

Mapping Oyster Reef Habitats in Mobile Bay

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Oyster reefs around the world are declining rapidly, and although they haven't received as much attention as coral reefs, they are just as important to their local ecosystems and economies. Oyster reefs provide habitats for many species of fish, invertebrates, and crustaceans, as well as the next generations of oysters. Oysters are also harvested from many of these reefs and are an important segment of many local economies, including that of Mobile Bay, where oysters rank in the top five commercial marine species both by landed weight and by dollar value. Although the remaining Mobile Bay oyster reefs are some of the least degraded in the world, projected climate change could have dramatic effects on the health of these important ecosystems. The viability of oyster reefs depends on water depth and temperature, appropriate pH and salinity levels, and the amount of dissolved oxygen in the water. Projected increases in sea level, changes in precipitation and runoff patterns, and changes in pH resulting from increases in the amount of carbon dioxide dissolved in the oceans could all affect the viability of oyster reefs in the future. Human activities such as dredging and unsustainable harvesting practices are also adversely impacting the oyster reefs. Fortunately, several projects are already under way to help rebuild or support existing or previously existing oyster reefs. The success of these projects will depend on the local effects of climate change on the current and potential habitats and man's ability to recognize and halt unsustainable harvesting practices. As the extent and health of the reefs changes, it will have impacts on the Mobile Bay ecosystem and economy, changing the resources available to the people who live there and to the rest of the country, since Mobile Bay is an important national source of seafood. This project identified potential climate change impacts on the oyster reefs of Mobile Bay, including the possible addition of newly viable habitats in the southeastern regions of the Bay.

I. Introduction

Oyster reefs are an important resource for local ecosystems and economies worldwide. Oyster reefs protect shorelines from erosion, filter excess nutrients from local seawater preventing algal blooms, and are also home to many species of fish, crustaceans, and invertebrates, including future generations of oysters and other commercially valuable species, helping to ensure the continuation of a fishing industry that remains an important component of many local, regional, and national economies. Yet these valuable resources are being overexploited and are rapidly disappearing from the world's oceans with over 85% of historical reefs lost so far.¹ The oyster reefs in Mobile Bay, Alabama, on the northern coast of the Gulf of Mexico, are sharing this fate. Present day natural reefs are greatly diminished from their historical extents, potentially having lost as much as 2000 acres from 1952 to 1995¹¹, although direct comparisons are difficult due to the wide range of techniques used to measure the extent of the reefs. Today's

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reefs are primarily concentrated in the southwest corner of the bay near the Gulf of Mexico and Mississippi Sound, decreasing their economic and ecological value. Fortunately, the remaining reefs are among the healthiest in the country, making them perfect candidates for preservation.

Oyster reefs rely on a number of environmental factors being in balance in order to thrive. Appropriate levels of salinity, pH, dissolved oxygen, and total suspended solids (TSS) as well as the correct combination of water depth and reef height all contribute to the success of the reefs. These factors therefore need to be taken into account for the success of preservation efforts. Global climate change has the potential to cause significant impacts in the areas where the reefs are being rebuilt, leading to sometimes extreme variations in the parameters of these factors. By studying the possible effects of climate change on the Mobile Bay area, locations can be selected for the development of oyster reefs that are less likely to become unsuitable habitats in the future. The purpose of this project is to examine the challenges faced by existing oyster reefs from the probable impacts of future climate change and to identify existing regions of Mobile Bay that are likely to remain favorable to the maintenance and sustainability of oyster reefs in the future. This information will help organizations such as the University of South Alabama, National Estuary Program, and others who are already working to preserve existing reefs and create new ones by identifying the most effective areas to preserve or create oyster reefs in order to maintain their economic and ecological benefits. Oysters rank in the top five marine species exploited both by landed weight and by value in Alabama¹⁰, illustrating their economic value to the Mobile Bay region and to the state. The oysters harvested here are exported nationwide as well, making the preservation and restoration of these reefs important from a national economic standpoint as well.

II. General Information About Oysters

Eastern oysters, such as those found in Mobile Bay, build large reefs in shallow waters near coastlines as far north as New England and as far south as South America, providing habitats for many fishes and bottom-dwellers similar to those provided by coral reefs in warmer waters. Oysters also provide important services to the coastal environment, including filtration of the water, increased favorability of surrounding areas for the growth of submerged aquatic vegetation (SAV), and reduced likelihood of algal blooms since they eat the algae as well as removing excess nutrients from the water that could otherwise contribute to algal blooms. Oyster reefs also buffer the coast from wave action, preventing coastal erosion, and provide an important indicator of estuary health in addition to their economic value.

A. Life Cycle

Life for a young oyster begins when mature oysters are stimulated by changes in water temperature to release gametes into the surrounding water, a method known as broadcast spawning. Generally the spawning season occurs during the summer months from May to August. The gametes will combine in the water column to form larvae, which remain in the water column up to three weeks while they develop into pediveligers with simple straight-hinged shells and a basic foot. At this point, the juvenile oysters, known as spat, will settle out of the water and begin looking for a suitable setting location. Research shows that juvenile oysters prefer to attach themselves to the shells of other oysters, thereby creating oyster reefs⁷. With the exception of human interventions such as harvesting, the oyster will remain attached in its setting location for the rest of its life.

B. Habitat Requirements

Although mature oysters can tolerate extremes in salinity and temperature, in order for the development and reproduction processes to proceed normally the environmental conditions in the region should meet target levels for salinity, pH, temperature, total suspended solids, dissolved oxygen, and water depth. Mature oysters can survive

conditions well outside ideal ranges, but often at the expense of their reproductive or growth capabilities, which decreases their economic value and endangers the future of the oyster reef if these conditions are present for an extended period of time.

1. Salinity

The ideal salinity range for oysters is 10 to 30ppt⁵, although they can often survive in salinities as high as 40ppt. Higher salinity levels often allow for greater numbers of predators, such as mud crabs and oyster drills, near the reef, resulting in higher mortality rates from predation⁵. Low salinity levels are more likely to be directly fatal to the oyster reef as salinities less than 6ppt can inhibit reproductive functions, lead to abnormal feeding or even require the closure of the oysters' valves, preventing them from feeding. Salinity levels less than 12ppt can prevent immature oysters, known as spat, from settling and reduce growth rates^{5,9}.

2. pH level

Normal development of young oysters occurs at pH levels between 6.75 and 8.75⁵. As atmospheric concentrations of carbon dioxide have risen, larger amounts have been dissolved into the oceans, increasing their acidity. If this trend continues, increasing ocean acidity could prevent the formation of oysters' shells by reducing the availability of the calcium carbonate needed for their shells³.

3. Temperature

The ideal temperature range for oysters is 7-32°C, with temperatures above 20°C required for spawning⁵. Shorter intervals between spawning and settling are observed for temperatures above 28°C. Shorter settling intervals may lead to larger mature oysters, which would increase their economic value. For this reason, some increase in ocean temperature may actually benefit oyster fisheries.

4. Dissolved Oxygen

Dissolved oxygen concentrations must be at least 1ppm for oysters to survive long term; values below this can be tolerated by mature oysters for a few days. Growth impairment may begin at concentrations less than 1.5ppm. Optimal concentration is at least 3ppm⁵, but oysters require more oxygen as water temperature increases, so the amount of dissolved oxygen required may increase due to the effects of climate change⁹.

5. Water Depth

Most oyster reefs are found in water less than 6 meters deep, although occasional reefs are found in deeper water. The height of the reef itself is an influencing factor on the survival of the reef at a particular depth since the bottom layer of water in deeper waters is more likely to become hypoxic or anoxic, depriving the oysters of oxygen unless the reef is tall enough to suspend them above the hypoxic/anoxic zone.

6. Suspended Sediments

Heavy silt loads greater than 1g/L can be fatal to the oyster larvae, and will decrease meat and shell growth in older oysters, making them less economically valuable and potentially inhibiting their reproductive abilities. Oyster reefs will not survive if they are buried under sediment. However, experiments have shown that the majority of the oysters on reefs will survive suspended sediment levels as high as 250mg/L⁵.

C. Challenges Facing Mobile Bay Oyster Reefs

Challenges to oyster reef habitats include climate change-associated sea level rise and precipitation changes leading to changes in runoff, salinity, and silt loads as well as the expansion of diseases in the oyster community

which thrive in higher temperature, higher salinity environments^{6,8}. Oysters also face anthropogenic challenges such as destructive harvesting practices, including dredging, and degradation or loss of oyster habitat through measures to make shallow water bays accessible to ocean-going ships. Dredging for either harvest or transportation destroys the base of the oyster reef, decreasing the height of the reef for future generations and increasing the likelihood of the oysters being exposed to hypoxic or anoxic zones in deeper waters. Dredging can also bury existing reefs, eliminating the substrate for immature oysters to settle on, and even if the reef is not buried, the sediments disturbed by the dredging can suffocate the oysters.

III. Mapping Oyster Habitats in Mobile Bay

A. The Models

Two hydrologic models were used to track the changes in the water column of Mobile Bay caused by climate change. The first model used was the Loading Simulation Program in C++ (LSPC) model, which tracks runoff in the basins surrounding Mobile Bay and calculates the expected discharge from each of the 22 watersheds contiguous to and emptying into Mobile Bay. To evaluate the impacts of future climate change on Mobile Bay, the SRES A2 scenario created by the Intergovernmental Panel on Climate Change (IPCC) was used to provide the magnitude of expected climate changes. This scenario reflects a world of increasing heterogeneity in which countries focus on regional rather than global issues and population continues to increase. This scenario was selected because it was thought to be the most realistic and in many ways represents a worst case scenario for climate change. The percentage changes in temperature and precipitation were input to the LSPC model to evaluate changes in streamflow measurements based on the climate changes. The output from the LSPC model was then fed into the Environmental Fluid Dynamics Code (EFDC) model in addition to the expected sea level rise. The EFDC model tracks the flow of water through Mobile Bay and analyzes variables such as salinity, temperature, TSS, and water depth based on the changes in runoff and the climate change data. The outputs from this model were used to analyze the habitat suitability for oyster reefs in Mobile Bay.

B. Mapping the Habitats

The EFDC model output is approximately 1700 grid cells covering the entire Mobile Bay with the water column divided into 4 layers. The model was first run based on 2005 data in order to provide a baseline for the analysis. The southern portion of Mobile Bay from Dauphin Island north into the body of the bay was chosen as a target for analysis based on reports that current oyster reefs exist primarily in southern Mobile Bay. The output from the 2005 run was analyzed for each of the cells in this region for bottom salinity, maximum TSS levels, and water depth to identify potential oyster habitats.

The result of this analysis was a list of 96 cells considered to be potential oyster habitats. These cells were the subjects of a more in-depth analysis of salinity and temperature levels throughout the water column in addition to which the salinity gradient was calculated by finding the difference between the average bottom salinity and the average surface salinity. Once this data was compiled, the cells were classified as good, marginal, degraded, or unsuitable oyster habitats based primarily on minimum bottom salinity levels, the salinity gradient, which was used as a proxy for dissolved oxygen concentrations based on work by Buzzelli showing that a salinity gradient greater than 5ppt indicated a higher probability of hypoxic or anoxic conditions, and the maximum TSS levels as shown in Table 1. Once the cells had been categorized, the spreadsheet was imported to ArcMap and a habitat map was

created for oysters in Mobile Bay.

Table 1. Criteria used for Habitat Classification.

	Minimum Salinity	Average Salinity	Maximum TSS	Average Depth	Average Salinity Gradient
Good	>10ppt	10–30ppt	<250mg/L	<6m	<6ppt
Marginal	6–10ppt	30–32ppt	250–500mg/L	6–7m	6–8ppt
Degraded	5–6ppt	>32ppt	500–1000mg/L		8–10ppt
Unsuitable	<5ppt	<10ppt	>1000mg/L	>7m	>10ppt

The same data were subsequently compiled from the 2025 data set for the same domain that had been analyzed for the 2005 data, and six cells were added to list of potential oyster habitats. By focusing on the same cells, a direct comparison was possible and a direct analysis of the effects of climate changes could be made. The cells were again categorized and the information was imported to ArcMap to create a 2025 habitat map for oyster reefs in Mobile Bay. Comparisons were run between the data sets from 2005 and 2025, including the changes in the habitat status of each cell and the changes within each of the habitat parameters. Statistics were also compiled for each cell, including mean, maximum, and minimum values for each habitat parameter, which were compared for the two data sets along with the mapped changes in order to understand which parameters were having the greatest influence on the oyster habitats.

C. Analysis of Results

The LSPC model run for 2025 produced statistically significant changes in streamflow values for all of the 22 watersheds analyzed, although the numerical values of the annual changes were small enough to be considered not biologically significant. As a result, little significant change was expected to be seen in the water column when the data was input to the EFDC model. The LSPC data were originally evaluated on an annual basis, but this approach tended to equalize the positive and negative seasonal changes expected by the climate change scenario, so the data were re-evaluated by season, which showed that the overwhelming majority of changes in streamflow occurred in the spring, with average decreases in maximum flow of 82.25 cubic feet per second (cfs), although the decrease in mean flow was only 2.44cfs, which was not considered biologically significant.

The data from the LSPC model was used to define the relationships between the variables in the water column once the discharge data was combined with the EFDC outputs. Comparisons of TSS loads, bottom salinity levels, and discharge rates showed that the magnitude of the stream discharge was related to both the TSS load and the bottom salinity level. As seen in Figure 1, a direct relationship exists between the discharge and the TSS load and an indirect relationship exists between the discharge and the minimum bottom salinity. This data shows that stream discharge is a major source of TSS for Mobile Bay and that the bay is generally well-mixed, allowing less dense fresh water entering the bay from surrounding streams to influence salinity in the bottom layer of the water column. This relationship was potentially significant to the evaluation of oyster reef habitats in Mobile Bay since oysters rely on appropriate bottom salinity levels to thrive and the changes in precipitation that were inputs to the LSPC model caused changes in discharge, which then affected bottom salinity. Decreased discharge, such as in the spring season, allowed bottom salinity to increase, which generally improved the area for oyster reef habitats, while increased discharge such as in the winter months generally decreased bottom salinity and the suitability of the oyster

reef habitats.

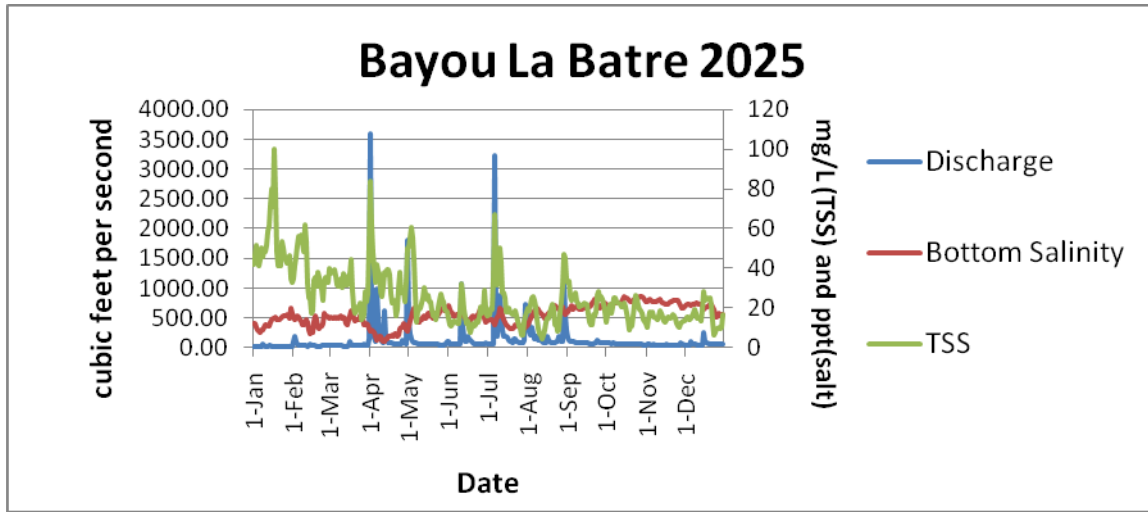


Figure 1. Relationships between bottom salinity, TSS, and discharge rates produced from LSPC and EFDC outputs.

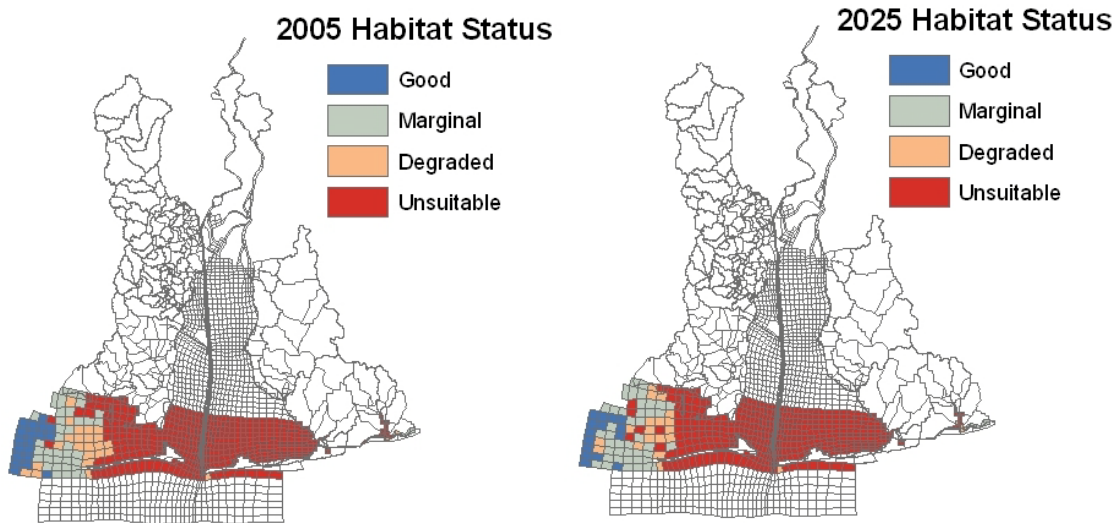


Figure 2. Comparison of 2005 and 2025 oyster reef habitat classifications

After the LSPC outputs were fed into the EFDC model and the cells had been evaluated and classified as to their suitability for oyster habitats, the habitat maps in Figure 2 were created. The habitat maps supported the reported observations that the Mobile Bay oyster reefs have migrated to the southwestern portions of the Bay and suggest that they will continue to migrate west. The 2005 map shows a greater number of good cells than the 2025 map, and the good cells on the 2025 map are located further west than those in the 2005 map. The maps also show that the body of Mobile Bay has become largely unsuitable for oyster reefs, necessitating their migration. Comparing these maps also shows areas in the Wolf Bay area that were unsuitable habitat in 2005 but improve by 2025 to be considered degraded instead of unsuitable. This area can be observed more closely in Figure 3, and the

improvements in the habitat status in eastern Wolf Bay can be seen clearly.

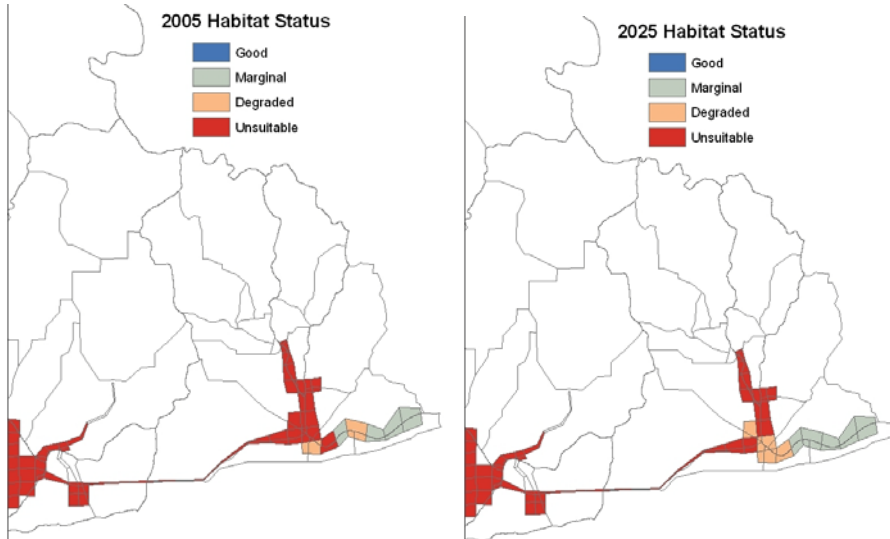


Figure 3. 2005 and 2025 habitat maps for the Wolf Bay area

Once the habitat suitability analysis had been performed for each year, a comparison between the years was necessary in order to identify the areas where the habitats were changing. The resulting map showing the changes in oyster reef habitat in Mobile Bay can be seen in Figure 4. This map clearly shows that the only changes in habitat status are occurring outside the main body of Mobile Bay in Mississippi Sound and in Wolf Bay. The habitat in Mississippi Sound is having mixed fortunes, but is overall declining while that in Wolf Bay is generally improving. The reasons for these changes in habitat status were evaluated by mapping the maximum TSS levels and minimum bottom salinity levels for each year as well as the changes in these parameters between 2005 and 2025. The number of cells classified at each habitat level was also calculated and compared for the study period. As seen in Table 2, the largest changes in habitat status were in cells classified as marginal, with 6 cells added to this class in 2025. It is worth noting that two thirds of these cells were added through degradation of habitats previously considered good

Table 2. Comparison of 2005 and 2025 habitat classifications.

	2005	2025
Good	19	15
Marginal	41	47
Degraded	25	23
Unsuitable	448	448

Table 3. Regression analysis between changes in habitat status and changes in maximum TSS levels

<i>Regression Statistics</i>	
Multiple R	0.49
R Square	0.24
Adjusted R Square	0.24
Standard Error	0.69
Observations	100

rather than the improvement of degraded habitats, which accounted for only two of the additional marginal cells.

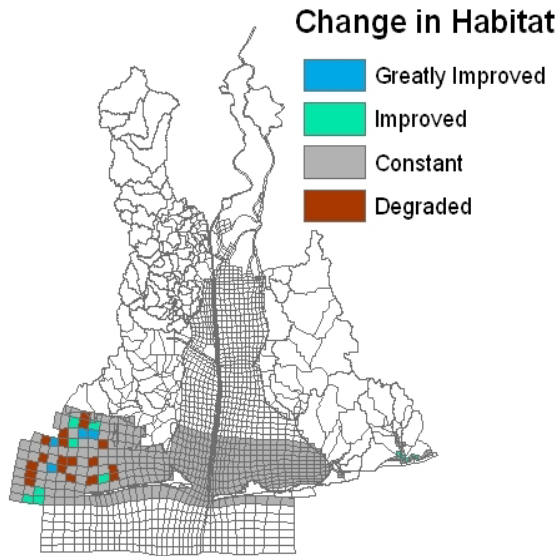


Figure 4. Changes in habitat status from 2005 to 2025.

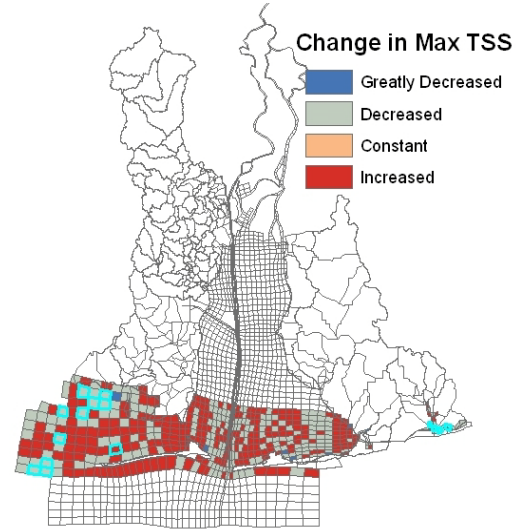


Figure 5. Correlation between decreasing maximum TSS loads improvement in habitat status represented by highlighted cells

The causes of the changes in habitat status were evaluated from maps such as the one in Figure 5 which shows the changes in the maximum TSS loads from 2005 to 2025. The highlighted cells are those in which the habitat status improved from 2005 to 2025. The maximum TSS load was found to be the main force driving the changes in habitat status, and it can be seen in Figure 5 that most of the cells showing an improved habitat are in areas in which the maximum TSS load decreased. A regression analysis was performed between the changes in habitat status observed from 2005 to 2025 and the changes in maximum TSS load observed over the same period. The results of this analysis are shown in Table 3. From this it can be seen that the changes in maximum TSS load accounted for 24% of the observed changes in habitat status. By comparison, the observed changes in minimum bottom salinity levels accounted for only 1.4% of the observed changes in habitat status.

The difference in these variables' influence on the habitat classifications reflects the sensitivity of the variables themselves to climate change, which is reflected in the magnitude of the changes shown between 2005 and 2025. The changes in the mean values of all four habitat parameters from 2005 to 2025 were evaluated for the entire study area, as seen in Table 4, as well as for the habitat cells, as seen in Table 5. Table 4 shows that in the study area as a whole, all four habitat parameters are increasing, with the greatest changes seen in maximum TSS loads, which increased 7.12%. By contrast, Table 5 shows that in the habitat cells maximum TSS levels and minimum bottom salinity levels decreased while average bottom salinity and water depth increased. The largest magnitude change was again seen in the maximum TSS levels, although the magnitude was smaller than that seen in the study area as a whole, being 2.97%. The changes in water depth were included in the climate file as sea level rise and were therefore expected to be similar in the study area and in the subareas of the habitat cells, however the magnitude of the changes in water depth differed when the entire study area was evaluated and when only the habitat cells were evaluated. In the study area as a whole, mean water depth increased 0.004 meters, while in the habitat cells the depth increased by only 0.001 meters. This difference can be explained by the more protected position of the habitat cells, often behind barrier islands or in sheltered bays, such as Wolf Bay, that are more protected from sea level rise. The changes in salinity levels and TSS levels were of greater interest since they were not inputs to the model but were

instead results from the model run. The mean maximum TSS loads in the habitat cells showed a 2.97% decrease from 2005 to 2025 with absolute decreases as great as 5373 mg/L in individual cells, while the TSS loads in the study area as a whole showed a mean increase of 39.95 mg/L. Combined with the observed changes in mean minimum bottom salinity, which showed a 0.24% decrease in the habitat cells with decreases as large as 3.68ppt in individual cells, these changes demonstrate the influence of freshwater discharge on the habitat cells, which are close to the shoreline and therefore nearer the source of the discharge. The increase in average bottom salinity in the habitat cells of 0.23%, combined with the decrease in the maximum TSS levels also indicates a decrease in the amount of freshwater flowing into the Bay, although the decreasing minimum bottom salinity levels suggest an increase in maximum water flows that appears to contradict the climate file. The increase in the average bottom salinity seen in both tables likely reflects the impacts of sea level rise, which would increase the amount of saltwater in the Bay. The denser saltwater would cause the largest increases in salinity in the bottom layer of the water column, where this study was focused. The smaller changes seen in the habitat cells are the result of the more protected position of the cells, which, in protecting them from sea level rise, also protect them from the saltwater intrusion that is increasing salinity levels in the study area as a whole, as well as the greater freshwater influence in these near shore areas. It should be noted that this increase in salinity levels is not uniform throughout the Bay, as can be seen in Figure 6, but instead demonstrates the shifting balance between fresh and salt water in the Bay. A more in-depth analysis of the forces driving the changes in these parameters would be necessary to determine the source of the observed changes, which would be useful for restoration efforts in Mobile Bay.

Table 4. Analysis of Changes in Habitat Parameters from 2005 to 2025 for all cells in the study area.

	2005 Mean	2025 Mean	Change in Mean	Percentage Change
Minimum Bottom Salinity	4.06	4.25	0.19	4.79%
Maximum TSS	561.10	601.05	39.95	7.12%
Water Depth	4.16	4.17	0.004	0.10%
Average Bottom Salinity	16.25	16.67	0.42	2.62%

Table 5. Analysis of Changes in Habitat Parameters in 2005 and 2025 in cells that qualified as oyster reef habitats.

	2005 Mean	2005 Minimum	2005 Maximum	2025 Mean	2025 Minimum	2025 Maximum	Change in Mean	%Change in Mean
Average Bottom Salinity	25.79	13.05	33.06	25.85	14.17	33.06	0.06	0.23%
Minimum Bottom Salinity	14.19	1.27	25.29	14.16	1.28	25.21	-0.03	-0.24%
Maximum TSS	413.69	53.38	5619.78	401.39	31.38	2355.28	-12.31	-2.97%
Average Water Depth	4.52	1.39	6.43	4.52	1.39	6.43	0.001	0.02%

Further analysis of minimum bottom salinity levels was done after significant differences between the 2005 and 2025 levels were noticed during the analysis of the habitat cells. The habitat analysis seen in Figure 6 shows the changes in minimum bottom salinity levels between 2005 and 2025. In this figure, it can be seen that the minimum bottom salinity levels are decreasing in the northernmost rows of the study area, possibly indicating a progression of freshwater down the Bay, which would explain the migration of existing oyster reefs down the bay as they are forced to relocate to avoid these low salinities. This freshwater intrusion could also help explain the decreasing minimum salinity levels seen in Table 5. The reasons for this progression need to be evaluated since the low minimum salinity levels are the single largest limiting factor to the viability of oyster reefs in Mobile Bay.

The largest impacts in minimum bottom salinity were observed in the southeastern corner of the bay, where annual minimum bottom salinity was observed to increase as much as 3ppt. A few cells in the Bayou La Batre and Wolf Bay areas that were unsuitable as oyster reef habitat in 2005 improved enough to be considered a degraded rather than unsuitable habitat as seen in Figure 3. The habitat improvements in this area were a direct result of increasing minimum salinity levels. This implies that further climate change could continue to improve the habitat in southeastern Mobile Bay, potentially allowing for the reestablishment of productive oyster reefs in this area. A third habitat analysis should be performed based on an EFDC run projected further into the future to quantify these changes.

Unlike the southeastern portion of Mobile Bay, approximately half of the southwest portions of Mobile Bay and Mississippi Sound, where the majority of current healthy oyster reefs are located, are expected to see decreasing minimum salinity levels, a trend which, if continued, could lead to some portions of the area becoming unsuitable for oyster reefs. In Figure 4, this trend can be seen in the number of degraded cells in this region. In theory, the improvement of the southeastern region of the bay could offset this degradation, but further projections would be necessary to determine whether the rates of degradation and improvement would balance each other out. Given that the increase in the number of cells classified as marginal seen in Table 2 was mainly due to the degradation of good cells rather than the improvement of degraded or unsuitable cells, it is uncertain whether the degradation and improvement rates will balance each other. Table 2 suggests that the degradation rate is approximately twice the rate of habitat improvement in the 2005-2025 time period, which does not bode well for the balancing act between the southwestern and southeastern bay. However, during the data analysis it was observed that several cells in the

southeastern region of the Bay were close to becoming at least degraded habitats, and if the minimum bottom salinity levels continue to increase at the rates shown from 2005 to 2025, it is possible that they would become marginal habitats by 2075 and possibly good habitats by 2100. Further model runs should be used to analyze the likelihood of the southeastern bay becoming a suitable area for oyster reefs and to analyze the rates of increase in bottom minimum salinity levels, since these levels are the main limiting factor to the establishment of oyster reefs.

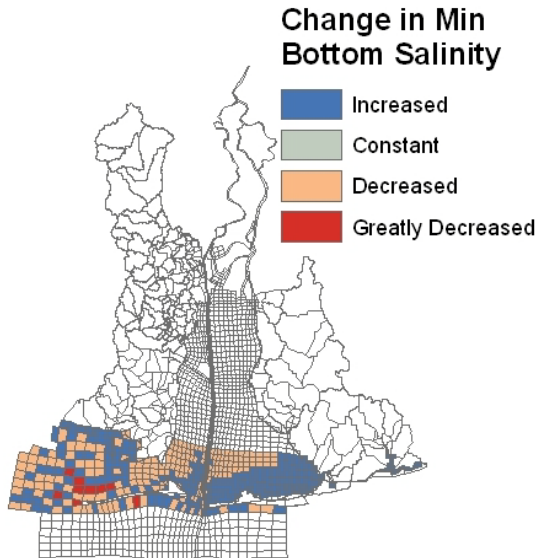


Figure 6. Changes in minimum bottom salinity

IV. Conclusion

The effects of climate change in Mobile Bay are not likely to be catastrophic to the survival of oyster reefs in the near future, provided that restorations are performed in areas that are likely to support the reefs, such as Mississippi Sound. In the future, it is possible that the southeastern bay will return to being a productive area for oyster reefs, but at this time it would not be recommended to focus restoration efforts in that area. The low minimum bottom salinity levels will prevent the spat from settling, endangering the livelihood of oyster reefs in this area. The habitat in Mississippi Sound will have to be monitored to ensure that salinity levels here remain high enough especially during the spawning season for oyster reefs to be self-sustaining in this area.

Further work needs to be done on oyster reefs in Mobile Bay, including a more detailed analysis of their habitat requirements. The model runs should also be projected both into the future and into the past in order to gain a better understanding of the relationships between climate change and the loss of oyster reefs in Mobile Bay. In addition, an analysis of the timing and duration of the low bottom salinity and high TSS events should be performed to increase understanding of their causes and their effects on the oyster reefs. Finally, a map of current live oyster reefs should be compiled for comparison to the habitat maps and to inform future restoration efforts.

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