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Paleoenvironmental and Archaeological Contexts in the New York and New Jersey Harbor Region

Donald M. Thieme

Geoarcheology Research Associates

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The shores of the Atlantic Ocean have become a particularly important area for geoarcheological study in the light of recent speculations about an independent peopling of the Americas from the northeast (Dixon, 2000; Stanford and Bradley, 2000). The New York and New Jersey Harbor Region sits right at the limit of Wisconsinan glaciation (Cotter et al., 1986; Stanford, 1997; Sirkin, 1986) and consequently would have made an ideal point of entry for people adapted to recently deglaciated tundra and boreal forest environments. Mammoths, mastodonts, and other large mammal prey were quite abundant based on skeletal remains found both on- and off-shore (Fisher, 1955; Harrington, 1984; Parris, 1983; Whitmore et al., 1967) and there is unique and relatively isolated evidence for human occupation of recently deglaciated land surfaces (Kraft, 1977a, 1977b; Ritchie and Funk, 1971). In general, however, the combined effects of both Holocene sea level rise and recent human activity make it quite a challenge to envision the past landscapes of this or any other major port on the Atlantic seaboard. Today I will present some new results from a "conjunctive" interdisciplinary approach (e.g. Butzer, 1982; Harrington, 1984; Taylor, 1948) employing bathymetric, lithostratigraphic, paleobotanical, and foraminiferal analyses of the active Harbor channels themselves. Such an approach provides a broader context for the archeological materials recovered to date and, more importantly, allows us to project where significant materials may remain both within the Harbor and on the present continental land surface.

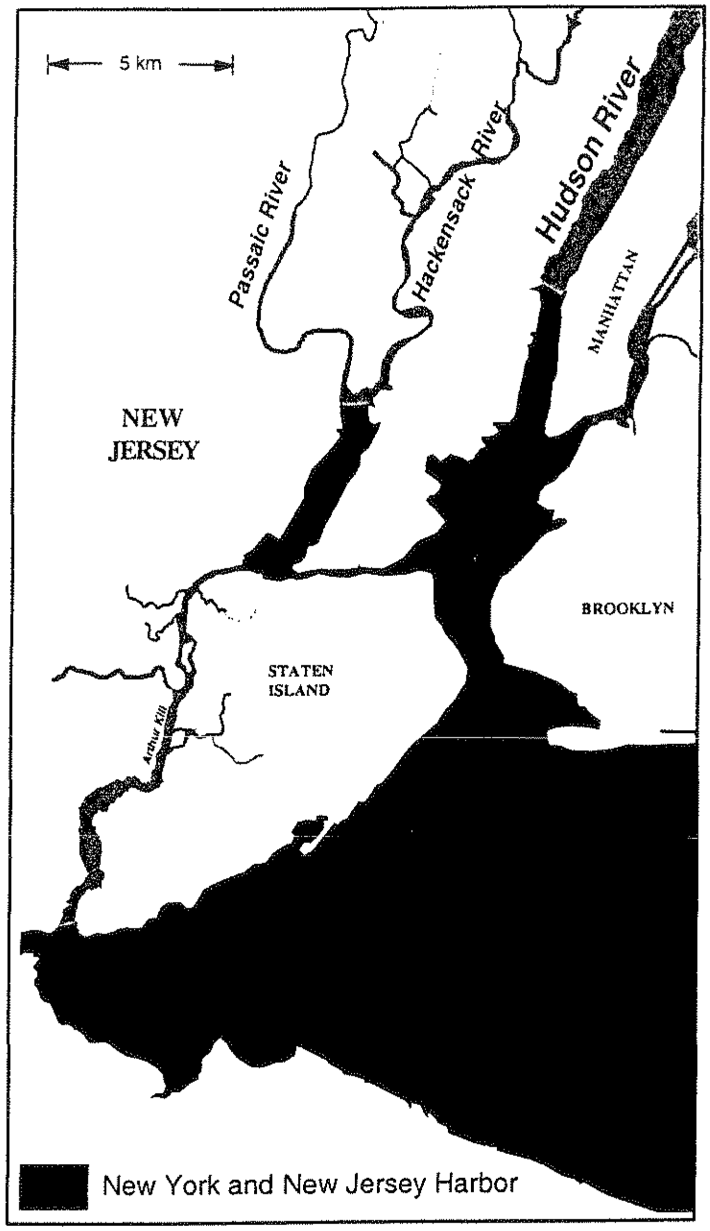


Figure 1: New York and New Jersey Harbor showing the Hudson, Hackensack, and Passaic river valeys

Regional Paleogeography and the Archeological Record for the Harbor Region

The estuary now known as New York and New Jersey Harbor (Figure 1) occupies a series of drowned continental river valleys whose north-south trending axes first developed as rifts during the breakup of Pangea (Isachsen et al., 1991, p. 50-51). During the Quaternary period, the Hudson, Hackensack, and Passaic river valleys were all overriden at least twice by the Laurentide ice sheet and then deepened and widened in its rapid retreat northward (Stanford, 1997; Stanford and Harper, 1991; Sirkin, 1986). Because nearly one percent of the Earth's water was transformed into glacial ice (Strahler, 1971), eustatic sea level plummeted at the last glacial maximum and a terrestrial Coastal Plain extended at least 100 km onto the present continental shelf (Bloom, 1983a, p. 220-222; Emery and Edwards, 1966; Stright, 1986, p. 347-350).

Sea level rise was extremely rapid in the period immediately following retreat of the Laurentide ice sheet (ca. 18,000 – 7,000 B.P.), partly because the weight of the ice was still depressing the continental land mass (Bloom, 1983b; Clark et al., 1978; Fairbridge and Newman, 1968). As the continent deglaciated, isostatic rebound slowed the rate of sea level rise during a period (ca. 7,000-4,000 B.P.) when coastal occupations became particularly prevalent in the northeastern United States (Funk and Pfeiffer, 1988; Pretola and Little, 1988; Ritchie, 1969, 1980; Salwen, 1962). As shown in Figure 3, bathymetric contours within the New York and New Jersey Harbor and seaward onto the continental shelf are projected to represent lower sea level positions at 11,000 (-30 m), 7,000 (-10 m), and 4,000 (-5 m) years B.P. for purposes of the present study. This conforms to previous paleoshoreline reconstructions for the mid-Atlantic

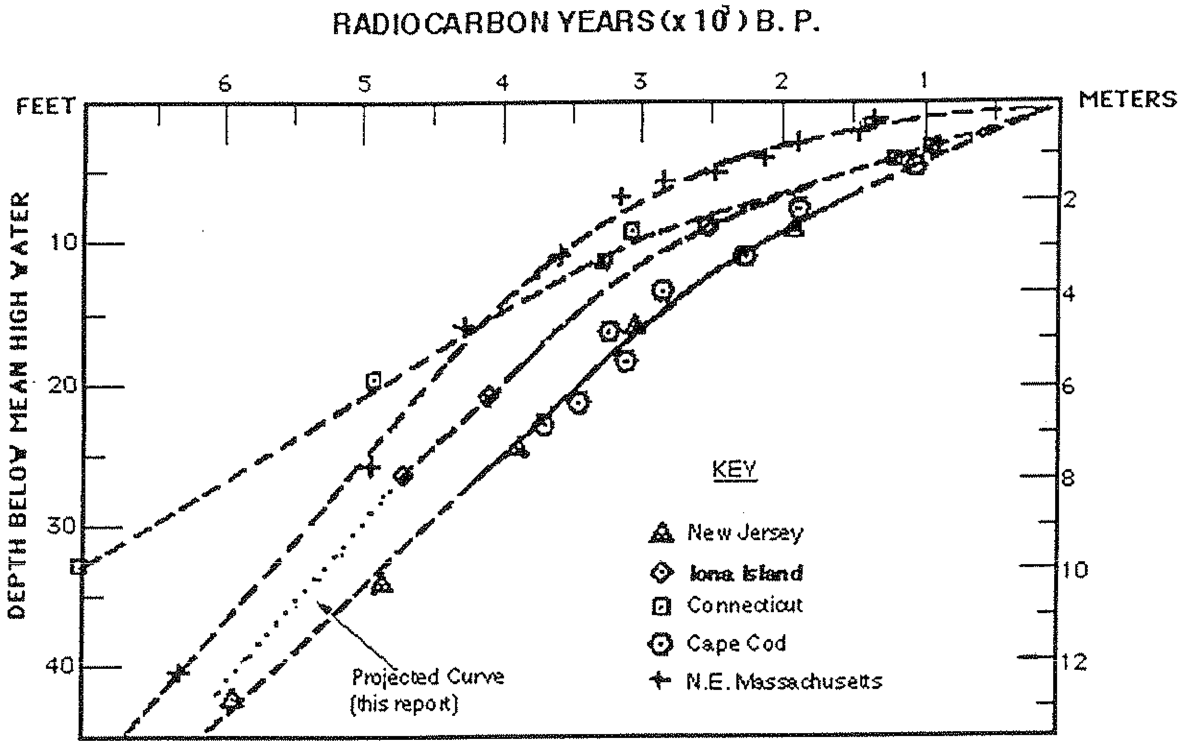


Figure 2: Relative Sea Level Curves for New York and New Jersey Harbor and Other Areas on the Atlantic Seaboard (base curves modified from Newman et al., 1969)

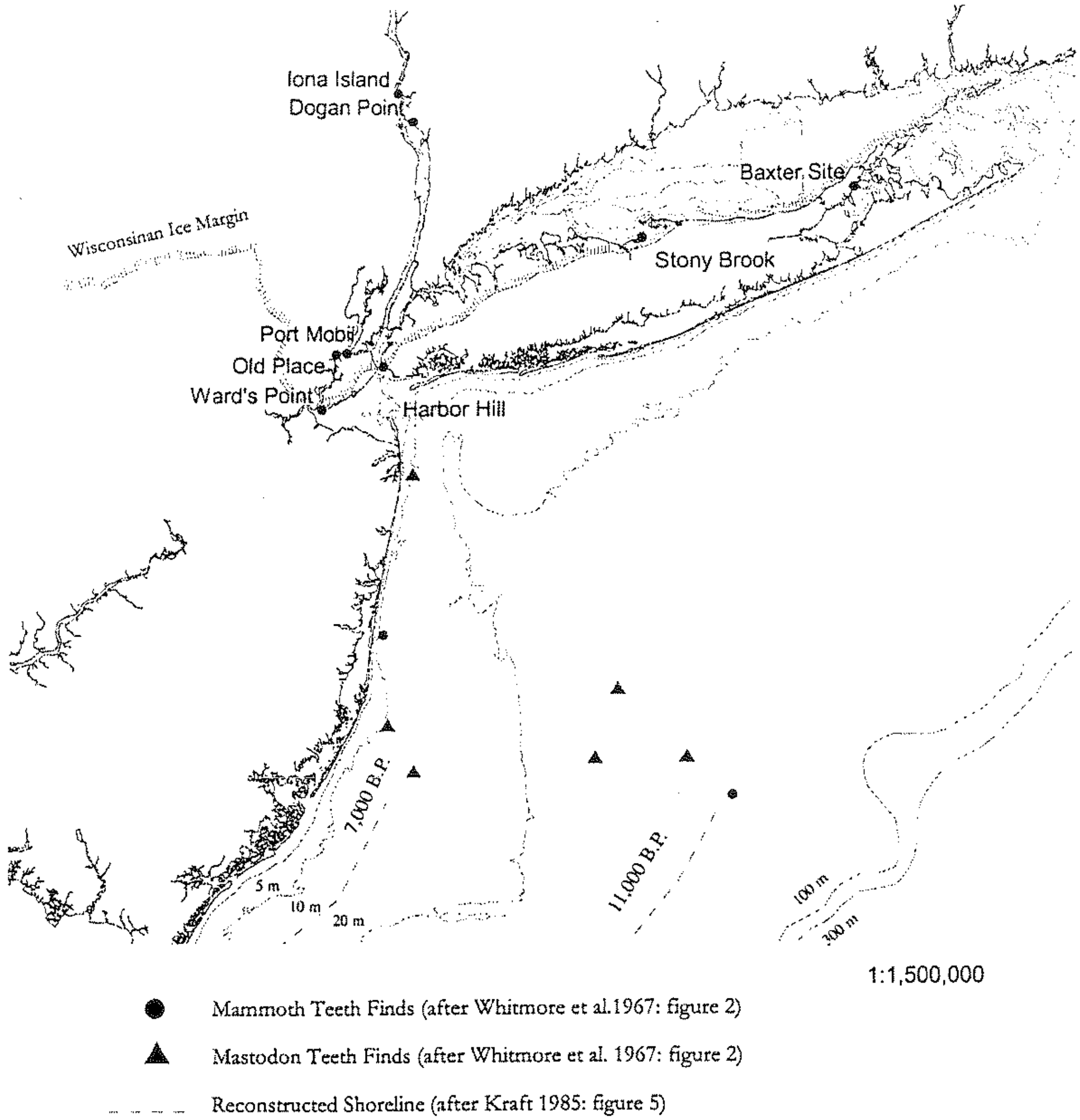


Figure 3: The New York and New Jersey Harbor Region showing bathymetric contours projected to represent lower Quaternary sea levels

region (Kraft et al., 1983, 1985; Newman et al., 1969) and suggests that there was still an additional 20 km of Coastal Plain at 7,000 B.P.

Several sites with diagnostic artifacts attributed to either the Late Paleoindian or Early Archaic (10,000-8,000 B.P.) cultural periods have been found on the western shore of Staten Island (Kraft, 1977a, 1977b; Ritchie and Funk, 1971). At Port Mobil, fluted points, end and side scrapers, and unifacial tools were among over 51 lithic artifacts recovered from a sandy slope between 5 and 15 m above sea level. Fluted points are also among the artifacts which have been found on Charlestown Beach south of Port Mobil. Projectile points classified as Kirk, Kanawha, LeCroy, and Stanly have been recovered from the Hollowell and Ward's Point sites at the island's southwestern tip. The Old Place site near the crossing of the Goethals Bridge appears to be primarily a Middle Archaic (8,000-6,000 B.P.) through Late Archaic (6,000-3,000 B.P.) encampment, although a radiocarbon date of 7,260±140 B.P. was obtained on hearth charcoal associated with Stanly, LeCroy, and Kirk points.

It is very likely that the sites with Paleoindian, Early Archaic, or Middle Archaic artifacts discovered to date represent only a very small portion of settlement networks which extended across surfaces within the Harbor Region that have since been inundated by rising sea level. Late Archaic sites, on the other hand, are extremely common in settings that are now at or slightly below present shoreline positions. Of five inundated sites along shores or tidal stream banks on Long Island reported by Stright (1990), for example, all are Late Archaic or Woodland period encampments. As discussed above, these differences in paleogeography are primarily due to a slowing of the rate of sea level rise, caused in part by postglacial crustal rebound (Bloom, 1971; Bloom and Stuiver, 1963; Fairbridge and Newman, 1968).

Exploitation of shellfish and other marine resources was a definite specialization among Late Archaic hunter-gatherers of coastal New York and New Jersey (Brennan, 1974, 1977; Kraft and Mounier, 1982; Ritchie, 1980, p. 165-167). The contemporary environmental settings in the Harbor Region are consequently more comparable to those at the time of occupation, although shellfish remains have been found much further upstream along the Hudson River than the present range of particular species (Classen, 1995a). At the particularly deep and well documented Dogan Point shell midden 50 km upstream of New York Harbor (Brennan, 1974, 1977; Classen, 1955b), the main shellfish gathering period dates from 5,900-4,400 B.P.. This correlates with many shell middens on the Harbor shore, such as the Twombly Landing site near Edgewater, New Jersey (Brennan, 1968). Dogan Point also had a small Middle Archaic component, as evidenced by both the radiocarbon chronology and presence of Neville, Stark, and other large side-notched projectile points (Classen, 1995c). The basal date of 6,950±100 B.P. correlates with pre-estuarine depositional contexts within the Harbor described later in this paper. Figures 4 and 5 summarize paleogeographic reconstructions of the Dogan Point site environs (Schuldenrein, 1995a) based on the same sea level positions projected for the Harbor Region in Figure 3 and corroborated by facies identified in stratigraphic trenches.

Orient culture semi-sedentary occupations at the Stony Brook and Baxter sites on Long Island and at several sites in Pelham Bay were correlated by Salwen (1962) with a fall in sea level of up to 3 m below the 6,000-4,000 B.P. "highstand" in the supposedly "eustatic" curve of

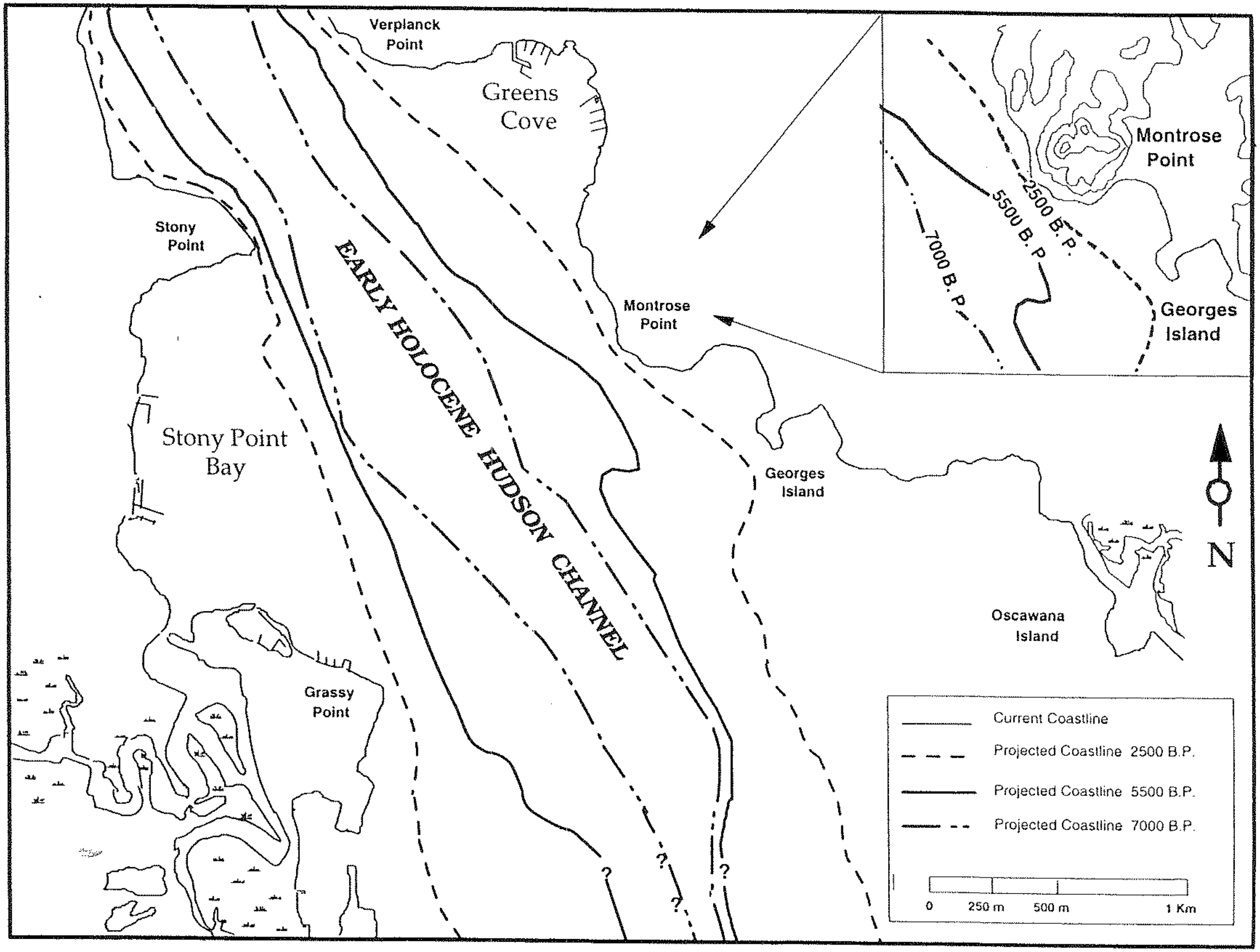
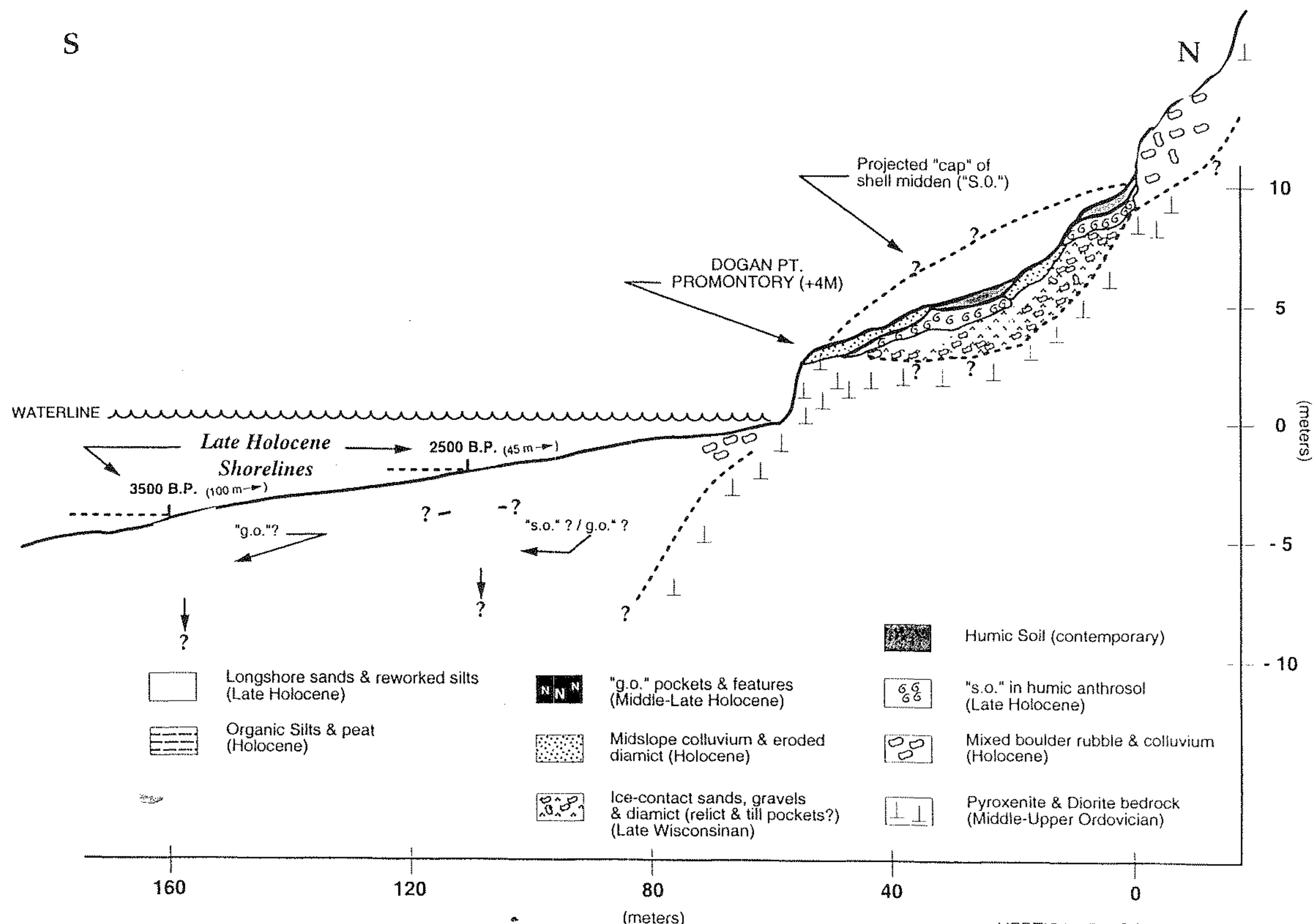


Figure 4: Holocene Shoreline Migrations: Lower Hudson Valley Estuary, Montrose Point, NY.

Figure 5: Schematic Lithostratigraphy and Hudson River Shorelines at Dogan Point, NY

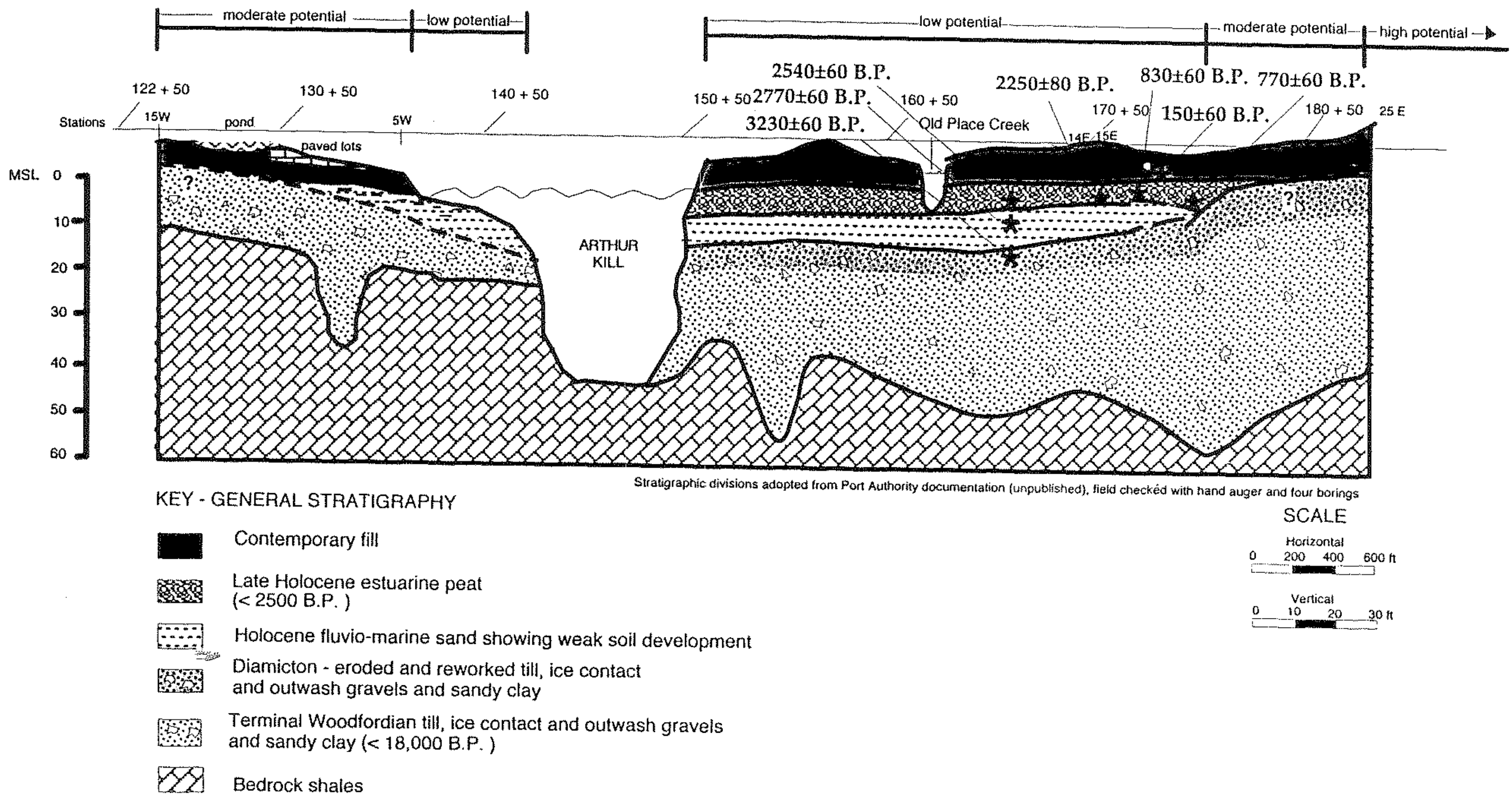


Fairbridge (1960a, 1960b, 1961). The more gradualist regional curve of Newman et al. (1969) presented in Figure 3 has a "kink" during the period which includes Fairbridge's Older and Younger Peron Highs and also shows 2-3 m of submergence since 3,000 B.P., Fairbridge's Pelham Bay Low. These oscillations in the long-term trend of postglacial sea level rise are clearly not eustatic, however, given their apparent association with regional crustal movements noted by Fairbridge and Newman (1968). They may nonetheless have affected both settlement patterns of Late Archaic and Woodland cultures and the differential preservation of associated archeological contexts.

Snook Kill or Orient features and middens do commonly intrude much older archeological contexts in tidal marsh settings (Kraft and Mounier, 1982; Ritchie, 1980, p. 165-167). An example is the Old Place site north of the Goethals Bridge on northwestern Staten Island (Ritchie, 1980, p. 140; Ritchie and Funk, 1971, p. 49; GRA, 1996, 1997). Six radiocarbon dates ranging from 2100-3250 B.P. were obtained by GRA (1997) from a sandy package ca. 1 m thick sandwiched between tidal marsh peat and basal ice-contact diamicton (see Figure 6). These dates generally agree with the Snook Kill assemblage recovered in previous excavations by amateur archeologists Albert and Robert Anderson. The Andersons also recovered Early Archaic Stanly, Le Croy, and Kirk projectile points from the same general location, however, as well as charcoal which was radiocarbon dated to 7,260±140 B.P.

While the Orient culture is generally considered to be a Terminal Archaic manifestation, early ceramics of the Windsor tradition have been found associated with steatite vessels and Orient Fishtail projectile points at several sites on Long Island (Smith, 1980). The limited record

Figure 6: Late Quaternary Stratigraphy in the Vicinity of the Old Place Creek Site, northwestern Staten Island



Note: Question Marks indicate areas where the extent or continuity of a horizon is inferred or it has not been demonstrated.

A.D. 1600-1850, according to van de Plassche et al. (1998). Other researchers previously found an increase in the rate of sea level rise at A.D. 1600, however, also coinciding with the Little Ice Age (Nydick et al., 1995; Thomas and Varekamp, 1991; Varekamp et al., 1992).

European colonization of the Harbor Region began in 1524 with the passage of the Florentine navigator Giovanni da Verrazano between the straits that now bear his name, and trade goods have been found in the upper levels of some Clasons Point phase sites (Ritchie, 1980, p. 270-272). The native inhabitants who sold the island they called Manhatta to the Dutch in 1626 were Algonquin relatives of the Delaware (Homberger, 1994, p. 16). The initial Dutch settlement was concentrated near the tip of the island, commanding naval access to both the Hudson River and the East River (Homberger, 1994, p. 20). By 1639, however, Dutch plantations thinly lined the East River and three small villages on Long Island were combined to form Breukelen in 1642 (Homberger, 1994, p. 30). Buildings on the East River waterfront faced a muddy shoreline until after Peter Stuyvesant became Director-General in 1647 (Homberger, 1994, p. 32) and there is therefore considerable potential for early historic as well as prehistoric archeological contexts beneath the present piers and seawalls.

Field Methods and Sampling Constraints

In the recent study funded by the New York District of the U. S. Army Corps of Engineers (COE), GRA evaluated the archeological potential within the New York Harbor navigation channels on the basis of interdisciplinary analyses of a suite of borings performed for geotechnical assessment (GRA, 1999). A total of 114 borings was performed during our field season in the winter of 1998-1999 and it was therefore necessary to develop methods of sampling that satisfied the geoarcheological objectives while not impeding the progress of the geotechnical work.

The generic lithostratigraphy was fairly well understood from previous borings, and we inspected and sampled materials which had been described in geotechnical logs and curated at the COE Caven Point facility. The standard 1.5 m (5 ft.) sampling interval in geotechnical borings limits their recovery of archeologically sensitive Holocene deposits in most estuarine settings. However, we were able to procure samples of peat and organic silt for radiocarbon dating from the curated materials as well as sediment samples which contained paleoenvironmental indicators such as foraminifera, pollen, and plant macrofossils. Contrasts between the Newark Bay and Lower Hudson subregions detailed below were also evident from differences in grain size, sorting, mineralogical composition, and bedforms, as well as in the occurrence of mollusc shells and shell hash.

Fieldwork consisted of supervising borings performed by Warren George, Inc. either from a barge towed to the drill site or from a larger ship, the Catherine G. Typically, two geoarcheologists went out on a single rig. One member of the team recorded the stratigraphy of the cores, while a second provided oral descriptions of the sedimentology. The standard geotechnical procedure was generally modified when geoarcheologists were present so that a continuous series of 0.7 m (2 ft.) spoons was taken until the sediments appeared to be of Pleistocene age based on the generic lithostratigraphy. Samples of bulk organic sediment were collected as well as any plant macrofossils observed. Latex gloves had to be worn to inspect and

Figure 7: Geoarcheologist Susan Malinboyce opens a two-foot split spoon from uppermost Harbor sediments using latex gloves

sample many of the uppermost sediments due to contamination with hydrocarbons and other hazardous materials (see Figure 7).

Samples of preserved plant material and organic silt were weighed, measured, and washed with deoinized water as applicable and submitted for radiocarbon dating to Beta Analytic, Inc. of Coral Gables, Florida. A total of 23 sediment samples from these investigations was submitted to Ellen Thomas and Kristina Beuning of Wesleyan University for analysis of foraminifera and pollen, respectively. Five plant macrofossil samples from the New York Harbor Region have also been analyzed for GRA by Lucinda McWeeney of Yale University. As summarized below, results of these specialized analyses provide an interdisciplinary perspective on significant paleoenvironmental contexts within the extant navigation channels as well as the potential for submerged archeological contexts in the Harbor Region in general.

Late Quaternary Pollen Records for the Harbor Region

The pollen dispersed by both flowering plants (angiosperms) and conifers such as spruce and pine represents one of the most complete and sensitive archives of late Quaternary landscape changes. Pollen grains are transported male gametes which fertilize a female counterpart attached to plants, forming their seed (Tschudy, 1969, p. 17). Because plants vary in both the amount of pollen produced and the means and timing of dispersal, the "pollen rain" in a given region is never a direct mirror image of its vegetation at any given time (Davis, 1963, 1966; Davis et al., 1973; Faegri and Iversen, 1989, p. 115-161). Cores from areas such as the arctic tundra which are sparsely vegetated, for example, typically register changes in forests up-wind due to long-distance transport of spruce, pine, and other arboreal pollen (Birks, 1973, 1981; Ogden, 1965).

Full glacial and late glacial pollen assemblages from the northeastern United States have been variously attributed to "tundra," "taiga," "spruce park," or "boreal forest" vegetation (Davis, 1965, 1969; Deevey, 1958; Martin, 1958; Ogden, 1959, 1965; Watts, 1979). Several authors have also pointed out that the late Pleistocene vegetation may not have clear analogs in present-day plant communities (Davis, 1969; Overpeck et al., 1985, 1992). Herb-dominated assemblages corresponding to the tundra zone "T" of Deevey (1958) have been identified in basal samples of cores from the Harbor Region studied by Les Sirkin (Sirkin et al., 1970) and Dorothy Peteet (Peteet et al., 1990). A radiocarbon date of 12,840±110 B.P. from Alpine Swamp Core A indexes the succession to the spruce-hardwood zone "A" (Peteet et al., 1990, p. 224). Newman et al. (1969) obtained a comparable radiocarbon date of 12,500±600 B.P. for zone A in their boring UH-1 from Salisbury Meadow on western Iona Island and Sirkin et al. (1970) report a radiocarbon date of 12,330±300 B.P. for Zone A in their boring SH-29 from a Coastal Plain bog west of Raritan Bay.

Spruce-dominated assemblages were present in the basal samples of five cores from the Lower Hudson River estuarine sediments analyzed by Weiss (1974), who obtained a radiocarbon date of 10,280±270 B.P. for the top of zone A in a core beneath the Tappan Zee bridge. Abundant spruce pollen was also characteristic of basal samples from borings for the Carlstadt Loop (Rue and Traverse, 1997; 3DI, 1992) and the North Arlington force main (Thieme and Schuldenrein, 1996; Thieme et al., 1996) in the Hackensack Meadowlands. The basal North

Arlington assemblage was interpreted to indicate scattered spruce trees on open, tundra-like terrain by Terryanne Maenza-Gmelch. An increase in "boreal" species such as spruce and paper birch between 11,000 and 10,000 B.P. was attributed by Peteet et al. (1990) to the Younger Dryas abrupt cooling of global climate.

A more direct cause of the migrations of plant species through the Harbor Region can be found in the irregular northwesterly retreat of the Laurentide ice sheet, as previously inferred from southern New England pollen records by Ogden (1959), Davis (1976), and others (Davis and Jacobson, 1985; Gaudreau, 1988; Gaudreau and Webb, 1985). Zone B of Deevey (1958) is thus characterized by declining spruce and increasing pine pollen, with at least three species of pine potentially represented by grains which can be classified into at most two pollen "taxa." Davis (1976, p. 19-21) maps the presence in the Harbor Region of *Pinus banksiana* (jack pine) and/or *Pinus resinosa* (red pine) by 11,000 B.P. and white pine (*Pinus strobus*) by 10,000 B.P. Hemlock, oak, birch, and alder pollen were also quite abundant in the Alpine Swamp Zone B assemblage (Peteet et al., 1990, p. 222).

A gradual shift toward an oak-dominated pollen assemblage defines the onset of Deevey's Zone C, with basal dates from the Harbor Region of 9,000±100 B.P. in the Alpine Swamp core and 7,100±180 B.P. in the Tappan Zee core. Pollen analysis of samples from a geotechnical boring in New York Harbor near the Lincoln Tunnel performed for the present study identified an assemblage dominated by oak (34%) with some hickory (6.2%), hemlock (5.7%), beech (4.7%), maple (4.3%), and birch (3.8%) pollen (LaPorta et al., 1999). Davis (1976, p. 22) maps beech present in the Harbor Region by 7,000 B.P., hickory by 6,000 B.P., and chestnut by 4,000

B.P. Basal samples from borings at Ring Meadow on western Iona Island were radiocarbon dated to 4,630±470 B.P. and 4,080±220 B.P.and the pollen assemblages are nearly 40% oak with hickory but no chestnut until 20 cm up from the base.

A radiocarbon date of 5,020±80 B.P. from Alpine Swamp indexes a decline in hemlock pollen found in cores throughout the northeastern United States and eastern Canada. This hemlock decline has recently been conclusively correlated to a pathogen outbreak (Bhiry and Filion, 1996; Davis, 1981) although warmer regional climate may have played an ancillary role. The radiocarbon dates are normally distributed with a mean of 4,650 B.P. and a standard deviation of 300 years (Gaudreau and Webb, 1985, p. 252-253).

The vegetation succession in the drained proglacial lakebeds of the Hackensack and Passaic River valleys was evidently somewhat different from that in the upland mixed deciduous forests. Pollen assemblages from Carlstadt Loop Core 2 attributed to an "oak-hemlock-hickory complex" by Rue and Traverse (1997, p. 214) nonetheless contained nearly 10% cyperaceae (sedge) and 20% gramineae (grass) pollen. Pollen of local freshwater marsh plants was predominant in the assemblage dated to 5,030±160 B.P. from North Arlington Core B-1 analyzed by Terryanne Maenza-Gmelch for GRA (see Figure 8). Tubuliflorae (ironweed), polypodiaceae (fern), *Osmunda* (flowering fern), and *Typha latifolia* (cattail) were identified in addition to gramineae and cyperaceae pollen (Thieme and Schuldenrein, 1996; Thieme et al., 1996).

Pollen from somewhat younger meadow peat cored just north of the Route 3 bridge over the Hackensack River was analyzed by Dorothy Peteet (Carmichael, 1980). A radiocarbon date of 2,610±130 B.P. was obtained on a clayey gyttja with a pollen assemblage described as

"*Carya-Quercus-Ulnus-Liquidambar*" (Carmichael, 1980, p. 529). Alder dominated in the overlying sedge peat dated to 2,060±120 B.P. and cyperaceae, gramineae, and polypodiaceae all appear to increase in the portion of the core dated to 810±110 B.P. *Ambrosia* (ragweed) and chenopodiaceae appear after this date and are generally considered to register disturbance following Euroamerican settlement along with certain of the gramineae such as *Phragmites communis*. All of these plants were native to the Harbor Region, however, although their distributions became much wider as forests were cleared and meadows were drained (Russell, 1993, 1997).

Peats and Plant Macrofossil Analyses

While pollen assemblages record the regional vegetation, particularly its dominant tree species, many local features are better determined through the larger "macrofossils" in sediment cores. The presence of tundra or at least "tundra-like" conditions within the Harbor Region during zone "T" of the Deevey (1958) pollen stratigraphy is conclusively demonstrated, for example, by macrofossils of *Dryas integrifolia* and *Salix herbacea* in the North Arlington Core B-1 (Thieme and Schuldenrein, 1996; Thieme et al., 1996). Spruce, larch, and paper birch from Alpine Swamp support the inferred abrupt Younger Dryas cooling in zone "A" (Peteet et al., 1990, p. 226). Development of the accelerator mass spectrometry method has made it possible to date individual macrofossils, and this method yielded determinations of 10,230±220 B.P. and 12,290±440 B.P. on spruce needles, and 10,430±880 B.P. and 10,470±440 B.P. on paper birch seeds from Alpine Swamp Core B.

Tidal and freshwater marshes now occupy large tracts from 0 to 10 m MSL within the lower reaches of the Hackensack and Passaic Rivers as well as the Arthur Kill, the Kill van Kull, and the lower reaches of the Hudson River. Herbaceous vegetation growing within these marshes is subtly zoned according to changes in elevation, salinity, and other physical or chemical properties of the estuary (Teal and Teal, 1969, p. 84-101). Tens of meters of peat or sediment rich in plant macrofossils underlie many of the modern marshes, particularly in the Hackensack "meadowlands" (Carmichael, 1980; Grossman and Associates, 1995; Heusser, 1949, 1963; Lovegreen, 1974; Schuldenrein, 1995b; Rue and Traverse, 1997; Thieme and Schuldenrein, 1996; Thieme et al., 1996; 3DI, 1992). Independent studies by Dorothy Peteet (Carmichael, 1980) and GRA (Thieme and Schuldenrein, 1996; Thieme et al., 1996) have identified a freshwater facies there, underlying the tidal marsh peat dominated by *Spartina alterniflora*. Radiocarbon dates reported in Table 1 suggest an age between 6,000 and 2,000 B.P. for these freshwater marshes and a stratigraphic position between –5 m and 5 m MSL.

Differences in plant metabolism roughly parallel the tolerance for salinity among species whose decaying macrofossils represent the stratigraphic "peats" of the Harbor Region (Bender, 1971; Haines, 1976; Smith and Epstein, 1971). The $\delta^{13}C$ ranged from –23 to –26 per mil for intertidal vascular plants of the "high marsh" in the Georgia site studied by Haines (1976) while cordgrass (*Spartina alterniflora*) and other "low marsh" plants are known to fix carbon via the Hatch-Slack C4 photosynthetic pathway and consequently have a less negative $^{13}C/^{12}C$ ratio relative to PDB (Bender, 1971; Faure, 1986, pp. 492; Smith and Epstein, 1971). Smith and Epstein (1971, p. 381) report a $\delta^{13}C$ of –13.1 per mil for *Spartina alterniflora* while Haines

(1976) reported –12.37±.10 per mil. Values of –14.4 and –13.4 per mil are further reported by Bender (1971, p. 1240) for other species of Spartinae.

Since the $\delta^{13}C$ is now routinely reported by most radiocarbon laboratories, it can give a general idea of paleogeographic setting for dated peats without undertaking the more difficult and tedious task of identifying the macrofossils themselves. Brackish to freshwater peat frequently has even more negative $\delta^{13}C$ values than those for the intertidal plants studied by Haines (1976). Bender (1971) reports values ranging from –26.9 to –29.1 per mil for species of *Scirpus* and –26.6 per mil for the even more common *Phragmites communis*. Cattails (*Typha latifolia*) are reported to have a $\delta^{13}C$ of –27.6 per mil by Smith and Epstein (1971, p. 381) while Bender (1971) reports a value of –31.0 per mil for *Typha angustifolia.*

Like the basal peats of the Hackensack Meadowlands studied by Dorothy Peteet (Carmichael, 1980) and GRA (Thieme and Schuldenrein, 1996; Thieme et al., 1996), samples from cores in the vicinity of the Old Place site on northwestern Staten Island appear to be predominantly from brackish to freshwater settings based on their $\delta^{13}C$ values (GRA, 1997). Samples collected from 4 m to 5 m b.s. range in age from 2540±60 B.P. to 3230±50 B.P. and have $\delta^{13}C$ values of –21.8, -23.4 and –24.5 per mil. Further downstream along the Arthur Kill, plant macrofossils from –9 m in a core in the navigation channel at Wards Point were radiocarbon dated to 7,950±70 B.P. and also suggested to represent an *in situ* freshwater peat (LaPorta et al., 1999). Stratigraphically higher and younger peats from throughout the Harbor Region, on the other hand, have less negative $\delta^{13}C$ values in ranges typical of *Spartina alterniflora* and other salt marsh species.

While the New Jersey side of the Harbor Region has the deepest and most extensive peat deposits, the stratigraphy appears to be similar within the Lower Hudson River valley. Newman et al. (1969) suggest an age of slightly less than 5,000 B.P. for terrestrial peat overlying bedrock at ca. –8 m along the edge of Iona Island. Basal organic silt from 10 m below the present ground surface in lower Manhattan in the vicinity of the Collect Pond dates to 3500±50 B.P. and rests unconformably on a paleosol dated to 4590±40 B.P. (Schuldenrein, 2000).

Many identifiable plant macrofossils from fluvial or estuarine contexts only provide maximum age constraints on the development of Holocene wetland and stream border communities (Brown, 1997, p. 50; Butzer, 1982, p. 69-76; Waters, 1992, p. 77-86). In the present study, for example, detrital wood from 10 m below the floor of the Anchorage Channel on the interfluve between the Kill van Kull and the Hudson River was radiocarbon dated to 9,400±150 B.P. Adjacent or overlying contexts preserving *in situ* terrestrial vegetation or prehistoric cultural material could presumably be considerably younger.

Foraminiferal Analyses

Foraminifera are single-celled organisms living either within the water column (planktonic) or on the bottom (benthic) in settings which range from salt marshes to brackish estuaries to the continental shelf to the ocean floor. Their soft tissues are enclosed within a test composed of organic matter or carbonate minerals secreted by the organism and, in the case of the "agglutinated" forms, foreign particles held together by these secretions (Lowe and Walker, 1998, p. 215; Thomas, 1999). Many species have unique test morphologies which can be identified from fossil or subfossil assemblages. Because most species only tolerate a limited range of water depth, salinity, and other physical and chemical properties, foraminifera assemblages can be quite diagnostic of past environments.

Four foraminifera assemblage zones were defined for the Hudson estuary by Weiss (1974), and modern assemblages shift abruptly from an assemblage dominated by agglutinated forms such as *Trochammina inflata* along with the calcareous *Ammonia beccarii* north of Tarrytown, New York to one dominated by species of the calcareous genus *Elphidium*, which tolerate salinities up to 12% in the lower estuary (McCrone and Schafer, 1968; Nieves, 1957; Schafer, 1968; Weiss, 1967, 1974). Subfossil *Trochammina inflata*, *Trochamina macrescens*, *Ammonia beccarii*, *Buccella frigida*, and *Elphidium excavatum* were identified by Ellen Thomas in samples from cores in the Harbor Region navigation channels. Out of the 23 samples analyzed, 18 contained benthic foraminifera. The relatively low abundance as compared with other samples deposited in similar environments (e.g. Buzas, 1965; Phleger, 1952; Saffert and Thomas, 1998; Weiss, 1974) appears to be the result of high terrigenous sedimentation rates at most of the core locations.

For several of the cores, environmental changes over time can be reconstructed since foraminifera assemblages were identified from several samples. While *Elphidium excavatum* predominated in all three samples from core 98-ANC-25, for example, the agglutinated species *Trochammina inflata* was also common in the upper sample, from 6.5 m down core. Combined with an increase in fragments of *Spartina alterniflora*, this suggests that salt marsh extended closer to the region of deposition of the core over the time period represented. Deposition after

A.D. 1750 is further suggested by the rare occurrence of centric diatoms in this sample, since these are known to have increased in response to nutrient loads from Euroamerican land clearing and fertilization (Brush, 1989; Brush et al., 1982; Cooper and Brush, 1991, 1993; Nixon, 1997).

Deposition below the intertidal zone but above -25 m MSL should characterize all assemblages dominated by *Elphidium excavatum*, including a sample from 5.8 m down core 98-ANC-29 and the samples from 6.5 m, 7.0 m, and 7.6 m down core 98-ANC-44 (Thomas, 1999). The sample from 7.0 m down this core, however, also contained rare agglutinated salt marsh foraminifera such as *Trochammina macrescens* and *Trochammina inflata*, suggesting that a salt marsh was nearby during this interval. Abundant *Spartina alterniflora* fragments but the absence of foraminifera in the sample from 8.2 m down this core suggests that the water depth may have increased toward deposition of the sample from 7.6 m. The occurrence of centric diatoms and the absence of benthic diatoms in the samples from 7.0 m and 7.6 m further suggests this increase in water depth may have coincided with significant deforestation in the mid-18th century (e.g. Cooper and Brush, 1991, 1993), as noted above for the core 98-ANC-25 location.

Most of the samples analyzed from cores taken in Newark Bay consisted of laminar reddish-brown silt, commonly attributed to proglacial Lake Hackensack (Stanford and Harper, 1991). Samples from 5.5 m and 9.5 m down core NB-98-28 contained no foraminifera, while the sample of brown loamy sand from 1 m down core contained abundant agglutinated salt marsh foraminifera, including *Trochammina macrescens*, *Miliammina fusca*, *Ammoastatuta inepta* as well as the calcareous *Ammonia beccarii*. The heterolithic coarse fraction, which included common metamorphic rock fragments as well as quartz and muscovite, suggests relatively high energy fluvial deposition but tidal conditions are clearly indicated by the foraminifera as well as *Spartina alterniflora* macrofossils and rare centric diatoms. Coarse fractions in the summer varves of the glaciolacustrine deposits contain common barite crystal aggregates ("desert rose"). These are derived from the local Newark Group lithologies but they weather rapidly and are therefore uncommon in other detrital deposits.

The identification of benthic foraminifera, including both *Ammonia beccarii* and *Elphidium excavatum*, in samples of laminar reddish-brown silt from 3 m and 4.5 m down core NB-98-24 suggests the possibility that glacial Lake Hackensack was at some point flooded gradually by the sea. Since *A. beccarrii* must have been deposited in a brackish water with a salinity of at least 15-20%, salt water appears to have penetrated the lake before a true connection to the sea existed. While no samples from this core were submitted for radiocarbon dating, a date of 29,600±360 B.P. (Beta-127020) was obtained on a sample of bulk sediment from 5.5 m down the nearby boring NB-98-28. This date appears to corroborate previous reconstructions of multiple Pleistocene lakes within the basin, at least one of which predates the terminal Wisconsinan glacial advance (Lovegreen, 1974; Reeds, 1925, 1926; 3DI, 1992; Widmer, 1964; Widmer and Parillo, 1964). Alternatively, anomalously "old" carbon may have somehow diffused into the sample either from natural groundwaters or petroleum contamination.

Generic Lithostratigraphy and Soil Forming Intervals

From upper Newark Bay east to the Hudson River, Quaternary deposits of the Harbor Region rest unconformably on Newark Group sedimentary rocks. The Stockton, Lockatong, and

Brunswick formations consist of redbed sediments deposited in a Triassic basin which was subsequently faulted and intruded by igneous magma. The most significant intrusion occurred on the eastern edge of the basin at the Palisades sill, adjacent to the Hudson River of today.

East of the Hudson River, the Manhattan Prong consists of outcropping Cambrian to Ordovician igneous and metamorphic lithologies of the New York City Group (Schuberth, 1968). Rare outcrops of gneiss or schist occur on Governors Island (Herbster et al., 1997; Schuberth, 1998, p. 82) and in Queens and Brooklyn, but these land masses consist primarily of Quaternary sediments or older marine units of the Atlantic Coastal Plain. A northeast trending axial ridge of gneiss and serpentinite comprises the core of Staten Island against which tens of meters of glacial till were lodged by the Laurentide ice sheet.

Several contributing drainages to Newark Bay follow channels inherited from the great southwest trending Pensauken River system of probable Pliocene age (Stanford, 1997). Diversion of the Pensauken River into the Hudson Canyon between the Pliocene and the Pleistocene refocused continental shelf deposition from the Baltimore Canyon area (Poag and Sevon, 1989; Stanford, 1997) but the Pensauken deposits have been long since scoured way from the Harbor Region. Cretaceous and possible interglacial (oxygen isotope stage 5e) sediments occur at the Narrows but sediments older than the Wisconsinan glaciation are otherwise missing from the lower Hudson as a result of erosion following base-level fall (Weiss, 1974, p. 1567).

Stanford (1997) maps both Illinoian (ca. 128-300 ka) and pre-Illinoian (> 300 ka) terminal moraines in northern New Jersey, and these ice advances may be represented by lower tills on Long Island such as the Montauk (Rampino and Sanders, 1981; Merguerian and Sanders, 1994).

An abundance of gneiss clasts gives the older tills a "dirty" appearnace and they can always be distinguished from late Wisconsinan deposits by the presence of some unweathered mudstone, sandstone, and igneous rock clasts in the late Wisconsinan deposits (Stanford, 1997).

The Hudson-Mohawk Lobe of the latest or Wisconsinan ice sheet advanced to its Harbor Hill terminal moraine by 20 ky B.P. (Sirkin, 1986, p. 14; Sirkin and Stuckenrath, 1980). Some organic sediments from the preceding interstadial period (oxygen isotope Stage 3) appear to have survived beneath or within the till and outwash. A radiocarbon date of 26,000±300 B.P. was obtained on bulk sediment from 4.6 m down a boring in the Buttermilk Channel between Brooklyn and Governors Island during the present study (see Table 1). Brown clayey silt beds from 1-2 m thick are insterstratified with coarse, poorly sorted sand, suggestive of "flow till" near a glacial margin (Boothroyd et al., 1998; Gustavson and Boothroyd, 1987). Distinct varving was observed at approximately the same depth in a nearby boring, gray-green, sandy "summer" varves alternating with brown "winter" muds. Varved sediments and sheet sands in the lower Hudson River valley have variously been attributed to proglacial Lake Flushing (Schuberth, 1968) or to a "postglacial freshwater lake" lasting until as late as 6 k.y. B.P.(Merguerian and Sanders, 1994).

On Governors Island itself ice-contact diamicton was encountered at 3-4 m MSL in a backhoe trench adjacent to Fort Jay (Thieme and Schuldenrein, 1999). Clasts of ripped-up marine (?) clay, granite, diabase, and other erraitcs up to a meter long were set in a matrix of yellowish brown sand and clay. Coarse bouldery diamicton was interbedded with red coarse sand in cycles of ~50 cm to the total depth of excavation. Sheet sands at slightly lower elevations make up the

Table 1: Radiocarbon Dates for Paleoenvironmental and Archeological Contexts in the New York and New Jersey Harbor Region

Location	Elevation		Lithofacies/ Biofacies	Material	14C yr B.P.	Calibrated 2-sigma (Calendar yr)	Lab Number
	m b s	m MSL					
Arthur Kill WP-V1 (off of Wards Point)	8.38		Fluvial lag?	wood	7950±70	BC 7064 (6980,6970,6946,6938,6901,6883,6826) 6642	Beta-?
Richmond Hill			Cultural sediment	wood charcoal	9360±120	BC 9136 (8627,8621,8612) 8288	I-4929
Wards Point	1.40		Cultural sediment	wood charcoal	8250±140	BC 7580 (7314,7218,7203) 6831	I-5331
Wards Point	1.25		Cultural sediment	wood charcoal	7260±125	BC 6398 (6158,6143,6082) 5843	I-4512
Old Place	1.40		Cultural hearth	wood charcoal	7260±140	BC 6417 (6150,6143,6082) 5813	I-4070
Hollowell	0.90		Cultural sediment	wood charcoal	3110±90	BC 1597 (1401) 1127	I-3965
Goethals Bridge G-1			Eroded diamicton	Plant macrofossils	3230±50	BC 1676 (1516) 1408	Beta-100254
Goethals Bridge G-1			Fluviomarine sand	Bulk sediment	2770±60	BC 1048 (904) 805	Beta-100252
Goethals Bridge G-1			Freshwater marsh	Peat	2540±60	BC 815 (779) 441	Beta-100256
Goethals Bridge G-2			Fluviomarine sand	Bulk sediment	2550±60	BC 825 (786) 412	Beta-100253
Goethals Bridge G-2			Eroded diamicton	Plant macrofossils	2100±50	BC 350 (146,142,113) AD 17	Beta-100255
Goethals Bridge B-305	3.95		Freshwater marsh	Peat	2250±80	BC 410 (363,269,262) 93	Beta-92924
Goethals Bridge G-4	3.20		Brackish marsh	Peat	830±60	AD 1036 (1218) 1288	Beta-100257
Goethals Bridge AT-4			Salt marsh	Peat	770±60	AD 1161 (1271) 1379	Beta-95083
Arthur Kill 95-5W (off of Shooters Island)	2.00	-2.30	Estuarine silt	wood	3040±120		Beta-137984
Arthur Kill 95-5N (off of Shooters Island)	1.68	-2.56	Fluvial lag?	Bulk sediment	6100±60		Beta-137985
Arthur Kill 95-5S (off of Shooters Island)	3.66	-4.60	Estuarine silt	Bulk sediment	4340±80		Beta-137986
~~Anchorage Channel~~ - 98ANC44	9.50	-24.50	Fluvial lag?	wood	9400±150	BC 9216 (8717,8713,8689,8663,9646,8642,8633) 8286	Beta-127019
Buttermilk Channel - 98BC27	17.98		Interglacial lacustrine?	Bulk sediment	26,000±300	NA	Beta-127022
Governors Island MT-9	0.85		Shoreline paleosol	Bulk sediment	2610±50	BC 833 (799) 598	Beta-107659
Governors Island MT-6	2.10		Cultural sediment?	Bulk sediment	1130±110	AD 663 (897,922,942) 1158	Beta-107658
Governors Island MT-12	2.80		Cultural sediment?	Bulk sediment	590±60	AD 1286 (1329,1343,1395) 1437	Beta-117732
Governors Island MT-16	1.90		Cultural sediment?	Bulk sediment	660±70	AD 1244 (1299,1375) 1418	Beta-117733
Collect Pond	9.40		Interior paleosol	Bulk sediment	4590±40	BC 3500 (3360) 3121	Beta-130396
Collect Pond	8.80		Freshwater marsh	Peat	3500±50	BC 1944 (1876,1842,1812,1799,1778) 1688	Beta-130395
Collect Pond	8.20		Freshwater marsh	Peat	2490±60	BC 800 (759,682,665,636,590,579,554) 402	Beta-130394
Collect Pond	7.60		Freshwater marsh	Peat	1220±60	AD 664 (779) 977	Beta-130393
North Arlington B-1	3.00	-1.00	Freshwater marsh	Peat	5030±160	BC 4223 (3888,3883,3797) 3384	Beta-80726
North Bergen Sewer B-10	6.00	-4.00	Ice-contact diamicton	Bulk sediment	19,450±60	BC 21,919 (21,112) 20,404	Beta-112240
North Bergen Sewer B-11	3.00	-1.00	Floodplain paleosol	Bulk sediment	3650±50	BC 2265 (2027,1992,1982) 1780	Beta-112241
North Bergen Sewer B-10	2.40	0.40	Brackish marsh	Peat	1130±60	AD 732 (897,922,942) 1020	Beta-112239
Carlstadt 91-3	8.00	-7.00	Glaciolacustrine?	Bulk sediment	22,310±1070	NA	Beta-55265
Carlstadt 91-3	6.00	-5.00	Glaciolacustrine?	Bulk sediment	22,040±550	NA	Beta-53001
Carlstadt 90-5	1.68	-0.70	Brackish marsh		2160±80	BC 396 (199,186,184) AD 17	Beta-39925
Carlstadt 91-2	0.58	0.50	Brackish marsh	Plant macrofossils	2140±90	BC 396 (195,173) AD 54	Beta-47271
Carlstadt 91-4	0.90	0.30	Brackish marsh	Plant macrofossils	1130±70	AD 694 (897,922,942) 1023	Beta-47272
Heusser	3.30	-2.30	Brackish marsh	Plant macrofossils	2025±300	BC 801 (39,28,23,9,2) AD 642	I-510
Hackensack/Rt 3 core	3.80	-2.80	Freshwater marsh	Plant macrofossils	2610±130	BC 1014 (799) 400	RL-1033
Hackensack/Rt 3 core	2.80	-1.80	Brackish marsh	Plant macrofossils	2060±120	BC 390 (50) AD 225	RL-1032
Hackensack/Rt 3 core	1.70	-0.70	Brackish marsh	Plant macrofossils	810±110	AD 1003 (1224,1231,1239) 1396	RL-1031
Hackensack/Rt 3 core	0.90	0.10	Brackish marsh	Plant macrofossils	240±110	AD 1438 (1656) 1954	RL-1030
HBLRT NC-04	3.70	-1.70	Brackish marsh	Plant macrofossils	930±50	AD 1002 (1043,1091,1119,1140,1155) 1219	Beta-82795

bulk of the island's intact natural deposits, and appear to represent outwash deposited in either marine, lacustrine, or fluvial contexts. Only five of 14 samples sieved at one phi intervals (see Figure 8) had the distinctive "fine tail" of muds characteristic of fluvial energy (Friedman, 1961, 1967; Friedman and Sanders, 1978). These five mud-rich samples also fall in a distinct field to the upper right in the plot of inclusive graphic skewness (SK_I) versus the inclusive standard deviation for the 14 samples (Figure 9). The remaining samples were winnowed of fines by wave action on what was probably a lake or bay shore given the lowered sea level at the last glacial maximum. Only one sample is negatively skewed as is typical of an ocean beach.

The generic Quaternary stratigraphy for the lower Hudson River valley thus consists of Wisconsinan ice-contact and meltwater deposits capped by quartzose sheet sands. The first evidence of soil formation and stability of Holocene shorelines dates after 4 ky B.P., although some earlier contexts may be submerged as noted above. Mid-Holocene terrestrial sediment packages appear to be more common at the margins of freshwater ponds or marshes such as the Collect Pond in lower Manhattan (Schuldenrein, 2000). The absence of early- to mid-Holocene sediments in the estuarine valley fills may result in part from erosion during the kink or "highstand" in the regional sea level curve (Figure 2 above or cf. Newman et al., 1969).

In Newark Bay and the lower reaches of the Hackensack and Passaic River valleys there is a somewhat different and more uniform sequence beginning with deeper and more extensive varved proglacial lakebeds (Antevs, 1925; Lovegreen, 1974; Reeds, 1925, 1926; Salisbury, 1902; Salisbury and Kummel, 1893; Stanford, 1997; Stanford and Harper, 1991; Widmer, 1964).

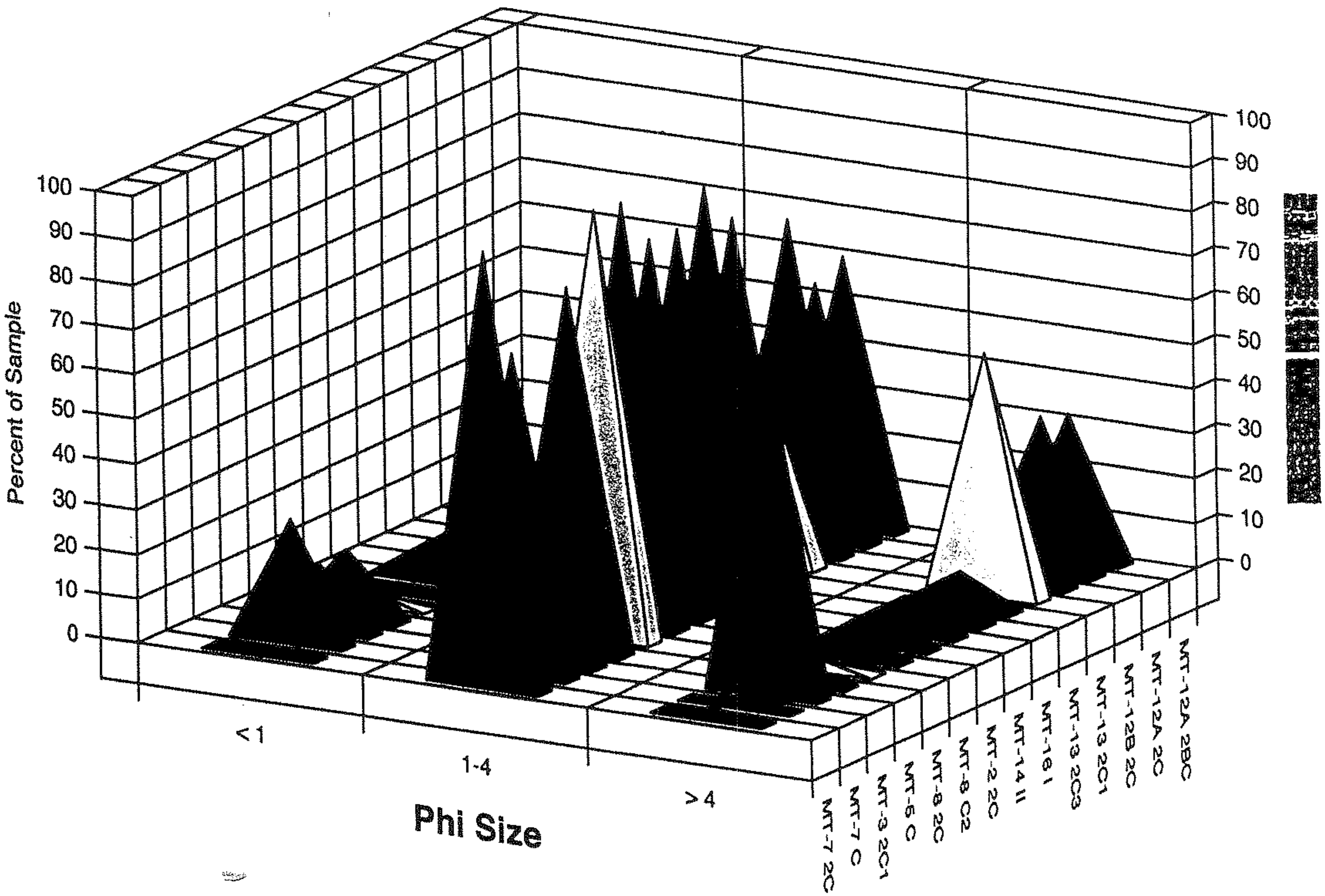


Figure 8: Grain Size Analyses of 14 Samples from the Governors Island National Historic Landmark District

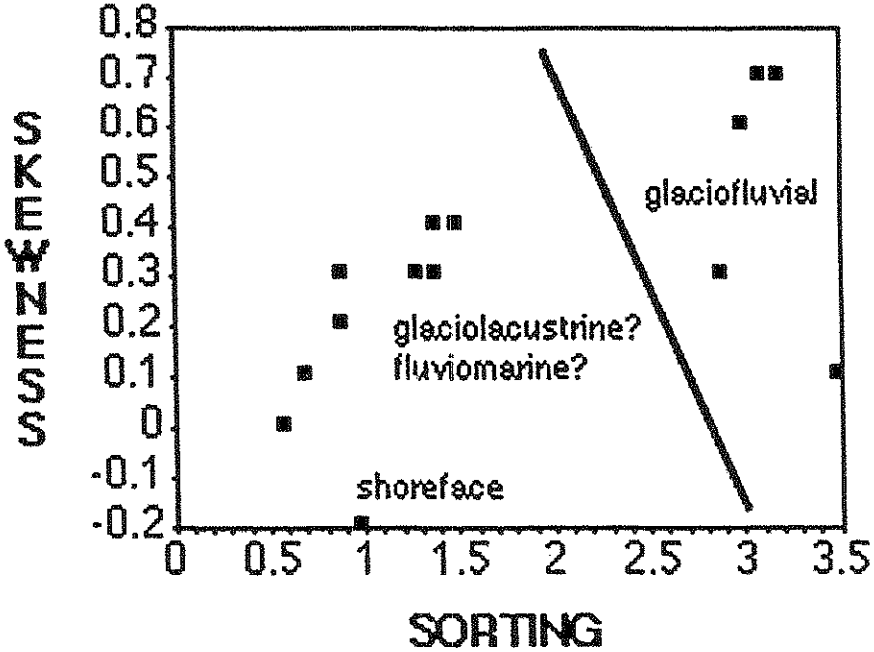


Figure 9: Plot of Inclusive Graphic Skewness versus the Inclusive Standard Deviation for 14 Samples from the Governors Island National Historic Landmark District

Reddish brown muds derived from Newark Group rocks typify the thicker winter varves while the more heterolithic sandy varves were deposited as the ice melted during the summer.

The top of the glaciolacustrine facies is typically an unconformable contact from 4 to 10 m below the present land surface in the Hackensack Meadowlands (Lovegreen, 1974). Relatively late Holocene peat often overlies the contact except for where sediment was stored by one of the pre-estuarine river systems. The relict floodplain preserved from 3-4 m below surface flanking the modern channel of Penhorn Creek is one example (Figure 10). The column fines upward from sandy loam to fine silt, indicating deposition on the natural levee of a meandering stream (Brown, 1997, p. 70-81; Waters, 1992, p. 134-135). The truncated remnant of the floodplain soil was dated to 3650±70 B.P. while plant stem fragments from overlying tidal marsh were dated to 1130±60 B.P. (Thieme and Schuldenrein, 1998).

Because they represent intervals of landform stability, buried soils are the most sensitive elements in a generic stratigraphy from the perspective of prehistoric cultural resources. Buried soils have been identified primarily within the interval 4-2 ky B.P. for terrestrial settings in the Harbor Region (GRA, 1996, 1997; Herbster et al., 1997; Schuldenrein, 1995a, 1995b, 1995c; Thieme and Schuldenrein, 1998, 1999). In some locations, such as on Governors Island and the north shore of Staten Island, the buried soils are at or even slightly below mean sea level. Earlier as yet undocumented soil forming intervals may be represented by stratigraphy which has been submerged, although no buried soils were identified during inspection of 24 geotechnical borings on board ship during the present study.

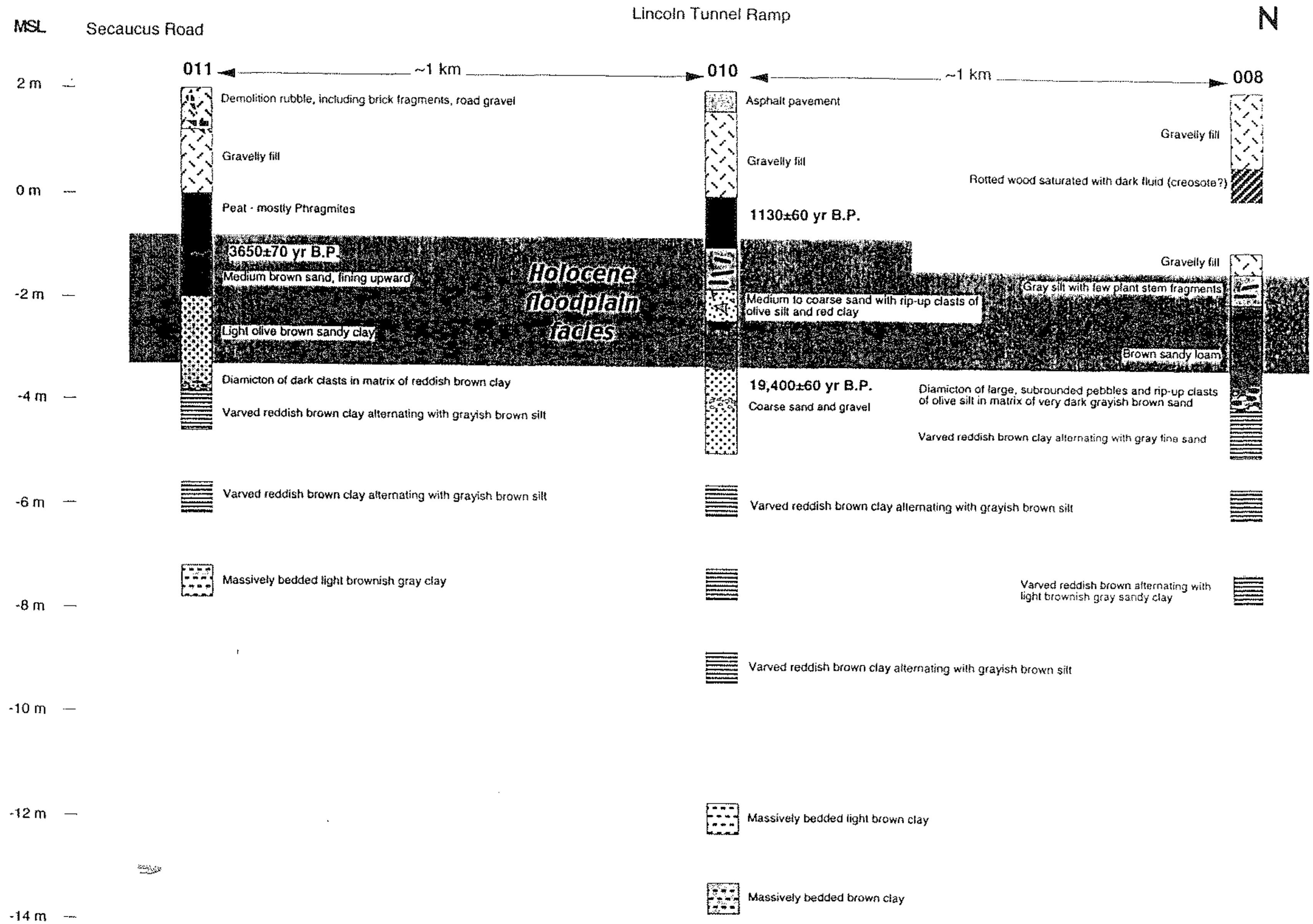


Figure 10: Stratigraphic Cross-Section east of Penhorn Creek in the Hackensack Meadowlands, North Bergen, New Jersey

Conclusion: Retrodicting Human Activities on Submerged Paleolandscapes

The preceding interdisciplinary assessment of paleoenvironmental contexts within the New York and New Jersey Harbor Region puts us one step closer to understanding the human activities associated with archeological materials recovered to date from the continental land surface. As in many other coastal settings worldwide (Kraft et al., 1983, 1985; Rapp and Hill, 1998, p. 74-81; Waters, 1992, p. 262-290), past human activities took place within considerably more extensive terrestrial landscapes with significantly different relief and drainage characteristics as well as floral and faunal communities.

We know that people were frequenting northwestern Staten Island at least by the ninth millennium B.C. (Kraft, 1977a, 1977b; Ritchie and Funk, 1971), when spruce was beginning to decline relative to pine in the boreal forest. Early Archaic sites which are today in shoreline or salt marsh settings represent the vestiges of campsites in the boreal forest alongside small freshwater rivers or ponds. Their apparent low density and isolated distribution suggests that people were visiting them seasonally as part of an annual round which also included more substantial base camps at locations now submerged within the harbor or on the continental shelf.

During the early Holocene, locations within Upper New York and New Jersey Harbor probably resembled fairly closely those at adjacent Paleoindian or Early Archaic campsites. Because those locations more than 5 m below mean sea level would have been drowned by the onset of the fourth millennium B.C., any assemblages recovered from these submerged contexts should represent more discrete periods of prehistoric activity than the typically mixed Paleoindian through Late Archaic assemblages recovered from the sites on northwestern Staten

Island. Many of the artifacts and ecofacts will have been eroded and redeposited far from their original context, however, particularly from sites which were surface scatters at the time of initial transgression. Transgression of the sea generally does not preserve archeological sites with undisturbed systemic context (Rapp and Hill, 1998, p. 78-79; Waters, 1992, p. 270-275).

The initial rapid rate of sea level rise does suggest that disturbance due to wave action would have been minimal until the shorelines began to stabilize after 4,000 B.P. Rapid submergence of sites followed quickly by burial in sediment should actually preserve artifacts and their spatial patterning better than gradual inundation (Stewart, 1999, p. 571-574; Waters, 1992, p. 275-280). Areas between -10 m and -3 m MSL have consequently been targeted as particularly sensitive in our preliminary empirical model for Upper New York and New Jersey Harbor (Figure 11). Unfortunately, several of the navigation channels themselves have already been dredged deeper than -10 m MSL (GRA, 1999, Appendix 4). Paleotopographic low areas such as the margins of freshwater marshes or stream terrace settings are the types of paleoenvironmental context which theoretically could preserve Paleoindian or Early Archaic cultural materials where those locations have not been dredged to Pleistocene substrates (Belknap and Kraft, 1985; Masters and Fleming, 1983; Pearson et al., 1986; Kraft et al., 1983; Waters, 1992, p. 278).

A more theoretical predictive model is now being developed by GRA (see Figure 12) which will integrate the disparate lines of evidence summarized above. To some extent paleoenvironmental reconstructions must be pursued independently since contexts which preserve the best floral or faunal records do not always occur in locations which are particularly

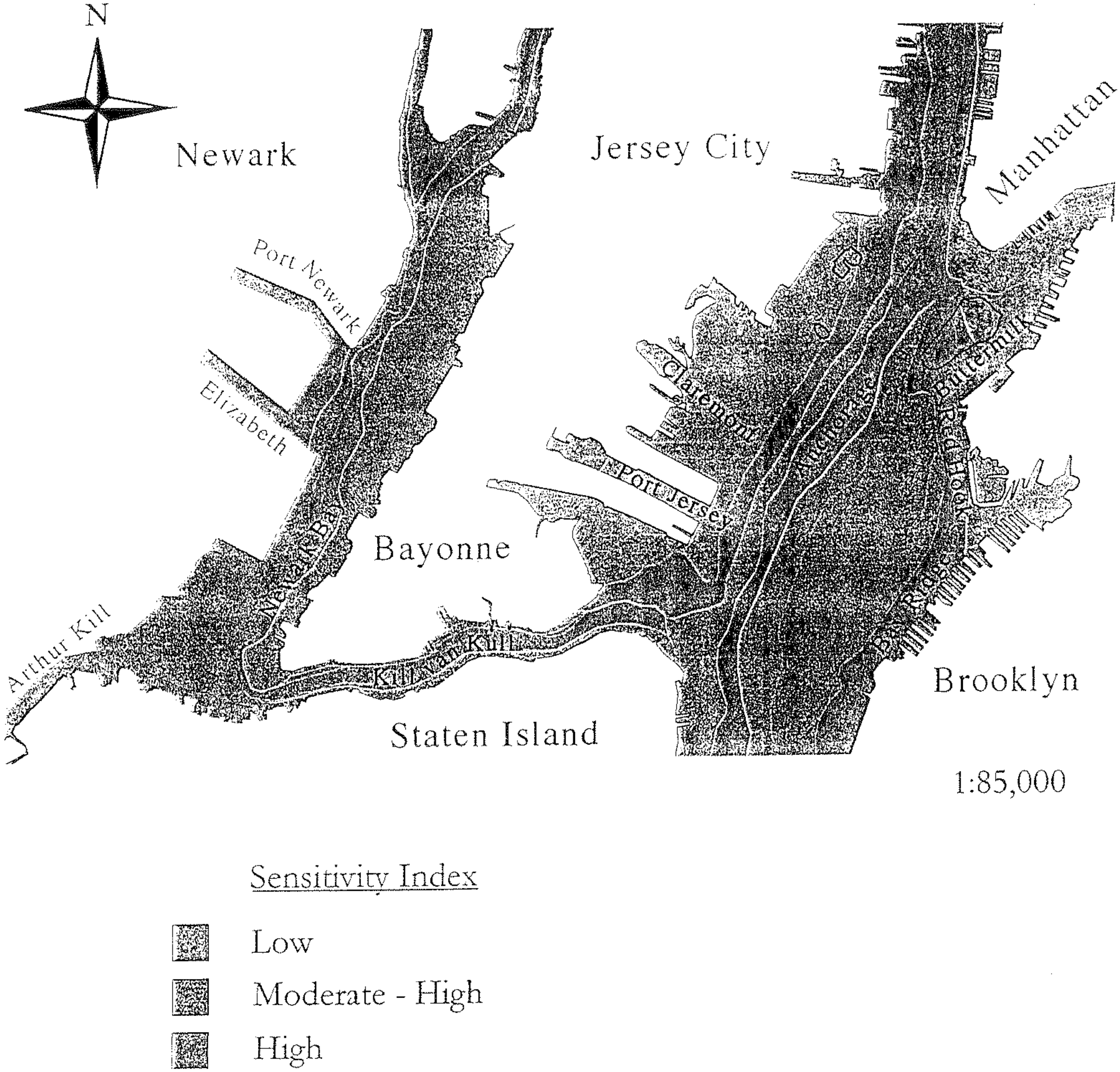


Figure 11: Preliminary Empirical Model of Archeological Sensitivity for Upper New York and New Jersey Harbor

sensitive in terms of cultural resources. We still need to know more about the distribution of freshwater marshes, for example, since these would have provided seeds and potherbs certainly by Middle Archaic times and perhaps even for the Paleoindians (Adovasio et al., 1977, 1978; Gardner, 1977, 1983; Funk and Steadman, 1994; McNett, 1985).

Detailed, location-specific reconstructions of salinity, water depth, and other factors affecting shellfish habitat within the early- to mid-Holocene estuarine waters are still needed to assess the apparently sudden appearance of shell-bearing sites such as Dogan Point during the sixth millennium B.C. (Brennan, 1974, 1977; Classen, 1995b). Without a comprehensive archeological survey of the continental shelf and sensitive settings within the Harbor Region it is not certain that this was in fact the earliest intensive harvesting of shellfish by prehistoric people (e.g. Classen, 1995b, p. 137-138; Schaper, 1993). Another possibility is that environmental conditions changed at this point to permit the combined procurement of faunal and floral resources whose previously disjunct distribution in coastal and interior settings required more "scheduling" of the annual round (Flannery, 1968). Continuation of residential mobility at least through the Middle Archaic is supported by Classen (1995b), however, with an annual round which included both the shellfish, seeds, meat, and hides available at Dogan Point and other unspecified resources available from interior locations such as the Goldkrest site northeast of Albany.

Travel by canoes and other watercraft was common throughout the Northeast at least as early as the fourth millennium B.C., and this is further substantiated by Woodland culture assemblages found on Ellis Island and Liberty Island (Boesch, 1994; Pousson, 1986) as well as the original portion of Governors Island (Herbster et al., 1997) within New York Harbor. Shooters Island along the upper Arthur Kill in New Jersey Harbor is unfortunately capped by a thick blanket of fill but must surely have been visited during at least periodic forays from the adjacent Bowmans Brook and Mariner's Harbor sites (Anderson, 1970; Rockman and Rothschild, 1979). "(T)races of prolonged occupation, fire-cracked stones, flint chips, potsherds, and the like" were observed "in every field" of the latter by Alanson Skinner (1909, p. 5). Many of these localities are now salt marsh, which appears to have expanded considerably since the time of prehistoric occupation. The GRA theoretical predictive model (Figure 12) should not be considered to preclude preservation of intact archeological contexts stratified beneath tidal marsh within the Harbor Region, as recently documented by Hartwick (2000) and Mueller(1997) for the southern New Jersey coast.

At this point we know just enough about the linkages between paleoenvironmental and archeological contexts in the Harbor Region to be dangerous. We have sufficient data to begin building models of the sort presented in Figure 12, and we already have some fairly sophisticated models for what may be missing from the current archeological record as a result of ongoing Holocene sea level rise (e.g. Emery and Edwards, 1966; Ritchie, 1980, p. 164-178; Salwen, 1962; Schaper, 1993; Stright, 1986, 1990; Stanford and Bradley, 2000) We still do not have the detailed subbottom stratigraphy or data on paleoenvironmental contexts at hand to pinpoint many "high probability" locations other than those in close proximity to known prehistoric sites. Results of the present study have nonetheless supplied the U. S. Army Corps of Engineers with the first

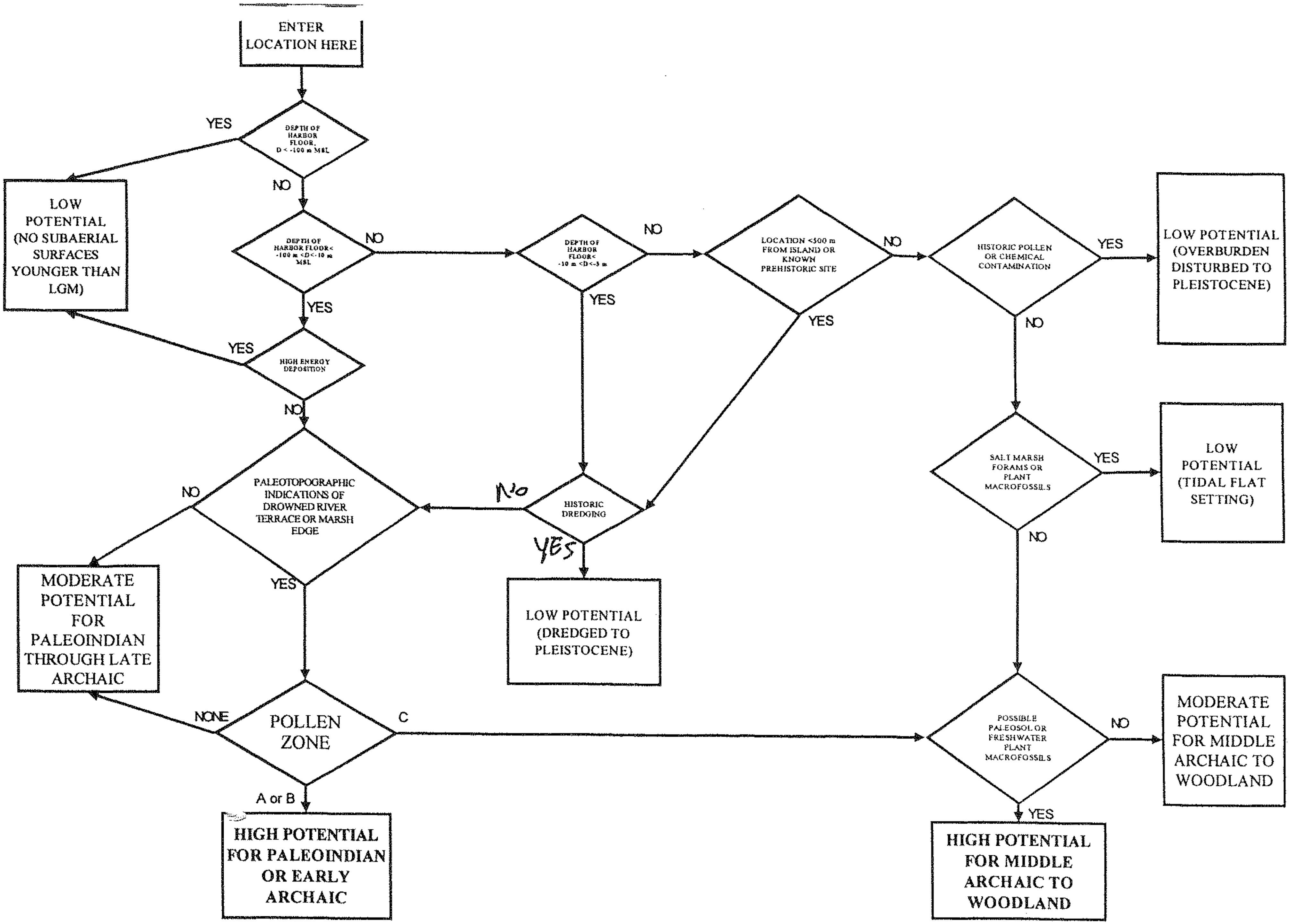


Figure 12: Working Theoretical Model of Prehistoric Site Preservation Potential for New York and New Jersey Harbor

synthetic analysis of generic lithostratigraphy and paleoenvironmental data focusing on locations where archeological materials may be preserved.

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