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Holocene Evolution of the Salpi Lagoon (Puglia, Italy)

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ABSTRACT

This paper attempts to reconstruct the evolution of the Salpi lagoon during the Holocene. The authors examined archaeological evidence and historical documents supplemented by field data. The research highlights the role of climatic variations and human interference in evolution of the lagoon. The data collected show that:

- At the beginning of the Holocene the sea level rise caused the development of a sandy barrier between Gargano Headland and Murge. This barrier enclosed a wide coastal lagoon, called "Laguna di Salpi".
- Favourable environmental conditions permitted human occupation on the inner side of the lagoon during the early Neolithic by populations coming from the eastern coasts of the Adriatic Sea.
- At the end of the Neolithic the lagoon evolved into a sabkha and the whole area was abandoned until end of the 3rd millennium B.C.
- Between the III and I millennium B.C. the lagoon, communicating by several entrances with the sea , was deep enough for navigation.
- Between the II and I century B.C. the Tavoliere coastal area was affected by malaria and the lagoon settlements were abandoned.
- During the Middle Ages the Tavoliere coastal plain was almost depopulated, whereas the area around the lagoon was densely inhabited.
- Despite many attempts at reclamation during the Modern Age the whole Tavoliere was a malarial area.
- The lagoon then turned into a large coastal swamp which survived up to the 1930s when, after the "Serpieri - Iandolo" law, radical reclamation activities began.
- Two areas of the ancient Holocene lagoon still survive: the first is a swamp called Palude Frattarolo, the second is an area dedicated to salt production, called Saline di Margherita di Savoia.

ADDITIONALINDEXWORDS: *coastal plain evolution, Gulf of Manfredonia.*

INTRODUCTION

The Salpi lagoon was a basin lying in the eastern part of the Tavoliere, the largest alluvial plain in southern Italy; the Tavoliere is borded by the Gargano Headland to the north, by the mountains of the Subappennino dauno to the west, by the Altopiano delle Murge in the south-east and faces the Adriatic Sea to the east.

In this area Quaternary alluvial sediments overlie Pleistocene and Plio-Pleistocene gravel and sandy deposits (Figure 1). The Tavoliere plain dips gently seaward and the adjacent continental shelf exhibits a more gentle dip. Fluctuations of sea level have left only limited morphological evidence, even though eight orders of terraced surfaces among 350 m and 5 m a.s.l. can be recognized and four orders of terraces occur among the 15 m and 110 m isobaths (CALDARA and PENNETTA, 1993a; CALDARA *et al*., 1994).

The objective in this paper is to reconstruct the Holocene history of a coastal basin in this area. The evolution of the Salpi lake – lagoon was reconstructed using geological, geomorphological and archaeological evidence as well as the documentary evidence of researchers, notables, travelers, etc., dating from the Roman period.

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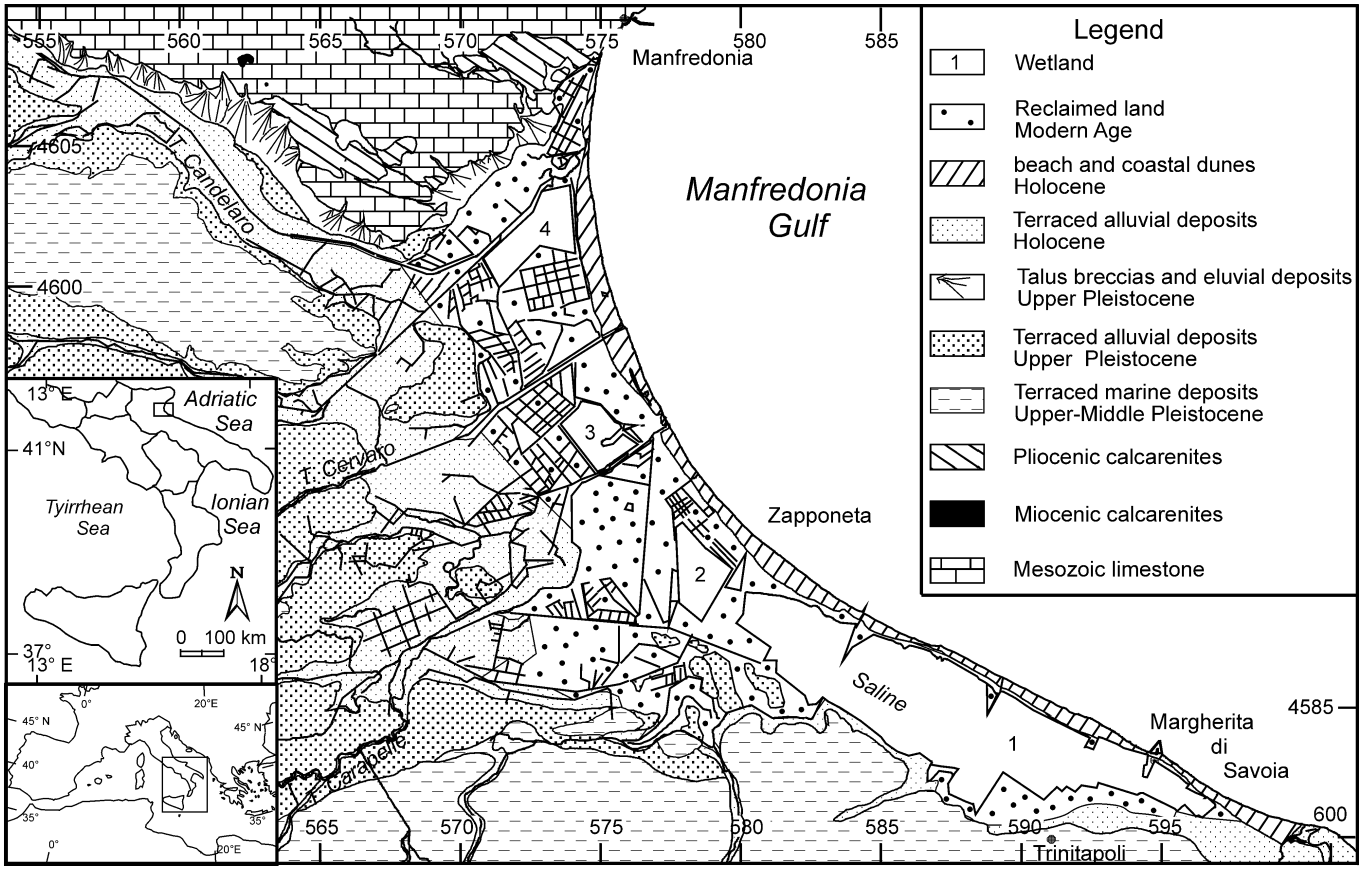

Figure 1. Schematic geological map showing residual wetlands 1) saltworks (Saline di Margherita di Savoia); 2) fishing and hunting reserve; 3) aquaculture ponds; 4) the Palude Frattarolo, a nature reserve in the Gargano National Park district.

LAST GLACIAL MAXIMUM (LGM) TO NEOLITHIC

During the last glaciation, the sea level was 120 m lower than present, and the coastline was about 70 km offshore of the present coast (CALDARA *et al*., 1994). The Daunian rivers incised and widened their valleys. This regressive erosion deeply affected the alluvial plain of the Gulf of Manfredonia in that it cut the clayey substrate (CALDARA and PENNETTA, 1991).

Therefore, at the peak of the glacial period, which was characterized by a cold-temperate rainy climate, a number of rivers crossed the Tavoliere plain. The pattern of these rivers was straight at the beginning, becoming more and more meandering on the coastal plain, due to the very low angle of slope (Figure 2). At that time the coastal plain was a large swamp, due to the abundant precipitation and poor drainage due to the low dip and the presence of the coastal dunes which represented an obstacle to water flow to the sea. The inland displacement of unconsolidated beach sediments and the abundant sediment discharge from the rivers in flood, due to the improvement of the climatic conditions and to the consequent gradual rise of the sea level, caused an increase of available sediment for the building of coastal dune ridges. As a result a coastal plain, characterized by ridges and dunes separating coastal lagoons connected to the sea, was established. In the Gulf of Manfredonia, the sea level rise was interrupted by short stillstands as the presence of now-submerged littoral ridges and offshore breaks in slope testify. These palaeocoastlines have been recognized at 90 m, 75 m and 15 m depth (CALDARA *et al*. 1994).

At the beginning of the Neolithic sea level was at about -10 to -15 m compared to the present and a narrow coastal ridge developed which became larger as the lagoon became isolated (Figure 3). Presently at least 3 - 4 rows of ridges can be recognized about 10 km offshore with their crests at a water depth of 8 meters (SEGRE, 1969). During this period the climate warmed. The change in climate prompted massive colonization by a population from the eastern Adriatic Sea coast. The new inhabitants settled the wide plain of Tavoliere and, in particular, the inner lagoon-shores and the areas close to the rivers flowing into the lagoon itself.

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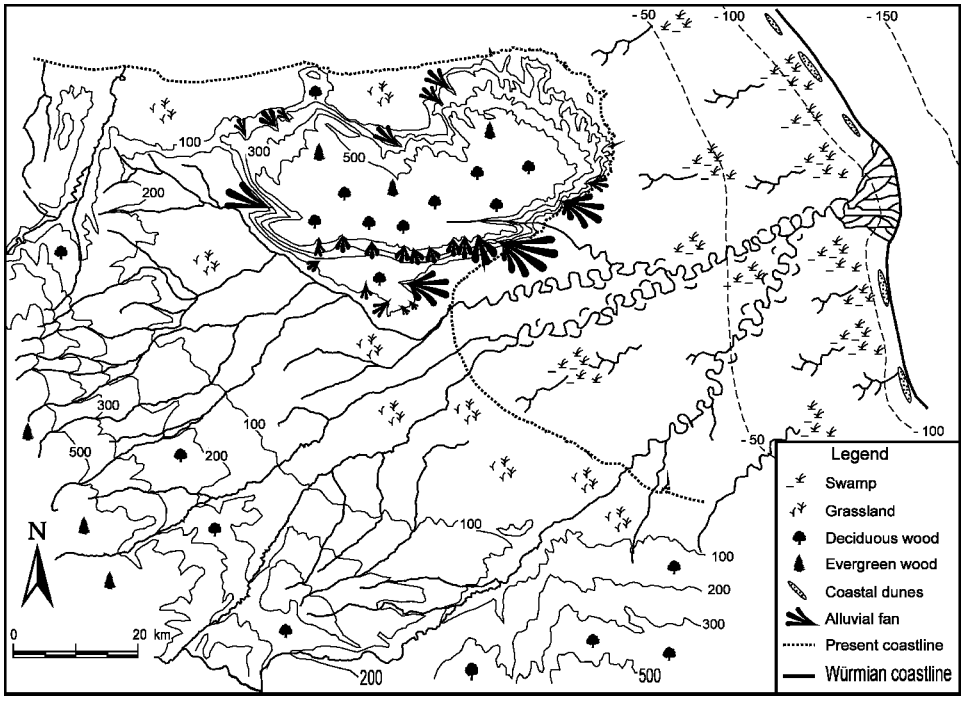

Figure 2. The Tavoliere landscape during the last glacial maximum. At the foot of the Gargano large alluvial fans developed. The rivers crossing the Tavoliere have a rectilinear pattern in the inner part of the plain and meanders in their lower reaches (now below the sea level) before meeting in a delta. Steppe vegetation covered the plain while a cold-climate flora developed in the higher areas.

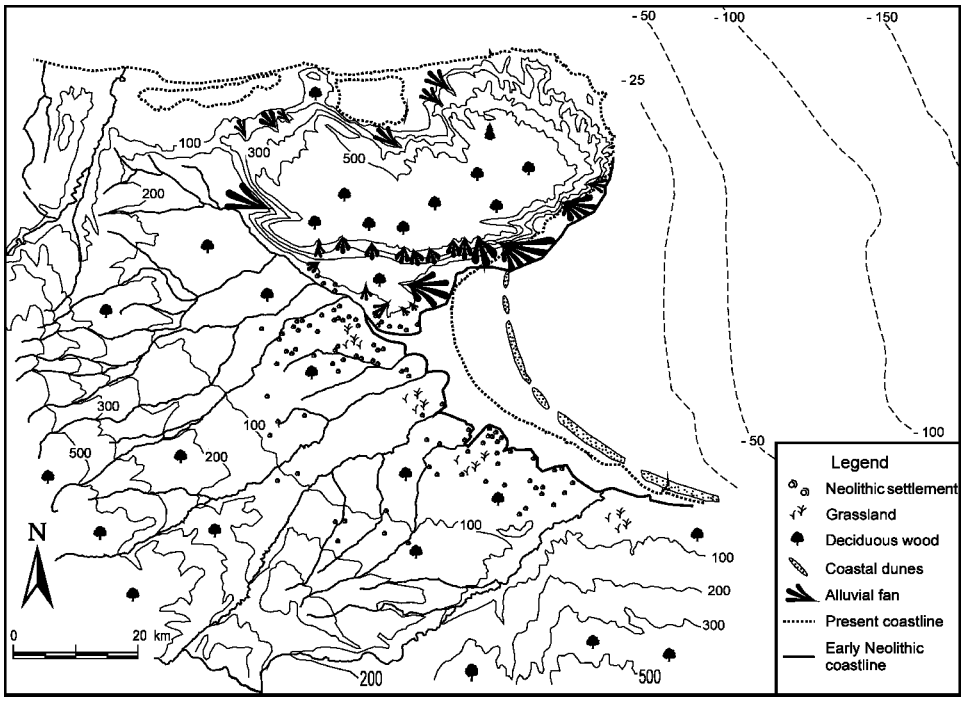

Figure 3. During the Early Neolithic the coastal lagoon was open to the sea through wide tidal inlets. The Gargano alluvial fans were truncated at their base by the wave action of the rising sea. The vegetation was rich and diversified; mixed woods mantled the higher areas.

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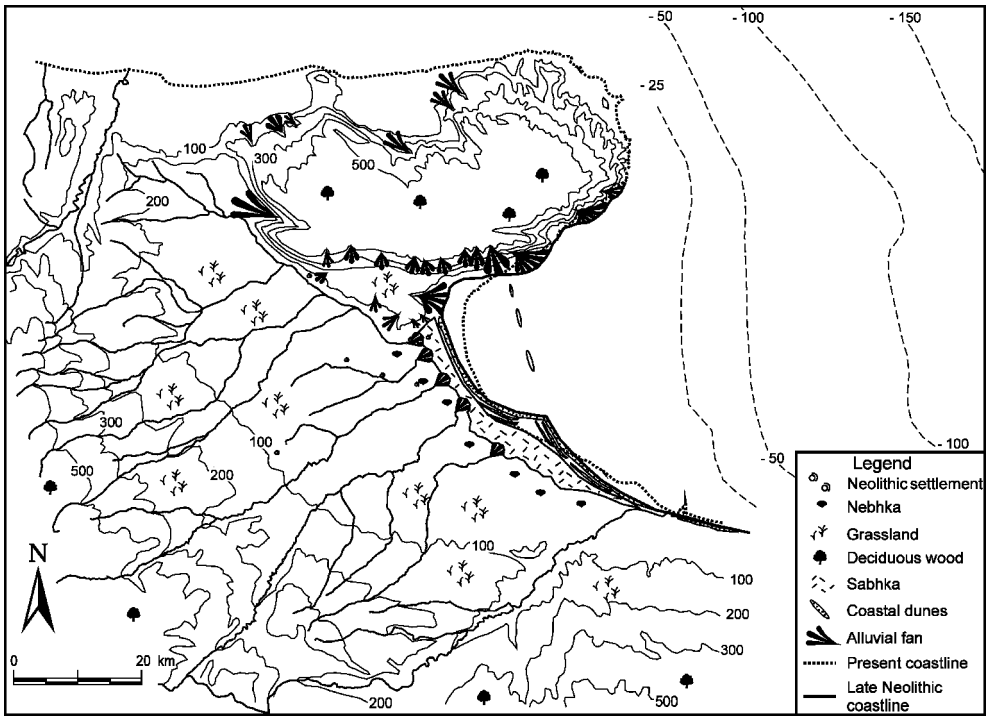

Figure 4. Late Neolithic pre-desert landscape. The rivers are ephemeral, the coastal plain is characterized by a sabkha and the shape of the shoreline is quite different to the present. The vegetation was quite thin in the higher areas, whereas tall grasses covered the plain.

Indirect indications regarding the existence of the lagoon during the Neolithic derive from the finds of the typical cardial impressed pottery in the numerous villages discovered in the Tavoliere plain (7600 ± 100 years BP at Santa Tecchia, BELLUOMINI and DELITALA, 1983; 6490 ± 150 years BP at Masseria Fontanarosa Uliveto, WHITEHOUSE, 1988) and from the abundance of flint microliths used to facilitate the opening of Cardium shells (DEITH, 1988). At the beginning of the Middle Neolithic the sea level had risen to the 3 m isobath (ANTONIOLI *et al*., 1998) and it seems to remain at this level for some millennia (Figure 4).

The sea level appeared to be close to the present position, but the coastline assumed a quite different pattern. In fact, it appeared to be largely withdrawn in its northern side, close to the Gargano Headland, whereas it stretched out many kilometers offshore in its middle part. This is suggested both by archaeological evidence below present sea level (LOPEZ 1987; VOLPE 1990) and by some dune ridges buried by recent sediment, whose pattern appears discordant to the actual shoreline (SCHMIEDT 1973).

The inner lagoon shoreline was indented due to the shape of the mouths of the rivers flowing into it. These streams delivered significant amounts of water during the whole of the year. During this phase the largest extent of human settlement was reached, most of which were close to the inner shore of the lagoon, where the inhabitants of the villages either lived by fishing or farming, depending on the season (JONES, 1987). The formation and the development of the dune ridges and the subsequent large extent of the lagoon suggest that during this period the climate, although in a temperate phase, appeared to be much wetter than present. As a result, during the Middle Neolithic the abandonment of a some inner coastal sites occurred due to frequent flooding, and the development of villages in areas of high relief took place (TINÈ and SIMONE, 1984).

The last period of the Middle Neolithic was characterized by a new phase of depopulation of the Tavoliere and, in particular, from the coastal areas; only the areas along the Fortore river and the first relieves of the Apennines were not affected by this phenomenon. During the same period caves at the foot of the Gargano were again inhabited as they had been during the Paleolithic. This period was characterized by a deep environmental crisis due to climatic deterioration. The farmers who populated the Tavoliere, in spite of their skills in advanced cultivation techniques of cereals (TINÈ and SIMONE, 1984), were forced to leave agriculture and started to breed sheep and goats rather than cattle (CASTELLETTI *et al*. 1987).

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Figure 5. Ruins of a navigable channel dug to connect the Salapia harbour to the open sea.

In particular a phase of intense aridity occurred and the whole coastal area fell under semi-desert conditions (BOENZI *et al*., 2001) characterized by low rates of precipitation and high temperatures. As a result, the lagoon, no longer communicating with the sea, turned to a sabkha (Figure 5). The finds of gypsum in the area confirm this hypothesis (CALDARAand PENNETTA, 1993b; BOENZI *et al*., 2001).

Rivers and streams flowing into the lagoon with wide outlets went through deep transformations. The presence of large areas totally lacking in vegetation favoured accelerated erosion along slopes and thick alluvial and colluvial sediments deposited in the valleys. The sediments were re-distributed at the outlet of rivers and ephemeral streams allowing the formation of large, flat alluvial cones. As a result of this sedimentation the bottom of the ancient lagoon was raised and the whole basin got smaller.

BRONZE TO IRON AGE

The areas close to the lagoon were again inhabited from the Middle Bronze Age, in the so called "Proappenninico B" archaeological phase (CAZZELLA and MOSCOLONI, 1995). During the Iron Age the areas surrounding the lagoon reached their maximum density of population as attested by the presence of many flourishing Daunian settlements such as: Coppa Nevigata (SCHMIEDT, 1973), Masseria Cupola (the pre-Roman Sypontum), Torretta dei Monaci (the pre-Roman Salapia) and Giardino (LAMACCHIA, 1987). These towns were surrounded by walls except for Masseria Cupola as it was built upon an island in the lagoon (DELANO SMITH, 1978). Reliable accounts of the characteristics of the lagoon at this time come both from the archeological record and from the works of many authors such as LYCOPHRON (Alexandra, 1129), STRABO (Geographia, VI, 5, 283), VITRUVIUS (De Architectura I, 4, 12), TITUS LIVIUS (Ab Urbe Condita Libri, XXXIX, 2), APPIANUS (De Bello Annibalico, XLV, Bellum Civile, I, 52), LUCANUS (Pharsalia, V, 377), PLINIUS (Naturalis Historia, III, 103) and other minor chroniclers.

Apart from the geological and archeological studies, the most ancient information about the lagoon comes from the Roman period, and relate in particular to the presence of the harbour of Salapia (DI BIASE, 1985; CALDARA and PENNETTA, 1990). This town was founded in the IX century B.C. by populations from the Dalmatian coast. STRABO (quoted work) and VITRUVIUS (quoted work) report that this town overlooked the inner shore of a coastal lagoon. Salapia represented an important port of shipment for the foodstuffs from the Tavoliere, competing with the port of Sypontum (TINÈ BERTOCCHI, 1975). The road network itself seemed to lead to the Salapia area (ALVISI, 1975), even though commercial trade with the settlements in the internal areas took place across the lagoon and streams; in fact, these were navigable rivers by means of barges, quite similar to those drawn by horses, as reported by HORATIUS (Satirae, I, 5, 10).

Around the III century the lagoon area started getting silted up due to an increasingly of turbid flow from the rivers (LIVIUS, quoted work). Areas all around Salapia became malarial and the town began a long period of decay. Nevertheless, as the harbour was located in an important place for the trades of Rome, the inhabitants of Salapia founded a new town upon a low hill 12 m in height (VITRUVIUS, quoted work), whose present name is Monte Salpi. To start a new harbour, a channel was dug to re-establish communications to the sea (Figure 5). At the mouth of the new channel a defensive post was erected, which is now located a few kilometers offshore (LOPEZ, 1987).

In spite of many efforts, communication between the lagoon and the sea could not be established and the lagoon continued to infill and evolve into a swamp. CICERO (De Lege Agraria, II, 27, 71) opposed the proposal for Roman settlements being located "in the pestilential swamp of Salapia". Some years later SENECA (Epistulae Morales, I, 34) gave a similar opinion, describing the Tavoliere as an "insalubrious, desert area".

LIVIUS (quoted work) reported that, due to the malaria that occurred between 195 and 185 B.C., the inhabitants of Sypontum were compelled to move to another site, a few kilometers south of the present Manfredonia. LIVIUS himself (quoted work) held that the fill of the lagoon was the effect of a sudden and strong increase in the turbid flow of the inflowing rivers. Sediment discharge from the Carapelle stream in particular divided the lagoon into two basins: the so-called Salpi lake in the southern area and the Salso lake in the northern area.

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THE MIDDLE AGES

There is no satisfactory documentation regarding the environmental conditions of the damp area during the Middle Ages. Reports regarding this area can be inferred from ancient geographic maps representing the Tavoliere, by old ledgers of notaries and excisemen in charge of the collection of taxes and by monastic chronicles. Analysis of these reports suggests that the lagoon changed its configuration many times, and ultimately became a swamp in which malaria was endemic.

The author who first hypothesized geological and climatic causes for the changes in the lagoon area was ALOE (in PASCALE, 1912); in fact he postulated that up to the XI century the entire Salpi area (the new name for Salapia) was affected by a continuous slow subsidence As a result, the buildings of Salpi were partially submerged.

About at the beginning of the XI century the coastal areas close to Salpi were covered by a wood whose extension was so large that it became one of the most important in the whole empire of Frederick II of Swabia. Furthermore, historical studies (MASSON, 1978) show that in that period the Tavoliere plain was depopulated, uncultivated and covered by thick vegetation, whereas the areas surroundings the lagoon had a high density of population.

During the XII century, the first circumstantial reports regarding the physical environment of the Tavoliere area can be found in Geographica, by GUIDONE (1119) where the thriving activity at the Salpi salt pans was documented.

Besides the chronicles by the monks and the noblemen, the first cartographic maps and documents started to be published in this period. The Tavoliere was represented for the first time by the Arabian voyager EDRISI (Libro del Re Ruggero, 1139 - 1154). Other maps representing the Tavoliere can be found in the Cronaca by JORDANUS (1134 - 1339 in manoscr. Vat. Lat. n. 1960) and in the so called Carta d'Italia del Trecento (Archivio di Stato, Firenze). Reliable reports describe this part of the Tavoliere plain as a damp area date back the first half of the XIII century. Around the year 1230 Emperor Frederick II allowed the ships of the Venetian Republic to be admitted freely to the lagoonal harbour of Salpi (CALDARA and PENNETTA 1992). This means that the lagoon was again navigable. Furthermore, in the year 1255, the Montevergine Monastery received from the Cardinal Ottaviano a "residence" in Salpi and the annuity of "two lakes" (the former, smaller, fresh-watered and placed in the internal area, the latter, closer to the sea, with salt-water) divided by a narrow ridge.

In the year 1223 a large earthquake razed Siponto and the lagoonal harbour almost closed down. The town was again destroyed in the 1255 due to another devastating earthquake which caused irreparable damage. Besides the decay of the town, the dereliction of the harbour occurred as it filled by fluvial and marine sediments. In addition, the presence of a sandy ridge caused the persistence of brackish malarial water (DE TROIA, 1985). This situation induced King Manfredi, the son of Emperor Frederick II of Swabia, to found, between the years 1256 and 1261, a new town in a healthy area: Manfredonia.

THE MODERN AGE

In the XV century the Tavoliere plain was quite depopulated: there were very few inhabitants in the towns, malaria was endemic and farming was hardly practiced. The whole coastal area remained as a lagoon until the XVI century. A document of the year 1487 (the document is kept at the library "De Gemmis" in Bari, volume Mss B/4, vol. 28, fol. 102), records exorbitant taxes imposed for the lake fishing in the territorial jurisdiction of Salpi. A document dated 1504 (library "De Gemmis" in Bari, volume Mss B/3, vol. 54, fol. 56) describes the lacustrine area as a "swamp".

At the beginning of the Modern Age the Lake of Salpi was separated from the sea by a narrow ridge of dunes about 150 m in width. In general, between the XV and the XVII century it was reported that (BULIFON, 1690; PARRINO, 1770) long dry spells occurred, which caused serious famines in the whole southern Italy. Maybe due to the drought itself, the entire coastal area turned to a marsh: it was in this period that the town of Salpi was abandoned due to malaria (ALBERTI, 1551).

During the XVI century the Tavoliere was a desolate landscape, subject to famines after long periods of drought. A great number of swamps started to dry up. During the following years a deep change in climatic conditions occurred. The increase in flows of the Candelaro river and the Cervaro stream caused water levels in the swamps all around Siponto to rise. The historical maps show the presence of three little basins in the southern area of Manfredonia: the areas on the left of the Candelaro river were occupied by the "Saline" (saltworks), which represented one of the few sources of income in the region; the saltworks continued to be productive up to the first years of the XVIII century; on the right of the Candelaro river the ancient maps show the presence of two lakes: the Bersentino lake (or Versentino lake), and the Salso lake.

The first attempt at land reclamation occurred after the famine and catarrh epidemic. It was carried out, between 1559 and 1562 (PASCALE, 1912). A detailed representation of the damp area near Salpi can be seen in a geographic map by MAGINI (in: ANGELINI and CARLONE, 1986). The map shows the swamp, a little pond in the internal area, some little Salt pans close to the mouth of the Ofanto river, the Salso lake, divided by the Salpi lake by the Carapelle stream, the Salt pans of Siponto, and a swamp fed by the Cervaro river, whose mouth does not reach the Candelaro river (Figure 6).

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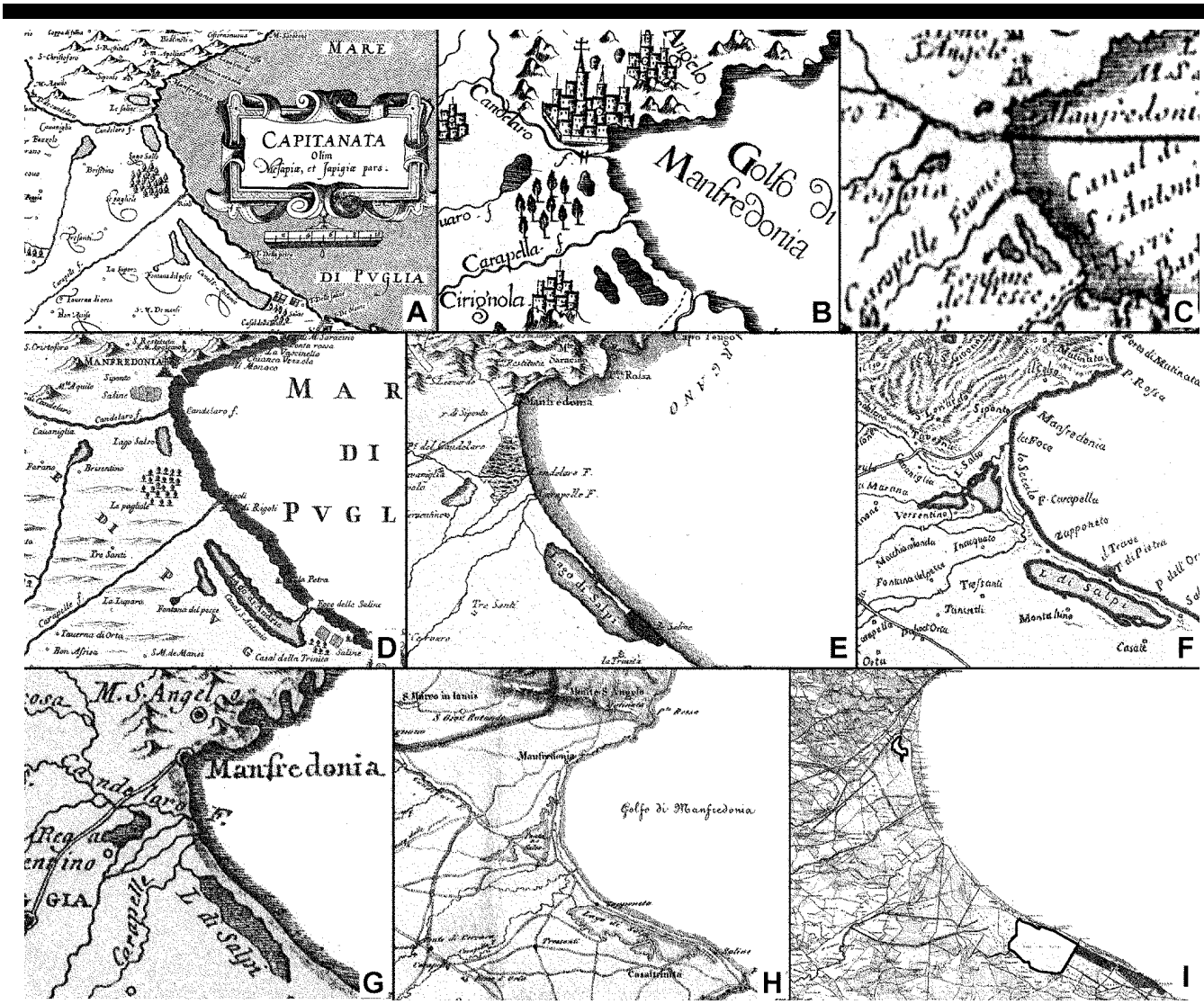

Figure 6. Salpi lake as represented in cartography between the XVII and XX Century; A) Magini, 1620; B) from the Capucinorum Atlas, 1649; C) Coronelli, 1688; D) Pietrasanta and De Rossi, 1714; E) Zatta, 1779 - 1785; F) Rosati, 1787; G) Anonymous, 1789; H) Marzolla, 1836; I) from the Italian Istituto Geografico Militare historical cartography 1909. A, B, D, F and H from ANGELINI and CARLONE, 1986; C, E from FONSECA, 1984; G from a map called Parte Occidentale del Regno di Napoli, kept at "De Gemmis" library in Bari;

There are only indirect and incomplete reports related to the first decades of the XVIII century. The data show that, during the years 1780 to 1825 rainfall was low during winter and high aridity occurred during summer. These conditions led the water level of the lagoon to fall below sea level. The bottom of the lagoon then became a salt pan. Abbé LONGANO (1790), during his journey in the Tavoliere described the Salpi lake as a swamp and he considered that the reason of the scarce population of the region was due to the arid climate. Maybe, this is the reason why this land was called Terra dei Morti (Dead Land).

The Salso lake and the Versentino lake reached their maximum development about at the end of the XVIII century, after the ruinous floods of the Cervaro and Carapelle rivers, about 1795 (GIUSTINIANI, 1795 - 1805). The Friar MANICONE (1806) gives more information about the physical conditions of the area. The Salpi lagoon resulted to be divided from the sea by a narrow strip of land, about 20 km in length and 3 km width. In the XIX century the coastal areas of the Tavoliere plain continued to be affected by malaria, in spite of the attempts at reclamation of lands, among which was the impressive project of AFAN DE RIVERAof 1808, that was never completed (AFAN DE RIVERA, 1845).

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After the Unity of Italy the idea for reclaiming the damp areas in the Tavoliere plain took place again (PARETO, 1865), but in spite of the efforts the projects were never completed because of insufficient funds and the inadequacy of the projects themselves (ANGELONI, 1884). Nevertheless, the Tavoliere landscape was changing. Maps and documents of the XX century show that the coastal swamps existed up to the 1930s (Figure 7). During these years projects for the reclamation of lands were provided by the Serpieri-Iandolo Law and, afterwards, by the "1938 Project for agrarian transformation" (Piano di Trasformazione Agraria) and by the "1948 Project for Land Transformation" (Piano di Trasformazione Fondiaria). After 1933 these lands came under the administration of the "Consorzio per la Bonifica della Capitanata", which realized the plan to reclaim the marsh, by filling the coastal lakes: the Salso and the Salpi lakes (COLACICCO, 1955; CICCONE and COMO, 1984).

After World War II, almost the whole coastal area underwent great modification as economic activities changed and the intensive, high-specialized agriculture replaced sheep-breeding and extensive agriculture. Coastal tourism also flourished and along a narrow strip of land between the mouth of Ofanto river and Manfredonia, during the last 40 years, many tourism facilities were developed, which can accommodate, during the summer holidays, tens of thousands of people (Figure 8).

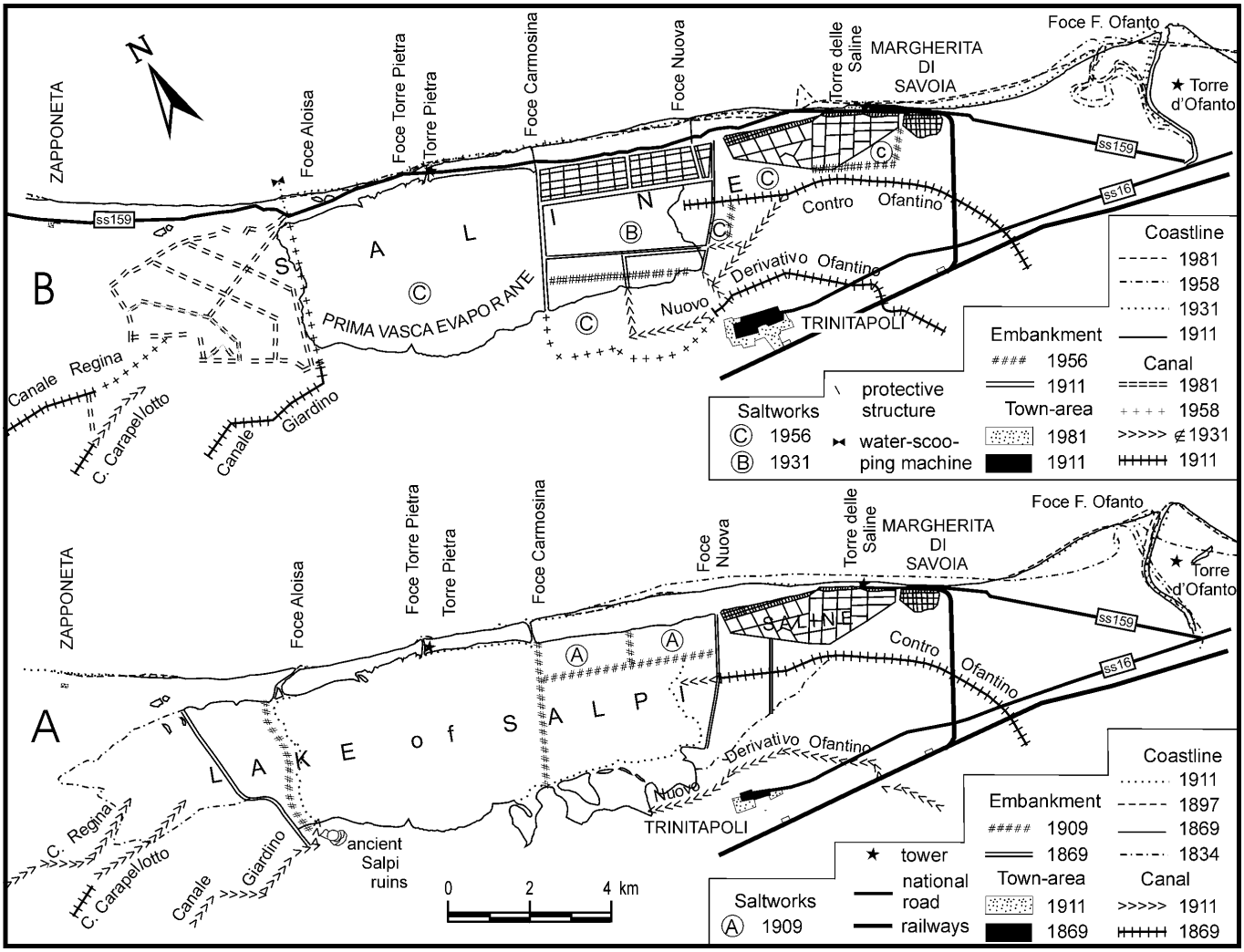

Figure 7 Transformations undergone by the Lake of Salpi since 1834, after the Carta di Cabotaggio della costa del Regno delle due Sicilie (Neaples, Reale Ufficio Topografico, 1834), Italian Istituto Geografico Militare and Istituto Idrografico della Marina historical cartography. This area is now occupied by the widest saltworks in Europe.

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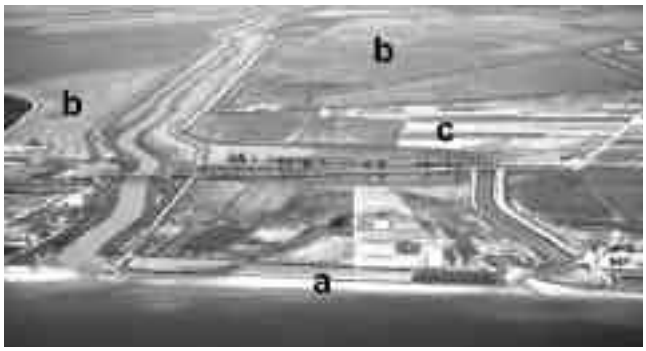

Figure 8. An aerial view of the mouth of the Carapelle stream. Besides the beach (a), wide plots of land (b) and some fish farmings (c) can be observed.

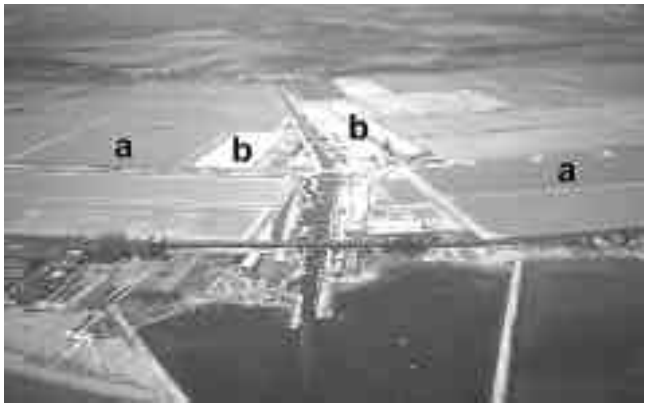

Figure 9. Aerial view of the Margherita di Savoia saltworks; in the foreground the evaporation ponds (greiysh surfaces) and the big salt piles (white surfaces) can be observed. The harbour extension works modified the longshore sediment drift.

In areas characterised by high clay content grounds, mechanical diggers are used to mix the superficial soils with sand from buried dunes a few meters below ground level. As a result, ground is better drained and is better suited to cultivation.

The great lagoon which was established at the beginning of the Holocene, is now almost disappeared after the agrarian transformations and reclamation. At present only a few areas remain: a small damp area called "Palude Frattarolo" (a relict of the ancient Salso lake included in the district of the Gargano National Park), the Margherita di Savoia Saltworks (Saline di Margherita di Savoia), protected after the 1970 Ramsar International Convention, and a number of small artificial basins used as aquaculture ponds or as fishing-hunting reserves.

ACKNOWLEDGMENTS

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