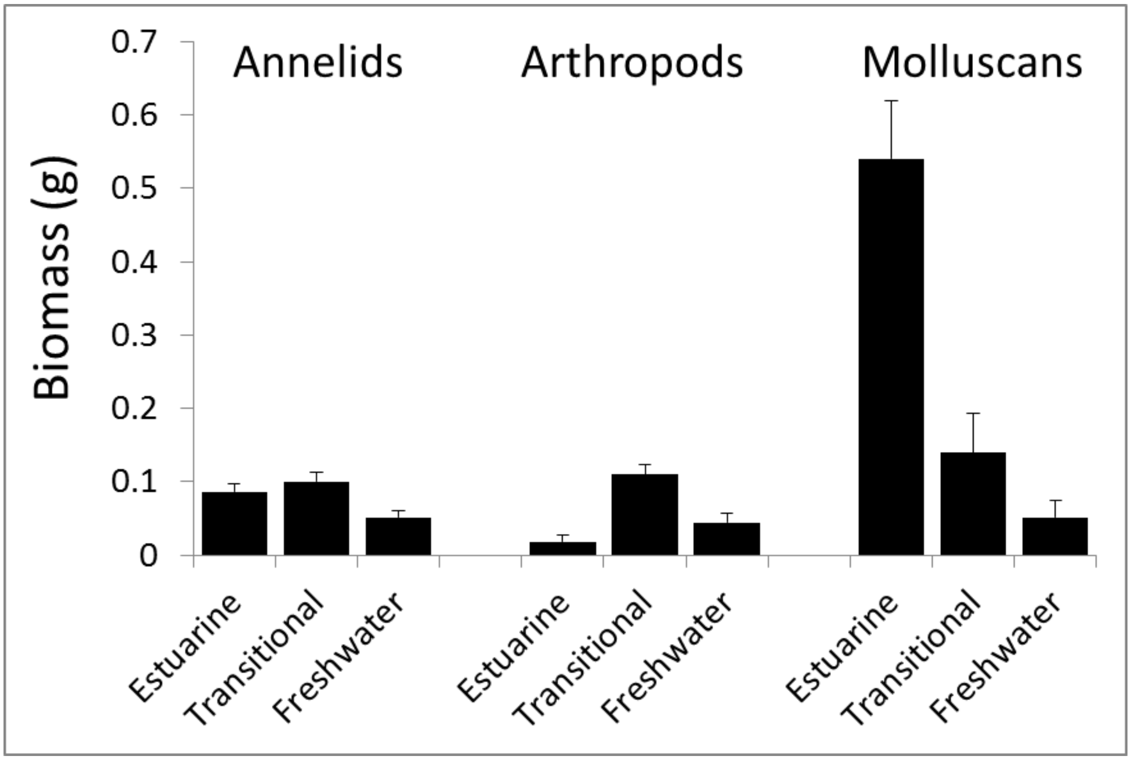


Figure 2.13. Mean spring biomass (+ standard error) of Annelids, Arthropods and Molluscs in each sampling area.

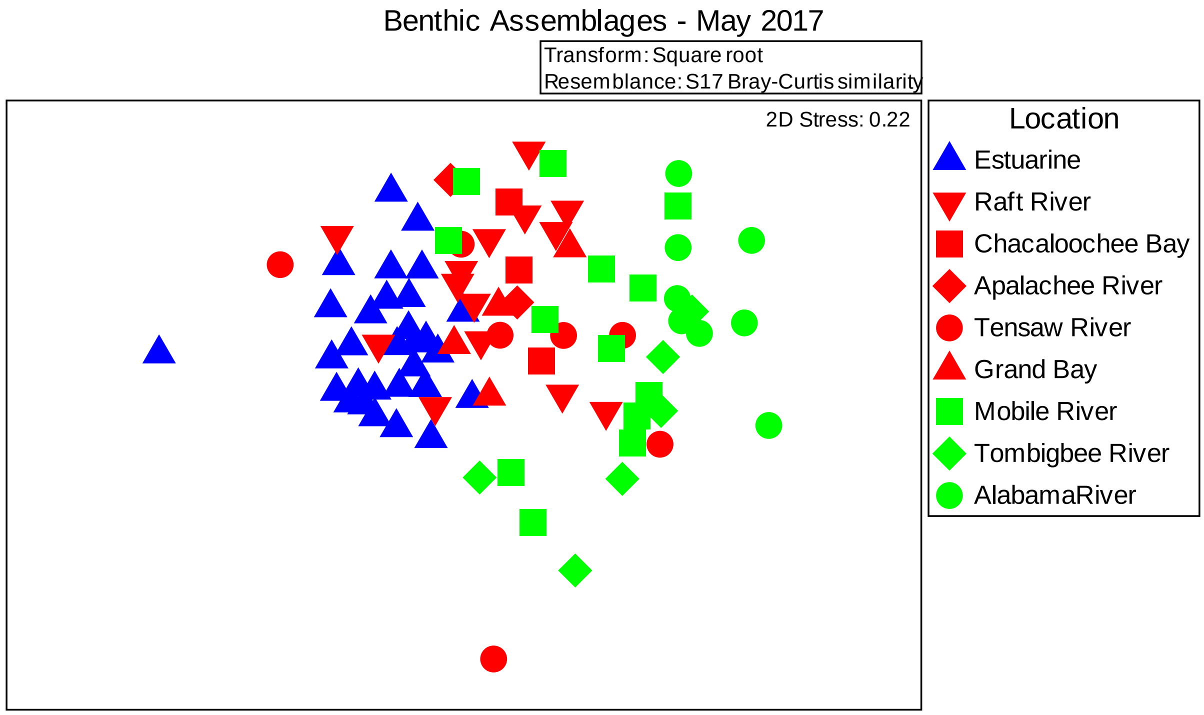


Figure 2.14. Non-metric multidimensional scaling plot of samples collected during spring sampling (May 2017) in the estuarine (blue symbols), transitional (red symbols), and freshwater (green symbols) zones.

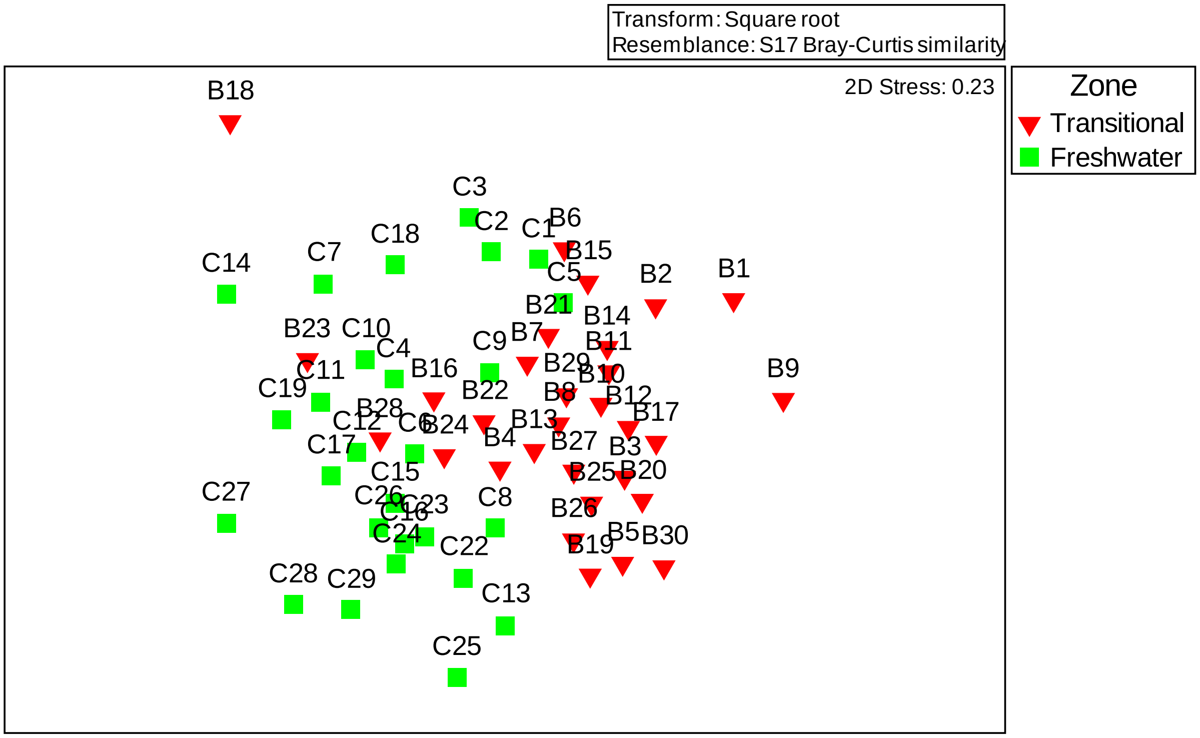


Figure 2.15. Non-metric multidimensional scaling plot of samples collected during spring sampling (May 2017) in the transitional (red symbols) and freshwater (green symbols) zones.

Chapter 3: Wetlands

Summary

Mobile Bay contains a wide variety of wetland types including freshwater, transitional and estuarine communities occurring within the study area. As a result, extensive on-site sampling and remote sensing approaches identified and mapped a total of 3525 individual wetland features based upon vegetation assemblages. The resulting map contained 41 wetland communities occurring over an area of 72505 acres, providing the most comprehensive wetland map available for the greater Mobile Bay ecosystem. The combination of elevation, salinity, and other factors dictate the distribution of wetland community types within the study area. As a result, the analysis of potential impacts associated with the proposed navigation channel deepening and widening focused on 1) anticipated increases in water salinity following project implementation and 2) impact of sea level rise on increased wetland inundation (e.g., drowning) under a projected 0.5 m (1.64 ft) sea level rise scenario. When examining potential salinity increases, projected salinity increases remained below established thresholds for both wetland community mortality and levels associated with decreased productivity. The highest projected salinity increases in area containing wetlands (< 2.0 ppt) occurred within the lower portion of the study area and adjacent to the navigation channel, where plant communities are already adapted to higher salinity conditions. Projected 0.5 m sea level rise scenarios will increase wetland inundation within the study area, potentially shifting wetland community types and/or increasing the amount of open water features. However, given the degree of natural sea level rise impacts, additional negative effects associated with the navigation project remain negligible. As a result, project implementation is not expected to negatively impact wetlands within the study area.

3.1 Introduction

General context: Wetlands occur in areas with sufficient surface inundation or ground water saturation at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions (Environmental Laboratory 1987). As a result of these characteristics, wetlands represent one of the most productive ecological components on the landscape (Reddy and DeLaune 2008) and wetland features can be readily delineated using a combination of on-site investigation and off-site mapping approaches (Tiner 2016). Wetlands provide a number of valuable ecological functions (e.g., flood water retention, storm surge reduction, wildlife habitat) which benefit society (e.g., recreation, flood risk reduction; Novitski 1996). The distribution of wetlands and various wetland community types on the landscape is dictated by elevation, substrate, hydroperiod, hydropattern, and water composition (Cowardin et al., 1979). In particular the salinity of water supporting wetlands maintains a controlling factor in wetland zonation in many areas (Huckle et al., 2000), with salinity displaying the capacity to alter patterns of wetland community distribution and productivity in coastal and estuarine environments (Crain et al., 2004). For example, alteration of natural salinity regimes and saltwater intrusion have contributed to wetland impacts in southern Louisiana and elsewhere (Day et al. 2000; Turner 1997). Potential forcing factors leading to increased salinity include increasing storm surge frequency and intensity, channel dredging, decreased freshwater inflows, and intensive groundwater withdrawal (Hauser et al. 2015; Yuan and Zhu 2015). In areas where increased salinity occurs, wetland plant communities may display decreased productivity, shift to more salt tolerant species, or undergo conversion to open water features (Boesch et al. 1994; Brock et al. 2005). Notably, wetland floral communities and fauna living in wetland sediments are adapted to life under anaerobic (i.e., low oxygen) conditions (NRC 1995). As a result, the assessment of potential water quality changes resulting from proposed dredging activities focuses on salinity and does not evaluate the dissolved oxygen levels examined in other aquatic resource categories discussed herein (e.g., oysters, fisheries, etc).

Problem statement: Mobile Bay supports one of the largest in tact wetland ecosystems in the United States, including over 250,000 acres within the Mobile-Tensaw River Delta (AWF 2018). Wetlands within the Bay provide essential habitat for a wide variety of recreational and commercially valuable species, including rearing and cover areas for fishes and waterfowl (Chabreck 1989). Additionally, Mobile Bay contains diverse plant communities including many rare, listed, and endemic species (Stout et al., 1998). The widening and deepening of the Mobile Bay Federal Navigation Channel poses potential environmental concerns because the possible influx of saltwater into upstream areas may alter wetland habitat assemblages, distribution, or productivity. Salinity in Mobile Bay is affected by river inflow, wind, and tides as well as periodic storm surges resulting from hurricanes and other weather events (Park et al. 2014). These natural patterns of spatial and temporal salinity fluctuations resulted in the development of diverse and resilient wetland community types within Mobile Bay. However, potential changes in water quality resulting from the implementation of the proposed Navigation Channel expansion must be evaluated to determine if post-project water quality conditions will impact wetland resources.

Model purpose: This chapter characterizes baseline wetland community assemblages and distribution in estuarine, transitional, and freshwater habitats throughout Mobile Bay and the associated Delta region. Potential changes in wetland community type, distribution, and productivity are documented to estimate whether and to what extent impacts may occur following channel deepening.

Model summary: Quantitative species composition data were collected at over 800 on-site locations to document the distribution and community assemblages of wetlands within the potential zone of influence of the harbor deepening project. Off-site approaches linked those ground measurements with aerial imagery and other resources to map the location and extent of each wetland community observed in the study area. Salinity tolerance classes were established for each wetland community using existing literature sources; including thresholds for decreased productivity and mortality. Hydrodynamic and water quality model results were evaluated to determine if post project conditions would increase salinity values beyond the established salinity thresholds to a degree that would alter wetland community productivity or distribution within Mobile Bay.

3.2 Methods – Model Development Process

Study Site

Mobile Bay, Alabama is located between the Fort Morgan Peninsula to the east and Dauphin Island, a barrier island on the west. Mobile Bay is 413 square miles in area, 31 miles long with a maximum width of 24 miles. The deepest (75 feet) areas of the Bay are located within the federal navigation channel, which serves Alabama's only port for ocean-going vessels, but the average depth of the bay is around 10 feet. The Mobile Bay watershed is the sixth largest river basin in the United States and the fourth largest in terms of hydrologic discharge. It drains water from portions of Alabama Georgia, Tennessee and Mississippi. Five river systems feed into the Bay including the Mobile, Tensaw, Dog, Deer, and Fowl Rivers, establishing a complex assemblage of habitats ranging from freshwater (northern portions of the Mobile-Tensaw River Delta) to increasing saline conditions as the Bay grades towards the northern Gulf of Mexico. Freshwater river discharges, and thus salinity, vary seasonally with high flows typically occurring in the late winter and early spring and low flows dominating during the summer. The lower and mid-portions of the Bay (e.g., estuarine habitats) receive seawater during normal tidal exchanges. Mobile Bay is located within Major Land Resource Area 152A – the Eastern Gulf Coast Flatwoods of Land Resource Region T - Atlantic and Gulf Coast Lowland Forest and Crop Region (NRCS 2006).

The study area utilized to evaluate wetlands focused on the central and southern portions of the Mobile Bay and the Five River Delta region, the area identified as having the highest likelihood of potential impacts associated with the proposed Navigation project (Figure 3.1). The study area included the portions of the Delta south of the Interstate 65 bridge, above which freshwater communities are dominant. The southern extent of the sampling included wetlands dominated by wetland communities adapted to saline conditions. As a result, the study area encompasses the entire salinity gradient occurring with the Mobile Bay region, ranging from salt-intolerant bottomland hardwood forest species assemblages in the north to the halophytic plant communities common throughout coastal wetlands of the northern Gulf of Mexico.

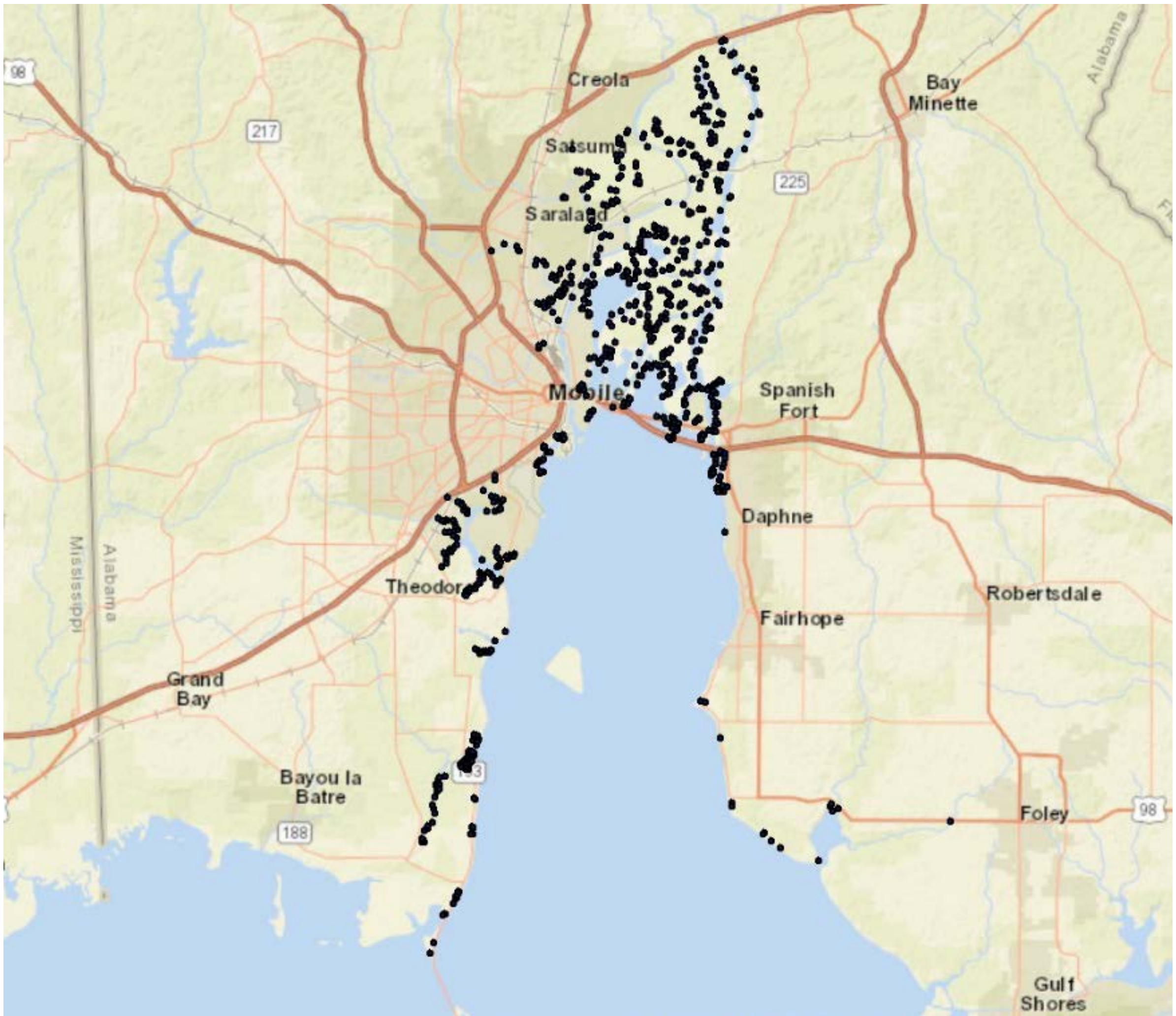


Figure 3.1. The study area focused on portions of the Mobile Bay and Five River Delta region south of the Interstate 65 bridge, encompassing the Dog river area and extending southward to Heron Bay in the west and Weeks Bay to the east. The points indicate on-site sample locations.

Wetlands within Mobile Bay developed on prograding alluvial deposits as the river sediments are discharged into the drowned Pleistocene river valley (Gastaldo 1989). As a result of the observed salinity gradient increasing from north to south, wetlands in the northern portion of the Bay are characterized by bottomland hardwood forests containing *Taxodium distichum, Nyssa aquatica, N. biflora*, *Acer sp., Carya sp., Fraxinus sp., Quercus sp., and Ulmus sp.* Herbaceous species within this zone include *Typha domingensis, T. latifolia, Sagittaria lancifolia, Schoenoplectus americanus*, and *Alternanthera philoxeroides*. Additionally a number of aquatic bed species (e.g., *Nuphar sp., Nelumbo lutea*) can be found adjacent to open water reaches in many wetland areas. Wetlands within the southern portion of the Delta form a transition zone of estuarine adapted, moderate salinity tolerant species dominated by a mixture of shrubs including *Baccharis glomeruliflora, B. halimifolia, Ilex sp., Morella cerifera, Persesa palustris,* and *Sabal minor*. The lower portions of the Bay include an array of moderate to high salt tolerant herbaceous species including *Spartina cynosuroides, Panicum virgatum, Cladium jamaicense, and Juncus roemerianus.* Dense nearly monotypic stands of *Phragmites karka* also occur within the study area, occupying both disturbed (i.e., near the highway 98 causeway) and natural portions of the Bay. A detailed description of species composition and distribution within Mobile Bay is provided in the results section below.

Sampling protocol – Process followed

1) On-site wetland sampling: Ground based wetland sampling occurred during November 2017, utilizing water-craft and the regional road network to access wetlands throughout Mobile Bay. Due to the warm climate and year round growing season of southern Alabama, November represents an appropriate time to conduct wetland surveys in the study area, as most vegetation maintain leaves and fruiting bodies during the fall and the full cohort of species has undergone the annual growth cycle (USDA-NRCS 2006). During that period, data from 802 distinct locations within the Bay were evaluated to enable development of a comprehensive map of wetland features within the study area (Figure 3.1). At each sample location, the species composition of each vegetation community was documented using established measurement techniques including determinations of percent groundcover, establishment of species dominance, and other factors according to the guidance provided for the Gulf and Coastal Plain regions as outlined in USACE (2010).

At a subset of study locations (65), 0.1 acres circular plots were established to further document species richness, abundance, and wetland community structure (Oliver and Larson 1996). Sample locations were selected at representative locations within specific wetland communities to characterize wetland community classes and support the large scale mapping objectives using a targeted sampling approach (Environmental Laboratory 1987). In narrow or elongate communities, plot dimensions were modified to prevent overlap with adjacent vegetation types (USACE 2010). Across all sample locations, trees were defined as woody vegetation, excluding vines, ≥ 4 in in diameter at breast height (DBH) and >20 ft in total height. Saplings/shrubs included all woody vegetation, excluding woody vines, greater than 3.2 ft in height, but less than 4 in DBH. Herbaceous plants were defined as any non-woody species, and woody species <3.2 ft in height regardless of size. Woody vines included all climbing woody vegetation greater than 3.2 ft in height, regardless of diameter. This approach allowed for determination of species richness, abundance density, and other common approaches to characterize wetland vegetation community dynamics (Tiner 2016).

Surface water (when present), was analyzed for salinity within a subset of wetland communities. When surface water was absent, sampling occurred within the upper 1 m of adjacent open water features using a YSI® Pro DSS water quality meter. The YSI® unit was calibrated using a standardized buffered solution of known conductivity and pH. Field work occurred during a seasonal low rainfall, low discharge period (late summer-fall), limiting the availability of surface waters within many sample locations. As a result of the climatic and hydrodynamic conditions, in-channel and wetland community surface water salinities likely remained at or near its annual maximum.

2) Digitization and wetland mapping: Wetland features within the study area were digitized based on direct observations, aerial imagery interpretation, topographic maps, National Wetland Inventory data, high-resolution ortho-imagery, light detection and ranging (LiDAR) analysis, data layers available in the geospatial data gateway (https://datagateway.nrcs.usda.gov/) and other resources (USFWS 2016). The digital mapping effort utilized approaches outlined in USDA-NRCS (1996) and Berkowitz et al., (2016; 2017) to assess reflectance patterns, texture, color signatures, and other characteristics; linking study locations with known species assemblages to areas displaying similar diagnostic features (Figure 3.2 and 2-3). Digitization efforts resulted in the high resolution mapping of over 77000 acres of wetlands within the study area. Each mapped wetland feature was uploaded to an ARC-GIS database in which each feature was given a unique identifier and wetland classification code within the database attribute table.

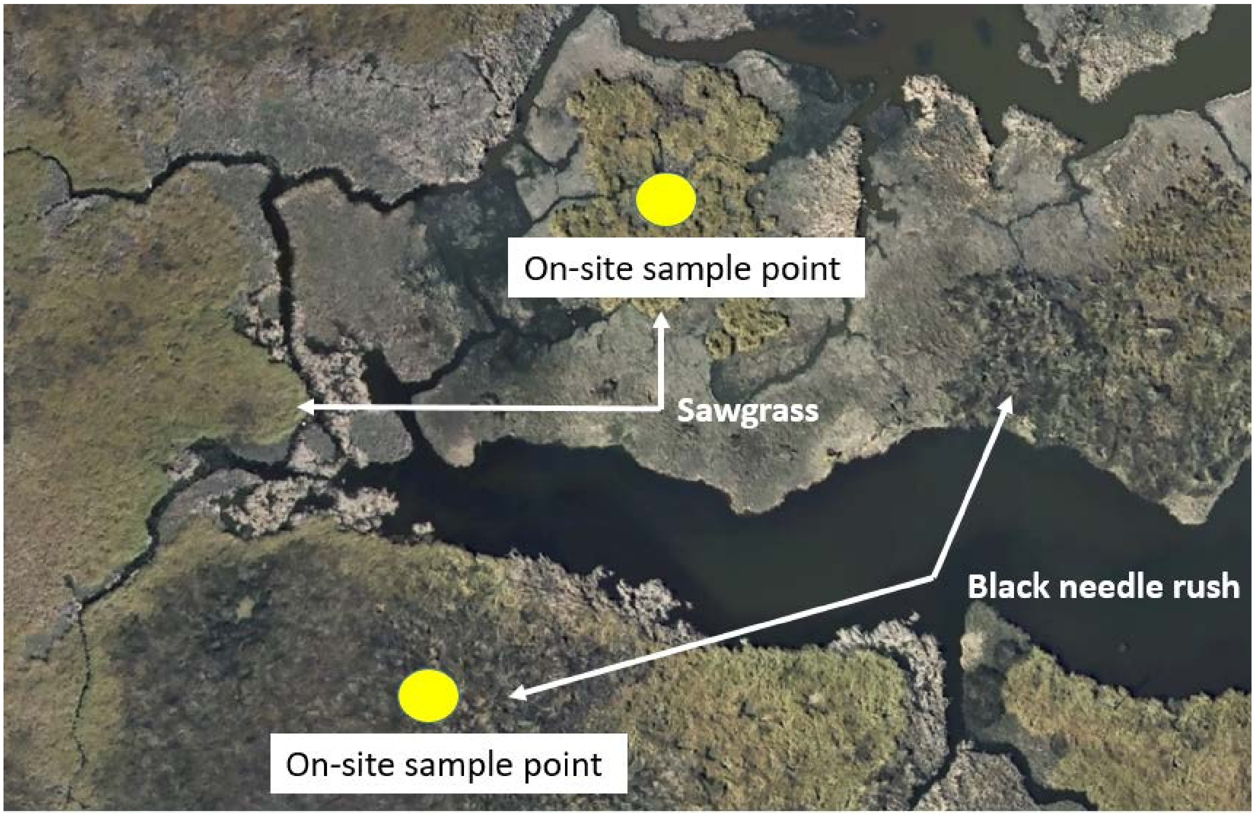


Figure 3.2: Example of wetland vegetation community mapping approach in which known on-site sample locations are used to extrapolate to un-sampled communities using distinct diagnostic features. Note that with salt-tolerant communities *Cladium jamaicense* (sawgrass) maintains a blonde color while *Juncus roemerianus* (black needle rush) displays a distinct dark color and rough texture.

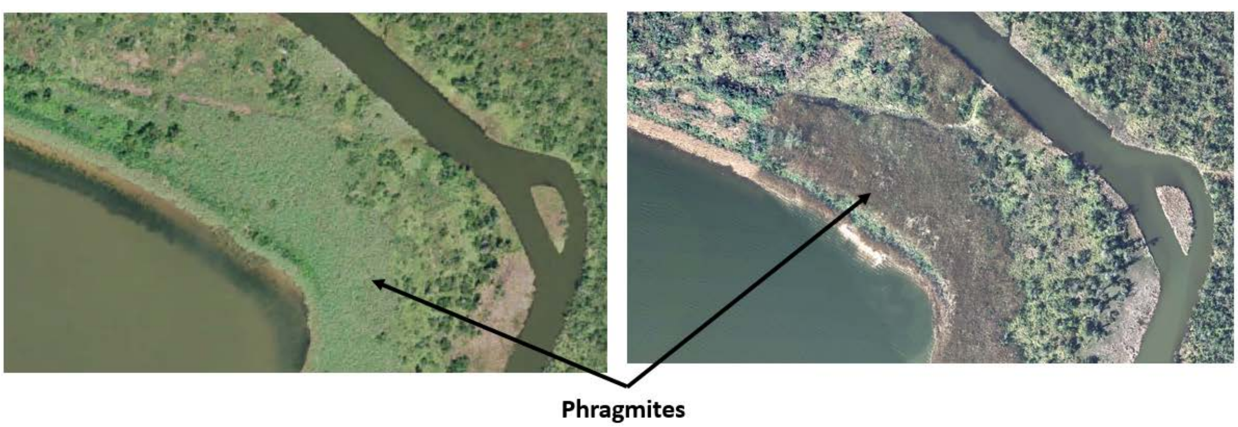


Figure 3.3. Example of wetland vegetation community mapping approach in which *Phragmites karka* occurs as largely monotypic, globular or linear shaped features located parallel to open water areas. Light green colors provide a distinctive signature for mapping using growing

season imagery, while late season and winter images display characteristic dark color. Coarse textures remain prevalent in images collected throughout the year.

3) Establishing salinity thresholds: Salinity tolerance thresholds for each wetland community type were obtained from peer reviewed journal publications and salinity classes documented within the United States Department of Agriculture (USDA) PLANTS database (https://plants.usda.gov). Two sets of species salinity thresholds were established for evaluation. First, plant species were evaluated to determine if changes in salinity would exceed available mortality thresholds. Second, plant species were evaluated to determine if changes in salinity would impact productivity and growth pattern as defined as a reduction in plant productivity (i.e., growth) of more than ten percent. For example, Crain et al. (2004) documented that Spartina patens (a halophyte) displayed significant mortality at very high salinity values (>60 ppt). However, the species tolerates salinities of 2.6 - 6.4 ppt (USDA PLANTS database; Table 3.2) and up to 35 ppt (Hester et al., 2005) without decreasing productivity. Similarly, *Typha domingensis* exhibited mortality at 15 ppt, while a decrease in growth was documented at salinities of 3.5 ppt (Glenn et al. 1995). In many cases, salinity based mortality thresholds were not available within the established literature as most studies of salinity focus on agricultural food crops not found in wetlands and other natural ecosystems (Downton and Läuchli 1984; Grieve 2012). In cases where no mortality thresholds were available, productivity thresholds were applied. Further, many of the plant communities examined contained a mixture of species. When mixed species communities were evaluated, the dominant species with the lowest established salinity threshold was applied. For example, wetland complexes containing a mixture of *Spartina cynosuroides* (a high salinity tolerance species adapted to value >6.4 ppt) and *Panicum virgatum* (a moderate salinity tolerant species with a preferred salinity range of 2.6 - 6.4 ppt) were evaluated using the moderate salinity productivity threshold of 2.6 – 6.4 ppt. This approach ensured that the assessment of potential wetland impacts provided a conservative estimate throughout the analysis. Once established the salinity thresholds were appended to the attribute table database for each mapped wetland feature outlined above.

4) Evaluation of potential changes in water quality: Extensive water quality and hydrodynamic data was generated to evaluate both present day (i.e., existing/basline) conditions within Mobile

Bay as well as estimated post-project conditions. Available water quality parameters included salinity, dissolved oxygen, and other factors (e.g., nutrients). For the assessment of wetland resources, potential changes in salinity were evaluated due to the fact that wetlands are adapted to saturated and anaerobic soil conditions (Vepraskas and Craft 2016). Additionally, the river systems flowing into Mobile Bay are rich in both nutrients and sediment resulting in fertile substrate within the Bay (AWF 2018), suggesting that change to the navigation channel would have little effect on other water quality parameters.

All hydrodynamic and water quality data was generated using a combination of approaches including the Geophysical Scale Multi-Block (GSMB) system, the Curvilinear Hydrodynamic in three-dimension Waterways Experiment Station (CH3D-WES) approach, and the CE-QUAL-ICM water quality component developed and maintained by the US Army Corps of Engineers Engineer Research and Development Center (Cerco and Cole 1995). Detailed model parameterization and implementation information is provided in other documentation associated with the proposed navigation project and is not reproduced herein. As a result, the section below outlines how the hydrodynamic and water quality outputs were interpreted and applied to the assessment of wetland resources within the study area.

The water quality data included baseline condition and estimated post product conditions for > 48000 individual cells organized into 30 blocks (or groups of cells) encompassing the entire area of Mobile Bay (Figure 3.4). Within each individual cell, surface water quality data was generated for three scenarios 1) baseline conditions, 2) post project implementation condition, and 3) post project condition with an estimated 0.5 m sea level projection. Scenario 3 was included in the analysis in accordance with current US Army Corps of Engineer guidance which requires incorporation of estimated sea level rise implications. A 0.5 m sea level rise projection was selected for analysis because it represents the intermediate projection for the study area.

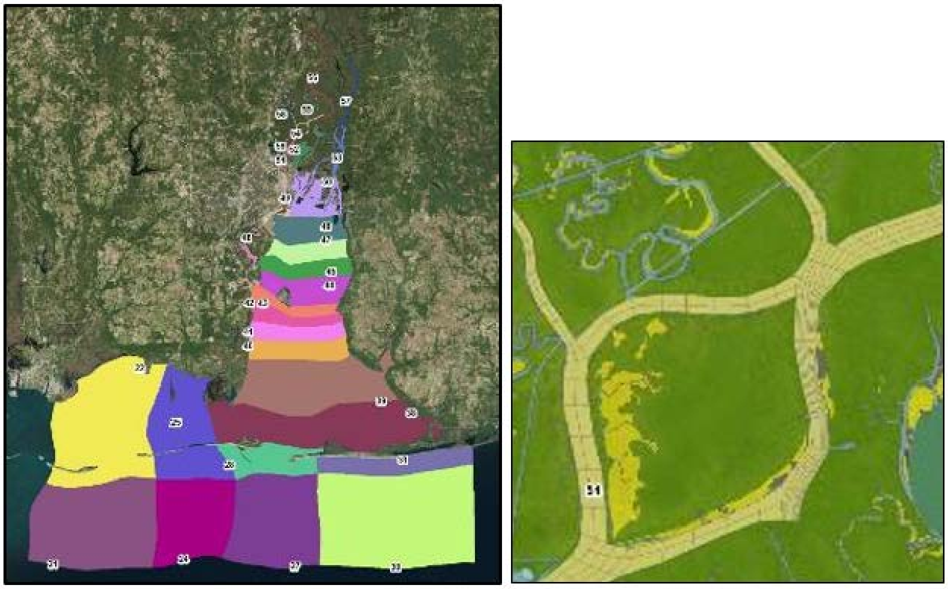


Figure 3.4. Overview of the area evaluated for potential changes in water quality, which consisted of 30 blocks (left). Each individual block was comprised of hundreds of smaller individual cells (right) each of which contained unique water quality data under the three scenarios: baseline, post project, and sea level rise. The data generated from each individual cell was linked with the nearest environmentally relevant wetland feature to evaluate potential changes in water quality resulting from the proposed navigation project.

In order to conduct the wetland assessment, the difference in monthly mean salinity values was determined between the three scenarios examined. For example, within each individual water quality cell, the difference between baseline conditions and estimated post project conditions were determined (scenario $2_{SALINITY}$ – scenario $1_{SALINITY}$). Similarly, the difference between the baseline condition and estimated sea level rise values was determined (scenario $3_{SALINITY}$ – scenario $1_{SALINITY}$). Following the determination of anticipated salinity differences between model scenarios, all cells with estimated changes in mean salinity $\geq$0.5 ppt for any month during the year were extracted from the grid and identified for further analysis.

A methodology was implemented to link each wetland feature within the closest cell within the study area. Specifically, any wetland feature within 1000 ft of a water quality cell within the study area was selected using a nearest neighbor feature in ARC-GIS. Salinity difference from the identified cells were then appended to attribute table of the wetland features for analysis. The link between wetland features and individual cells were evaluated to ensure that the selected cell provides a hydrologic connection to the adjacent wetland feature. This evaluation was required in areas where with high sinuosity, natural levees or other barriers, or other features that prevent the closest water quality cell from representing the source of water to the wetland feature. Once each wetland feature was linked with the appropriate cell, estimated changes in monthly salinity data were evaluated under the baseline condition, as well as under the post project implementation condition, and the post project condition plus 0.5 m sea level projection scenarios outlined above. The scenario results associated with each wetland feature were compared to the established salinity thresholds in order to identify potential impacts.

Statistical Approach – Process followed

Quantification: Extensive ground and remote sensing studies were implemented to quantify the distribution of wetland communities within the study area. For each wetland community assemblage identified, salinity tolerance thresholds were established. Water quality parameters were generated under the three scenarios described above and linked with tolerance limits for each wetland feature.

Evaluation: Descriptive statistics including monthly and seasonal mean values as well as standard deviations if the mean are reported for each wetland community. Additionally, the estimated increase in salinity was evaluated to determine of salinity tolerance limits were exceeded.

3.3 Results

3.3.1 Baseline conditions:

As discussed above, Mobile Bay contains a wide variety of wetland types. As a result, a total of 3525 individual features were identified based upon vegetation assemblages. The resulting map contained 41 wetland communities occurring over an area of 72505 acres (Table 3.1; Figure 3.5 and 2.6). The most abundant wetland community observed in the study area was the Baldcypress

– tupelo – bottomland mix which accounted for 30% of the total wetland area, mostly located in upper portions of the study area and along the north eastern shore of the Bay. Additionally, the Baldcypress – tupelo – swamp bay – palmetto – shrub mix and the Tidal shrub mix each comprised nearly 15% of the total wetland area, occurring in the upper to middle of the transition zone between freshwater and estuarine habitats. The distribution of wetlands within in the study area reflects a combination of elevation (Figure 3.7) and salinity tolerance (Table 3.2).

It should be noted that while the current report provides the most detailed assessment of wetland communities in the region, some wetland features likely contain inclusions of other communities. The scale of the study area places limitations on narrow, linear communities occurring at the contact between landscape features. Some vegetation types may not provide a distinct texture and/or color at all locations due to quality of available imagery and recent disturbance events. The northern Gulf Coast contains substantial areas dominated by various evergreen species (broadleaf and needle-leaf) due in part to sandy soils that are relatively low in nutrients, where retaining leaves for multiple years is advantageous, and mild day-time temperatures during winter that allow evergreens to carry out photosynthesis while deciduous species are dormant (Gilliam, 2014). These species can produce similar colors and textures in aerial imagery, making delineations problematic for some evergreen woody plant communities.

Table 3.1. Wetland classes, species names, and area of extent within the study area

Class Name	Representative species	Area (acres)
Baldcypress – black willow – Chinese tallow	*Taxodium distichum – Salix nigra – Triadica sebifera*	155
Baldcypress – tupelo	*Taxodium distichum – Nyssa aquatica*/*N. biflora*	2900
Baldcypress – tupelo – bottomland mix	*Taxodium distichum – Nyssa aquatica*/*N. biflora* – (*Acer sp.* — *Carya sp.* — *Fraxinus sp.* — *Quercus sp.* — *Ulmus sp*)	22687
Baldcypress – tupelo – slash pine	*Taxodium distichum – Nyssa aquatica*/*N. biflora* – *Pinus elliottii*	1114

Baldcypress – tupelo – slash pine – Atlantic white cedar	*Taxodium distichum – Nyssa biflora – Pinus elliottii – Chamaecyparis thyoides*	1018
Baldcypress – tupelo – swamp bay – palmetto – shrub mix	*Taxodium distichum – Nyssa biflora – Persea palustris* - (*Baccharis sp., Morella cerifera, Ilex sp.*)	10566
Big cordgrass	*Spartina cynosuroides*	31
Big cordgrass – switchgrass	*Spartina cynosuroides – Panicum virgatum*	442
Big cordgrass – switchgrass – bagpod	*Spartina cynosuroides – Panicum virgatum – Sesbania vesicaria*	83
Big cordgrass – switchgrass – sawgrass	*Spartina cynosuroides – Panicum virgatum – Cladium jamaicense*	1342
Black needlerush	*Juncus roemerianus*	569
Black needlerush – Big cordgrass	*Juncus roemerianus – Spartina cynosuroides*	763
Black needlerush – Big cordgrass – switchgrass	*Juncus roemerianus – Spartina cynosuroides – Panicum virgatum*	553
Bottomland mix	*Acer sp. — Carya sp. — Fraxinus sp. — Quercus sp. — Ulmus sp.*	5500
Bulrush	*Schoenoplectus californicus/S. tabernaemontani*	3
Chinese tallow – Black willow – tidal shrub mix	*Triadica sebifera – Salix nigra – Baccharis sp. – Morella cerifera*	971
Giant cutgrass	*Zizaniopsis miliacea*	263
Live oak – Magnolia – Pine (Hammock)	*Quercus virginiana – Magnolia grandiflora – Pinus elliottii/Pinus taeda*	440
Mexican water-lily	*Nymphaea mexicana*	1
Phragmites	*Phragmites karka*	2913
Pine flatwoods	*Pinus elliottii/P. palustris/P. taeda*	3862
Saltmeadow cordgrass	*Spartina patens*	5
Sawgrass	*Cladium jamaicense*	638
Sawgrass – tidal shrub mix	*Cladium jamaicense – Baccharis sp., Ilex sp., Morella cerifera, Persesa palustris, Sabal minor*	751

Slash pine – live oak – tidal shrub mix	*Pinus elliottii* – *Quercus virginiana* – (*Baccharis sp., Ilex sp., Morella cerifera, Persesa palustris, Sabal minor*)	109
Smooth cordgrass	*Spartina alterniflora*	3
Sweetbay – swampbay – yellow-poplar – netted chainfern	*Magnolia virginiana – Persea palustris – Liriodendron tulipifera – Woodwardia areolata*	61
Tidal shrub mix	*Baccharis glomeruliflora, B. halimifolia, Ilex sp., Morella cerifera, Persesa palustris, Sabal minor*	12511
Torpedograss	*Panicum repens*	54
Typha	*Typha domingensis*	164
Typha – arrowhead – alligatorweed	*Typha domingensis/T. latifolia – Sagittaria latifolia – Alternanthera philoxeroides*	24
Typha – bulltongue	*Typha domingensis – Sagittaria lancifolia*	321
Typha – bulltongue – three-square – alligatorweed	*Typha domingensis/T. latifolia – Sagittaria lancifolia – Schoenoplectus americanus – Alternanthera philoxeroides*	2525
Typha – bulltongue – wild-rice	*Typha domingensis – Sagittaria lancifolia – Zizania aquatica*	108
Typha – bulrush	*Typha domingensis – Schoenoplectus californicus/S. tabernaemontani*	5
Water hyacinth – water spangles – Cuban bulrush	*Eichhornia crassipes – Salvinia minima – Oxycaryum cubense*	24
Water lotus	*Nelumbo lutea*	78
Wild-rice	*Zizania aquatica*	153
Yellow pond-lily	*Nuphar advena/N. ulvaceae*	28
Total		73741

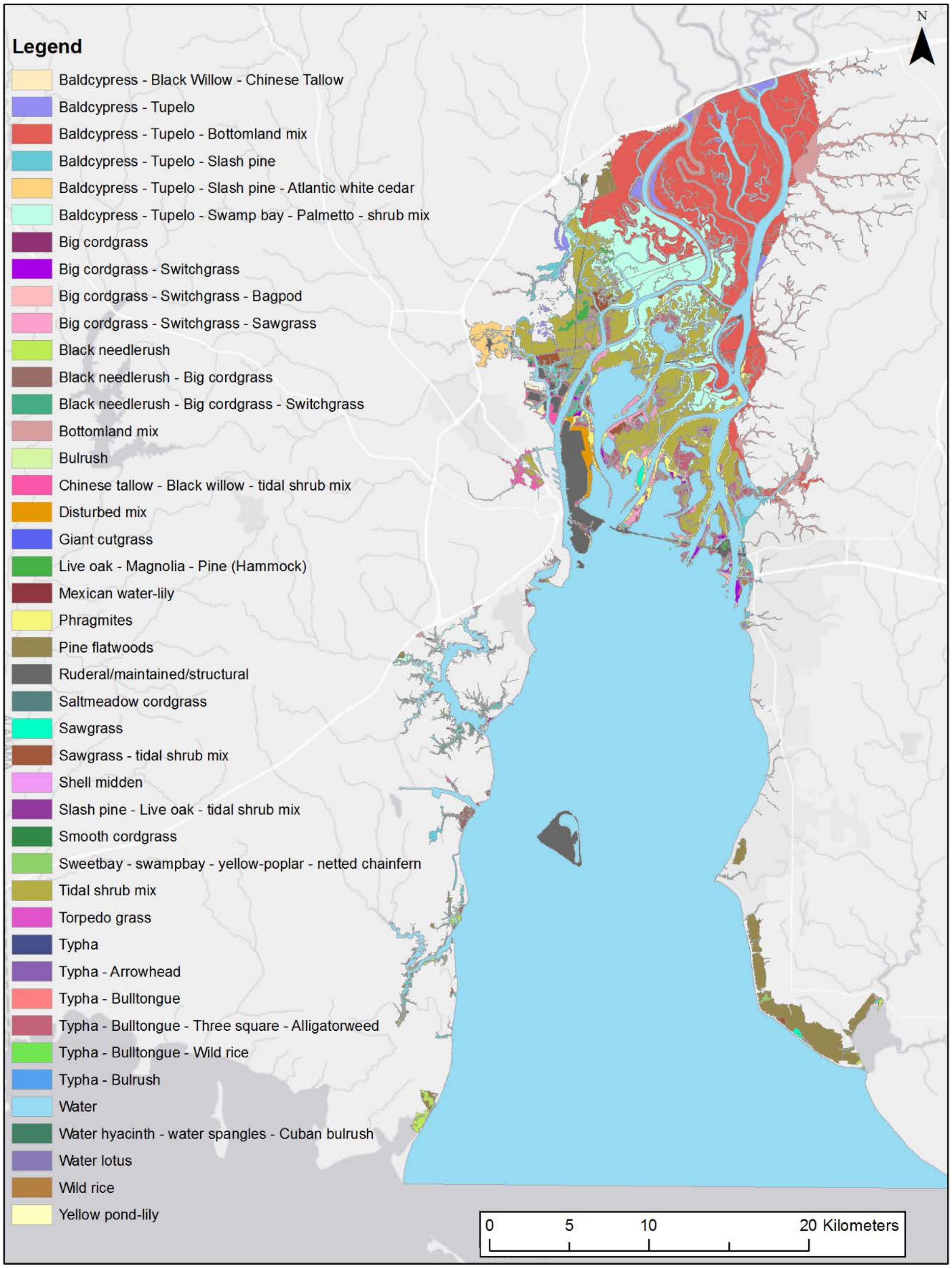


Figure 3.5. Distribution of wetland communities within the study area.

Figure 3.6. Detail of wetland community distribution within the lower Delta and upper Bay portions of the study area. The navigation channel can be seen in the center-left portion of the figure. Wetland community are identified by color using the legend provided in Figure 3.5.

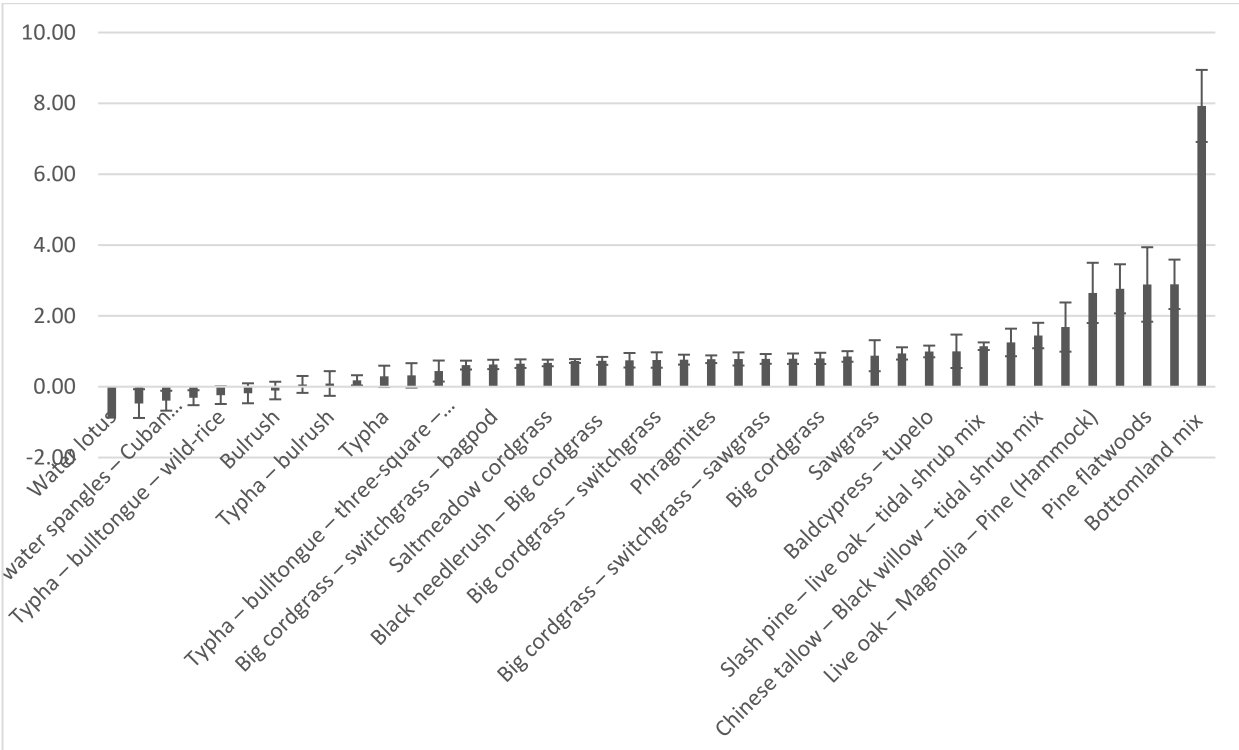


Figure 3.7. Elevation distribution (feet) of wetland community classes based upon digital elevation mapping. Error bars represent one standard deviation of the mean.

Table 3.2. Salinity tolerance ranges for each wetland plant community. Salinity thresholds are absolute values based upon ideal growth conditions and do not reflect mortality (USDA plants database).

Class name	ppt	Class name	ppt
Baldcypress – black willow – Chinese tallow	2.6-6.4	Pine flatwoods	0-1.30
Baldcypress – tupelo	1.31-2.59	Saltmeadow cordgrass	2.6-6.4
Baldcypress – tupelo – bottomland mix (Maple, Hickory, Ash, Oak, Elm)	0-1.30	Sawgrass	2.6-6.4
Baldcypress – tupelo – slash pine	1.31-2.59	Sawgrass – tidal shrub mix	2.6-6.4
Baldcypress – tupelo – slash pine – Atlantic white cedar	1.31-2.59	Slash pine – live oak – tidal shrub mix	1.31-2.59
Baldcypress – tupelo – swamp bay – palmetto – shrub mix	2.6-6.4	Smooth cordgrass	>6.4
Big cordgrass	>6.4	Sweetbay – swampbay – yellow-poplar – netted chainfern	0-1.30
Big cordgrass – switchgrass	2.6-6.4	Tidal shrub mix	2.6-6.4
Big cordgrass – switchgrass – bagpod	2.6-6.4	Torpedograss	2.6-6.4
Big cordgrass – switchgrass – sawgrass	2.6-6.4	Typha	1.31-2.59
Black needlerush	>6.4	Typha – arrowhead – alligatorweed	1.31-2.59
Black needlerush – Big cordgrass	>6.4	Typha – bulltongue	1.31-2.59
Black needlerush – Big cordgrass – switchgrass	>6.4	Typha – bulltongue – three-square – alligatorweed	1.31-2.59

Bottomland mix (Maple, Hickory, Ash, Oak, Elm)	0-1.30	Typha – bulltongue – wild-rice	1.31-2.59
Bulrush	1.31-2.59	Typha – bulrush	1.31-2.59
Chinese tallow – Black willow – tidal shrub mix	2.6-6.4	Water hyacinth – water spangles – Cuban bulrush	0-1.30
Giant cutgrass	1.31-2.59	Water lotus	0-1.30
Live oak – Magnolia – Pine (Hammock)	0-1.30	Wild-rice	0-1.30
Mexican water-lily	1.31-2.59	Yellow pond-lily	0-1.30
Phragmites	>6.4		

The following section describes of each the wetland community classes found within the study area. Common and scientific names of diagnostic species, number of features, area occupied, landscape position(s), and noteworthy co-occurring species are provided. Ruderal and non-wetland features such as hammocks that were embedded within aquatic and/or wetland features are also discussed. The diagnostic species for each class were maintained at a level that provides a recognizable assemblage based on direct visual observations, with the majority of diagnostic species having published salinity tolerance values for maximum productivity. As noted above, when conducting the wetland assessment the lowest salinity tolerance rating was applied in wetland communities exhibiting a variety of salinity tolerance classes.

Baldcypress – black willow – Chinese tallow (*Taxodium distichum – Salix nigra – Triadica sebifera*) occurred as eight features on approximately 154.8 acres of previously disturbed areas, typically inside berms of former disposal facilities (Figure 3.8). This community had low species richness, with the understory dominated by buttonbush (*Cephalanthus occidentalis*) and redvine (*Brunnichia ovata*).

Figure 3.8. Baldcypress – black willow – Chinese tallow forest located inside a former disposal facility, north of Mobile Harbor, Mobile County, AL.

Baldcypress – tupelo (*Taxodium distichum – Nyssa aquatica*/*N. biflora*) occurred as 72 features on 1,173.8 acres, that are freshwater to slightly brackish, and inundated seasonally to year-round. The understory was relatively sparse compared to other forest types that share these overstory species, with buttonbush and green ash (*Fraxinus pennsylvanica*) dominating the sapling/shrub stratum (Figure 3.9). Water-willow (*Justicia ovata*), arrow-arum (*Peltandra virginica*), and savanna phanopyrum (*Phanopyrum gymnocarpon*) dominated the herbaceous stratum. Sawgrass (*Cladium jamaicense*) dominated the herbaceous stratum in areas that are adjacent to slightly brackish waters, with pondcypress (*Taxodium ascendens*) frequently co-occurring.

Figure 3.9. Baldcypress – tupelo forest, dominated by water tupelo (*N. aquatica*), Baldwin County, AL.

<u>Baldcypress – tupelo – bottomland mix (Maple, Hickory, Ash, Oak, Elm)</u> (*Taxodium distichum* – *Nyssa aquatica*/*N. biflora* – [*Acer sp.* — *Carya sp.* — *Fraxinus sp.* — *Quercus sp.* — *Ulmus sp.*]) occurred as 72 features on 22,687.2 acres (Figure 3.10). The diagnostic species found in the tree stratum also dominated the sapling/shrub stratum. Pumpkin ash (*Fraxinus profunda*), Carolina ash (*Fraxinus caroliniana*), and swamp cottonwood (*Populus heterophylla*) frequently occurred in both the tree and sapling/shrub strata, but rarely as dominants. Dwarf palmetto typically dominated the herbaceous stratum.

This community occupies expansive areas of the northern portions of the delta. Some communities mapped as this type could potentially be separated as either “baldcypress – tupelo” or “bottomland mix”; however, broad-scale disturbances to the natural vegetation through timber harvesting have altered the corresponding texture and colors produced in both infrared and high-resolution ortho-imagery, precluding further separation based on available data.

Figure 3.10. Baldcypress – tupelo – bottomland mix adjacent to the upper Mobile River, Mobile County, AL.

Baldcypress – tupelo – slash pine (*Taxodium distichum* – *Nyssa aquatica*/*N. biflora* – *Pinus elliottii*) occurred as 103 features on 1,113.9 acres, often situated above tidal marshes and shrub dominated communities, or along blackwater streams (Figure 3.11). Swampbay (*Persea palustris*) and titi (*Cyrilla racemiflora*) dominated the shrub stratum. This community was mapped predominately south of I-10 and concentrated near the Dog River and Fowl River.

Figure 3.11. Baldcypress – tupelo – slash pine forest located adjacent to the Dog River, Mobile County, AL.

Baldcypress – tupelo – slash pine – Atlantic white cedar (*Taxodium distichum – Nyssa biflora – Pinus elliottii – Chamaecyparis thyoides*) occurred as 11 features on approximately 1,018.1 acres along acidic, blackwater streams, with the best examples adjacent to Chickasaw Creek (Figure 3.12). This community may be referred to locally as "juniper bogs" (Laderman, 1989). Sweetbay, titi, big gallberry (*Ilex coriacea*), and fetterbush (*Lyonia lucida*) dominated the shrub stratum. Royal fern (*Osmunda spectabilis*) and nettedchain fern (*Woodwardia areolata*) dominated the herbaceous stratum.

Atlantic white cedar is a distinctive component of this community and commonly occurred on stream banks, often leaning over the channel. This species is restricted to a narrow band of freshwater wetlands, typically near the coast, from Maine to Mississippi. It once covered expansive areas but is now considerably reduced due to excessive harvesting for its valuable, decay resistant wood, changes to hydrologic regime via ditching and draining, and conversion to agriculture or development (Laderman, 1989).

Figure 3.12. Baldcypress – tupelo – slash pine – Atlantic white cedar forest along Chickasaw Creek, Mobile County, AL.

Baldcypress – tupelo – swamp bay – palmetto – shrub mix (*Taxodium distichum – Nyssa biflora – Persea palustris* - [*Baccharis sp., Morella cerifera, Ilex sp.*]) occurred as 227 features occupying 10,566.2 acres. This community covered extensive areas in the central portions of the delta and as narrow bands along brackish channels on fronts and natural levees (Figure 3.13) This community is transitional to the "tidal shrub mix" community, and is defined here as having a tree stratum with ≥30 percent cover. Several species of *Ilex* were encountered in this community including yaupon (*I. vomitoria*), winterberry (*I. verticillata*), dahoon (*I. cassine*), American holly (*I. opaca*), myrtle holly (*I. myrtifolia*), and big gallberry. Dwarf palmetto typically dominated the herbaceous stratum of this community.

Figure 3.13. Baldcypress – tupelo – swamp bay – palmetto – shrub mix located adjacent to Bayou Sara, Mobile County, AL.

Big cordgrass (*Spartina cynosuroides*) occurred as 27 features on approximately 131.2 acres in the irregularly flooded zones of brackish and tidally influenced freshwater marshes (Figure 3.14). This species was typically a co-dominant component of other wetland communities and mapped here as monotypic stands in limited areas.

Figure 3.14. Big cordgrass dominated marsh, near the Dog River, Mobile County, AL.

Big cordgrass – switchgrass (*Spartina cynosuroides – Panicum virgatum*) occurred as 43 features on approximately 441.8 acres in the irregularly flooded zones of brackish and tidally influenced freshwater marshes, often above black needle rush, or co-occurring as a patchy mix.

Big cordgrass – switchgrass – bagpod (*Spartina cynosuroides – Panicum virgatum – Sesbania vesicaria*) occurred as nine features on 83.13 acres of irregularly flooded brackish marsh near the I-10 corridor (Figure 3.15). Bagpod occurred frequently as a minor component in many wetland communities throughout the study area; however, its abundance and co-dominance in the "big cordgrass – switchgrass" communities at some locations was noteworthy, and may be explained by previous disturbance activities.

Figure 3.15. Big cordgrass – switchgrass – bagpod (left) near the I-10 corridor, Baldwin County, AL; bagpod fruit (right).

Big cordgrass – switchgrass – sawgrass (*Spartina cynosuroides – Panicum virgatum – Cladium jamaicense*) occurred as 74 features on approximately 1,342.1 acres in the irregularly flooded zones of brackish and tidally influenced freshwater marshes, often above black needle rush. This community frequently transitioned upslope to the "tidal shrub mix" community.

Black needlerush (*Juncus roemerianus*) occurred as 114 features on 569.4 acres, forming monotypic stands in the irregularly flooded zones of polyhaline to oligohaline marshes (Figure 3.16). It frequently co-occurred with big cordgrass, or as a patchy mix with sawgrass and switchgrass. This species is the dominant plant of tidal marshes in the northern Gulf of Mexico (Tiner, 1993).

Figure 3.16. Black needlerush occupying the irregularly flooded zones of a brackish marsh, Mobile County, AL.

Black needlerush – Big cordgrass (*Juncus roemerianus – Spartina cynosuroides*) occurred as 212 features on approximately 763.1 acres in the irregularly flooded zones of polyhaline to oligohaline marshes.

Black needlerush – Big cordgrass – switchgrass (*Juncus roemerianus – Spartina cynosuroides – Panicum virgatum*) occurred as 106 features on approximately 552.9 acres in the irregularly flooded zones of polyhaline to oligohaline marshes.

Bottomland mix (Maple, Hickory, Ash, Oak, Elm) (*Acer sp. — Carya sp. — Fraxinus sp. — Quercus sp. — Ulmus sp.*) occupied 158 features on approximately 5,500.4 acres adjacent to freshwater streams (Figure 3.17). This community dominates the fronts and natural levees of large creeks and rivers, and the riparian corridors of minor tributaries to Mobile Bay. Dominant species include red maple (*Acer rubrum*), green ash, laurel oak (*Quercus laurifolia*), overcup oak, water oak (*Quercus nigra*) and American elm (*Ulmus americana*). Areas that have experienced timber harvesting within the recent past, or receive periodic natural disturbance from high flow events such as sand bars, typically included black willow, river birch (*Betula nigra*), and cottonwood (*Populus deltoides*) as dominants.

Figure 3.17. Bottomland mix adjacent to the upper Mobile River, Mobile County, AL.

Bulrush (*Schoenoplectus californicus*/*S. tabernaemontani*) occurred as six features occupying approximately 3.6 acres in the regularly flooded zones of brackish and tidally influenced freshwater marshes (Figure 3.18).

Figure 3.18. Bulrush in the regularly flooded zone of a brackish marsh near the Dog River, Mobile County, AL.

Chinese tallow – Black willow – tidal shrub mix (*Triadica sebifera – Salix nigra – Baccharis sp. – Morella cerifera*) occupied 102 features on approximately 971.3 acres, and occurred on both anthropogenic and naturally disturbed areas along channels (Figure 3.19). This community is most abundant along riparian corridors of urban and suburban areas.

Figure 3.19. Chinese tallow – black willow – tidal shrub mix near McDuffie Island, Mobile County, AL.

Disturbed mix occupied two features on approximately 481.8 acres near the Mobile Harbor. These sites appear to have experienced severe disturbances to the original hydrology and natural vegetation. The resultant plant community has no natural analog, and is represented by species from various communities that normally do not co-occur, especially as small disjunct patches, contrasting with the predictable zonation and large monotypic stands found in representative wetland communities.

Giant cutgrass (*Zizaniopsis miliacea*) occurred as 125 features on approximately 263.1 acres often forming near monotypic stands in areas of freshwater and slightly brackish marsh (Figure 3.20). This species frequently lined the margins of stream channels occurring as a narrow band (~3 ft) that could not be mapped at the scale of this effort.

Figure 3.20. Freshwater marsh dominated by giant cutgrass, Baldwin County, AL.

Live oak – Magnolia – Pine (Hammock) (*Quercus virginiana – Magnolia grandiflora – Pinus elliottii/Pinus taeda*) occurred as 21 features on 439.6 acres, embedded within a variety of wetland communities. These features are well-drained and often occur on deep sands (Figure 3.21). Yaupon and wax myrtle dominated the shrub stratum. Dwarf palmetto and saw palmetto (*Serenoa repens*) dominated the herbaceous stratum.

A series of dredge disposal areas located adjacent to a canal connecting the Mobile and Tensaw Rivers are included here. These sites are occupied by mature forest composed of the diagnostic species found on naturally occurring hammocks and appear to function similarly.

Figure 3.21. Live oak – Magnolia – Pine (Hammock) community located on Goat Island, Mobile County, AL.

Mexican water-lily (*Nymphaea mexicana*) occurred at a single location near Dauphin Island Parkway, and occupied 1.3 acres (Figure 3.22). This community is likely underrepresented, and may occur frequently in beaver ponds constructed on small tributaries to Mobile Bay. These open water features are conspicuous on aerial imagery but are inaccessible by boat and predominantly located on private property.

Figure 3.22. Mexican water-lily in the upper reach of Whitehouse Bayou, Mobile County, AL.

Phragmites (*P. karka*; Tropical reed) occupied 500 features on approximately 2,913.0 acres. This species often formed dense stands, frequently occurring on or near areas that appear to have been previously disturbed (Figure 3.23). The taxonomic treatment of *Phragmites* has been convoluted, with Gulf Coast populations considered to be *P. australis* (Common reed), or at the subspecific level as *P. australis ssp. berlandieri* (Subtropical reed). Ward (2010) concluded that Gulf coast populations appeared to be native and shared more morphological similarity with *P. karka* than *P. australis*. Molecular work on *Phragmites* DNA by Lambertini et al. (2012) supported Ward's findings, but suggests that there has been at least some gene flow from outside of North America, leaving its native status up for debate.

Figure 3.23. *Phragmites* along the banks of a brackish channel (left), Baldwin County, AL; *P. karka* is distinguished in part by its open, drooping inflorescence (right).

Pine flatwoods (Slash pine/longleaf pine/loblolly pine [*Pinus elliottii*/*P. palustris*/*P. taeda*]) occurred as 28 features occupying 13,862.3 acres, on level to gently sloping areas (Figure 3.24). These features were situated above high tide. In the absence of fire, most of these stands have developed a dense shrub layer dominated by yaupon, wax-myrtle, buckwheat-tree (*Cliftonia monophylla*), big gallberry, and inkberry (*Ilex glabra*). With frequent prescribed or lightning-ignited fire, the sapling/shrub stratum is reduced or sparse, with a diverse abundance of forbs and grasses. These stands represent one of the most species rich terrestrial communities found in the temperate zone (Noss, 2013).

Figure 3.24. Pine flatwoods community located near Dauphin Island Parkway, Mobile County, AL.

Ruderal/maintained/structural occurred as 160 features occupying approximately 4,715.4 acres, and consists of a variety of wetland and non-wetland features including roads, levees, utility corridors, fill, structures, and highly disturbed/managed vegetation. Utility corridors situated in naturally occurring herbaceous communities were not included here since the vegetation has the potential to develop to its natural condition.

Saltmeadow cordgrass (*Spartina patens*) occurred as five features on approximately 25.5 acres, forming near monotypic stands in the irregularly flooded zones of brackish marshes, typically above black needlerush. This community often has a distinct “cow-licked” appearance (Figure 3.25). This species did not produce a readily detectable pattern, color, or texture in aerial imagery and may occur within features mapped as other herbaceous wetland community types.

Figure 3.25. Saltmeadow cordgrass, with black needlerush in the background, adjacent to Fowl River, Mobile County, AL.

Sawgrass (*Cladium jamaicense*) occurred as 234 features occupying 638.1 acres, in the irregularly flooded zones of brackish and tidally influenced freshwater marshes (Figure 3.26). It routinely occurred immediately above stands of black needlerush, and occasionally as a mix with big cordgrass and/or switchgrass.

Figure 3.26. Monotypic stand of sawgrass in the irregularly flooded zone of a brackish marsh (left), Mobile County, AL; sawgrass inflorescence (left).

Sawgrass – tidal shrub mix (*Cladium jamaicense – Baccharis sp.*, *Ilex sp.*, *Morella cerifera*, *Persesa palustris*, *Sabal minor*) occurred as 29 features on 751.4 acres, as a transitional community typically between monotypic stands of sawgrass and tidal shrub communities.

Shell midden plant communities occurred on shell deposits, often embedded within various other plant communities, and at the margins of shallow bays. These areas are often small (< one hectare) and share some vegetation overlap with other adjacent communities, but are floristically unique with several species that were not recorded elsewhere (e.g., Southern flatsedge [*Cyperus thyrsiflorus*], Small-flowered buckthorn [*Sageretia minutiflora*], and Florida soapberry [*Sapindus marginatus*]). The common cultivated garden fig (*Ficus carica*) occurred on a midden near the northern shore of Grand Bay (Figure 3.27). In the absence of data, this community cannot be delineated based on aerial imagery unless the shell substrate is visible, which applied to only one site in the study area (Grand Bay). Two features totaling 3.23 acres were evaluated during this study.

Figure 3.27. Shell midden located along the northern shore of Grand Bay, Baldwin County, AL.

Slash pine – live oak – tidal shrub mix (*Pinus elliottii* – *Quercus virginiana* – [*Baccharis sp., Ilex sp., Morella cerifera, Persesa palustris, Sabal minor*]) occurred as 86 features on approximately 109.4 acres. This community occurred on margins and higher zones embedded in mesohaline to oligohaline marshes (Figure 3.28). Many of these features appear to be naturally occurring, but some are linear in shape and situated parallel to channels, suggesting they may be a result of minor dredging and channelization activities.

Figure 3.28. Slash pine – live oak – tidal shrub mix embedded within a mesohaline marsh, Mobile County, AL.

Smooth cordgrass (*Spartina alterniflora*) occupied eight features on approximately 3.15 acres. It occurred as monotypic stands in polyhaline marshes and as a narrow band in the regularly flooded zones of mesohaline marshes (Figure 3.29). These narrow bands could not be mapped at the scale of this effort, reducing the reported abundance and distribution of this species within the study area. This community often transitioned to black needle rush in irregularly flooded zones.

Figure 3.29. Smooth cordgrass forming a monotypic stand along the regularly flooded zone of a brackish marsh (left) at the northern shore of Polecat Bay, Mobile County, AL; smooth cordgrass inflorescence (right).

Sweetbay – swampbay – yellow-poplar – netted chainfern (*Magnolia virginiana – Persea palustris – Liriodendron tulipifera – Woodwardia areolata*) occurred as four features on approximately 61.4 acres, situated on slopes or along riparian corridors. This community may be referred to as "bayheads" locally, and likely underrepresented, as some areas encountered in the field were not mapped by USFWS-NWI (2016). Many acres of this community may be embedded in developed areas located on private property that are inaccessible. However, these wetland features are not affected by tidal events and are predominately driven by groundwater discharge to the surface, and sheetflow following rainfall events.

Yellow-poplar is widely considered a tree of mesic upland forests, but occurred frequently as a wetland component in headwater and riparian wetlands within the study area. Most of the individuals encountered in these communities appeared to be a variety that is currently undergoing taxonomic review as "Southern yellow-poplar". This variety is restricted to swamps and headwater wetlands of the outer Gulf and Atlantic coastal plain (Weakley, 2010).

Tidal shrub mix (*Baccharis glomeruliflora, B. halimifolia, Ilex sp., Morella cerifera, Persesa palustris, Sabal minor*) occurred as 266 features on approximately 12,511.8 acres, from polyhaline marshes to oligohaline areas (Figure 3.30). *Baccharis sp.* dominated areas to the near exclusion of other shrubs in areas that were polyhaline. This community was often transitional to

“Baldcypress – Tupelo – Swamp bay – palmetto – shrub mix” and is defined here as having a tree stratum with <30 percent cover. Dwarf palmetto typically dominated the herbaceous stratum but occasionally transitioned to combinations of big cordgrass, sawgrass, and/or switchgrass.

Figure 3.30. Tidal shrub mix, with scattered tree-sized individuals of swamp bay, Mobile County, AL.

Torpedograss (*Panicum repens*) occupied 20 features on approximately 53.6 acres, as near monotypic stands in the irregularly flooded zones of brackish and tidally influenced freshwater marshes (Figure 3.31). Torepdo grass is considered native to Europe but is now widely distributed across the tropics and sub-tropics. It is a pervasive weed forming dense stands and can spread rapidly by rhizomes that fragment and disperse via water (Holm et al., 1977).

Figure 3.31. Torpedograss forming a near monotypic stand in the irregularly flooded zone of a brackish marsh.

Typha (*Typha domingensis*) occurred as 77 features on approximately 163.5 acres, in the regularly flooded zones of mesohaline and oligohaline marshes (Figure 3.32). This species typically occurred as a co-dominant in other wetland communities but occupied some areas in the lower delta and along the west side of Mobile Bay, to the near exclusion of other species.

Figure 3.32. Typha dominating the regularly flooded zone of a brackish marsh, Baldwin County, AL.

Typha – arrowhead – alligatorweed (*Typha domingensis/T. latifolia – Sagittaria latifolia – Alternanthera philoxeroides*) occurred as ten features on approximately 24.2 acres in freshwater marshes near the Tensaw River (Figure 3.33).

Figure 3.33. Typha – arrowhead – alligatorweed (foreground) along the margins of the Tensaw River, Baldwin County, AL.

Typha – bulltongue (*Typha domingensis* – *Sagittaria lancifolia*) occupied 220 features on approximately 321.5 acres, and occurred predominantly in the regularly flooded zones of brackish and tidally influenced freshwater marshes (Figure 3.34). This zone varied considerably in width, and often formed a narrow band (<6 ft) that could not be mapped at the scale of this effort. This community is transitional to the Typha – bulltongue – three-square – alligatorweed community that dominates higher areas that flood irregularly.

Figure 3.34. Typha – bulltongue occupying the regularly flooded zone of a brackish marsh.

Typha – bulltongue – three-square – alligatorweed (*Typha domingensis/T. latifolia – Sagittaria lancifolia – Schoenoplectus americanus – Alternanthera philoxeroides*) occupied 384 features on approximately 2,524.6 acres in the irregularly flooded zones of brackish and tidally influenced freshwater marshes. This community typically has a low statured appearance due to the co-dominance of alligatorweed, and reduced abundance of Typha compared to other characteristic communities to which it has been assigned (Figure 3.35).

Figure 3.35. Typha – bulltongue – three-square – alligatorweed along the northern shore of Chuckfee Bay, Baldwin County, AL.

Typha – bulltongue – wild-rice (*Typha domingensis* – *Sagittaria lancifolia* – *Zizania aquatica*) occurred as 31 features on approximately 108.6 acres in the regularly flooded zones of brackish and tidally influenced freshwater mashes.

Typha – bulrush (*Typha domingensis* – *Schoenoplectus californicus*/*S. tabernaemontani*) occupied three features on approximately 4.6 acres, in the regularly flooded zones of brackish and tidally influenced freshwater marshes.

Water hyacinth – water spangles – Cuban bulrush (*Eichhornia crassipes* **–** *Salvinia minima* **–** *Oxycaryum cubense*) occupied 30 features on approximately 24.3 acres, forming floating rafts in slackwater areas and slow-flowing brackish and freshwater channels. Water hyacinth and water spangles are free-floating aquatics but appeared to be rafted together by the root system of the co-dominant Cuban bulrush (Figure 3.36). The formation of rafts in shallow water areas by these non-native, invasive species negatively effects habitat quantity and quality for many aquatic organisms by reducing dissolved oxygen, and altering macroinvertebrate communities (Shultz and Dibble, 2012).

Figure 3.36. Floating raft (left) composed of Cuban bulrush (right), water hyacinth, and water spangles, located in the bend of a stream channel, Baldwin County, AL.

Water lotus (*Nelumbo lutea*) occurred as 40 features on approximately 77.9 acres as an emergent aquatic in freshwater areas (Figure 3.37). Much of this community was senescent during the time of the survey, but is distinctive on growing-season aerial photography due to its relatively large, round, blue-green foliage.

Figure X-37. Water lotus (foreground) in the margins of a stream channel, Baldwin County, AL.

Wild-rice (*Zizania aquatica*) occurred as 18 features on approximately 153.0 acres in the regularly flooded zones of freshwater and brackish marshes, frequently co-occurring with the "Typha – bulltongue" community. Large stands were present on the eastern side of Mobile Bay, near the Apalachee and Blakely rivers, and D'Olive Bay. This annual species was senescent at the time of the survey, which may lead to low estimates of coverage (Figure 3.38). However, because it is an annual and relies solely on seed dispersal, its presence and abundance at a given location may be variable from year to year based on tidal events and weather-related phenomena.

Figure 3.38. A senescent stand of wild-rice near D'Olive Bay, Baldwin County, AL.

Yellow pond-lily (*Nuphar advena/N. ulvaceae*) occurred as 26 features on approximately 28.0 acres as an emergent aquatic in slackwater areas and along margins of freshwater and slightly brackish stream channels (Figure 3.39). Two distinct taxa belonging to this community are likely present in the study area. Some of the specimens that were encountered appeared to be *Nuphar ulvaceae*, a coastal plain endemic known only from Alabama, Florida, and Mississippi (Weakley, 2015). It is a state listed species in Alabama (Alabama Natural Heritage Program, 2012). Most of the specimens belonging to this community appeared to be *Nuphar advena*. This species is considered common and widely distributed throughout eastern North America (USDA 2000).

Figure 3.39. Yellow pond lily along the margin of Halls Mill Creek, Mobile County, AL.

3.3.2 Post project conditions:

General observations: The selection of appropriate water depths for the evaluation of wetland conditions is important due to season and periodic stratification that results in high salinity values at greater depths within Mobile Bay (O'Neil and Mettee 1982). Several wetland features along the eastern shore of Mobile Bay (and elsewhere) also receive freshwater inputs from seeps, groundwater discharge. And overland flow. However, the majority of wetlands within the study area exhibit surface hydrodynamic connections with adjacent open water features, with tidal fluctuations and riverine inputs driving hydrologic conditions. The water quality models utilized for the wetland assessment assessed riverine and tidal inputs, providing data for each individual cell in 10 equally spaced depth intervals. For example, if the water depth in a given cell is 10 ft, water quality data is generated in 10 – one ft increments. Similarly, if the water depth is one ft, the water quality outputs are generated in 10 – 0.1 ft increments. As a result, an analysis was conducted to evaluate differences between surface water salinities (i.e., upper increment of water quality outputs only) and the integrated upper third of the water column (i.e., top three water quality outputs). That analysis confirmed that water quality cells adjacent to wetland features displayed little or no differences in salinity between the two approaches (Figure 3.40). The close associated of the two depth intervals results from the location of wetland features in predominately shallow shoreline geomorphic positions. Where present, differences between depth intervals were associated with the navigation channel itself and other deep water areas of Mobile Bay that lack wetlands. As a result, surface water salinities were selected for all further analysis.

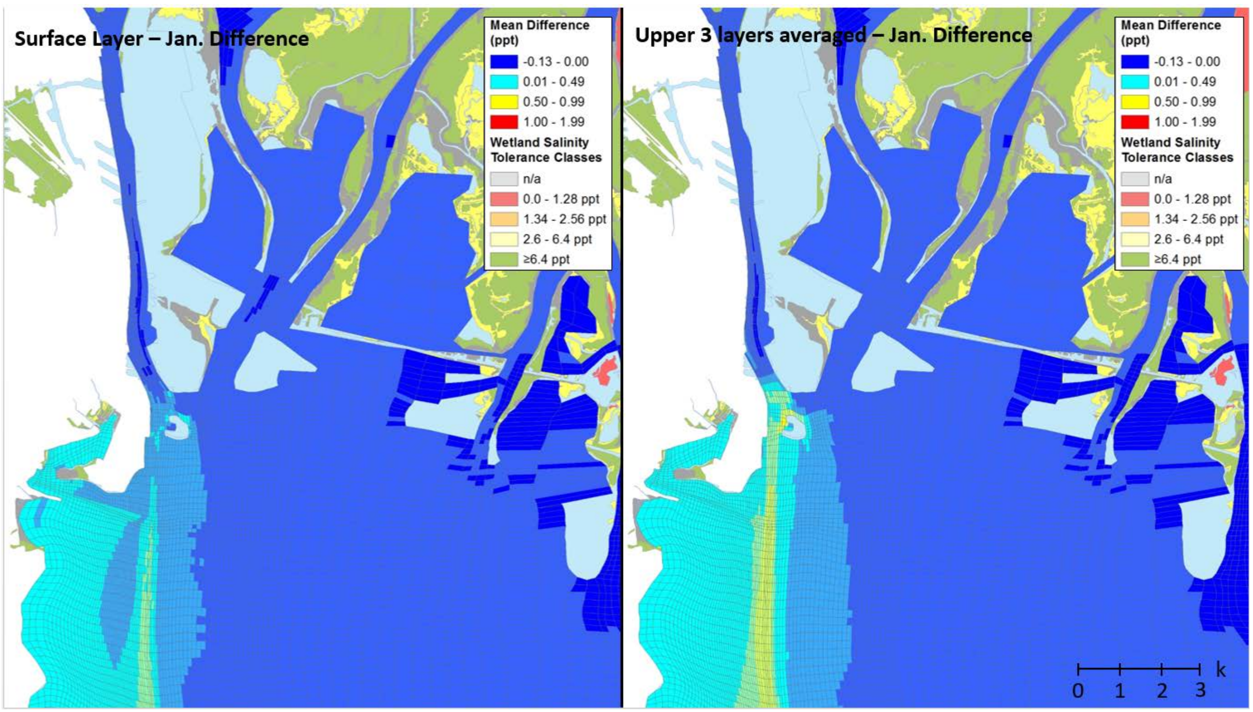


Figure 3.40. Comparison of analysis conducted using surface water salinity (left) and integrated top third of the water column (right) during January. Note that the observed differences between the two approaches is restricted to areas directly adjacent to the navigation channel (bottom left of each figure) and that no differences are observed in areas adjacent to wetland features. January data is presented, similar results occurred throughout the year.

Within the study area, species richness generally increased as salinity decreased (Gough 1994). As a result, tidally influenced freshwater marshes (≤0.5 ppt salt) in the northern portion of the study area exhibit the highest species richness found within tidal continuum. Polyhaline (18-30 ppt salt) and mesohaline (5-18 ppt salt) communities tend to have lower species richness, with several characteristic species (e.g., black needlerush, smooth cordgrass) forming predictable, abruptly zonated, monotypic stands. Oligohaline communities (0.5-5 ppt salt; "brackish") may contain a variety of species that are representative of both saline and freshwater environments (Tiner, 1993; Cowardin et al., 1979). These observations holds true within both baseline and post project conditions, as anticipated shifts in salinity remain limited. For example, within the study area most wetland features are anticipated to experience negligible increases in salinity, with only 636 (17%) of the 3525 wetland features identified displaying potential salinity increases > 0.5 ppt (herein referred to as the "potential impact area"). This represents an area of 7153 acres, or 9.8% of the 72505 acres study area. As a result, the post project conditions are not anticipated to have any potential impacts on the majority (>90 %) of wetland resources within the study area. Examining only the communities with a potential to display salinity changes > 0.5 ppt, the mean monthly surface salinity increase across all months and wetland communities was 0.68±0.38 ppt (mean ±standard deviation) with monthly minimum and maximum values of 0.2 and 1.1 ppt respectively. The text, tables 3.4 – 3.5, and figures 3.41 – 3.52 below provide data on the post project salinity conditions of wetland communities within the potential impact area, evaluating potential exceedance of mortality and productivity thresholds.

Potential mortality analysis: The wetland assessment evaluated wetland features using mortality threshold data available in the published literature (Table 3.3). Note that species specific mortality data was not available for most of the species observed. However, an examination of available mortality thresholds is provided herein for the wetland species and associated community assemblages for which data was available. Because wetlands are adapted to the conditions within the study area, the analysis evaluated potential changes in water quality as opposed to absolute water quality values. This approach accounts for local variation in salinity tolerance ranges which differ regionally and genetically across a given species or vegetation assemblage (Kozlowski 1997; Munns and Tester 2008).

To conduct the analysis, each wetland feature was linked with an adjacent water quality cell as described above to determine if the estimated changes in salinity between baseline and post project conditions would exceed the published mortality thresholds. In order to provide a conservative approach the mortality analysis utilized the maximum estimated increase in salinity for each vegetative community. Results indicate that maximum estimated increases in salinity would not exceed salinity thresholds for the vegetation communities examined (i.e., those with available mortality data; Table 3.3). For example, across all vegetation communities containing baldcypress the maximum estimated salinity increase was 2.0 ppt (average increase of 0.7 ppt). No cases were identified where a 2.0 ppt increase in salinity above baseline conditions would surpass the 10 ppt required to induce mortality (Table 3.4). Similarly, the under story species wax myrtle was associated with Live oak - Magnolia - Pine (Hammock) and Pine flatwoods communities and those communities exhibited a maximum estimated salinity increase was 1.5 ppt (average 0.53 ppt) and 1.3 ppt (average 0.39 ppt) respectively, below the 8.7 ppt increase required to induce mortality. This analysis suggests no wetland feature mortality thresholds would be surpassed based upon post project conditions. While the number of species with specific mortality thresholds is limited, the available species occur in a number of common wetland community types within the study area. As a result the mortality analysis accounts for 3108 acres (43%) of the 7153 acres potential impact area. Therefore the analysis provides supporting evidence that no anticipated mortality is anticipated under the post project scenario across the study area.

Table 3.3. Mortality thresholds for select species. Salinity and exposure (duration) based upon absolute values available in published literature.

Species	Salinity (ppt)	Duration (d)	Citation
Baldcypress	10	14	Conner et al. (1997)
Chinese tallow	10	42	Conner and Askew (1993)
Green ash	10	14	Conner et al. (1997)
Red maple	20-27	<5	Conner and Askew (1993)
Saltmeadow cordgrass	>60	14	Crain et al. (2004)
Smooth cordgrass	>33	Long term	USDA (2000)
Southern cattail	15	68	Glenn et al. (1995)
Water tupelo	10	14	Conner et al. (1997)
Wax myrtle	>8.7	35	Sande and Young (1992)

Table 3.4. Vegetation mortality analysis comparing the maximum estimated salinity increase with published salinity thresholds. Note that the maximum increases remain < 20% of increases required to induce mortality.

Species	Salinity mortality threshold (ppt)	Maximum estimated salinity increase (ppt)
Baldcypress	10	2.0
Chinese tallow	10	1.9
Green ash	10	1.5
Red maple	20-27	1.2
Saltmeadow cordgrass	>60	2.1
Smooth cordgrass	>33	2.1
Southern cattail	15	1.9
Water tupelo	10	2.0
Wax myrtle	>8.7	1.5

Wetland productivity assessment: In addition to the mortality threshold study presented above, an analysis was conducted utilizing the ideal growth tolerances developed by USDA (2000). This approach is initiated because ideal growth tolerances are available for all wetland community types occurring within the potential impact area, while only a subset of wetland plants have mortality thresholds available in published literature. These ideal growth salinity ranges available from USDA (2000) are not associated with mortality, but represent salinity levels required to induce an estimated 10% reduction in plant productivity. As a result, the assessment represents a conservative approach to evaluating potential wetland impacts. Evaluating differences in mean salinity data between baseline and post project conditions, each wetland feature within the potential impact area was assessed to determine of the growth salinity tolerance ranges were exceeded (Table 3.5). This was conducted on a monthly and seasonal basis. For example, the Baldcypress - Black Willow - Chinese Tallow wetland community has an estimated growth salinity tolerance range of 2.6-6.4 ppt. Estimated salinity increases are limited to 0.11, 0, 0.25, and 0.44 during winter, spring, summer and fall respectively. As a result, no negative impacts to wetland productivity are anticipated in that community. Examining the data in Table 3.5, none of the estimated salinity increases within the potential impact area exceed the salinity tolerance threshold ranges, suggesting that no impacts to wetland productivity will result under the post project conditions. To emphasize these findings figures were generated for each season within the upper (Figures 2.41-2.44), central (Figures 2.45-2.48), and southern (Figures 2.49-2.52) portions of the study area. These images provide seasonal visual representations of post project conditions representing predominantly fresh, intermediate, and estuarine wetland plant community assemblages. Note that within each figure, the estimated changes in salinity remain below the salinity tolerance thresholds identified for individual wetland features.

Table 3.5. Mean estimated post-project seasonal change in salinity, standard deviation for each vegetation community (all units are ppt). Salinity tolerances for optimal growth are also provided.

Wetland community	Salinity tolerance	Winter	Spring	Summer	Fall
Baldcypress - Black Willow -	2.6-6.4	0.11, 0.2	0, 0	0.25,	0.44, 0.14
Baldcypress - Tupelo	1.31-2.59	1.09, 0.23	0.78, 0.21	0.98,	1.29, 0.12
Baldcypress - Tupelo - Slash pine	1.31-2.59	0.8, 0.35	0.61, 0.07	0.8, 0.11	1.19, 0.01
Baldcypress - Tupelo - Swamp bay -	2.6-6.4	0.68, 0.42	0.57, 0.01	0.7, 0.05	1.05, 0.06
Big cordgrass	>6.4	0.66, 0.43	0.39, 0.1	0.86,	1.21, 0.1
Big cordgrass - Switchgrass	2.6-6.4	0.17, 0.22	0.04, 0.01	0.32,	0.53, 0.09
Big cordgrass - Switchgrass -	2.6-6.4	0.29, 0.27	0.16, 0.01	0.41,	0.64, 0.02
Black needlerush	>6.4	0.84, 0.26	0.61, 0.16	0.87, 0.2	1.22, 0.05
Black needlerush - Big cordgrass	>6.4	0.94, 0.35	0.65, 0.16	0.97,	1.37, 0.04
Black needlerush - Big cordgrass -	>6.4	0.71, 0.33	0.47, 0.11	0.84,	1.21, 0.07
Bottomland mix	0-1.30	0.63, 0.38	0.53, 0.03	0.65,	0.98, 0.05
Bulrush	1.31-2.59	0.56, 0.36	0.45, 0.01	0.56,	0.88, 0.05
Chinese tallow - Black willow - tidal	2.6-6.4	0.6, 0.35	0.35, 0.1	0.76,	1.01, 0.09
Giant cutgrass	1.31-2.59	0.72, 0.39	0.61, 0.01	0.7, 0.07	1.05, 0.06
Live oak - Magnolia - Pine	0-1.30	1.13, 0.3	0.82, 0.28	1.03,	1.41, 0.13
Mexican water-lily	1.31-2.59	1.14, 0.17	0.82, 0.27	1.02,	1.27, 0.12
Phragmites	>6.4	0.48, 0.3	0.26, 0.08	0.6, 0.23	0.88, 0.06
Pine flatwoods	0-1.30	0.27, 0.09	0.2, 0.04	0.45, 0.2	0.6, 0.12
Sawgrass	2.6-6.4	0.54, 0.27	0.38, 0.04	0.59,	0.88, 0.03
Sawgrass - tidal shrub mix	2.6-6.4	0.41, 0.23	0.27, 0.03	0.49,	0.73, 0.05
Slash pine - Live oak - tidal shrub	1.31-2.59	0.97, 0.3	0.7, 0.18	0.99,	1.36, 0.04
Smooth cordgrass	>6.4	0.53, 0.4	0.27, 0.07	0.66,	0.99, 0.09

Sweetbay - swampbay - yellow-poplar - netted chainfern	0-1.30	0.08, 0.07	0.03, 0.03	0.32, 0.38	0.39, 0.17
Tidal shrub mix	2.6-6.4	0.68, 0.29	0.47, 0.11	0.76, 0.2	1.09, 0.03
Torpedo grass	2.6-6.4	1.14, 0.17	0.82, 0.27	1.02, 0.31	1.27, 0.12
Typha	1.31-2.59	0.53, 0.38	0.37, 0.03	0.6, 0.13	0.91, 0.03
Typha - Bulltongue	1.31-2.59	0.42, 0.32	0.31, 0.01	0.49, 0.1	0.75, 0
Typha - Bulltongue - Three square - Alligator reed	1.31-2.59	0.13, 0.21	0.01, 0.01	0.24, 0.16	0.46, 0.07
Typha – Bulrush	1.31-2.59	0.84, 0.54	0.47, 0.15	1.08, 0.43	1.64, 0.27

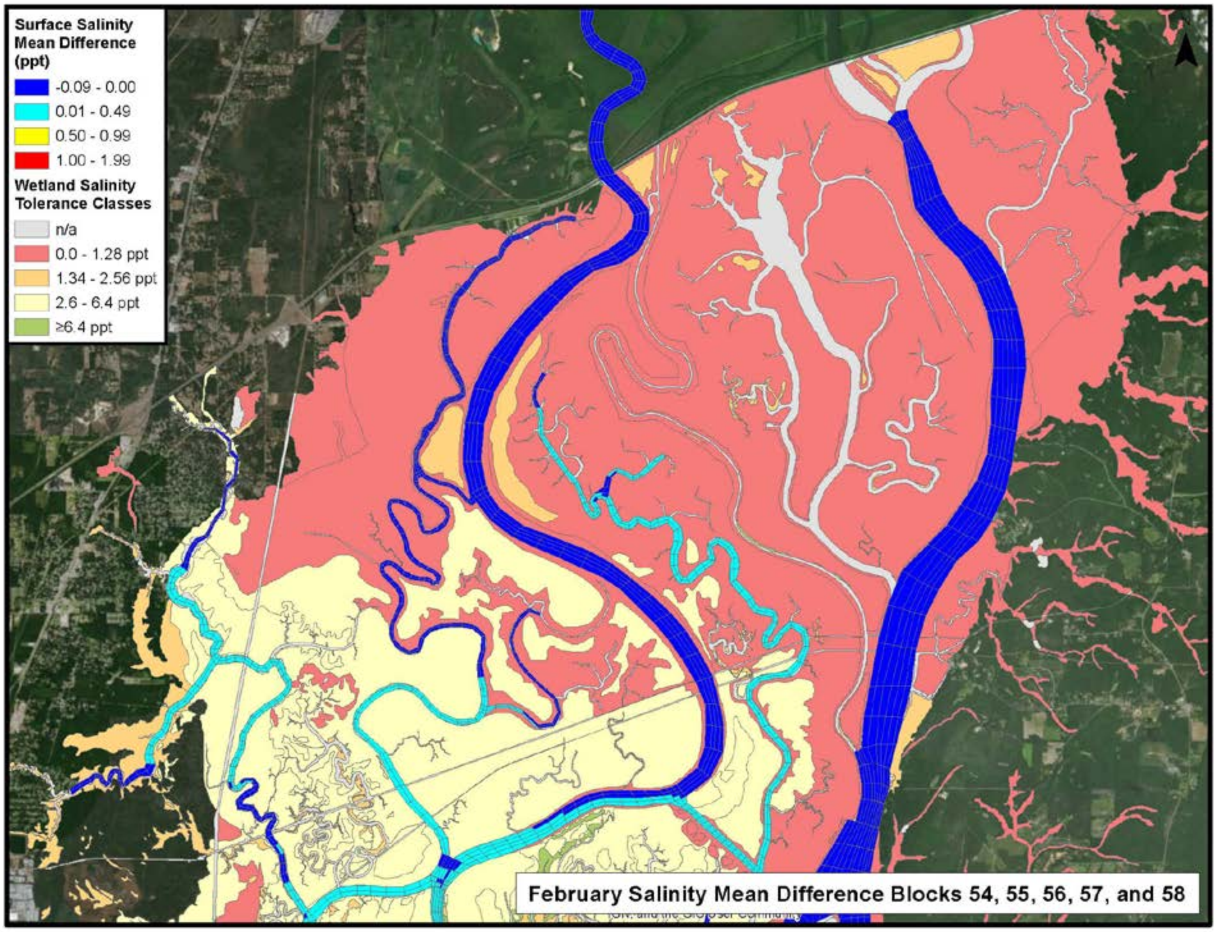


Figure 3.41. Estimated increase in salinity during the winter period (February data shown for example) within the upper (freshwater) portion of the study area. Note that estimated salinity increases are limited to 0.0, or <0.5 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

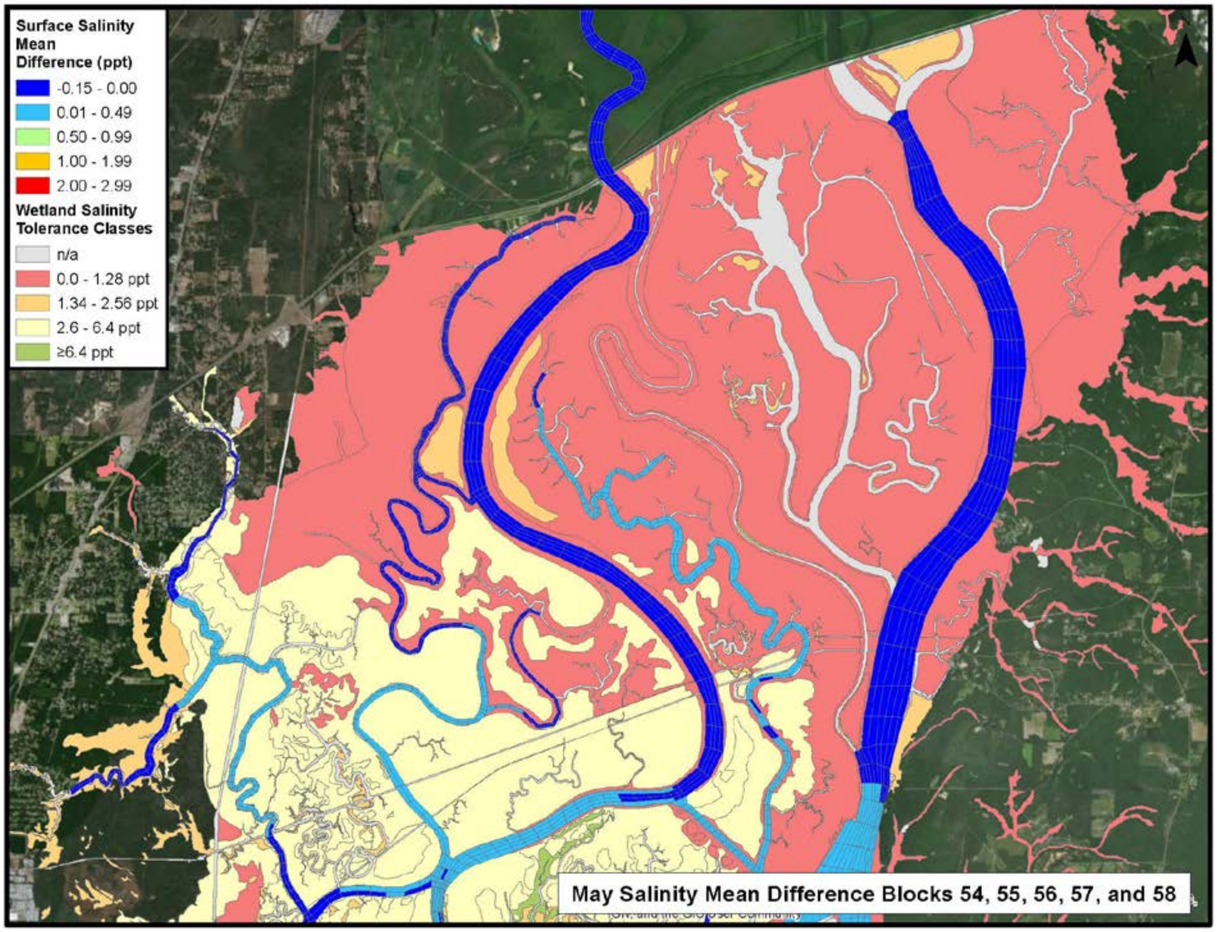


Figure 3.42. Estimated increase in salinity during the spring period (May data shown for example) within the upper (freshwater) portion of the study area. Note that estimated salinity increases are limited to 0.0, or <0.5 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

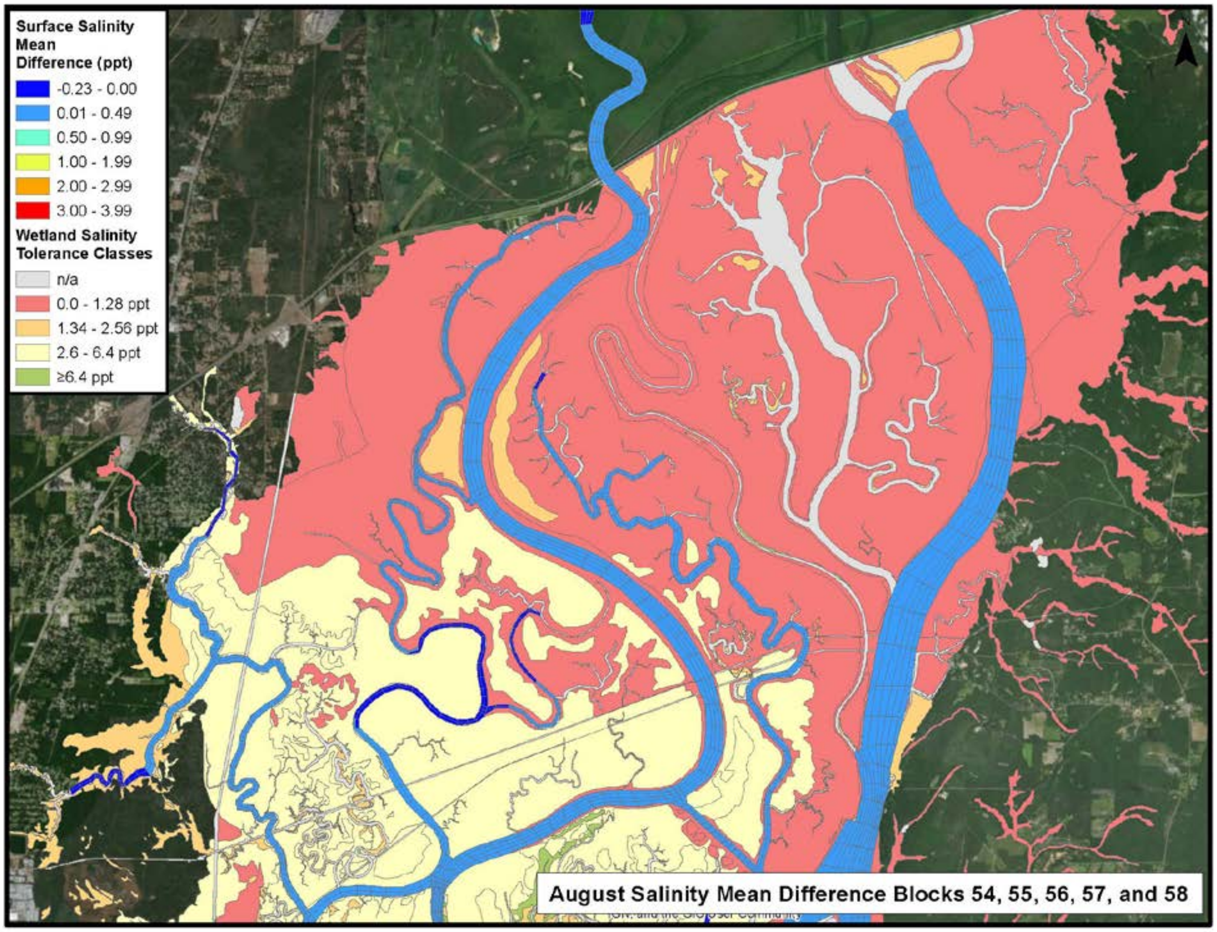


Figure 3.43. Estimated increase in salinity during the summer period (August data shown for example) within the upper (freshwater) portion of the study area. Note that estimated salinity increases are limited to 0.0, or <0.5 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

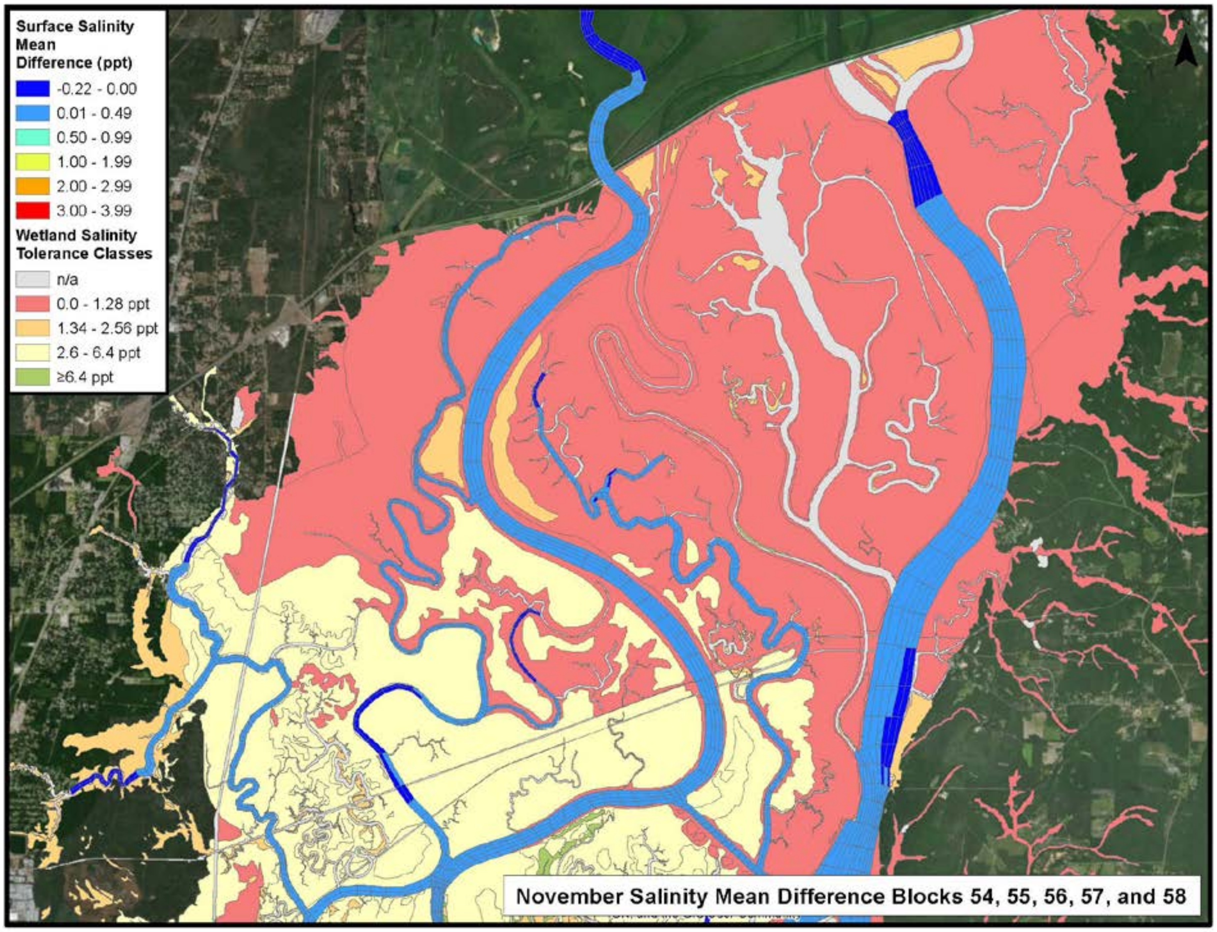


Figure 3.44. Estimated increase in salinity during the fall period (November data shown for example) within the upper (freshwater) portion of the study area. Note that estimated salinity increases are limited to 0.0, or <0.5 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

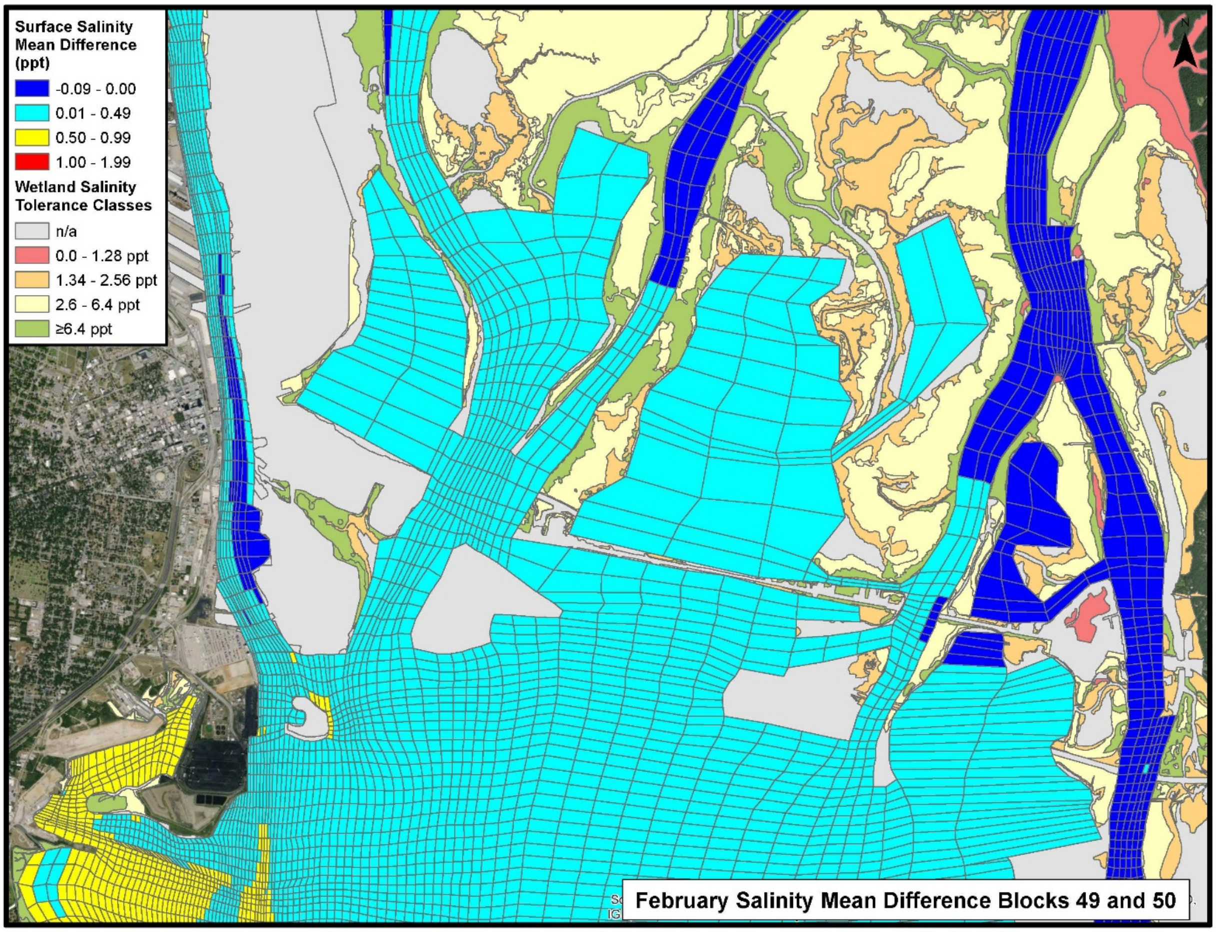


Figure 3.45. Estimated increase in salinity during the winter period (February data shown for example) within the central (transitional) portion of the study area. Note that estimated salinity increases are limited to 0.0, <0.5, or <1.0 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

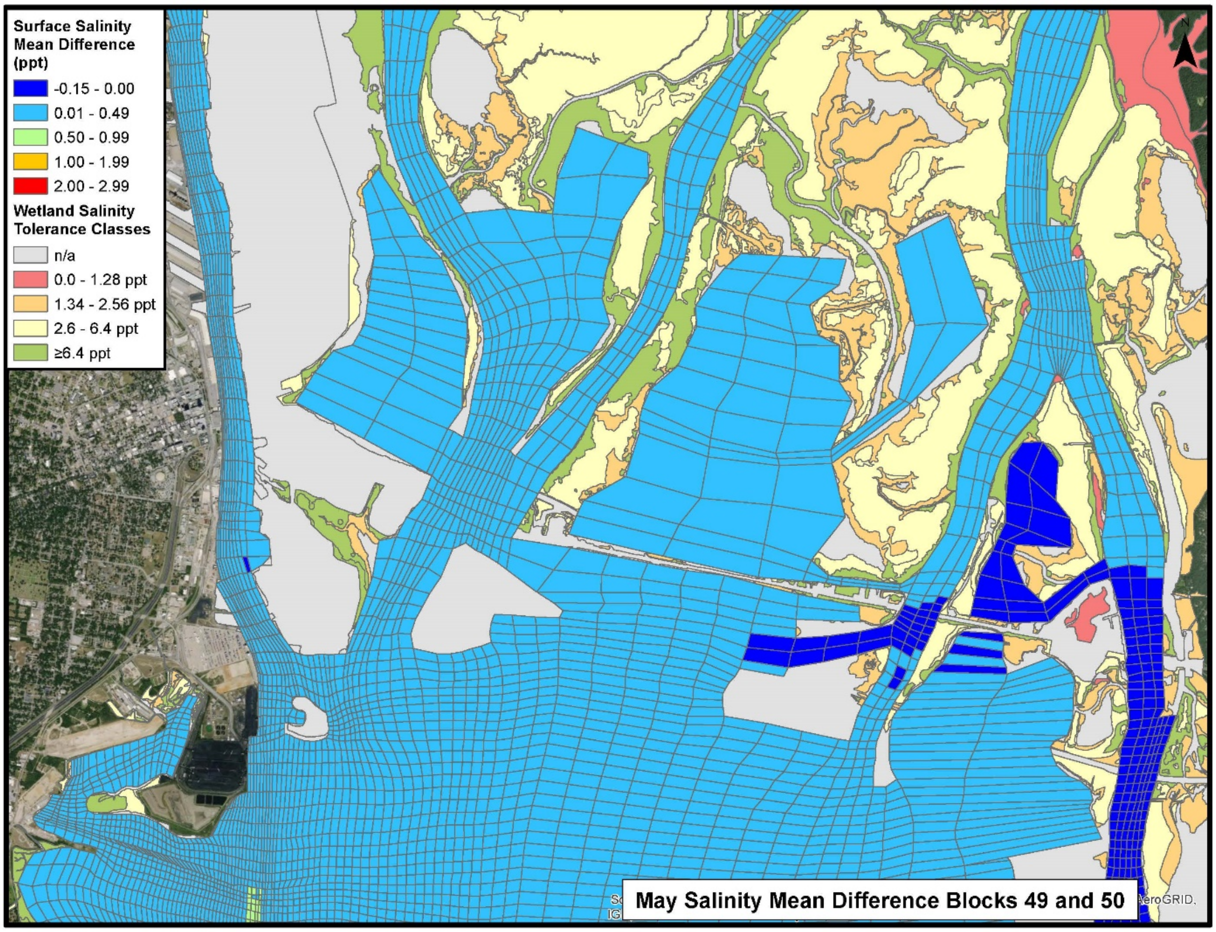


Figure 3.46. Estimated increase in salinity during the spring period (May data shown for example) within the central (transitional) portion of the study area. Note that estimated salinity increases are limited to 0.0, or <0.5 ppt. In areas where salinity increases may occur, wetland communities are adapted to predicted conditions.

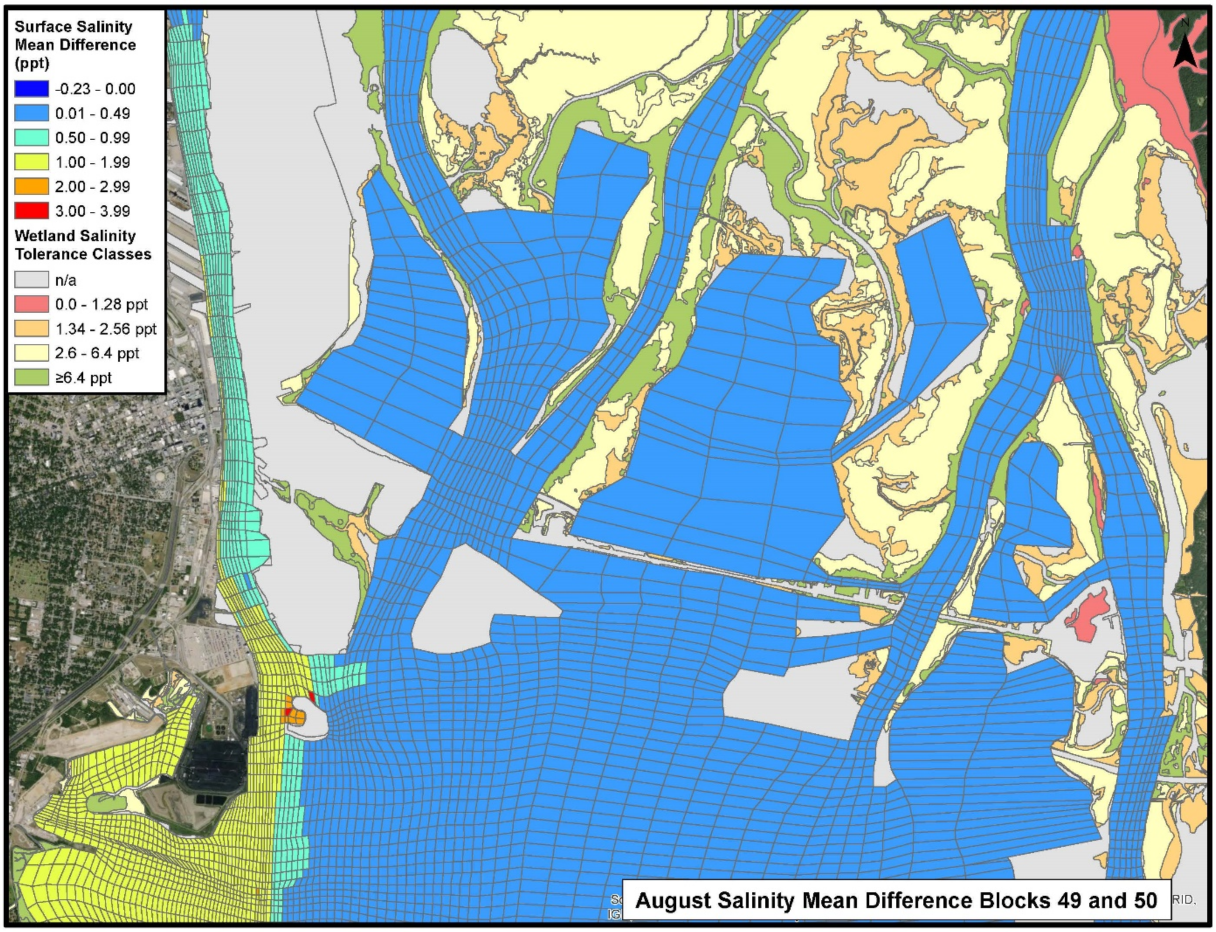


Figure 3.47. Estimated increase in salinity during the summer period (August data shown for example) within the central (transitional) portion of the study area. Note that in areas containing wetlands estimated salinity increases are limited to 0.0, <0.5, or <1.0 ppt. In areas where increases may occur, wetland communities are adapted to predicted conditions.

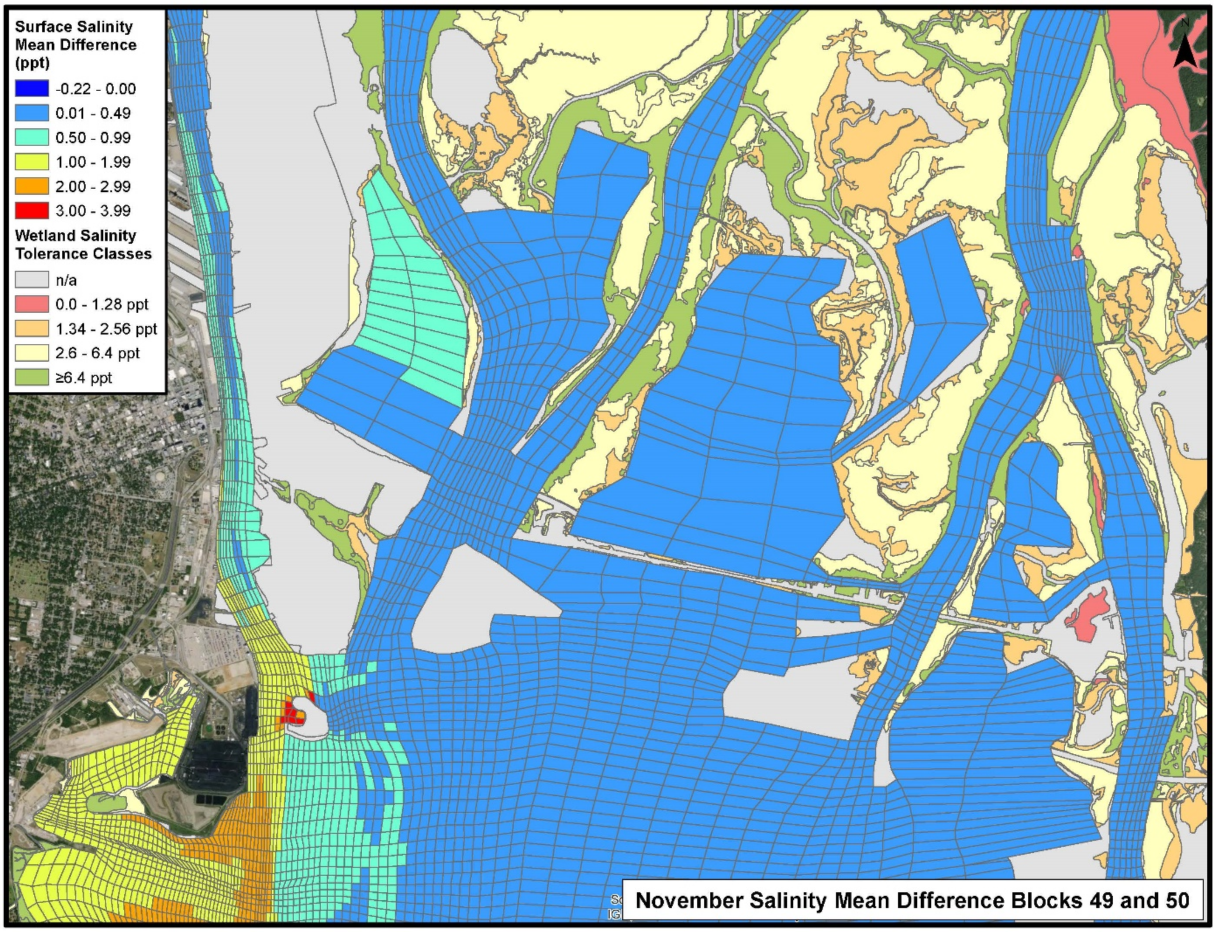


Figure 3.48. Estimated increase in salinity during the fall period (November data shown for example). Note that in areas containing wetlands estimated salinity increases are limited to 0.0, <0.5, or <1.0 ppt. In areas where increases may occur, wetland communities are adapted to predicted conditions. Higher increases in salinity (e.g., >2 ppt) may occur adjacent to the navigation channel, but no wetlands are located in those areas (bottom left).

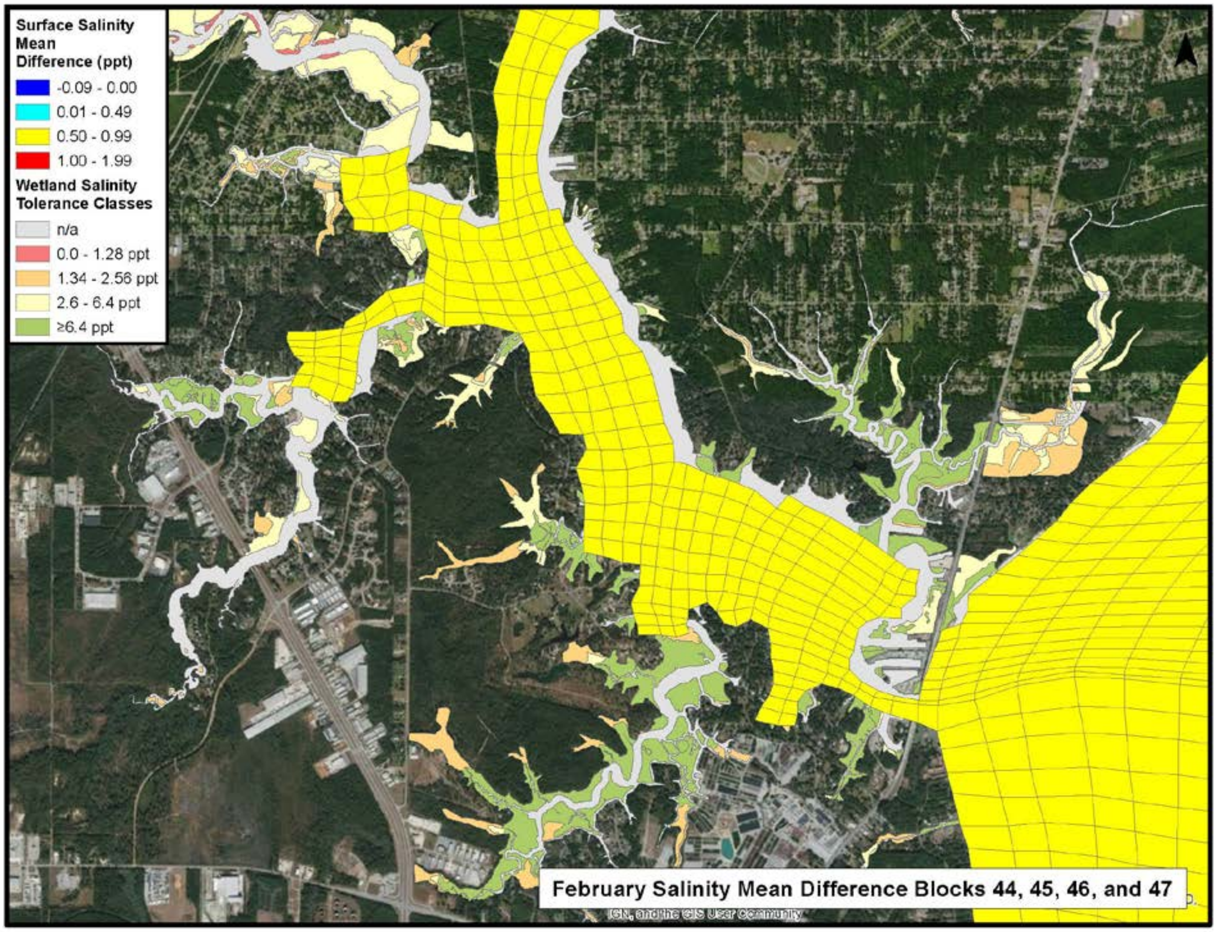


Figure 3.49. Estimated increase in salinity during the winter period (February data shown for example) within the lower (estuarine) portion of the study area. Note that in areas containing wetlands estimated salinity increases are limited to <1.0 ppt. In areas where increases may occur, wetland communities are adapted to predicted conditions.

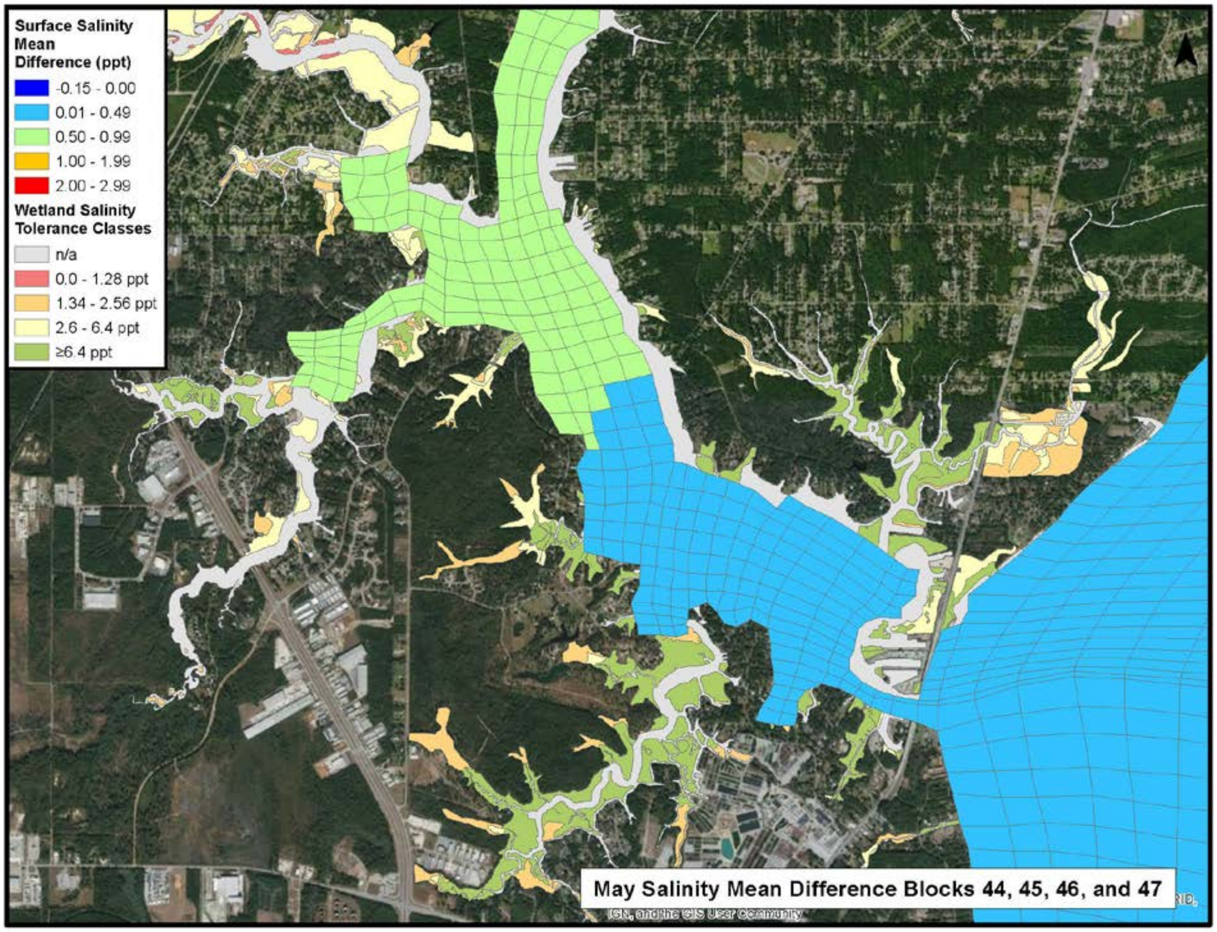


Figure 3.50. Estimated increase in salinity during the spring period (May data shown for example) within the lower (estuarine) portion of the study area. Note that in areas containing wetlands estimated salinity increases are limited to <0.5 or <1.0 ppt. In areas where increases may occur, wetland communities are adapted to predicted conditions.

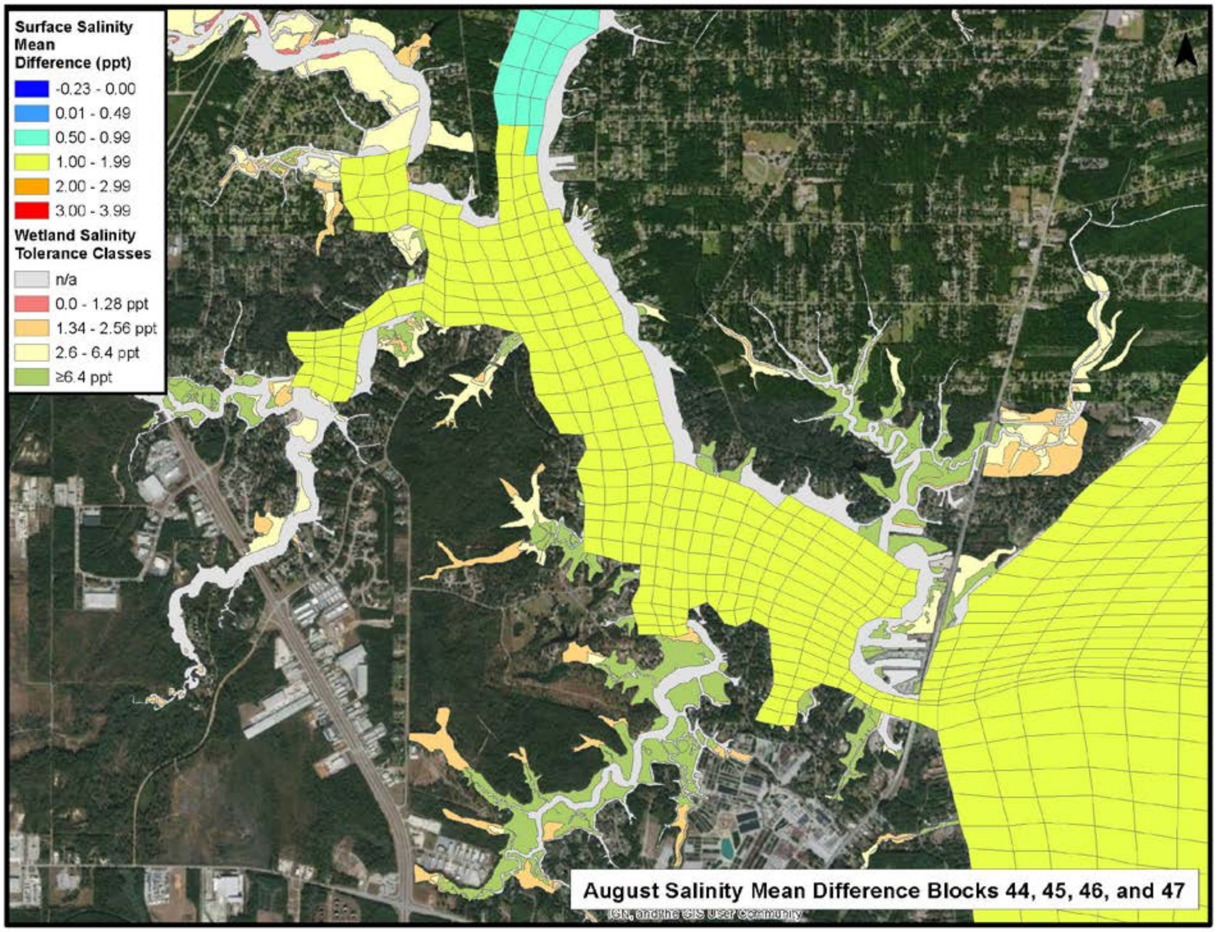


Figure 3.51. Estimated increase in salinity during the summer period (August data shown for example) within the lower (estuarine) portion of the study area. Note that in areas containing wetlands estimated salinity increases are limited to <1.0 or <2.0 ppt. In areas where increase may occur, wetland communities are adapted to predicted conditions.

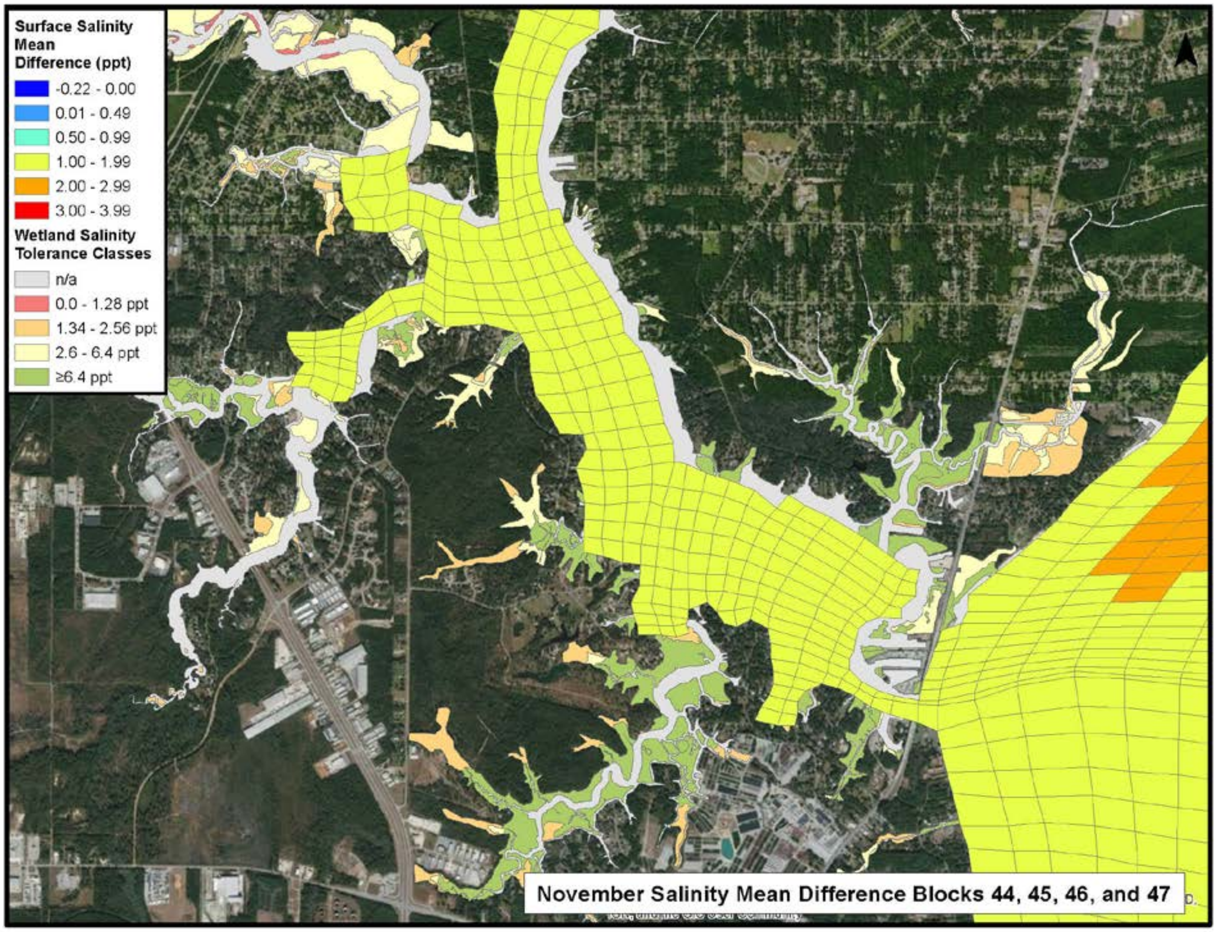


Figure 3.52. Estimated increase in salinity during the fall period (November data shown for example) within the lower (estuarine) portion of the study area. Note that in areas containing wetlands estimated salinity increases are limited to <1.0 ppt. In areas where increase occur, wetland communities are adapted to predicted conditions. Higher increases in salinity (e.g., <3.0 ppt) may occur adjacent to the navigation channel, but no wetlands are located in those areas (center right).

Sea level rise: The selected 0.5 m sea level rise scenario was assessed using a different approach than the one outlined above for wetland community mortality and productivity. Changes in salinity and other water quality parameters are expected to impact wetland assemblages and distributions as sea level rise occurs (Kirwan and Megonigal, 2013). However, in many regions the predominant impact of long term seal level rise will be excessive inundation leading to a conversion of wetland features to open water areas, especially in landscapes where landward retreat is restricted (USGS, others). As a result, the wetland assessment conducted as part of the proposed navigation channel expansion focuses on increased inundation, with an emphasis on determining wetland features that would become submerged following the 0.5 meter sea level rise scenario. To conduct the analysis, the water elevation provided in hydrodynamic models was appended to the wetland mapping and classification attribute table for each wetland feature. The projected elevation change in the nearest model cell was compared with the current elevation of each wetland feature. Features were considered impacted (i.e., inundated) when the projected elevation differences exceeded the current wetland feature elevation.

Results suggest that as many as 930 wetland features may be inundated as a result of the 0.5 m sea level rise projection, representing an area of 8440 acres. This includes forested areas predominantly dominated by freshwater communities (e.g., bottomland hardwoods), salt-tolerant halophytic communities (e.g., black needle rush, big cordgrass), and transitional communities (e.g., tidal shrub mix, Typha). Incorporating post project conditions into the assessment, a potential exists for inundation of four additional wetland features occupying an area of 10 acres. Notably, the inundation assessment does not account for the potential landward migration of wetlands into adjacent areas which may offset sea level rise impacts. Additionally, increased inundation may not result in the loss of wetlands but may lead to a shift of wetland types. For example, seasonally inundated wetlands may convert to more permanently saturated conditions. These changes have the potential to alter both species composition and structure, occurring over multi-years to multi-decadal timescales. As a result, predicting the end-state conditions and isolating impacts resulting from the proposed navigation project remains challenging. Given the limited estimated extent of potential project-induced impacts (10 acres) in the context of much larger potential sea level rise implications (>8000 acres) occurring over a 50 year interval suggests that any wetland impacts related to implementation of the project remain negligible within the larger sea level rise context. Additional research into sea level rise implications for wetlands in the region are needed to further account for future conditions, but remains beyond the scope of the current assessment which focuses on the proposed navigation channel expansion only.

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Chapter 4: Submerged Aquatic Vegetation

Summary

This Chapter describes the potential impacts of the proposed channel deepening and widening of the Mobile Bay Federal Navigation Channel on the Submerged Aquatic Vegetation (SAV) within the Mobile Bay system as a consequence of project related salinity changes. We used field verified SAV distribution maps to determine seasonal species distribution and determined species specific salinity thresholds through literature reviews. Using hydrodynamic model predictions of salinity change due to project implementation, we were able to assess increases in salinity above relative SAV salinity threshold ranges. We focused our analysis on the estuarine transition zone, and determined that the largest increase in salinity was 1.5 ppt above species-specific salinity threshold values. Four species of SAV, Eurasian Watermilfoil, Wild Celery, Southern Naiad, and Widgeon Grass, were predicted to experience an increase in salinity up to 1.5ppt above threshold values due to proposed project implementation. None of these increases are expected to significantly impact SAV habitat. No impact due to dissolved oxygen changes resulting from the project are expected. Predicted salinity impacts of sea level rise (SLR) are greater than those predicted under project implementation.

4.1 Introduction

General context: Submerged Aquatic Vegetation (SAV) refers to a subset of vascular plants that have adapted to live underwater, in marine, estuarine and freshwater conditions. Healthy SAV beds are important habitats that are beneficial in many ways. By buffering wave energy, modifying wave currents, preventing erosion, consolidating sediment and influencing deposition, SAV can help to maintain and shape coastal landscapes (Biber and Cho 2017). In addition, coastal seagrass beds represent one of the most productive ecosystems on the planet and provide food, shelter and nesting grounds to many commercially and ecologically important invertebrate and vertebrate communities.

SAV diversity and distribution are limited by a number of water quality parameters. Light attenuation and water clarity, as measured through Photosynthetically Active Radiation (PAR) and Turbidity, are critical as these are vascular plants that require light. In addition to light, predominant limiting factors to SAV distribution and diversity are salinity and temperature. For this impact assessment, the parameters that were available for evaluation of impacts from the accompanying hydrodynamic and water quality models (described in detail in supplemental report and in sections below addressing assessment of model results) were salinity and dissolved oxygen.

Problem statement: The proposed channel deepening and widening of the Mobile Bay Federal Navigation Channel may cause changes in the salinity regime within the Mobile Bay system. If there is an influx in saltwater into upstream habitats, increased salinities may have impacts on SAV communities, depending on where the salinity changes occur (geographic location), how long they last (duration) and how these changes align spatially with existing SAV habitat.

Model Purpose: The current chapter focuses on groundtruthing and utilizing baseline maps of SAV habitat within the system, identifying variation in SAV distribution across several years and seasons, and assessing potential species specific impacts of increased salinity resulting from hydrodynamic and water quality models of the proposed widening and deepening of the Mobile Bay Federal Navigation Channel.

Model summary: Baseline data, leveraged from existing maps of SAV distribution initially developed in conjunction with the Mobile Bay National Estuary Program (MBNEP) and Alabama Department of Conservation and Natural Resources State Lands Division (SLD), were field verified to check accuracy and temporal variation in order to establish baseline distribution, within Mobile Bay. Salinity tolerance thresholds were identified for local SAV species through a review of published literature to use to determine impacts of potential salinity change due to project implementation. Following establishment of salinity thresholds and ranges, we used the output of the hydrodynamic and water quality model results to 1) estimate salinity values for SAV polygons within the estuarine transition zone but outside of model domain, 2) assess change in depth averaged mean and 75th percentile salinity monthly during 2015 due to project implementation (with/without project salinity), and 3) identify SAV patches that would be impacted with above threshold salinity values due to project implementation. The impact of salinity changes with and without project under a sea level rise scenario were also assessed. Finally we looked at predicted changes in dissolved oxygen (DO) as a result of the project and assessed the potential impacts due to DO.

4.2 Methods - Model Development Process

Study Area

To assess potential impacts of the Mobile Harbor Channel Deepening on SAV coverage and distribution, we used SAV survey maps developed by the environmental and research consulting group Barry A. Vittor and Associates, Inc (Vittor). These surveys were supported by the MBNEP and Alabama Department of Conservation and Natural Resources SLD. The surveys focused on near-shore estuarine and marine aquatic ecosystems in coastal Alabama including the entire coastline (Vittor, 2004, Figure 4.1). The northern boundary of these surveys was the Louisville and Nashville (L & N) Railroad north of Mobile Bay, with the exception of the streams and bays of the waterway north of the L&N Railroad (i.e., McReynolds Lake/The Basin).

Existing SAV surveys

SAV surveys of Mobile Bay have been completed by the environmental and research consulting group Barry A. Vittor and Associates Inc. for several years to support the Mobile Bay National Estuary Program and the Alabama Department of Conservation and Natural Resources. These SAV surveys used a combination of aerial imagery mapping and field verification. As described in their reports, Vittor used the following methodology:

> “ Ortho imagery was created from true color aerial photography acquired with a digital mapping camera. The orthorectification process relied on the aerial imagery, camera calibration data, aerotriangulation data, and a digital elevation model. The procedure was performed in a fully digital workflow environment, using measurements obtained from airborne global positioning system and an inertial measurement unit to provide accurate exterior orientation of the imagery. Outlines of SAV signatures in the ortho imagery were digitized in a GIS environment, using the seasonal mosaics as base maps. Digitized areas were field verified to document habitat characteristics at the surface level.” (Vittor et al. 2004)

Through the on the ground field surveys, Vittor identified species composition of the SAV beds. Surveys were conducted in 2002, 2009, and the summer (July/August) and fall (October) of 2015 (Vittor and Associates, Inc. 2004, 2010, 2016). To our knowledge, the Vittor surveys provide the best available SAV mapping data for the Mobile Bay region and we focused on their mapping efforts from the fall of 2015 to address potential impacts to SAV species as a result of the proposed channel deepening (Figures 4.2 [entire study area], 4.3 [estuarine transition zone], and 4.4). We used maps developed in other seasons and years to assess natural variation in species distribution (aerial coverage and composition).

Field verification and assessment of variation

For additional QA/QC of the baseline maps developed by Vittor, ERDC ran a hydroacoustic survey in October of 2016 to groundtruth and compare to the 2015 Vittor et al survey. ERDC’s SAV hydroacoustic survey utilized the Submersed Aquatic Vegetation Early Warning System (SAVEWS Jr.) which incorporated a boat mounted Humminbird high-frequency sonar that can detect SAV in high turbidity water and is integrated with a GPS system (Sabol et al. 2014). The transducer is synced with a GPS enabling estimation of the edges of SAV beds within 1 m resolution. Variation in SAV coverage by year was examined by comparing mapped SAV polygon size using ArcGIS 10.3.1.

Salinitiy tolerance estimates

Salinity tolerances of SAV were estimated using a literature review of published salinity thresholds for local SAV species. In cases in which salinity threshold data were not available, reports of species distribution coupled with known salinity conditions were used to estimate the salinity range. Salinity range refers to the expected salinity conditions a species is exposed to within a given location, whereas salinity threshold tolerance refers to the lowest and highest salinity values a species can withstand. For most species, even when a salinity threshold has been identified, the impact of duration or length of time of exposure to that threshold value is not known. Where more than one tolerance threshold was published, we used both the report with the closest geographic proximity (i.e., nearest study sites to Mobile Bay) and the lowest reported maximum threshold value in an effort to provide conservative estimates of tolerance.

When we intersected the Vittor fall 2015 SAV coverage map with the modeled baseline salinity data, we found that a number of species were persistent in areas with modelled salinity above reported threshold values. To adjust to modeled salinity output, we estimated relative tolerance thresholds for Mobile Bay SAV. To do so, we intersected SAV survey maps from the fall 2015 Vittor aerial survey with seasonal (Fall: October, Winter: February, Spring: May, Summer: August) baseline model mean, depth averaged salinity data using ArcGIS 10.3.1. Although we present results from all seasons, we focused on the Fall (October data) because it has the highest salinity values, and represents the month in which plants are exposed to the most saline conditions in the year. Salinity values predicted from the hydrodynamic model that were higher than published maximum threshold values were assigned as relative maximum threshold values. Any predicted increase in salinity above this relative maximum threshold as a result of project implementation was considered a salinity value above the species specific relative maximum. SAV salinity tolerance estimates were only taken where the water quality model overlapped the SAV beds, not where we estimated salinity values for SAV beds (i.e., not in unmodeled beds). Relative maximum salinity threshold values are species specific and were applied to the entire survey area (beds that were within and outside of the model domain).

Assessing impact of hydrodynamic and water quality modelling results

Hydrodynamic and water quality data were modelled for Mobile Bay, estimating baseline (i.e., existing, without project) conditions as well as conditions post-project implementation using the Geophysical Scale Multi-Block (GSMB) system, the Curvilinear Hydrodynamic in three-dimension Waterways Experiment Station (CH3D-WES) approach, and the CE-QUAL-ICM water quality component developed and maintained by the US Army Corps of Engineers Engineer Research and Development Center (Cerco and Cole 1995), as described in chapters that supplement the current one. The hydrodynamic and water quality models were used to predict baseline conditions, conditions following project implementation, and baseline and project conditions under a 0.5m sea level rise projection scenario. The 0.5m sea level rise projection is considered the intermediate projection for the Mobile Bay area. Specifically, the monthly depth averaged mean salinity value was calculated for each individual model cell, under baseline and post project conditions and with and without sea level rise. Because the depth in which SAV occur is so shallow, we used the depth averaged model outputs for parameters of interest as it was most relevant to what the entire plant (roots to shoots) would experience (as opposed to the top or bottom three depth layers). To estimate the changes due to project implementation, baseline salinity values were subtracted from post-project salinity values. This process was completed on a cell by cell basis, so that salinity change could be determined for the entire model domain. Once predicted salinity change was estimated for the whole model domain, we intersected the mapped SAV beds within the domain using ArcGIS software to isolate salinity output to regions where SAV were present. We then compared the change in mean, depth averaged salinity from baseline to project as predicted by the hydrodynamic model to the relative salinity threshold values established for local SAV species an reported any predicted increases. In cases in which an SAV bed contained multiply species, we used the salinity tolerance of the species most intolerant of increased salinity (i.e., the species with the lowest salinity tolerance values) to evaluate impacts. In addition to the mean monthly salinity values, we also investigated the 7^{5th} percentile hydrodynamic model outputs for salinity, following the same methodology.We included an analysis of the 75^{th} percentile to provide an indication and assessment of the variation in modelled salinity that were similar, but slightly more conservative than a standard deviation approach (i.e. reporting 1 standard deviation from mean measurements). The 75^{th} percentile results provide an indication of the variation around mean values, and highlight that in this case, variation from mean estimates are small. Note that higher salinity values predicted using the 75th percentile have very short durations and small geospatial footprints. We used the same approach in determining the potential impacts of salinity change due to project implementation in combination with 0.5m modelled Sea Level Rise scenario. In addition to salinity, we also assessed DO outputs from the Water Quality model to determine whether we could predict any impact of decreased DO on submerged plants from baseline to post project conditions.

Assigning water quality to SAV beds outside of model domain

SAV beds in the Mobile Bay delta tend to be in relatively shallow water (<1m). In some cases, the hydrodynamic and water quality model domains did not overlap with shallow regions that contained SAV. Of the 6300 acres of SAV beds in the 2015 fall surveys, 2376 acres did not have overlapping water quality data from either model (Figure 4.5). In order to assign estimated water quality parameters values to the 2376 “unmodeled” acres of SAV, the mean water quality value of interest of all adjacent model polygons touching the unmodeled SAV bed was assigned to that unmodeled bed (Figure 4.6). In cases in which there were no adjacent model water quality polygons (e.g. SAV beds were far up a creek), we 1) measured the distance from the mouth of the creek to the SAV beds, 2) applied that distance in an upstream direction in the nearest adjacent polygons that were within the model domains, and 3) assigned the value obtained at the distance and location identified in step 2 to the unmodeled SAV beds in question. This approach likely overestimates some salinity values that will reach distant SAV beds. This, in effect, makes our interpretation of project impacts more conservative.

4.3 Results – Application

Field verification and assessment of variation

The SAVEWs survey covered a distance of 64 km throughout the Mobile Bay, with the goal of mapping the edges of various SAV beds to compare to beds recently mapped by Vittor (Figure 4.7, 4.4). A total of 31,684 points were mapped and 1788 of these points (~0.06%) detected the presence of SAV. Because of variance in SAV coverage seasonally and annually, we compared our October 2016 hydroacoustic survey against the fall 2015 shapefile data supplied by Vittor. Of the 1788 points, the hydroacoustic survey detected SAV about 85% overlapped with the SAV polygons mapped by Vittor (Figure 4.8). The remaining 15% of hydroacoustic SAV detections were within 10 meters of the Vittor SAV polygons. The 15% difference can likely be attributed to annual variation. The hydroacoustic survey could only determine absence or presence of SAV and not species composition. During the hydroacoustic survey, a rake was used to collect SAV for species identification and the GPS position was recorded for every rake sample. The species identification for each rake sample location had 100% agreement with the Vittor fall 2015 survey. The agreement of the two techniques shows the SAV coverage of Mobile Bay is accurately portrayed in the Vittor fall 2015 survey and is suitable for the use of potential impacts that the Mobile Bay deepening project may have on SAV. Another benefit to using the fall 2015 SAV aerial survey is that the salinity results from the hydrodynamic and water quality models (See chapters X and XX) estimate the greatest salinity differences between the no project and project salinity values in Mobile Bay to occur in October. The model also estimates that salinities are naturally highest during October so this is when plants will be most susceptible to salinity stress.

Year to year and seasonal variation in SAV coverage by year is both common and extensive (Table 4.1). The species with both the most coverage and the most temporal variation in coverage were Eurasian Watermilfoil *(Myriophyllum spicatum*), Water Celery (*Vallisneria neotropicalis*), Southern Naiad *(Najas guadalupensis*), Water stargrass (*Heteranthera dubia*), and Coons Tail (*Ceratophyllum demersum*). These species ranged in mean acreages of ~1600 to 4000 with high variance (standard deviation ranged from ~1300-2000 acres). In comparison, on average, the rest of the common species covered less than 1000 acres each and all but Widgeon Grass (*Ruppia maritima*) covered less than 400 acres each.

Salinitiy tolerance estimates

Species specific salinity tolerance thresholds and range estimates, as compiled from published reports and peer reviewed literature is presented in Table 4.2. As is expected in a geographic region that encompasses fresh water, brackish, and estuarine conditions, the SAV species found in the region have tolerance ranges that vary considerable depending on whether the plant is adapted to variable salinity exposure or not. For example, Water Stargrass, *Heteranthera dubia*, is a predominantly freshwater species with a limited salinity tolerance of 0-3.5 ppt. In contrast, Widgeon grass, *Halodule wrightii*, has a very broad salinity tolerance of 0-60+ ppt. These species specific differences provide critical information for evaluating potential impacts of increased salinity due to projects implementation. Spatial alignment of project related salinity increases with SAV species occurrence makes it possible to evaluate impacts. For example, an increase in salinity from 2ppt to 10ppt would not indicate potential impacts if this increase occurred in an SAV bed made up of Widgeon grass. If the bed were composed of Water Stargrass, this same increase in salinity would likely have negative effects on the species.

Assessing impact of hydrodynamic and water quality modelling results

Salinity

Results of the hydrodynamic model indicate that predicted depth averaged salinity changes due to project implementation are less than 2 parts per thousand (ppt) during the months of January-June (Figure 4.9). There is an increased range in predicted depth averaged mean salinity starting in July, and peaking in October, with a range above 5 ppt (Figure 4.9). Summaries of the 75th percentile results show similar trends, with a larger range of increased predicted salinity in October and November (Figure 4.10). These results indicate the October is the most critical month to examine in terms of potential impact of salinity increases on SAV distribution and coverage. In fact, our analysis indicated that there are no increases in salinity above relative threshold values due to the proposed project in the Spring, Summer or Winter months (Figures 4.11, 4.12 and 4.13).Therefore, we focused our impact analysis on the month of October. In addition, we found that there were minimal changes that impacted salinitity threshold values for SAV in the lower bay, and focused our results on the estuarine transition zone, where larger changes in salinity are expected (see mapped domain extent in figures).

When predicted increases in salinity above the species-specific SAV threshold values were evaluated, we found that the majority of SAV habitat was not predicted to experience an increased salinity regime or be impacted by salinity changes due to the channel deepening project (Figure 4.14). 83% of the mapped fall 2015 SAV habitat is predicted to experience a negligible (≤0.5ppt) monthly mean change in salinity (Table 4.3). The range in mean salinity threshold increases were from 0-1.5ppt. Similar patterns were seen when evaluating the monthly 75th percentile hydrodynamic model output. In this case, post-project impacts were predicted to be ≤0.5ppt for 80.7% of all mapped SAV and increases in salinity thresholds were from 0-1.5ppt (Table 4.3). There was a total of 52 (mean) and 58 (75th percentile) acres of SAV habitat that showed predicted increases above 1 ppt in October salinity threshold values following project implementation (Table 4.3).

In order to get a better understanding and evaluate these potential impacts further, we ran a species specific analysis for potentially impacted species with low salinity thresholds. These species include Water Star Grass, Eurasian Watermilfoil, Southern Naiad, Widgeon Grass, Wild Celery, Carolina Fanwort and Coon's Tail. Of these, only four species, Eurasian Watermilfoil, Wild Celery, Southern Naiad, and Widgeon Grass were predicted to experience an increase in salinity up to 1.5ppt above threshold values (Tables 4.4 & 4.5).

The majority of the potentially impacted SAV habitat is made up of Widgeon Grass, followed by Southern Naiad. Widgeon Grass can tolerate hypersaline conditions up to 100ppt, so an increase in salinity of 1.5ppt of up to 22 acres of Widgeon Grass does not a represent an impact to this species (Table 4.2 and references therein, Table 4.4). Southern Naiad has a salinity range up to 10ppt, with best growth occurring in a salinity range of 0-5 ppt and decreasing growth up to salinities of 10ppt (Moore 2012). However, mortality does not occur until plants experience an exposure duration of 10 ppt for a month or more (Moore 2012). Therefore, the duration of high salinities is critical. An increase of 1.5ppt above relative threshold values is unlikely to impact the 21 acres of Southern Naiad in question, unless these increased salinities have extended (i.e. multiple weeks) duration.

Two to twenty-six acres of Wild Celery were also predicted to experience elevated salinities 1-1.5ppt above threshold values (mean, 75th percentile, respectively) due to project implementation (Tables 4.4 & 4.5). At a maximum reported salinity threshold of 18 ppt (Table 4.2), post-project estimates suggest salinity exposure to increase to 20.5ppt. These results do not contain duration information, despite the importance of exposure time to elevated salinity. A short exposure (<

4hrs) to elevated salinity will likely have a smaller impact than a long (>24 or 48 hrs) exposure time. The extent of the impact is due to both magnitude of salinity increase, duration of exposure, and the specific species of interest. For many SAV species, duration data are not reported. Fortunately, studies have been conducted using Wild Celery, showing that this species can survive salinity up to 25ppt in pulses of less than 7 days (Frazer et al. 2006). As the predicted salinity impact due to project implementation are lower than this, we expect that the predicted salinity increases should have a minimal impact Wild Celery, if any.

Eurasian Watermilfoil, an aquatic invasive species native to Europe, Asia and North Africa. This species was introduced to the U.S. and first sighted in the early 1940s. It is now introduced nationwide. Eurasian Watermilfoil reproduces through fragmentation, grows quickly and outcompetes native species. Due to its invasive status, impacts to this species are unlikely to require mitigation or have a negative impact on local SAV species.

Sea Level Rise and Salinity

Results from the hydrodynamic model indicate that a 0.5m sea level rise projection will contribute to salinity changes in the Mobile Bay region. Changes from existing baseline condition to baseline conditions (i.e., no project) with sea level rise show an increase in relative salinity tolerance thresholds for mapped SAV species ranging from -1 to 3 ppt (Figure 4.15). This is a greater range of change seen post-project without sea lever rise conditions, and the distribution of change is different (Figures 4.15 & 4.16). A larger proportion of SAV habitat will be exposed to higher salinities due to sea lever rise impacts than project implementation impacts. To illustrate this point further, the increase in salinity above relative SAV salinity thresholds due to project implementation under a 0.5 sea level rise scenario shows the same range in salinity increases and distribution as those with sea level rise under baseline conditions (Figures 4.15 & 4.16).

Dissolved Oxygen

While low levels of dissolved oxygen (DO) in the water column can cause mortality of invertebrates and fish, and can have a devastating impact within a bay system, SAV, like all vascular plants, produce oxygen and some release oxygen from their roots under low oxygen conditions (Sand-Jensen et al, 1984). In order for dissolved oxygen conditions to create stressful condition for SAV, the conditions would need to be very low, persistent DO. As reported in other chapters, the lowest post-project DO levels predicted in the water quality model were minimum summer (June-September) DO concentrations ranging from 6.7-7.1 mg/L. These concentrations of DO would not have an impact on the SAV species present.

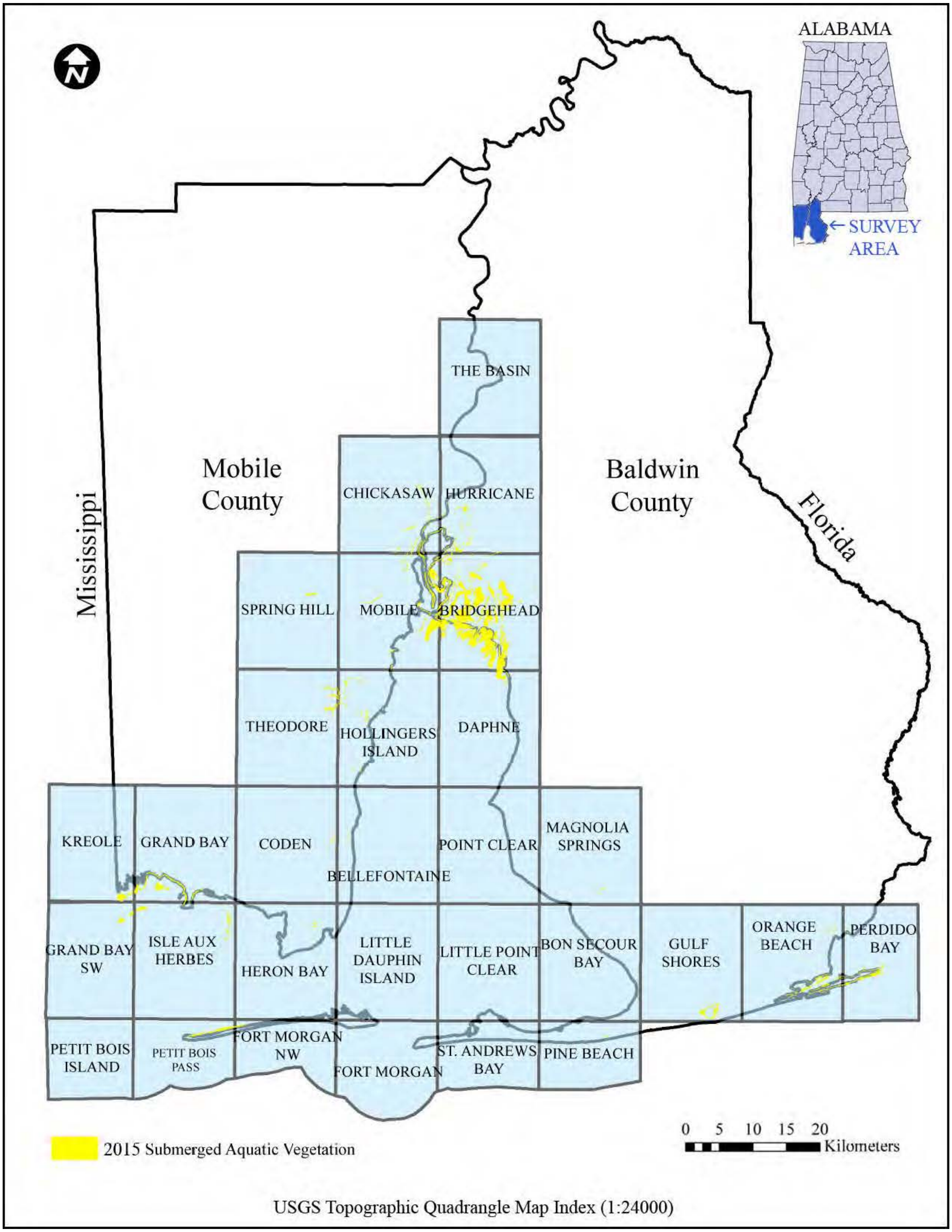

Figure 4.1. Map of surveyed region used to map SAV via remote sensing techniques. From B.A. Vittor and Associates, Inc. (2016).

Figure 4.2. Spatial Distribution of SAV beds (Fall 2015) within the entire study area using Vittor & Associates data.

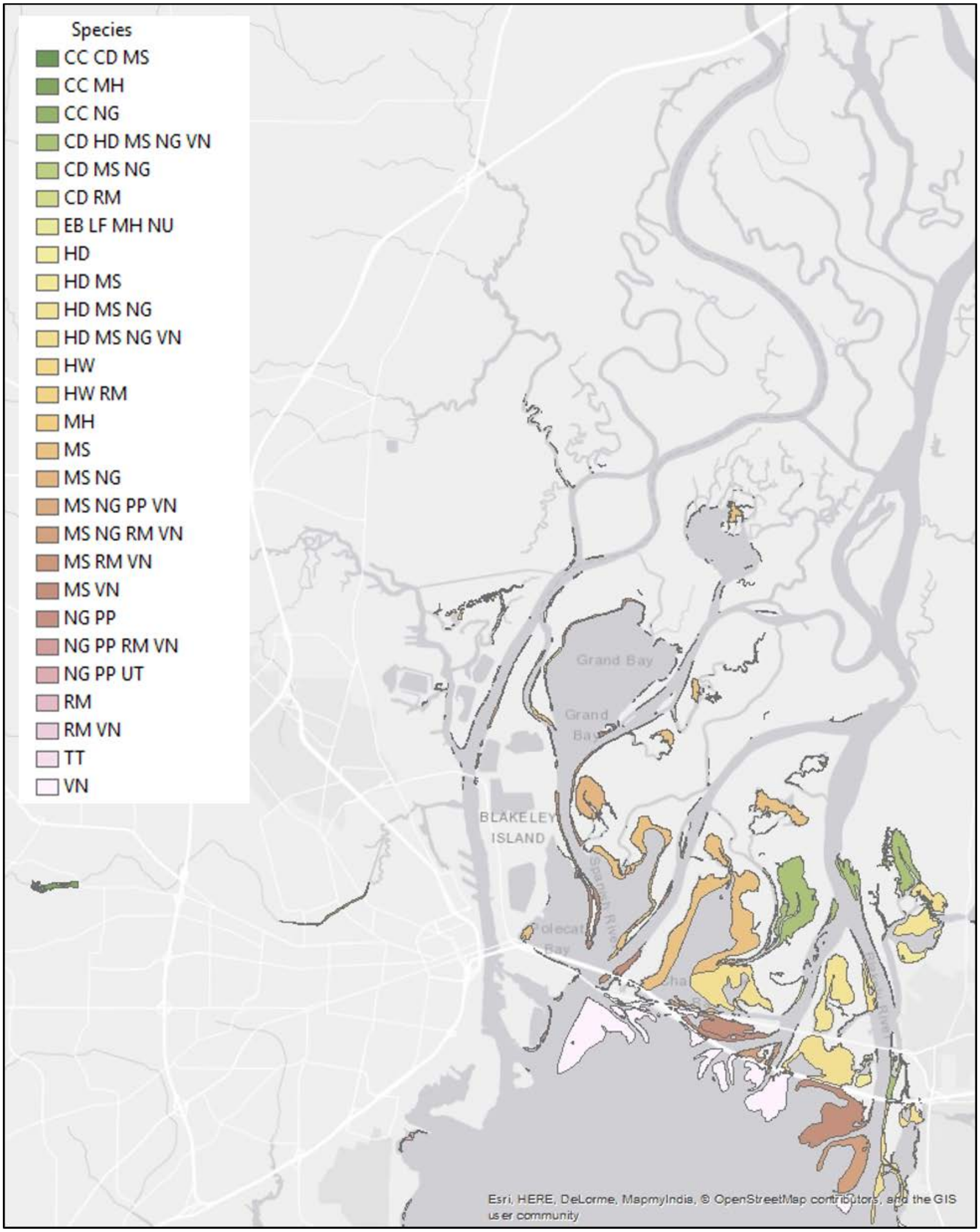

Figure 4.3 Fall 2015 SAV distribution within Mobile Bay as mapped by Vittor & Associates. Species codes can be found in Figure 4.4 and Table 4. 1.

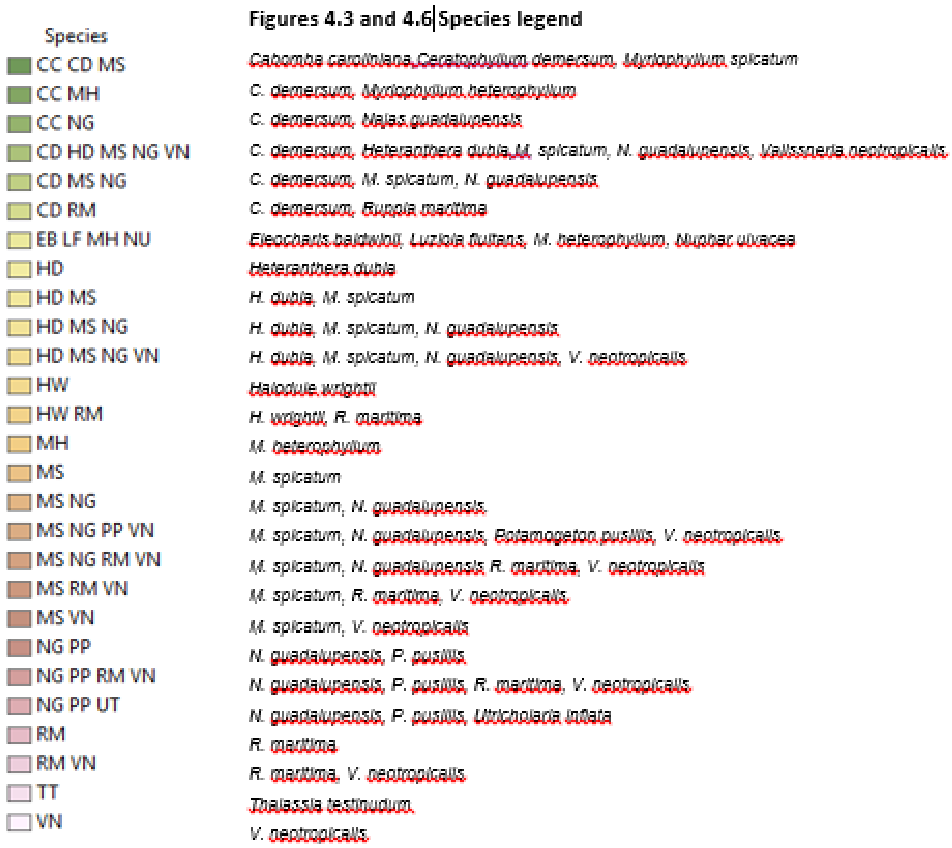

Figure 4.4. Species specific legend for SAV patches mapped in figures 4.3 and 4.6.

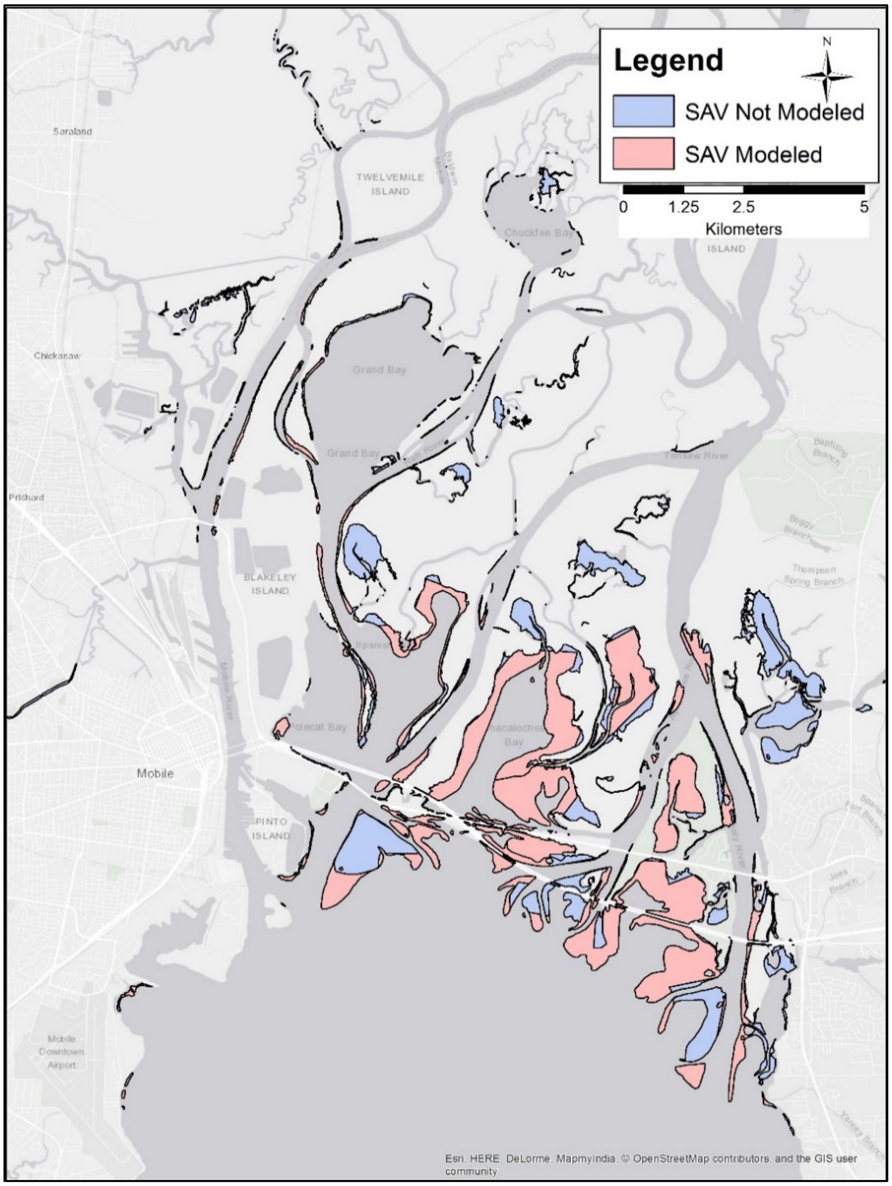

Figure 4.5. Mapped SAV beds in and out of the hydrodynamic and water quality model domains within the estuarine transition zone. The red areas are where the hydrodynamic and water quality model domains overlapped the fall 2015 Vittor SAV coverage. The blue areas are SAV beds where hydrodynamic and water quality data were not modeled so values were estimated from neighboring polygons as described in the text.

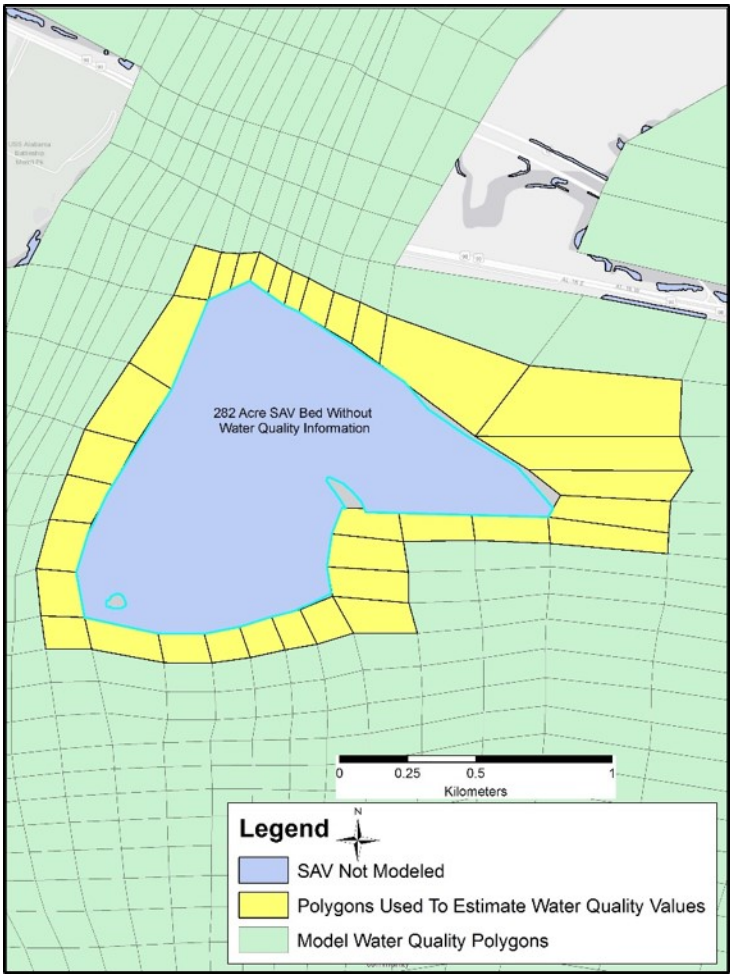

Figure 4.6. Assigning water quality values to SAV beds within the estuarine transition zone but outside of model domain. The blue area is a SAV bed where water quality data were not modeled.Values were estimated using the mean value of neighboring polygons (yellow).

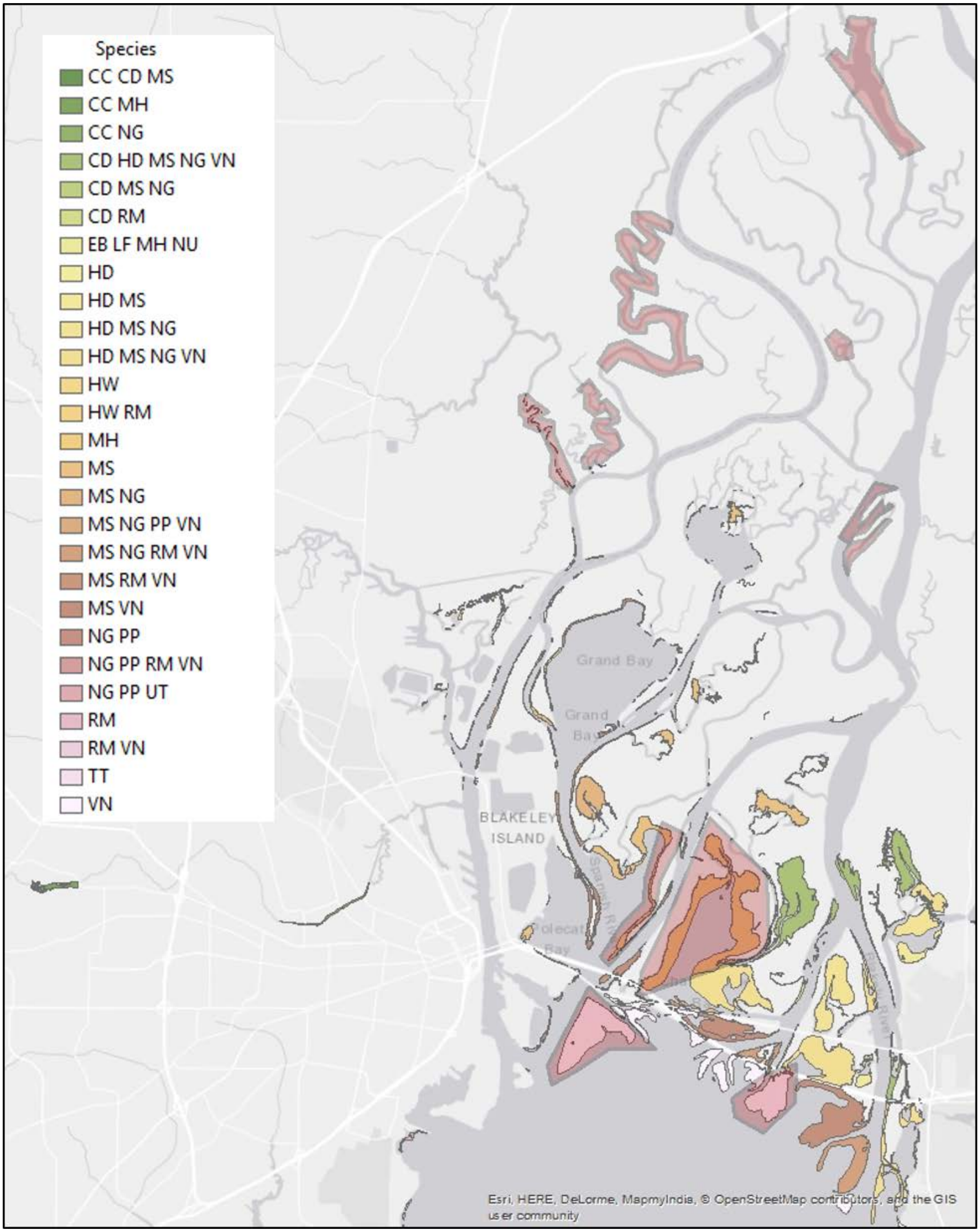

Figure 4.7. Fall 2016 Field verification sites (highlighted red polygons) and Fall 2015 SAV distribution within Mobile Bay as mapped by Vittor & Associates. Species codes can be found in Figure 4.4 and Table 4. 1.

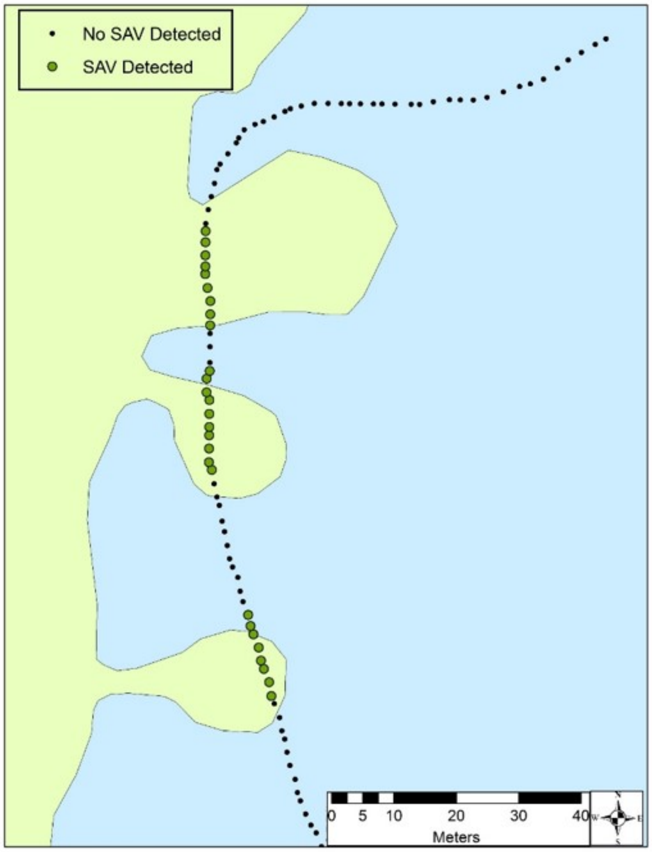

Figure 4.8. Hydroacoustic field verification of Vittor 2015 SAV maps. The light green area is SAV coverage reported by fall 2015 Vittor aerial survey and the points are hydroacoustic locations surveyed by ERDC.

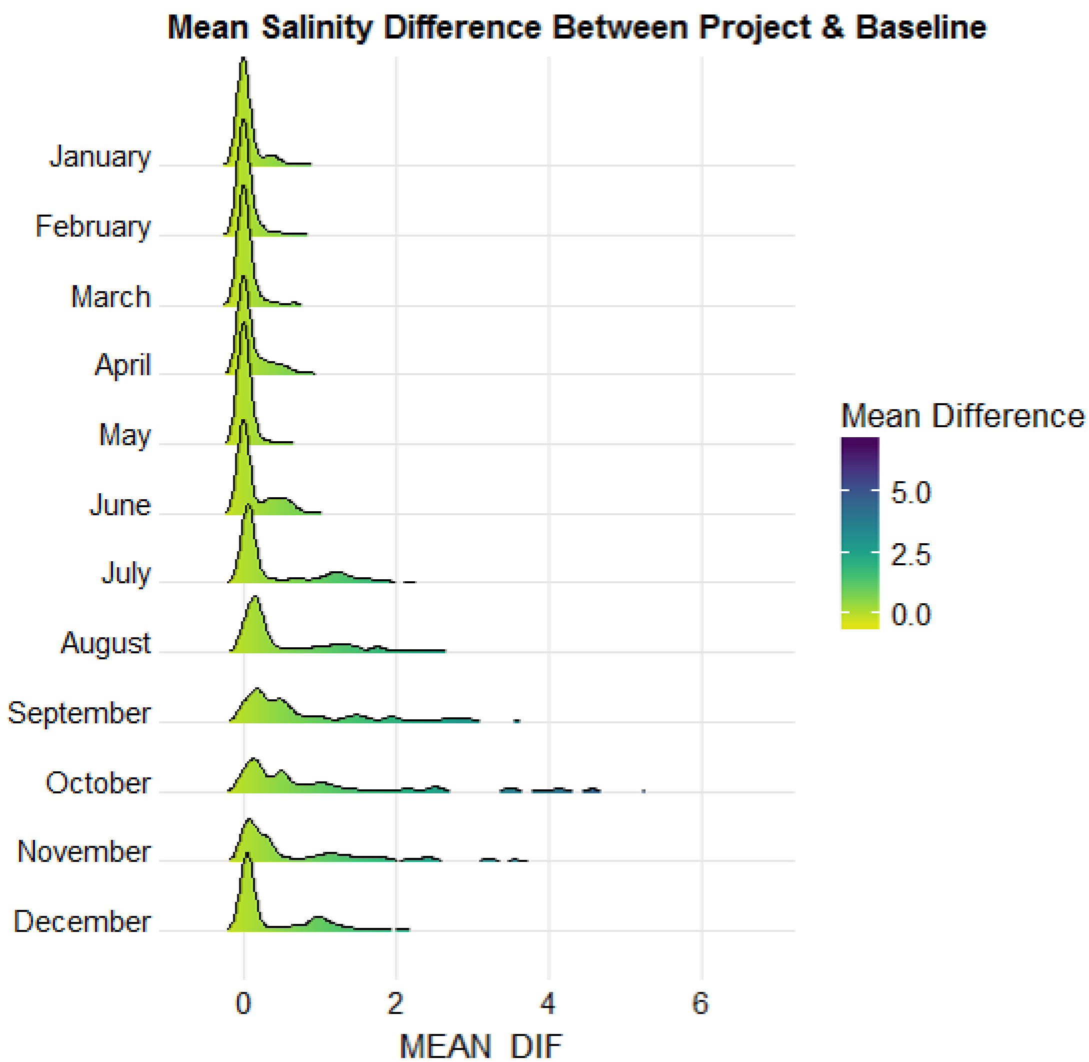

Figure 4.9 Mean depth averaged salinity differences resulting from project implementation as predicted by the hydrodynamic model (CH3D). Note largest range is in October.

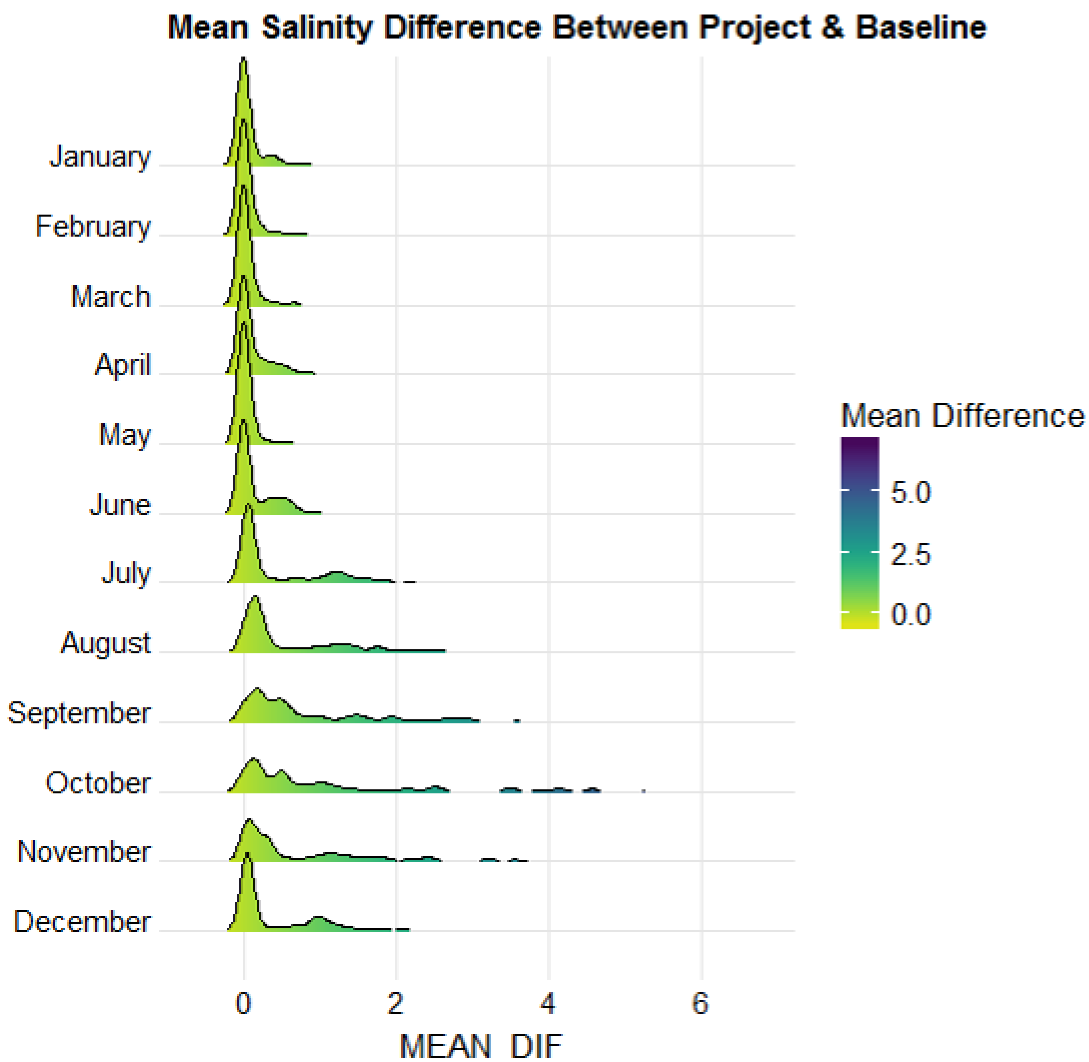

Figure 4.10. Seventy fifth percentile depth averaged salinity differences resulting from project implementation as predicted by the hydrodynamic model (CH3D). Note largest ranges are in October and November.

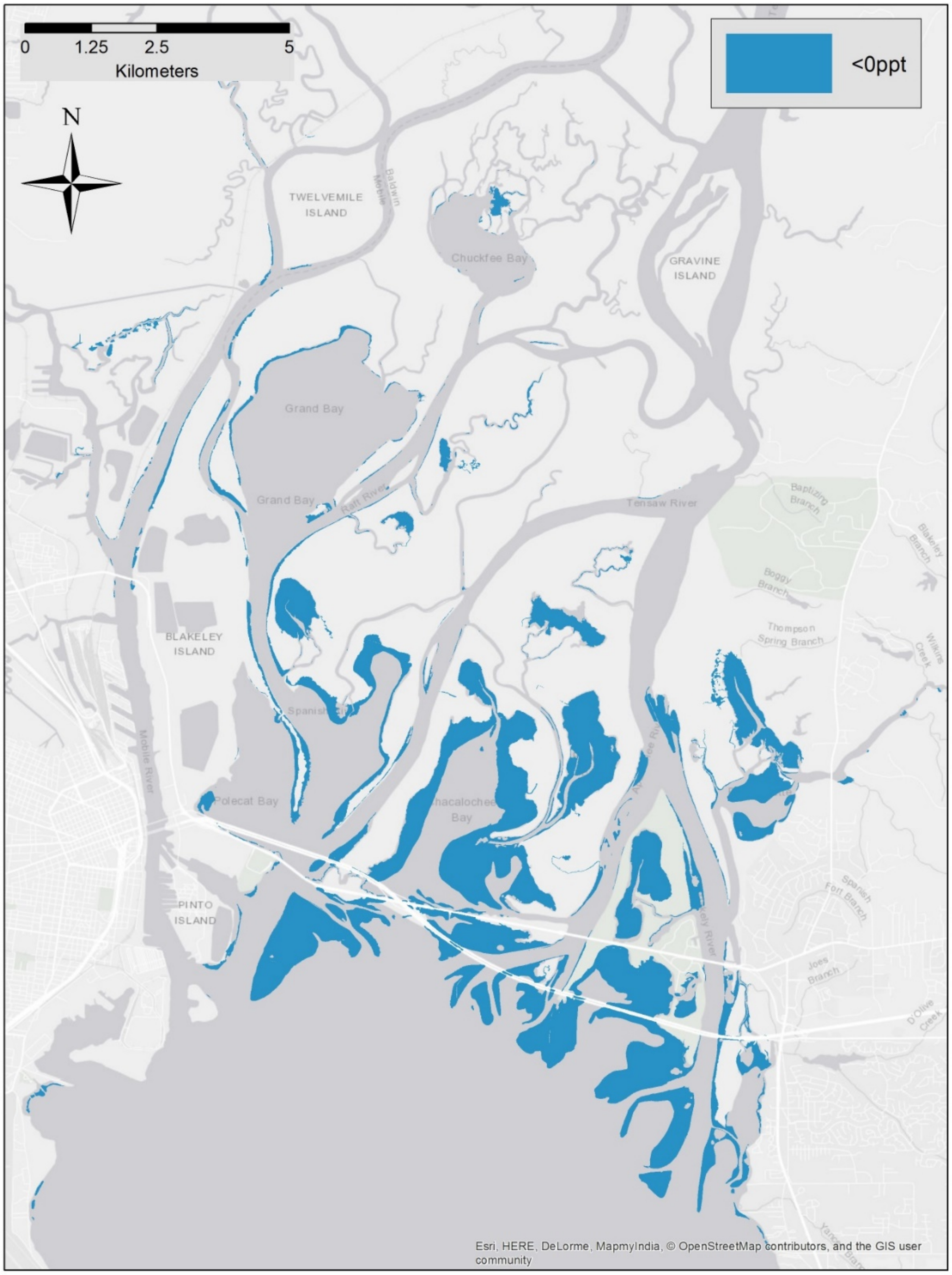

Figure 4.11.Increase in Spring (May) salinity (ppt) above relative species specific thresholds values due to project implementation (i.e., post-project – baseline salinity) within the estuarine transition zone.

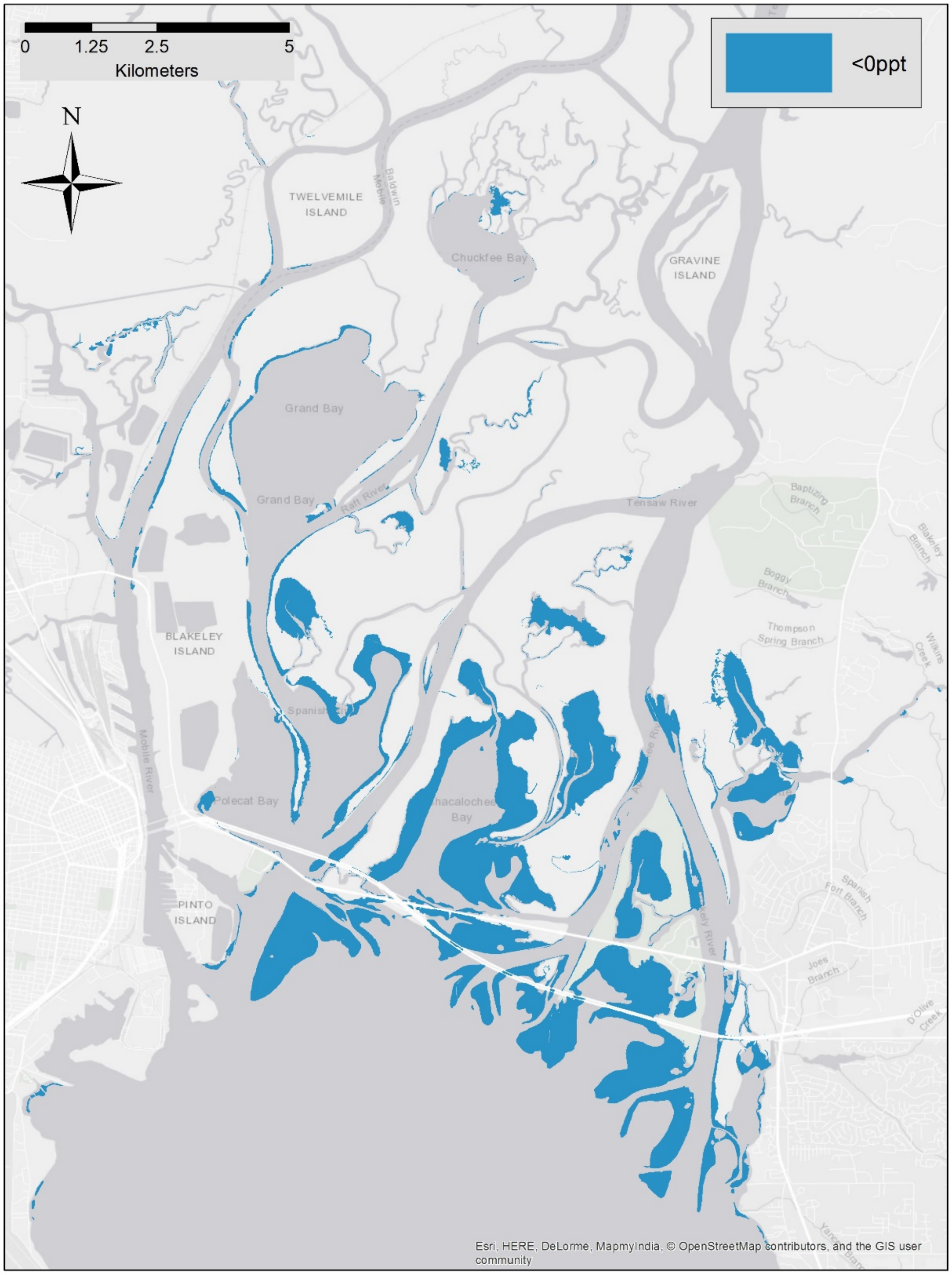

Figure 4.12. Increase in Summer (August) salinity (ppt) above relative species specific thresholds values due to project implementation (i.e., post-project – baseline salinity) within the estuarine transition zone.

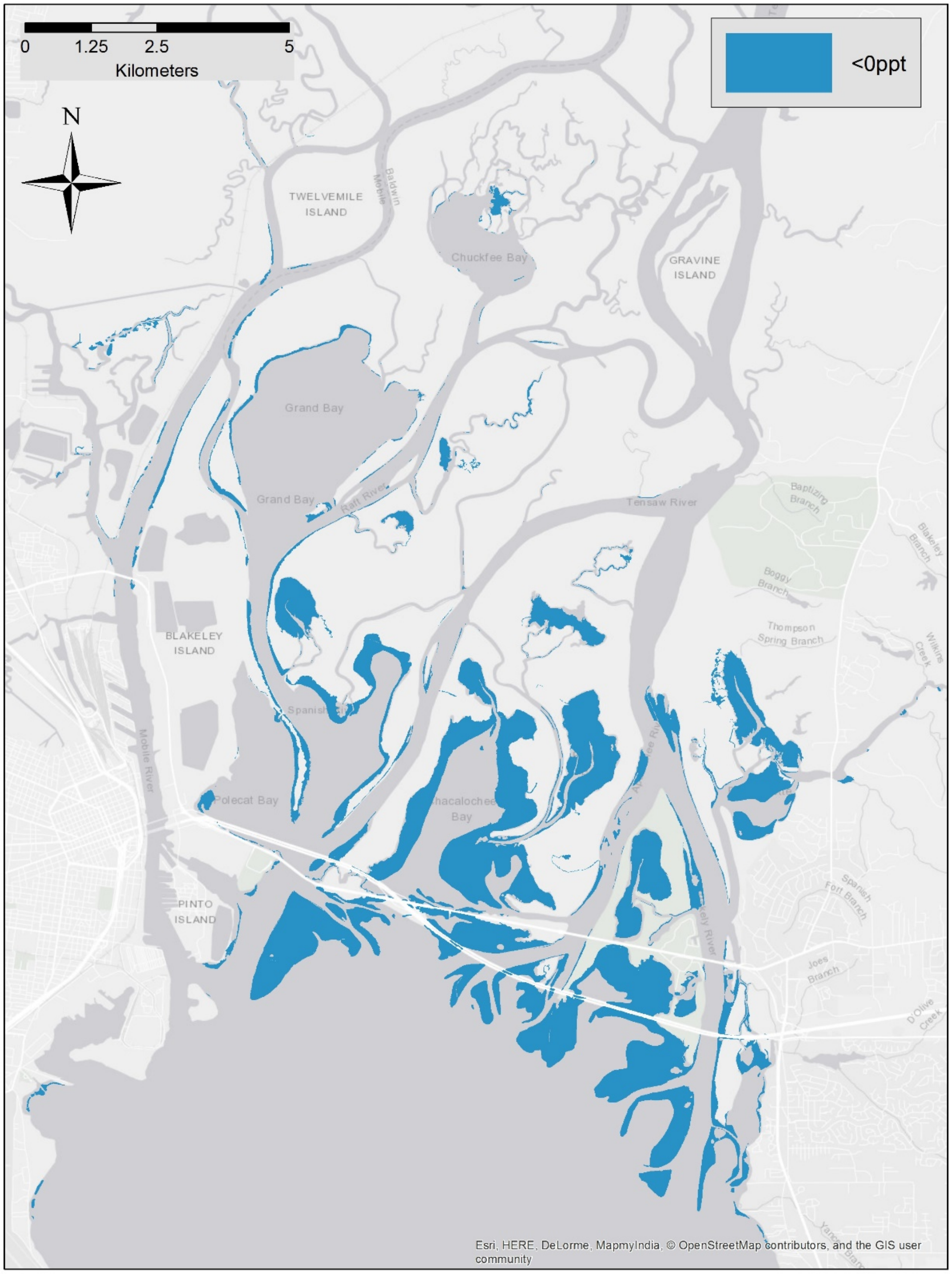

Figure 4.13. .Increase in Winter (February) salinity (ppt) above relative species specific thresholds values due to project implementation (i.e., post-project – baseline salinity) within the estuarine transition zone.

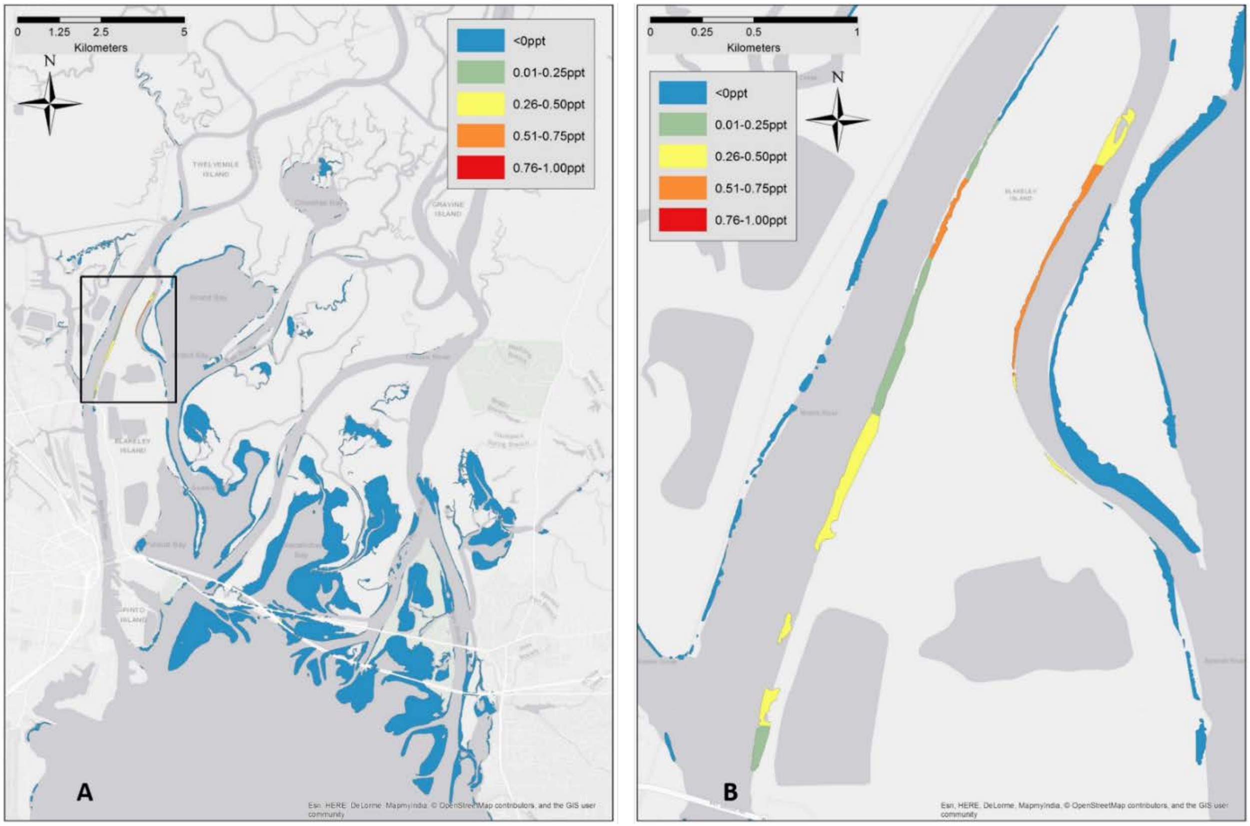

Figure 4.14.Increase in Fall (October) salinity (ppt) above relative species specific thresholds values due to project implementation (i.e., post-project – baseline salinity) within the estuarine transition zone (A) and detailed within region of higher predicted salinity change (B, region outlined in black in A).

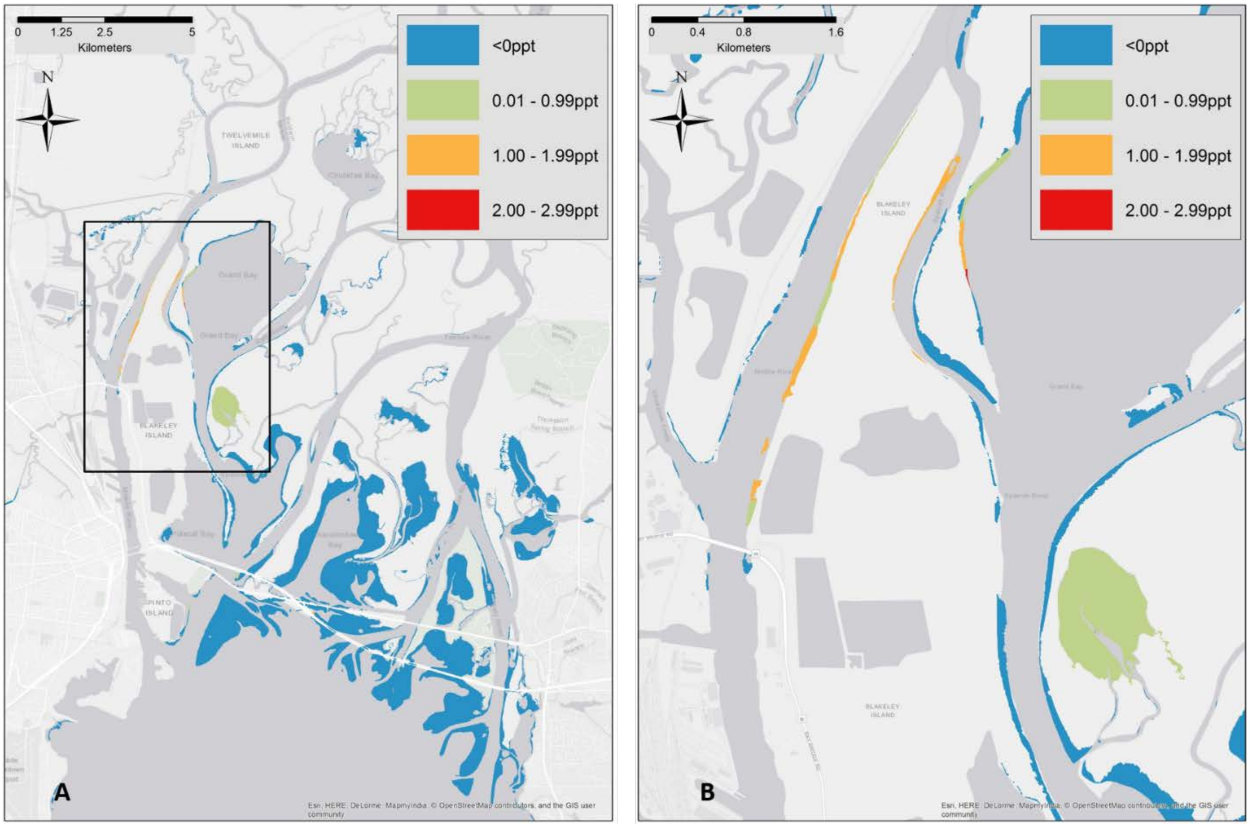

Figure 4.15. Increase in salinity (ppt) above relative species specific thresholds values from current baseline conditions to projected 0.5m sea level rise conditions with no project implementation (i.e., SLR baseline – current baseline) within estuarine transition zone (A), and detailed within region of higher predicted salinity change (B, region outlined in black in A). SLR projections predict higher salinity increase than salinity increase due to project implementation alone.

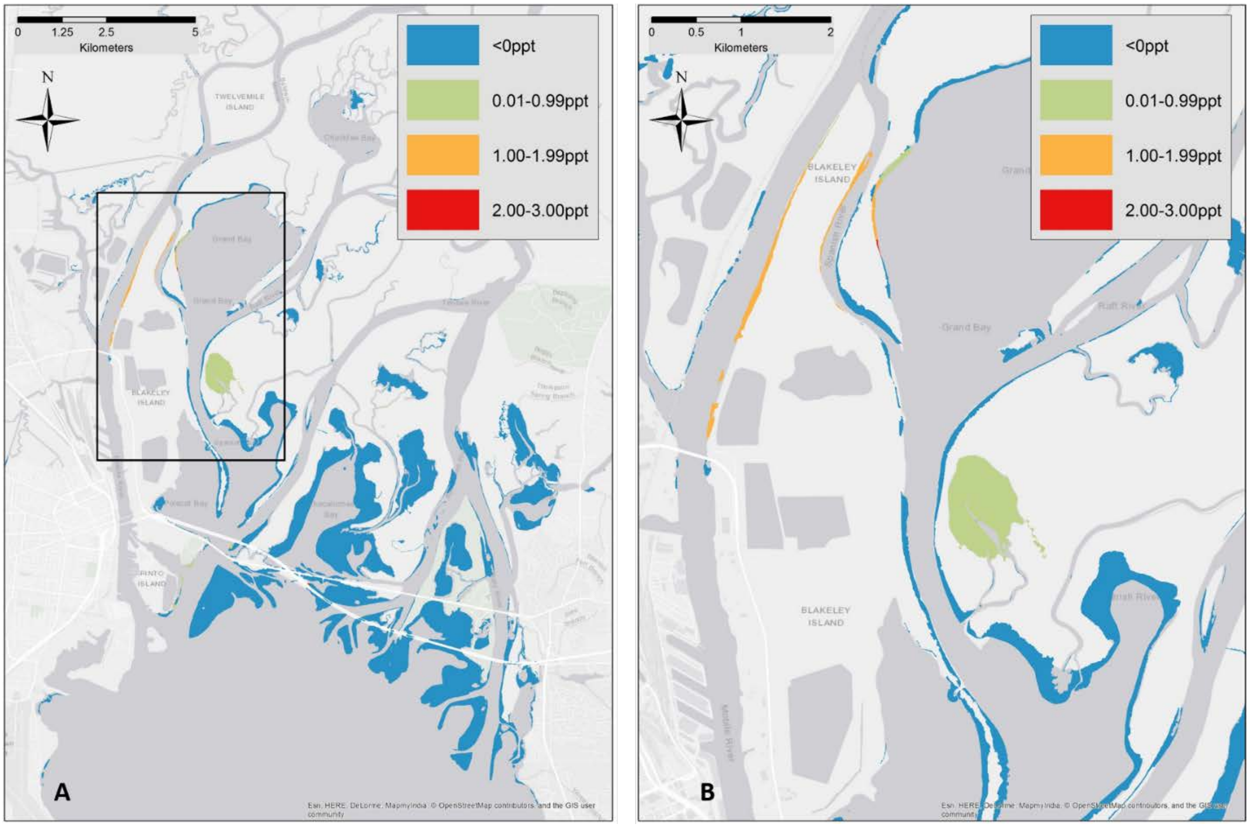

Figure 4.16. Increase in salinity (ppt) above relative species specific thresholds values from current baseline conditions to projected 0.5m sea level rise conditions with project implementation (i.e., SLR post project – current baseline) within estuarine transition zone (A), and detailed within region of higher predicted salinity change (B, region outlined in black in A).. SLR projections predict higher salinity increase than salinity increase due to project implementation alone.

Table 4.1. Variation in acreage over time. Values are obtained from Vittor SAV survey maps. Highlighted species are those predicted to experience increased salinities above 1ppt due to project implementation.

Species	**Acres**					
	2003	**2009**	**Summer 2015**	**Fall 2015**	**Mean**	**Standard Deviation**
Myriophyllum spicatum	2318.5	2955.2	6734.8	4647.3	4163.9	1975.7
Vallisneria neotropicalis	2610.4	2499.7	5304.3	2851.1	3316.4	1333.4
Najas guadalupensis	762.2	1773.6	4832.9	2041.2	2352.5	1742.9
Heteranthera dubia	427.8	312.0	3540.0	3075.9	1838.9	1707.5
Ceratophyllum demersum	954.6	188.8	2002.1	3329.4	1618.7	1361.3
Ruppia maritima	475.2	293.1	1767.6	632.1	792.0	665.0
Stuckenia pectinata	0	238.9	1280.2	5.7	381.2	609.6
Potamogeton pusillus	0	17.1	1115.1	131.2	315.8	536.0
Cabomba caroliniana	0	1.9	28.1	768.8	199.7	379.6
Potamogeton crispus	0	27.9	375.3	9.8	103.2	181.7
Utricularia foliosa	0	5.7	213.4	114.1	83.3	101.4
Zannichellia palustris	0	0	198.8	0.2	49.8	99.4
Hydrilla verticillata	0	76.1	16.7	91.2	46.0	44.4
Nuphar ulvacea	0	46.0	5.7	29.9	20.4	21.4
Myriophyllum heterophyllum	0	0	5.7	29.9	8.9	14.3
Myriophyllum aquaticum	0	0	0	0.1	0	0.1

Table 4.2. Reported Salinity tolerance thresholds and ranges for local SAV species. Where threshold information was not available, published salinity range in known locations is reported and designated as 'Range'.

Species	Abbreviation	Common Name	Reported Salinity Tolerance or Range (ppt)	Citations	Notes
Cabomba caroliniana	*CC*	carolina fanwort	0-0.5	Poirrer et al. 2010	Rare in study area, mostly in the side creeks
Ceratophyllum demersum	*CD*	coon's tail	0-0.7 0-5	Poirrer et al. 2010 Izzati 2015	Present throughout the delta, very abundant
Halodule wrightii	*HW*	shoal grass	0-60 0-70 5-80	Texas Parks and Wildlife 1999 Kock et al. 2007 McMahan 1968, McMillian 1974	All along the Gulf of Mexico, likely not affected by project
Heteranthera dubia	*HD*	water stargrass	0-3.5 0-5	Poirrer et al. 2010 Izzati 2015	Very abundant on the east side of the delta
Hydrilla verticillata	*HV*	hydrilla	0-6.6 0-10 0-12 0-13	Haller et al. 1974 Poirrer et al. 2010 Twilley et al. 1990 Steward and Van 1987	invasive, only at 5 points up creeks in the right side of the delta
Myriophyllum aquaticum	*MA*	parrot's feather	0-10	Haller et al. 1974	Very rare in study area, in upland areas, invasive
Myriophyllum heterophyllum	*MH*	southern watermilfoil	0-5 (Range) ~6 (Range)	Sivaci et al. 2008 Eggleston et al. 2008	Very rare in study area, one patch far up a creek
Myriophyllum spicatum	*MS*	Eurasian watermilfoil	0-13 0-15 0-15 0-20	Haller et al. 1974 Aiken et al 1979 Izzati 2015 Poirrer et al. 2010	Present throughout the delta, invasive
Najas guadalupensis	*NG*	southern naiad	0-3.5 0-10 0-10	Poirrer et al. 2010 Texas Parks and Wildlife 1999 Haller et al. 1974	Present throughout the delta, very abundant
Potamogeton crispus	*PC*	curly pondweed	0-8 (Range)	Vincent 2001	Rare but spread throughout the delta, invasive
Potamogeton diversifolius	*PD*	water thread pondweed	0 (Range)	USDA, NRCS 2018	Present in the bay far downstream of areas of salinity change
Potamogeton nodosus	*PN*	longleaf pondweed	0 (Range) 0-1.3 (Mean, Range)	USDA, NRCS 2018 Castellanos and Rozas 2001	Present in the bay far downstream of areas of salinity change
Potamogeton pusillus	*PP*	small pondweed	0-3.5	Poirrer et al. 2010	Present in the bay far downstream of areas of salinity change
Ruppia maritima	*RM*	widgeon grass	0-60 0-70 0-100	Phillips 1960 Kock et al. 2007 Kantrud 1991	Present throughout the entire study region
Stuckenia pectinata	*SP*	sago pondweed	0-15, can likely handle above 20	Borgnis and Boyer 2014	Present only in lower part of the delta, not likely to be affected by project
Thalassia testudinum	*TT*	turtle grass	5-45 20-40 36-70	Lirman and Cropper 2003 Zieman 1982 Kock et al. 2007	One patch by the Gulf of Mexico, out of project area
Utricularia foliosa	*UF*	leafy bladderwort	0-5 (Range) 1-3.5 (Range)	Camargo and Florentino 2000 Ross et al. 2000	A few patches up the creeks on the east side of the lower delta
Utricularia inflata	*UI*	floating bladderwort	0-0.02 (Range)	de Roa et al. 2002	Rare, one patch miles away from the lower delta
Vallisneria neotropicalis	*VN*	wild celery	0-18 0-18 0-18 0-18	Doering et al. 2001 Kraemer et al. 1999 Boustany et al. 2010 Lauer et al. 2011	Widespread, species observed in areas higher than 18 ppt
Zannichellia palustris	*ZP*	horned pondweed	0-6	Greenwood and DuBowy 2005	A few patches present up creeks at the mouth of the Bay, not likely to be affected by the project

Table 4.3.Number of SAV acres predicted to experience a change in salinity exposure, displayed by range of predicted salinity change.

Post Project Salinity (ppt) above SAV tolerance threshold		
Range	**Mean Acres**	**75th Percentile Acres**
<0	0	82
0-0.25	5249	5235
0.25-0.5	774	556
0.5-0.75	1080	601
0.751-1.0	120	742
1-1.25	50	58
1.25-1.5	2	1

Table 4.4. Number of SAV acres, by most vulnerable species, predicted to experience a change in mean monthly salinity exposure, displayed by range of predicted salinity change.

	Species within SAV Bed with lowest Salinity Tolerance						
Post-Project Monthly Mean Salinity (ppt) above SAV tolerance threshold	Water Star Grass	Eurasian Watermilfoil	Southern Naiad	Widgeon Grass	Wild Celery	Carolina Fanwort	Coon's Tail
<0							
0-0.25	3288	561	284	5	401	82	41
0.25-0.5	18	257	60	12	106	15	
0.5-0.75		313	164		412		25
0.75-1.0		1		1	9		
1-1.25		3	21	20	2		
1.25-1.5				2			

Table 4.5. Number of SAV acres, by most vulnerable species, predicted to experience a change in monthly 75th percentile salinity exposure, displayed by range of predicted salinity change.

	Species within SAV Bed with lowest Salinity Tolerance						
Post-Project Monthly 75th Percentile Salinity (ppt) above SAV tolerance threshold	Water Star Grass	Eurasian Watermilfoil	Southern Naiad	Widgeon Grass	Wild Celery	Carolina Fanwort	Coon's Tail
<0							
0-0.25	3285	557	281	16	386	82	41
0.25-0.5		171	185	4	62	15	
0.5-0.75	25	380	52	14	66		25
0.75-1.0		32	11	3	309		
1-1.25		4	21	3	25		
1.25-1.5					1		

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Chapter 5: Oysters

The eastern oyster (*Crassostrea virginica*) is a reef-forming organism commonly found in estuaries throughout the Atlantic and Gulf coasts of North America, and is the only species of oyster in these areas. Eastern oyster reefs provide several ecosystem services, including water filtration, habitat diversity, and storm surge protection, among others. Inter-reef recruitment is the key driver for maintaining oyster reef complexes within bay systems; however, oyster larvae are difficult to track due to their small size and pelagic nature. Salinity and dissolved oxygen (DO) are critical physical parameters that can increase mortality of oyster larvae if they exceed certain threshold values (DO < 2.4 ppm; $5 >$ salinity > 35 ppt. Similarly, adult oysters can experience increases in mortality in response to changes in salinity. The interactions between oysters and their environment necessitates an integrated modeling approach to capture the complexity of the system. For Mobile Bay, we developed an integrated hydrodynamic ecological model to simulate how changes in physical and environmental conditions in Mobile Bay affected the oyster complex. Our results indicated that the Mobile Bay project's impact on oysters would be minimal. Modeled salinity and dissolved oxygen did not exceed oyster thresholds for either larvae or adults. Larval tracking model results indicated that oyster larvae remained in Mobile Bay and would likely contribute recruits to other reefs in the system.

5.1 Introduction

Eastern oyster (*Crassostrea virginica*) recruitment is the key driver for maintaining oyster population over time. However, this process is poorly understood due to the difficulty in tracking oyster larva over time. Recruitment occurs through the settlement of larval from their natal reef (intra-reef recruitment), or from other reefs within the system (inter-reef recruitment). Intra-reef recruitment has been shown to be relatively low, indicating that inter-reef recruitment is crucial for sustaining oyster populations in hydrodynamically-driven systems. Oyster larvae have limited swimming abilities so their movement is controlled in large part by hydrodynamic transport. Oyster larvae have a maximum swim speed on the order of two to three mm/s (North et al., 2006, 2008), which is negligible in comparison to the horizontal velocities typically observed in most estuarine systems. However, vertical velocities are much lower, and veligers are able to overcome vertical velocity gradients to change their vertical position in the water column. In addition to hydrodynamic forcings oyster veligers also respond to changes in water quality (e.g., temperature, salinity, DO). Salinity is a recognized driver for both larval and adult oyster dynamics (Gunter 1955, Kennedy et al. 1996), with the optimal range of salinities being in mesohaline conditions, which facilitates oyster growth in disease-prone waters (Carnegie & Burreson 2011, Levinton et al. 2011).

Understanding the oyster larvae movement and reef recruitment dynamic is critical towards understanding how potential project actions will impact oyster populations within a project footprint. Specifically, if oyster recruitment within the Mobile Bay area is altered so that a higher percentage of oyster larvae are flushed out of the bay due to hydrodynamic changes caused by alterations to the navigation channel, this could be detrimental to local oyster recruitment.

The complexity of the oyster life cycle, coupled with the difficulty in tracking oyster larva in the field, facilitates an integrated ecological modeling approach for understanding system dynamics. Eulerian-Lagrangian particle tracking models developed for visualizing flow fields, estimating contaminant transport paths, or estimating sediment transport can be adapted for tracking biological particles by applying behavior rules that can supersede physical rules (e.g., Tate et al. (2012) successfully modified it to simulate various fish egg behaviors in the Mississippi River Gulf Outlet). A common particle tracker, PT123 (Cheng et al. 2011), uses water level and current estimates from two- and three-dimensional hydrodynamic models to predict where sediments or other discrete constituents are transported. We modified PT123 with biologically-based behaviors to simulate and track oyster larvae within the system (conceptualized in Figure 5.1).

The main objectives were to assess oyster larvae movement and survival under four different scenarios for Mobile Bay, including: 1) a baseline scenario of future-without-project and without projected sea level rise (SLR), 2) a project involving the implementation of deepening Mobile harbor via dredging the navigation channel within Mobile Bay and without projected SLR conditions, 3) a scenario of future-without-project with projected SLR, and 4) a project involving the implementation of harbor deepening with projected SLR conditions. A secondary objective was to determine if salinity values exceeded or subceeded threshold values for adults.

5.2 Methods

Model Development Process

The model was developed by first conceptualizing the interactions oyster larva and the physical environment (Figures 5.1 and 5.2). The conceptual model was used as a template for integrating the quantitative models (Figure 5.3), and to visualize the responses of oyster larvae to physical processes and biological behavior (Figures 5.4 & 5.5). The model produces a veliger particle transport success rate which must be combined with a veliger particle mortality rate dependent upon simulated local water quality conditions to provide an estimate of recruitment rates.

The model was implemented as a library that was added to PT123, an existing particle tracking/engineering model. In this case, biological behaviors were parameterized as a set of conditional rules (e.g., if-then-else statements) that represent the current state of knowledge of larval life history strategies (e.g., growth, settling rate) and how oyster larva respond to the physical environment, including flow, temperature, salinity, among others. The model is based on the proof-of-concept version developed by Kjelland et al., 2015.

Model Description

The model is driven by the CH3D hydrodynamic code, which simulates water level, current velocities, and constituent transport in the system of interest. CH3D uses a horizontal boundary-fitted curvilinear grid with a vertical sigma grid, and is suitable for application to coastal and near shore waters (Cerco and Noel 2004). The integrated compartment model (ICM), i.e., water quality model, was coupled with CH3D to provide water quality parameters for The Model. Both CH3D and ICM are mature codes that have been thoroughly documented in other studies (Cerco and Noel 2004). We focus on providing details for the model we developed for quantifying the processes and dynamics of the biological behaviors of pelagic oyster veligers. The model was applied in the Mobile Bay system (Figures 5.3-5.5).

An existing Eulerian-Lagrangian particle tracking model, i.e., PT123, (Cheng et al. 2011), was modified with oyster larval behaviors to simulate oyster reef connectivity and recruitment within Mobile Bay. Given velocities, PT123 can track massless particles in 1-, 2-, and 3-D unstructured or converted structured meshes. The elements used to construct PT123 meshes are line elements in 1-D, triangular and/or quadrilateral elements in 2-D, and tetrahedral, triangular prism, and/or hexahedral elements in 3-D (Cheng et al. 2011). One adaptive (embedded 4th- and 5th-order) and three non-adaptive (1st-, 2nd-, and 4th-order) Runge-Kutta (RK) methods are included in PT123 to solve the ordinary differential equations describing the motion of particles (Cheng et al. 2011). Particles are tracked along the closed boundary and stops tracking when a particle encounters the open boundary through which particles enter or exit the computational domain. The start and end times of tracking are flexible as long as their corresponding velocities can be computed via temporal interpolation using the given velocities (Cheng et al. 2011).

For each scenario, salinity from the Multi-Block hydrodynamic model of Mobile Bay and other water quality parameters from water quality model were summarized--monthly statistics were calculated for mean, standard deviation, minimum, maximum, and the following percentiles 1, 5, 10, 25, 50, 75, 90, 95, and 99. For vertical reference, statistical values were assessed for depth-averaged, top, top 3 layers, bottom 3 layers, and bottom layers.

For the oyster model, 42868 node grids (sigma-stretched grid) were built (Figure 5.1). Every 30 minutes, water levels were calculated for the node layers. Three dimensional velocities were also put on the node layers every 30 minutes. Daily averaged values of salinity and other water quality parameters such as temperature and dissolved oxygen were put on the nodes as well. Model variables and corresponding parameters can be found in Table 5.1. The juvenile and adult survival analysis consisted of comparing average minimum and average maximum monthly temperature values across the bay. The tolerance threshold values for the evaluation came from Kjelland et al. (2015). For example, if the minimum tolerance threshold for oyster survival is ≥ 2.4 ppm, and oyster reefs were not located in areas within the bay that did not have a DO < 2.4 ppm during the model simulation, then oysters would not be impacted by DO.

Model Rules

Veliger density and swimming ability changes with age, temperature, and salinity, so the basic behavior rules were simplified to best approximate the vertical distribution of veligers in a well-mixed system. We developed a rule set to achieve a temporally varying vertical distribution of veliger particles consistent with North et al. (2008). Veliger particles were assumed to be neutrally buoyant when released near the water surface and advection was allowed to distribute the particles throughout the model domain. Once the veligers matured to age at which settlement could occur (assumed to be 14 to 21 days), they migrated to within one meter of the bottom where their movement was dominated by boundary layer processes until they came into contact with a suitable substrate for settlement. For this iteration of PT123, we assumed that oyster larvae could settle anywhere within the bay, although attachment success was not accounted for, and no recruitment entered the system from outside the modeled reefs. Five instantaneous particle releases were simulated (consistent with North et al. (2008) from Brookley reef, 43 particles each release, as well as a randomized release location of an additional 43 particles.

The particles were modified to capture the behavior of oyster larvae using the following rules:

1) Particle size increases linearly from 50 to 300 um over a three week period after release into the system (i.e., a constant growth rate of 12.5 um/day)

2) Horizontal swimming speed (m/s) depends on size and is calculated following North et al. 2008:

Horizontal swimming speed = 0.00892*size - 0.0076

3) Vertical settling velocity is also size dependent and is calculated as settling velocity = 0.0304*size - 1.099

Particles will migrate downward based on their size until the larva reaches bottom or until the maximum time span allotted for oyster larvae mobility is reached, at which point they then settle to the bottom.

4) Time span oyster larvae are mobile: 14 to 21 days.

For analyzing differences in larvae transport and survival, larvae release locations were randomized or located at the Brookley reef. Sensitivity analyses were conducted by adjusting the environmental parameter survival thresholds or exposure times. Exposure time consisted of the cumulative time that oyster larvae could be exposed before mortality occurred. In addition to larvae tracking, 13 adult oyster reefs were assessed (>3,600 acres) for salinity and DO potential impacts based on juvenile and adult oyster tolerance thresholds. Based on the tolerance threshold values from Kjelland et al. (2015). The minimum tolerance threshold for oyster survival is ≥ 2.4 ppm and the minimum DO values did not drop below 2.4 ppm indicating that oysters would not be impacted by DO for any of the four scenarios. Salinity was also within the tolerance ranges for the four scenarios, based on tolerance thresholds of <5 ppt for spat and <3 ppt or sub-adult and adult minimum tolerance thresholds or > 35 ppt for the maximum tolerance threshold.

5.3 Results and Discussion

Model Evaluation and Application

Simulated oyster larvae movement through integrated hydrodynamic, water quality, and larval tracking modeling was successfully implemented. Differences in larvae transport and survival among scenarios and randomized release locations were found (i.e., Tables 5.2 & 5.3) versus Brookley reef (Tables 5.4 & 5). Sensitivity analyses were conducted with regard to adjusting the environmental parameter survival thresholds or exposure times (i.e., Table 5.6). Results of the sensitivity analyses demonstrated consistency with expected mortality rates of oysters based on the scientific literature (Kjelland et al. 2015).

Oyster larvae particle tracking resulted in 100% survivorship under all scenarios when particles were released using a randomized location. However, the scenarios with SLR (i.e., Scenarios 3 & 4) resulted in a much higher mortality of oyster larvae when released at Brookley reef, although that was not the case for the scenarios without SLR. Importantly, the oyster model results do not project an increase in larvae flushing out of Mobile Bay under the with channel modification project scenarios (i.e., Scenarios 2 & 4).

The analyses of juvenile and adult survival included assessing 13 adult oyster reefs (>3600 acres) for potential salinity and DO impacts (Figures 5.6 & 5.7) based on survival tolerance thresholds. Dissolved oxygen levels stay well above the minimum oyster tolerance threshold for simulated scenarios with and without SLR. Similarly, salinity stays within oyster tolerance survival threshold for all scenarios.

Communication

The results from The Model are intended to be presented to an audience with a general technical background, particularly environmental planners, operations personnel, and natural resource managers. Results should facilitate a deeper understanding of the relative impact of project alternatives on inter-reef recruitment of oysters in Mobile Bay.

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Tables

Table 5.1. Overview of oyster model components including: input variables and environmental parameters

PARAMETER	VALUE (Status/Unit of measure)
Spatial scale	42,868 grid nodes
Adaptive time step	Seconds (s)
Length of simulation	March through September
Initial oyster larvae	# particles
Depth (# of layers)	Averaged to 3 layers
Low Dissolved Oxygen (DO) threshold	3 ppm
High Dissolved Oxygen (DO) threshold	50 ppm
Low Salinity threshold	3 ppm
High Salinity threshold	50 ppm
Low H_2O Temperature threshold	10°C
High H_2O Temperature threshold	30°C
DO mortality threshold duration	10,000 s to live outside threshold
Salinity mortality threshold duration	10,000 s to live outside threshold
Temperature mortality threshold duration	10,000 s to live outside threshold

Table 5.2. PT123 particle tracking model results summary: Running 17 particles at a time (per run) with random larvae release locations.

Scenario	Number of Runs	Number of Oyster Deaths
Baseline	5	0
Project	5	0
Baseline (SLR)	3	0
Project (SLR)	3	0

Table 5.3. PT123 particle tracking model results with random larvae release locations.

SCENARIO	#Particles	#Flushed	#Settled	#Dead
Baseline	42	1	41	0
Project	42	1	41	0
Baseline (SLR)	42	0	42	0
Project (SLR)	42	0	42	0

Table 5.4. PT123 particle tracking model results summary: Running 43 particles at a time (per run) with Brookley Reef larvae release location.

Scenario	Number of Runs	Number of Oyster Deaths
Baseline	5	0
Project	5	0
Baseline (SLR)	5	215
Project (SLR)	5	215

Table 5.5. PT123 particle tracking model results with Brookley Reef larvae release location.

Scenario	#Particles	#Flushed	#Settled	#Dead
Baseline	215	5	210	0
Project	215	5	210	0
Baseline (SLR)	215	5	210	215
Project (SLR)	215	5	210	215

Table 5.6. PT123 particle tracking model sensitivity analyses results with Brookley Reef larvae release location.

SCENARIO: Variable	#Particles	#Flushed	#Settled	#Dead
Baseline: DO*	43	1	42	43
Baseline: Salinity*	43	1	42	43
Baseline: Temperature*	43	1	42	43
Baseline: Exposure Time**	43	1	42	0

* Changed from original thresholds to much lower thresholds, i.e., DO: Low to High = 0-1 ppm, Salinity: Low to High = 0-1 ppm, Temperature: Low to High = 0-1°C for 10,000 seconds exposure time to induce mortality.

** Changed from 10,000 to 100 seconds for all three environmental variables

Figures

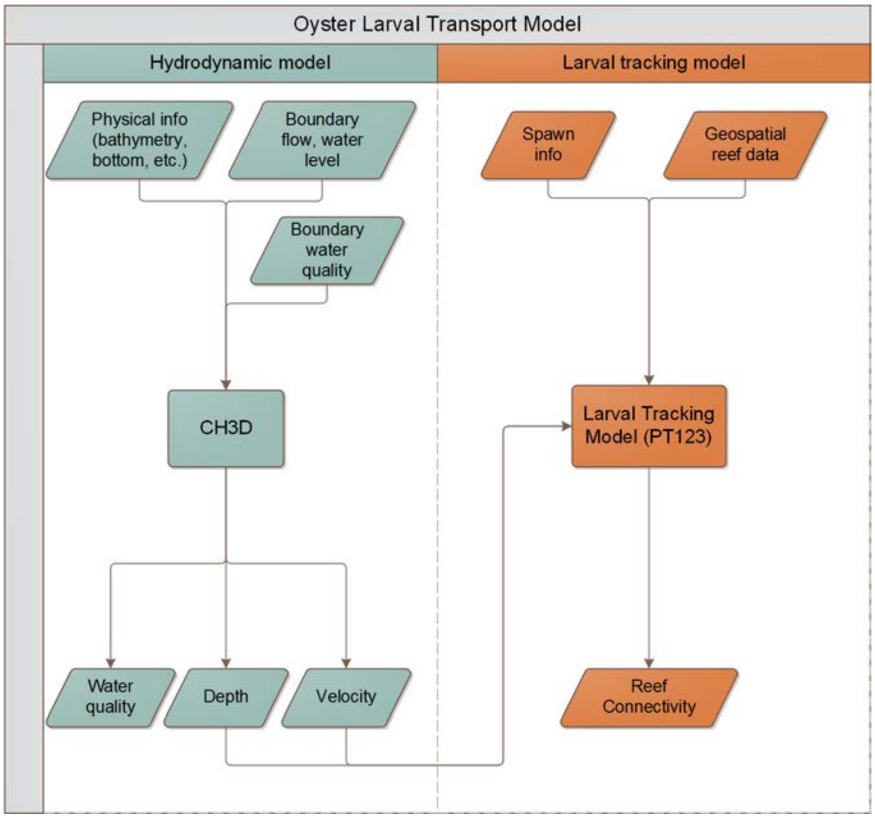

Figure 5.3. Conceptualization of The Model.

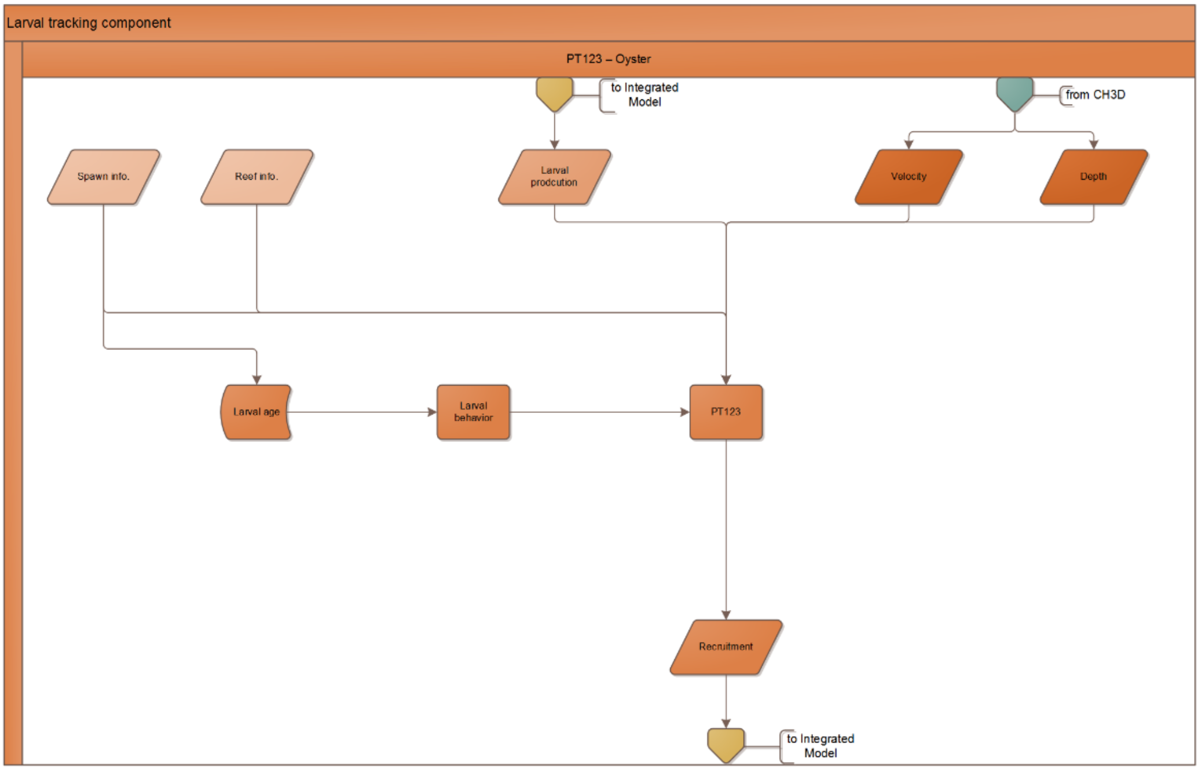

Figure 5.4. Conceptualization of Larval Tracking Model.

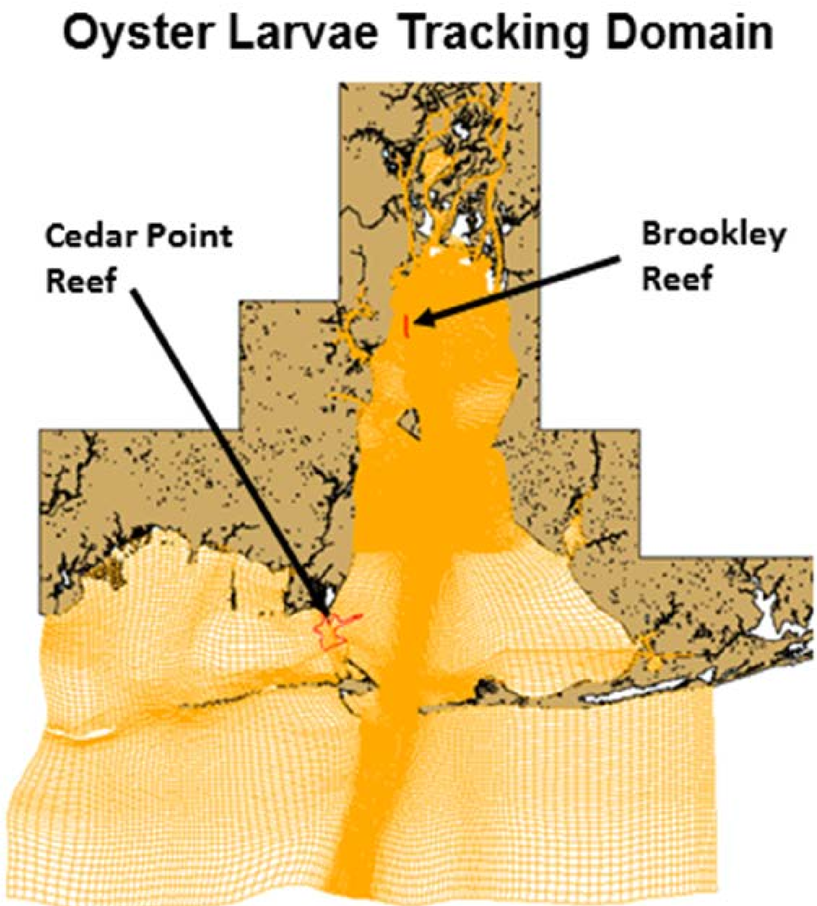

Figure 5.3. PT123 particle tracking modeling grid: Mobile Harbor oyster larvae tracking domain.

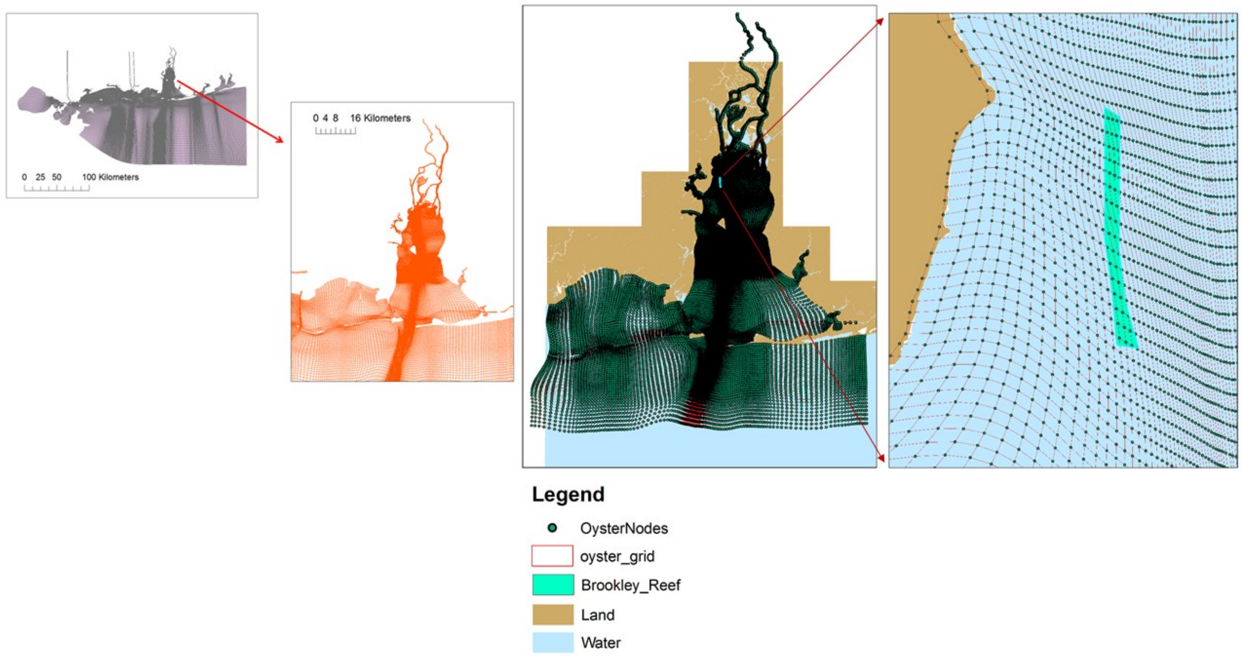

Figure 5.4. Mobile Bay Model Domain.

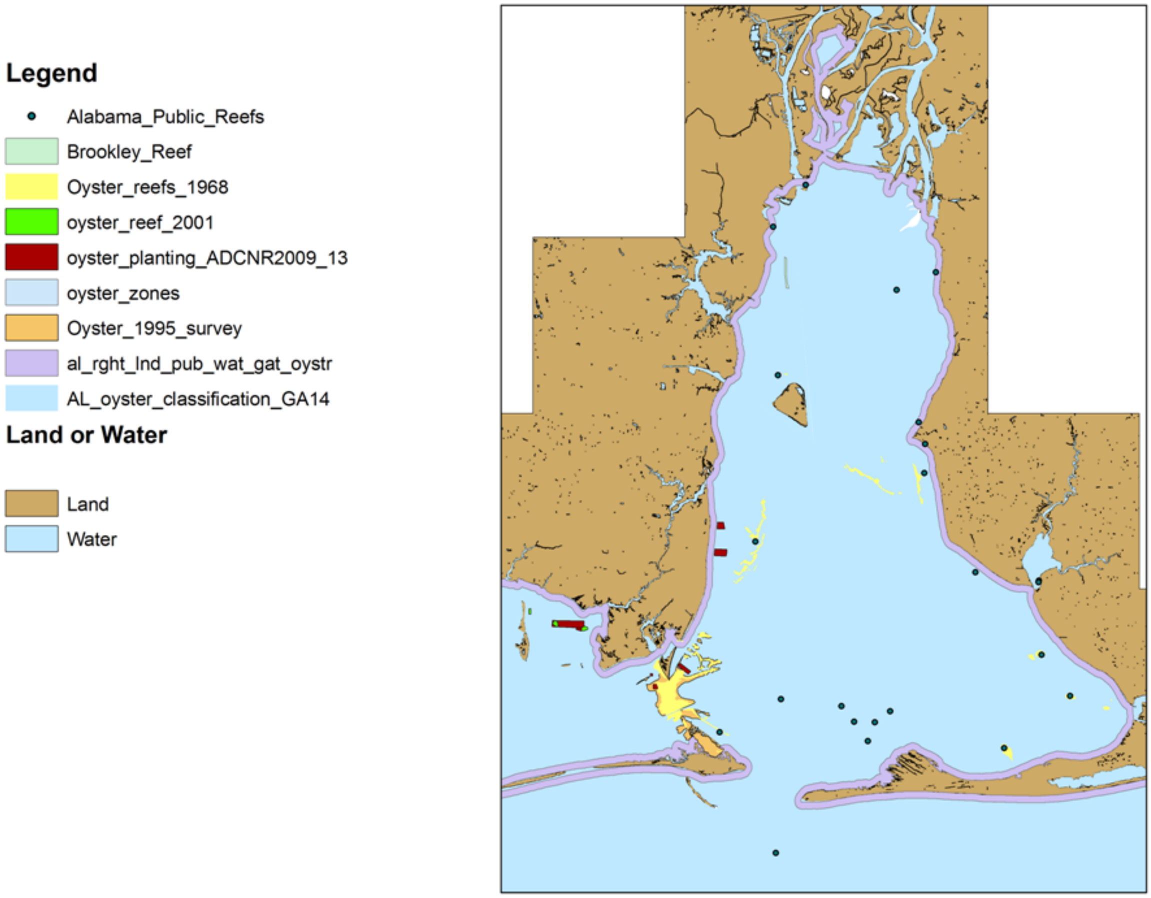

Figure 5.5. Mapped reefs in Mobile Bay Model Domain. The Brookley reef was treated as the source reef for larval tracking modeling. Salinity values at each mapped reefs locations were recorded at each time step of the simulation to determine if thresholds for viable populations had been surpassed.

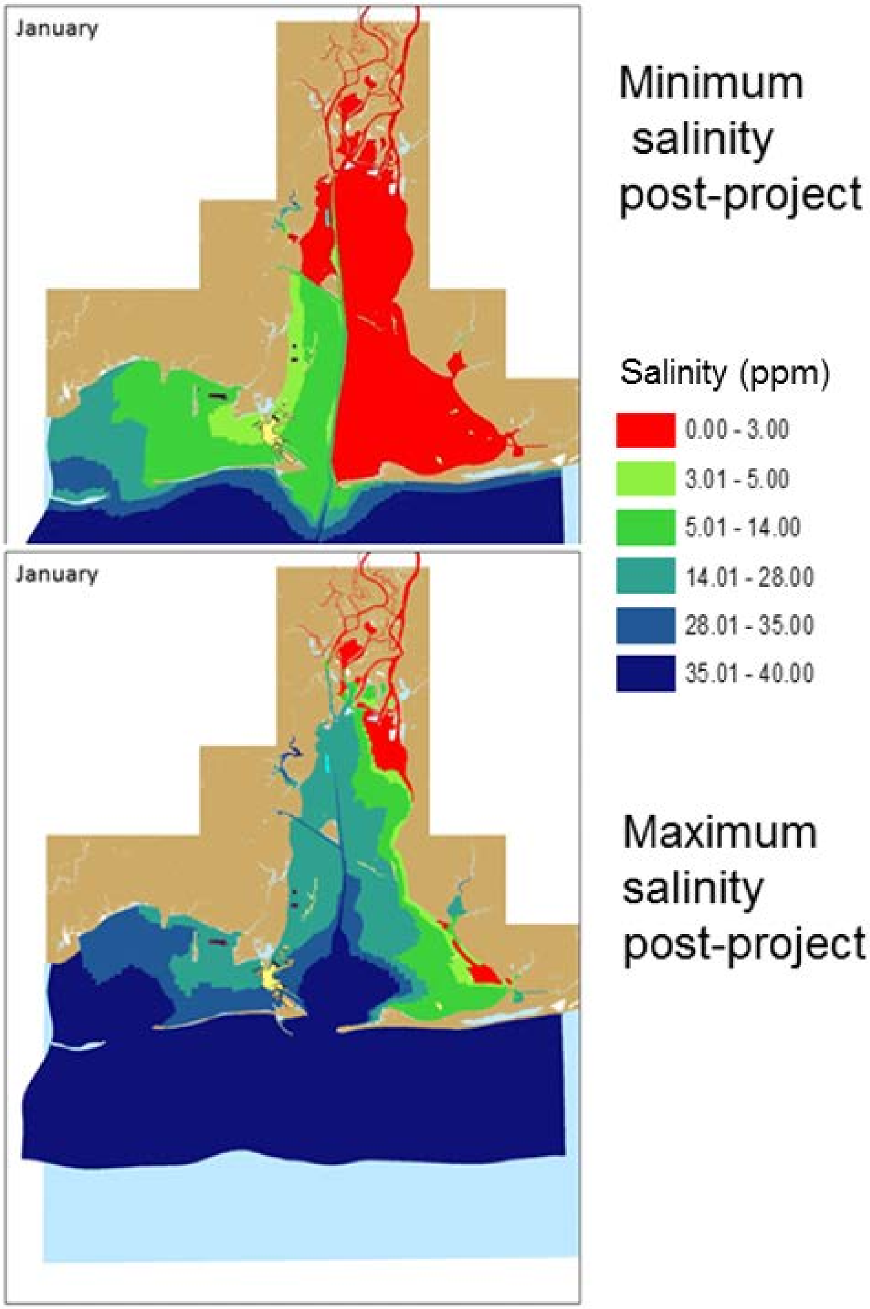

Figure 5.6. PT123 Mobile Harbor oyster larvae tracking domain maximum and minimum salinity post-project.

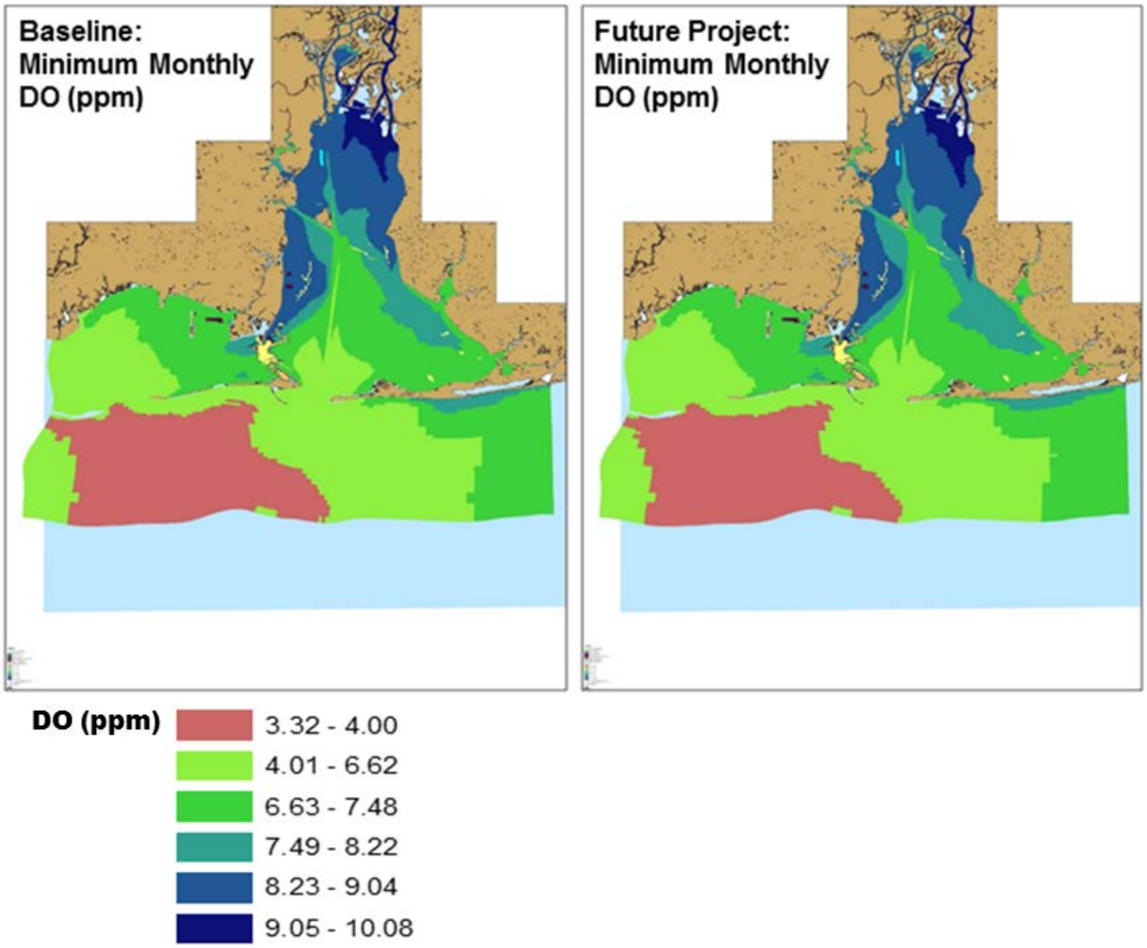

Figure 5.7. PT123 Mobile Harbor oyster larvae tracking domain minimum monthly Dissolved Oxygen (DO) Baseline and Future with Project.

Chapter 6 - Fishery Assessment

Summary

An analysis of potential fishery-related impacts of deepening Mobile Harbor was conducted using data collected in 2016-17 by ERDC and Fisheries Assessment and Monitoring Program (FAMP) database (seine and trawl) collected by the Alabama Department of Marine Resources from 2000-2015. The principal objective was to develop statistical relationships between salinity and fish assemblage structure to establish baseline conditions and evaluate impacts of the project. A total of 2,097,836 individuals representing 162 species were recorded and used in the analysis. Mean abundance was calculated from the overall database for salinity tolerance guilds of the Mobile Bay fish community and included freshwater only, freshwater entering estuary, resident estuary, marine entering estuary, and marine only. Quantile regression was used to calculate statistical relationships between salinity and guild abundance to identify those guilds most susceptible to changes in salinity due to project effects. Two of the guilds showed a narrow range of salinity tolerance: Marine only between approximately 20-33 ppt and freshwater only less than 5 ppt. However, both of these guilds were rarely collected in the Mobile Bay. The three other guilds had a much wider range of salinity utilization suggesting that major changes in salinity were necessary to impact these groups of species. Modelled changes in salinity between baseline and post-project with and without sea level rise ranged from -1.0 to 6.0 ppt with an average of approximately 2.0 ppt. Small changes in salinity indicates that impacts to the Mobile Bay fishery are not expected. The freshwater entering estuary guild is likely the most susceptible to changes in salinity due to project construction, but the range they occupy suggests that salinity differences between baseline and post-project would not impact survival of the Mobile Bay fish community.

6.1 Introduction

Mobile Bay occurs in southwestern Alabama and extends 31 miles from the mouth of the freshwater Mobile-Tensaw River Delta south to its outlet into the Gulf of Mexico. It is one of the largest estuaries in the Gulf of Mexico, draining 70,267 square miles (Mullins et al. 2002). The width of the bay ranges from 8 miles near the mouth of the Mobile River to a maximum of 24 miles where it connects to the intercoastal waterway and Gulf of Mexico. Mobile Bay is relatively shallow with an average depth of approximately 10 feet with daily tide changes averaging 1.6 feet (Mullins et al 2002). The deepest areas of the Bay occur within the shipping channel maintained at 45 feet deep by USACE and can exceed 75 feet at some locations.

Mobile Bay ranks first in in the number of freshwater species in the Southeastern Atlantic and Gulf of Mexico drainages, with a total of 157 species recorded, 40 of which are endemic (Swift et al 1986). Long-term collections in Mobile Bay estuary by the Alabama Marine Resource Division, catalogued in the Fisheries Assessment and Monitoring Program (FAMP) database, list 140 species of estuarine fishes. Mobile Bay is also an important shrimp fishery in the Gulf of Mexico with average monthly harvests approaching 100,000 pounds from August to October (Loesch 1976). High biodiversity reflects the ecological importance of this drainage network, including inflows from the Black-Warrior, Tombigbee, and Alabama Rivers. Habitat complexity in the Bay, including seagrass beds, dunes and interdune wetland swales, saltwater marshes, freshwater wetlands, and bottomland hardwood forests, directly maintains this high biodiversity (Rashleigh et al. 2009).

An interesting phenomenon that occurs in Mobile Bay is referred to as a “jubilee.” First reported by Loesch (1960) and later evaluated by May (1973), jubilees occur in the summer and fall when water becomes anoxic due to decaying plankton blooms and aquatic vegetation driving fish and shellfish towards the shore where oxygen is higher. Aquatic fauna become trapped between the shore and the anoxic water where they are easily harvested. Park et al (2007) further explained that Mobile Bay hypoxia is associated with a large oxygen demand during destratification events, can reoccur within hours to days depending on time of year, and has been identified a one of the priority areas of concern (Rabalais et al 1985). Other impairments to Mobile Bay include erosion, loss of emergent wetlands due to industrial, navigational, and urban development, dredging, and nonpoint source pollution (Roach et al.1987; Duke and Kruczynski 1992).

The ecological importance of Mobile Bay necessitates a complete evaluation of future water resource projects. The Water Resources Development Act of 1986 authorized USACE to deepen the Mobile Harbor as follows: deepening and widening of the entrance channel to 57 feet by 700 feet, and deepening and widening of the Mobile Bay channel from the mouth to south of Mobile River to 55 feet by 550 feet, for a total of 27 miles; deepening and widening an additional 4.2 miles of the Mobile Bay channel to 55 feet by 650 feet; and a 55-foot deep anchorage and turning basin in the vicinity of Little Sand Island. Portions of the authorized project have been constructed including deepening of the entrance channel to 47 feet by 600 feet and extending the upper channel by 4,600 feet to a depth of 45 feet. Changes in depth may alter salinity patterns in the surrounding estuarine ecosystem and impact fish and other faunal groups. The objectives of the fishery assessment was to establish baseline conditions in the project area including species distribution and abundance, and evaluate relationships between salinity and fish assemblage structure to predict potential environmental impacts on this resource.

6.2 Methods

Fish were collected during September 2016 to evaluate recruitment and growth and May 2017 to evaluate the spawning period and young-of-year survival. The purpose of these collections were to establish baseline conditions and become familiar with the project area. ERDC conducted sampling in the freshwater, transition and upper bay zones for a total of 11 sites utilizing the same gear and protocol as with the Fisheries Assessment and Monitoring Program (FAMP) database (seine and trawl). Our sampling efforts in the upper bay zone was conducted to provide complementary data in that zone and to also aide in calibrating our efforts in the transition and freshwater zones with comparable efforts in the remaining zones. Data used for the fishery analysis encompassed 2000-2015, and ERDC data collected in 2016 and 2017.

A map depicting the sample station distribution (overall map with two insets) was created that illustrates the FAMP stations historically and currently sampled by Alabama Marine Resources Division (1981-present) as well as the location of the ERDC samples. The inclusion of all FAMP data provides a visual aide supporting the breadth of geographic coverage represented by the data. However, despite the broad geographic coverage represented by their database, we only included those stations that were located within the footprint of the model grid to be used as snapshots of modeled environmental parameters within the project area (Figure 6.1).

Physical Model

All sample stations (ERDC and FAMP) were plotted in ArcMap with the addition of a 500 m buffer to capture the variability in environmental conditions for any given sample. For the ERDC samples, we also included the buffer around the entire length of each trawl sample to capture the habitat variability associated with each effort. We then added the model grid layer to the ArcMap project for each modeled environmental parameter: bottom and mean salinity (with and without sea level rise) and bottom and mean dissolved oxygen (without sea level rise). The intersecting cells from the respective model grid and the station buffer layer were extracted for evaluation of project impacts (Figure 6.2).

The initial model output provided for use for the fisheries assessment included modeled baseline conditions, with project conditions and the numerical difference (change) between baseline and project values. Basic summary statistics were generated (i.e., mean, minimum, maximum, standard deviation, percentile) for each modeled cell within the grid and for each respective condition. We utilized the MAX-DIFF value (maximum value of difference between baseline and project values per cell) to evaluate potential project impacts. We chose this parameter to illustrate a worst case scenario with regard to changes in salinity and dissolved oxygen due to the project.

Fish Model

Fish were collected by trawling and seining. A two-seam, 16-ft otter trawl was used to sample benthic fish over a range of water depths. A total of 2-5 trawl samples were taken at each site. The body of the trawl was made of 1⅜-inch webbing and the cod end liner was 3/16-inch mesh to retain smaller bodied individuals. Trawling occurred in water depths ranging from 5 to over 30 ft. The length of the tow lines were about three-times the water depth to ensure that the footrope of the trawl remained along the bottom. A tickler chain was attached to the footrope to disrupt the substrate and increase catch efficiency of benthic organisms. The net was deployed from the bow followed by the otter boards as the boat slowly backed up. Any twists or crossing of the ropes were corrected during deployment. A float line was tied to the cod end in case the trawl became entangled on underwater obstructions. If entangled, a trailer boat grabbed the float line and slowly backed up lifting the trawl from the obstruction; the sample was usually discarded. A GPS recorded average speed and distance travelled during a 10-minute trawl sample, which was the duration used for the FAMP data. The trawl was retrieved after completion of the sample and contents of the cod end was emptied into a sorting container.

A 50 x 4 ft., 3/16-inch mesh knotless bag seine was used to sample shoreline fish and shellfish. One seine haul was taken per site, which was the same effort used for the FAMP data. Two people carried the seine out from the shoreline 60-ft, then moved parallel to the shore a short distance to avoid disrupting the sample area. The 60-ft distance was confirmed by a person with a range finder standing along the shoreline. The seine was unfurled and hauled towards the shoreline ensuring that the lead line was in full contact with the substrate. In structurally-complex areas (e.g., vegetation), a third person was located behind the mid-section of the seine in case the lead line became entangled on a snag. If entangled, the third person reached down and pulled back the lead line usually freeing the net from the snag. If the seine was readily freed, the sample was discarded and an adjacent site was sampled. Once the shoreline had been reached by the seiners, the wings of the seine was shaken down until all organisms are in the bag area where they were removed.

All organisms collected by trawl and seine were identified to species or the lowest practical taxon, enumerated, and measured. Large-bodied fish and shellfish were released at the point of capture after processing. Smaller bodied fish, shellfish, and other invertebrates were preserved in 10% formaldehyde and processed in the laboratory. A label was placed in each sample container including location, date, and sample number. Total length was measured for all fish. Carapace or disc width were measured for crabs, anemone, and other shellfish. Mantle length was measured for squids.

Physical and water quality habitat measurements were taken in conjunction with fishery collections at each site. A GPS location was recorded at each sampling site. Surface and bottom water quality were measured using a calibrated YSI multi-parameter meter and included temperature, pH, conductivity, salinity, and dissolved oxygen. Depth was recorded from boat-mounted transducers, and surface velocity was measured using a Marsh-McBirney flow meter. Substrate type (i.e., sand or mud/silt) was visually assessed from otter boards or using a stadia rod to probe the bottom.

All data, including FAMP from 2000-2005 and ERDC from 2016-17, were transferred to Excel spreadsheets and analyzed using the Statistical Analysis System 9.4. Salinity tolerance for project alternatives was the principal focus of the analysis. Salinity tolerance guilds of the fish community in Mobile Bay study areas were identified according to the Gulf Coastal Research Laboratory publication by Christmas (1973) following the recommendations by Elliott et al (2007). Guilds included: freshwater only, freshwater entering estuary, resident estuary, marine entering estuary, and marine only. Guilds representing species that are anadromous, catadromous, and freshwater introduced were not included. Mean abundance by guild was calculated prior to curve fitting techniques in SAS 9.4 (SAS 2013. Abundance was log transformed (log_{10} +1) to account for outliers and skewed data to approximate normality.

The physical model was used to predict changes in salinity gradients for baseline and alternatives. Therefore, relationships between salinity and guild abundance were evaluated using quantile regression using the sparsity method for confidence limits (SAS 2013). Species abundance-habitat relationships are typically skewed with zero-inflated count data, contains outliers, and does not meet the assumptions of normality required for linear regression (Terrell et al. 1996; Vaz et al 2008). Quantile regression is a non-parametric method of modeling response variables when assumptions of ordinary least squares regression are not met. It estimates multiple rates of change (slopes) from the minimum to maximum response, providing a more complete picture of the relationships between variables missed by other regression methods (Cade and Noon 2003). The 0.90 regression quantile was considered in model development, which represents the upper bounds of species–environment relationships and thus estimates how the environment is limiting the distribution of a species (Vaz et al. 2008). We used diagnostic options in SAS 9.4

6.3 Results and Discussion

Physical Model

Extracted cells from the model grid based on the intersect with the station buffer GIS layers ranged 132,216 – 159,801 cells per run depending on the chose environmental parameter (salinity, dissolved oxygen), parameter status (mean, bottom) and project condition (with/without sea level rise). The MAX-DIFF values for mean salinity without sea level rise ranged -1.961 to 5.821 with a mean value of 0.942 (95% CI: 0.00306) and a median value of 0.965. Bottom salinity for the same condition had similar values (range: -1.599 to 5.827; mean: 0.562 (95% CI: 0.00304); median: 0.633) although modeled mean salinity exhibited a greater range in values, the largest proportion were within the 0-2 MAX-DIFF range (Figure 6.3).

Figure 6.4 illustrates the seasonal variability in modeled output at each sample station for mean salinity without sea level rise. Some stations illustrate a wide range of salinity conditions through a typical water year; other vary less implying some underlying geographic pattern (e.g., transition, upper, middle or lower bay). However, the overwhelming majority of the values for mean salinity are below the 2 ppt threshold suggesting little concern for impact. Those values exceeding 3 ppt were projected for January – May and were associated primarily with Little Sand Island adjacent to the current shipping channel. A similar pattern was exhibited for bottom salinity (without sea level rise) (Figure 6.5.) with few stations exceeding the 3 ppt salinity threshold.

Salinity changes evaluated under the "with sea level rise" condition exhibited a narrower range in MAX-DIFF values for both mean (range: -1.655 to 6.370; mean: 0.872 (95% CI: 0.00275); median: 0.887) and bottom salinity (range: -1.473 to 6.248; mean: 0.489 (95% CI: 0.00275; median: 0.536) conditions (Figure 6.6). There was a slight reduction in central tendencies of the dataset for both mean (mean: 0.942 vs 0.872; median: 0.965 vs 0.887) and bottom salinity (mean: 0.562 vs 0.489; median: 0.633 vs 0.536) when considering comparisons to values generated under both project conditions (with/without sea level rise. However, the distribution of extracted model values from each condition were not significantly different (mean salinity KS test, $D = 0.17722$, $p = 0.1672$; bottom salinity KS test, $D = 0.088608$, $p = 0.9157$) (Figure 6.7, 8) indicating no appreciable differences in salinity values between current conditions and those projected under the sea level rise scenario.

Conditions for dissolved oxygen (without sea level rise) showed a smaller range in variability in the extracted values for both mean (range: -0.897 to 0.974; mean: -0.129 (95% CI: 0.000952); median: -0.107) and bottom conditions (range: -0.723 to 2.385; mean: 0.382 (95% CI: 0.00344; median: -0.0149) compared to responses of salinity under similar conditions. The distribution of extracted values for dissolved oxygen were significantly different (KS test, $D = 0.53582$, $p = 0.000003077$) between mean water column and bottom conditions (Figure 6.9). Bottom conditions experienced less variability with 98% of the MAX-DIFF values occurring between -0.5 and 0.5 indicating little projected change in dissolved oxygen levels for benthic oriented fishes. In contrast, 70% of the MAX-DIFF values for mean water conditions occurred between -

0.5 and 0.5. Nearly 29% of the values exceeded the 0.05 mg/L MAX-DIFF condition with 1% exceeding the 2.0 mg/L MAX-DIFF condition. These results suggest overall changes in dissolved oxygen are likely to occur, but the extent of change will likely be minimal and expressed in reduced spatial and/or temporal basis.

Fish Model

Almost 1200 measurements of salinity and dissolved oxygen were taken during fish collections by both Alabama Marine Resources Division and ERDC (Table 6.1). A salinity gradient occurred among zones with the lower bay averaging 23 ppt, the middle bay at 12 ppt, upper bay at 8.9 ppt, transition zone at 3.7 ppt, and the freshwater sites at 0.1 ppt. Mean dissolved oxygen was approximately 7.0 mg/l at all zones. However, hypoxia (minimum dissolved oxygen) was measured at all zones except for the transition and freshwater zones. Higher dissolved oxygen in the two latter zones may have been due to the low sample size compared to Mobile Bay.

A total of 2,097,836 individuals representing 162 species were recorded and used in the analysis. Species were classified according to the salinity tolerance guilds (Table 6.2). The most speciose assemblage was represented in the marine entering freshwater guild, indicating the importance of the Mobile Bay to this group of fishes. This guild was dominated by three species comprising 79% of the total number of individuals: Spot, Gulf Menhaden, and Atlantic Croaker. The freshwater estuarine guild was next in number of species (21) with a total of 10,315 individuals. Three species comprised 75% of the total number of individuals: Sailfin Molly, Threadfin Shad, and Blue Catfish. The resident estuarine guild had 20 species comprised of 891,773 individuals, but the Bay Anchovy was overwhelming dominate making up 94% of the total. The freshwater only guild had 13 species dominated by Silverside shiner comprising 94% of the total. However, small sample size at these locations contributed to fewer number of species. The marine only guild had nine species, with Red Snapper comprising 91% of the total.

The relationship between guild abundance and salinity was portrayed as a box and whisker plot (Figure 6.10). To avoid a dominance biased analysis, the following species were not used in the evaluation of salinity: Bay anchovy, Spot, Gulf Menhaden, Atlantic Croaker, Pinfish, Spotfin Mojarra, and Inland Silverside. Two of the guilds showed a narrow range of salinity tolerance:

Marine only between approximately 20-33 ppt and freshwater only less than 5 ppt. However, both of these guilds were rarely collected in the Mobile Bay. The three other guilds had a much wider range of salinity utilization suggesting that major changes in salinity were necessary to impact these groups of species.

Quantile regression models were developed seasonally for each guild further supporting the wide tolerance range of most species that occur in Mobile Bay (Figure 6.11). The mean abundance of freshwater entering estuary guild was negatively correlated to salinity, whereas the marine entering estuary and marine only were positively correlated. The resident estuarine model suggested little to no correlation with salinity indicating their overall tolerance and ability to osmoregulate as they move between salinity gradients. Given these relationships, and the physical model results presented previously, impacts to the Mobile Bay fishery are not expected. The freshwater entering estuary guild is likely the most susceptible to changes in salinity due to project construction, but the range they occupy suggests that differences between baseline and project alternative with and without sea level rise would have to much greater than the physical model suggests.

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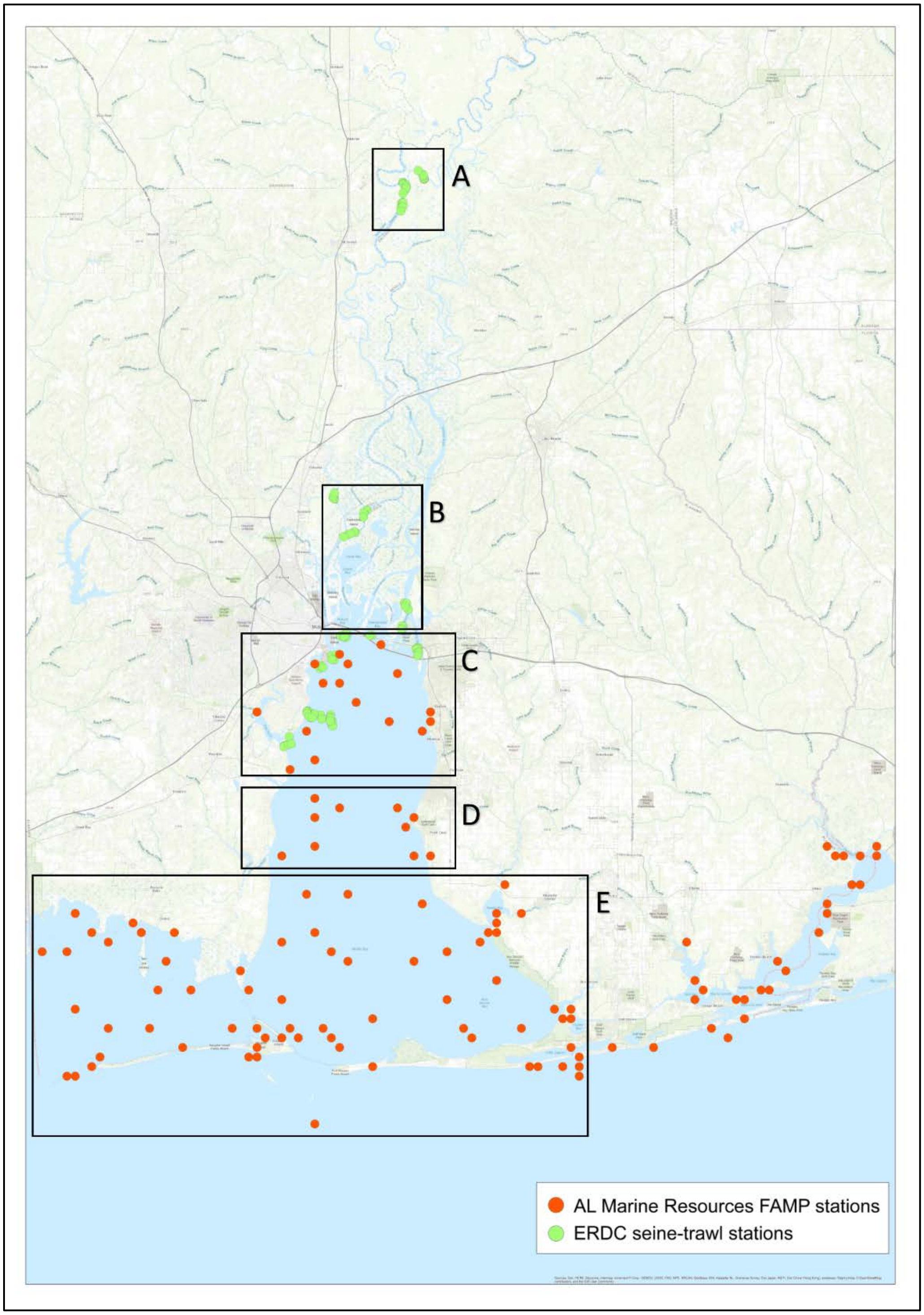


Figure 6.1. Distribution of ERDC sample stations (green) and Alabama Marine Resources FAMP stations (red) utilized for fisheries assessment. Zones within the project area are coded as freshwater (A), transition (B), estuarine-upper bay (C), middle bay (D) and lower bay (E).

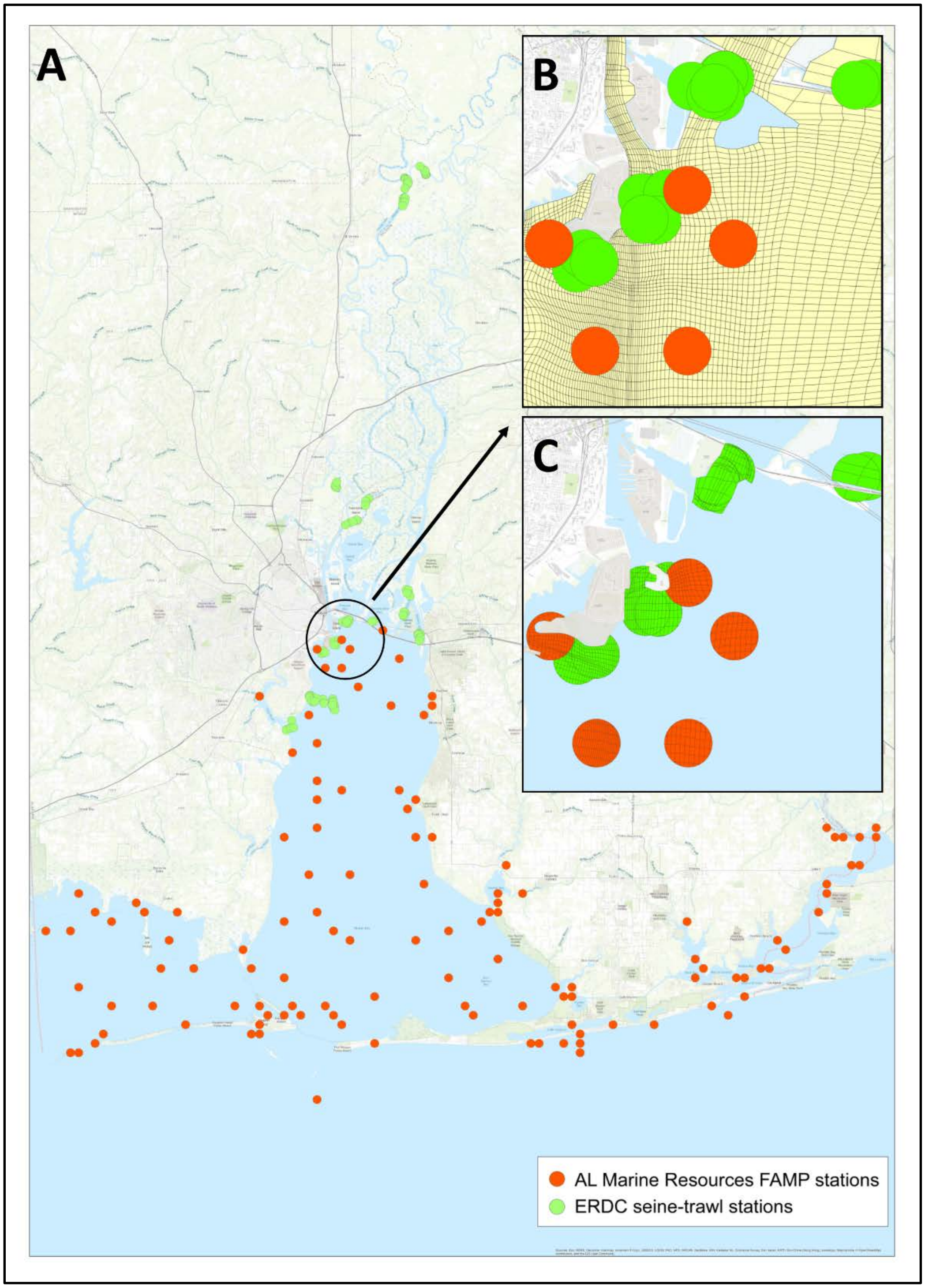


Figure 6.2. Distribution of ERDC sample stations (green) and Alabama Marine Resources FAMP stations (red) utilized for fisheries assessment (A). Panel B highlights a portion of the upper bay zone which depicts the station buffer layer and model grid. Panel C illustrates the extracted model grid cells for the corresponding sample stations.

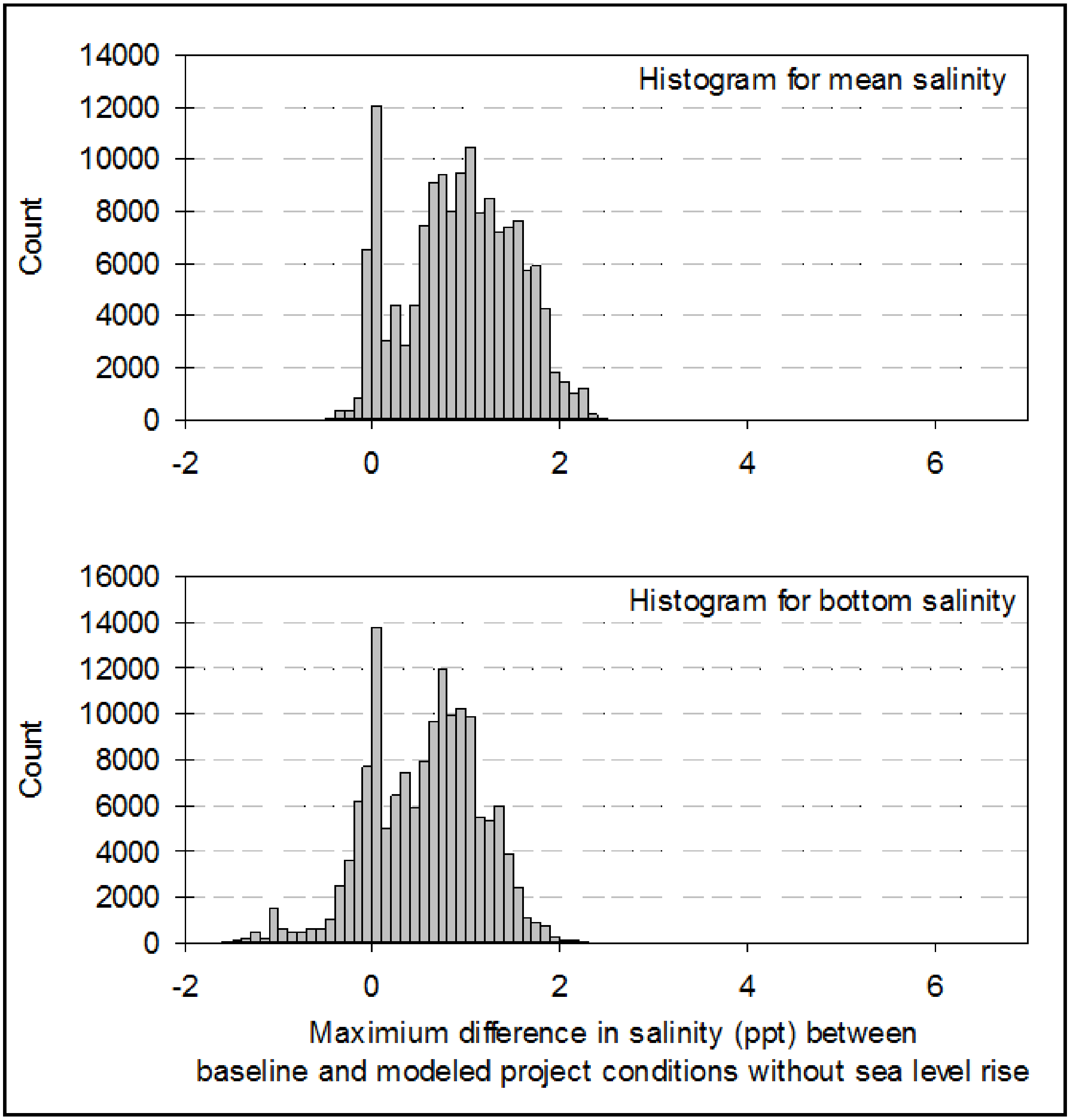


Figure 6.3. Maximum difference in model output between baseline and project conditions without sea level rise for mean and bottom salinity environmental parameters. Output values are based on intersect procedure between model grid and sample stations.

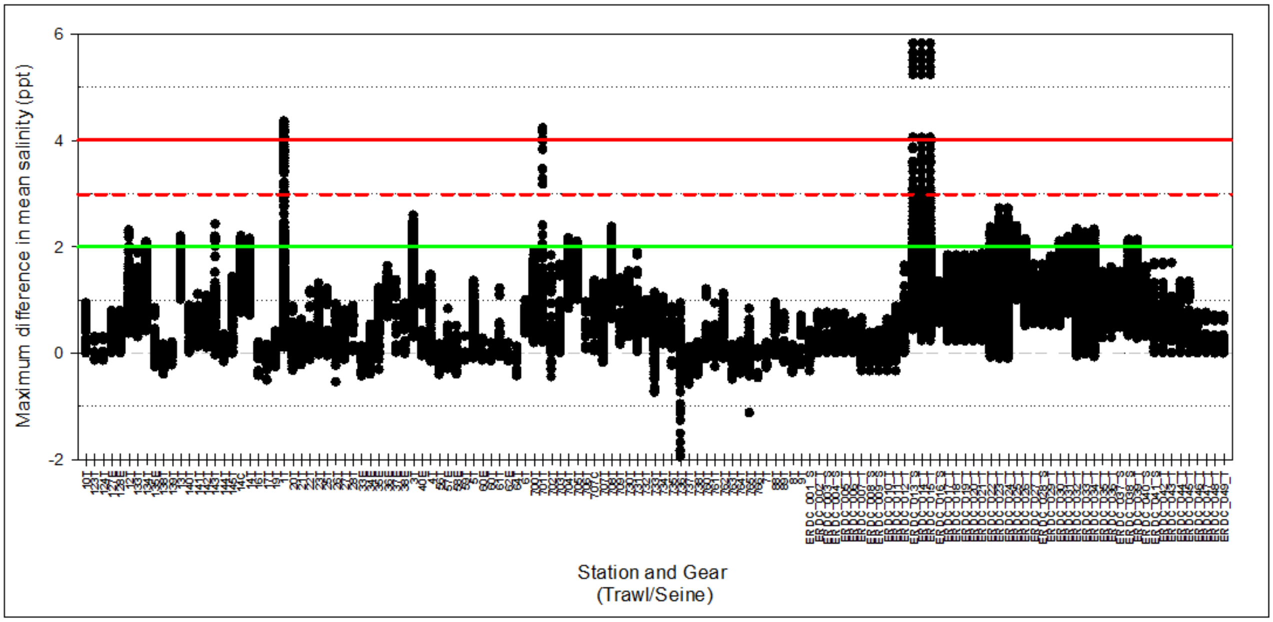


Figure 6.4. Model output for mean salinity (water column) with maximum difference in salinity (ppt) between baseline and modeled project conditions for all months at each designated AL Marine Resources and ERDC sample stations. For each station, the vertical row of dots represents all of the intersected cells from the model grid across all months. The stations are arranged alphabetically by station number and there is no geographic perspective (i.e., upper, middle or lower bay) portrayed by the order of the stations. Salinity thresholds are portrayed at 2 (horizontal green line), 3 (horizontal dashed red line) and 4 ppt (solid horizontal red line).

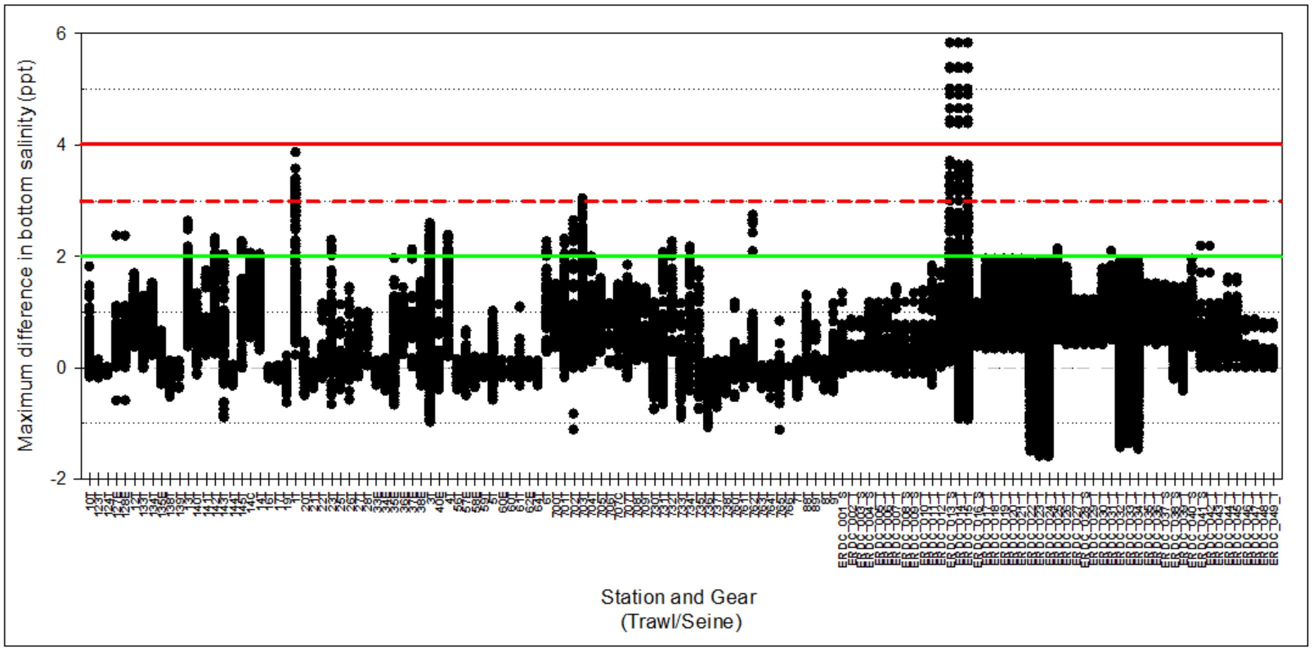


Figure 6.5. Model output for bottom salinity (lower third of water column) with maximum difference in salinity (ppt) between baseline and modeled project conditions for all months at each designated AL Marine Resources and ERDC sample stations. For each station, the vertical row of dots represents all of the intersected cells from the model grid across all months. The stations are arranged alphabetically by station number and there is no geographic perspective (i.e., upper, middle or lower bay) portrayed by the order of the stations. Salinity thresholds are portrayed at 2 (horizontal green line), 3 (horizontal dashed red line) and 4 ppt (solid horizontal red line).

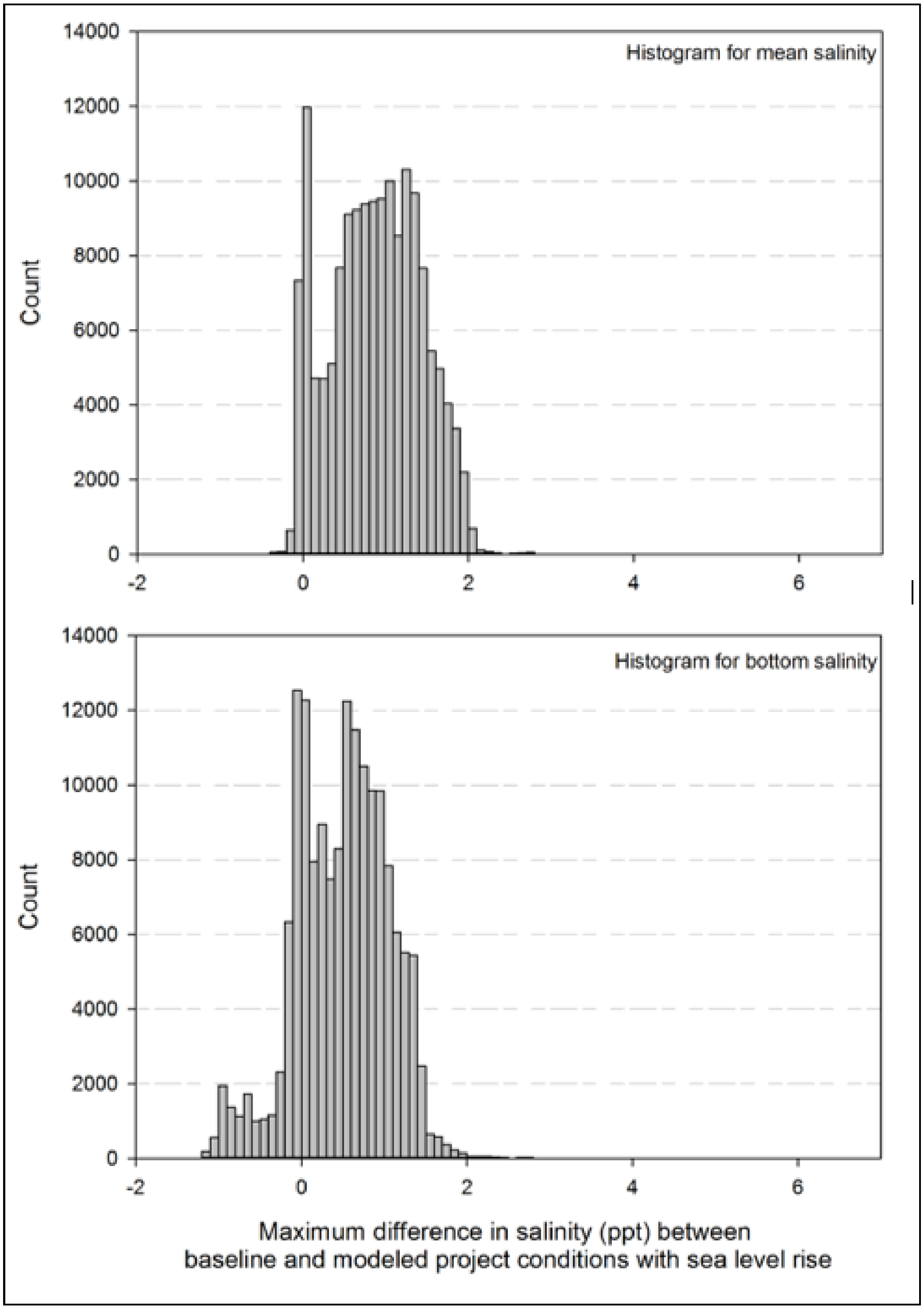


Figure 6.6. Maximum difference in model output between baseline and project conditions with sea level rise for mean and bottom salinity environmental parameters. Output values are based on intersect procedure between model grid and sample stations.

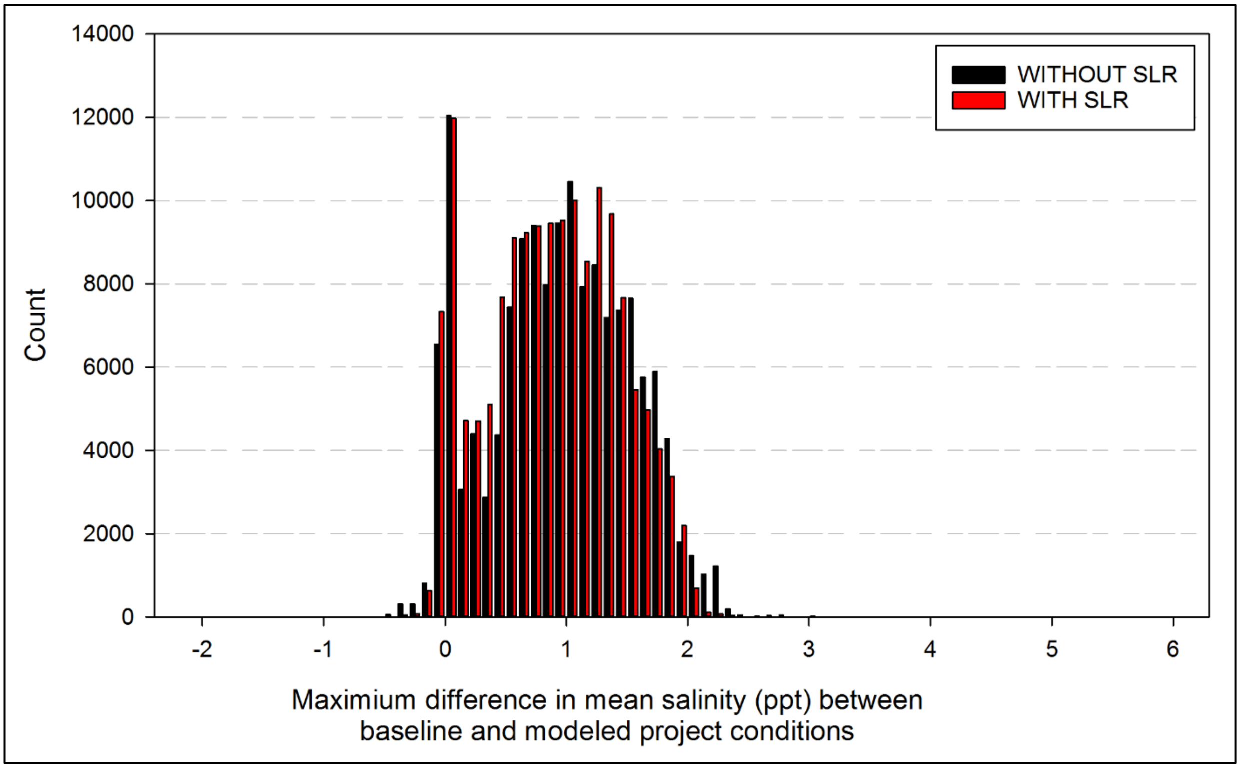


Figure 6.7. Comparative distribution for without and with sea level model projections regarding maximum differences in computed mean salinity values (ppt) between baseline and modeled project conditions.

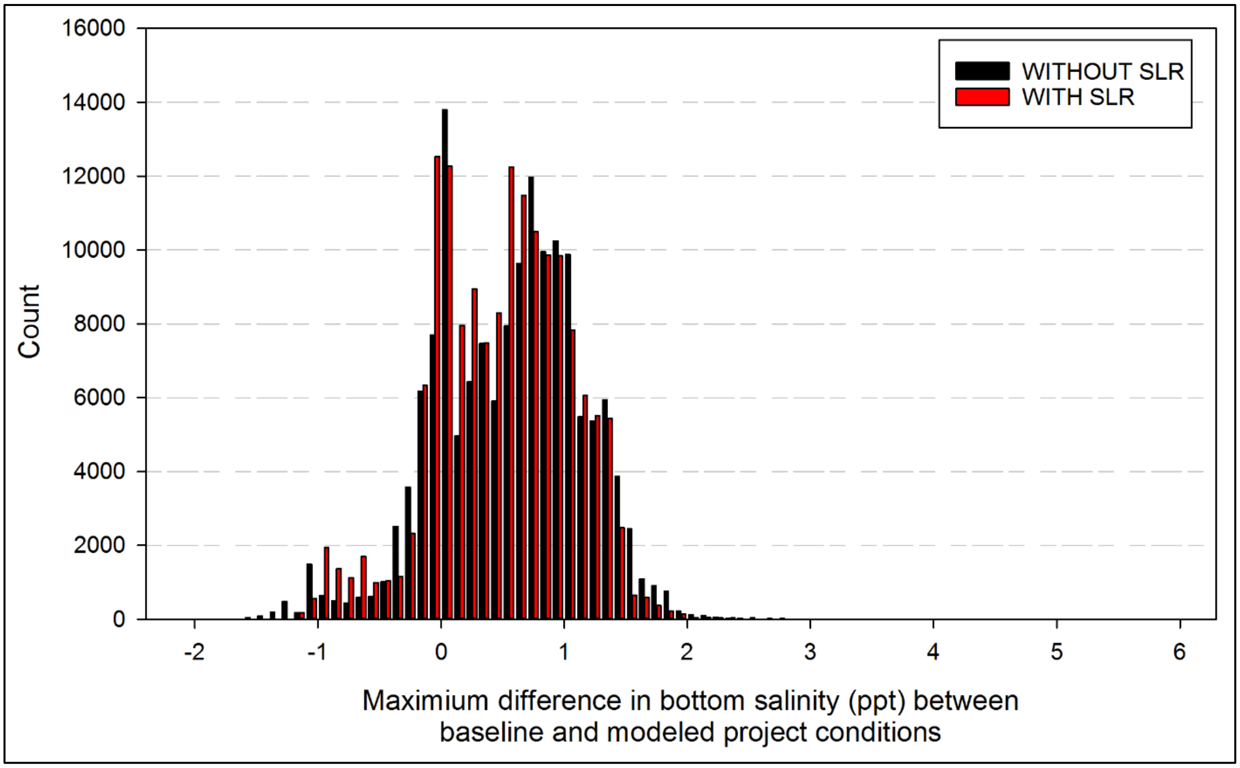


Figure 6.8. Comparative distribution for without and with sea level model projections regarding maximum differences in computed bottom salinity values (ppt) between baseline and modeled project conditions.

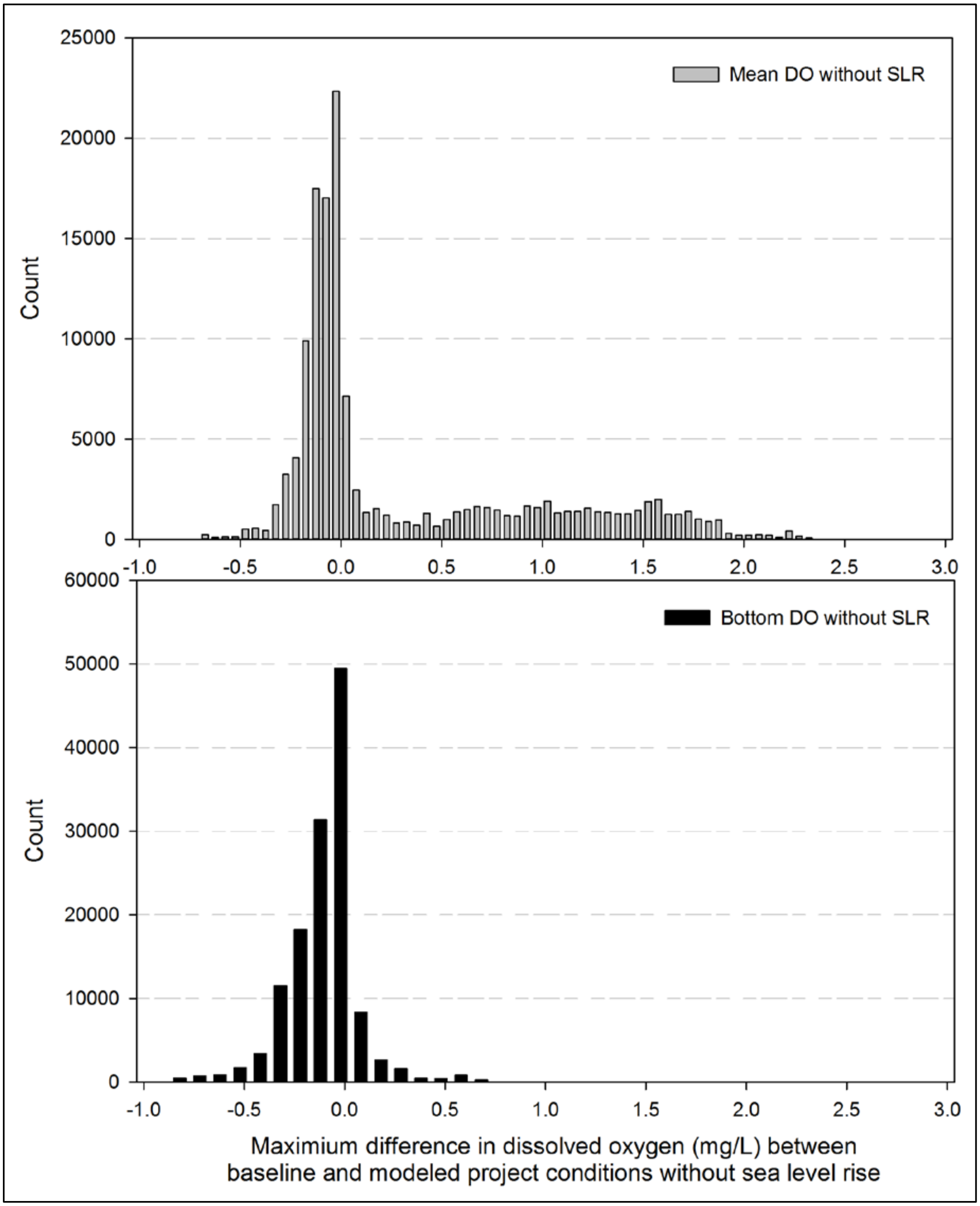


Figure 6.9. Maximum difference in model output between baseline and project conditions without sea level rise for mean and bottom dissolved oxygen environmental parameters. Output values are based on intersect procedure between model grid and sample stations.

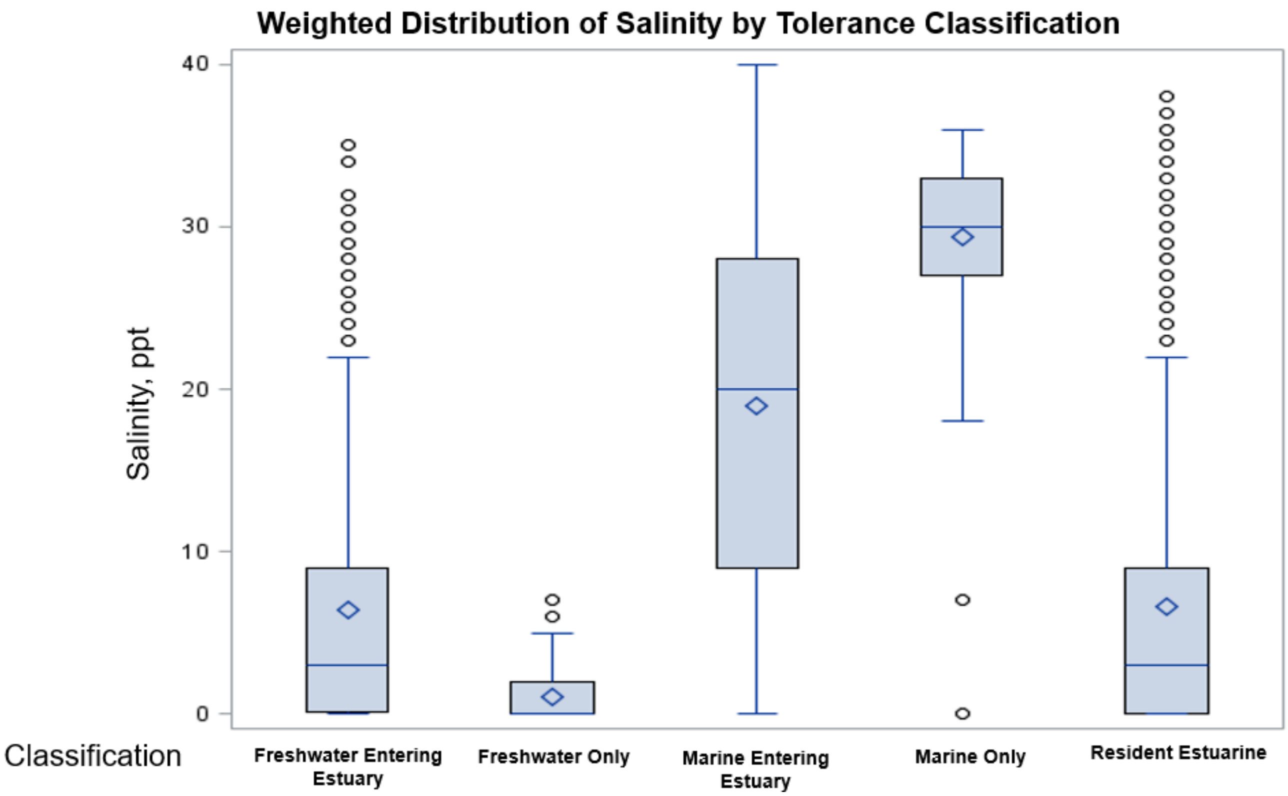
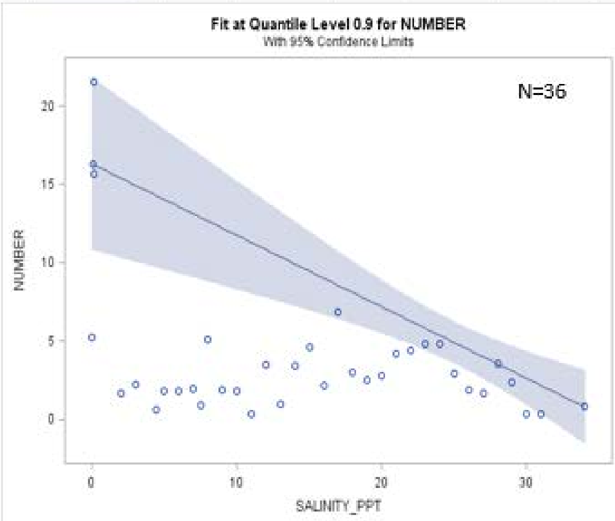


Figure 6.10. Box and whiskers plot of the weighted distribution of fish and shellfish by salinity tolerance classification in the Mobile Bay project area. Data based on FAMP and ERDC collections from 2000-2017. Each box includes mean weighted abundance (diamond), median (horizontal line inside box), first and third quartile (lower and upper edge of box, respectively) and minimum and maximum values (endpoint of lower and upper whisker, respectively). Circles represent extreme values outside of the normal distribution.

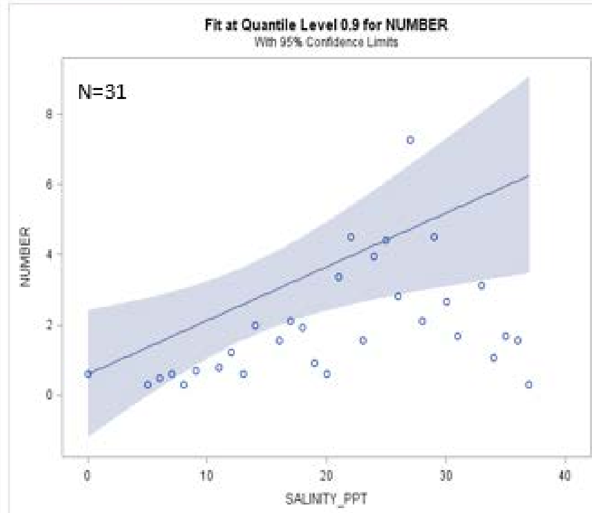
SEASON=Fall CLASSIFICATION=Freshwater entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	16.3051	2.7515	10.7134	21.8969	5.93	<.0001
SALINITY_PPT	1	-0.4567	0.1068	-0.6738	-0.2395	-4.27	0.0001



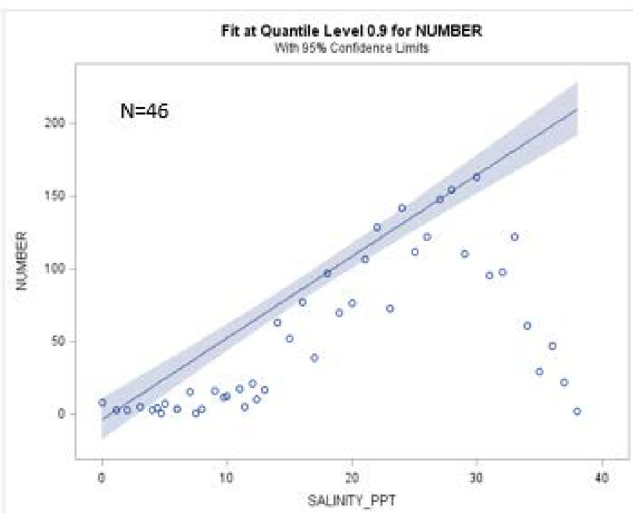
SEASON=Fall CLASSIFICATION=Resident estuarine

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	0.6021	0.8995	-1.2377	2.4418	0.67	0.5086
SALINITY_PPT	1	0.1528	0.0548	0.0408	0.2648	2.79	0.0092



SEASON=Fall CLASSIFICATION=Marine entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	-3.7033	7.1645	-18.1423	10.7357	-0.52	0.6078
SALINITY_PPT	1	5.6069	0.3731	4.8550	6.3588	15.03	<.0001



SEASON=Fall CLASSIFICATION=Marine only

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	-5.7755	0.4258	-6.7127	-4.8384	-13.56	<.0001
SALINITY_PPT	1	0.3218	0.0164	0.2857	0.3579	19.62	<.0001

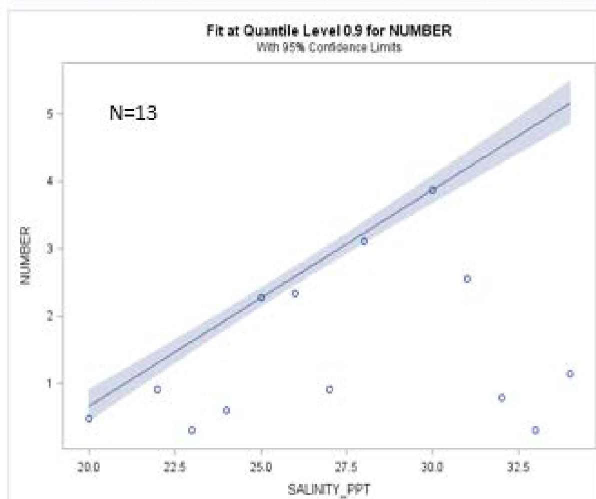
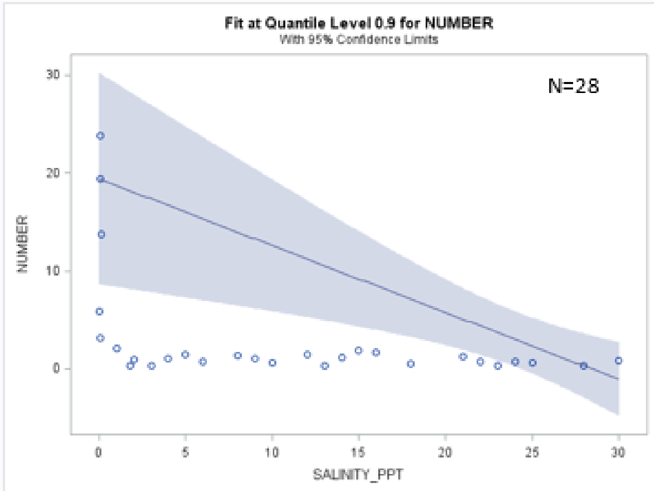


Figure 6.11. Quantile regression between numbers of fish classified according to salinity tolerance and salinity in ppt. The line indicates the 90% quantile and the shaded portion is the 95% confidence interval around the regression line. Parameter estimates are provided along with the probability of significance. Figures are shown by season.

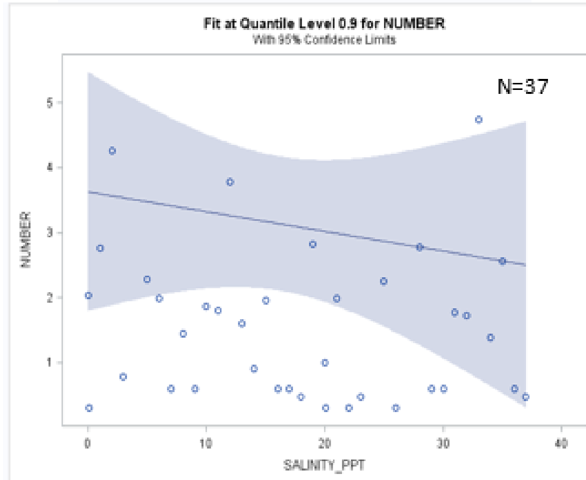
SEASON=Spring CLASSIFICATION=Freshwater entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	19.4019	5.3415	8.4224	30.3814	3.63	0.0012
SALINITY_PPT	1	-0.6822	0.2128	-1.1195	-0.2448	-3.21	0.0035



SEASON=Spring CLASSIFICATION=Resident estuarine

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	3.6274	0.9176	1.7646	5.4902	3.95	0.0004
SALINITY_PPT	1	-0.0303	0.0468	-0.1252	0.0646	-0.65	0.5208



SEASON=Spring CLASSIFICATION=Marine entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	26.3135	3.4457	19.3646	33.2623	7.64	<.0001
SALINITY_PPT	1	1.0889	0.2297	0.6256	1.5522	4.74	<.0001

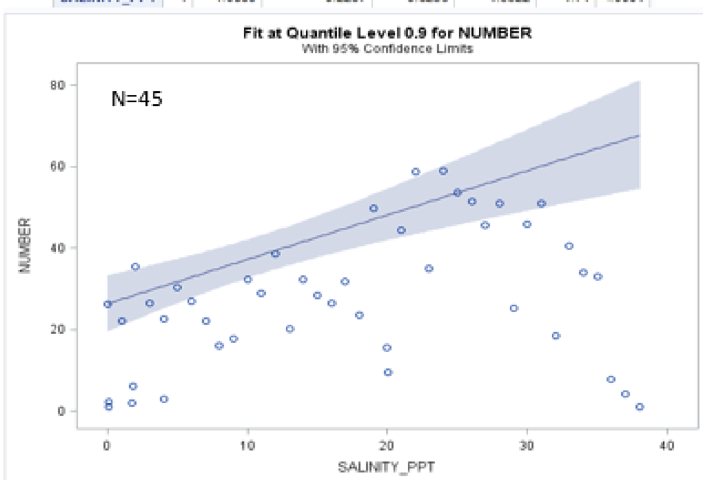
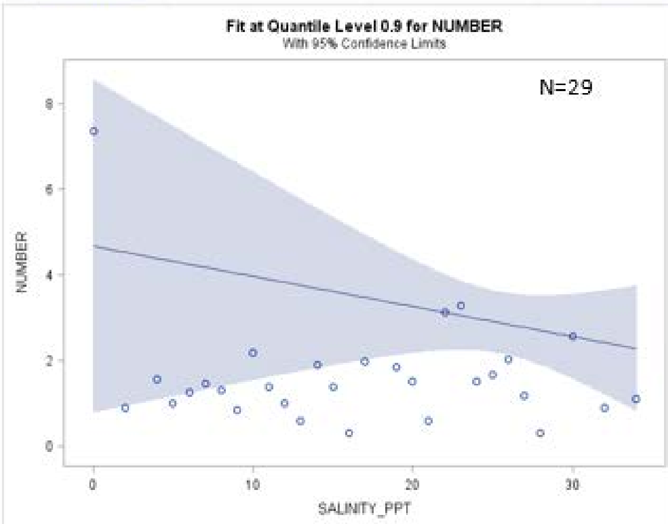


Figure 6.11. (Continued)

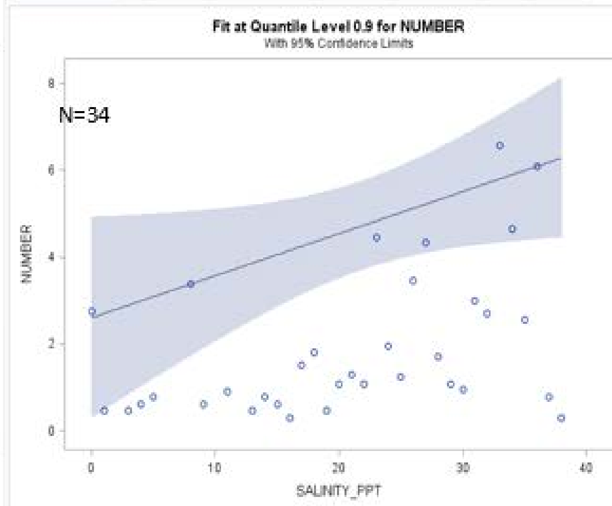
SEASON=Summer CLASSIFICATION=Freshwater entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	4.6754	1.9289	0.7176	8.6332	2.42	0.0223
SALINITY_PPT	1	-0.0703	0.0743	-0.2227	0.0821	-0.95	0.3521



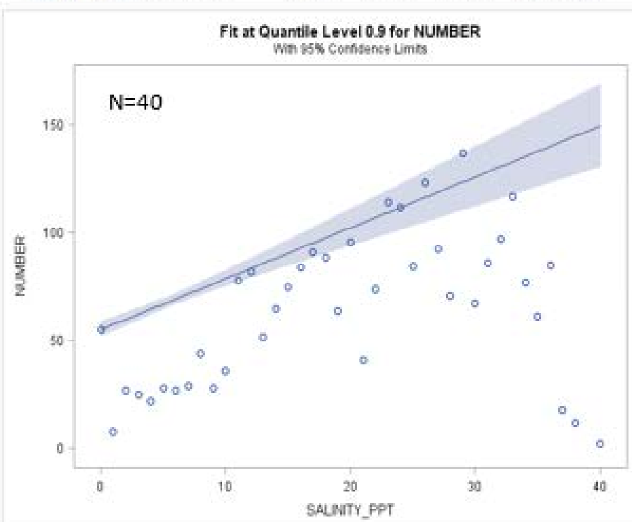
SEASON=Summer CLASSIFICATION=Resident estuarine

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	2.6055	1.1533	0.2562	4.9547	2.26	0.0308
SALINITY_PPT	1	0.0968	0.0473	0.0006	0.1931	2.05	0.0487



SEASON=Summer CLASSIFICATION=Marine entering

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	55.1491	1.8615	51.3806	58.9176	29.63	<.0001
SALINITY_PPT	1	2.3624	0.2720	1.8118	2.9130	8.69	<.0001



SEASON=Summer CLASSIFICATION=Marine only

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	-0.2756	1.9123	-4.4421	3.8910	-0.14	0.8878
SALINITY_PPT	1	0.1075	0.0699	-0.0448	0.2599	1.54	0.1501

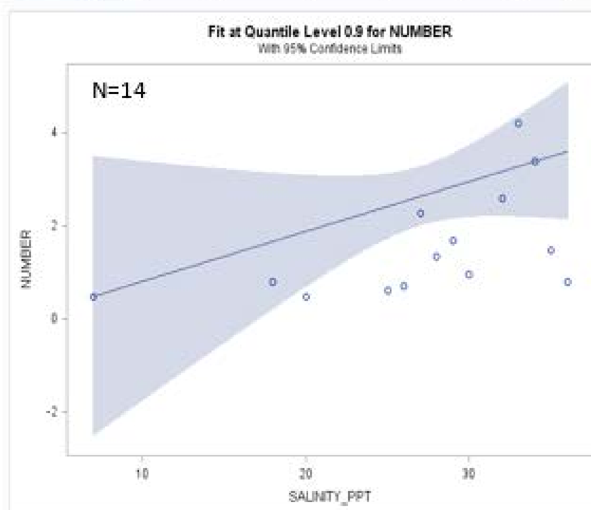


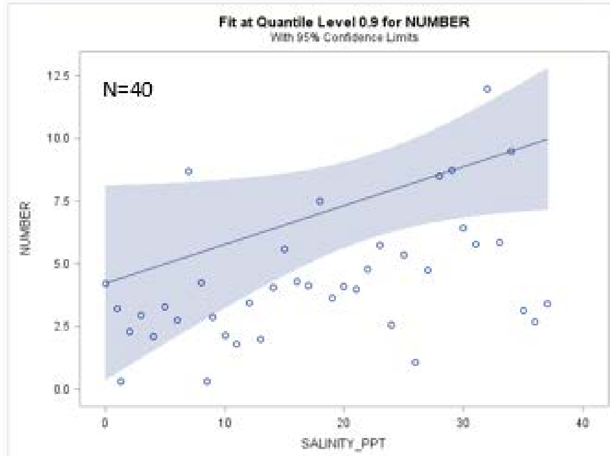
Figure 6.11. (Continued)

SEASON=Winter CLASSIFICATION=Freshwater entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	10.3734	2.0819	6.1425	14.6043	4.98	<.0001
SALINITY_PPT	1	-0.2332	0.1042	-0.4451	-0.0214	-2.24	0.0319

SEASON=Winter CLASSIFICATION=Resident estuarine

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	4.2278	1.9430	0.2944	8.1612	2.18	0.0358
SALINITY_PPT	1	0.1551	0.0781	-0.0031	0.3132	1.99	0.0544



SEASON=Winter CLASSIFICATION=Marine entering estuary

Parameter Estimates							
Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t Value	Pr > |t|
Intercept	1	17.8073	0.7788	16.2320	19.3825	22.87	<.0001
SALINITY_PPT	1	2.4613	0.3030	1.8485	3.0742	8.12	<.0001

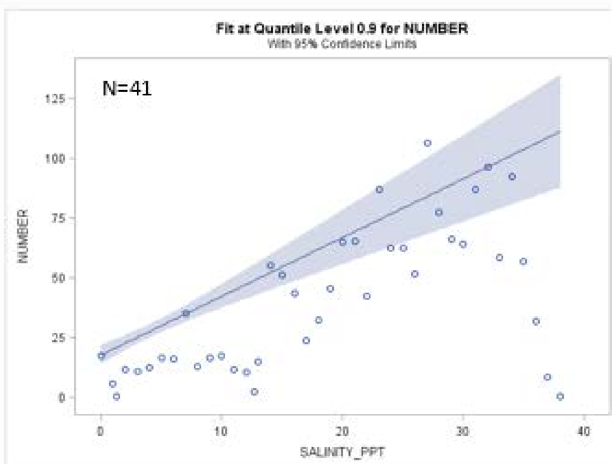


Figure 6.11. (Continued)

Table 6.1. Mean values of Salinity (ppt) and Dissolved Oxygen (mg/l) by zone in Mobile Bay project area.

ZONE	Variable	N	Mean	Std Dev	Minimum	Maximum
Lower Bay	Salinity	864	23.1	8.4	0.5	37.3
	Dissolved Oxygen	863	6.6	1.7	0.4	12.2
Middle Bay	Salinity	272	12.0	7.3	0.5	30.5
	Dissolved Oxygen	272	6.8	2.0	0.5	12.0
Upper Bay	Salinity	199	8.9	6.3	0.3	24.5
	Dissolved oxygen	198	6.5	2.1	1.7	13.0
Transition	Salinity	12	3.7	3.7	0.1	9.7
	Dissolved Oxygen	12	7.0	1.3	5.0	8.8
Freshwater	Salinity	4	0.1	0.0	0.1	0.2
	Dissolved Oxygen	4	7.4	0.6	6.7	8.0

Table 6.2. Species abundance in the Mobile Bay project area by salinity classification.				
CLASSIFICATION=Freshwater only				
COMMON NAME	Frequency	Percent	Cumulative	Cumulative
			Frequency	Percent
Banded pygmy sunfish	1	0.05	1	0.05
Crystal darter	2	0.09	3	0.14
Emerald shiner	24	1.1	27	1.24
Flathead catfish	1	0.05	28	1.29
Fluvial shiner	9	0.41	37	1.7
Freshwater drum	40	1.84	77	3.54
Golden shiner	6	0.28	83	3.82
Green sunfish	4	0.18	87	4
Mississippi silvery minnow	8	0.37	95	4.37
Silver chub	17	0.78	112	5.15
Silverside shiner	2060	94.71	2172	99.86
Starhead topminnow	2	0.09	2174	99.95
Taillight shiner	1	0.05	2175	100
CLASSIFICATION=Freshwater entering estuary				
COMMON NAME	Frequency	Percent	Cumulative	Cumulative
			Frequency	Percent
Alligator gar	1	0.01	1	0.01
Black crappie	133	1.25	134	1.26
Blue catfish	1932	18.17	2066	19.43
Bluegill	143	1.34	2209	20.77
Channel catfish	301	2.83	2510	23.6
Coastal shiner	1	0.01	2511	23.61
Gizzard shad	79	0.74	2590	24.35
Golden topminnow	1	0.01	2591	24.36
Largemouth bass	740	6.96	3331	31.32
Least killifish	6	0.06	3337	31.38
Longear sunfish	18	0.17	3355	31.55
Longnose gar	11	0.1	3366	31.65
Redear sunfish	460	4.33	3826	35.98
Redspotted sunfish	369	3.47	4195	39.45
River carpsucker	2	0.02	4197	39.46
Sailfin molly	3141	29.53	7338	69
Saltmarsh topminnow	14	0.13	7352	69.13
Skipjack herring	18	0.17	7370	69.3
Smallmouth buffalo	19	0.18	7389	69.48
Spotted gar	16	0.15	7405	69.63

Threadfin shad	2910	27.36	10315	96.99
Western mosquitofish	319	3	10634	99.99
White crappie	1	0.01	10635	100
CLASSIFICATION=Resident estuarine				
COMMON	Frequency	Percent	Cumulative	Cumulative
			Frequency	Percent
Bay anchovy	840659	94.27	840659	94.27
Black drum	40	0	840699	94.27
Clown goby	954	0.11	841653	94.38
Code goby	5	0	841658	94.38
Diamond killifish	257	0.03	841915	94.41
Feather blenny	1	0	841916	94.41
Freckled blenny	9	0	841925	94.41
Green goby	145	0.02	842070	94.43
Gulf killifish	540	0.06	842610	94.49
Gulf toadfish	56	0.01	842666	94.49
Highfin goby	511	0.06	843177	94.55
Inland silverside	30448.1	3.41	873625.1	97.96
Naked goby	324	0.04	873949.1	98
Rainwater killifish	12137	1.36	886086.1	99.36
Sheepshead minnow	2551	0.29	888637.1	99.65
Speckled worm eel	1256	0.14	889893.1	99.79
Spotted seatrout	1024	0.11	890917.1	99.9
Striped blenny	1	0	890918.1	99.9
Striped killifish	852	0.1	891770.1	100
Twoscale goby	3	0	891773.1	100
CLASSIFICATION=Marine entering estuary				
COMMON NAME	Frequency	Percent	Cumulative	Cumulative
			Frequency	Percent
Atlantic bumper	7215	0.6	7215	0.6
Atlantic croaker	172572	14.47	179787	15.07
Atlantic cutlassfish	757	0.06	180544	15.13
Atlantic midshipman	69	0.01	180613	15.14
Atlantic moonfish	579	0.05	181192	15.19
Atlantic needlefish	381	0.03	181573	15.22
Atlantic stingray	755	0.06	182328	15.28
Atlantic thread herring	64	0.01	182392	15.29
Atlantic threadfin	1	0	182393	15.29
Banded drum	1774	0.15	184167	15.44
Bandtail puffer	2	0	184169	15.44
Bay whiff	4357.667	0.37	188526.7	15.8

Bighead searobin	1628	0.14	190154.7	15.94
Blackcheek tonguefish	5753	0.48	195907.7	16.42
Blackwing searobin	39	0	195946.7	16.43
Blue runner	2	0	195948.7	16.43
Bluefish	19	0	195967.7	16.43
Bluespotted searobin	3	0	195970.7	16.43
Bluntnose jack	109	0.01	196079.7	16.44
Chain pipefish	252	0.02	196331.7	16.46
Clearnose skate	6	0	196337.7	16.46
Cobia	6	0	196343.7	16.46
Cownose ray	1	0	196344.7	16.46
Crested blenny	10	0	196354.7	16.46
Crested cusk-eel	187	0.02	196541.7	16.48
Crevalle jack	204	0.02	196745.7	16.49
Dusky anchovy	12567	1.05	209312.7	17.55
Dwarf sand perch	142	0.01	209454.7	17.56
Emerald sleeper	10	0	209464.7	17.56
Fat sleeper	23	0	209487.7	17.56
Florida blenny	1	0	209488.7	17.56
Florida pompano	31	0	209519.7	17.56
Frillfin goby	1	0	209520.7	17.56
Fringed flounder	1921	0.16	211441.7	17.72
Gafftopsail catfish	2868	0.24	214309.7	17.96
Gray snapper	130	0.01	214439.7	17.98
Great barracuda	1	0	214440.7	17.98
Guaguanche	71	0.01	214511.7	17.98
Gulf butterfish	2852	0.24	217363.7	18.22
Gulf flounder	93	0.01	217456.7	18.23
Gulf kingfish	9	0	217465.7	18.23
Gulf menhaden	238228	19.97	455693.7	38.2
Gulf pipefish	389	0.03	456082.7	38.23
Hardhead catfish	14575	1.22	470657.7	39.45
Harvestfish	436	0.04	471093.7	39.49
Inshore lizardfish	1934	0.16	473027.7	39.65
Ladyfish	149	0.01	473176.7	39.66
Lane snapper	341	0.03	473517.7	39.69
Least puffer	2184	0.18	475701.7	39.88
Leatherjacket	194	0.02	475895.7	39.89
Leopard searobin	133	0.01	476028.7	39.9
Lined seahorse	23	0	476051.7	39.91
Lined sole	10	0	476061.7	39.91
Longspine porgy	67	0.01	476128.7	39.91
Lookdown	270	0.02	476398.7	39.93

Lyre goby	2	0	476400.7	39.94
Marsh killifish	647	0.05	477047.7	39.99
Northern kingfish	19	0	477066.7	39.99
Northern sennet	8	0	477074.7	39.99
Pigfish	994	0.08	478068.7	40.07
Pinfish	46220	3.87	524288.7	43.95
Pygmy sea bass	5	0	524293.7	43.95
Red drum	288	0.02	524581.7	43.97
Rock sea bass	250	0.02	524831.7	43.99
Rough silverside	6076	0.51	530907.7	44.5
Round scad	11	0	530918.7	44.51
Roundel skate	1	0	530919.7	44.51
Sand seatrout	28855	2.42	559774.7	46.92
Scaled sardine	1022	0.09	560796.7	47.01
Scrawled cowfish	3	0	560799.7	47.01
Sharksucker	4	0	560803.7	47.01
Sheepshead	127	0.01	560930.7	47.02
Shortnose batfish	1	0	560931.7	47.02
Silver jenny	689	0.06	561620.7	47.08
Silver perch	5174	0.43	566794.7	47.51
Silver seatrout	1160	0.1	567954.7	47.61
Singlespot frogfish	10	0	567964.7	47.61
Skilletfish	38	0	568002.7	47.61
Smooth butterfly ray	44	0	568046.7	47.62
Smooth puffer	3	0	568049.7	47.62
Southern flounder	444	0.04	568493.7	47.65
Southern hake	1113	0.09	569606.7	47.75
Southern kingfish	1484	0.12	571090.7	47.87
Southern puffer	6	0	571096.7	47.87
Southern stargazer	40	0	571136.7	47.88
Southern stingray	6	0	571142.7	47.88
Spadefish	399	0.03	571541.7	47.91
Spanish mackerel	47	0	571588.7	47.91
Spot	531328	44.54	1102917	92.45
Spotfin mojarra	38045	3.19	1140962	95.64
Spotted hake	754	0.06	1141716	95.71
Spotted whiff	62	0.01	1141778	95.71
Star drum	11950	1	1153728	96.71
Striped anchovy	8794.9	0.74	1162523	97.45
Striped mullet	28125.8	2.36	1190648	99.81
Tripletail	2	0	1190650	99.81
White mullet	2281	0.19	1192931	100
Yellowfin menhaden	7	0	1192938	100

CLASSIFICATION=Marine only				
COMMON NAME	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Blackedge cusk-eel	8	2.54	8	2.54
Broad flounder	9	2.86	17	5.4
Dusky flounder	2	0.63	19	6.03
Mexican searobin	1	0.32	20	6.35
Red snapper	288	91.43	308	97.78
Rough scad	3	0.95	311	98.73
Round herring	1	0.32	312	99.05
Smoothhead scorpionfish	1	0.32	313	99.37
Spotted batfish	2	0.63	315	100

ENVIRONMENTAL APPENDIX C

ATTACHMENT C-2

DRAFT 404(b)(1) EVALUATION REPORT

Draft Section 404(b)(1) Evaluation Report for the Mobile Harbor General Reevaluation Report

Mobile County, Alabama

DESCRIPTION OF THE AUTHORIZED AND EXISTING FEDERAL PROJECT

The authorized dimensions of all segments of the Mobile Harbor Project have not been constructed. A summary of both the authorized and the existing maintained dimensions are listed in **Table 1**. The maintained dimensions of the bay channel are 45' by 400' and the outer bar channel is 47' by 600'. Each of these areas is maintained to a depth that is 10 feet less than the authorized depth. Several additional features of the authorized project have not been constructed at this time. The anchorage areas that would be located south of the mouth of the Mobile River have not been constructed, and the bay channel and the bar channel, have not been widened. The new Mobile Harbor Turning Basin (MHTB) opposite McDuffie Island, between Pinto Island and Little Sand Island was constructed in 2010.

Table 1. Authorized and Existing Dimensions for Mobile Harbor

Channel	Authorized Dimensions	Existing Dimensions
Outer Bar Channel (a.)	57' x 700'	47' x 600'
Bay Channel (b.)	55' x 550'	45' x 400'
Anchorage Area (c.)	55' x 750' x 4,000'	*Not Constructed*
Turning Basin (d.)	55' x 1,500' x 1,500'	45' x 755' x 1,320'
River Channel (e.)	40' x 500'-700'	*As Authorized*
Turning Basin (f.)	40' x 800' – 1,000' x 2,500'	*As Authorized*
Turning Basin (g.)	40' x 1,000' x 1,600'	*As Authorized*

Approval for advanced maintenance for the Federal Mobile Harbor navigation project was received from South Atlantic Division in the mid-1990s as per the Navigation Regulations ER1130-2-530, 29 November 1996. As such, the navigation channels have associated advanced maintenance to accomplish dredging in an efficient, cost-effective, and environmentally responsible manner. In addition to the federally-authorized channel dimensions providing for navigation, two (2) sediment basins in the Mobile River and three (3) sediment basins in the bay channel, have been previously authorized and approved. These sediment basins are to provide improved channel maintenance efficiency. Each of these basins are several thousand feet long and have depths ranging from four (4) to ten (10) feet lower than the existing navigation channel bottom. The basins decrease frequency of dredging to provide a more cost effective and reliable channel. In addition to sediment basins, an advanced widening feature is authorized for the bar channel.

II. DESCRIPTION OF THE PROPOSED ACTION:

Mobile Harbor, Alabama, is located in the southwestern part of the state, at the junction of the Mobile River with the head of Mobile Bay. The port is approximately 28 nautical miles north of the Bay entrance from the Gulf of Mexico and approximately 170 nautical miles east of New Orleans, Louisiana. The navigation channel dredging in Mobile Bay and Mobile River began in 1826 with enactment of the River and Harbors Act of 1826. Over subsequent years, the federal project at Mobile River and Mobile Bay was expanded to include adjoining channels within the bay. Section 104 of the River and Harbors Act of 1954 (House Document 74, 83rd Congress, First Session, as amended, and previous acts) authorized a 40-foot channel. Improvements to the existing federal project were authorized in the Water Resources Development Act (WRDA) of 1986 (PL 99 – 662, Ninety-ninth Congress, Second Session), which was approved November 17, 1986, and amended by Section 302 of the WRDA of 1996.

Multiple 404(b)(1) evaluations have been completed for varying aspects of the overall Mobile Harbor Federal Navigation Project. In 2012, a 404(b)(1) evaluation, dated April 18, 2012, was completed for routine operation and maintenance (O&M) dredging and placement activities. An updated 40(b)(1) evaluation was completed on July 25, 2014, for the inclusion of in-bay open water placement of O&M dredged material from the Mobile Harbor Federal Navigation Project.

The Mobile Harbor Project is divided into three (3) general areas: the river channel section, the bay channel section, and the bar channel section. Dredging activities include placement of dredged material originating from the project into previously-approved disposal areas. The description of the proposed action is presented below, and the project features are illustrated in **Figure X**.

The currently proposed Tentatively Selected Plan (TSP) consists of dredging and placement activities for approximately 27,000,000 cubic yards (cys) of new work material associated with the GRR improvements of Mobile Harbor, and subsequent future O&M dredging and placement activities. The TSP consists of: deepening the existing Mobile Harbor Bay and Bar channels an additional 5 feet (existing 45-foot deep channel in the bay to 50 feet and existing 47-foot deep channel in the bar to 52 feet); adding an additional 100 feet of widening for a distance of approximately three (3) miles beginning at the upper end of the bend area at the 50-foot depth contour; including bend easing with the deepening at the upper end of the bar channel; and, modification to the Choctaw Pass turning basin to ensure safe operation at the 50-foot depth contour. For preparation of the Draft GRR and Draft Supplemental Environmental Impact Statement, the District conducted extensive modeling of a "maximum potential impacts" scenario with potential environmental effects equal to or greater than the TSP (i.e. dredging to a depth of 50 feet with widening of a five-mile channel section by 100 feet). It should be noted that the actual TSP represents conditions less than the modeled channel dimensions. The proposed dredging operations and placement activities are required to continually provide for safe navigation and maintain the Mobile Bay channels to the federally authorized dimensions. The action is a result of normal rates of shoaling and a need existing to maintain full commercial shipping capacity for the Port of Mobile.

a. General Description of the Dredged or Fill Material. A geotechnical investigation was conducted to determine the physical characteristics of the material contained in the proposed project area. A summary of the findings are discussed below. The sediment proposed for excavation was also sampled and tested for possible contaminants. A summary of this investigation is also summarized below.

(1) Geotechnical Investigation: In general, maintenance sediments from both Mobile River and Mobile Bay were found to be predominantly silt + clay, ranging from 46.9% to 97.7% silt + clay. The grain size of sediments from the Mobile Bar Channel were variable with two locations composed of more than 90% sand and two locations composed of roughly 50% sand and 50% silt+clay. New work material grain sizes, associated with the Mobile Harbor GRR improvements, varied based on the area of study. New work material in the turning basin was sandier, with as much as 90% percent being classified as sand. From the upper limits of the project down to around Gaillard Island, the new work material is predominantly sand (approximately 70%). Clays and silts are more present in the southern part of this stretch. From Gaillard Island to about 1 mile north of the Gulf Intracoastal Waterway, borings indicate that this material is 100% clay, however, pockets of sand may be present. Cores taken for the sediment analysis of proposed widening new work material were comprised of fractions of sand, silts, and clays. The upper portions of the widener (DU's 1 through 3) were mainly comprised of 10-50% sand, 65% silt, and 70% clay. DU's 4 and 5 were comprised of approximately 50% sand, 30% silts, and 30% clays. The new work soils in the bar channel (DU's 6 and 7) are comprised of approximately 50% clays and 50% silts.

(2) Sediment Contaminant Analyses: Sampling results of recent studies (MHTB 2008, O&M 2010, and Limited Reevaluation Report (LRR) 2014) form a baseline for comparison to future new work sediment analyses during the PED phase of the Mobile Harbor GRR. Sediment samples were analyzed for physical characteristics (grain size determination, specific gravity, and percent solids), bulk sediment analysis, standard and modified elutriate testing, water column bioassays, whole sediment bioassays, and bioaccumulation studies of sediment samples to determine material suitability for placement in the Mobile ODMDS under Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 (full Tier III analyses). Sampled areas included the proposed dredge sites, a reference site for comparison, and also at the Mobile ODMDS. For greater detail and descriptions of the proceeding discussion, refer to the Mobile Harbor GRR Environmental Appendix C attached to the Mobile Harbor GRR Integrated SEIS, which includes references to the sediment evaluation reports for Mobile Harbor testing events.

In the MHTB, sediment chemical analyses indicated that within the upper portion (0-10 feet below the surface) of sampled material, four metals, four polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyls (PCBs) concentrations, and four chlorinated pesticides were detected between the threshold effects level (TEL) and probable effects level (PEL) values, but did not exceed critical thresholds. Each of the detected analytes were present in at least one of the sediments from MHTB. One insecticide slightly exceed the PEL at only one location in the MHTB. Similarly, sediments from the MHTB lower portion (10-52 feet below the surface) of sampled material, four metals (arsenic, copper, mercury, and nickel), five PAHs, total PCB concentrations, and four chlorinated pesticides were detected between the threshold effects level (TEL) and probable effects level (PEL) values, but did not exceed critical thresholds. Each of the detected analytes were present in at least one of the sediments from MHTB. Two insecticides exceeded the PEL value at multiple sampling locations and one composited sample location.

Mobile Harbor O&M material was sampled in 2010, and included analyses for concentrations of metals, chlorinated pesticides, Semi-volatile Organic Compounds (SVOC)s, PAHs, PCB congeners, ammonia, cyanide, total sulfide, Total Kjehldahl Nitrogen (TKN), total phosphorus, nitrate, nitrite, AVS/SEM (sediment only), and total organic carbon (TOC) were identified in sediment, site water, standard and effluent elutriate samples. Concentrations of analytes detected in the sediments from Mobile Harbor were generally higher than concentrations of analytes detected at the reference site. None of the 101 chemical constituents detected in the Mobile Harbor sediments exceeded EPA PEL values. Three metals had concentrations exceeding EPA TEL values by factors ranging from 1.0 to 1.8. PAH levels in Mobile River and Bay sediments were below the TEL value of 1,684 µg/kg. Total PCB concentrations were detected at one sampling location in the upper Bay channel between the TEL and PEL values. One pesticide and gamma-BHC (lindane) were detected in Mobile River and Mobile Bay sediment samples at concentrations that exceeded the TEL value by factors ranging from 1.0 to 2.0. Dioxin and furan congeners were detected at low concentrations, and dioxin toxicity quotients (TEQs) ranged from 5.81 to 19.1 ng/kg.

On April 20, 2010 *The Deepwater Horizon* exploded in the Gulf of Mexico while drilling on the Macondo oil well approximately 41 miles southeast of Louisiana. Oil spilled into the Gulf of Mexico until it was capped on July 15, 2010. A sampling effort was conducted on behalf of USACE, Mobile District in late-November and early-December 2010 to determine if surface sediment quality in the Mobile Harbor Federal Navigation Channels had been impacted by the oil spill. Based on results of PAH and total petroleum hydrocarbon (TPH) testing of surface sediments collected in the Mobile Lower Ship Channel, Mobile Bar Channel, U.S. Environmental Protection Agency (EPA)-designated reference site, and the Mobile ODMDS, there were no discernable changes observed in the sediment quality that could be attributed to the *Deepwater Horizon* Oil Spill.

Mobile Harbor LRR material (proposed widening an approximately 7-mile stretch of channel) was sampled in 2014 and sediments from the Lower Bay Channel. A total of 21 discrete sample locations were then composited in to seven analytical samples for analysis. Two metals were detected between TEL and PEL values, with no metals exceeding PEL values. The majority of organic constituents (PAHs, PCB congeners, chlorinated pesticides, and SVOCs) were detected at concentrations estimated below the laboratory reporting limit in the Lower Bay Channel sediments. However, two chlorinated pesticides were detected above the reporting limit in one Lower Bay Channel composite sample.

c. General Description of the Discharge Sites.

(1) Location. Mobile Harbor, Mobile, Alabama. Maps illustrating the location of the existing channels and disposal areas are presented in the Mobile Harbor GRR Environmental Appendix C attached to the Mobile Harbor GRR Integrated SEIS.

(2) Type of Habitat. Previously-approved upland disposal areas (i.e., North Blakeley, ALCOA Mud Lakes, South Blakeley and North Pinto) located in the upper harbor area and the Gaillard Island disposal area are existing upland and confined disposal sites that are approved to accept materials that contain sand and fine-grained sediments. The Mobile ODMDS is a previously designated ocean disposal site and is approved to accept material from this project. The approved open water placement will impact approximately 3,750 acres of bay bottoms predominantly composed of mud flats. These areas were historically utilized, prior to 1990, for the maintenance of the bay channel and provide sufficient time for benthic recovery. The material will be moved in a strategic fashion so that the areas used are in the more expansive portions of the bay. The SIBUA is part of the ebb tidal shoal associated with the mouth of Mobile Bay. This sediment is characterized as predominantly fine to medium quartz sand. This zone is a very dynamic environment that changes drastically as a function of currents and wave conditions. The direction of the littoral transport in this location is from east to west. Due to the dynamic nature of this environment, the benthic community generally consists of opportunistic invertebrates. The constantly shifting sediments do not allow aquatic vegetation to become rooted or attached to the unconsolidated sandy substrate.

(3) Timing and Duration of Discharge. Discharge could occur at any time in the year at any disposal location. This proposed action is merely a recertification of an authorized action.

d. Disposal Method. Placement of materials in the approved upland disposal sites (North Blakeley, ALCOA Mud Lakes, South Blakeley and North Pinto) will be accomplished by hydraulic dredge with a pipeline or hopper. Also, placement of materials in the Gaillard Island site will be accomplished by hydraulic pipeline. It is expected that some support equipment such as bull dozers, marsh buggies, etc. may be necessary to redistribute the sediment within these sites. Sediment placed in the SIBUA and Mobile ODMDS will likely be accomplished using a hopper dredge or scow. Emergency pipeline dredging operations will extend from the northern limit of the bay channel south to the mouth of Mobile Bay.

III. FACTUAL DETERMINATIONS.

a. Physical Substrate Determinations.

(1) Substrate elevation and slope. Substrates placed in approved upland placement sites, open water in-bay placement, as well as the ODMDS, will be confined

within those placement areas. The elevation of the approved upland placement sites ranges from 21 feet to 46 feet. The intent of the SIBUA is to keep sandy materials in the littoral system. The materials placed will be redistributed by local currents and waves to a more natural configuration consistent with the ebb tidal shoal.

Previous studies of open water placement in Mobile Bay by Nichols (1978), show that disposal initially raised the bed approximately 30 cm and increased the average bed slope from 1:3000 to 1:2000. After placement, mud consolidates, bulk density increases and slopes decrease. Between disposal operations, the placement area bathymetry returns to broad swells and troughs with maximum relief of two (2) feet representing topography modified by waves and tidal currents. Very little long-term mounding has resulted from the disposal of maintenance material in the bay. Significant mounding has occurred in the Upper Mobile Bay as a result of disposal of new work material from channel deepening in the 1960's. Continued disposal of maintenance material in the upper bay has not added to that mounding.

(2) Sediment type. Approximately 5.9 million cys of current maintenance dredged material would be removed from the river, bay and bar channel(s) on an annual basis. New work material grain sizes, associated with the Mobile Harbor GRR improvements, varied based on the area of study. New work material in the turning basin was sandier, with as much as 90% percent being classified as sand. From the upper limits of the project down to around Gaillard Island, the new work material is predominantly sand (approximately 70%). Clays and silts are more present in the southern part of this stretch. From Gaillard Island to approximately 1 mile north of the Gulf Intracoastal Waterway, borings indicate that this material is 100% clay, however, pockets of sand may be present. Cores taken for the sediment analysis of proposed widening new work material were comprised of fractions of sand, silts, and clays. Portions of the widener area were mainly comprised of 10-50% sand, 30-65% silt, and 30-70% clay. New work sediments in the bar channel are comprised of approximately 50% clays and 50% silts.

(3) Dredged/fill material movement. Dredge material placed in the approved upland disposal area sites will be confined. The intent of the SIBUA is to keep sandy material in the natural littoral transport system. The materials placed will be redistributed by local currents and waves to a more natural configuration consistent with the ebb tidal shoal. Salinity associated with the Mobile ODMDS is high enough to promote rapid settling of finer particles. Current velocities range from approximately 8 inches per second (in/s) to 16 in/s at the Mobile ODMDS. The directions of the currents measured during tide conditions moved towards the east while flood tide conditions moved to the north-northwest.

(4) Physical effects on benthos. Within the open-water disposal sites, SIBUA and the ODMDS some benthic organisms would be destroyed by the proposed action; however, due to the constant movement of material by currents, benthic organism diversity and abundance would appear to be low. Research conducted by the USACE, ERDC under the Dredged Material Research Program (DMRP) (Berkowitz *et al.*, 2018

(included in reference list for the Mobile Harbor GRR)) suggests that the benthic community is adapted to a wide range of naturally occurring environmental changes and that no significant or long-term changes in community structure or function are expected.

Bottom organisms include polychaete worms, crabs, shrimp, mollusks, and enchinoderms. Non-motile species are directly covered by the dredged material, engulfed by mud flow or covered by heavy siltation within 1,200 feet of the dredge discharge. Responses of benthic infauna to large scale disturbance by dredge material placement were studied in areas around Corpus Christi, Texas. The study looked at biological responses to dredged material disturbance that were linked to both pre-disturbance conditions and differences between disturbed and neighboring undisturbed areas. Results for this study area indicated that benthic communities are poised to respond relatively quickly to disturbances given their historical exposure to impacts and resultant colonization by opportunistic species. The impacts of the dredged material placement were evident for less than a year. The response of benthic communities to disposal of dredged material was assessed at three (3) sites in Mississippi Sound in 2006. The findings indicated that adults re-colonized the newly deposited sediments either through vertical migration or later immigration from adjacent areas within a period of three (3) to 10 months. A related study conducted in Mississippi Sound associated with the Gulfport Federal navigation project indicated benthic recovery rates to predisposal conditions occurred within 12 months.

A major factor influencing benthic recovery rates is the prior disturbance history of a particular area. Studies indicate that benthic recovery occurs more rapidly in relatively shallow areas, such as Mobile Bay, where the resident benthic communities are already adapted to dynamic conditions and shifting sediments. Being that Mobile Bay is a depositional shallow water body with dynamic sediment processes, it would be expected that benthic recovery would be consistent with that shown by previous studies.

(5) Other effects. Effects of harbor deepening (such as those proposed for the Mobile GRR) on benthic macrofauna due to salinity intrusion are predicted to be negligible, with minimal effects on higher trophic levels, such as fish, because prey availability and distributions are unlikely to be affected (Berkowitz *et al.*, 2018). No other significant effects due to movement of the physical substrate are noted.

(6) Actions taken to minimize impacts. No actions, which would further reduce impacts due to the placement of the dredged material are deemed necessary.

b. Water Circulation/Fluctuation, and Salinity Determination.

(1) Water

(a) Salinity. No significant effects.

(b) Water chemistry. Sampling results of recent studies (2008, 2010, and 2014) of the elutriate analyses indicate little, to no discernable changes, on water chemistry for the proposed action.

(c) Clarity. Water clarity may locally be decreased slightly during the proposed placement of dredged material, but this would not be significant.

(d) Color. No effects.

(e) Odor. No effects.

(f) Taste. No effects.

(g) Dissolved gases. No effects.

(h) Nutrients. No effects.

(i) Eutrophication. No effects.

(2) Current Patterns and Circulation

(a) Current patterns and flow. Changes in water circulation and flow due to placement of dredged material in upland sites, the SIBUA, relic mined placement (oyster holes), and the Mobile ODMDS are not expected to occur. Natural currents and flow will occur during tidal, wave, and storm activities.

(b) Velocity. No significant effects.

(c) Stratification. No effects.

(d) Hydrologic effects. No significant effects.

(3) Normal Water Level Fluctuations. No effects.

(4) Salinity Gradients. No significant effects.

(5) Actions That Will Be Taken To Minimize Impacts. No other actions that would minimize impacts on water circulation/fluctuation and salinity are deemed necessary.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected changes in suspended particulate and turbidity levels in the vicinity of the disposal site. The suspended particulate and turbidity levels are expected to undergo minor increases during dredging and placement activities; however, suspended sediment of this type will quickly return to normal conditions. No significant effects would occur as a result of these increases.

(2) Effects on the chemical and physical properties of the water column.

(a) Light penetration. Increased turbidity levels in the project area as a result of the placement of dredged material would reduce the penetration of light into the water column only slightly and would be a minor short-term impact.

(b) Dissolved oxygen. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(c) Toxic metals and organics. No significant effects.

(d) Pathogens. No effects.

(e) Aesthetics. The placement of dredged material would likely decrease the aesthetic qualities of the project area for a short period of time during and shortly after placement. The disposal areas equilibrate and rapidly return to normal upon exposure to the wave climate.

(f) Others as appropriate. None appropriate.

(3) Effects on biota.

(a) Primary production, photosynthesis. No significant effects greater than those experienced under current project conditions are anticipated.

(b) Suspension/filter feeders. Some local increases in suspended particulates may be encountered during the dredging and disposal actions, but these increases would not cause significant impacts to these organisms unless they are directly covered with sediment. If directly covered with dredged material, it is expected that some organisms will be destroyed. Rapid recruitment of these organisms will promote a rapid recovery to normal populations. Overall, the impact to these organisms is expected to be minor and insignificant.

(c) Sight feeders. Sight feeders would avoid impacted areas and return when conditions are suitable. However, it is difficult to relate the presence or absence of sight feeders in an area to the placement of dredged material. Sight feeders, particularly fishes, may vary in abundance as a result of temperature changes, salinity changes, seasonal changes, dissolved oxygen level changes, as well as other variables. No significant impacts are expected to occur on sight feeders.

(4) Actions taken to minimize impacts. No further actions are deemed appropriate·

d. Contaminant Determination. No significant effects. Sampling results of recent chemical analysis studies (2008, 2010, and 2014) indicated that a few metals and PAHs, pesticides, and insecticides were detected in Mobile Harbor sediments, but did not exceed critical thresholds (PEL levels). Also, based on post oil-spill testing results from 2010, PAH and TPH testing of surface sediments collected in the Mobile Lower Ship Channel, Mobile Bar Channel, EPA-designated reference site, and Mobile ODMDS in

November and December 2010, there are no discernable changes in the sediment quality that are attributable to the *Deepwater Horizon* Oil Spill.

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on plankton. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(2) Effects on benthos. Benthic organisms would be destroyed by the deposition of dredged material below the waterline in the open water placement areas, but no significant effects are expected on the benthic community as a result of the proposed action.

(3) Effects on nekton. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(4) Effects on aquatic food web. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(5) Effects on special aquatic sites.

(a) Sanctuaries and refuges. Not applicable

(b) Wetlands. As a result, project implementation is not expected to negatively impact wetlands within the study area. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(c) Mud flats. Not applicable.

(d) Vegetated shallows. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(e) Coral reefs. Not applicable.

(f) Riffle and pool complexes. Not applicable.

(6) Threatened and endangered species. The project area is host to fisheries and wildlife on the State and Federal protected species list. Of particular concern in the proposed project vicinity are sea turtles, Florida manatee, and Gulf sturgeon.

Potential impacts on the five species of listed sea turtles and Gulf sturgeon from hopper dredging activities were assessed in the 2003 Gulf Regional Biological Opinion (GRBO). In the opinion, NMFS concluded that sea turtles and Gulf sturgeon can be adversely affected by hopper dredges. The Gulf sturgeon is a subspecies of the Atlantic sturgeon. The proposed project area may be used by Gulf sturgeon for foraging during their migration periods. However, Mobile Bay is not within designated Gulf Sturgeon critical habitat.

The Florida manatee is a subspecies of the West Indian Manatee. Although rare, manatee sightings have been documented in Mobile Bay and/or its tributaries for the past several years, during the period May through December. In the unlikely event that a manatee would be located in the vicinity of the nearshore project site, and U.S. Fish and Wildlife Service (USFWS) “Standard Manatee Construction Conditions" would be implemented.

The USACE, Mobile District, does not anticipate sperm, blue, fin, humpback, or sei whales would be adversely affected by the varying dredging methods (i.e. hydraulic, hopper, and/or mechanical) described by the proposed action along the entire proposed action area. Given their likely absence, feeding habits, and very low likelihood of interaction, the USACE, Mobile District, does not anticipate the proposed actions identified in this EA will affect these species.

The piping plover, red knot, and least tern occur along the Gulf Coast and also may occur on Sand Island or other nearby land forms. Since this project is located over water and away from any land forms, it is highly unlikely that these birds would be disrupted by the continued maintenance dredging and placement activities would have no impact on them. Due to high bird nesting use, material to be placed in Gaillard Island would only occur in accordance with the *Migratory Bird Treaty Act* and any associated regulatory agency agreements

The USACE has determined that the proposed action may affect but is not likely to adversely affect the species discussed above.

(7) <u>Other wildlife</u>. No significant effects.

(8) <u>Actions to minimize impacts</u>. No other actions to minimize impacts on the aquatic ecosystem are deemed appropriate.

f. Proposed Disposal Site Determination.

(1) <u>Mixing zone determinations</u>. The Alabama Department of Environmental Management (ADEM) delineates mixing zones on a case-by-case basis. Any requirements placed on the project would be followed to the maximum extent practicable.

(2) <u>Determination of compliance with applicable water quality standards</u>. Preliminary findings show that action would be in compliance to the maximum extent practicable, with all applicable water quality standards.

(3) <u>Potential effects on human use characteristics</u>.

(a) Municipal and private water supply. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(b) Recreational and commercial fisheries. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(c) Water-related recreation. No significant effects greater than those experienced under current project conditions are anticipated (Berkowitz *et al.*, 2018).

(d) Esthetics. No significant effects.

(e) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. Not applicable.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. No significant cumulative effects on the aquatic ecosystem would occur as a result of the proposed action.

h. Determination of Secondary Effects on the Aquatic Ecosystem. No significant effects.

IIII. FINDING OF COMPLIANCE.

a. Adaptation of Section 404(b)(1) Guidelines. No significant adaptations to the guidelines were made relative to this evaluation.

b. Alternatives. The proposed action discussed in this EA and Section 404(b)1 only encompasses the recertification of an ongoing maintenance project. Therefore, only 'Action' and 'No Action' alternatives have been evaluated in this assessment. It is believed that greater negative economic and environmental impacts will result from not re-issuing certification of continual maintenance dredging and disposal activities. Other Alternatives for dredging and disposal were evaluated in the 1980 EIS for Mobile Harbor Channel Improvements.

c. Compliance with State Water quality Standards. A Clean Water Act (CWA), Section 401 Water Quality Certification is required for the proposed action. Certification will be coordinated with ADEM for the proposed action.

d. Compliance with Applicable Toxic Effluent Standard or Prohibition under Section 307 of the Clean Water Act. The action is consistent with the Alabama Coastal Program to the maximum extent practicable. Recertification of the existing project will be coordinated through and approved by the State of Alabama.

e. Compliance with Endangered Species Act. The proposed activity is not expected to harm federally-protected species. No critical habitats of any federally-protected species exist within the project area. Regarding potential impacts to federally-protected species, coordination with the appropriate Federal agencies will be initiated through a Public Notice and completed. Sufficient safeguards exist to protect federally-protected species which may enter into the project area.

f. Compliance with Specific Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act. The proposed activity would not result in any significant adverse effects on human health or welfare, including municipal or private water supplies, recreation and commercial fishing, plankton, fish, shellfish, and wildlife. The life stages of aquatic life and other wildlife would not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, esthetic, and economic values would not occur. No wetlands would be impacted by the proposed action.

g. Evaluation of Extent of Degradation of the Waters of the United States. The proposed fill plan is specified as complying with the requirements of these guidelines.

h. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem. The proposed fill plan is specified as complying with the requirements of these guidelines.

i. On the Basis of the Guidelines, the proposed Disposal Site for the Discharge of Dredged Material. Specified as complying with the requirements of these guidelines.

DATE: ____________________

____
James A. DeLapp
Colonel, U.S. Army
District Engineer

ENVIRONMENTAL APPENDIX C

ATTACHMENT C-3
AIR QUALITY ANALYSIS

APPENDIX C-1

AIR QUALITY IMPACT ANALYSIS

TABLE OF CONTENTS

1.0 INTRODUCTION 3

1.1 AIR QUALITY STANDARDS AND REGULATIONS 3

1.1.1 NATIONAL AMBIENT AIR QUALITY STANDARDS 3

1.1.2 ATTAINMENT STATUS AND AREA CLASSIFICATION AND CLEAN AIR ACT CONFORMITY 13

1.1.3 STATIONARY SOURCE PERMITTING REGULATION 13

1.1.4 MOBILE SOURCES REGULATION 14

1.2 METHODOLOGY AND IMPACT DETERMINATION 15

1.3 CRITERIA POLLUTANT EMISSIONS ANALYSIS 18

1.3.2 2035 PROJECTED PORT EMISSIONS 21

1.4 REFERENCES 25

List of Figures

Figure 1 - Port of Mobile 5
Figure 2 – Emission Sources at Port of Mobile_ Part 1 16
Figure 3 – Emission Sources at Port of Mobile_ Part 2 17

List of Tables

Table 1. Criteria Pollutants - Sources and Impacts 6
Table 2. National and Alabama Ambient Air Quality Standards for Criteria Pollutants 12
Table 3. C-PORT Predicted Annual Port-wide Operational Emissions 20
Table 4. Truck Annual Emissions 20
Table 5. Coal Storage Pile PM Emissions 21
Table 6. 2011 Baseline Annual Emissions 21
Table 7. Vessel/Tug Counts and Vessel Calls 22
Table 8. Projected 2035 No Action Alternative Annual Emissions 22
Table 9. Projected Changes in 2035 Emissions under Channel Deepening Alternative 23

1.0 INTRODUCTION

This appendix presents a discussion of how air quality is defined, the regulatory approach used to evaluate potential impacts as a result of operations within the Port of Mobile (the port) as shown in Figure 1, and a determination of impact significance.

Air quality can be affected by air pollutants produced by mobile sources, such as vehicular traffic and non-road equipment used for port material handling activities, vessels, and by fixed or immobile facilities, referred to as “stationary sources.” Stationary sources can include coal piles, stationary combustion exhaust stacks, and other sources.

1.1 AIR QUALITY STANDARDS AND REGULATIONS

1.1.1 National Ambient Air Quality Standards

The U.S. Environmental Protection Agency (USEPA), under the requirements of the 1970 Clean Air Act (CAA), as amended in 1977 and 1990 (Clean Air Act Amendments), has established National Ambient Air Quality Standards (NAAQS) for six contaminants, referred to as criteria pollutants (40 Code of Federal Regulations [CFR] 50). These six criteria pollutants are:

- Carbon monoxide (CO)
- Nitrogen dioxide (NO_2)
- Ozone (O_3), with nitrogen oxides (NO_x) and volatile organic compounds (VOCs) as precursors
- Particulate matter (PM_{10}—less than 10 microns in particle diameter; $PM_{2.5}$—less than 2.5 microns in particle diameter)
- Lead (Pb)
- Sulfur dioxide (SO_2)

Table 1 presents a description of the criteria pollutants and their effects on public health and welfare.

The NAAQS are comprised of primary and secondary standards, as shown in Table 2. The primary standards were established to protect human public health. Typical sensitive land uses and associated sensitive receptors protected by the primary standards include publicly accessible areas, such as residences, hospitals, libraries, churches, parks, playgrounds, and schools. The secondary standards were established to protect the environment, including plants and animals, from adverse effects associated with pollutants in the ambient air.

The air emissions that may result from the proposed action are addressed in this study for all criteria pollutants with the exception of lead. As a result of regulatory efforts, levels of lead in the air have been reduced 98 percent from 1980 to 2014. Much of this reduction is a result of federal programs to control vehicle emissions by eliminating the use of lead-containing fuel. Ozone is a regional pollutant that is not usually addressed on a project basis; however, one of its precursor's emissions (NO_x) representing NO_2 is quantified in this study.

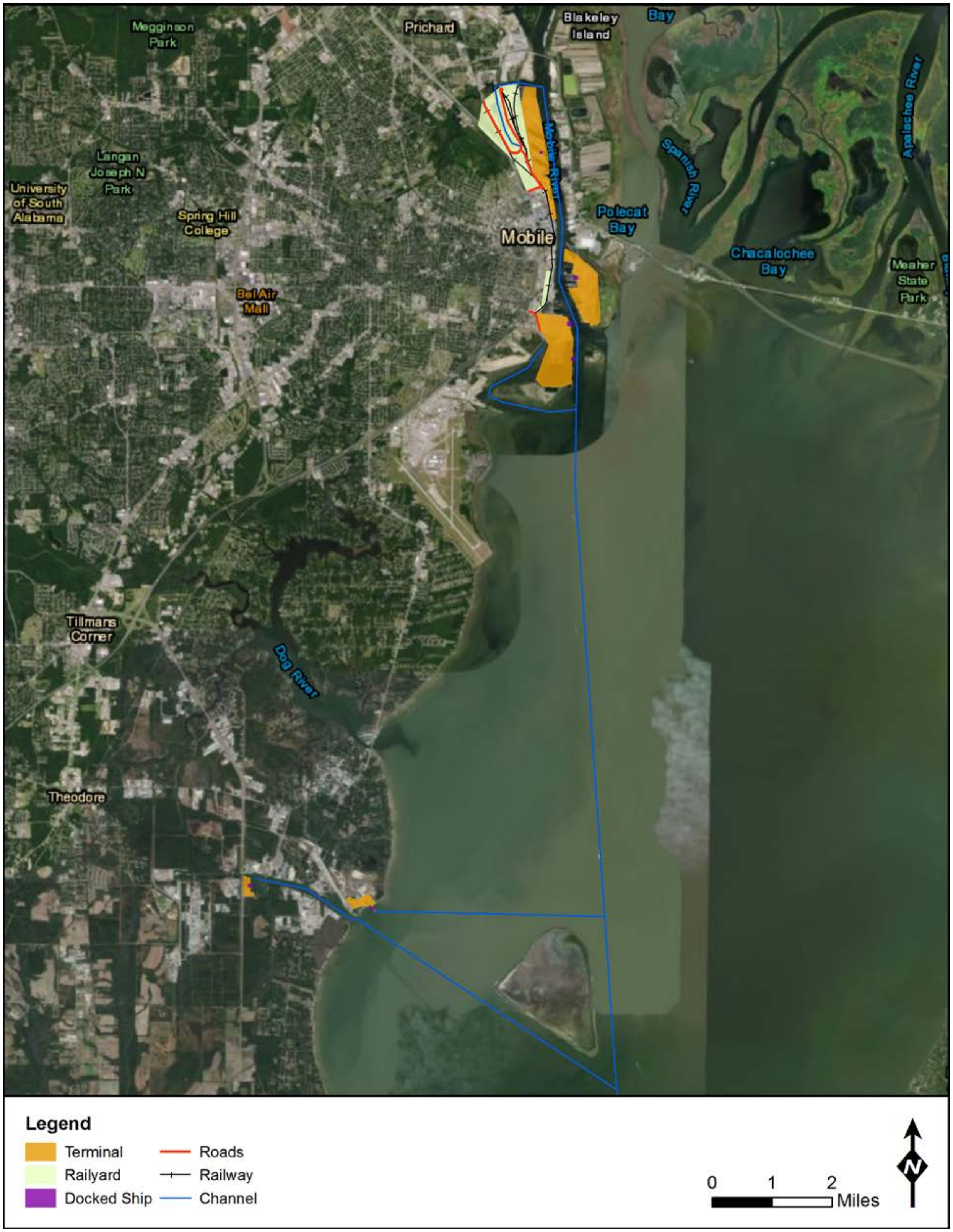


Figure 1 - Port of Mobile

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Ozone (O_3): a gas composed of three oxygen atoms. It is not usually emitted directly into the air, but is created at ground level by a chemical reaction between nitrogen oxides (NO_x) and volatile organic compounds (VOC) in the presence of heat and sunlight. Ground-level O_3 is known as smog. O_3 has the same chemical structure whether it occurs miles above the earth or at ground level and can have positive or negative effects, depending on its location in the atmosphere. Most O_3 (about 90%) occurs naturally in the stratosphere approximately 10 to 30 miles above the earth's surface. It forms a layer that protects life on earth by absorbing most of the biologically damaging ultraviolet sunlight. In the earth's lower atmosphere, O_3 comes into direct contact with living organisms. High levels of ground-level O_3 can cause toxic effects, detailed in the adjacent column. VOC + NO_x + Heat + Sunlight = O_3: Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOC that help to form O_3. Sunlight and hot weather cause ground-level O_3 to form in harmful concentrations in the air. As a result, it is considered an air pollutant, particularly in summer. Many urban areas tend to have high levels of O_3, but rural areas are also subject to increased O_3 levels because wind carries O_3 and associated pollutants hundreds of miles away from their original sources.	Health Problems: O_3 can irritate lung airways and cause inflammation much like sunburn. Other symptoms include wheezing, coughing, pain when taking a deep breath, and breathing difficulties during exercise or outdoor activities. People with respiratory problems are most vulnerable, but even healthy people that are active outdoors can be affected when O_3 levels are high. Repeated exposure to O_3 pollution for several months may cause permanent lung damage. Anyone who spends time outdoors in the summer is at risk, particularly children and other people who are active outdoors. Even at very low levels, ground-level O_3 triggers a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. Plant and Ecosystem Damage: Ground-level O_3 interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, and harsh weather. Aesthetic Damage: O_3 damages the leaves of trees and other plants, injuring them and impacting the appearance of cities, national parks, and recreation areas. Agricultural Damage: O_3 reduces crop and forest yields and increases plant vulnerability to disease, pests, and harsh weather.

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Carbon Monoxide (CO): a colorless, odorless gas that is formed when carbon in fuel is incompletely burned. It is a component of motor vehicle exhaust, which contributes about 56% of all CO emissions nationwide. Non-road engines and vehicles (such as construction equipment and boats) contribute about 22% of all CO emissions nationwide. Higher levels of CO generally occur in areas with heavy traffic congestion. In cities, 85 to 95% of all CO emissions may come from motor vehicle exhaust. Other sources of CO emissions include industrial processes (e.g., metals processing and chemical manufacturing), residential wood burning, and natural sources such as forest fires. Woodstoves, gas stoves, cigarette smoke, and unvented gas and kerosene space heaters are sources of CO indoors. The highest levels of CO in the outside air typically occur during the colder months of the year when inversion conditions are more frequent and pollutants are trapped near the ground beneath a layer of warm air.	**Health Problems**: CO can cause harmful health effects by reducing oxygen delivery to the body's organs (e.g., heart, brain) and tissues. **Cardiovascular Effects** – The health threat from lower levels of CO is greatest for those who suffer from heart disease (e.g., clogged arteries, congestive heart failure). For a person with heart disease, a single exposure to CO at low levels may cause chest pain and reduce their ability to exercise; repeated exposures may contribute to other cardiovascular effects. **Central Nervous System Effects** – Even healthy people can be affected by high levels of CO. People who breathe high levels of CO can develop vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks. At extremely high levels, CO is poisonous and can cause death. **Smog** – CO contributes to the formation of smog (ground-level O_3), which can trigger serious respiratory problems.

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Sulfur Dioxide (SO_2): SO_2 belongs to the family of sulfur oxide gases (SO_x). These gases dissolve easily in water. Sulfur is prevalent in raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SO_x gases are formed when fuel containing sulfur, such as coal and oil, is burned, when gasoline is extracted from oil, or when metals are extracted from ore. SO_2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and the environment. Over 65% of SO_2 released to the air, or more than 13 million tons per year, comes from electric utilities, especially those that burn coal. Other sources of SO_2 are industrial facilities that derive their products from raw materials like metallic ore, coal, and crude oil, or that burn coal or oil to produce process heat. Examples are petroleum refineries, cement manufacturing, and metal processing facilities. Also, locomotives, large ships, and some non-road diesel equipment currently burn high sulfur fuel and release SO_2 emissions to the air in large quantities.	SO_2 causes a wide variety of health and environmental impacts because of the way it reacts with other substances in the air. Particularly sensitive groups include people with asthma who are active outdoors, children, the elderly, and people with heart or lung disease. **Health Problems**: **Respiratory Effects from Gaseous SO_2** – High levels of SO_2 in the air can cause temporary breathing difficulty for people with asthma who are active outdoors. Longer-term exposures to high levels of SO_2 gas and particles cause respiratory illness and aggravate existing heart disease. **Respiratory Effects from Sulfate Particles** – SO_2 reacts with other chemicals in the air to form tiny sulfate particles. When these are breathed in, they collect in the lungs and are associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. **Plant and Ecosystem Damage**: **Acid Rain** – SO_2 and NO_x react with other substances in the air to form acids, which fall to earth as rain, fog, snow, or dry particles. Some may be carried by the wind for hundreds of miles. **Plant and Water Damage** – Acid rain damages forests and crops, changes the makeup of soil, and makes lakes and streams acidic and unsuitable for fish and other aquatic life. Continued exposure over a long time changes the community of plants and animals in an ecosystem. **Visibility Impairment:** Haze occurs when light is scattered or absorbed by particles and gases in the air. Sulfate particles are the major cause of reduced visibility in many parts of the United States. **Aesthetic Damage:** SO_2 accelerates the decay of building materials and paints, including monuments, statues, and sculptures.

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Nitrogen Oxides (NO_x): the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the NO_x are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2), along with particles in the air can often be seen as a reddish-brown layer over many urban areas. NO_x forms when fuel is burned at high temperatures, as in a combustion process. The primary sources of NO_x are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.	NO_x causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of NO_x, including NO_2, nitric acid, nitrous oxide (N_2O), nitrates, and nitric oxide. **Health Problems**: **Ground-level O_3 (smog)** is formed when NO_x and VOCs react in the presence of heat and sunlight. Children, people with respiratory difficulties (e.g., asthma), and people who work or exercise outside are susceptible to adverse effects such as damage to lung tissue and reduction in lung function. O_3 can be transported by wind currents and cause health impacts far from original sources. Millions of Americans live in areas that do not meet the health standards for O_3. **Particles** – NO_x reacts with ammonia, moisture, and other compounds to form nitric acid and related particles. Human health concerns include effects on the respiratory system, tissue damage, and premature death. Small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory diseases such as emphysema and bronchitis, and aggravate existing heart disease. **Toxic Chemicals** – In the air, NO_x reacts readily with common organic chemicals and even O_3, to form a wide variety of toxic products. Examples of these chemicals include the nitrate radical, nitroarenes, and nitrosamines.

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Nitrogen Oxides (NO_x) – continued	**Plant and Ecosystem Damage**: **Acid Rain** – NO_x and SO_2 react with other substances in the air to form acids that fall to earth as rain, fog, snow, or dry particles, which can be carried by wind for hundreds of miles. Acid rain causes lakes and streams to become acidic and unsuitable for fish and other aquatic life. **Water Quality Deterioration** – Increased nitrogen loading in water bodies, particularly coastal estuaries, upsets the chemical balance of nutrients used by aquatic plants and animals. Additional nitrogen accelerates eutrophication, which leads to oxygen depletion and reduces fish and shellfish populations. **Global Warming** – One of the NO_x, N_2O, is a greenhouse gas. It accumulates in the atmosphere with other greenhouse gasses causing a gradual rise in the earth's temperature. This leads to increased risks to human health, a rise in sea level, and other adverse changes to plant and animal habitats. **Visibility Impairment**: Nitrate particles and NO_2 can block the transmission of light, reducing visibility in urban areas and on a regional scale in other areas. **Aesthetic Damage:** Acid rain damages cars, buildings, and historical monuments.

Table 1. Criteria Pollutants - Sources and Impacts

Pollutants and Their Sources	Health and Environmental Impacts
Particulates (PM_{10} and $PM_{2.5}$): Particulate matter (PM) is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope. Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Other particles may be formed in the air from the chemical change of gases. They are indirectly formed when gases from burning fuels react with sunlight and water vapor. These can result from fuel combustion in motor vehicles, at power plants, and in other industrial processes.	**Health Problems**: Many scientific studies have linked breathing PM to a series of significant health problems, including: aggravated asthma, increases in respiratory symptoms (e.g., coughing; difficult or painful breathing etc.), chronic bronchitis, decreased lung function, and Premature death. **Plant and Ecosystem Damage:** PM can be carried over long distances by wind, settling on ground or water. The effects of this atmospheric deposition include contributing to acidification of water bodies, changing the nutrient balance in coastal waters and large river basins, depleting the nutrients in soil, and damaging sensitive forests and farm crops. **Visibility Impairment:** PM is the major cause of reduced visibility (haze) in parts of the United States. **Aesthetic Damage:** Soot, a type of PM, stains and damages stone and other materials, including monuments and statues.

Legend: CO = carbon monoxide; NO_x – nitrogen oxides; NO_2 = nitrogen dioxide; N_2O = nitrous oxide; O_3 = ozone; PM = particulate matter; SO_2 = sulfur dioxide; SO_x = sulfur oxides; VOC = volatile organic compound.

Source: USEPA 2012b.

Table 2. National and Alabama Ambient Air Quality Standards for Criteria Pollutants

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		primary and secondary	Rolling 3-month average	0.15 µg/m^{3}(1)	Not to be exceeded
Nitrogen Dioxide		Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb(2)	Annual mean
Ozone		primary and secondary	8-hour	0.070 ppm(3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particulate Matter	$PM_{2.5}$	Primary	Annual	12 µg/m^{3}(4)	Annual mean, averaged over 3 years
		Secondary	Annual	15 µg/m^3	Annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		Primary	1-hour	75 ppb(5)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Legend: ppm = parts per million; ppb = parts per billion; µg/m^3=micrograms per cubic meter.

Notes: [1]Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m^3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[2]The official level of the annual nitrogen dioxide standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of a clearer comparison to the 1-hour standard.

[3] Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

[4]Final rule signed January 15, 2013. The primary annual fine particle ($PM_{2.5}$) standard was lowered from 15 to 12 µg/m^3.

[5]Final rule signed June 2, 2010. The 1971 annual and 24-hour sulfur dioxide standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Source: USEPA 2016.

1.1.2 Attainment Status and Area Classification and Clean Air Act Conformity

Areas where concentration levels are below the NAAQS for a criteria pollutant are designated as being in "attainment." Areas where a criteria pollutant level equals or exceeds the NAAQS are designated as being in "nonattainment." Based on the severity of the pollution problem, nonattainment areas are categorized as marginal, moderate, serious, severe, or extreme. Where insufficient data exist to determine an area's attainment status, it is designated as either unclassifiable or in attainment.

The CAA, as amended in 1990, mandates that state agencies adopt State Implementation Plans that target the elimination or reduction of the severity and number of violations of the NAAQS in a nonattainment area. State Implementation Plans set forth policies to expeditiously achieve and maintain attainment of the NAAQS. For those nonattainment areas that are redesignated attainment, the state is required to develop a 10-year maintenance plan to ensure that the areas remain in attainment status for the same pollutant.

The CAA, as amended in 1990, also expands the scope and content of the act's conformity provisions in terms of their relationship to the State Implementation Plan. Under Section 176(c) of the CAA, a project is in "conformity" if it corresponds to State Implementation Plans' purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving their expeditious attainment. Conformity further requires that such activities would not:

- Cause or contribute to any new violations of any standards in any area
- Increase the frequency or severity of any existing violation of any standards in any area
- Delay timely attainment of any standard or any required interim emission reductions or other milestones in any area

The USEPA published final rules on general conformity (40 CFR Parts 51 and 93) in the Federal Register on November 30, 1993 and subsequently revised the rules on March 24, 2010. The rules apply to federal actions in nonattainment or maintenance areas for any of the applicable criteria pollutants. The rules specify *de minimis* emission levels by pollutant to determine the applicability of conformity requirements for a project on a local level. A conformity applicability analysis is the first step of a conformity evaluation and assesses if a federal action must be supported by a conformity determination. However, the rules do not apply in unclassifiable/attainment areas for the NAAQS.

The area where the port is located is considered in attainment for all criteria pollutants; therefore, the rules do not apply to the implementation of the Tentatively Selected Plan (TSP) and a general conformity applicability analysis is not required.

1.1.3 Stationary Source Permitting Regulation

Stationary sources of air emissions include combustion turbines, boilers, generators, and storage piles. The 1990 amendments to the CAA set permit rules and emission standards for pollution sources of certain sizes. An air permit application is submitted by the prospective owner or operator of an emitting source in order to obtain approval of the source construction permit. A construction permit generally specifies a time period within which the source must be constructed. Permits are reviewed for any modifications to the site or the air emissions sources to determine permit applicability.

The USEPA oversees the programs that grant stationary source operating permits (Title V of the CAA) and new or modified major stationary source construction and operation permits. The New Source Review program requires new major stationary sources or major modifications of existing major stationary sources of pollutants to obtain permits before initiating construction. The New Source Performance Standards apply to sources emitting criteria pollutants, while the National Emission Standards for hazardous air pollutants apply to sources emitting hazardous air pollutants.

Hazardous air pollutants, also known as toxic air pollutants, are chemicals that can cause adverse effects to human health or the environment. The 1990 amendments to the CAA directed the USEPA to set standards for all major sources of air toxics. Thus, the USEPA established a list of 187 hazardous air pollutants. This list includes substances that cause cancer, neurological, respiratory, and reproductive effects.

The Title V major source thresholds for pollutant emissions are:

- 100 tons per year for any criteria pollutant
- 25 tons per year total hazardous air pollutants
- 10 tons per year for any one hazardous air pollutant

The USEPA also established Prevention of Significant Deterioration (PSD) regulations to ensure that air quality in attainment or unclassified areas does not significantly deteriorate as a result of construction and operation of major stationary sources. A PSD increment is the maximum allowable increase in concentration of a pollutant that is allowed to occur above a baseline concentration. A typical major PSD source is classified as any source of air pollutant emissions with the potential to emit 250 tons per year of any regulated pollutant in an attainment area. However, for several types of major source operations, including fossil fuel-fired steam electric plants of more than 250 million British Thermal Units (BTUs) per hour heat input, 100 tons per year is the major PSD threshold.

Because the implementation of the TSP would not involve installation of any permanent stationary combustion sources on-port, no adverse air quality impacts from these sources would occur. Since the underlying supposition of the General Reevaluation Report (GRR) and associated Supplemental Environmental Impact Statement (SEIS) is based on the anticipated increase in commodities at the port over the next 50 years and the fact that the coal terminal has limited options for expansion, implementation of the TSP is not anticipated to increase the capacity of on-terminal combustion source operations and the throughput of stationary coal piles more than already anticipated over the next 50 years. However, due to specific concerns expressed by local communities during scoping and in individual Focus Group meetings, the potential operating emissions from on-port point sources such as terminal exhaust stacks and coal transport operations were quantified.

1.1.4 Mobile Sources Regulation

Mobile sources to be affected by the proposed action include:

- Drayage, Cargo handling equipment, and on-terminal activities
- Harbor craft
- Ocean going vessels including

  - Ships at terminal
  - Ships underway along the channels
- Roadway vehicles including trucks in and out of the port
- Rail road and rail yard

The emissions from these mobile sources are regulated under Title II of the CAA, which establishes emission standards that manufacturers must achieve. Therefore, unlike stationary sources, no permitting requirements exist for operating mobile sources.

1.2 METHODOLOGY AND IMPACT DETERMINATION

Since the localized air quality condition can be correlated with the close proximity of major emission sources, sensitive receptors (e.g., individuals with respiratory conditions) that are close to major emission sources generally tend to have more air quality concerns than those located far from emission sources.

Because port operational activities are mostly associated with mobile source operations conducted around port terminals and river channels within a relatively large geographic area, the air quality impact analysis selected for this SEIS purpose estimates emissions that occur on-port from operational activities under both baseline 2011 conditions and the future 2035 no action and build alternatives. The sources of criteria pollutant emissions evaluated include those identified within the port boundary and depicted in Figures 2 and 3.

Based on the USEPA's overall emission inventory evaluation process, in general, air emissions are calculated by determining the size of the engine, the amount of time the engine is used, the load upon the engine, and the emission rate for a specific type of pollutant. There are many details which can affect the final calculated emission value, including age of the engine and the type of fuel that it burns, etc. the USEPA has implemented such an evaluation process in developing 2011 baseline on-port emissions for many US ports including the port using the C-TOOLs modeling system. The inputs and outputs established by the USEPA for the port were used as the basis for establishing both baseline 2011 and future 2035 emissions inventories. For those source categories that were not included or not well defined for emission estimate purposes in the C-TOOLs model, such as emissions from on-port truck running and coal storage piles, additional USEPA-developed analysis tools or documents were used in emissions estimate. The available vessel counts provided by the port and the projected vessel calls provided by the Corps were further used to prorate the 2011 emission levels and derive the emissions under the 2035 no action condition.

In C-TOOLs program, the representative criteria pollutants of the greatest concern to human health have been identified and quantified by the USEPA and include NO_2 (presented in terms of NO_x), CO, SO_2 and $PM_{2.5}$. The PM_{10} emissions in this appendix for those C-PORT module-identified combustion source categories, vessels, locomotives, and nonroad equipment were predicted using the approximate ratio of 9% difference between PM_{10} and $PM_{2.5}$ applicable for typical ship diesel engines using Marine Residual Oil (RO) fuel taken from the USEPA's *Current Methodologies in Preparing Mobile Source Port-related Emission Inventories* (USEPA 2009).

Figure 2 – Emission Sources at Port of Mobile_ Part 1

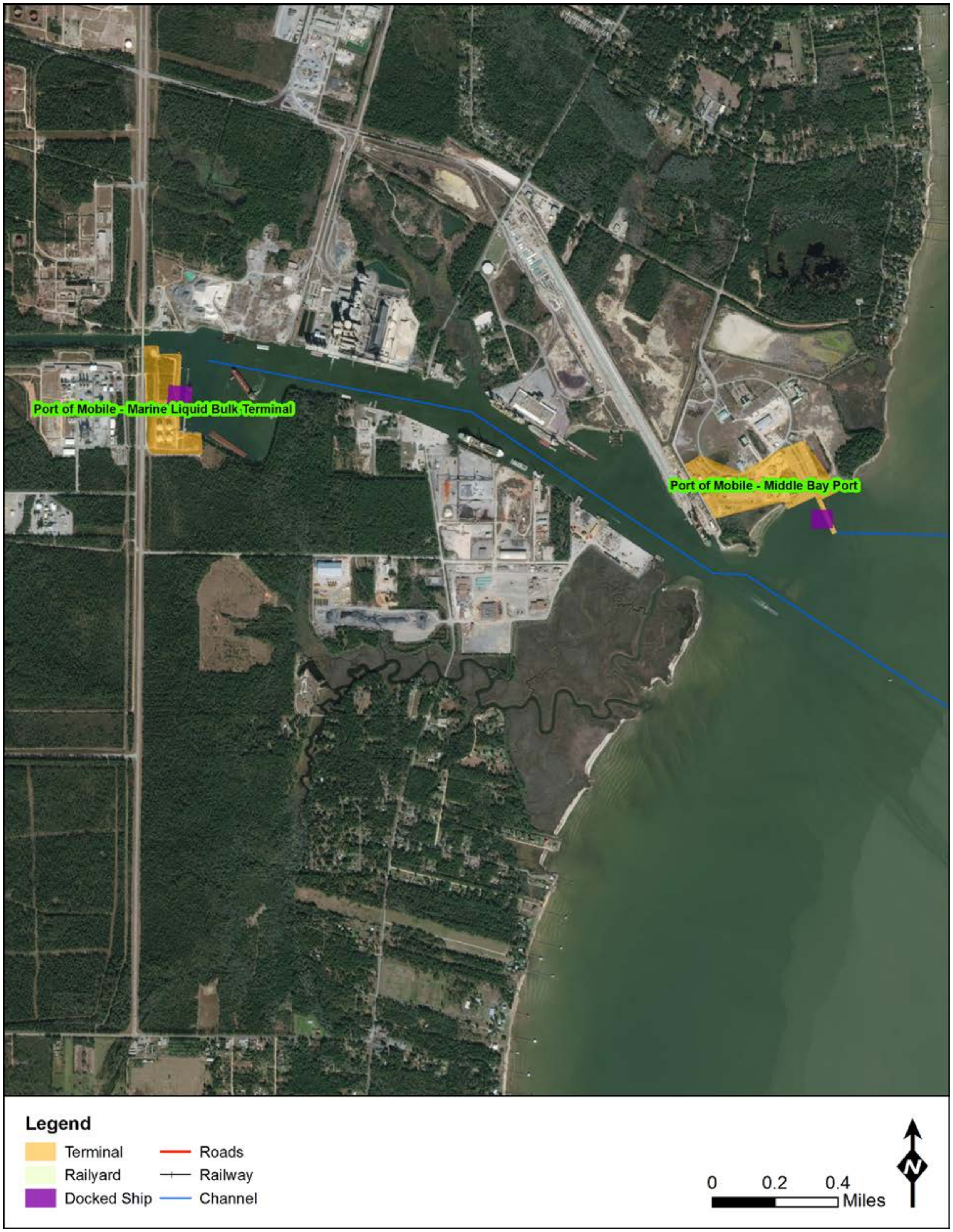


Figure 3 – Emission Sources at Port of Mobile_ Part 2

Given essentially similar purposes of widening and deepening the port channel proposed under the Charleston Harbor Navigation Improvement Project, to improve harbor mobility and cargo transporting efficiency, it is anticipated that implementation of the TSP would improve emission inventory at the port similar to that of the Charleston Harbor Navigation Improvement Project (USACE 2014).

Under the with project conditions, the Corps expects the total number of vessels to decrease within the Harbor of Mobile with deepening, as vessels will be able to load more efficiently under the improved conditions. As a result, the proposed action would not affect the number of containers that move through the areas that surround the port. The economic benefits of implementation of the TSP would result from the use of larger, more cost-effective container ships, not an increase in the number of containers. Therefore, future build alternative emission levels would likely be reduced as compared to the no action alternative as a result of improved mobility in harbor traffic and approximately a four-percent reduction in total vessel counts - a similar trend as shown in the Charleston Harbor Navigation Improvement Project. The future emission trends predicted by the Charleston Harbor Navigation Improvement Project are used as the reference in discussing potential emission impacts as a result of proposed action in the port.

The estimated change in emissions compared with the future no action condition are compared against the thresholds established in the CAA's PSD program on a local level to evaluate the extent of potential localized air quality impacts.

The areas around the port are considered attainment for all criteria pollutants. When emissions associated with a federal action would occur in areas that are in attainment, the CAA general conformity rule is not applicable, but NEPA and its implementing regulations require analysis of the significance of air quality impacts from these sources. However, neither NEPA nor its implementing regulations have established *de minimis* emission thresholds to determine potential significance of air quality impacts in attainment areas on a local level as compared to an area that is nonattainment. To determine air quality impacts for the implementation of the TSP, the "major stationary source" definition is used as explained below.

Under the CAA general conformity rule applicable to nonattainment areas, the USEPA uses the major stationary source definition under the New Source Review program as the *de minimis* levels to separate presumably exempt actions from those requiring a positive conformity determination on a project level, but not on a regional level. Because implementation of the TSP would occur in an area that is in attainment for all criteria pollutants, the major stationary source definition of 250 tons was selected as a comparable project-level significant impact threshold for this SEIS.

1.3 Criteria Pollutant Emissions Analysis

The air emissions analysis was performed for 2011 baseline condition and 2035 future no action and build conditions.

1.3.1 2011 Baseline Emissions

The USEPA developed the 2011 on-port emissions for the port using C-LINE and C-PORT modules within C-TOOLS suite of models for those source categories depicted in Figures 2 and 3. Although these models were developed primarily for comprehensive pollutant dispersion modeling purposes, they offer emission levels for identified on-port sources over terminals, truck routes, rail road, rail yard, vessel channels, etc. The 2011 criteria pollutant emission levels considered in these models for the port are used as the basis to project future 2035 emissions for the purpose of this SEIS.

The C-LINE module is used for roadway emissions and the C-PORT module adds more sources associated with the port operations such as rail, port terminals including nonroad equipment and stationary exhaust stacks, and ships.

Within the C-LINE module, specific emissions for each road line are calculated by combining national database information on annual average daily traffic (AADT) volume and fleet mix with emission factors predicted using the USEPA's MOtor Vehicle Emissions Simulator (MOVES) modeling system (USEPA 2015). For link-specific parameters, given the complex operational and meteorological conditions that affect vehicle exhaust, tail pipe and tire wear emission factors, C-LINE only provides the user with traffic volumes and speeds that can then be used for emission estimate purposes. Therefore, to predict emissions along those C-LINE identified on-port truck route emissions, the most recent emission factor model, MOVES2014a, was used in association with the national default county-specific input parameters to predict on-port truck emission factors along those C-LINE links with available 2011 truck volumes and speeds.

Within the C-PORT module which builds upon C-LINE, various source categories, as shown in Figures 2 and 3, are modeled as:

- Area sources
    - nonroad equipment such as drayage, cargo handling equipment within terminals and the USEPA's National Emissions Inventory (NEI) 2011 emissions are spatially allocated over terminals
    - Rail yard
- Line sources
    - harbor craft along port channels
    - ships underway along shipping channels representing a path to the terminal from the sea based on ACE shipping lane segments with freight activity
- Point sources
    - ships at the terminal
    - stationary combustion sources within the port

In addition to the USEPA-established 2011 point-, line-, and area-specific emissions for the port, dust emissions from coal pile operations at the port were also considered in the SEIS for the 2011 processing capacity and estimated using USEPA emission factors (USEPA 2005) in association with average wind speed data in the area.

1.3.1.1 C-PORT-predicted Emissions

Table 3 summarizes the C-Port-predicted port-wide 2011 emissions from each of the model considered operational source categories on-port.

Table 3. C-PORT Predicted Annual Port-wide Operational Emissions

Source Category	*NO_x (tons)*	*CO (tons)*	*SO_2 (tons)*	*$PM_{2.5}$ (tons)*	*PM_{10} (tons)*
Ships and Harbor Craft along Channels (line sources)	1151.6	448.1	107.2	35.5	38.7
Terminal Areas and Railyards (area and point sources)	2122.5	411.1	69.5	67.0	73.0
Railways (line sources)	45.5	6.3	0.4	1.4	1.5

1.3.1.2 On-port Truck Emissions

The USEPA's MOVES2014a emission factor model (USEPA 2015) was used to predict emission factors for on-port short haul trucks along each link identified in the C-LINE module for the port shown in Figures 2 and 3. The national default model input parameters applicable to Mobile County, where the port is located, were used. The predicted link-specific 2011 truck emission factor was multiplied by the truck traffic volume and corresponding link length to derive truck emissions on an annual basis as presented in Table 4.

Table 4. Truck Annual Emissions

Source Category	*NO_x (tons)*	*CO (tons)*	*SO_2 (tons)*	*$PM_{2.5}$ (tons)*	*PM_{10} (tons)*
On-Port Trucks	21.8	10.8	0.0	1.8	2.5

1.3.1.3 Coal Handling and Storage Pile PM Emissions

PM emissions from a storage pile material handling process result from:

- Loading of materials onto storage piles (batch or continuous drop operations)
- Equipment traffic in storage area
- Wind erosion of pile surfaces and ground areas around piles
- Loadout of materials for shipment or for return to the process stream (batch or continuous drop operations)

The following formula was used to calculate PM emission factors from material handling within storage piles caused by wind erosion effects (USEPA 1995):

$$E = k\ (0.0032)\ (U/5)^{1.3} / (M/2)^{1.4}\ \text{(pound/ton)}$$

Where:

- E = Emission factor in pounds of pollutant per ton of material processed
- k = particle size multiplier
- U = mean wind speed in meters per second

- M = material moisture content as a percentage

The mean wind speed over the past five years in the city of Mobile and the mean moisture content available for western surface coal mining were used in applying the equation. The emission factors were then applied to the 2011 annual throughput of coal handled at the McDuffie terminals and the bulk material handling plant to predict annual PM emissions.

To account for several drops made during each complete coal transport cycle, approximately 10 drops per loading and unloading cycle were assumed. This number likely include transporting coal to and from ships, barges, rail dumps, stackers and reclaimers, piles, etc. The calculated PM emissions were further adjusted by the average number of drops for loading and unloading during each transporting cycle. Since water spray is utilized around coal to suppress dust, a typical water suppression control efficiency of 50% was applied to the results as summarized in Table 5.

Table 5. Coal Storage Pile PM Emissions

Annual Coal Throughput (tons)	*Mean Wind Speed (mph)*	*Moisture Content (%)*	*Control from Watering*	*Number of Load/ Upload Processes*	*$PM_{2.5}$ Emissions (tons)*	*PM_{10} Emissions (tons)*
13,498,389	6.4	6.9	50%	0.70	0.70	4.6

1.3.1.4 2011 On-port Emission Inventory

The total combined 2011 emissions inventory for each criteria pollutant of concern on-port is presented in Table 6.

Table 6. 2011 Baseline Annual Emissions

Source Category	*NO_x (tons)*	*CO (tons)*	*SO_2 (tons)*	*$PM_{2.5}$ (tons)*	*PM_{10} (tons)*
All	3,341.4	876.3	177.1	106.4	120.3

1.3.2 2035 Projected Port Emissions

The future port operational emissions are directly proportional to the port processing capacity driven by the number and size of vessels coming in and out of the harbor. The historic vessel/tug counts and future projected vessel calls provided in Table 7 were used to prorate the 2011 baseline emission inventory to derive the 2035 emission inventory.

Table 7. Vessel/Tug Counts and Vessel Calls Records/Forecasts

Year	*Vessel/Tug Counts (in and out)NO_x*	*Vessel Calls/Counts (without Project)*	*Vessel Counts (with Project)*
2011	1876	1002[1]	--
2012	1823	--	--
2013	1567	--	--
2014	1904	1017	--
2015	1868	--	--
2016	2097	--	--
2017	2315	--	--
2025	--	1487	1439
2035	--	1781	1711

1. Estimated based on available ratio from 2014 calls and vessel counts

1.3.2.1 No Action Alternative

As shown in Table 7, the vessel calls projected under the 2035 no action condition would increase approximately by 78 percent over the 2011 condition. This ratio of increase in vessel traffic was applied to the 2011 emissions inventory to predict the 2035 emission inventory under the no action alternative as presented in Table 8. It should be noted that this predicted inventory is considered to be conservatively high because future combustion engines used for vessels, trucks, locomotives, and nonroad equipment would be cleaner as a result of implementation of emission control programs on both federal and state levels. The use of cleaner engines would partially offset the adverse emission impacts from an increased demand of harbor operational activities in the future.

Table 8. Projected 2035 No Action Alternative Annual Emissions

Source Category	*NO_x (tons)*	*CO (tons)*	*SO_2 (tons)*	*$PM_{2.5}$ (tons)*	*PM_{10} (tons)*
All	5939.2	1557.6	314.8	189.1	213.8

1.3.2.2 Tentatively Selected Plan

The proposed deepening and widening of approximately 39 miles of harbor channel would be a major construction project requiring certain large dredges to be used over several years. These dredges are currently used for channel maintenance dredging activities. Since the deepening activity emissions would not take place along the channel at the same location for a long duration, they are considered temporary resulting in less than significant air quality impacts to the community along the channel.

Under the channel deepening operational condition, the overall throughput levels at the port would not change as compared to the no action alternative. A slight reduction of overall vessel counts would occur and certain amount of larger ships would have access to the port resulting in an improvement of cargo transporting efficiency with less delay than anticipated under the no action alternative. Therefore, it is predicted that the short-duration (e.g., worst-case) daily emissions at the port including vaporized VOC emissions released during the fueling process between larger ships and fuel farms could increase, but the overall annual emissions would likely be less under the implementation of the TSP than the No Action Alternative.

Given the uncertainty of the mix and size of vessels using the port and the change in vessel travel time in the future after channel deepening, a precise calculation of the change in annual emissions under the proposed action is not feasible. However, the on-port operational activities that would be affected by the channel deepening and widening are anticipated to be similar to those under the Charleston Harbor Navigation Improvement Project (USACE 2014). According to the emissions forecasted for the Charleston Harbor deepening project, the alternative with the largest deepening from a no action depth of 45/45 to the 2037 build alternative with a deepening of 52/48 depth would result in emission reduction ratios ranging from approximately 1 to 3 percent for the criteria pollutants as shown in Table 9. Given the similarity of the proposed harbor navigation improvement scheme at both harbors, these ratios were applied to roughly estimate the changes in emissions in 2035 as summarized in Table 9.

Table 9. Projected Changes in 2035 Emissions under Channel Deepening Alternative

Source Category	***NO_x (tons)***	***CO (tons)***	***SO_2 (tons)***	***$PM_{2.5}$ (tons)***	***PM_{10} (tons)***
Emissions Reduction Ratio from Charleston Harbor Deepening Project 2037 No Action to Build (%)	-1.1	-0.8	-3.4	-1.0	-1.0
Estimated Likely Change from 2035 No Action Alternative to Build Alternative from Mobile Harbor Deepening Project	-65.3	-12.5	-10.7	-1.9	-2.1
PSD Threshold	250	250	250	250	250

Reasonably foreseeable changes in emissions associated with the implementation of the proposed action were estimated and compared to the 250 tons per year threshold on an annual basis to determine potential air quality impacts. If the total emissions exceed the PSD threshold, a further evaluation of the emissions resulting from the proposed action should be conducted to assess the emissions impact on sensitive land uses to determine the potential significance of air quality impacts.

As indicated in Table 9, the proposed action would result in a net emission reduction for each criteria pollutant and therefore, the proposed action would result in less than significant air quality impacts.

1.4 References

USACE. (2014). *Charleston Harbor Post 45, Charleston South Carolina, Final Feasibility Report and Environmental Impact Study, Air Emissions Inventory, Appendix D.* October 2014. Retrieved from http://www.sac.usace.army.mil/Portals/43/docs/civilworks/post45/mainreport/Appendix%20N%20-%20Air%20Emission%20Inventory.pdf

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ENVIRONMENTAL APPENDIX C

ATTACHMENT C-4

THREATENED AND ENDANGERED SPECIES

&

ESSENTIAL FISH HABITAT

REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

May 31, 2018

Coastal Environment Team
Environmental Resources Branch

Mr. William Pearson
U.S. Fish and Wildlife Service
1208-B Main Street
Daphne, Alabama 36526

Dear Mr. Pearson:

The U.S. Army Corps of Engineers (USACE), Mobile District is proposing modifications to the existing Mobile Harbor Federal Navigation channel. The proposed modifications consists of overall deepening of the Federal channel to a depth of 50-feet and widening of 100 feet for 3 miles, and a modification to an existing turning basin. The Mobile Harbor Federal Navigation Project is divided into three general areas: the River Channel section, the Bay Channel section, and the Bar Channel section. The Tentatively Selected Plan (TSP) consists of: dredging and placement activities for approximately 27,000,000 cubic yards (cys) of new work material associated with the improvements of Mobile Harbor, and subsequent future operations and maintenance dredging and placement activities. It also consists of deepening the existing channel an additional 5 feet (existing 45 foot deep channel in the bay to 50 feet and existing 47 foot deep channel in the bar to 52 feet); adding an additional 100 feet of widening for a distance of three miles beginning at the upper end of the bend area at the 50 foot depth; including bend easing with the deepening at the upper end of the bar channel; and, modification to the Choctaw Pass turning basin to ensure safe operation at the 50 foot depth (see Figures 1-9). Material dredged during the improvements will be placed at a relic shell mined area and the Mobile Ocean Dredged Material Disposal Site (ODMDS). Any suitable bar channel new work material dredged in sufficient quantity to warrant placement at the Sand Island Beneficial Use Area (SIBUA) will be accomplished accordingly. Future material from channel maintenance will be placed at those previously noted disposal sites in addition to open-water sites adjacent to the channel, the northwestern SIBUA expansion, and/or previously approved upland disposal sites.

The most recent Section 7 coordination occurred in December 2016 when the USACE, Mobile District sought consultation for the continued operations and maintenance of the existing Mobile Harbor Federal Navigation Project, Mobile County. In January 2017, the U.S. Fish and Wildlife Service concurred with the USACE's determination that the continued operations and maintenance of the Mobile Harbor Federal Navigation Project may affect, not likely to adversely affect federally listed species.

Analysis of Effects

The U.S. Fish and Wildlife Service lists the following species as either threatened and/or endangered that may occur within the project area: Bald eagle, Wood stork, Piping plover, Red knot, Alabama heelsplitter, Atlantic sturgeon, Loggerhead sea turtle, Eastern indigo snake, Black pine snake, Gopher tortoise, Southern clubshell, Alabama sturgeon, West Indian manatee, Hawksbill sea turtle, Leatherback sea turtle, Kemp's ridley sea turtle, and the Alabama red-bellied turtle.

The species of particular concern for the Mobile Harbor Federal Navigation Improvements Project includes the Alabama red bellied turtle, gulf sturgeon, sea turtles and the West Indian manatee. For this project the sea turtles and Gulf sturgeon fall under the National Marine Fisheries Service jurisdiction. For sea turtles and Gulf sturgeon, the USACE will refer to the National Marine Fisheries Service issued Gulf Regional Biological Opinion for Dredging of Gulf of Mexico Navigation Channels and Sand Mining Areas Using Hopper Dredges by COE Galveston, New Orleans, Mobile, and Jacksonville Districts (Consultation Number F/SER/2000/01287) dated November 19, 2003 and subsequent revisions. The Alabama red bellied turtle is known to inhabit certain areas within the Mobile Harbor project, especially the River channel and the upper reaches of the upper channel. Dredging and disposal operations within the maintained channels and existing upland disposal areas have not been identified in the past as actions that would be threatening to this species. West Indian manatees are known to exist throughout the entire project area. The USACE has historically agreed to implement "Standard Manatee Construction Conditions" during dredging and disposal operations in Alabama. The USACE anticipates that if these measures are implemented there will be no adverse impact to West Indian manatees.

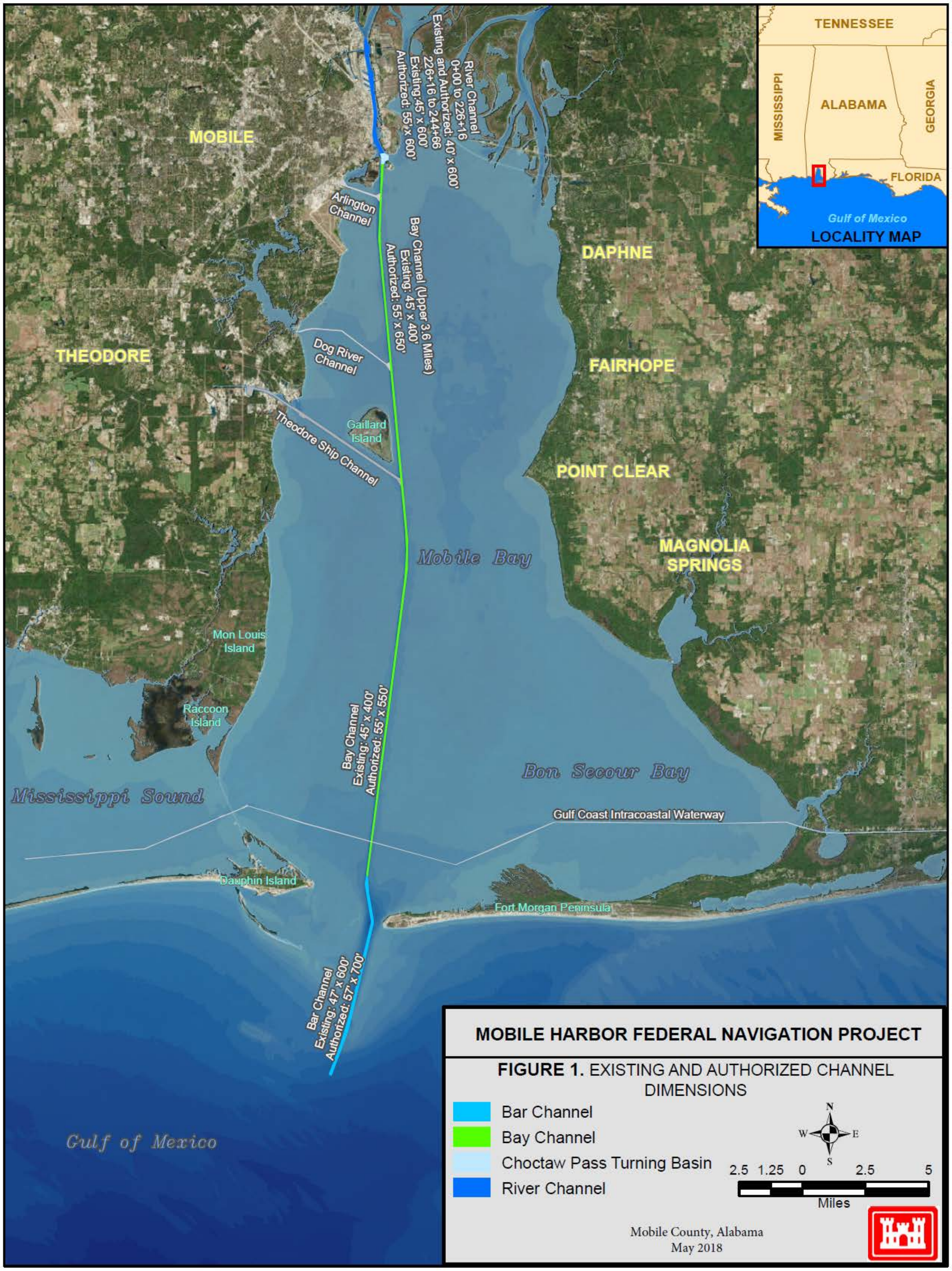
Based on this information, the USACE, Mobile District finds that the proposed modification activity is not likely to adversely affect any listed endangered and/or threatened species or their associated critical habitat. Under Section 7 coordination of the Endangered Species Act, the USACE, Mobile District requests your concurrence with the determination for the channel improvements of the Mobile Harbor Federal Navigation Project. If we can be of any further assistance to you, please contact Mr. Larry Parson at (251) 690-3139 or larry.e.parson@usace.army.mil.

Sincerely,

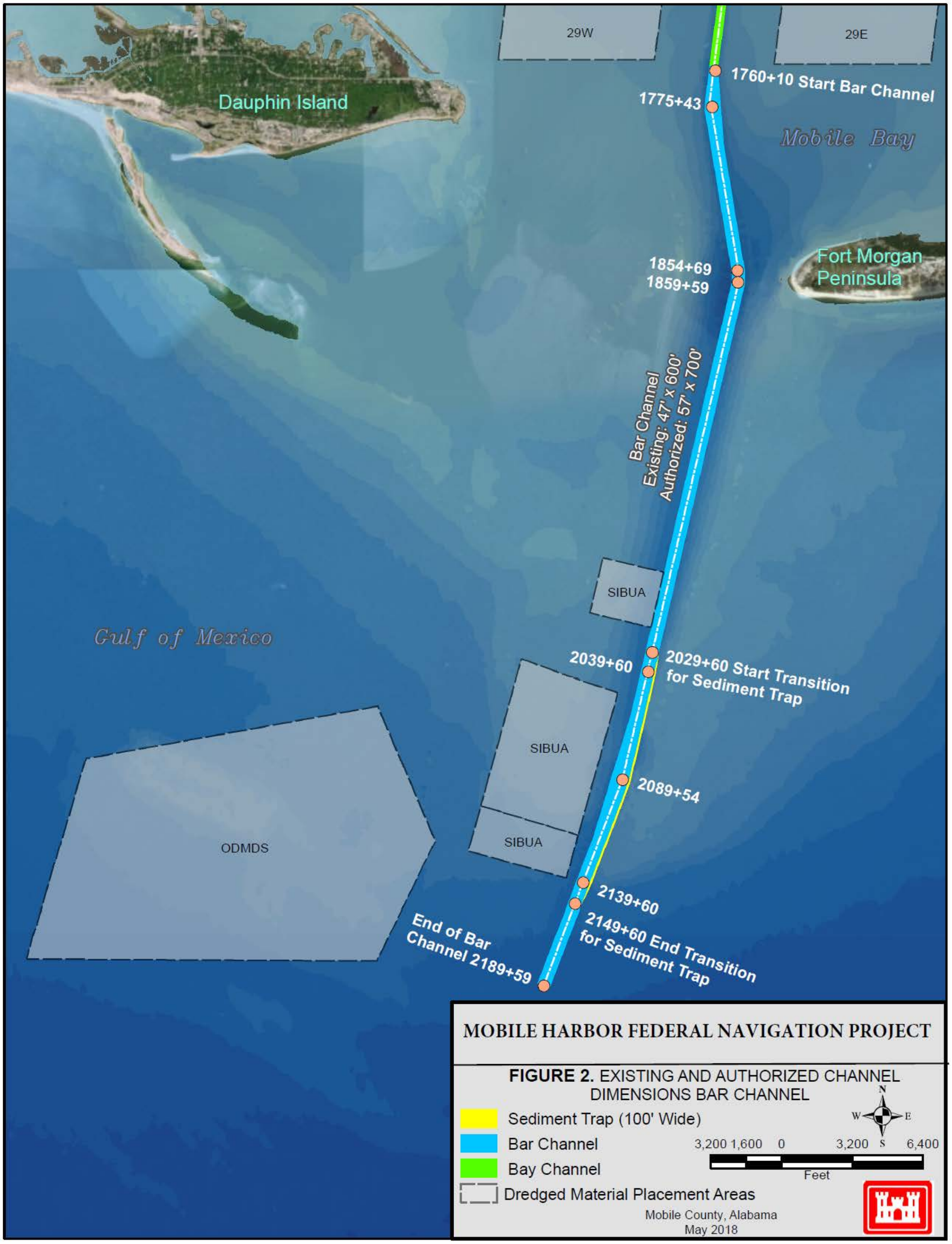
Lekesha W. Reynolds
Chief, Coastal Environment Team

Enclosures

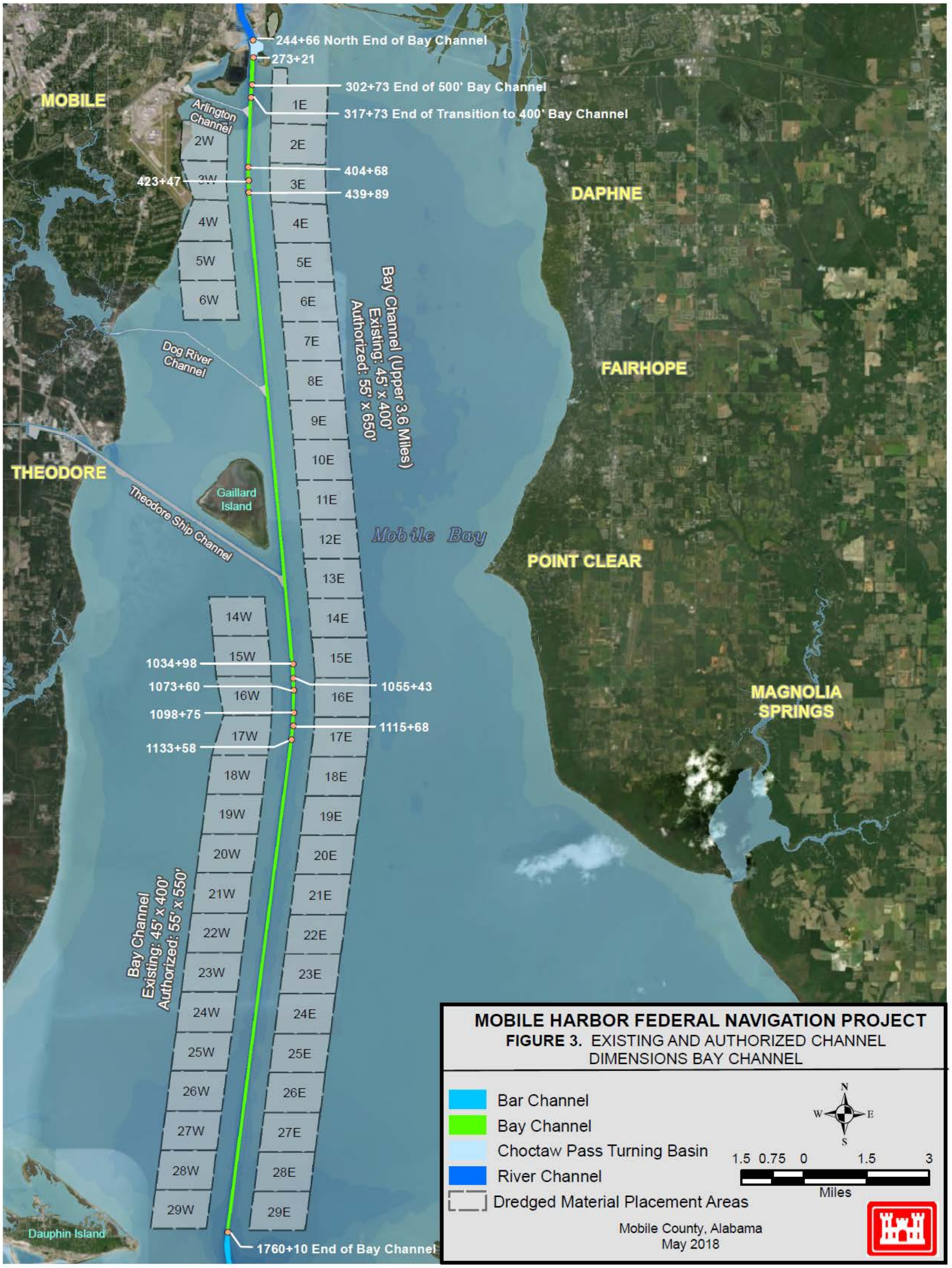
Enclosures (Figures 1-9)



TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
Gulf of Mexico
LOCALITY MAP
MOBILE
River Channel
0+00 to 226+16
Existing and Authorized: 40' x 600'
226+16 to 244+66
Existing:45' x 600'
Authorized: 55' x 600'
Arlington Channel
Bay Channel (Upper 3.6 Miles)
Existing: 45' x 400'
Authorized: 55' x 650'
DAPHNE
THEODORE
Dog River Channel
FAIRHOPE
Gaillard Island
Theodore Ship Channel
POINT CLEAR
Mobile Bay
MAGNOLIA SPRINGS
Mon Louis Island
Raccoon Island
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
Bon Secour Bay
Mississippi Sound
Gulf Coast Intracoastal Waterway
Dauphin Island
Fort Morgan Peninsula
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
Gulf of Mexico
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 1. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS
Bar Channel
Bay Channel
Choctaw Pass Turning Basin
River Channel
N
W
E
S
2.5 1.25 0 2.5 5
Miles
Mobile County, Alabama
May 2018



29W
29E
1760+10 Start Bar Channel
1775+43
Dauphin Island
Mobile Bay
1854+69
1859+59
Fort Morgan Peninsula
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
SIBUA
Gulf of Mexico
2039+60
2029+60 Start Transition for Sediment Trap
SIBUA
2089+54
ODMDS
SIBUA
2139+60
End of Bar Channel 2189+59
2149+60 End Transition for Sediment Trap
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 2. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS BAR CHANNEL
Sediment Trap (100' Wide)
Bar Channel
Bay Channel
Dredged Material Placement Areas
N
W
E
S
3,200 1,600 0 3,200 6,400
Feet
Mobile County, Alabama
May 2018


244+66 North End of Bay Channel
273+21
302+73 End of 500' Bay Channel
317+73 End of Transition to 400' Bay Channel
404+68
423+47
439+89
MOBILE
Arlington Channel
DAPHNE
FAIRHOPE
THEODORE
Dog River Channel
Gaillard Island
Theodore Ship Channel
Mobile Bay
POINT CLEAR
MAGNOLIA SPRINGS
Bay Channel (Upper 3.6 Miles)
Existing: 45' x 400'
Authorized: 55' x 650'
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
1034+98
1055+43
1073+60
1098+75
1115+68
1133+58
1760+10 End of Bay Channel
Dauphin Island
1E
2E
3E
4E
5E
6E
7E
8E
9E
10E
11E
12E
13E
14E
15E
16E
17E
18E
19E
20E
21E
22E
23E
24E
25E
26E
27E
28E
29E
2W
3W
4W
5W
6W
14W
15W
16W
17W
18W
19W
20W
21W
22W
23W
24W
25W
26W
27W
28W
29W
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 3. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS BAY CHANNEL
Bar Channel
Bay Channel
Choctaw Pass Turning Basin
River Channel
Dredged Material Placement Areas
N
S
E
W
1.5 0.75 0 1.5 3
Miles
Mobile County, Alabama
May 2018


US 43
0+00 North End of River Channel
Blakeley Island
30+38
72+09
98+82
River Channel
0+00 to 226+16
Existing and Authorized: 40' x 600'
Spanish River
Delvan Bay
Polecat Bay
MOBILE
157+18
I-110
US 42
Pinto Pass
Mobile Bay
198+77
Pinto Island
213+05
I-10
226+16
River Channel
226+16 to 244+66
Existing: 45' x 600'
Authorized: 55' x 600'
244+66 End of River Channel
Choctaw Point
Little Sand Island
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 4. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS
RIVER CHANNEL
Mobile County, Alabama
Choctaw Pass Turning Basin
River Channel
Dredged material Placement Areas
N
W
E
S
1,400 700 0 1,400 2,800
Feet
May 2018


TENNESSEE
ALABAMA
FLORIDA
Gulf of Mexico
LOCALITY MAP
MOBILE
4
Bay Channel (Upper 3.6 miles)
Existing: 45' x 400'
Authorized: 55' x 650'
TSP: 50'x400'
DAPHNE
FAIRHOPE
THEODORE
GAILLARD ISLAND
POINT CLEAR
MAGNOLIA SPRINGS
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50'x400'
3 Mile Widener for Passing: 50' x 500'
3
Gulf Coast Intracoastal Waterway
DAUPHIN ISLAND
2
FORT MORGAN
1
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP : 52' X 600'
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 5. Tentatively Selected Plan
Bar Channel
Bay Channel
3 Mile Widener for Passing
Choctaw Pass Turning Basin
River Channel
Plate Reference
N
W
E
S
2.5 1.25 0 2.5 5
Miles
Mobile County, Alabama
May 2018

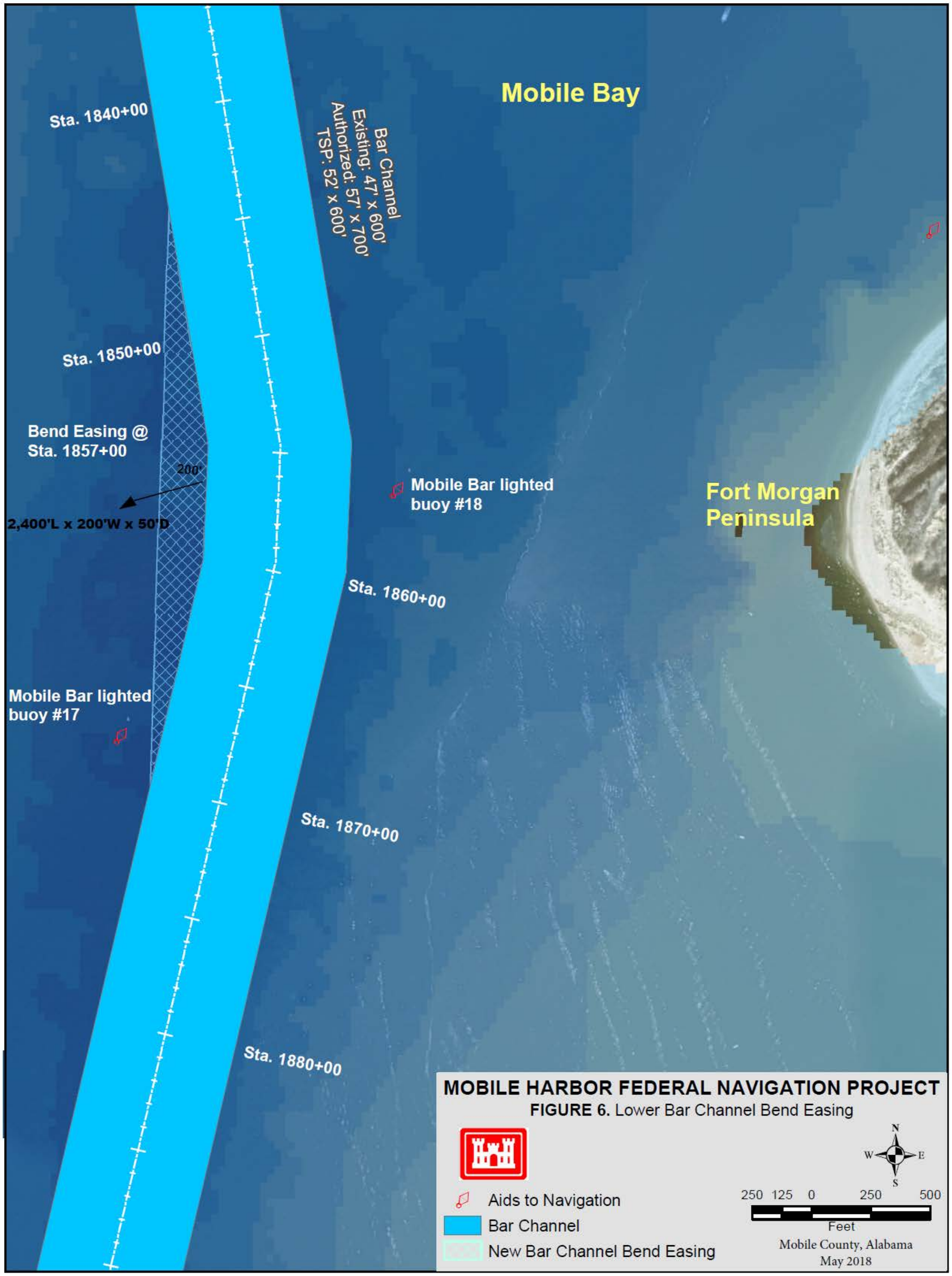
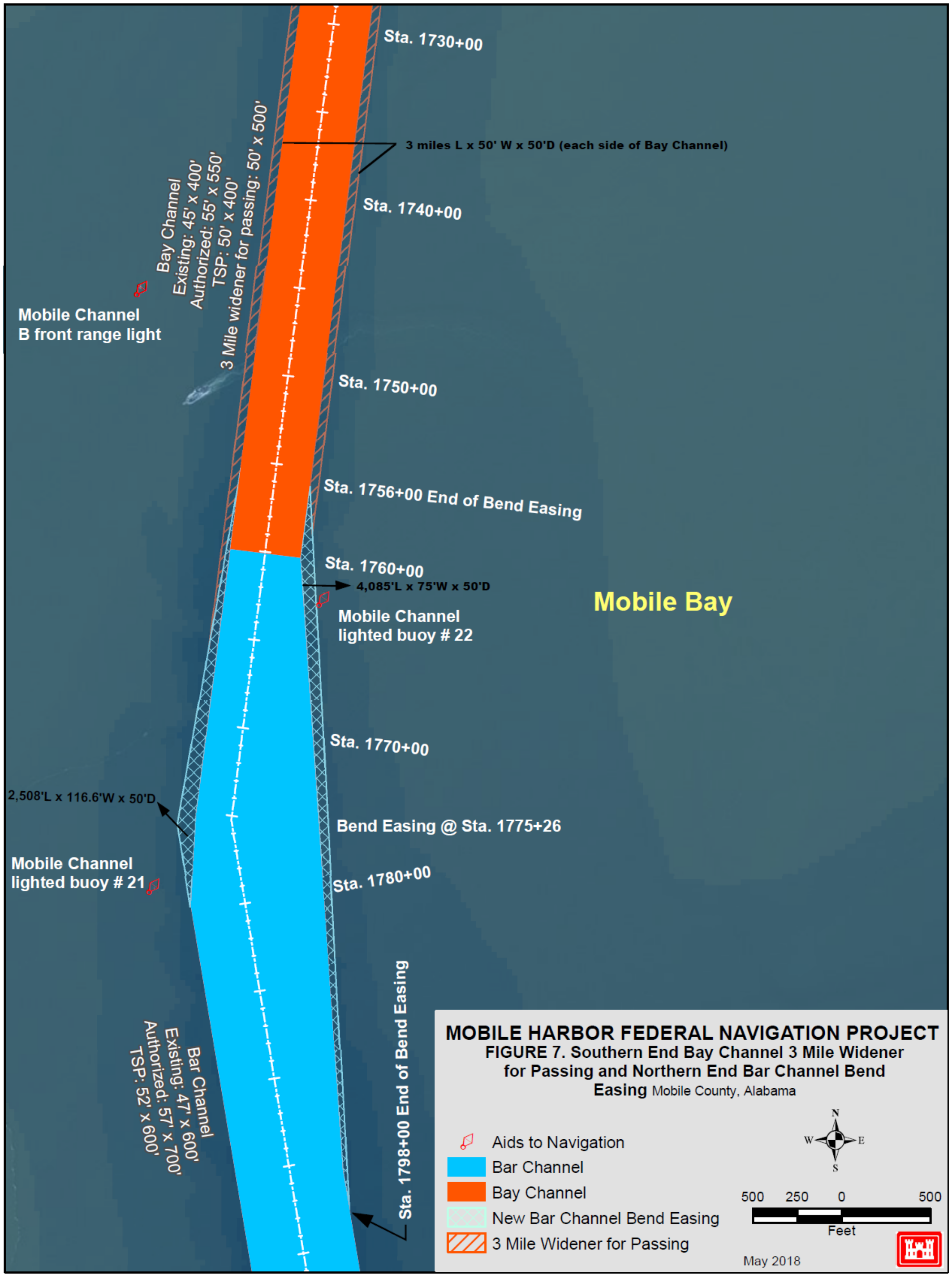
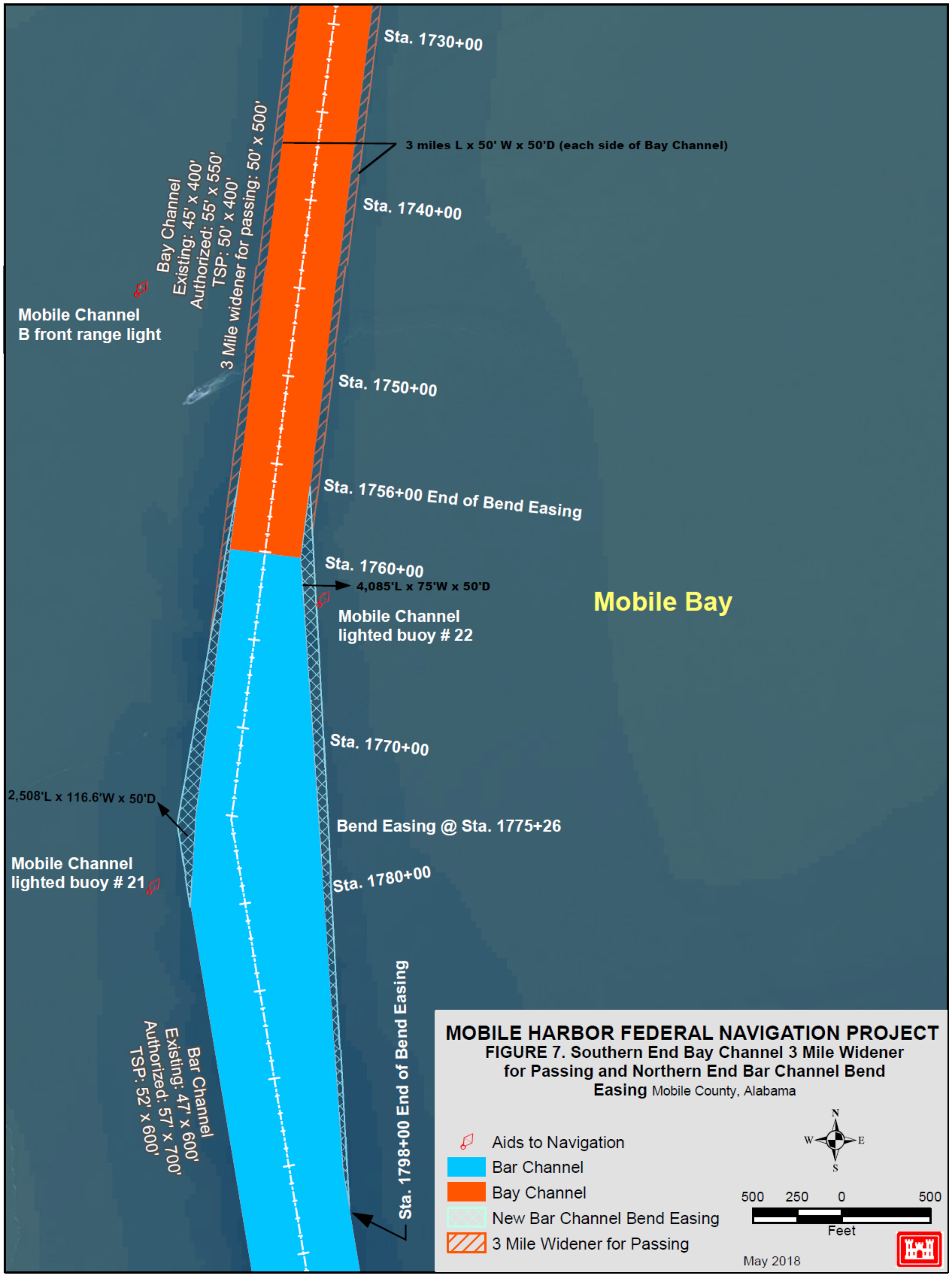
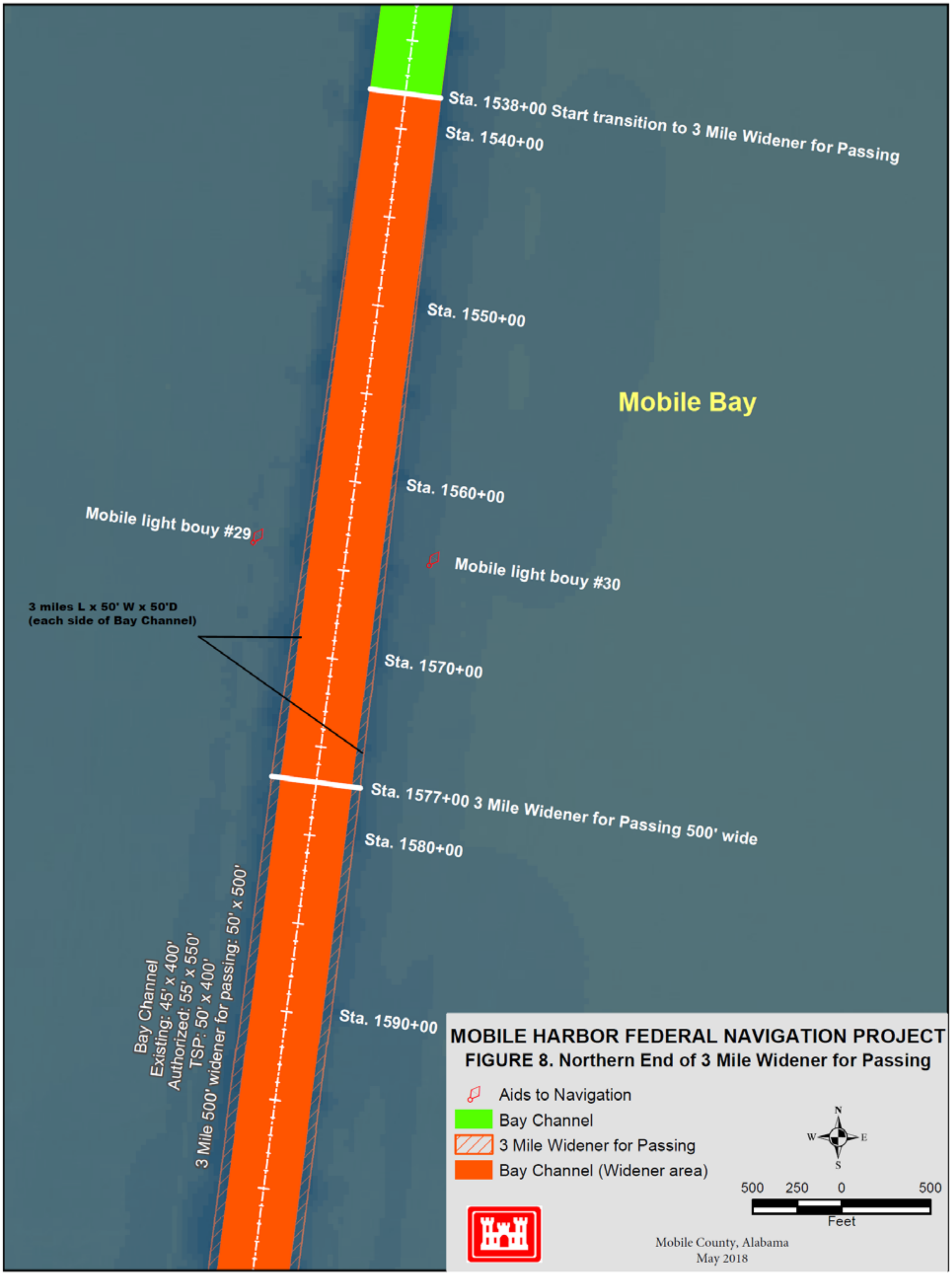
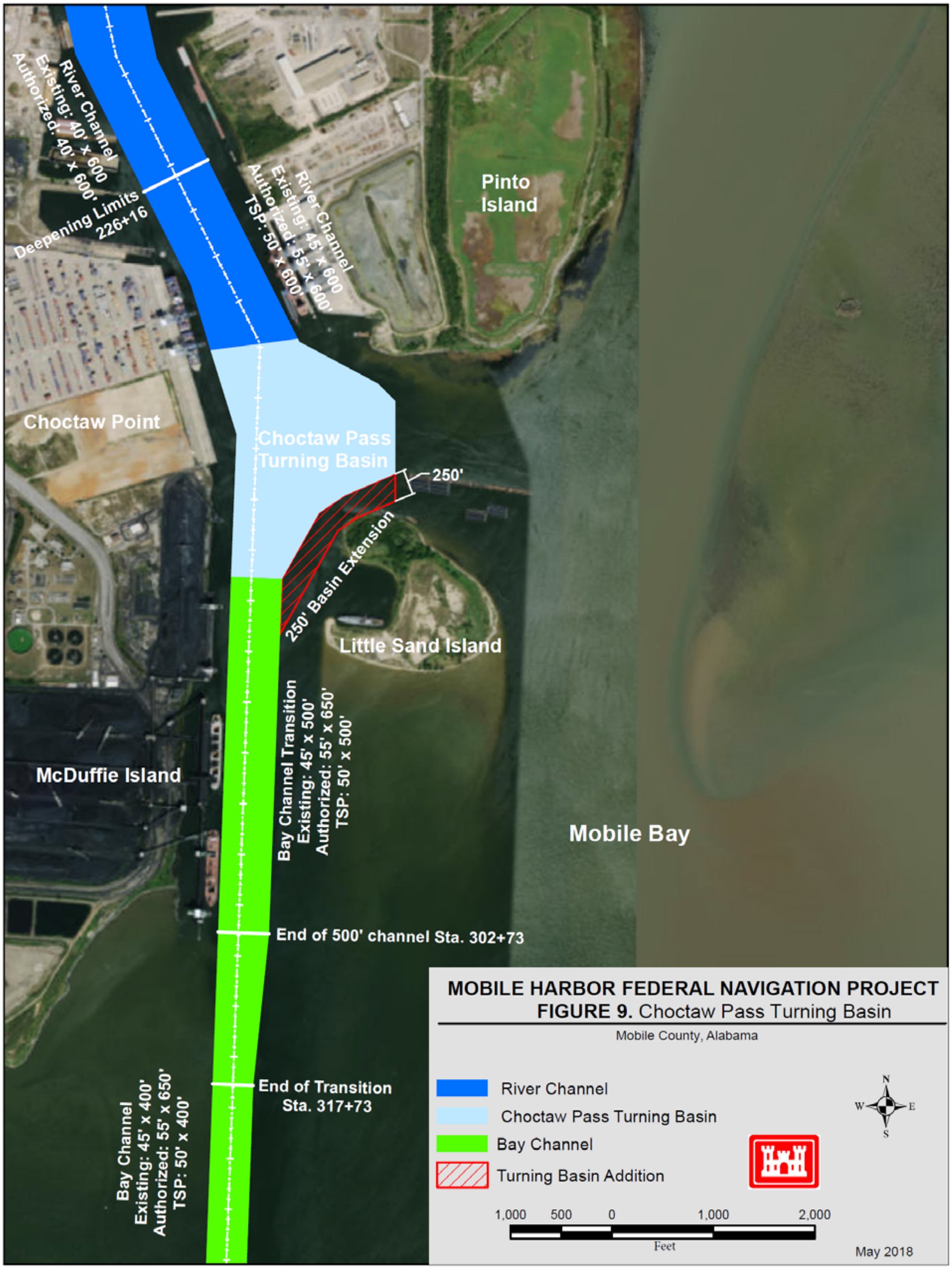


FIGURE 6. Lower Bar Channel Bend Easing


Sta. 1730+00
3 miles L x 50' W x 50'D (each side of Bay Channel)
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50' x 400'
3 Mile widener for passing: 50' x 500'
Sta. 1740+00
Mobile Channel
B front range light
Sta. 1750+00
Sta. 1756+00 End of Bend Easing
Sta. 1760+00
4,085'L x 75'W x 50'D
Mobile Channel
lighted buoy # 22
Mobile Bay
Sta. 1770+00
2,508'L x 116.6'W x 50'D
Bend Easing @ Sta. 1775+26
Mobile Channel
lighted buoy # 21
Sta. 1780+00
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP: 52' x 600'
Sta. 1798+00 End of Bend Easing
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 7. Southern End Bay Channel 3 Mile Widener for Passing and Northern End Bar Channel Bend Easing Mobile County, Alabama
Aids to Navigation
Bar Channel
Bay Channel
New Bar Channel Bend Easing
3 Mile Widener for Passing
N
W
E
S
500 250 0 500
Feet
May 2018


Sta. 1730+00
3 miles L x 50' W x 50'D (each side of Bay Channel)
Sta. 1740+00
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50' x 400'
3 Mile widener for passing: 50' x 500'
Mobile Channel
B front range light
Sta. 1750+00
Sta. 1756+00 End of Bend Easing
Sta. 1760+00
4,085'L x 75'W x 50'D
Mobile Channel
lighted buoy # 22
Mobile Bay
Sta. 1770+00
2,508'L x 116.6'W x 50'D
Bend Easing @ Sta. 1775+26
Mobile Channel
lighted buoy # 21
Sta. 1780+00
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP: 52' x 600'
Sta. 1798+00 End of Bend Easing
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 7. Southern End Bay Channel 3 Mile Widener
for Passing and Northern End Bar Channel Bend
Easing Mobile County, Alabama
Aids to Navigation
Bar Channel
Bay Channel
New Bar Channel Bend Easing
3 Mile Widener for Passing
N
W
E
S
500 250 0 500
Feet
May 2018


Sta. 1538+00 Start transition to 3 Mile Widener for Passing
Sta. 1540+00
Sta. 1550+00
Mobile Bay
Sta. 1560+00
Mobile light bouy #29
Mobile light bouy #30
3 miles L x 50' W x 50'D
(each side of Bay Channel)
Sta. 1570+00
Sta. 1577+00 3 Mile Widener for Passing 500' wide
Sta. 1580+00
Sta. 1590+00
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50' x 400'
3 Mile 500' widener for passing: 50' x 500'
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 8. Northern End of 3 Mile Widener for Passing
Aids to Navigation
Bay Channel
3 Mile Widener for Passing
Bay Channel (Widener area)
N
W
E
S
500 250 0 500
Feet
Mobile County, Alabama
May 2018


River Channel
Existing: 40' x 600'
Authorized: 40' x 600'
Deepening Limits
226+16
River Channel
Existing: 45' x 600'
Authorized: 55' x 600'
TSP: 50' x 600'
Pinto
Island
Choctaw Point
Choctaw Pass
Turning Basin
250'
250' Basin Extension
Little Sand Island
Bay Channel Transition
Existing: 45' x 500'
Authorized: 55' x 650'
TSP: 50' x 500'
McDuffie Island
Mobile Bay
End of 500' channel Sta. 302+73
End of Transition
Sta. 317+73
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 650'
TSP: 50' x 400'
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 9. Choctaw Pass Turning Basin
Mobile County, Alabama
River Channel
Choctaw Pass Turning Basin
Bay Channel
Turning Basin Addition
1,000 500 0 1,000 2,000
Feet
May 2018

MOBILE HARBOR

NAVIGATION IMPROVEMENTS

GENERAL REEVALUATION REPORT

MOBILE AND BALDWIN COUNTIES, ALABAMA

ESSENTIAL FISH HABITAT ASSESSMENT

May 25, 2018

INTRODUCTION

This document presents the assessment of Essential Fish Habitat (EFH) conducted by the United States Army Corps of Engineers (USACE), Mobile District as evaluated in the Mobile Harbor General Reevaluation Report (GRR) with Integrated Supplemental

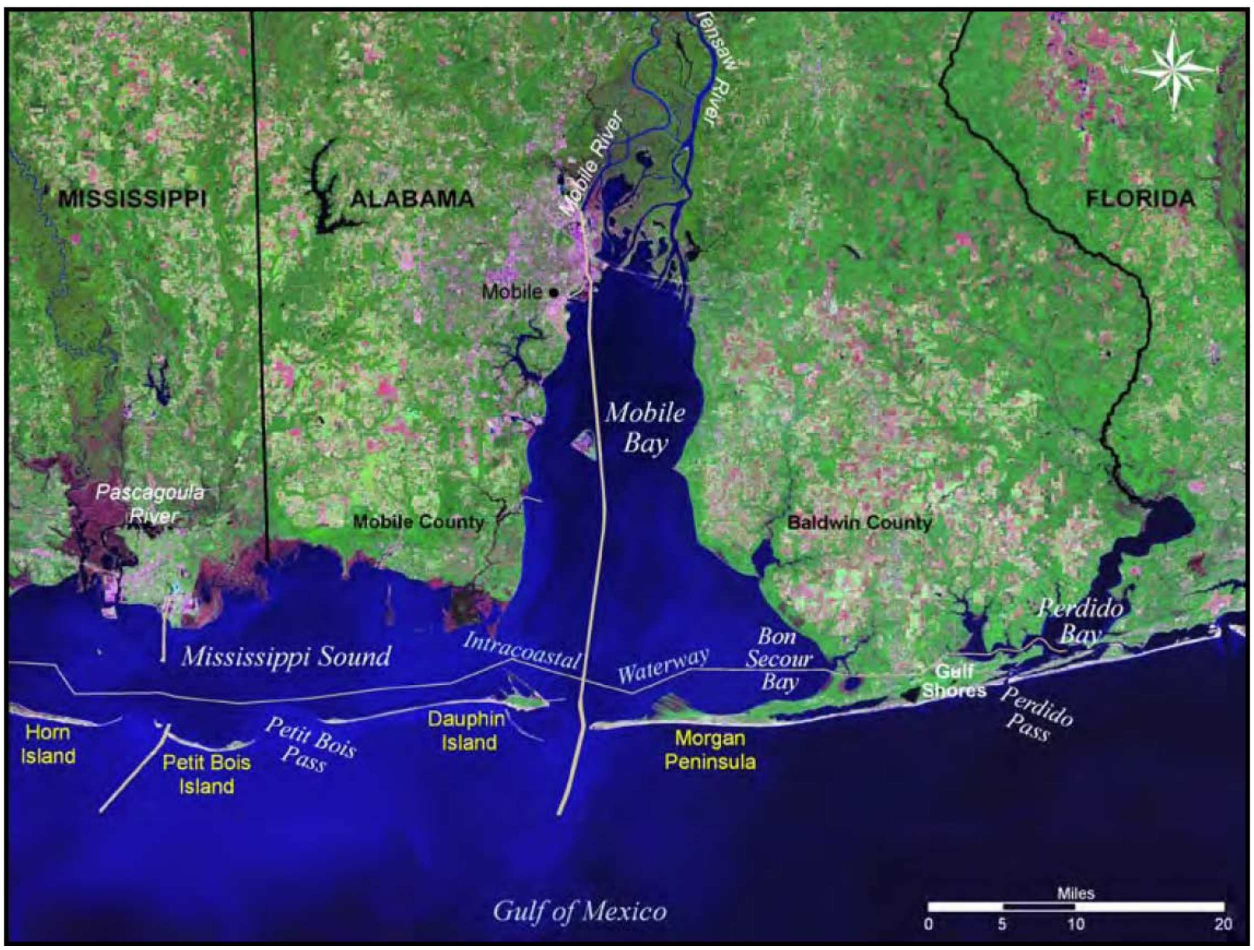


Figure 1. Mobile Bay

Environmental Impact Statement (SEIS). The project is located within Mobile Bay, Mobile and Baldwin Counties, Alabama.

Mobile Bay is an estuary which serves as a transition zone where the freshwater from the rivers mixes with the tidally-influenced salt water of the Gulf of Mexico. The Mobile Bay and the Mobile Tensaw river delta supports a diverse set of fish and wildlife habitats including: bogs, bottomland hardwoods, freshwater and hardwood swamps, freshwater wetlands, maritime forests, pine savanna, submerged aquatic vegetation (SAV), tidal and brackish water marshes and oyster reefs. These habitats are present along the northern, eastern and western shores and upper and lower part of the Bay.

PROJECT DESCRIPTION

The Tentatively Selected Plan (TSP) consists of: deepening the existing channel an additional 5 feet (existing 45 foot deep channel in the bay to 50 feet and existing 47 foot deep channel in the bar to 52 feet); adding an additional 100 feet of widening for a distance of three miles beginning at the upper end of the bend area at the 50 foot depth; including bend easing with the deepening at the upper end of the bar channel; and, modification to the Choctaw Pass turning basin to ensure safe operation at the 50 foot depth (see Figures 1-9). For preparation of the draft Mobile Harbor GRR with Integrated SEIS, the USACE, Mobile District conducted extensive modeling of a "maximum potential impacts" scenario with potential environmental effects equal to or greater than the TSP (i.e. dredging to a depth of 50 feet with widening of a five-mile channel section by 100 feet). It should be noted that the actual TSP represents conditions less than the modeled channel dimensions. Material dredged during the improvements will be placed at a relic shell mined area and the Mobile Ocean Dredged Material Disposal Site (ODMDS). Any suitable bar channel new work material dredged in sufficient quantity to warrant placement at the Sand Island Beneficial Use Area (SIBUA) will be accomplished accordingly. Future material from channel maintenance will be placed at those previously noted disposal sites in addition to open-water sites adjacent to the channel, the northwestern SIBUA expansion, and/or upland disposal sites. .

EFH DEFINED

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882) (MSFCMA) established regional Fishery Management Councils and mandated that Fishery Management Plans (FMP) be developed to responsibly manage exploited fish and invertebrate species in waters of the United States. When Congress reauthorized this Act in 1996 as the Sustainable Fisheries Act, several reforms and changes were made. One change was to charge the NMFS with designating and conserving EFH for species managed under existing FMPs. This is intended to minimize, to the extent practicable, adverse effects on habitat caused by fishing or non-fishing activities, and to identify other actions to encourage the conservation and enhancement of such habitat.

EFH is defined as “those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity” [16 U.S.C. § 1801(10)]. The EFH interim final rule summarizing EFH regulations (62 FR 66531-66559) outlines additional interpretation of the EFH definition. “Waters,” as defined previously, include "aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate." “Substrate” includes “sediment, hardbottom, structures underlying the waters, and associated biological communities.” “Necessary” refers to "the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem." “Fish” includes "finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds," and "spawning, breeding, feeding or growth to maturity" covers the complete life cycle of those species of interest.

The Gulf of Mexico Fishery Management Council currently maintains FMPs for a total of 21 selected species. These species or species complexes are shrimp (brown, pink, and white), red drum, reef fish (red, gag, and scamp grouper; red, gray, yellowtail, and lane snapper; greater and lesser amberjack; and tilefish); coastal migratory pelagic species (king and Spanish mackerel, cobia, and dolphin); stone crab, spiny lobster, and coral. For the Gulf of Mexico, EFH includes all estuarine and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone (EEZ).

The National Marine Fisheries Service (NMFS) has identified EFH for the Gulf of Mexico in its FMP Amendments. These habitats include estuarine areas, such as estuarine emergent wetlands, seagrass beds, algal flats, mud, sand, shell, and rock substrates, and the estuarine water column. **Table 1** provides a list of the species that NMFS manages under the federally implemented FMP in the vicinity of the proposed action.

RESOURCES ASSESSMENT RESULTS

Potential impacts of the navigation improvement project on biological resources in Mobile Bay are a concern to natural resource managers because changes in saltwater – freshwater exchanges in the estuary could affect the distribution of biotic communities, including benthic macroinvertebrates and the fish that feed on them.

Mobile Bay contains a variety of natural resources. An assessment of aquatic resources was conducted by an interagency team to evaluate potential changes in salinity and water quality as a result of the proposed project implementation and those impacts on habitat related to five aquatic resource categories including: benthic macroinvertebrates, wetlands, SAV, oysters, and fish. The results of the hydrodynamic and water quality models indicate that minimal changes in salinity and water quality are expected between the existing and with project conditions for the 0 and 0.5 m sea level rise cases.

The assessment described baseline characterization and distribution of existing resources, followed by analysis of projected post-project conditions (e.g., salinity, dissolved oxygen) with the potential to impact the presence and productivity of each target aquatic resource. A 0.5 m sea level rise scenario was also evaluated.

The wetland assessment identified >40 habitat types occurring across a wide range of salinity regimes. Projected changes in water quality will not exceed wetland plant community mortality or productivity thresholds within the study area, suggesting that impacts to wetlands are not expected. While the 0.5 m sea level rise scenario will result in increased wetland inundation within portions of Mobile Bay, implementation of the project is expected to have limited additional impacts on wetlands.

The SAV assessments identified > 600 acres of sea grasses encompassing 55 community types. Expected post project conditions suggest that > 93% of SAV communities will not experience substantial salinity increases. Where potential salinity thresholds may be exceeded, affected species are dominated by invasive species (Eurasian watermilfoil) or occur during short duration (<7 day) events. Dissolved oxygen levels remain within SAV tolerance limits across all scenarios examined.

Simulated oyster larvae movement through integrated hydrodynamic, water quality, and larval tracking modeling was successfully implemented. Dissolved oxygen levels stay well above the minimum oyster tolerance threshold for simulated scenarios with and without sea level rise. Similarly, salinity stays within oyster tolerance survival threshold for all scenarios. Importantly, the oyster model results do not project an increase in larvae flushing out of Mobile Bay due to project implementation.

For the fisheries assessment, a total of 2,097,836 individuals representing 162 species were recorded and used in the analysis, which include five salinity tolerance guilds ranging from freshwater to marine habitat conditions. The mean abundance of freshwater entering estuary guild was negatively correlated to salinity, whereas the marine entering estuary and marine only were positively correlated. The resident estuarine model suggested little to no correlation with salinity indicating their overall tolerance and ability to osmoregulate as they move between salinity gradients. Given these relationships, impacts to the Mobile Bay fishery are not expected.

The benthic macroinvertebrate assessment results indicate that benthic macrofaunal assemblages transition from polychaete-rich assemblages in the estuary to being dominated by insects in freshwater habitat. Expected post project conditions suggest mean bottom salinity increases of 1 -3 practical salinity units (psu). The greatest salinity increases are projected to occur within the transitional and estuarine zones where benthic macrofaunal assemblages are dominated by polychaete worms that are well adapted to experiencing salinity fluctuations that occur during tidal exchanges. Impacts of harbor deepening on benthic macrofauna due to salinity intrusion are predicted to be negligible, with no effects on higher trophic levels, such as fish, because prey availability and distributions are unlikely to be affected.

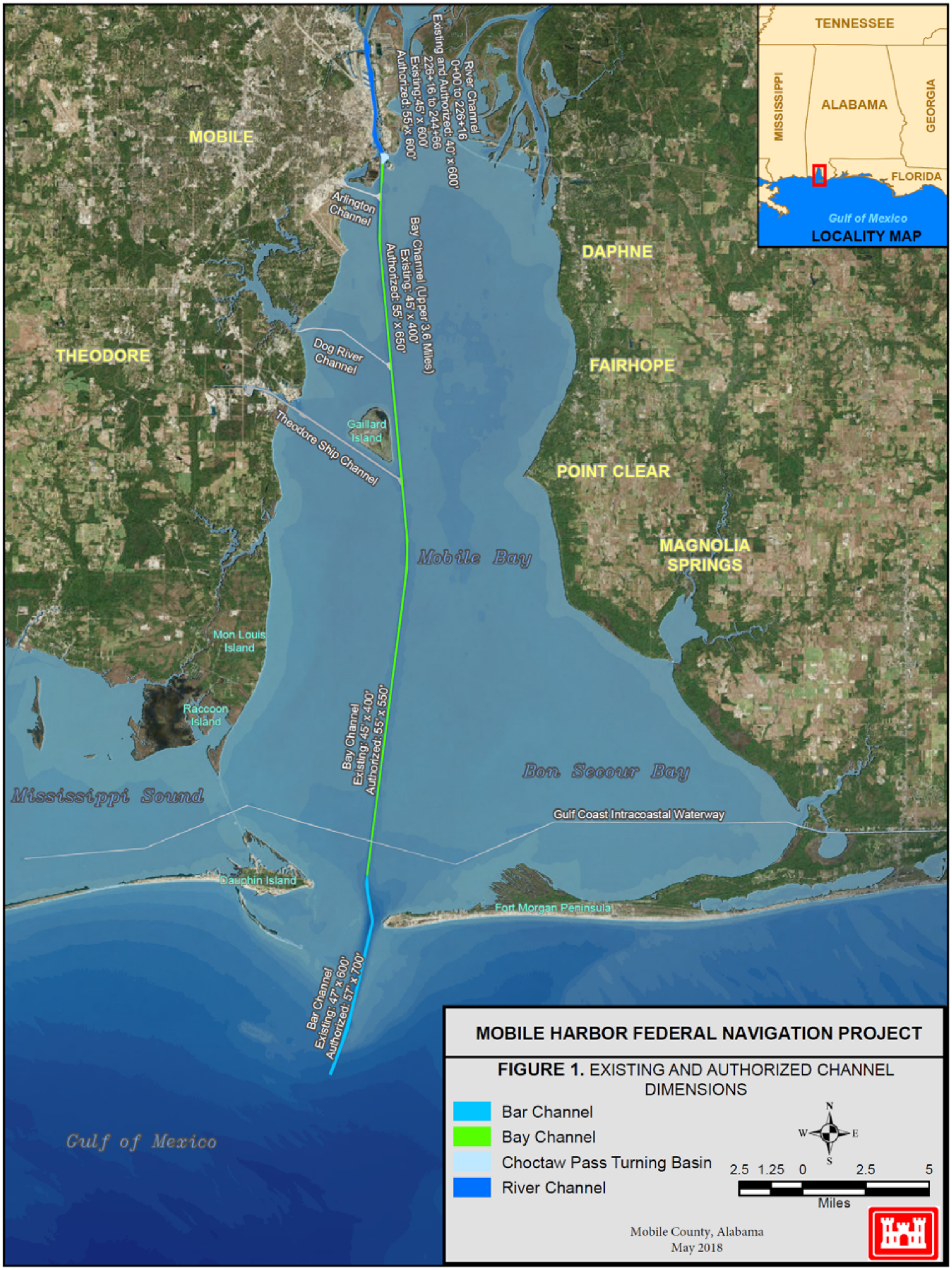
EFH EFFECTS FROM PROPOSED ACTION

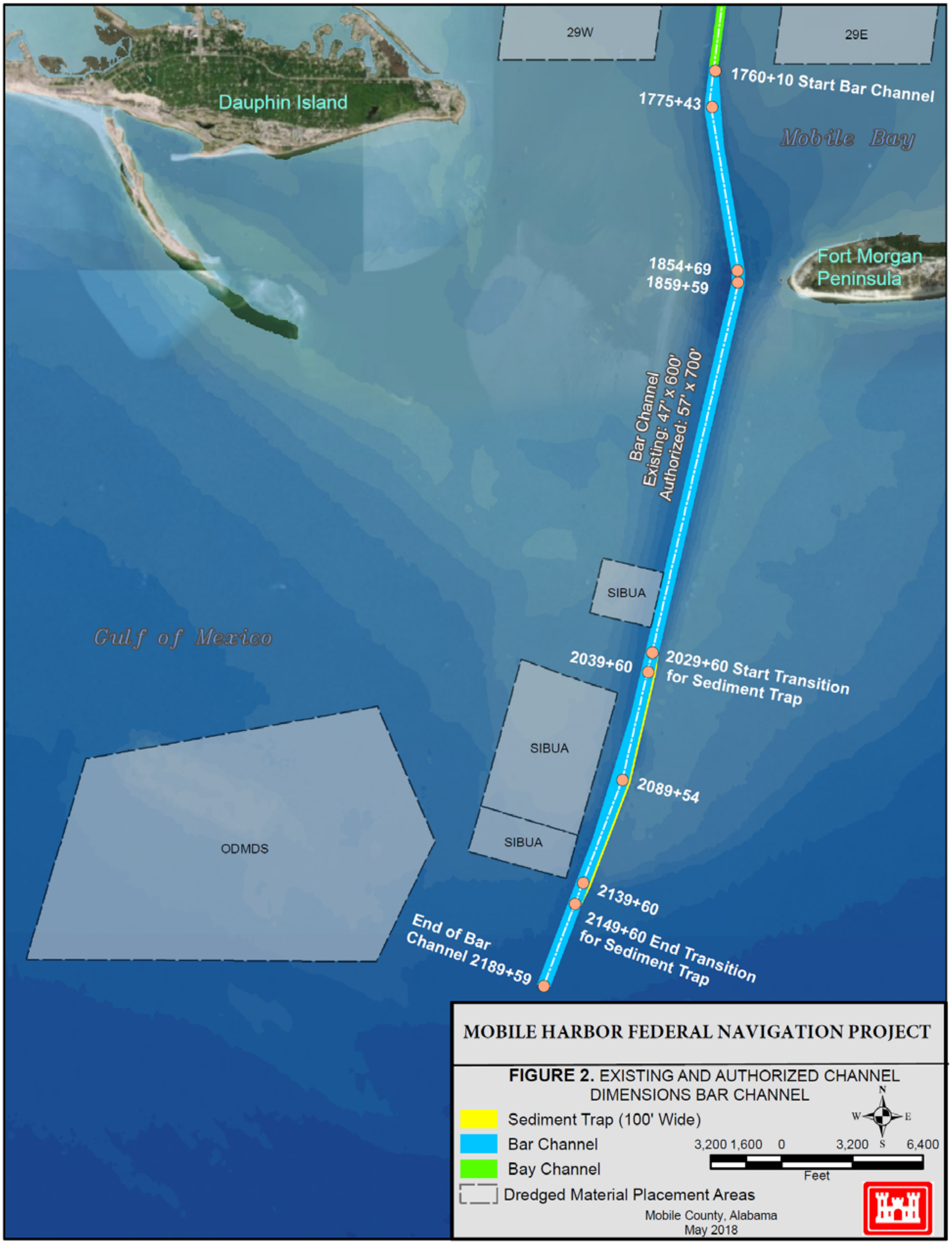
The USACE, Mobile District takes extensive steps to reduce and avoid potential impacts to EFH as well as other significant area resources. Adverse impacts to wetlands, oyster reefs, or SAVs from the implementation of the project would be anticipated to be no-effect, limited or negligible. Most of the motile benthic and pelagic fauna, such as crab, shrimp, and fish, should be able to avoid the disturbed area and should return shortly after the activity is completed. No long-term direct impacts to managed species of finfish or shellfish populations are anticipated. However, it is reasonable to anticipate some non-motile and motile invertebrate species will be physically affected through dredging and disposal operations. These species are expected to recover rapidly soon after the operations are complete. No significant long-term impacts to this resource are expected as result of this action. Increased water column turbidity during dredging would be temporary and localized. No change is anticipated to occur to the habitat types. Overall, Impacts to EFH would be temporal in nature associated with the dredging and placement activities in Mobile Harbor. The proposed activities would not significantly affect coastal habitat identified as EFH in the project area. Based on the extent of this habitat in the general vicinity of the project and the temporal nature of the impact, the overall impact to fisheries resources is considered negligible.

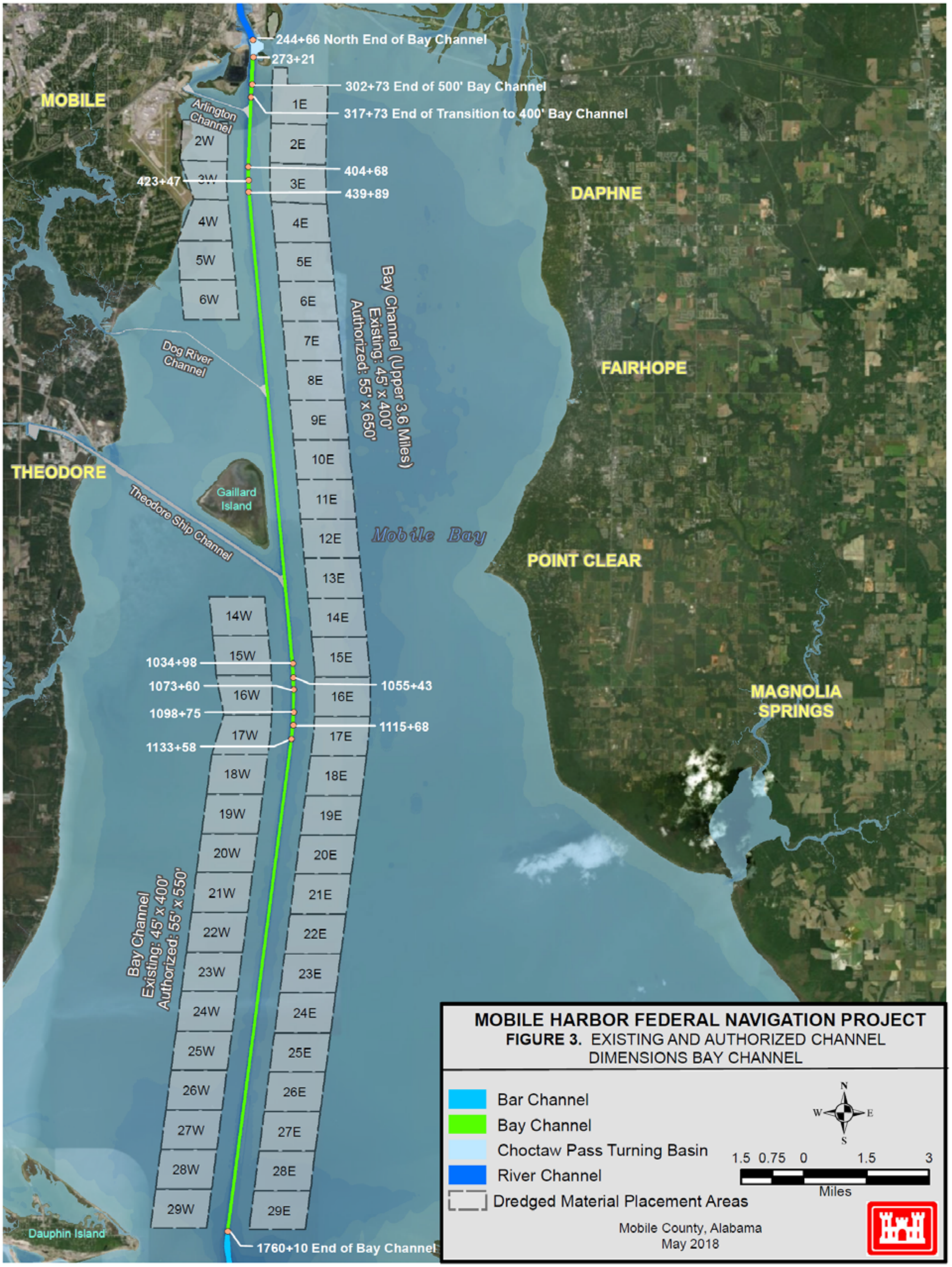
Beneficial impacts would occur from the use of dredged material to fill in relic mined shell areas. The excavation of these oyster holes which are created depressions in the bay bottom that were associated with poor water quality conditions, such as high organic content and low dissolved oxygen (DO) concentrations. The Mobile GRR cooperating agencies and the USACE Mobile District recognized the potential for beneficial use of dredged material from the Mobile Bay navigation channel to restore these areas to the pre-mining bathymetry. Studies indicate that benthic recovery occurs more rapidly in shallow areas, such as Mobile Bay, where the resident benthic communities are already adapted to dynamic conditions and shifting sediments. Being that Mobile Bay is a depositional shallow waterbody with dynamic sediment processes, it would be expected that benthic recovery would be consistent with that shown by previous studies. Placing new work material in shell mined impact areas would aid in returning the bay bottom to historic characteristics by increasing environmental productivity.

Management Plan	Common Name	Scientific Name
Coastal Migratory Pelagic	King Mackerel	*Scomberomorus cavella*
	Spanish Mackerel	*Scomberomorus maculatus*
	Cobia	*Rachycentron canadum*
Red Drum	Red Drum	*Sciaenops ocellatus*
Reef Fish		
Snappers	Queen Snapper	*Etelis oculatus*
	Mutton Snapper	*Lutjanus analis*
	Blackfin Snapper	*Lutjanus buccanella*
	Red Snapper	*Lutjanus campechanus*
	Cubera Snapper	*Lutjanus cyanopterus*
	Gray (Mangrove) Snapper	*Lutjanus griseus*
	Lane Snapper	*Lutjanus synagris*
	Silk Snapper	*Lutjanus vivanus*
	Yellowtail Snapper	*Ocyurus chrysurus*
	Wenchman	*Pristipomoides aquilonaris*
	Vermillion Snapper	*Rhomboplites aurorubens*
Groupers	Speckled Hind	*Epinephelus drummondhayi*
	(Atlantic) Goliath Grouper	*Epinephelus itajara*
	Red Grouper	*Epinephelus morio*
	Yellowedge Grouper	*Hyporthudus flavolimbatus*
	Warsaw Grouper	*Hyporthudus nigritus*
	Snowy Grouper	*Hyporthudus niveatus*
	Black Grouper	*Mycteroperca bonaci*
	Yellowmouth Grouper	*Mycteroperca interstitialis*
	Gag	*Mycteroperca microlepis*
	Scamp	*Mycteroperca phenax*
	Yellowfin Grouper	*Mycteroperca venenosa*
Tilefishes	Goldface Tilefish	*Caulolatilus chrysops*
	Blueline Tilefish	*Caulolatilus microps*
	Tilefish	*Lopholatilus chamaeleonticeps*
Jacks	Greater Amberjack	*Seriola dumerili*
	Lesser Amberjack	*Seriola fasciata*
	Almaco Jack	*Seriola rivoliana*
	Banded Rudderfish	*Seriola zonata*
Triggerfishes	Gray Triggerfish	*Balistes capriscus*
Hogfish	Hogfish	*Lachnolaimus maximus*
Shrimp	Brown Shrimp	*Penaeus aztecus*
	White Shrimp	*Penaeus setiferus*
	Pink Shrimp	*Penaeus duorarum*
	Royal Red Shrimp	*Pleoticus robustus*
Spiny Lobster	Caribbean Spiny Lobster	*Panulirus argus*
Coral and Coral Reefs	Hydrozoa Corals (stinging and hydrocorals)	** There are over 140 species of corals listed in the Coral Fishery Management Plan. Taxonomy is undergoing review and will be updated in Coral Amendment 7.*
	Anthozoa (stony and black corals)	

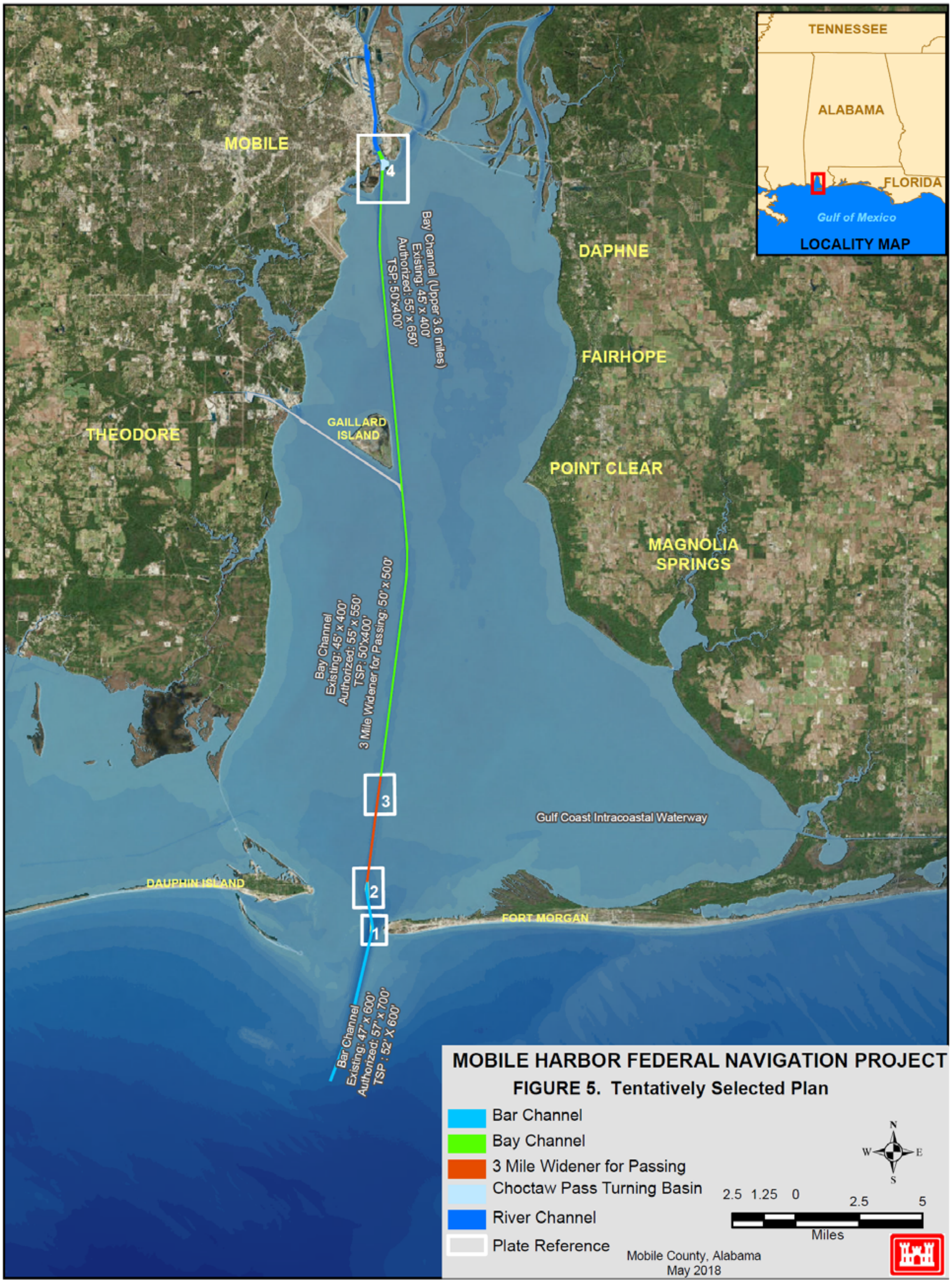
Table 1. Gulf Coast

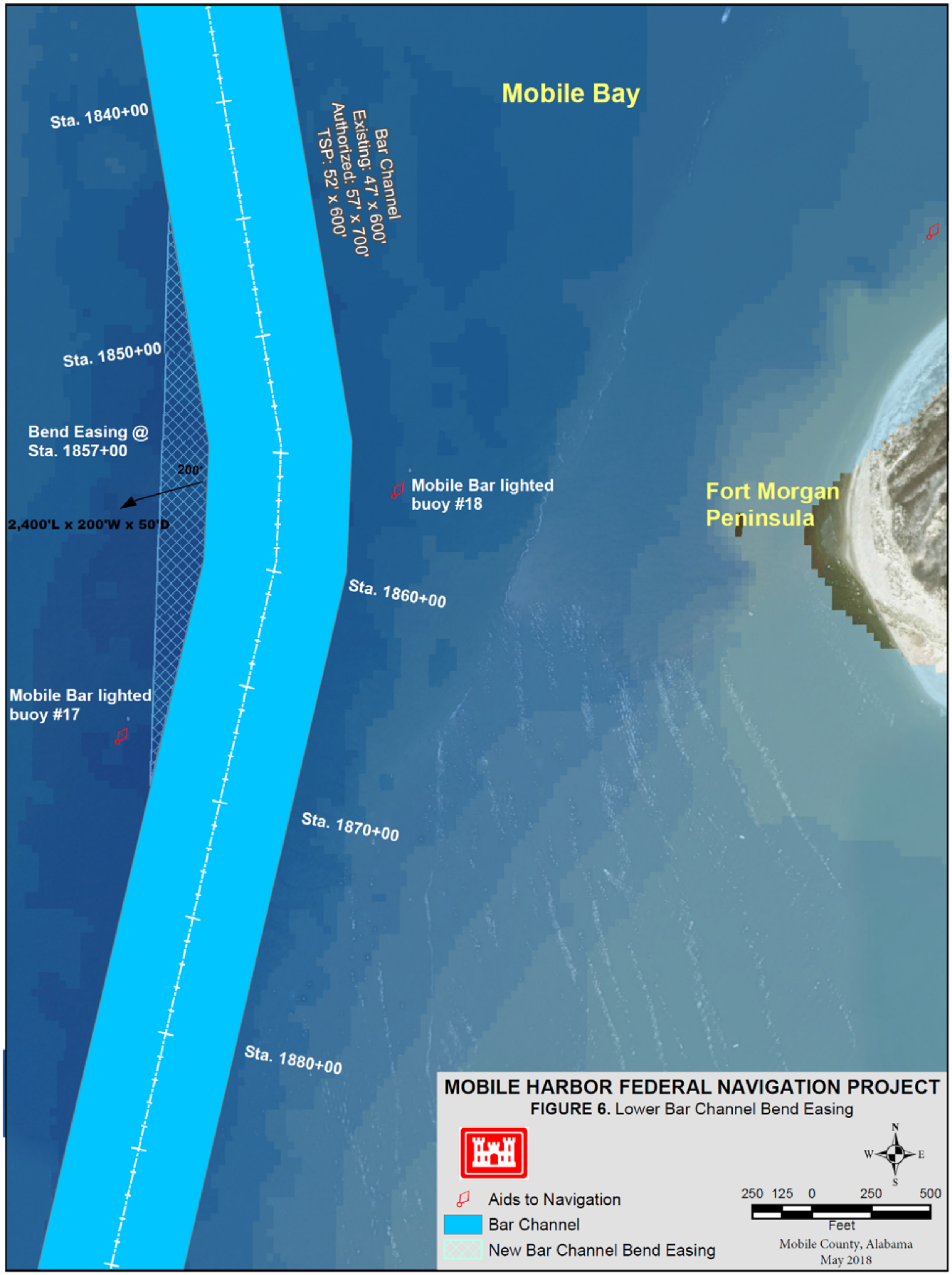

TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
Gulf of Mexico
LOCALITY MAP
MOBILE
River Channel
0+00 to 226+16
Existing and Authorized: 40' x 600'
226+16 to 244+66
Existing: 45' x 600'
Authorized: 55' x 600'
Arlington Channel
Bay Channel (Upper 3.6 Miles)
Existing: 45' x 400'
Authorized: 55' x 650'
DAPHNE
THEODORE
Dog River Channel
FAIRHOPE
Gaillard Island
Theodore Ship Channel
POINT CLEAR
Mobile Bay
MAGNOLIA SPRINGS
Mon Louis Island
Raccoon Island
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
Bon Secour Bay
Mississippi Sound
Gulf Coast Intracoastal Waterway
Dauphin Island
Fort Morgan Peninsula
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
Gulf of Mexico
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 1. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS
Bar Channel
Bay Channel
Choctaw Pass Turning Basin
River Channel
N
W
E
S
2.5 1.25 0 2.5 5
Miles
Mobile County, Alabama
May 2018

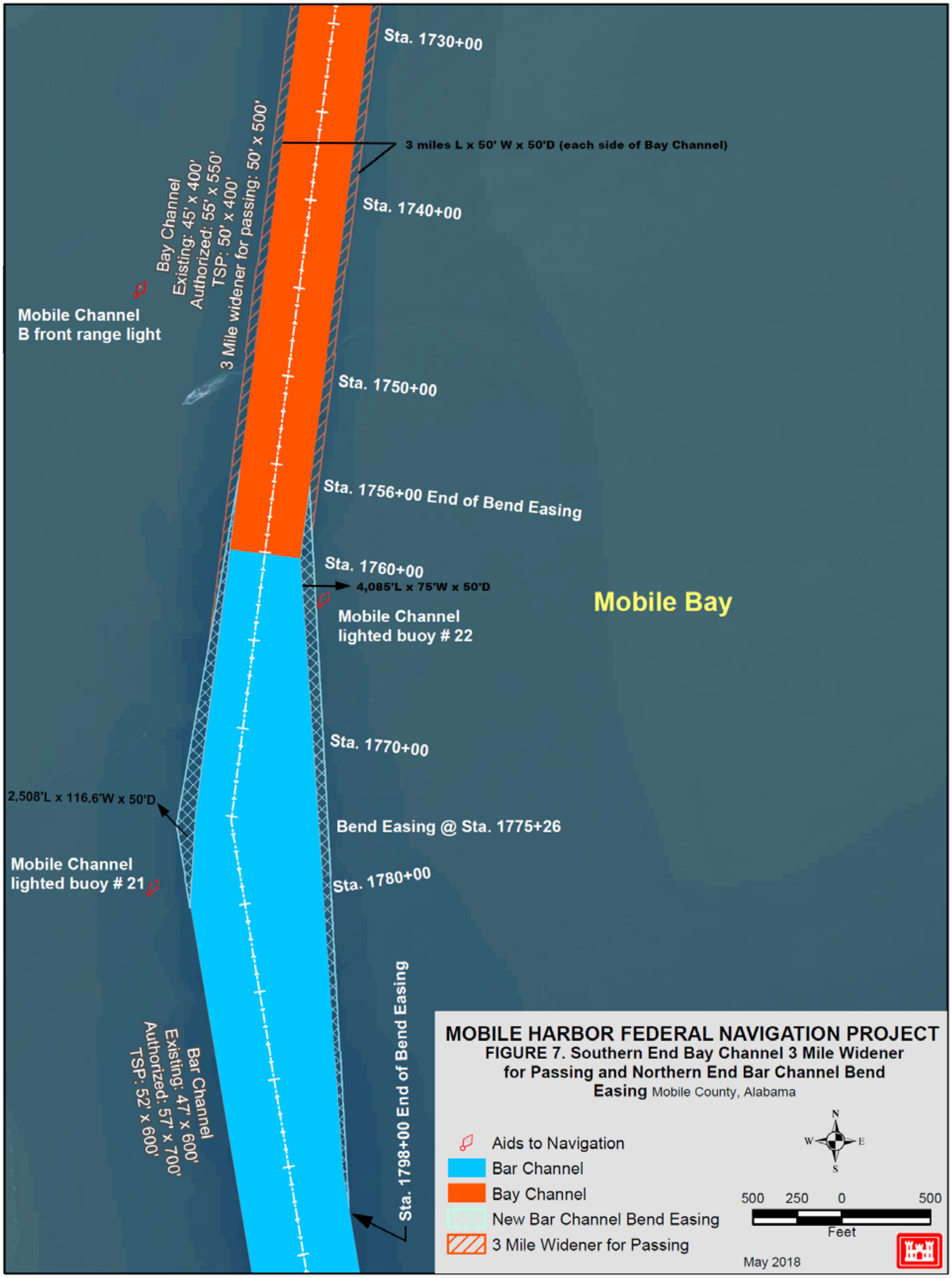

29W
29E
Dauphin Island
1760+10 Start Bar Channel
1775+43
Mobile Bay
1854+69
1859+59
Fort Morgan Peninsula
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
SIBUA
Gulf of Mexico
2039+60
2029+60 Start Transition for Sediment Trap
SIBUA
2089+54
SIBUA
ODMDS
2139+60
End of Bar Channel 2189+59
2149+60 End Transition for Sediment Trap
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 2. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS BAR CHANNEL
Sediment Trap (100' Wide)
Bar Channel
Bay Channel
Dredged Material Placement Areas
3,200 1,600 0 3,200 6,400
Feet
N
S
E
W
Mobile County, Alabama
May 2018

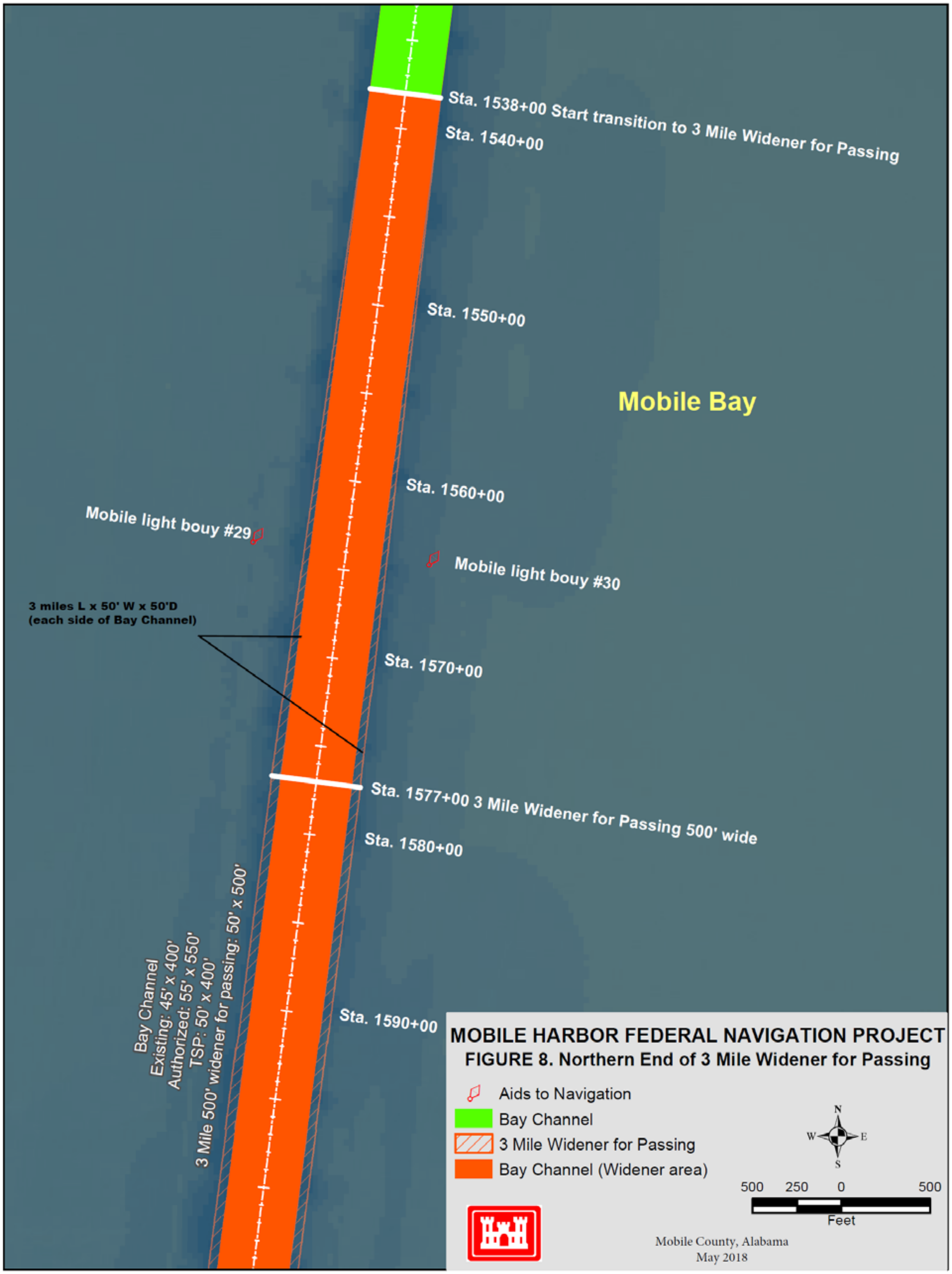

244+66 North End of Bay Channel
273+21
302+73 End of 500' Bay Channel
317+73 End of Transition to 400' Bay Channel
404+68
423+47
439+89
MOBILE
Arlington Channel
DAPHNE
FAIRHOPE
THEODORE
Dog River Channel
Gaillard Island
Theodore Ship Channel
Bay Channel (Upper 3.6 Miles)
Existing: 45' x 400'
Authorized: 55' x 650'
Mobile Bay
POINT CLEAR
MAGNOLIA SPRINGS
1034+98
1055+43
1073+60
1098+75
1115+68
1133+58
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
Dauphin Island
1760+10 End of Bay Channel
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 3. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS BAY CHANNEL
Bar Channel
Bay Channel
Choctaw Pass Turning Basin
River Channel
Dredged Material Placement Areas
1.5 0.75 0 1.5 3
Miles
Mobile County, Alabama
May 2018

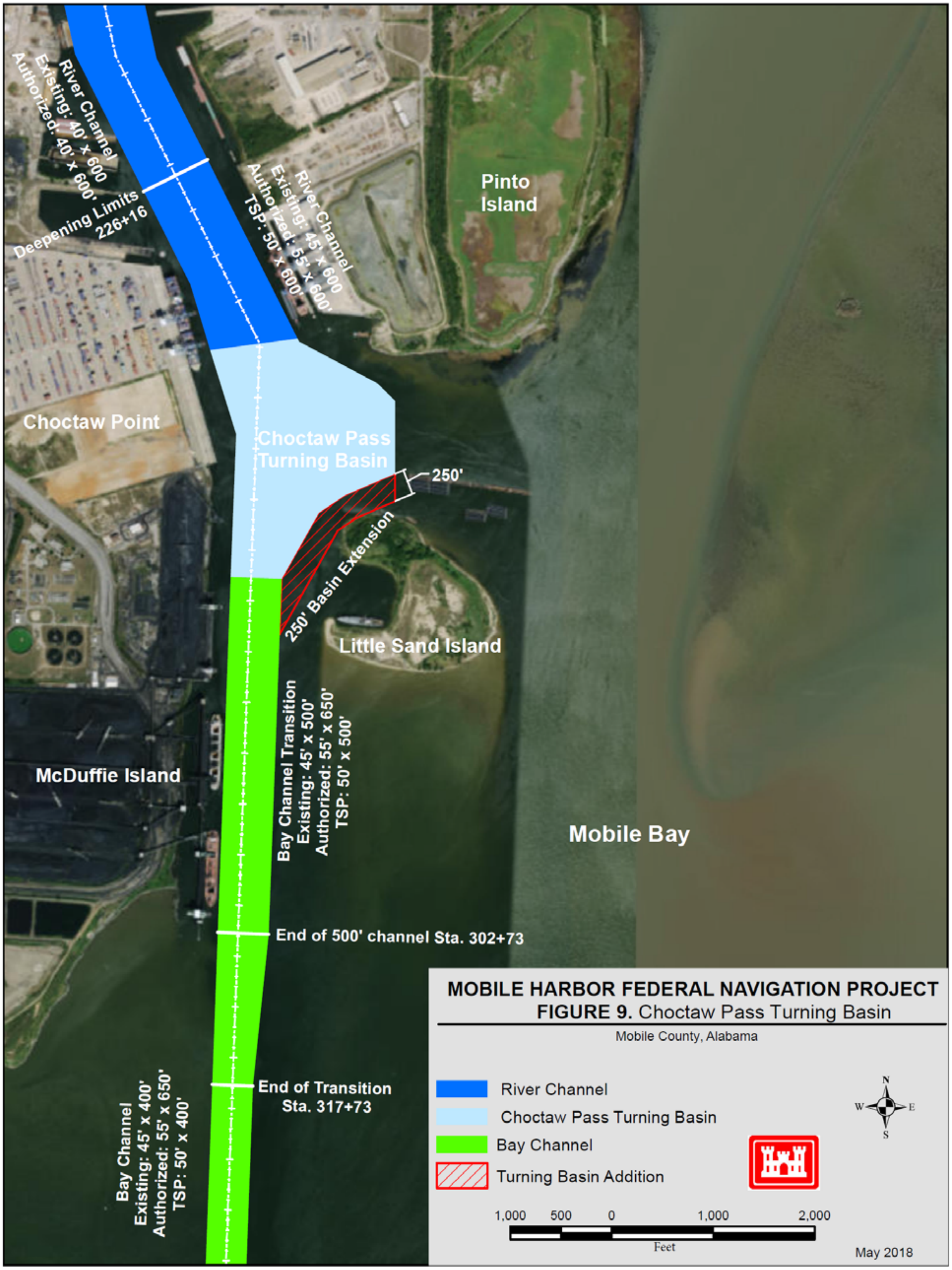

US 43
0+00 North End of River Channel
Blakeley Island
30+38
72+09
98+82
157+18
198+77
213+05
226+16
River Channel
0+00 to 226+16
Existing and Authorized: 40' x 600'
River Channel
226+16 to 244+66
Existing: 45' x 600'
Authorized: 55' x 600'
244+66 End of River Channel
Choctaw Point
Little Sand Island
MOBILE
I-10
Spanish River
Delvan
Bay
Polecat Bay
I-110
US 42
Pinto Pass
Pinto Island
Mobile Bay
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 4. EXISTING AND AUTHORIZED CHANNEL DIMENSIONS
RIVER CHANNEL
Mobile County, Alabama
Choctaw Pass Turning Basin
River Channel
Dredged material Placement Areas
1,400 700 0 1,400 2,800
Feet
May 2018


TENNESSEE
ALABAMA
FLORIDA
Gulf of Mexico
LOCALITY MAP
MOBILE
DAPHNE
FAIRHOPE
THEODORE
GAILLARD ISLAND
POINT CLEAR
MAGNOLIA SPRINGS
DAUPHIN ISLAND
FORT MORGAN
Gulf Coast Intracoastal Waterway
Bay Channel (Upper 3.6 miles)
Existing: 45' x 400'
Authorized: 55' x 650'
TSP: 50'x400'
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50'x400'
3 Mile Widener for Passing: 50' x 500'
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP : 52' X 600'
1
2
3
4
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 5. Tentatively Selected Plan
Bar Channel
Bay Channel
3 Mile Widener for Passing
Choctaw Pass Turning Basin
River Channel
Plate Reference
N
W
E
S
2.5 1.25 0 2.5 5
Miles
Mobile County, Alabama
May 2018


Mobile Bay
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP: 52' x 600'
Sta. 1840+00
Sta. 1850+00
Bend Easing @
Sta. 1857+00
200'
2,400'L x 200'W x 50'D
Mobile Bar lighted
buoy #18
Fort Morgan
Peninsula
Sta. 1860+00
Mobile Bar lighted
buoy #17
Sta. 1870+00
Sta. 1880+00
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 6. Lower Bar Channel Bend Easing
N
W
E
S
Aids to Navigation
Bar Channel
New Bar Channel Bend Easing
250 125 0 250 500
Feet
Mobile County, Alabama
May 2018


Sta. 1730+00
3 miles L x 50' W x 50'D (each side of Bay Channel)
Sta. 1740+00
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50' x 400'
3 Mile widener for passing: 50' x 500'
Mobile Channel
B front range light
Sta. 1750+00
Sta. 1756+00 End of Bend Easing
Sta. 1760+00
4,085'L x 75'W x 50'D
Mobile Channel
lighted buoy # 22
Mobile Bay
Sta. 1770+00
2,508'L x 116.6'W x 50'D
Bend Easing @ Sta. 1775+26
Mobile Channel
lighted buoy # 21
Sta. 1780+00
Bar Channel
Existing: 47' x 600'
Authorized: 57' x 700'
TSP: 52' x 600'
Sta. 1798+00 End of Bend Easing
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 7. Southern End Bay Channel 3 Mile Widener for Passing and Northern End Bar Channel Bend Easing Mobile County, Alabama
Aids to Navigation
Bar Channel
Bay Channel
New Bar Channel Bend Easing
3 Mile Widener for Passing
N
W
E
S
500 250 0 500
Feet
May 2018


Sta. 1538+00 Start transition to 3 Mile Widener for Passing
Sta. 1540+00
Sta. 1550+00
Mobile Bay
Sta. 1560+00
Mobile light bouy #29
Mobile light bouy #30
3 miles L x 50' W x 50'D
(each side of Bay Channel)
Sta. 1570+00
Sta. 1577+00 3 Mile Widener for Passing 500' wide
Sta. 1580+00
Sta. 1590+00
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 550'
TSP: 50' x 400'
3 Mile 500' widener for passing: 50' x 500'
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 8. Northern End of 3 Mile Widener for Passing
Aids to Navigation
Bay Channel
3 Mile Widener for Passing
Bay Channel (Widener area)
N
W
E
S
500 250 0 500
Feet
Mobile County, Alabama
May 2018


River Channel
Existing: 40' x 600'
Authorized: 40' x 600'
Deepening Limits
226+16
River Channel
Existing: 45' x 600'
Authorized: 55' x 600'
TSP: 50' x 600'
Pinto Island
Choctaw Point
Choctaw Pass Turning Basin
250'
250' Basin Extension
Little Sand Island
Bay Channel Transition
Existing: 45' x 500'
Authorized: 55' x 650'
TSP: 50' x 500'
McDuffie Island
Mobile Bay
End of 500' channel Sta. 302+73
End of Transition
Sta. 317+73
Bay Channel
Existing: 45' x 400'
Authorized: 55' x 650'
TSP: 50' x 400'
MOBILE HARBOR FEDERAL NAVIGATION PROJECT
FIGURE 9. Choctaw Pass Turning Basin
Mobile County, Alabama
River Channel
Choctaw Pass Turning Basin
Bay Channel
Turning Basin Addition
1,000 500 0 1,000 2,000
Feet
May 2018

ENVIRONMENTAL APPENDIX C

ATTACHMENT C-5

TRANSPORTATION ANALYSIS

SECTION 1. Affected Environment

1.1. Transportation

This section describes an overview of existing transportation resources within the project area, and the potential impacts on these transportation resources that would be associated with the Proposed Action and No Action alternative. Components of transportation resources that are analyzed include roads, traffic, railroads and airports.

1.1.1. *Highways and Roadways*

1.1.1.1. Interstate Highways

Interstate (I-) 10 is the most southern major highway connector in the United States; it travels in an east-west direction, linking Florida to California. In the southeastern United States, I-10 stretches from Jacksonville, Florida, to Houston, Texas, covering a majority of the coastline of the Gulf of Mexico. Along the Gulf, major seaports, including Pensacola, Florida; Mobile, Alabama; Gulfport, Mississippi; New Orleans, Louisiana; and Houston, Texas, are linked. Mobile is located at approximately the halfway point between Houston, Texas, and Jacksonville, Florida. I-10 in the vicinity of the Mobile Harbor is a multi-lane (6 to 8 lanes), divided interstate level highway with controlled access. The speed limit is signed for 65 to 70 miles per hour (mph) (USACE 2003).

To the west of the harbor, I-10 has numerous interchanges with the Mobile Central Business District (CBD) and then crosses under the Mobile River by means of the Wallace Tunnels, a four-lane facility. Hazardous truck cargoes must bypass the tunnels by exiting at Water Street and detouring to cross the Mobile River via the Cochrane-Africatown USA Bridge to the north. I-10 then crosses the Mobile Bay by the four-lane I-10 Bayway to the Eastern Shore (Daphne in Baldwin County). I-10 continues east to Florida.

The I-10 tunnels cross the proposed activities at Mobile Harbor and are in close proximity to the northern portion of the proposed channel activities. The three closest interchanges on the west side of the harbor are located at Broad Street, Virginia Street, and Texas Street. In 2016, the average daily traffic count was 71,940 on I-10 between Broad Street and Texas Street (Alabama Department of Transportation [ALDOT] 2016). The closest interchange to the harbor on the east side is at Battleship Parkway/US-90. The ALDOT reports that in 2016, 75,320 vehicles travelled through the George C Wallace tunnel crossing the channel daily (ALDOT 2016).

In Mobile, about 5 miles west of the proposed Mobile Harbor and Channel activities, I-10 has a major interchange with I-65 providing easy access to the north. I-65 is routed north to Montgomery, where it intersects with I-85 northeast to Atlanta, Georgia; continuing to Birmingham, I-65 intersects with I-59 and I-20; and then to Huntsville and major cities to the north in the Midwest region of the United States. I-165 connects downtown Mobile with I-65 approximately 5 miles northwest of where the I-10 tunnels cross the Mobile River (Google Earth

2018a, FHA and ALDOT 2014). Currently, trucks carrying hazardous materials are detoured off the I-10 at either the I-65 or I-165 interchanges, or along surface streets. Trucks then travel north to cross the Mobile River on the Cochrane-Africatown Bridge (FHA and ALDOT 2014).

The I-10 Wallace Tunnels are currently nearing their capacity and have congestion during peak hours of use. However, a project to increase capacity for the I-10 corridor crossing of the Mobile River and Mobile Bay is currently proposed. The project is designated as the I-10 Mobile River Bridge and Bayway Widening (Project DPI-0030(005)). The Proposed Action includes eleven miles of improvements to the I-10 corridor from Broad Street in Mobile County to just east of the US 98 interchange in Daphne, Baldwin County, Alabama. The proposed improvements consist of: the widening of I-10 from Broad Street eastward to the proposed bridge; deletion of the existing Texas Street interchange; modification of the existing Virginia Street interchange; construction of a six-lane, cable-stayed bridge with 190 feet of vertical clearance over the Mobile River navigation channel; widening the I-10 Bayway by two lanes to the inside (resulting in a total of eight lanes); and tapering the eight lanes from the Bayway into the existing I-10 corridor in the vicinity of the existing US 98 interchange in Daphne (ALDOT/FHWA 2003). The proposed Mobile River I-10 Bridge will provide for additional capacity with acceptable level of service through the design year 2025. Additionally, a detour to the Cochrane-Africatown Bridge for hazardous truck cargoes will no longer be required. The Wallace Tunnels will remain as a "business" connector to the downtown area. Traffic studies and modelling associated with the I-10 bridge and bayway project revealed that by the year 2030, most of the interchanges in the Mobile Harbor area would be operating at level of service (LOS) D or F during peak hours (FHA and ALDOT 2014).

1.1.1.2. Surface Streets

Direct access for the Mobile Harbor to I-10 and its connecting network can be made by Broad Street and Virginia Street to their interchanges with I-10. A variety of other surface streets provide access to the harbor including Old Water Street, Water Street and State Docks Road (Google Earth 2018a). Currently, Broad Street and Virginia Street are two-lane roadways between the harbor and I-10.

1.1.1.3. Harbor-Related Truck Traffic

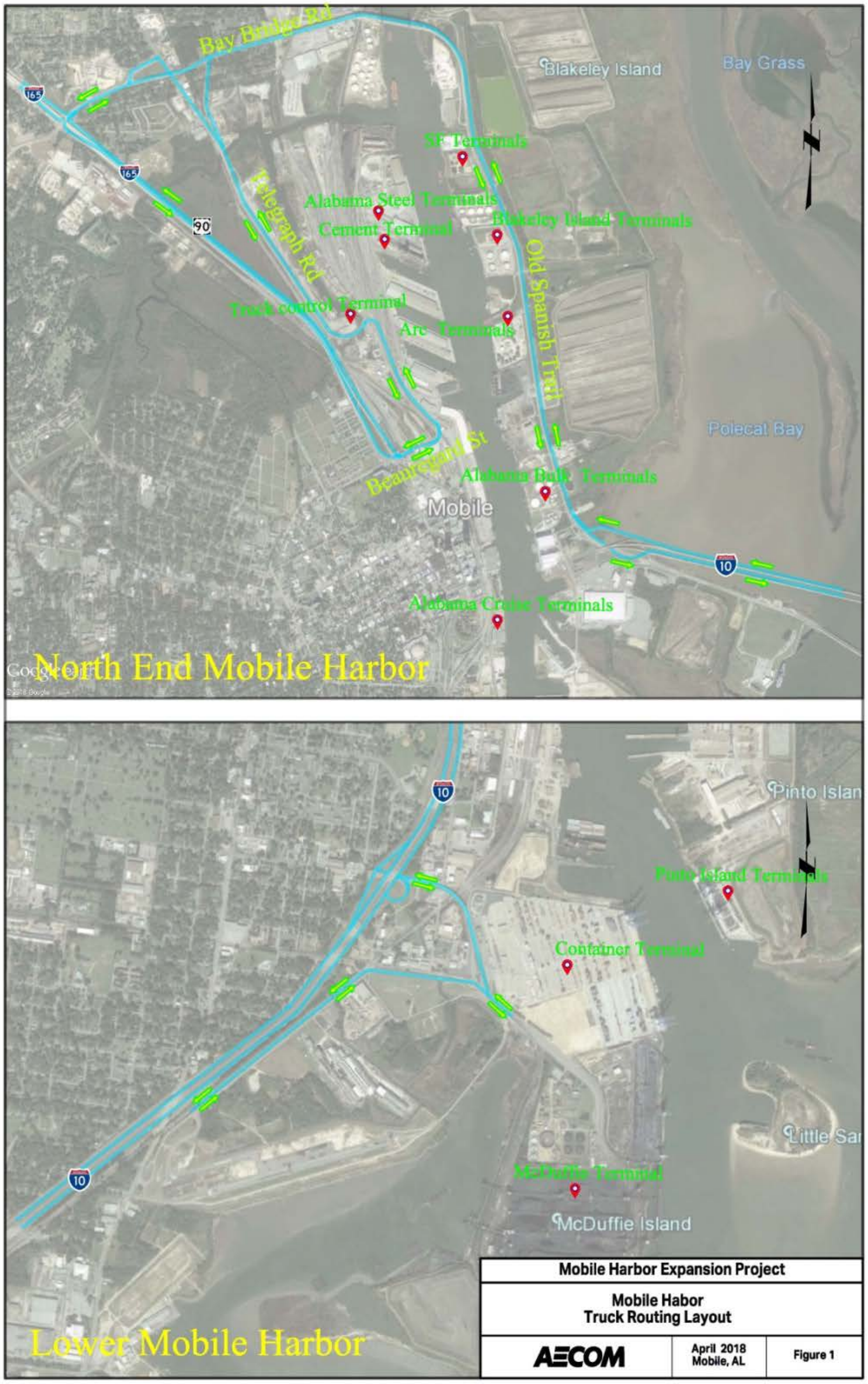
Traffic patterns for cargo at the North End of Mobile Harbor are different from the Lower End of Mobile Harbor. The North End of the Mobile Harbor moves petroleum, asphalt, metals, forest products and poultry. For terminals located on Blakeley Island off of Old Spanish Trail, freight will either travel south to I-10 or north to I-165 using the Cochran Africatown USA Bridge and New Bay Bridge Road. Terminals located off of Telegraph Road travel south to Beauregard Street and then to I-165 or north to Conception Street, New Bay Bridge Road and then to I-165. A map of the north end truck routes is shown in Figure X-1 (AECOM 2018).

Lower Mobile Harbor consists of three terminals:

- Container Terminal

- McDuffie Coal Terminal
- Pinto Terminal

Figure X-1. Mobile Harbor Truck Routes



The Container Terminal is served by ship, truck and rail. The McDuffie Coal Terminal and Pinto Terminal only move cargo through ship, rail or barge. Only service vehicles and employees utilize the roadway system from these two terminals. There is terminal to terminal movement for vehicles along Baker Street and terminal to I-10 movement along Ezra Trice Boulevard to Virginia Street. A Map of the lower harbor truck routes is shown in Figure X-1 (AECOM 2018).

1.1.1.4. Annual Average Daily Traffic Counts

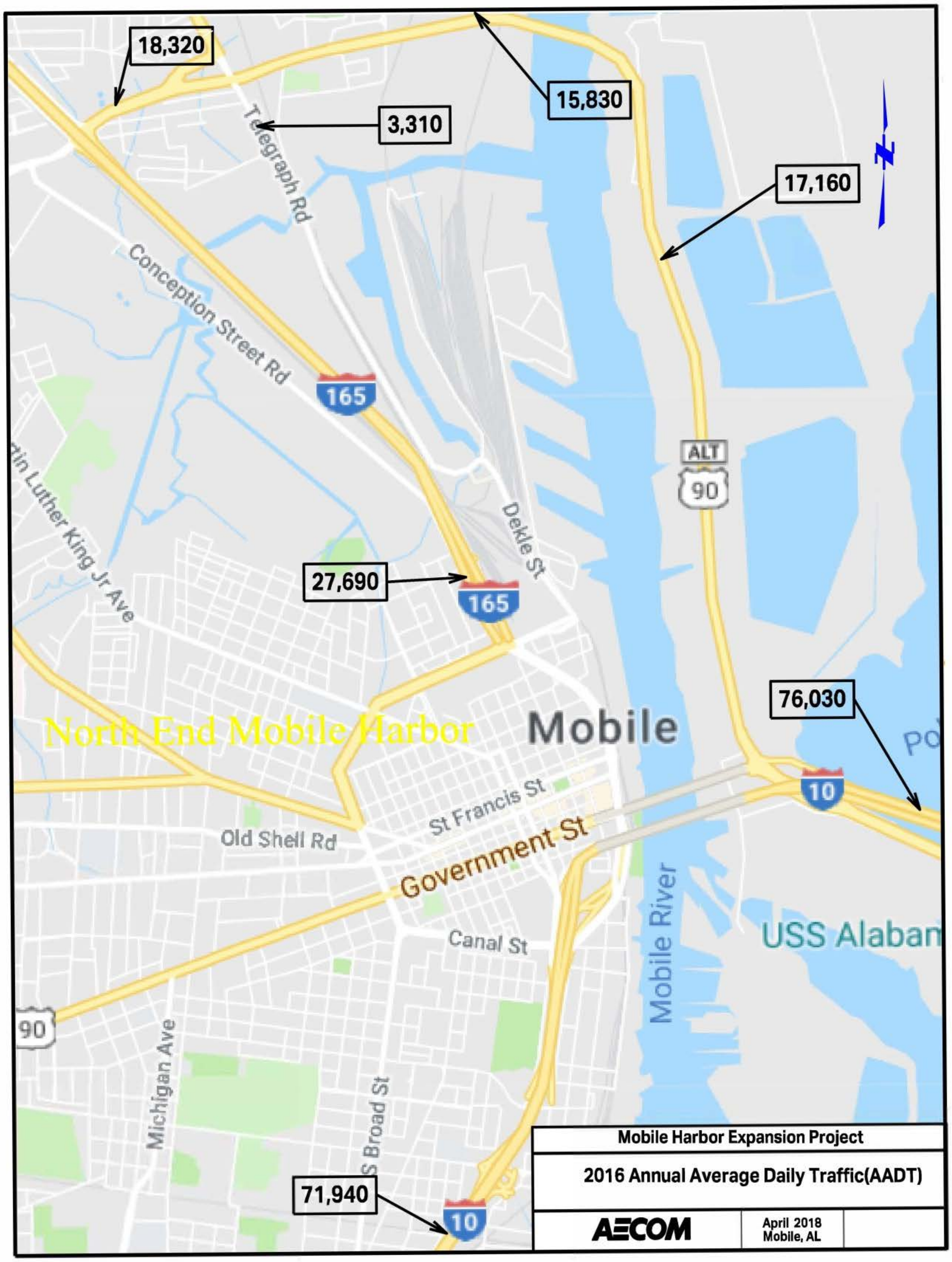
Annual average daily traffic counts (AADT) were collected by ALDOT in 2016 and are presented in Table X-1. Generally, traffic levels are highly variable in the vicinity of the port, depending on which roads are examined. Overall, the freeways (I-10, I-65, and I-165) are more travelled than the smaller surface roads and State Highways (ALDOT 2016). Figure X-2 shows a map of the AADT traffic counts for 2016.

Table X-1: AADT in the vicinity of Mobile Harbor

Intersection/Segment	2016 AADT
Bay Bridge Road/Peter Lee Street	19,370
Cochrane-Africatown Bridge - West	15,830
Cochrane-Africatown Bridge -East	16,650
Baybridge Road/US-90	18,320
US-90/Beauregard Street	27,690
Beauregard Street/US-90	11,410
US-98/St. Emanuel Street	23,290
I-10 between Texas and Canal Streets	64,890
I-10 at Baltimore Street	71,940
I-10 Bayway - West	76,030
US-90 Bayway - West	16,990
US-90 north of I-10 - West	17,160
Telegraph Road/Edwards Street	8110
Telegraph Road/Traffic Street	3110

Source: ALDOT 2016

Figure X-2: ALDOT Traffic counts for 2016 near the Port of Mobile.



ALDOT does not analyze LOS unless a particular project calls for a traffic study. The FHA and ALDOT completed a Draft EIS for the construction of a bridge over the Mobile River and the widening of the I-10 Bayway. A traffic study was completed during this analysis. Part of this study was a projection of LOS in 2030 on portions of the existing I-10. Table X-2 presents the conclusions from this analysis. The predictions reveal that by 2030, most of the I-10 in the vicinity of Mobile Harbor would be operating at an LOS of D or worse during peak conditions (FHA and ALDOT 2014). LOS is calculated in different ways for different road types. Generally, for a typical freeway segment, LOS F occurs when there are more than 28 vehicles per lane per kilometer (Mathew and Rao 2006).

Table X-2: Predicted 2030 LOS in the vicinity of Mobile Harbor

Roadway	Location	Direction	2030 Peak Hour LOS
I-10 West of Project	West of Duval Street	Eastbound	D
		Westbound	D
I-10 Mobile	Between Broad St. and Virginia St.	Eastbound	E
		Westbound	E
I-10 Wallace Tunnels	Under Mobile River	Eastbound	F
		Westbound	F
I-10 Bayway	Between Mid-Bay Interchange and US 90/98	Eastbound	F
		Westbound	F
I-10 East of Project	East of US 98	Eastbound (2 lanes)	F
		Eastbound (3 lanes)*	D
		Westbound (2 lanes)	F
		Westbound (3 lanes)*	D
Cochrane Africatown Bridge	Over Mobile River	Eastbound	D
		Westbound	D
Bankhead Tunnel	Under Mobile River	Eastbound	F
		Westbound	F

*ALDOT has an approved project to widen I-10 to three lanes, to the east in both directions, between the I-10/US 98 interchange and SR 181.
Source: FHA and ALDOT 2014

The Florida Department of Transportation (FDOT) developed LOS tables for future roadway planning purposes by looking at travel lanes available, AADT, and speed limit within urbanized or rural areas. These tables were utilized to estimate the existing and future roadway capacity in the area of the Mobile Port. A LOS “D” which consists of a high density but stable traffic flow is considered an acceptable level for urban design purposes. **Table X-3** summarizes the vehicle capacity of the existing roadway system (AECOM 2018).

Table X-3: Existing Roadway Capacity

Route	Roadway Laneage	Existing Capacity (LOS D)	2016 ADT	Under Capacity	% Trucks	Speed Limit
Al 13 (Telegraph Rd)	4 lane undivided	24,300	3,310	yes	18%	30
AL 16 (Old Spanish Trail)	4 lane undivided	29,850	17,160	yes	13%	55

Table X-3: Existing Roadway Capacity

Route	Roadway Laneage	Existing Capacity (LOS D)	2016 ADT	Under Capacity	% Trucks	Speed Limit
AL 16 (Baybridge Rd)	4 lane divided	39,800	15,830	yes	14%	45
AL 16 (New Baybridge Rd)	4 lane divided	39,800	18,320	yes	16%	40
I-10	4 lane Interstate	77,900	76,030	yes	15%	65
I-10	8 Lane Interstate	154,300	71,940	yes	13%	65
I-165	6 lane Interstate	116,600	27,690	yes	8%	65

1.1.1.5. Rail Transportation

The public terminals at the Mobile Port are connected to two interstate systems (I-10 and I-65) and five Class I railroads- CSX, Canadian National, Burlington Northern Santa Fe (Alabama & Gulf Coast Railroad), Norfolk Southern, and Kansas City Southern. All-water, rail connections into Mexico's national railroad system is offered by C.G. Railway every four days between Mobile and Coatzacoalcos, Mexico (Alabama Department of Commerce 2016).

1.1.2. *Air Transportation*

1.1.2.1. Mobile Downtown Airport

Mobile Downtown Airport, previously and locally known as Brookley Field, is located approximately 2.75 miles southwest of the Mobile Harbor turning basin. This facility is a former U.S. Air Force Base. The closing of Brookley Field was initiated in 1964, and the City of Mobile accepted ownership on July 3, 1969. Management of the facility was transferred to the Mobile Airport Authority in 1982. The facility is now managed by the Mobile Airport Authority as a public facility, with private aviation and non-aviation light industrial companies located on the property (USACE 2003). The airport currently also houses the Mobile Aeroplex at Brookley (Mobile Aeroplex at Brookley 2018)

Airport services include the availability of 100LL JET-A fuel, hangars, tiedowns, major airframe repair, and major power plant service and repair. Other services available include air cargo, charter flights, flight instruction, aircraft rental, and aircraft sales (SkyVector 2018).

The Mobile Downtown Airport has two major runways as follows:

- Runway 14/32 – 9618x150 feet with precision instrument and high-intensity edge and approach lighting, and
- Runway 18/36 – 7800x150 feet with medium intensity edge lighting (SkyVector 2018).

Currently, there are 31 aircraft based at the field with a breakdown as shown in Table X-4.

Table X-4: Aircraft based in the Mobile Downtown Airport

Classification	Number
Single engine airplanes	21
Multi-engine airplanes	4
Jet airplanes	5
Helicopters	1

Source: SkyVector 2018

In 2017, there were 1,774 commercial aircraft operations, 42,095 military operations, 2,792 air taxi operations, 4,710 local operations, and 10,451 itinerant operations (SkyVector 2018).

Sufficient additional capacity for flights at the field is available to support additional intermodal transfer of containerized cargo if needed. Space is also available for development of support facilities for such shipping. In addition, the Mobile Downtown Airport is very accessible to transfer containerized cargo from the Alabama State Port Authority (ASPA) Choctaw Point Terminal by truck using I-10 or surface streets or, if necessary, by rail (USACE 2003).

1.1.2.2. Mobile Regional Airport

Mobile Regional Airport is the primary commercial passenger airport serving the Mobile area. It is located approximately 11 miles west of the Mobile Harbor turning basin and does not have rail access. The primary highway routes between the harbor and the airport are I-10, I-65, and Airport Boulevard (Google Earth 2018b).

1.1.3. *Water Transportation*

The USACE tracks port and dock facilities throughout the country. The Master Docks list available at http://www.navigationdatacenter.us/ports/ports.htm, lists 433 docks in the City of Mobile at 147 facilities owned by 55 different entities. Of these docks, 386 are capable of handling cargo. Table X-5 shows the docks owned by the State of Alabama at the Port of Mobile (USACE 2018).

Table X-5: Docks facilities owned by ASPA

Navigation Unit ID	City	Facility Location	Facility Owner Name	Facility Type	Cargo Handling Ability
38773	Mobile	Alabama Shipyard, Pier L	Alabama Shipyard, Inc.	Dock	Yes
28262	Mobile	Alabama State Docks Department	Alabama State Docks Department	Dock	Yes
28262	Mobile	Farmers Grain Dock, Alabama State Docks	Alabama State Docks Department	Dock	Yes

Table X-5: Docks facilities owned by ASPA

Navigation Unit ID	City	Facility Location	Facility Owner Name	Facility Type	Cargo Handling Ability
28262	Mobile	Pier 2	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 3	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 4	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 5	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 6	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 7	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier 8	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier A River	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier A North	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier A South	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier River B	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier North B	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier South B	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier River C	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier North C	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier South C	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier D	Alabama State Docks Department	Dock	Yes
28262	Mobile	Pier D-2	Alabama State Docks Department	Dock	Yes
28262	Mobile	South D	Alabama State Docks Department	Dock	Yes

Table X-5: Docks facilities owned by ASPA

Navigation Unit ID	City	Facility Location	Facility Owner Name	Facility Type	Cargo Handling Ability
30644	Mobile	Alabama State Docks Department, Pier B and Slip C End Wharf.	Alabama State Docks Department.	Dock	Yes
30646	Mobile	Alabama State Docks Department, Pier D South Grain Elevator Wharf.	Alabama State Docks Department.	Dock	Yes
30650	Mobile	Alabama State Docks Department, Pier A North Wharf and Slip B End Wharf.	Alabama State Docks Department.	Dock	Yes
30343	Mobile	Jordan Pile Driving, South Bank Mooring.	Alabama State Docks Department.	Dock	Unknown
30443	Mobile	Alabama State Docks Department, Industrial Canal North Wharf.	Alabama State Docks Department.	Dock	Yes
30444	Mobile	Alabama State Docks Department, Industrial Canal South Wharf.	Alabama State Docks Department.	Dock	Yes
30463	Mobile	Alabama State Docks Department, McDuffie Terminal Barge-Cleanup Wharf.	Alabama State Docks Department.	Dock	Yes
30463	Mobile	Alabama State Docks Department, McDuffie Terminal Barge-Cleanup Wharf.	Alabama State Docks Department.	Dock	Yes
30464	Mobile	Alabama State Docks Department, McDuffie Terminal Ship Wharf No. 1.	Alabama State Docks Department.	Dock	Yes
30464	Mobile	Alabama State Docks Department, McDuffie Terminal Ship Wharf No. 1.	Alabama State Docks Department.	Dock	Yes
30482	Mobile	Alabama State Docks Department, McDuffie Terminal Ship Wharf No. 2.	Alabama State Docks Department.	Dock	Yes
30560	Mobile	Alabama State Docks Department, McDuffie Terminal Barge Mooring.	Alabama State Docks Department.	Dock	Yes
30560	Mobile	Alabama State Docks Department, McDuffie Terminal Barge Mooring.	Alabama State Docks Department.	Dock	Yes

Table X-5: Docks facilities owned by ASPA

Navigation Unit ID	City	Facility Location	Facility Owner Name	Facility Type	Cargo Handling Ability
37366	Mobile	Central Gulf Railway (CGI), Choctaw Point	Alabama State Docks Department.	Dock	Yes
38252	Mobile	P & H Construction Corp., Mobile Dock	Alabama State Docks Department.	Dock	Yes
38252	Mobile	P & H Construction Corp., Mobile Dock	Alabama State Docks Department.	Dock	Yes
38253	Mobile	University Of South Alabama, Boathouse Slip	Alabama State Docks Department.	Dock	No
38254	Mobile	Radcliff/economy marine services, pier no. 4	Alabama State Docks Department.	Dock	Yes
37366	Mobile	Alabama State Docks Choctaw Point	Alabama State Docks Department.	Dock	Yes
38257	Mobile	Crescent Towing & Salvage Co., River A Wharf	Alabama State Docks Department.	Dock	No
38264	Mobile	Term R/W ALA State Docks Dept E Side Transfer BR	Alabama State Docks Department.	Dock	Yes
38775	Mobile	Damrich Coatings, Mobile Wharf	Alabama State Docks Department.	Dock	No
38795	Mobile	International Paper Co Industrial Canal Dock	Alabama State Docks Department.	Dock	No
38795	Mobile	International Paper Co Industrial Canal Dock	Alabama State Docks Department.	Dock	No
38797	Mobile	Alabama State Docks Dept Industrial Canal Mooring	Alabama State Docks Department.	Dock	No
38798	Mobile	Dana Marine Service Industrial Canal Dock	Alabama State Docks Department.	Dock	No
38799	Mobile	Glenn Towing, Industrial Canal Wharf	Alabama State Docks Department.	Dock	No
38258	Mobile	Term Railway ALA STATE Dock West Side Transfer BRG	Alabama State Docks Department.	Dock	Yes
38796	Mobile	H&B Welding Service, Industrial Canal Dock	Alabama State Docks Department.	Dock	No
38796	Mobile	H&B Welding Service, Industrial Canal Dock	Alabama State Docks Department.	Dock	No
37366	Mobile	Mobile Container Terminal, LLC	Alabama State Docks Department.	Dock	Yes

Table X-5: Docks facilities owned by ASPA

Navigation Unit ID	City	Facility Location	Facility Owner Name	Facility Type	Cargo Handling Ability
30650	Mobile	Alabama State Docks Department, Pier A North Wharf and Slip B End Wharf.	Alabama State Docks Department; and Mobile Bay Towing, a Hvide Marine Co.	Dock	Yes
28259	Mobile	McDuffie Terminal No. 3	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	McDuffie Terminal No. 3	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	Alabama State Docks Dept McDuffie Term Ship Wharf	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	Alabama State Docks Dept McDuffie Term Ship Wharf	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	Corus Direct Reduced Iron (DRI)	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	Corus Direct Reduced Iron (DRI)	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	McDuffie Terminal No. 1	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	McDuffie Terminal No. 1	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	McDuffie Terminal No. 2	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes
28259	Mobile	McDuffie Terminal No. 2	Alabama State Docks Dept McDuffie Term Ship Wharf	Dock	Yes

1.1.4. *Public Transportation*

The Wave Transit System, funded by the City of Mobile, is the largest fixed-route transit system in the region. It provides service within Mobile limits, limited service into Prichard to the north, and paratransit service, in accordance with the Federal Transit Authority mandated 3/4 of a mile to those who qualify and neighborhood curb-to-curb service in predefined areas. Wave Transit operates a network of 14 fixed routes and one downtown circulator in Mobile. According to the Mobile Transit Development Plan, all fixed-route services operate Monday through Saturday, with weekday operations beginning between 5 a.m. and 6 a.m. Nine weekday routes in the Wave Transit system end at 7:25 p.m. or earlier, with the remaining weekday routes ending between 9:55 p.m. and 10:25 p.m. Weekend service routes begin between 6 a.m. and 7 a.m., ending around the same time as weekday service routes. All fixed-route services operate on a

60-minute frequency with the exception being *moda!*, a fare-free downtown circulator that arrives every 10 to 20 minutes (SARCOR et al. 2014).

Some populations have a higher propensity to take public transit than the national average. These populations include the young, elderly, low income, those with no access to personal vehicles, and minorities. Downtown, northwest of downtown along I-165 into Prichard, and southwest along I-10 just north of the Brookley Aeroplex are the areas with the highest propensity for transit. These areas currently have fixed route bus service from Routes 5, 9, 11, and 16 (SARCOR et al. 2014). These areas are also close to the Port of Mobile.

Less than one percent of the working population, ages 16 and older, use public transportation for their commute in Mobile and Mobile County. Of those without access to a vehicle, only 7.6 percent of individuals and 8.6 percent of individuals, respectively, use public transportation to commute. Even though the majority of the jobs are located within the city, many workers do not use public transportation. This could be attributed to living outside of the public transportation service area, the commute is during hours when transit is out of service, or the frequency of the transit is not sufficient for adequate travel times (SARCOR et al. 2014).

Most bus routes converge on the CBD which is immediately west of the Port of Mobile. The routes traveling along the active port area include 5, 9, 11, and 16 (SARCOR et al. 2014).

1.2. No Action Alternative

The available annual average daily traffic (AADT) volumes from the street system surrounding the port were used to estimate past traffic growth by calculating the linear growth between the years 2011 to 2016. The vehicular growth is shown in Table X-6 (AECOM 2018).

Table X-6 Projected AADT Growth

Route	Growth Rate per Year	2016 ADT	2015 ADT	2014 ADT	2013 ADT	2012 ADT	2011 ADT
Al 13 (Telegraph Rd)	-8.0%	3,310	3,230	3,170	5,780	5,730	5,033
AL 16 (Old Spanish Trail)	8.4%	17,160	16,750	16,420	11,420	11,330	11,440
AL 16 (Baybridge Rd)	1.5%	15,830	15,450	15,150	15,150	-	-
AL 16 (New Baybridge Rd)	-0.2%	18,320	17,880	17,530	18,480	18,330	18,520
I-10	0.4%	76,030	75,500	77,000	75,180	-	
I-10	-0.9%	71,940	79,430	75,520	73,630	-	75,350
I-165	4.9%	27,690	26,100	21,400	21,060	20,850	21,780

Population growth of Mobile and Baldwin Counties was also considered. 2010 Census data and population predictions from the University of Alabama's Center for Business and Economic

Research for a 6.2 percent increase between 2010 and 2014 were used to estimate the yearly growth rate. The population growth rate is shown in Table X-7 (AECOM 2018).

Table X-7: Population Growth Rate

2010 Census Data	2040 UA Research	Growth Rate per Year	2066 Estimated
412,992	438,598	0.2%	461,885

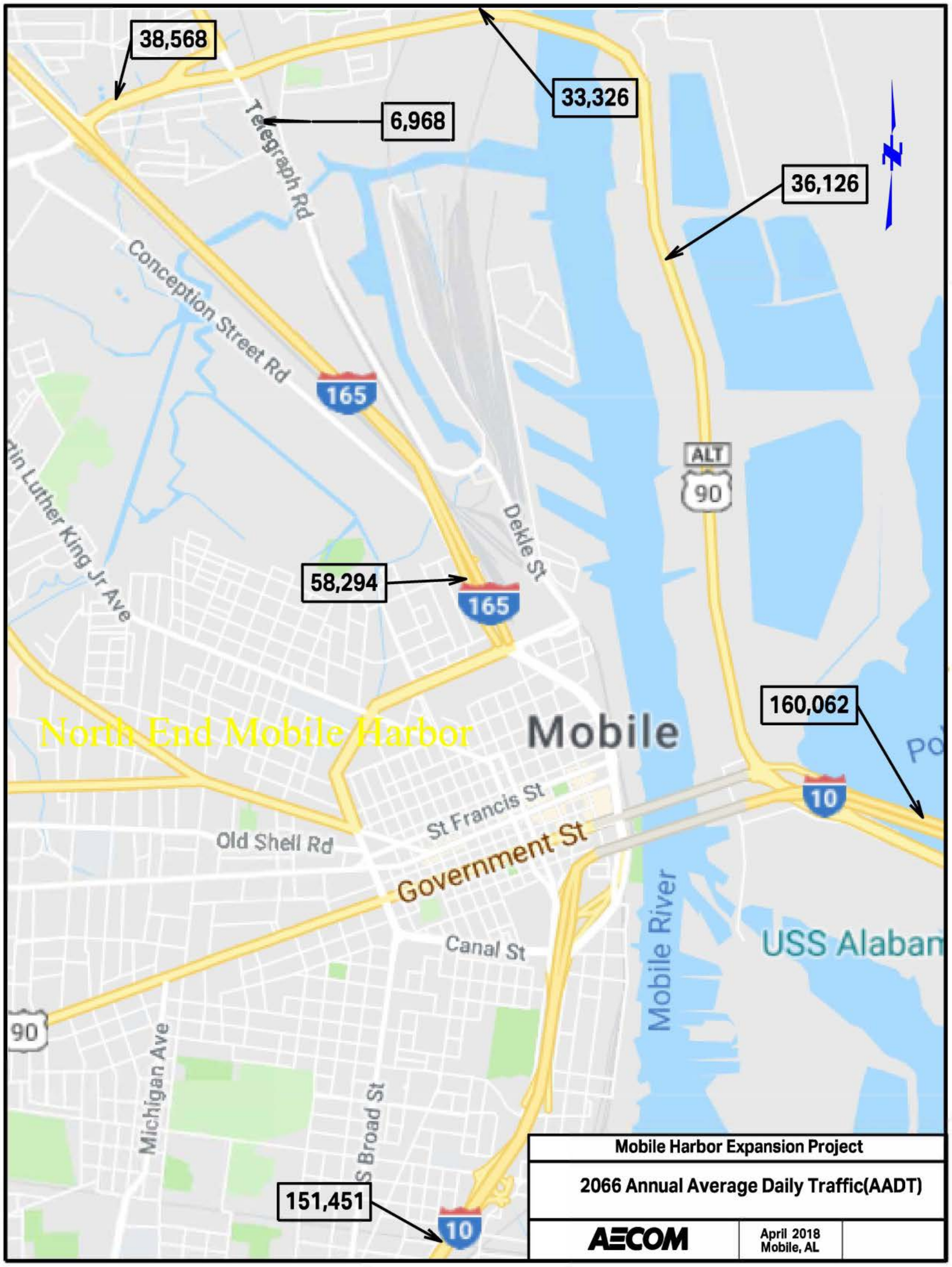
The traffic volumes on Telegraph Road and Old Spanish Trail varied greatly over the last 5 years while Baybridge Road and I-10 remained fairly consistent. Interstate I-165 showed an increase in traffic especially in year 2016 and 2017. Traffic predictions are generally forecasted for a 20 year period for roadway improvement projects and past growth can be a good indication of future growth. However, for the 50 year timeframe used in this study, the low population growth prediction was considered. Rather than apply negative growth rates to some of the roadways and high growth rates to others over a 50 year period, a conservative 1.5 percent growth rate from the base year of 2016 was applied (AECOM 2018). Table X-8 shows calculated future traffic volumes and capacities.

Table X-8. Future Traffic Volumes

Route	Existing Capacity (LOS D)	Under Capacity 2066	2066 ADT	2016 ADT	Estimated Growth Rate
Al 13 (Telegraph Rd)	24,300	Yes	6,968	3,310	1.5%
AL 16 (Old Spanish Trail)	29,850	No	36,126	17,160	1.5%
AL 16 (Baybridge Rd)	39,800	Yes	33,326	15,830	1.5%
AL 16 (New Baybridge Rd)	39,800	Yes	38,568	18,320	1.5%
I-10 (4 lanes)	77,900	No	160,062	76,030	1.5%
I-10 (8 lanes)	154,300	Yes	151,451	71,940	1.5%
I-165	116,600	Yes	58,294	27,690	1.5%

Old Spanish Trail and I-10 from Battleship Parkway to US 90/98 east of the port are expected to exceed capacity by 2,066 without roadway improvements. The I-10 Mobile River Bridge is identified and included for expansion from four lanes to eight lanes on the 2040 Long Range Transportation Plan. Other roadway improvements may be required within the corridor to maintain acceptable traffic flow. The 2066 AADT volumes are shown on the map in **Figure X-3**.

Figure X-3. 2066 Annual Average Daily Traffic (AADT)



SECTION 2. Environmental Consequences

This section describes the potential impacts to transportation resources should the Proposed Action or No Action alternative be implemented.

2.1. Transportation

2.1.1. *No Action Alternative*

Under the No Action Alternative, no changes to the current transportation system would occur. Maintenance dredging of the harbor and channel would continue. Over the next 50 years, channel traffic and harbor operations may increase independently of a deepening and widening project. This could potentially lead to increased traffic on local roads, railroads and airports. Therefore, under the No Action Alternative, traffic volumes in the channel, harbor and local transportation systems may increase slightly, but this increase would be insignificant. If proposed road improvements are made on the I-10, these impacts would be further reduced.

Indirect impacts to transportation in the Mobile Harbor area are possible under the No Action Alternative. At current depths, carriers and shippers cannot fully utilize available vessel capacity. If channel improvements are not made, it is possible that vessel traffic would call on other deep water ports that provide shipping efficiencies at a lower cost. Over time, this may result in less maritime, rail and vehicular traffic associated with the port.

2.1.2. *Proposed Action Alternative - Tentatively Selected Plan*

The Tentatively Selected Plan (TSP) consists of: deepening the existing channel an additional 5 feet (existing 45 foot deep channel in the bay to 50 feet and existing 47 foot deep channel in the Bar Channel to 52 feet); adding an additional 100 feet of widening for a distance of three miles beginning at the upper end of the bend area at the 50 foot depth; including bend easing with the deepening at the upper end of the bar channel; and, modification to the Choctaw Pass turning basin to ensure safe operation at the 50 foot depth.

2.1.2.1. Construction

During construction, harbor operations are expected to continue without construction related interruption. Dredge activity would be halted and moved to accommodate vessel traffic. Currently, two dredges operate in the harbor and the channels for maintenance activities. The construction of the TSP would only require one additional dredge. Therefore, no significant change to existing transit methods and routes of goods entering and exiting the harbor are anticipated. Only an additional 34 workers would be required, which would not impact existing road traffic characteristics in the area. No change in surface transportation routes used to and from the harbor are anticipated as a result of construction. Under the proposed action, direct impacts to harbor traffic and surrounding transportation systems would be minor.

Indirect impacts to transportation as a result of construction activity in the harbor would be insignificant. Dredging equipment would yield to vessel traffic, minimizing any associated change in the water or land transportation patterns. The increase of approximately 34 workers travelling to and from dredge crew boat landing spots would not increase traffic on roads in the area.

2.1.2.2. Operation and Maintenance

Port traffic, including a 25 percent increase in trick traffic associated with build-out of the container terminal, is included in the existing traffic volumes and in the 1.5 percent growth rate applied to the future volumes and includes the expected increase in truck traffic associated with the build-out of the container terminal.

Direct impacts to transportation over the long term are possible. Although the harbor and channel enlargement is not predicted to increase the volume of products being shipped through the harbor, the method of transportation (in larger vessels) could change. The larger container ships would transport larger volumes at once. This may lead to a minor increase in traffic on local roads during loading/unloading operations as more longshoremen may be required loading/unloading of the larger vessels. Fewer un-loadings would occur, but each unloading would require more transportation vehicles than currently needed; however, this increase in vehicles is accounted for in the 1.5 percent growth rate applied to future volumes.

Overall, changes to transportation could occur under the proposed alternative, such as short term increased traffic during loading/unloading operations. However, with proper management by the ASPA, these impacts would be minimized and would result in the same LOS currently available in the area. As stated above, possible local and interstate roadway improvements would also decrease the possible negative impacts to transportation in the port area.

Indirect impacts to transportation could occur under the proposed action over the long term. If larger vessels could use Mobile Harbor, these vessels may choose Mobile over other ports. Additionally, a general reduction in the number of large shipping vessels could occur over time as shipping larger volumes at once is more efficient. Shipping companies may elect to retire their existing vessels in favor of larger ones. Overall, switching from more smaller vessels to fewer larger vessels would not be considered a significant indirect impact to transportation.

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