Assessing the Impact of Sea Level Rise on Horseshoe Crab Spawning Habitat in Cape May, NJ

Erik Hunter Czaja
5/8/09
Advanced Geomatics
Final Paper

The Delaware Bay region between New Jersey and Delaware is home to the largest spawning congregations of Horseshoe Crabs in the world. The Horseshoe crab, a creature that relies heavily on our coastal shores for a limited reproductive period during the year, is facing an ecological problem it may never have dreamed of in its million-year existence. With rising sea level projections surfacing there is fear of severe loss of valuable habitat for this particular creature and many others alike. The Horseshoe Crab and the alignment of its spawning period every May and June with migratory birds are both an environmental spectacle and bears important ecological implications (Odell 741). The greatest numbers of Horseshoe crab spawning occurs in a specific area of the beach known as the swash zone which is an area located between the low and high end of the beach (Nordstrom et al. 439). For the sake of the Horseshoe Crabs future this small zone or one of comparable conditions must exist.

What are the implications of all this? Let alone for the other animals in the ecosystem that rely on this animal's spawning period for food? "At least 11 species of shorebirds-principally red knots, ruddy turnstones, sanderlings…feed on horseshoe crab eggs to provide energy for the final legs of their migration" (Berkson & Shuster 6). Humans have also discovered important uses for this creature in scientific laboratories. It was "discovered that Limulus amoebocyte Lysate (LAL), refined from the unique copper-based blood of horseshoe crabs, could be used to detect small amounts of endotoxin contaminants in medical products slated for human use" (Odell 736). Humans therefore are stakeholders in the Horseshoe Crab.

There have been numerous studies conducted on the Horseshoe Crab in the Delaware Bay region. One such study was conducted by Penelope Pooler, in which the goal was to estimate the quantity of Horseshoe Crab eggs along sixteen beaches. The study had beach sediment collected in cores placed in a 3-meter wide zone on a 100-meter segment of beach during the heaviest spawning periods. Found from the study was that eggs in shallower locations, those between zero and five centimeters, had consistently lower densities of eggs when compared to those of deeper locations, up to twenty centimeters (Pooler Et al. 700). With sea level rise it will be important to note new locations in which Horseshoe crabs will be able to burrow further down into the soil, in suitable areas for their spawning and how the rise will affect the depth of eggs.

In a study by Karl E Nordstrom the variables of fluctuations in spawning crabs, wave energy, tidal cycles and beach elevation were analyzed in order to gauge the amount of eggs for bird consumption (439). This study was conducted before a beach nourishment procedure. Particular interest was taken in the study to look at the swash region of the beach where horseshoe crabs typically lay their eggs. It was found that during higher tides the number of horseshoe crab eggs increased in swash areas and as the water level fell so did the numbers. Therefore optimal foraging for the birds was occurring in the swash region during high tide along the beach, since eggs were more motile with the water and eggs in a higher elevation were sessile and could be consumed at a later time (Nordstrom et al. 446). Putting sea level rise into the equation will affect this greatly; it will change how each of the above factors will influence our coasts, perhaps making the environment much worse for the creature in question and those that rely on it.

In the paper by John A Sweka a life cycle probability was used to simulate the mortality of horseshoe crabs in a twenty-year span in relation to the harvest time of the creature (before or after spawning at Delaware Bay). The best estimates were used in the study and resulted in findings that showed with low to medium egg mortality with harvests there was still an eighty percent chance of horseshoe crab rise; however, if a high mortality occurred to eggs in the population the chance of increase would be less than fifty percent (Sweka 277). This model also proclaimed to be the "the first attempt to link the population dynamics of horseshoe crab with the availability of eggs for shorebirds" (Sweka 284). This model did not incorporate the addition of sea level rise. It could be seen that with the loss of horseshoe crab habitat that the population would be impacted, and in accordance with this paper it may have a chance to maintain itself in the face of drastic losses to its population in a sea level rise scenario.

The objective for this study on Horseshoe Crabs was to assess the future habitat of the crabs at the sea level rise scenarios of 0.6 meter and 1.2 meters with the North American Vertical Datum (NAVD) being the base at 0 meters. To analyze the results geospatial analyses would be conducted. These two levels of rise would be an initial test to show if there would be a decrease in optimal spawning habitat for the crabs. Also it would show where new spawning habitat would become optimal as well as where we would lose original spawning sites. In relation to the class as a whole this project meets the objectives of using placed based decision-making processes. Seeing where the crabs will be able to spawn will hopefully influence the planning of municipalities and with the passage of laws to protect certain areas that now may be seen as unimportant, but in fact after SLR will for Horseshoe Crabs. As far as for the ecological group objectives, all the projects were mostly done with only using the 0 meter base level of the NAVD and not involving spring high water levels (except in certain circumstances special to other members interests). Also using the low and high-end values of 0.6m and 1.2m the group followed similar structure in analysis scenarios.

To create data for this study, areas on the coastline after inundation levels needed to be identified and outlined as well as classified and given values to state the potential for future Horseshoe Crab habitat. Before this study began the assistance of Richard G. Lathrop Jr. was consulted for data pertaining to his study done in 2006 with Aaron Love and Michael Allen. They had previously done a similar assessment of the coast that would be on similar terms with the nature of this project. They had studied the coastline as it was in 2002 and the suitable nature of the coastline for Horseshoe Crabs. To start this assessment the application of the digital elevation map (DEM) of Cape May, NJ was used and acquired from the classes LiDAR allocation. The necessary scenarios were than reclassified into the DEM in feet (0.6 meters ~ 1.9 feet, 1.2 meters ~ 3.9 feet). From this remaining land after a scenario was classified as the value 1 and water was value 0. After this new land was found, digitizing of the new coasts was needed to do further analysis. After both coasts were outlined, by creating a polyline, a buffer of 10 meters was processed over the new coastline. When the buffer was finished the 2002 land use land cover data (LULC) from the New Jersey Department of Environmental Protection (NJDEP) was then utilized by clipping it into the coasts 10 meter buffered area. Then in the properties of this strip of LULC all values were classified to a range of colors to signify their level of importance to the Horseshoe Crab for future spawning (Green, Blue, Red). All types of LULC that pertained to forests, shrublands, open space, beach, pristine areas, etc were categorized as green meaning optimal for spawning. Any LULC that related to wetlands were made blue and seen as less than optimal for spawning activities. LULC that had industry, homes, or other built up environments were made red and seen as unsuitable. After this was undertaken polygons were digitized around the buffer and LULC data and given a ranked value between one and five in the attribute table. Those with the value one were areas that contained only green spots and seen as optimal, areas with spots of green and blue were given a two and said to be suitable, blue was given a three and seen as fair (that or a mix of red and green was also seen as a three), a mix of blue and red was given a four and seen as poor, and finally a red area was given a five and was deemed unsuitable for spawning. After all these areas were identified the areas of those pertaining to certain colors were statistically derived.

The results for this project show what may happen to the Horseshoe Crab with rising sea level in that optimal habitat for the Horseshoe Crab may decrease as sea level rise encroaches on the mainland. It was found that with a 0.6 meter rise optimal habitat would be 55.8%, suitable 20.5%, fair 23.2%, poor 0%, and unsuitable 0.5% (see figure A). When it came to the 1.2 meter rise optimal decreased to 38%, as did suitable to 18.6%, fair increased to 31.2%, as did poor to 10.2%, and finally unsuitable to 2% (see figure B). The reason for these changes may be do to the thin area assessed in this project. Because of the constraints of the Horseshoe crab by it only spawning the majority of its time in the swash zone, the assessment could not reach further back into new territory that may have been suitable. In this study a few things could have made it more successful and precise. By only using LULC the data here could be seen as a starting point, but since soil is also an important attribute to the spawning activities of the Horseshoe Crab further studying using soils data may lead to more reliable results. Also another issue could be the digitizing of the coastline, the polygon creation and classification scheme. The eyes of one individual do not always agree with another set.

In the end it was found that Horseshoe Crabs will have a nearly 18% drop in optimal habitat and have increasing in all the worst areas for its spawning activities. Ultimately for the best interests of Humans and the ecosystem as a whole, careful interest should be kept on the Horseshoe Crab to make sure it remains fruitful. Further research with the application of these scenarios and possibly others would only benefit. This study is to be used as a building block for future analysis of this ecological impact.

Impacts of Sea Level Rise on Horseshoe Crab Habitats (0.6m Rise) in Cape May County, NJ

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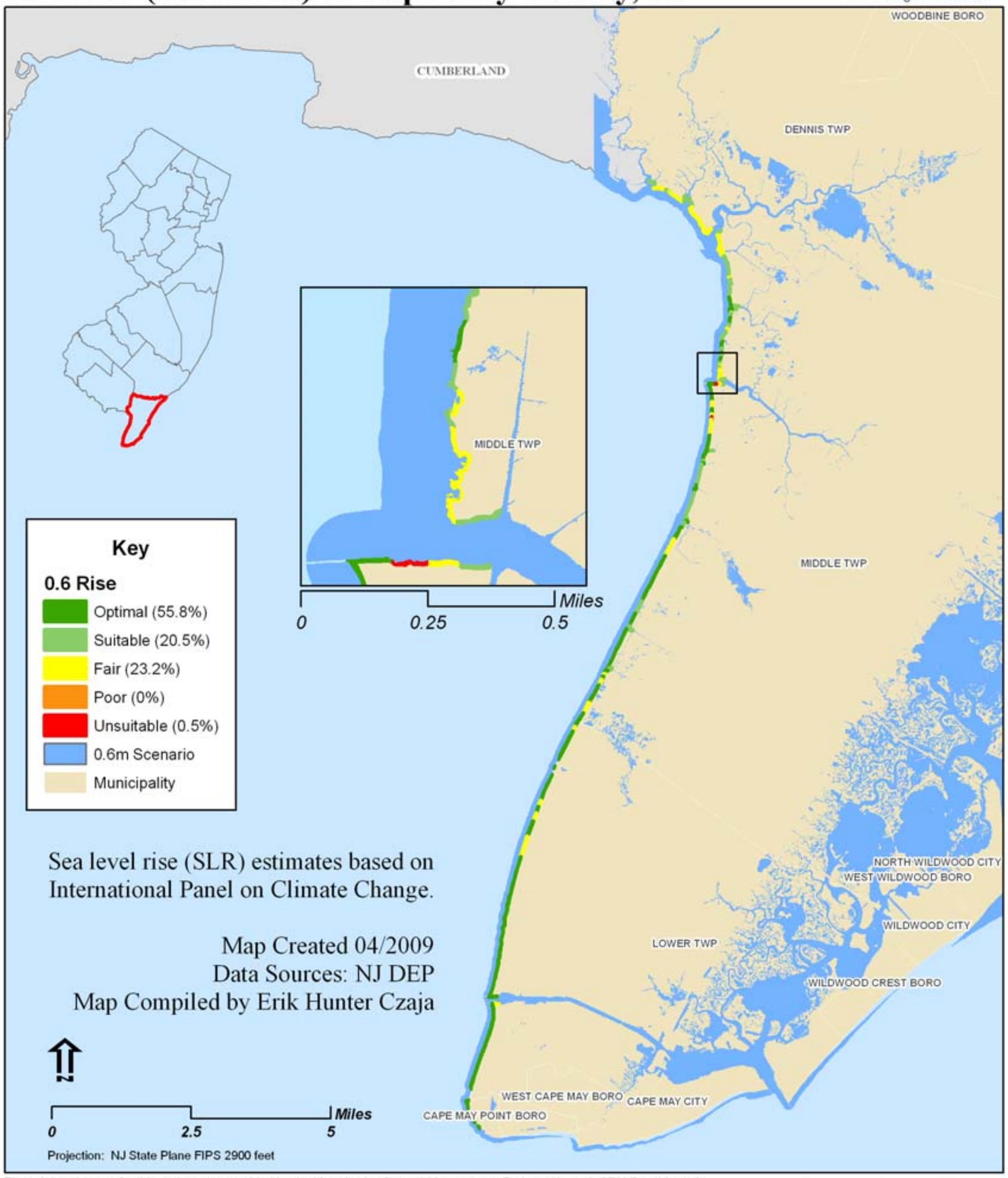

Financial assistance for this project was provided by the New Jersey Coastal Management Program through CZM Grant Awards #NA06NOS4190228 and NA07NOS4190186 awarded through the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration. Additional funding was provided by the New Jersey State Police through the FY2007 EMPG Program, the Natural Resource Conservation Service of the U.S. Department of Agriculture, the U.S. Army Corps of Engineers, Philadelphia, PA, the United States Geologic Survey, and the New Jersey Department of Environmental Protection, Office of Information Resources Management.

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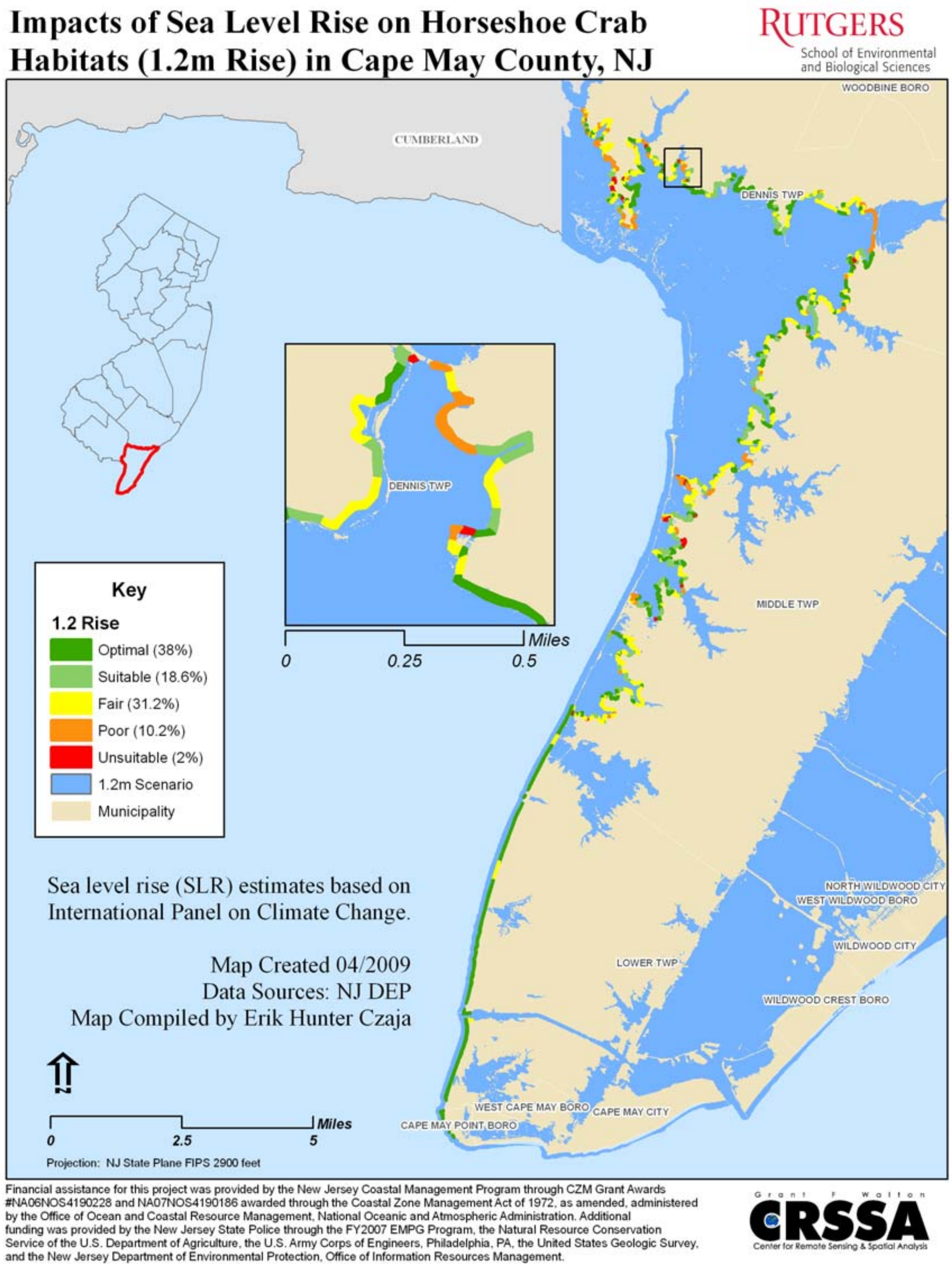
(Figure A)



Impacts of Sea Level Rise on Horseshoe Crab Habitats (1.2m Rise) in Cape May County, NJ
RUTGERS
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WOODBINE BORO
CUMBERLAND
DENNIS TWP
MIDDLE TWP
NORTH WILDWOOD CITY
WEST WILDWOOD BORO
WILDWOOD CITY
LOWER TWP
WILDWOOD CREST BORO
WEST CAPE MAY BORO
CAPE MAY CITY
CAPE MAY POINT BORO
Miles
0
0.25
0.5
Key
1.2 Rise
Optimal (38%)
Suitable (18.6%)
Fair (31.2%)
Poor (10.2%)
Unsuitable (2%)
1.2m Scenario
Municipality
Sea level rise (SLR) estimates based on International Panel on Climate Change.
Map Created 04/2009
Data Sources: NJ DEP
Map Compiled by Erik Hunter Czaja
N
0
2.5
5
Miles
Projection: NJ State Plane FIPS 2900 feet
Financial assistance for this project was provided by the New Jersey Coastal Management Program through CZM Grant Awards #NA06NOS4190228 and NA07NOS4190186 awarded through the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration. Additional funding was provided by the New Jersey State Police through the FY2007 EMPG Program, the Natural Resource Conservation Service of the U.S. Department of Agriculture, the U.S. Army Corps of Engineers, Philadelphia, PA, the United States Geologic Survey, and the New Jersey Department of Environmental Protection, Office of Information Resources Management.
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(Figure B)

Works Cited

Berkson, Jim, and Carl N. Shuster. "The Horseshoe Crab: The Battle for a True Multiple-use Resource." Fisheries Management 24 (1999): 6-10.

Nordstrom, Karl F., Nancy L. Jackson, David R. Smith, and Richard G. Weber. "Transport of Horseshoe Crab Eggs By Waves and Swash on an Estuarine Beach: Implications for Foraging Shorebirds." Estuarine, Coastal and Shelf Science 70 (2006): 438-448.

Odell, Jay, Martha E. Mather, and Robert M. Muth. "A Biosocial Approach for Analyzing Environmental Conflicts: A Case Study of Horseshoe Crab Allocation." BioScience 55 (2005): 735-748.

Pooler, Penelope S., David R. Smith, Robert E. Loveland, Mark L. Botton, and Stewart F. Michels. "Assessment of Sampling Methods To Estimate Horsehoe Crab (Limulus Polyphemus L.) Egg Density in Delaware Bay." Fishery Bulletin 101 (2003): 698-703.

Sweka, John A., David R. Smith, and Michael J. Millard. "An Age-Structured Population Model for Horseshoe Crabs in the Delaware Bay Area to Assess Harvest and Egg Availability for Shorebirds." Estuaries and Coasts 30 (2007): 277-286