Journal of Coastal Research	17	3	553–562	West Palm Beach, Florida	Summer 2001

Climatic Versus Geomorphologic Changes: Influence on Landing Processes in Eastern Coasts of North America

J. J. Diez

Catedratico of Oceanography and Coastal Engineering
Politechnical University of Madrid
Madrid, Spain

ABSTRACT

DIEZ, J.J., 2001. Climatic versus geomorphologic changes: influence on landing processes in eastern coasts of North America. *Journal of Coastal Research,* 17(3), 553–562. West Palm Beach (Florida), ISSN 0749-0208.

Since Bruun's rule, which linked shoreline regressions and coastal erosions due to them, "sea level rise" has increasingly drawn the attention of different fields of knowledge, particularly coastal sciences and engineering. Certainly, it has been taken into consideration more for future climatic estimations than for analysis of the past climate. Climatic changes must have had a strong influence on the development of sailing routes. They must also have affected the access to land through their effect on beach slopes and on the configuration of bays, estuaries, lagoons and inlets, all of them linked to sheltered harbor areas. They could also be significant factors in landing and settling processes as well as other climatic and environmental considerations have affected life conditions, especially in low and wet lands. Columbus' "obsessive" search for a pass towards Cipango and China cannot explain the delay of the European settlements on the whole east coast of North-America. This paper also deals with other types of climatic impacts on coastal evolution. The possibility of identifying those impacts which are really due to the "sea level rise" is critically analyzed.

ADDITIONAL INDEX WORDS: *Coastal morphology, coastal settlements, sea level rise, coastal evolution.*

INTRODUCTION

Climatic changes along the "human era" are fairly well known, although they are not totally well defined. Until recently, only "great changes" have been taken into account, and climate (not weather) has been considered as something constant, for all practical purposes. At present, other minor climatic changes are receiving increasing attention, particularly those that have affected protohistoric and, above all, historic times. The generally assumed relation between the carbon dioxide emission rates and some present climatic changes, through the "greenhouse effect", has led to a significant perception of the climate variability and its impacts on the environment and other human life conditions. Although the effect of global climatic warmth on the sea level rise rates has alarmed many, it also has allowed to speak about a "climatic determination" of the History. Little Ice Ages and genial warm periods in the past have been noticed from literary and other artistic descriptions (LAMB, 1982), but they are now being analyzed and quantified in a more accurate and comprehensive way.

Since Bruun's rule (1962), which linked the shoreline movements and the coastal erosions / accretions related to them with sea level changes, the present "sea level rise" has increasingly attracted attention. In spite of its evidence, the climatic influence on sea level changes has only recently been emphasized in short term analysis, and related to present (a) increasing carbon dioxide emission rates, (b) warmer climate and (c) sea level rise. On the other hand, the well-known influence of maritime climate on coastal morphology and morphodynamics does not appear to have been fully considered until recently; longshore and onshore-offshore littoral transports, erosive and sedimentary processes and genesis and migration of barrier islands and other forms of sedimentary deposits have been thoroughly studied, though primarily in relation to current environmental impacts; however, other longer term morphodynamics and pattern changes have not been so extensively considered. A time-correlation has been found (DIEZ, 1992) between different post-Würm orientations of a restricted shoreline stretch and the contemporary average latitudes of the paths of extratropical cyclones which also seem to be linked to the succession of pluvial and interpluvial periods in the Saharanian area and Eastern Canary Islands (M. de Pison). That correlation implies an "immediate response" of sufficiently short coastal stretches to the average direction of waves. The same hypothesis could explain the perceivable change of orientation of Long Beach Island (N.J.) during the last two centuries (C.E.R.C. Figs. 4.7–4.9, 1984).

Climate, affecting the pattern of oceanic winds and currents, had a strong influence on sailing routes; it restrained land accessibility, through its effect on beach slopes and coastal configurations which also affected harbors related to them. These, as well as other climatic and environmental factors, have influenced settlements, especially in low and wet coastal areas. An accurate analysis of the problem is only possible with the documents of the last two or three centuries. This can be done more easily in the eastern coasts of North America than in Europe due to the availability of doc-

97055 received 22 March 1997; accepted in revision 10 October 2000.

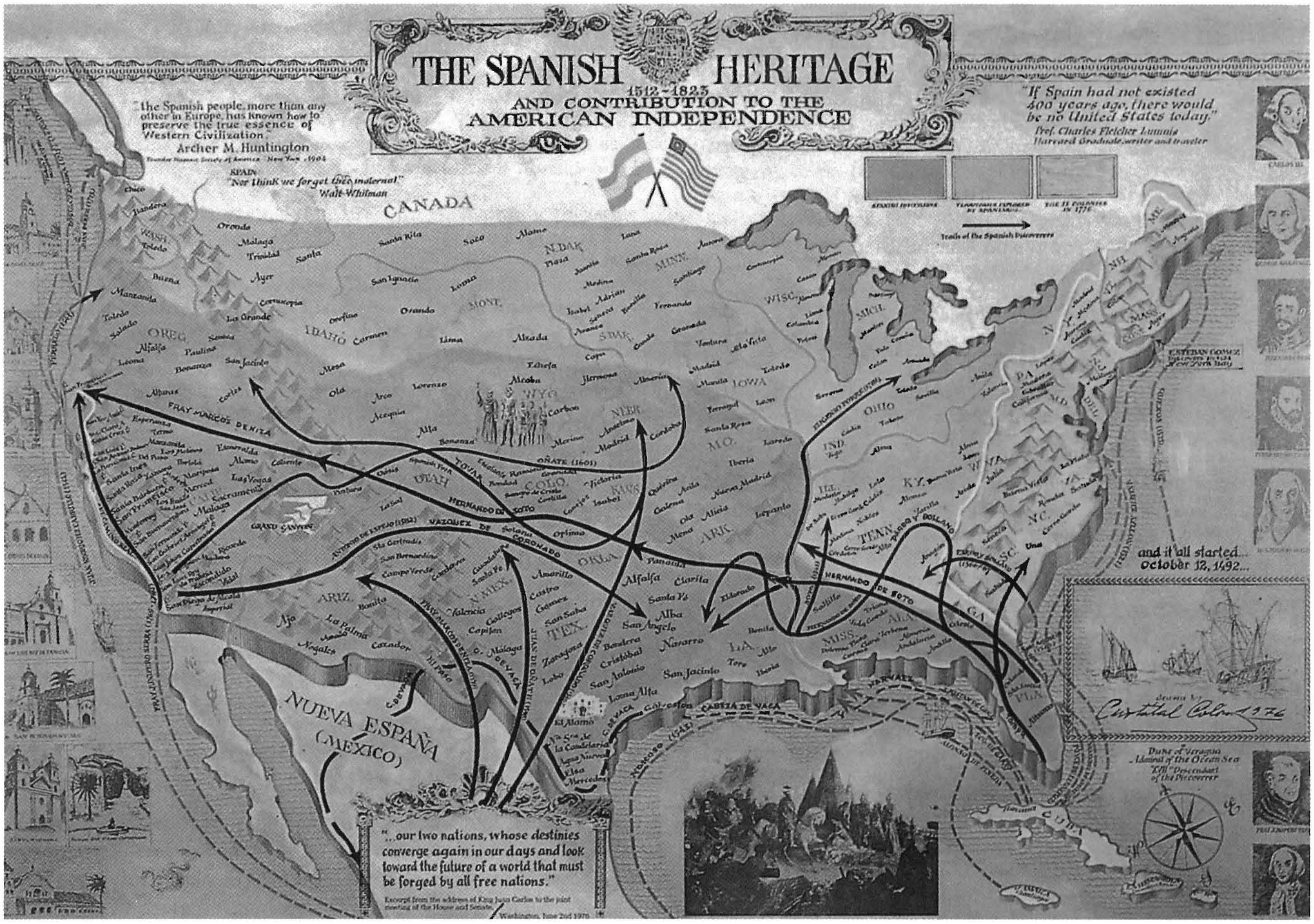

Figure 1. Shows the pioneer Spanish expansion in North-America (courtesy of the Cultural Office, Embassy of Spain, Washington.)

umentation about pre-anthropic coastal conditions. When Europeans arrived in North America they were able to map accurately, but at that time coastal lowlands in Europe were already notoriously anthropized. Unfortunately the little Ice Age had practically overpassed its maximum in the middle of the eighteenth century, when the first detailed maps and charts were available. The scarce information on previous coastal cartography might have been due to the special difficulties of settling in the coastal areas of the Gulf and the Atlantic coasts of North-America. Columbus' hypothetical aim and insistence in looking for a pass towards "Cipango" and China can explain a certain delay in the Spanish exploration and landing in more northern latitudes, though it cannot explain why the whole east coast of North America remained practically *unoccupied* for such a long time (Figures 1 and 2).

RECENT & LATE QUATERNARY CLIMATIC CHANGES

The process of global warming has been more or less persistent and relatively fast since the last glaciation (15000–25000 yr. depending on different authors) until well into the Neolithic, though it must have suffered significant fluctuations following marine transgressions and regressions (RABAN, 1985 & GALILI, 1985 - cfr. SIVAN, 1990). The Würm glaciation reached its warmest moment with an average temperature of about 5° C less than the present one (Figure 3). The late Paleolithic ends in Eurasia with a long hunting march after deer, while ices retired, and a warmer climate may have been the main factor which allowed the rising of the Neolithic in the Mediterranean area of the Middle-East (around 11000 years b.p.). The transgression attenuated and even stopped about 9000 years ago and, afterwards, a significant regression took place during the following (cooler) millennium (RABAN, 1985). "Sea peoples" appeared then in the eastern Mediterranean Sea. Since a climate yet cooler than today's, a very stabilizedly (although with some fluctuations) but increasingly warmer period ("Atlantic"), followed for nearly two millennia (when Indo-European peoples emerged). The Mesopotamian and Egyptian civilizations and empires flourished in that time. And then a new cool period ("subboreal") followed for another 2000 years; this epoch allowed the rising of the "Sea peoples" and the golden Greek world in the

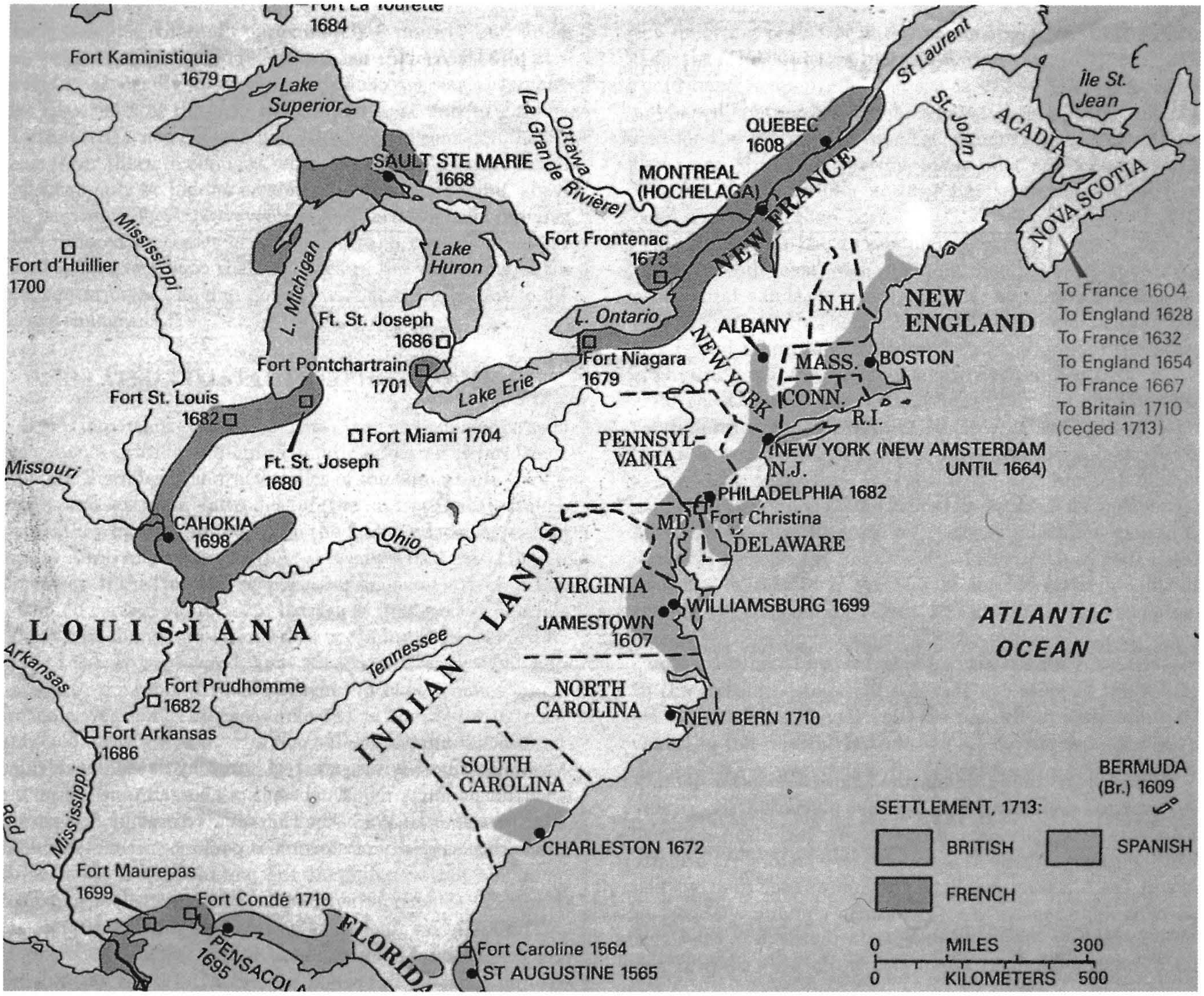

Figure 2. Shows the settlement process in the eastern Atlantic coast of North America.

whole Mediterranean basin; in the following millennium, increasingly warmer, the Roman empire emerged and died. The warmest moment of this postglaciar period seems to have been about 6000 years ago, with around 1° C above today's average temperature.

So a certain historical determinism seems to relate cool periods with the emergence and domination of nations from Mediterranean and southern and low lands, while warm epochs made nations from northern and high areas more predominant. A warm period weakened Rome and extended "barbarian" people. The cold of the former "Middle Age" made flourish the Mediterranean societies until the establishment of the Muslim and Roman-Germanic empires. And the new warmth of the later Middle Age ("little climatic optimum", 900/1000–1300/1400) (*) led to their decadence, the emergence of Hansa, the Romanic and Gothic artistic periods and the expansion of Vikings. The beginning of the episode known as "little ice age" is widely placed between 1300 and 1400. Life conditions hardened then in all central and North-Europe which became extremely cold and dry except in its west end, softened by the Gulf Stream, as it has been shown in contemporary documents (LAMB, 1982); conversely, they were mild round the Mediterranean, becoming more humid (in agreement with the hypotheses of beforementioned African "pluvials") coinciding with glacial episodes, wealthier and much healthier (epidemies, so frequent in the previous time, decreased). That led to the "Renaissance" (Christian and Islamic) and permitted, among many other events, the establishment of the Ottoman and Spanish empires which characterize the Modern Age. This period must have been very cold, given the increase of ice surfaces in polar and mountainous areas.

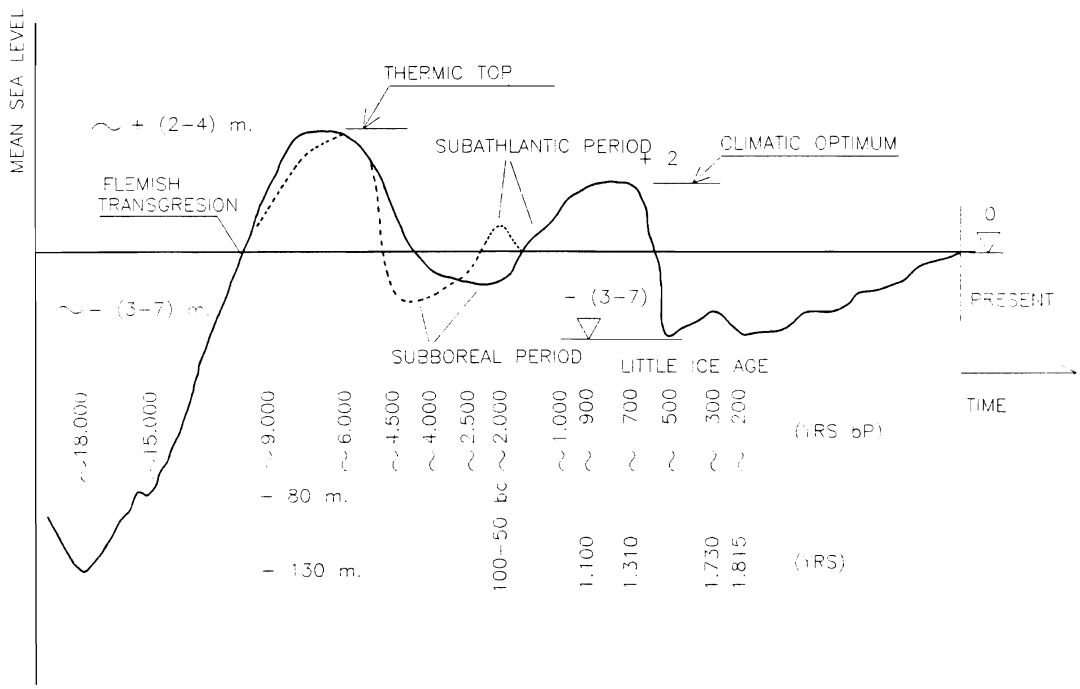

Figure 3. Shows a scheme of the sea level / temperature evolution.

SEA-LEVEL CHANGES

As a general trend, the marine transgression has followed the climate evolution since the last glaciation. There have been some fluctuations and the climate has also been modified by other isostatic and sedimentary factors. As a matter of fact the sea level has been the main factor that has been used to approximate the quaternary climatic changes. According to Sivan, the transgression attenuated in the Calcolithic (10000–7000 b.p.), and probably, the Flemish transgression could have reached its maximum between 6000 and 4000 years ago, in the range of 2 to 4 meters above p.s.l. (present sea level); then fell down to 1 meter under p.s.l. 2000 years ago. Soon after the first millennium the netherlanders of Frisia required some dike-dam protection, what indicates the beginning of a marine transgression (corresponding to the "little climatic optimum") whose last episode (the penultimate of the Flemish transgression), the Dunquerquian, began in the 13th century. On the contrary, several "polders" (BEEMSTER, PURMER, VERMER, SHERMER. . .) were drained in The Netherlands along the 16th & 17th centuries, making good use of the strong regression of the "little ice age". The average temperature must have decreased more than 1°C in that period and this change of temperature was enough to induce not only volumetric changes but a significant eustatism as well.

At Little Climatic Optimum (AD 900/1000–1300/1400) the North Magnetic Pole lay over NE Siberia, and Northern Atlantic (around Iceland and Greenland) was mostly calm and ice-free in summer, so the Vikings could get an Easterly following wind and make settlements in New Foundland and New England (Cape Cod). Winter storms with dominant westerly winds, which are registered by dated beach ridges in Hudson Bay, N. Quebec, Spitsbergen and Finnmark (FLETCHER et al. 1996: The Holocene, refered by JCR reviewer) with periodicity of stormness peaks between 45 and 360 yr, made however difficult the permanency of these settlements.

The Little Ice Age (AD 1300/1400—around 1850) is a cold period with a lot of fluctuations, indeed, whose last maximum cooling must be happened around AD 1650–1700. Eustatic sea level drop is difficult to be established for the interference of isostasic and subsident processes. American EPA admits until 7 m for some subsident stretches of the Eastern coast, allthough some authors (JCR reviewer) limits its maximum value to 0.5 m. They consider however that shifts of atmosteric pressure systems and wave set-up by shift in prevailing wind could account for around 2 m. The effect of these LIA storm surges were felt right across the Atlantic in the eastern (drier and more arid) Cannary Islands (dune system of NW coast of Fuerteventura) and in the three rings of Cedar trees in Morocco; warm cycles shown by drought in Morocco and by dust & dunes in NE & SE (cross-bedding dunes) of Fuerteventura island following the easterly allysious winds. Throughout last 1000 years there had been fluctuations in the principal storm frequency as can be noticed in long wave erosion and propagation along US east coast; comparable alternations are seen on Argentinian coast (GONZÁLEZ, 1996).

Ignoring all other factors, and taking into account the relative sea levels corresponding to the coldest moment of the last glaciation (80 to 130 m., depending on authors and places) and to the warmest moment of the Holocene (2 to 7 m.), the last regression must have been very important; the generally accepted band of approximately 3 m. over and under the present sea level could have been underpassed in that moment, especially in strongly subsident/isostasic coastal areas (like most of those in the Middle East and in Eastern Northamerica are). Nevertheless, we must consider that in long term thermic changes, eustatic and volumetric variations can only be hidden or amplified by tectonic and, above all, isostasic effects. However, in short term thermic changes, even differed processes of subsidence and consolidation can notably interfere with them. Therefore the variations of the last centuries can be due not to eustasic changes but to different changes.

RELATED COASTAL MORPHODYNAMICS

It is important to notice that transgression/regression movements are not the only climatic effect on littoral morphology. Significant characteristics of the climate are the average and extreme latitudes of the extratropical cyclone paths; they have an influence on the fetch and, consequently, on the effective direction of the wind waves that cause littoral processes. If the "inertial response" of a coastal stretch is lower than a certain value (as in barrier islands, pocket beaches, . . .) it can change its orientation becoming more perpendicular to the average wind wave direction. This is what happens with the groin-artificial beaches (pocket beaches) under variable weather. The cases referred in the following paragraph (Jávea in Spain, and Long Beach island in N.J.) are supposed to obey to this kind of morphodynamic evolution.

Concerning to the East coast of North America, between Yucatan and Terranova, three types of coastal zones (corresponding to four main stretches) can roughly be distinguished: (1) North of Long Island: glacier origin, rock-morrenic morphology and ancient positive subsidence; (2) Florida platform: karstic, stable and no subsident; and (3) Gulf and Mid-Atlantic coastal zones: sandy and with negative subsidence.

(1) The "rigidity" of the first glacier region keeps most of its structural morphology and its rocky and tortuous bottoms relatively invariable (notice their bathymetries). However transgression has led to coastal accretion of marine sands and gravel produced from cliffs and bottom erosion. Landing on this coast without charts or without a previous knowledge of the zone is extremely risky; and it had to be worse in the 15th to the 17th century, with a lower sea level.

(2) Florida may be used as the best reference in North America when considering the sea level movements and their effects. While the remarkable reefs must only have been affected by erosion and sea level changes, both related, we must question the existence or, at least, the characteristics of the present barrier islands, due to the scarcity of sandy materials during the 15th to 17th centuries; these seem to have increased during the last three centuries for anthropic deforestation in the Appalachian region of Georgia. Their present magnitude implies that they must have been generated by littoral drift, as spits (WILLIAM and BUILDING, 1982). In any case, their growth as dunes and other continental sand deposits must have increased during the cold period (in which littoral dynamics must have greatly intensified) and during the following period of anthropic deforestation of the Appalachians. The landward migration of sediments (their growth could have compensated the sea level rise effects, as it has happened in other hyperstable coasts (BORES, 1975)) affected neither the morphology nor the dimensions of lagoons and bays; and since tidal prisms favor inlet steadiness against longshore drift, sailing and landing conditions must have been worse then than now.

(3) Within the Third Coastal Type

(a) The Gulf coast, with relatively small tides and abundant continental sands, is mainly deltaic, hyperstable, subsident and with many spit-barriers, so that the importance of barrier island migration is also uncertain; therefore the accessibility to mainland must have also been difficult.

(b) The Atlantic coast, with greater tides and estuaries, less continental sediments, except in Georgia and part of South Carolina where most estuaries have become deltas, can be subdivided, depending on subsidence and amount of sediments, in two regions approximately separated by Cape Hatteras. In the northern stretch, barrier migration caused by sea level changes has been shown (LEATHERMAN *et al.*, 1982) and may be related to the lack of natural nourishment; the subsidence is moderated there; the estuaries—in glacier valleys—and bays have become bigger, saltier and less "estuarine"; shorelines have retreated and wetlands have reduced. In the southern stretch the deltaic evolution of the estuaries—in narrower fluvial valleys—has led to a shoreline advance, to the renovation of the outer barrier islands, and to the increase of wetlands with less salty waters. The slopes of the offshore and shelf zones in the northern stretch are appreciably different from those of the southern stretch and this has an influence on the morphodynamics of both zones. It is important to realize: (a) the existence of several multi-barrier stretches whose bays and lagoons become narrower as one moves to the south; that gives a certain continuity to every stretch as if the islands formed only one long spit. And (b) the inversion in the sense of the longshore transport in the northern part of each barrier island due to the wave refraction on ebb tidal deltas. Both circumstances affect the unsteadiness of inlets, even more during the "little ice age," and this must have reduced the accessibility to mainland.

CASES OF HISTORY

The evolution of Javea bay (Figures 4. a and b)

In the North Atlantic area the most important atmospheric features are the nature and paths of extratropical cyclones. Most of the times they dissipate in the Central European plain; the rest cross Europe, keeping still active over the western Mediterranean area. Depending on their strength and latitude, they may stay over the Ligur gulf or over North Africa. On the Spanish Mediterranean coast, the northern extratropical cyclones generate significant north-eastern winds; the southern cyclones, whatever their origin and type, may produce south-eastern and eastern winds. All of them are significant in the littoral processes in the area of Javea,

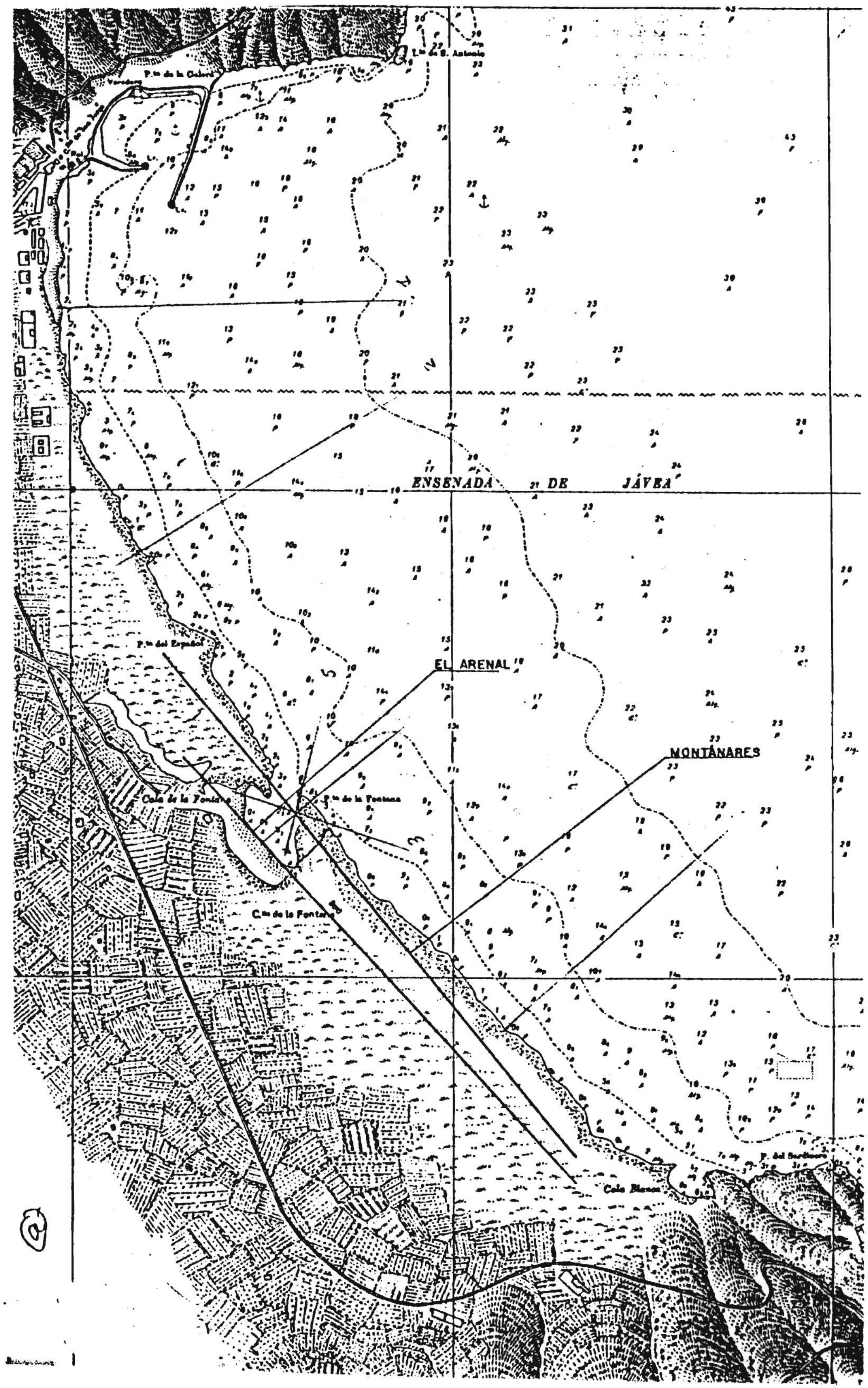

Figure 4. (a) Chart of Jávea bay (from Spanish Instituto Hidrográfico de La Marina).

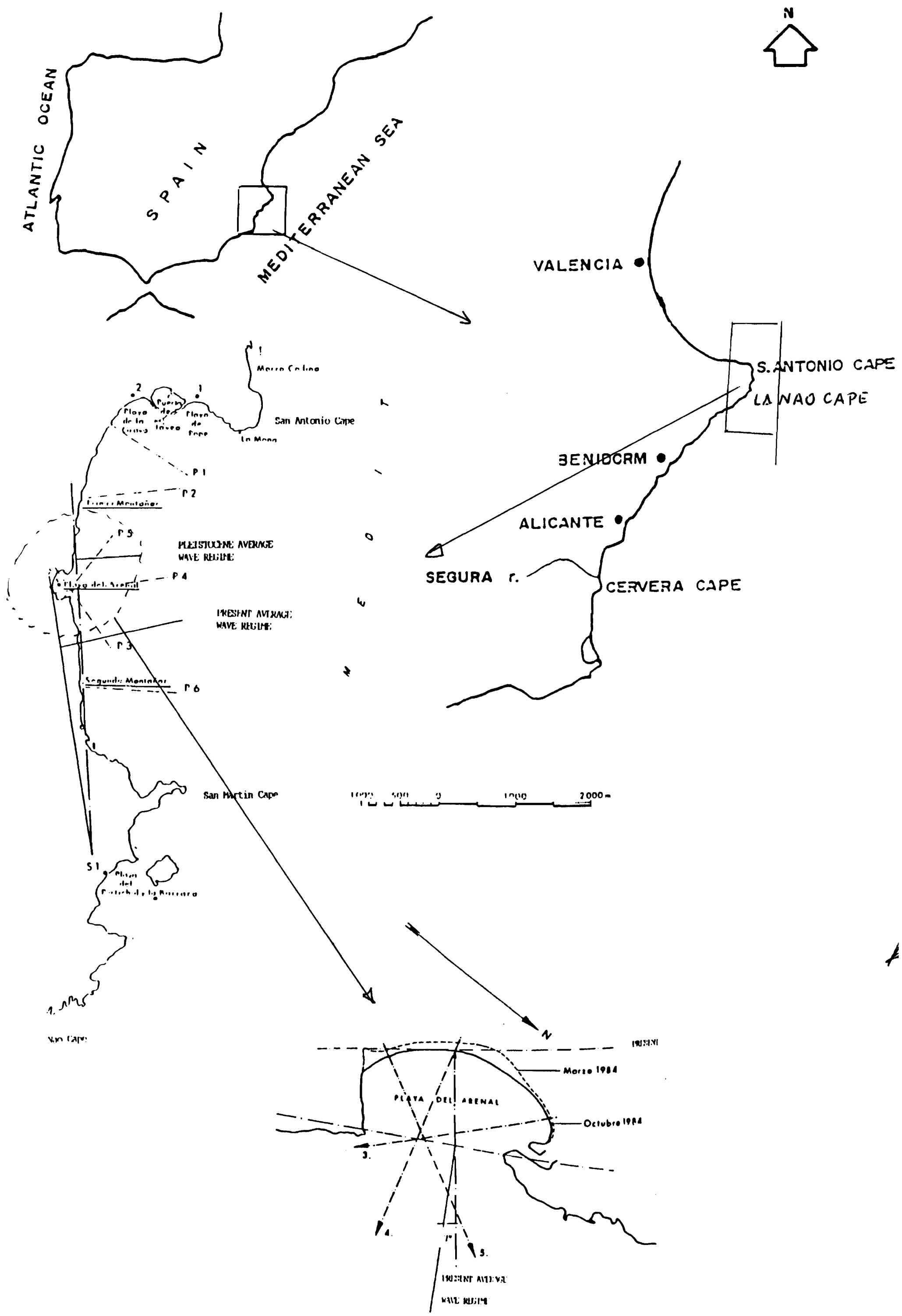

Figure 4. (b) Situation and schemes of Jávea bay and Arenal beach.

especially in the determination of wind regimes, the generation of waves and the rates of longshore transport.

Javea bay extends between San Antonio and La Nao capes, in the east of the Iberian peninsula. The natural depression of Javea was infilled by quaternary deposits. The mouth of the river Gorgos, the only river draining the depression of Javea, is situated in the bay of Javea. Beach materials consist in gravel, mostly calcareous. At present, there is only one sandy beach in this area, the Arenal beach, and a relict barrier with deposits of gravel and sand. This barrier closed a system of lagoons, almost infilled today. This geomorphologic scheme is also very characteristic of the whole area to the north of San Antonio headland, along the gulf of Valencia. The sequence of quaternary sediments of the area has been studied (FUMANAL *et al.,* 1993) from subaerial profiles and from drillings reaching the substratum. It presents a complete morphological record except a representation of the Lower Pleistocene.

The oldest material belongs to the Middle Pleistocene and is related to an episode of marine transgression. At the end of this period the present morphology was conformed. During the upper Pleistocene a transgression led to the formation of the beach-barrier-lagoon system. A significant regression took place later, in the last glacier period, which made possible a continental progradation. Erosion during the Holocene broke the relict barrier allowing the formation of a pocket beach, El Arenal.

Littoral processes in the area were defined from the results obtained by Fumanal. They have permitted to establish the average annual wave values. The present average wave resultant in Javea bay is remarkably perpendicular to the shoreline. The cross-shore transport is thus more significant than the longshore transport in Arenal beach, although it exists a certain obliquity with respect to the relict barrier. Since the Middle Pleistocene the weather and the shape of the coastline favored the transport of continental sediments towards the coastline. Littoral dynamics were strong enough to make successive chains of barriers which determined the continental progradation from their initial position (either mesozoic or tertiary).

The Evolution of Long Beach Island (Figure 5)

This study is based on the figures presented in the Shore Protection Manual (C.E.R.C. 1984, vol.I, figures 4.7 to 4.9) as an example of long term apparent changes in the almost permanent shifting of the shoreline. Long Beach Island is one of the several barrier islands along the coast of New Jersey, extending between Barregat and Egg inlets and closing Manahawkin Bay and Little Egg Harbor. The Manual presents three sea sides shoreline stretches of the barrier near Ship Bottom, between 39° 32′ and 39° 39′ North Latitude, and their evolution from 1839 to 1924, trying to give an example of shorelines under long term erosion and accretion.

From the data collected since 1924, the general theory of the landward migration of barrier islands due to sea level rise can be partly assumed, but the most relevant fact from the figures is the apparent rotation of every stretch, and even of the whole barrier, from 1838 to, at least, 1872 with the rotation superposed to the migration.

More information about the evolution of the shoreline along the whole island is needed in order to confirm this hypothesis, but it can be said, from the figures, that the stable point of the barrier island could have been around a latitude of 39° 36′ and a longitude of 74° 12′ in the 19th century. The rotation angle may have been over 2°, with possible local modifications depending on the nature of the barrier and the depth of the bottom of the sea in front of it.

A certain relationship must exist between the change intensity and the length of the observed stretch (morphologically isolated). Long stretches have a kind of inertia to accommodate to the changes; shorter stretches accommodate so quickly that their changes can have been ignored by old cartographers. Nevertheless they can be noticed with a monitoring program, in the same way that seasonal changes have been monitored.

HISTORICAL REVIEW

The first permanent settlement of Europeans in the Atlantic coast of North America was Saint Agustin, Florida (1565) (Quebec, previously settled, cannot be considered a coastal place), and, initially, it had almost only a military function: the protection of the Spanish convoys in their return to Spain. Afterwards, the Spaniards looked for the expansion into the country towards the Tennessee valley, and they only established another permanent settlement in the coast (Perrin Island, 1566), which was abandoned in 1587, after the destruction of Saint Agustin by Drake in 1586; by then, the enclave of Roanoac (which would later disappear "mysteriously") had been settled in 1586 in Albermale Sound (North Carolina). However, the several wrecks that took place north and south of Cape Hatteras show both that Spaniards unsuccessfully tried to establish along the coast, up to at least Chesapeake bay, and that it was a dangerous coast for trade-wind exposure; the difficulty for tacking of spanish galleons ought to have moved them to avoid the coast except for emergency, but the sudden morphological coastal changes must have happened and surprised to them with unforeseable frequency; and the more easily navigated pirate vessels, often schooner-rigged, permited them to take advantage of that changes for assailing, shifting and hiding. (*)

The first French and English settlements did not take place until 1605 (Port Royal, Nova Scotia) and 1606 (Jamestown, Virginia). An accurate map of the bay area around this settlement, drawn in 1616 by Harriot & White, shows that the morphology of Cape Henry was very different then. The headland was hooked toward the northeast instead of towards the southwest as it is at present. The differences have to be related to the average wind wave direction, which must be, at present, more oblique from the northeast and with more capability for longshore littoral transport. This is consistent with higher latitudes of the extratropical cyclone paths and with a warmer climate.

In any case, the establishment of settlements on the Atlantic coast was strangely delayed, especially if we consider how early the explorations began. Columbus' obsessive search of

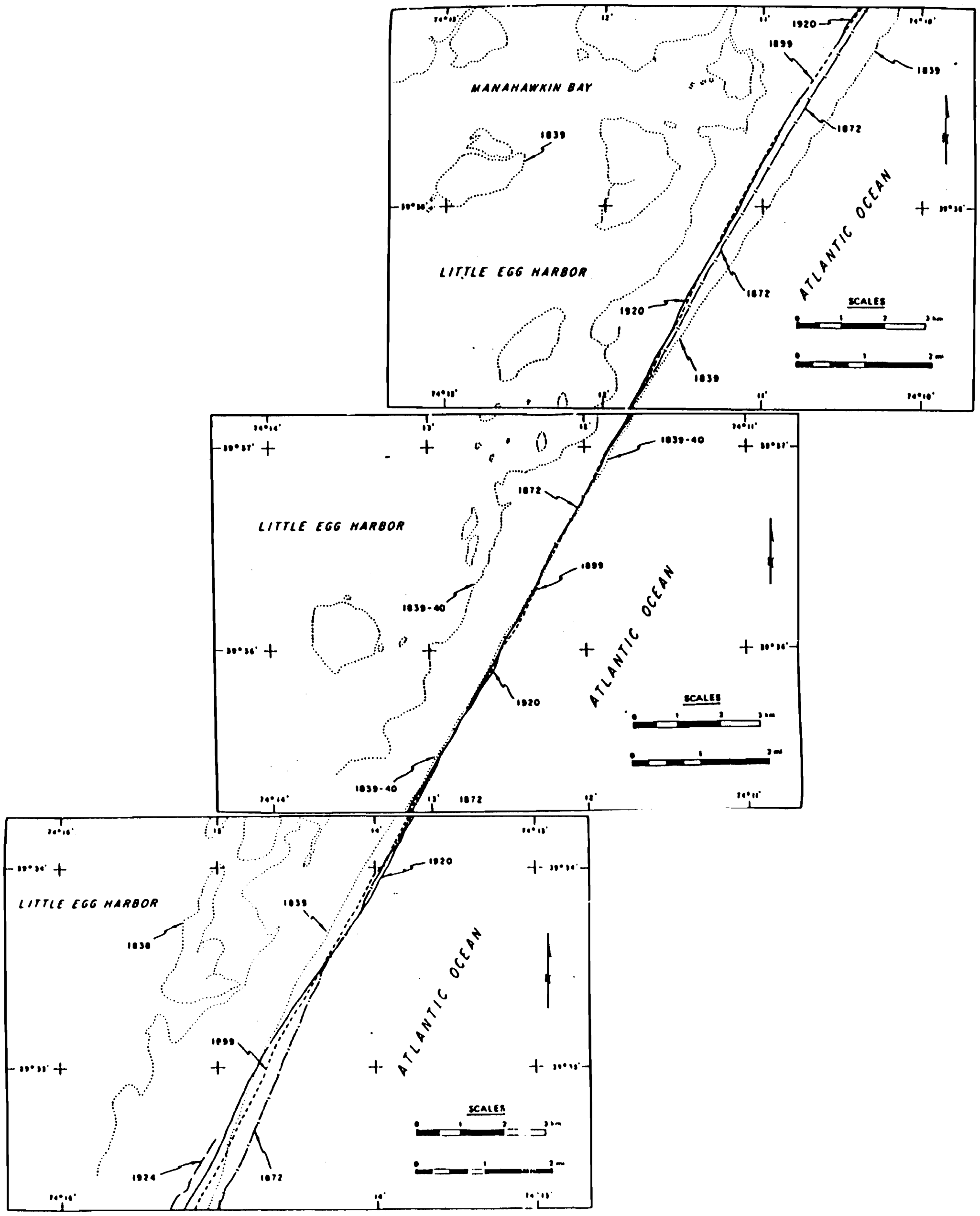

Figure 5. Shoreline evolution of in Long Beach island. (from CERC, 1984).

a new way to Asia cannot explain this, not even before his death, given the different objectives of the Spanish Crown. Other reasons based on piracy practices or in the lack of interest of Europeans for North America, have been proved inconsistent (DIEZ, 1992). The explanation given in the next paragraph is based on climatic conditions and, above all, on their littoral morphodynamic effects.

HYPOTHETICAL CONCLUSION

Although the aim of this paper is not an investigation in detail, the question that has been approached is very appropriate nowadays that climatic characteristics seem to be so dramatic. This short review shows that major climatic changes have happened along relatively recent episodes; some of them can be related to historical problems, directly and through their influence on coastal morphology. This hypothesis can be supported by the following deductions about Atlantic and Gulf coasts (the whole coast between Yucatan and Long Island seems to be very homogeneous but there are significant genetic and morphodynamic differences):

- The general configuration of the Gulf coast may have been similar to today's, but the ancient lower sea level, probably attenuated at present by posterior subsidence, must have accentuated the advantages in harbor entrance and landing of some punctual singularities like the ancient reefs of Florida and Yucatan (tertiary) and the younger littoral reefs of Veracruz (probably quaternary), or the structural headlands of Alabama. These singular points have served as landing areas to settle and penetrate the continent westward from the Appalachians. Florida, dangerous for its many reefs and unsteady inlets, poor, karstic, humid and not yet infilled with sands from littoral drift, was only used for the protection of convoys and as a platform to cross the mountains towards the Tennessee valley.

• Climatic conditions in New England were more homogeneous. The sense of the present subsidence is not clear, but the region undoubtely suffered a worse climate and worse sailing conditions (due to ice and storms). Besides, the nature of the whole coast made its access very difficult; Plymouth was one of the very few points accessible from the sea. The successful landing in Cape Cod and the survival of the people there, were believed to be miraculous and providential (from which the name of Providence, R.I.). It remains as a first cornerstone of the American History and reveals the difficulties of the adventure, even in 1616. The rest of the coastal settlements were approached from land.

• The biggest coastal changes must have happened in front of the Appalachians, where the access to mainland had to be specially difficult with inappropriate ships and under extremely variable morphodynamic conditions. These coasts were also an usual refuge for "privateers" (origin of the word pirate) and corsairs. The sea level could be 3 to 5 m lower than nowadays (depending on the subsidence); this difference was smaller to the north of Cape Hatteras (first English settlements) with less subsidence and continental deposits. The bigger subsidence south of the cape could have been partially compensated with a shoreline advance due to continental–fluvial–deposits. There must have been a great variability of inlets and shoals and of sailing and landing conditions. A similar process must have happened between Cape Henry and Long Island, although with less deposits and subsidence (differed); three big estuaries make easy the access to mainland in this stretch nowadays, but nothing can explain why the first landing was in Chesapeake bay, the most infilled and less fluvial of all of them. Morphological conditions and climate must have been an important factor, as in New England.

ACKNOWLEDGMENTS

To the Spanish University authorities and to the Spanish-North American ensemble committee for their respective grants.

LITERATURE CITED

BORES, P.S., 1975. Clasificación de formas costeras simples–Madrid: *Interior report. E.T.S. Ingenieros de Caminos, Canales y Puertos,* 82p.

BRUUN, P., 1962. Sea level rise as a cause of shore erosion. *Proceedings, ASCE* 88(WWI).

C.E.R.C., 1984. *Shore Protection Manual. Department of the Army, Waterway Experiment Station,* Vicksburg. Mississippi, 2 Vols.

DEAN, R.G., 1990. Equilibrium beach profile: characteristics and applications Gainesville: *Final Report. UFL/COEL-90/001. University of Florida.*

DIEZ, J.J., 1984. Estudio de los procesos litorales en la Bahía de Jávea (Alicante). *Technical Raport for Javea Council.* (Restricted document, 160p).

DIEZ, J.J., 1992. Cambios climáticos y geomorfológicos: su influencia en el proceso de asentamientos españoles en América. *Rev. Obras Públicas. Oct. pp. 91–102.* (Madrid).

DIEZ, J.J. and ESTEBAN, V., 1994. Large scale answer in plan of open sandy shorelines to climate changes. Höfn, Iceland: *Proceedings International Coastal Symposium, pp. 485–492.*

E.P.A., 1990. Climatic changes effect. *Report*. Washington. D.C.

FAIRBRIDGE, R., 1997. Personal comments as reviewer.

FUMANAL, M. ET AL., 1993. Evolución cuaternaria de la bahía de Jávea (Alicante). *Estudios sobre el cuaternario. pp. 17–26. Universidad de Valencia.* (Valencia)

GIEGENGACK, R., 1991. *Personal comment.* Philadelphia.

GIGENGACK, R., 1993. Global Warming: *The Scientific and Policy debate.* (manuscript for printing in *Grupo Eurociber*).

GONZALEZ, M.A., 1996. Global environmentel trends and probable impacts on the coasts of South American mid-latitudes. *Journal of Coastal Research* 12(4), 1034–1037.

JCR REVIEWER., 1997. *Personal reviewing.*

LAMB, H.L., 1982. Climate History and the modern World. New York. *Methuen.*

LEATHERMAN, S. ET AL., 1982. Virginia barrier island configuration. A reappraisal. *Science,* 215, 285–287.

MARTINEZ DE PISON, E., 1986. *Personal lecture.* Fuerteventura.

SIVAN, D., 1990. *Personal communication.* Asseategui Seminair. Sandy Hoock, New Jersey.

WILLIAM, S. and BUILDING, K., 1982. Barrier island shorelines: an assesment of their genesis and evolution. *Restricted paper. Fort Belvoir.*