Nursery Habitat Suitability Model for Juvenile Blue Crabs in the Chesapeake Bay

Introduction

The Blue Crab (*Callinectes sapidus)* is one of the most charismatic species of the Chesapeake Bay, a recognizable symbol for the mid-Atlantic region. Apart from its cultural importance, the blue crab fishery is the most important shellfish fishery in the Bay, and the second largest commercial crab fishery in the world (Chesapeake Bay Program, 1994). It is also one of the most vulnerable species to both natural and anthropomorphic environmental change. Therefore, the recent declines in catches, and abundance in the Bay has drawn the attention of scientists, politicians, economists, and waterman alike. Developing ways to protect the blue crab and prevent the collapse of the fishery is of utmost importance and is the focus of several research institutions and government agency located near the Bay.

Identifying protected areas for the blue crab population is a difficult task as the crabs utilize almost all areas of the bay, from high salinity to low salinity regions, and from shallow to deep waters, depending on the sex and age of the crab. For instance, the megalopae stage juvenile crab (Figure 1) settles in well-structured, low-to-medium salinity (13-22ppt), seagrass bed habitats, which provide shelter from predation as well as ample food resources, while adult males bury in the mud in the deep waters of the main-stem, and females migrate to the high salinity bay mouth to spawn (van Montfrans et al., 2003; Pugh, 2005). As not all stages can be a protected with one management strategy, scientists have been focusing much effort on one stage - the juvenile stages and their nursery habitats – as without continued recruitment and healthy growth of new recruits, the population will continue to decline.

The continued development and increasing human activities around the bay pose the greatest threats to blue crab recruitment and juvenile nursery habitat, as it has lead to declining water quality and damaged habitat (Pugh, 2005). Therefore it is important to identify the remaining areas in the Bay which are suitable for Blue Crab megalopae larvae, and focus protection efforts on those areas. The purpose of this project is to use GIS to determine the areas in the Chesapeake Bay that are the most suitable nursery habitats for the megalopae juvenile stage. The most important factors influencing juvenile crab habitat selection and survival were analyzed in the model: dissolved oxygen (DO) (mg O_2/L), submerged aquatic vegetation (SAV) density, depth (m), salinity (ppt), and land-use.

Figure 1: Megalopae stage blue crab larvae.

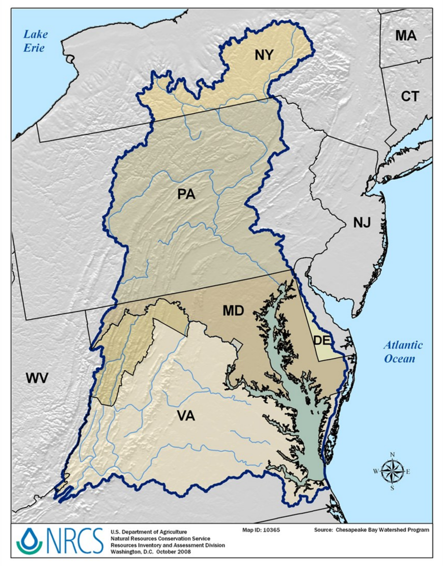

Figure 2: Map of the Chesapeake Bay and its watershed

Methods

To determine the suitable nursery grounds for the megalopae larval stage of the Blue Crab , in the Chesapeake Bay, four of the most important environmental factors were analyzed using ArcMap 10 GIS software. These factors were dissolved oxygen (DO) concentration, salinity, submerged aquatic vegetation (SAV) density, and depth. Land use in the surrounding watershed was also considered, but was not used to determine suitable habitat. Datasets were found online from the Chesapeake Bay Program Data Hub, PASDA, and VIMS's Chesapeake bay SAV monitoring program. The depth layer was created by selecting by attribute ("Depth") from the DO layer.

All layers were projected into NAD_1983_StatePlane_Maryland_FIPS_1900 (Meters). The DO and salinity layers were first defined into the WGS_1984 Geographic coordinate system and then projected. Select by attribute was used to select only those data points that were for the bottom (B) and below pycnocline (BP) layers of the Bay, for the DO, salinity and Depth layers. This was because the juvenile crabs only live on or near the bottom and thus surface conditions are not important factors in determining habitat quality (Pugh, 2005). Interpolation using "spline with barriers" was used to convert the DO, salinity and Depth values to bay wide, continuous, raster data layer. The barrier was created by selecting the Bay (water body) attribute from the land-use basemap, and exporting it as its own polygon layer. Extract by mask was then used on the results of the splines, to make sure that the raster output only included those values that were inside the boundary of the Bay itself. The SAV layer was converted from polygon to raster, and then extract by mask, was used to create a layer which included only those values that were within the confines of the bay boundary.

Each masked layer (DO, salinity, depth, SAV), was then reclassed from 1 to 5, with 5 being the most suitable. Dissolved oxygen concentrations of 5-8 mg O_2/L were the best, and below 2 were the worst. Medium salinities (14-22) were most suitable, with slightly too low being better then too high. High SAV density was ranked the best, with low or no SAV being the worst condition. Depths less than 3ft were most suitable, and anything deeper than 12ft was ranked as worst.

The last step was to use raster calculator to create the additive model for the reclassed data layers, to give a layer showing the "most" suitable juvenile crab nursery habitats. The possible values ranged from 4 to 20, however the results had an actual range of 5 to 17.

Suitable Nursery Habitat & Land Use

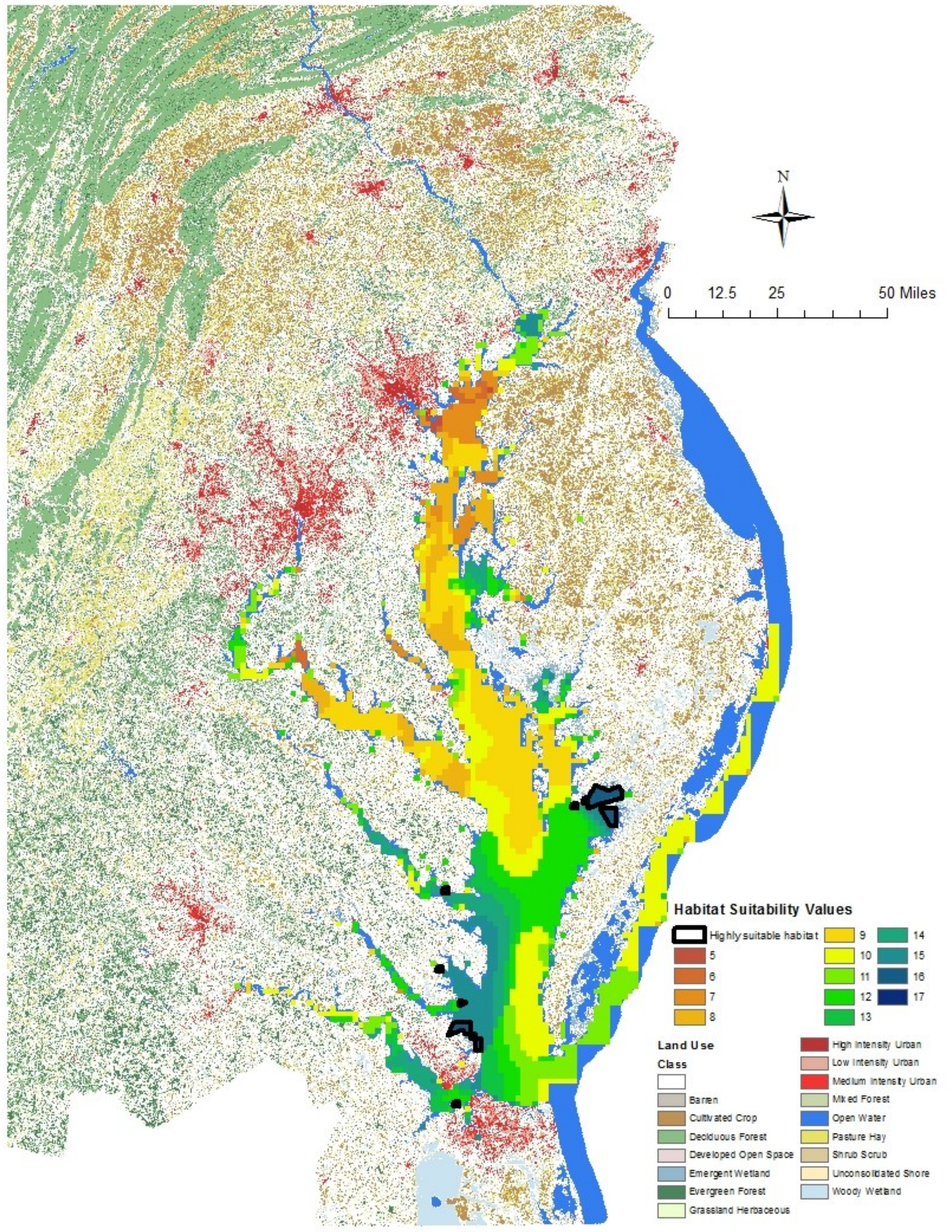

Figure 3: Nursery habitat suitability additive model, with land use in the surrounding bay watershed

Contributing Factors

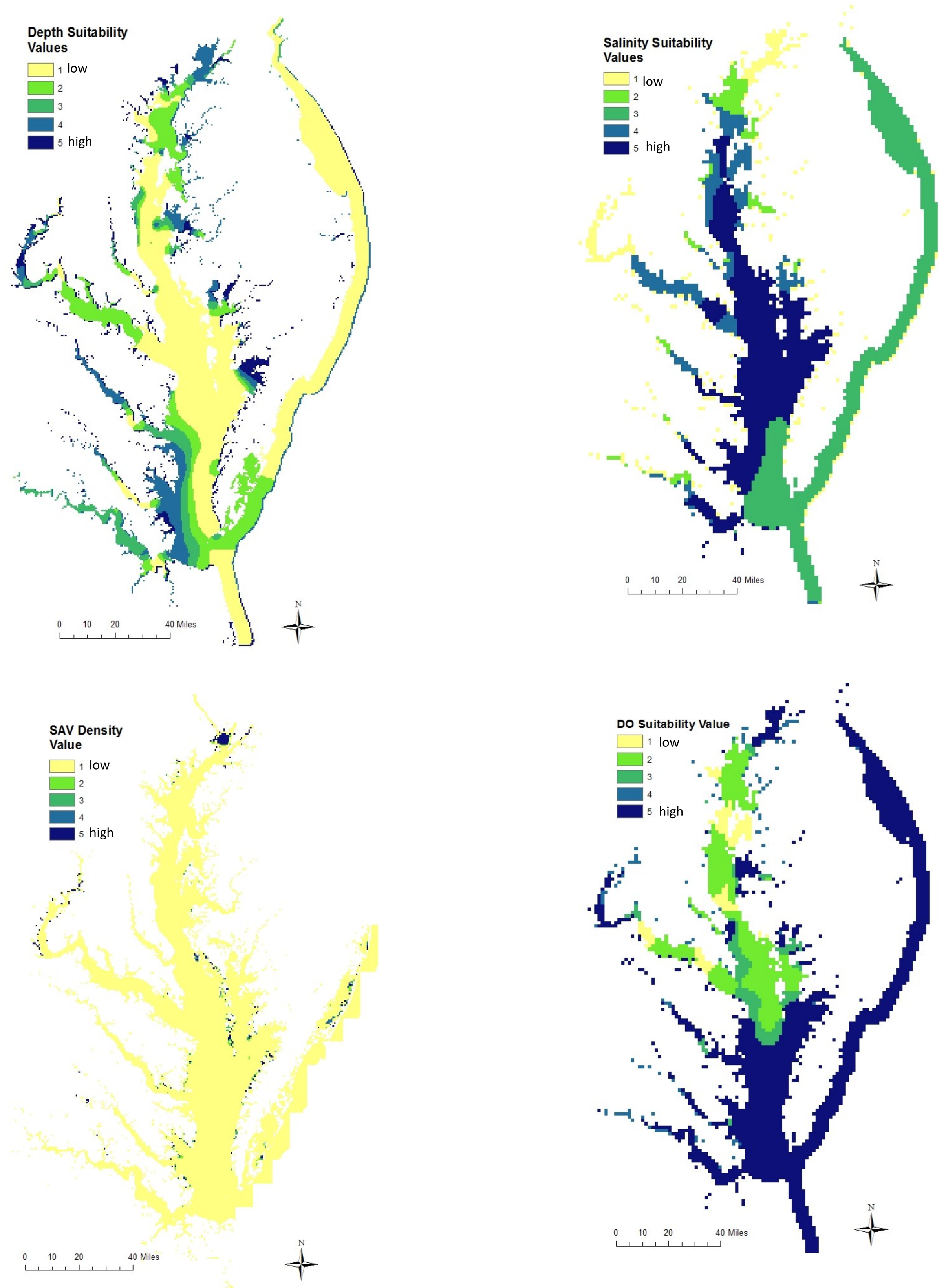

Figure 4: The four contributing factors reclassified for use in the suitability model. From top left to bottom right: depth, salinity, SAV and DO.

Results

Based on the suitability model developed using the 4 environmental factors of importance, there are no remaining habitat in the bay which scores 100% suitable for all 4 factors. The most suitable habitat scored a 17, and only 2 areas had this high of a score. The next highest suitability was 16, with 34 sites. These sites were 80-85% suitable for megalopae juvenile blue crab nursery habitat, and come to 153.95 km^2. This may seem like a large area, but when you consider the large area of the Bay (11,601 km^2), it makes up only 1.3% of the entire Bay area.

Graphing the frequency of each suitability count also illustrates that high suitable habitat areas are rare compared to medium quality habitats (figure 5).

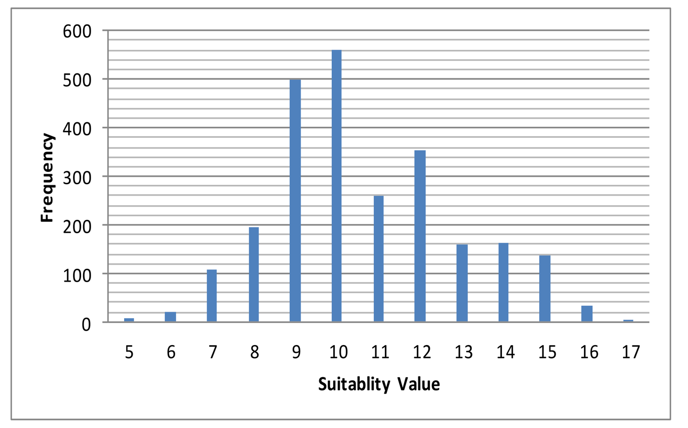

Figure 5: Graph of the number of areas with each suitability value

Comparison of most suitable nursery habitat to surrounding land use shows that the suitable habitat is located in two small coves which are surrounding by emergent and woody wetland which serves as a buffer from the cultivated crop and pasture land. The wetland buffer helps prevent excess nutrients from entering the bay causing eutrophication and lowered DO, and death of SAV. It is also important to note that these areas are also void of much development. One of the coves has almost no development in the surrounding area, and the other areas has a very small amount of low development. These results are consistent with the data collected by King et al. (2003), who found that juvenile crabs were most abundant in areas surrounded by wetlands, and least abundant in areas surrounded by urban development

Conclusion

The results of the suitability model emphasizes how the threatened condition of blue crab nursery habitat in the Bay ecosystem. Conservation and management efforts should be focused on protecting the two remaining coves of suitable juvenile blue crab habitat. This should include limiting the amount of urban development around the coves, and the protection of the wetland buffer. Urban development in the area would drastically decrease the suitability of the habitats as it would increase runoff, which would be even more destructive as the development would also threaten the wetland buffer.

In areas with high levels of urban development the DO and SAV suitability is quite low and the overall suitability drops to 7-11. Therefore, future management and protection plans should focus the two clusters of suitable habitat isolated in this model and work to keep levels of urban development to a minimum in the surrounding area.

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Class: ENV 107 Introduction to GIS

Data sources: Chesapeake Bay Program Data Hub, VIMS Chesapeake Bay SAV survey, PASDA

Projection: NAD_1983_StatePlane_Maryland_FIPS_1900(meters)

References:

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