Holocene Sea-level Rise in New Jersey: An Interim Report

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EXECUTIVE SUMMARY

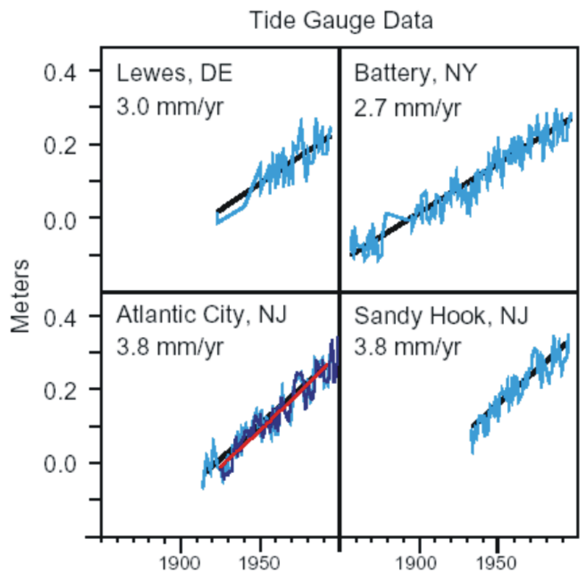
The study shows that the preanthropogenic sea-level rise in New Jersey was 2 mm/y, suggesting that the anthropogenically induced rise in global sea level due to global warming was ~1 mm/yr from 1900-1995. Thus, human-induced effects on sea-level in New Jersey are 1-2 mm/y which is up to one-half of the total observed rate of rise.

The history of pre-anthropogenic Holocene global sea level has not been well described. We provide Holocene sea-level estimates for five new boreholes on the New Jersey (NJ) coast (Rainbow Island, Great Bay I, Great Bay II, Cape May, and Island Beach). We analyzed facies, radiocarbon dated marsh deposits, and derived a sea-level record by compiling new and previously published NJ data. Our sea-level record shows a constant rise of ~2 mm/yr from ~7000 years ago to the present. This contrasts sharply with previous NJ estimates that suggested a slowing in rise since 2000 years ago rather than a constant rate of rise. Comparison with other NJ locations suggests surprising uniformity in the rate of rise amongst sites as far flung as Cape May and Cheesequake (200 km apart), suggesting a far-field response to the Laurentide ice sheet. The "Barbados/western North Atlantic reef sea-level" record shows a major decrease in the rate of rise from 12 mm/y to ~ 2 mm/y between 7000 and 8000 years ago. Data from NJ and western North Atlantic reefs indicate a constant rate of rise of ~2 mm/y since ~7000 years ago. This suggests a background, pre-anthropogenic sea-level rise of 2 mm/y for the entire east coast of the U.S. This background includes both the global (water volume) rise and far-field geoidal subsidence due to removal of the Laurentide ice sheet and water loading (estimated as 1 mm/yr in the modern). Applying the modern subsidence rate to the Holocene suggests a global sea-level rise of ~1 mm/yr since 7000 years ago. Based on tide gauge data, regional sea-level rise averaged 3 mm/yr from 1900-1995, with higher rates (4 mm/yr) locally due to compaction and groundwater withdrawal.

INTRODUCTION

There are valid concerns about the rates and effects of sea-level rise in the New Jersey region[1]. Sea level is rising globally at a rate of 2mm/yr (Barnett, 1990), yet the rate of sea-level rise is significantly higher in New Jersey. Tide gauge data for the Mid-Atlantic region (Fig. 1) shows a current regional rate of approximately 3 mm/yr of sea-level rise, with a higher rate of 3.8 mm/yr at Atlantic City and Sandy Hook (Psuty and Collins, 1986). The higher rate of rise in this region is due to coastal subsidence associated with rebounding from the Laurentide ice-sheet removal (Peltier, 1987). The rates probably are higher locally at Atlantic City and Sandy Hook due to groundwater withdrawal and compaction, respectively. However, both the regional and local rates of rise and the effect of anthropogenic warming on the rise are still are poorly constrained.

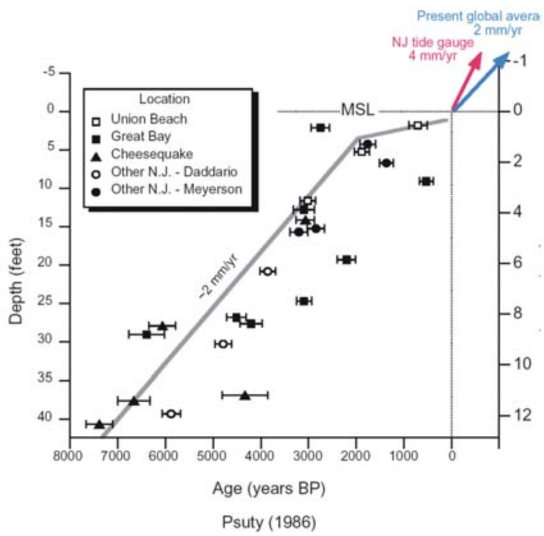
Figure 1.
Tide Gauge data from Psuty and Collins (1986) and Psuty (personal communication, 2004). The higher rates of rise versus global sea-level are attributable to a 1 mm/y regional subsidence rates.



[1] Question from Senator Frank Lautenberg to William Curry, testifying before congress on the effects of global warming: "My home State of New Jersey, with more than 127 miles of densely populated shoreline, has been rising at about 1.5 inches per year [NB the Senator meant per 10 years] or about double the high estimate for the globe. Clearly, New Jersey is at risk of extensive coastal damage in the coming years. EPA predicts that by 2100, New Jersey's sea line will rise by 27 inches [NB 34 cm is the 2100 global estimate]. That represents an enormous loss in terms of the human and economic costs. Is it known how such a major increase in sea level might impact New Jersey, its coastline and coastal towns?"

Several studies have been conducted addressing the nature and timing of Holocene[2] sea level rise on the New Jersey coastline. It has been suggested that sea level rose rapidly starting 7000 yr before present[3], with a slow-down occurring somewhere between 2000 and 2500 yBP (Psuty, 1986) (Fig. 2). We present new data obtained from several new sites cored on the southern New Jersey coastline, combined with data obtained from previous studies, that provide a new insight into pre-anthropogenic rates of sea-level rise.

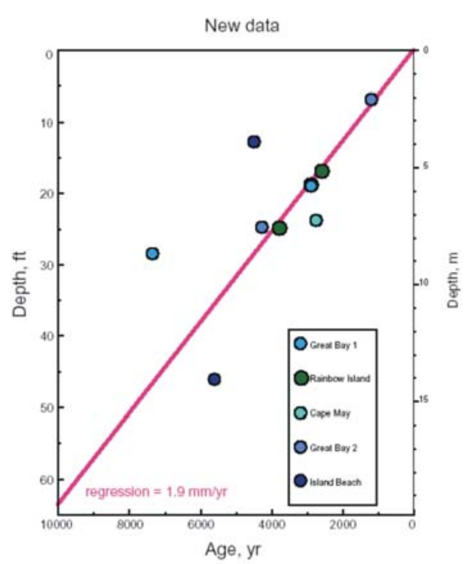
Figure 2.
Previous New Jersey sea-level curve of Psuty and Collins (1986) that includes data from Meyerson (1972) and Daddario (1961). Note the major change in the rate of sea-level rise at 2000-2500 yBP.



RESULTS

Holocene transgressive sequences recovered at Great Bay and Rainbow Island in New Jersey yield new data on the rate of sea level rise for the region. Two cores at Great Bay and a third obtained from Rainbow Island were sampled to obtain C-14 dates at several depths in each core. The results were then plotted along with new data from Island Beach (Miller et al, 1994) and Cape May (Miller et al, 1996) (Fig. 3). We also compared our results with the previous New Jersey sea-level record of along with data

Figure 3. Our new data from 5 New Jersey coreholes. Regression is through all points younger than 5000 yBP.



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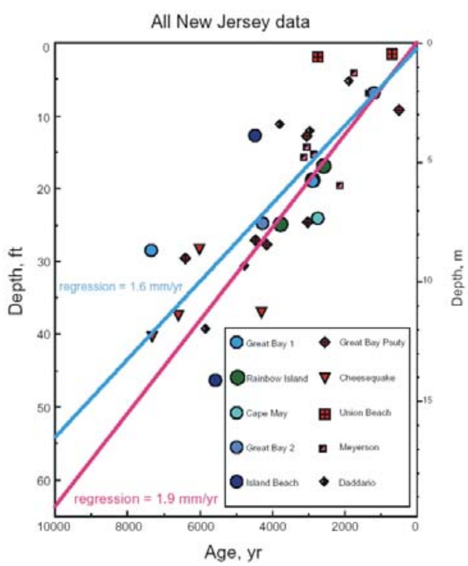
[2] The Holocene Epoch is the last 10,000 years and is a warm period following the last major glaciation.
[3] yBP, defined as 1950 being present.

from Psuty (1996) that includes dates from Union Beach, Great Bay and Cheesaquake, NJ and data from other New Jersey coastline studies (Daddario, 1961; Meyerson, 1972). The result of this plot yielded two linear regressions; one using all data points, and another which eliminated data points that appeared to be anomalous.

A plot of all the new data produces a linear regression of 1.9 mm/yr (Fig. 4). The two data points from Island Beach require redating for confirmation because they appear to be statistical outliers. Equally important is that our sea-level curve lacks slowing down of rise at 2500 yBP as previously suggested (Psuty, 1986). When the data from all New Jersey sites are examined together, a linear regression from at least 7500 yBP to present provides an excellent fit, suggesting a constant rate of sea level rise for approximately the past 7500 years.

Figure 4. Comparison of new data with Psuty and Collins's (1986) compilation. Shows regression through all data points (blue; depth (m) = 0.163*(age, y); r = 0.88; n =34) and through our data points alone (magenta; depth (m) = 0.195*(age, y); r = 0.75; n = 9).



Data collected from Great Bay and Rainbow Island cores has suggested the evolution of a stable back-barrier island system by approximately 4000 years B.P. Radiocarbon dates provided at depths of 24 ft at Great Bay 2 and 18 ft at Great Bay 1 provide constraints for dating the evolution of the barrier system. Our preliminary interpretation is based on sediment analysis of the Great Bay 1 & 2 and Rainbow Island 1 transects, which were found to have fine/medium-grained sediments progressing to clay/organic dominated sediments. The organic-rich clay facies are suggestive of a stable marsh system behind the barrier island on top of sandy deposits characteristic of tidal channels or barrier island beaches. This interpretation is also supported by palynological analyses performed on several samples from the Great Bay 1 and 2 cores. Specifically, the analysis yielded a salt marsh paleoecology at 22 feet in the Great Bay 2 core, which is consistent with the development of a back barrier island system approximately 4000 years B.P. Further support for the development of the system has been yielded by a preliminary foraminiferal analysis of the Great Bay 1, 2 and Rainbow Island 1 cores. Samples at depths from depths ranging from 8.7ft to 12ft (Great Bay 1), 1ft to 24ft (Great Bay 2) and 15ft to 20ft (Rainbow Island 1) were dominated by lagoon and marsh-type foraminifera in all three cores. Further foraminiferal analysis of Great Bay 1 + 2 and Rainbow Island 1+2 will yield more data as to the paleoenvironment and evolution of the barrier islands. The data collected from the palynological, foraminiferal and lithologic analysis with radiocarbon dates points to the development of a marsh sequence at approximately 4000 years B.P. at Great Bay 2, and a mature marsh by 3000 years B.P. at Great Bay 1. Data collected in a previous study at Cape May, NJ suggest the development of a backbarrier island system at approximately 3000 yBP, with evidence of an older marsh system. This fits well with the preliminary data from the Great Bay and Rainbow Island cores. Continued lithologic and faunal analysis of the Great Bay and Rainbow Island cores is ongoing to fully understand the nature and development of the backbarrier island system at those locations.

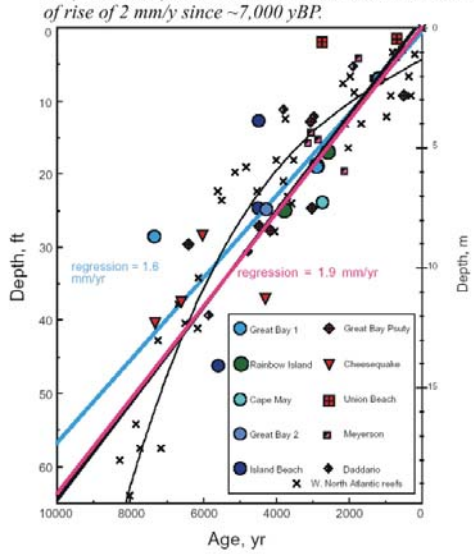
Conclusions

This report is the final deliverable for the CEI Mini grant from the NJDEP to K. Miller and P. Sugarman. Using a new generation of radiocarbon dates, our sea-level estimate reconciles previous results into a testable curve. Our study provides a new record of sea-level rise that contrasts sharply with previous estimates (e.g., Psuty, 1986); we do not observe the slowdown in sea-level inferred in that previous study. Our preliminary interpretation is that there is surprising uniformity amongst sites as far flung as Cape May and Union Beach. Comparison of our sea-level data with the "Barbados/Western North Atlantic reef sea-level" record[4] of Fairbanks (1989) shows (Fig. 5) that the reef data indicate a major decrease in rate from 12 mm/y to ~ 2 mm/y between 7000 and 8000 yBP. Data from NJ (all sources) and the reefs are consistent with a constant rate of rise

[4] which is actually based on Lighty et al.'s (1982) western North Atlantic reef data for ages less than ~8 ka

of 2 mm/y since ~7,000 yBP. This suggests a background, preanthropogenic sea-level rise of 2 mm/y for the entire east coast of the U.S. This background includes both the global rise (which is currently not constrained) and far-field subsidence due to removal of the Laurentide ice sheet (estimated as 1 mm/y in the modern; Peltier, 1997). Thus, human-induced effects on sea-level in New Jersey are 1-2 mm/y which is up to one-half of the total observed rate of rise.

Figure 5.
Comparison of our sea-level data with the "Barbados sea-level" record of Fairbanks (1989) which is actually based on Lighty et al.'s (1982, Florida data for ages less than ~8 ka. Two regressions through the Florida data are shown, the first is a third-order polynomial, the second is a linear regression for all data younger than 7500 yBP. Note that the Florida data indicate a major decrease in rate from 12 mm/y to ~ 2 mm/y between 7000 and 8000 yBP. Data from NJ (all sources) and Florida are consistent with a constant rate of rise of 2 mm/y since ~7,000 yBP.



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