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# The vegetation of S'Ena Arrubia lagoon (centre-western Sardinia)

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**Abstract**
This study describes the vegetation of S'Ena Arrubia lagoon, in the Gulf of Oristano, in the centre-western coast of Sardinia. This lagoon is classified as: Special Protection Zone (S.P.Z.) according to EEC Directive 79/409, community importance site according to EEC Directive 92/43, I.B.A. (Important Birds Area) site and fixed oasis of fauna protection and natural reserve. Throughout the years it was subject to several alterations. The most important ones were carried out in the Seventies and allowed the marine water upwelling and the fast removal of freshwater coming from the watershed. Before the fulfilment of these interventions, lagoon waters had a low salinity, as demonstrated by previous vegetation studies that showed the presence of freshwater communities and, only to a smaller extent, of halo-tolerant and halophile ones.
This phytosociologic study led to the identification of several associations that are showed in the groups of merely halophile vegetation, in the freshwater and subhalophile lagoon vegetation and in the merely anthropogen vegetation typologies. The location of the considered typologies is represented with distributive patterns, which synthesise the current state of vegetation referring to the salinity.
Two new associations, the *Inulo crithmoidis-Paspaletum vaginati* and the *Astero tripolii-Bolboschoenetum maritimi*, are here described. The first is dominated by the presence of *Paspalum vaginatum* Swartz, recorded for the second time in Italy and for the first time in Sardinia. It is recorded near the inlet, where it forms mosaics together with *Salicornietum emerici* association and it is also present, as *bolboschoenetosum maritimi* subassociation, in more inland and less salty zones. The latter new association includes the subhalophile reedswamps that are present in the areas flooded by salty waters for a long time, where it replaces the *Scirpetum compacto-littoralis*, a less halophile association present in several sites of the Mediterranean and also in Sardinia.
In addition, it is necessary to point out the recovery of *Salicornietum venetae* association, characterised by the presence of *Salicornia veneta* Pign. et Lausi, which was believed endemic in the North Adriatic lagoons.
Finally, the significance of environmental changes fulfilled in the basin, which are the reason for some vegetation modifications and are detected by comparison between current associations and those at the beginning of the Seventies, is pointed out.

Key words: diachronous analyses, environmental changes, halophile and freshwater vegetation, phytosociology, Sardinia.

**Riassunto**
*La vegetazione della laguna di S'Ena Arrubia (Sardegna centro-occidentale).* Viene descritta la vegetazione della laguna di S'Ena Arrubia, situata lungo la costa centro-occidentale della Sardegna, nel Golfo di Oristano. La laguna, classificata come zona a protezione speciale (Z.P.S.) in base alla Direttiva 79/409 CEE, sito d'importanza comunitaria in base alla Direttiva 92/43 CEE, sito I.B.A. (Important Birds Area), oasi permanente di protezione faunistica e riserva naturale, ha subito negli anni numerose trasformazioni. Le più importanti, realizzate negli anni '70, consentirono la risalita delle acque marine e il veloce smaltimento delle acque dolci provenienti dal bacino idrografico. Prima che questi interventi fossero realizzati, le acque della laguna avevano un basso tenore di salinità, come attestano gli studi effettuati in precedenza sulla vegetazione, che mostrano ambienti caratterizzati soprattutto dalla presenza di comunità d'acqua dolce e in misura minore di alotolleranti ed alofile.
Lo studio fitosociologico realizzato ha portato al riconoscimento di numerose associazioni che vengono presentate nei gruppi della vegetazione francamente alofila, della vegetazione lacustre dulciacquicola e subalofila e delle tipologie chiaramente antropogene.
La localizzazione delle tipologie considerate viene rappresentata con schemi distributivi che sintetizzano l'attuale stato della vegetazione in rapporto con la salinità dei luoghi.
Vengono in particolare descritte le nuove associazioni *Inulo crithmoidis-Paspaletum vaginati* e *Astero tripolii-Bolboschoenetum maritimi.* La prima, dominata dalla presenza di *Paspalum vaginatum* Swartz, che viene segnalato per la seconda volta in Italia e per la prima in Sardegna, si rinviene in prossimità della foce dove forma mosaici con l'associazione *Salicornietum emerici* mentre in zone più interne e meno salate è presente con la subassociazione *bolboschoenetosum maritimi.* La seconda nuova associazione inquadra i canneti subalofili presenti in aree lungamente inondate da acque ancora ricche in sali, dove vicaria l'associazione *Scirpetum compacto-littoralis,* meno alofila, e già rinvenuta in numerose località del Mediterraneo e per la Sardegna.
Da segnalare il rinvenimento dell'associazione *Salicornietum venetae*, caratterizzata dalla presenza di *Salicornia veneta* Pign. et Lausi, che si riteneva endemica delle lagune nord-adriatiche.
Da ultimo, nelle conclusioni, si enfatizza il significato delle trasformazioni ambientali subite dal bacino che hanno indotto le trasformazioni sulla vegetazione e che sono rilevate attraverso i confronti tra le associazioni attuali e quelle presenti agli inizi degli anni '70.

Parole chiave: analisi diacroniche, fitosociologia, Sardegna, trasformazioni ambientali, vegetazione alofila e dulciacquicola.

## Introduction

S'Ena Arrubia lagoon is located along the centre-western coast of Sardinia, in the Gulf of Oristano (Fig. 1). In the northern part, it borders on the temporary lagoon of Zrugu Trottu, from which it is divided by a road, and it is surrounded with agricultural lands owing to the reclamation performed by Consorzio di Bonifica Terralba-Arborea. The lagoon is classified as: Special Protection Zone (S.P.Z.) according to EEC Directive 79/409, community importance site according to EEC Directive 92/43, I.B.A. (Important Birds Area) site, fixed oasis of fauna protection and natural reserve.

This work is a part of an ecological research, included in LIFE Nature Project 97, promoted by the Province of Oristano: since 1997 it has been carrying out by the Department of Botany and Plant Ecology of Sassari University. The general aim is the integrated management and the protection of the lagoon, and this research deals with the phytosociological study finalised to the drawing up of the 1:2,500 vegetation map.

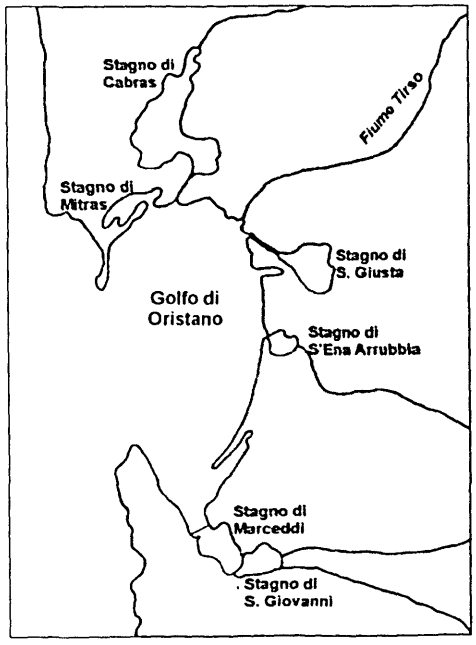


Fig. 1 – Geographical location of S'Ena Arrubia Lagoon (Oristano, Sardinia)

## Environmental characteristics

S'Ena Arrubia lagoon is the residual of the wider Sassu pond, reclaimed in 1934 together with its adjacent wetlands. Formerly, the pond was connected to the sea through a wide natural inlet. In consequence of the land reclamation, it received supplies from its catchment area through some man-made canals currently flowing into the south-eastern shore and pouring into the lagoon rain and waste waters. These supplies caused the obstruction of the natural inlet, so that during the Seventies a canal was built in the coastal dune to get the lagoon to communicate permanently with the sea. Moreover, a bottom canal running along the main axis of the lagoon starts from the sea inlet and reaches the freshwater inlet area. Its building had the aim to allow an efficient upwelling of seawaters during the tide and a fast removal of waters coming from the watershed. Before these human interventions, lagoon waters had a low salinity. This is demonstrated by vegetation studies where the presence of freshwater community and, to a smaller extent, of halo-tolerant and halophile ones is described (Valsecchi, 1972; Corbetta & Lorenzoni, 1976).

At present S'Ena Arrubia lagoon, which is part of a wet land system facing the Gulf of Oristano, extends over about 1.43 $Km^2$; its depth ranges between 30 and 150 cm, with a mean depth of 45 cm, while the water volume is about 1.2 x $10^6$ $m^3$ (Sechi, 1982).

The Gulf of Oristano, characterised by low and sandy shores, is the sea mouth of a tectonic depression linked with the NNW trending normal fault system, which caused the deepening and the fill of the Campidano Graben during the Pliocene and the Pleistocene. The centre of the great scythe-like inlet forming the coast of the Gulf is the consequence of Pleistocene eustatic dynamics and shows a plane and depressed morphology, where the main wetlands are located. The most spread quaternary deposits are old terraced floods, recent and current sandy dunes, mud-sandy and subordinately pebbly floods of Tirso delta, sand- and mud-clayey lagoon and brackish facies and recent marine sands (Di Gregorio, 1976).

The typology of the main spread soils shows a very considerable evolution, with formation of well-defined clayey profiles, high depth, scanty organic matter and lack of carbonates, mean to high permeability. Predominant soils are Typic, Aquic and Ultic Palexeralf, while the subordinate ones are Xerofluvents and Ochraqualfs. The present use is mainly agricultural, with restrictions due to the excess of skeleton, slow to very slow drainage and moderate danger of erosion (Vacca, oral comment).

Thermal rain gage data related to the thirty-year period 1951-1981 (Annali Idrologici del Servizio Idrografico) at the thermometric station of S. Giusta and rain gage station of Sassu show that precipitation has a typically seasonal trend and is concentrated between October and March. The most rain month is December

with a mean of 99,6 mm, the driest one is July with 3,6 mm. Diurnal mean temperature is 16.9°C, the maximum mean of the warmest month (July) is 32.3°C, the minimum mean of the coldest month (January) is 5.2°C. The absolute maximum is 39.8°C, the absolute minimum is 1.6°C; annual thermal range is 10.4°C. The area is affected by a Mediterranean half-dry climate, with warm and not very rainy summers and relatively rainy and not very cold winters.

## Materials and Methods

The study of vegetation was carried out with the phytosociologic method. Relevés multivariate analysis was conducted with the statistical programme "Matedit" (Burba *et al.*, 1992).

## Vegetation

The study of vegetation concerned all the populations growing around S'Ena Arrubia lagoon, in the morphologic depression of its basin. Xerophile formations that cover the highest substratum belonging to subsequent phases of the Mediterranean shrub vegetation or psammophile vegetation of the dune field near the inlet are omitted.

For the sake of expository convenience, the identified associations are introduced in the groups of merely halophile vegetation, freshwater and subhalophile lagoon vegetation and in the merely anthropogen typologies. The location of the considered typologies is represented with distributive patterns, which synthesise the current state of vegetation with reference to the salinity of the place.

## Halophile vegetation

Vegetation typologies pertinent to the clearly halophile components often create a mosaic among the perennial formations – hemicryptophytes, chamaephytes and nanophanerophytes – and the therophytes, dominated by different species of the genus *Salicornia*. The distribution of these vegetation types is determined by the substratum morphology, the soil granulometry, together with salinity variations and the pertinent level of soil humidity. Variations of ecological gradients induced by anthropic interventions are also important, as it will be pointed out in the conclusions.

### Chamaephytic halophile vegetation

Relevés carried out on perennial halophile vegetation can be grouped in four vegetation typologies that are pointed out in the dendrogram of Fig. 2, where salinity gradient variations are clear, as it was already observed in the studies performed to define the ecological valence of association in Sacca di Bellocchio, North Adriatic Sea (Andreucci *et al.*, 1998 and 2000).

*CYNOMORIO COCCINEAE-HALIMIONETUM PORTULACOIDIS* (Tab. 1)

Along canals, at altitudes slightly higher than other formations constituting the halophile grasslands, the vegetation caracterized by *Halimione portulacoides* growing on well-drained soils is found. This association was described for the little islands of La Maddalena Archipelago (Biondi, 1992). In Sardinia and in Ratino Island, Southern Corsica (Paradis & Lorenzoni, 1995), it is the vicarious of *Puccinellio festuciformis-Halimionetum portulacoidis* association, described for Camargue (Géhu *et al.*, 1992) and gived for other coastal sites of France and continental Italy (Géhu & Biondi, 1995).

*PUCCINELLIO CONVOLUTAE-ARTHROCNEMETUM MACROSTACHYI* (Tab. 2)

This association, already recorded in Sardinia (Géhu *et al.*, 1984) and in Corsica (Géhu & Biondi, 1994), is found along the northern and western lagoon shores, where it is bounded to hyperhyaline soils, higher than vegetation of the following association with which it is generally in contact.

*PUCCINIELLO FESTUCIFORMIS-SARCOCORNIETUM FRUTICOSAE* (Tab. 3)

This association, found in several coastal sites of Sardinia (Géhu *et al.*, 1984; Mossa & Biondi, 1992) and Corsica (Géhu & Biondi, 1994), presently covers wide areas of the lagoon forming mosaics with *Salicornia emerici* glasswort vegetation and making contact with halophile hemicryptophyte formations, such as *Spartina juncea* and *Juncus maritimus*. Fine granulometric soil is subject to short flood periods and, however, keeps a certain level of humidity in summer. The relevé 50 (Tab. 3) shows the contact with *Puccinellio convolutae-Arthrocnemetum macrostachyi* association.

*SARCOCORNIETUM DEFLEXAE* (Tab. 4)

This association with Mediterranean distribution is dominated by a prostrated and rooted form of *Sarcocornia*

Tab. 1 - CYNOMORIO COCCINEAE - HALIMIONETUM PORTULACOIDIS Biondi 1992

| | | Number of relevé | 7 | 97 | 89 | 8 | 40 | 53 | 54 | 55 | 60 | 46 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | Surface (sqm) | 20 | 5 | 30 | 30 | 10 | 10 | 10 | 25 | 20 | 25 | 20 |
| | | Character species of the association | | | | | | | | | | | |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | 5.5 | 5.5 | 4.5 | 4.5 | 5.5 | 4.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 |
| MEDIT.-TURAN. | G rhiz | Cynomorium coccineum L. | 1.1 | . | . | . | . | 1.2 | . | . | . | . | . |
| | | Character species of superior unities | | | | | | | | | | | |
| MEDIT.ATL.(STENO) | Ch suffr | Inula crithmoides L. | . | 1.2 | . | 2.3 | 3.3 | . | . | +.2 | 1.2 | 1.2 | +.2 |
| EURIMEDIT. | H ros | Limonium narbonense Miller | 2.2 | 2.3 | 2.2 | 1.1 | 2.2 | . | . | . | . | . | . |
| EURIMEDIT. | H caesp | Agropyron elongatum (Host) Beauv. | . | 1.2 | +.2 | +.2 | 3.3 | . | . | . | . | . | . |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott | . | + | +.2 | 1.2 | . | . | . | . | . | . | . |
| STENOMEDIT. | Ch succ | Arthrocnemum macrostachyum (Moric.) Moris | . | . | . | . | . | . | . | +.2 | +.2 | . | . |
| EURASIAT. | H bienn | Aster tripolium L. | . | . | . | . | . | . | . | . | . | . | 2.3 |
| | | Other species | | | | | | | | | | | |
| SUBCOSMOP. | G rhiz | Juncus maritimus Lam. | . | . | . | +.2 | + | . | . | . | . | . | . |
| ANFI ATL. | G rhiz | Spartina juncea (Michx.) Willd. | . | . | . | . | 1.2 | . | . | 1.2 | + | + | . |
| W-STENOMEDIT. | H caesp | Juncus multibracteatus Tineo | . | . | . | 3.4 | . | . | +.0 | . | . | . | . |
| EURIMEDIT. | H caesp | Juncus acutus L. | . | . | . | . | +.2 | . | . | . | . | . | . |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | . | . | . | . | . | . | +.0 | . | . | + | 1.2 |

Tab. 2 - PUCCINELLIO CONVOLUTAE - ARTHROCNEMETUM MACROSTACHYI (Br.-Bl. (1928) 1933) Géhu ex Géhu et al. 1984

| | | Number of relevé | 45 | 90 | 47 |
|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 100 |
| | | Surface (sqm) | 5 | 5 | 10 |
| | | Character species of the association | | | |
| STENOMEDIT. | Ch succ | Arthrocnemum macrostachyum (Moric.) Moris | 4.5 | 5.5 | 5.5 |
| | | Character species of superior unities | | | |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | 1.2 | . | 3.4 |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott | 2.3 | . | . |
| MEDIT.ATL.(STENO) | Ch suffr | Inula crithmoides L. | . | . | 1.2 |
| SUBCOSMOP. | G rhiz | Juncus maritimus Lam. | . | . | +.2 |
| | | Other species | | | |
| EURIMEDIT. | H caesp | Agropyron elongatum (Host) Beauv. | . | . | +.2 |

Tab. 3 - PUCCINELLIO FESTUCIFORMIS - SARCOCORNIETUM FRUTICOSAE (Br.-Bl. 1928) Géhu 1976

| | | Number of relevé | 50 | 64 | 51 | 91 |
|---|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 100 | 100 |
| | | Surface (sqm) | 25 | 30 | 25 | 4 |
| | | Character species of the association | | | | |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott | 3.4 | 5.5 | 5.5 | 5.5 |
| | | Character species of superior unities | | | | |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | 3.4 | 2.3 | 2.3 | . |
| MEDIT.ATL.(STENO) | Ch suffr | Inula crithmoides L. | 3.4 | 2.3 | . | . |
| STENOMEDIT. | Ch succ | Arthrocnemum macrostachyum (Moric.) Moris | 1.2 | . | . | . |
| EURIMEDIT. | H ros | Limonium narbonense Miller | + | . | . | . |
| | | Other species | | | | |
| EURIMEDIT. | H caesp | Agropyron elongatum (Host) Beauv. | (+.2) | . | . | . |
| S-MEDIT. | G rhiz | Juncus subulatus Forsskal | 1.1 | . | . | . |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | . | 1.0 | . | . |
| EURIMEDIT. | H scap | Inula viscosa (L.) Aiton | + | . | . | . |

*fruticosa* (L.) A.J. Scott. This form was described by Rouy (1910) as *Salicornia fruticosa* var. *deflexa* and for a long time it was confused with *Sarcocornia perennis* (Miller) A.J. Scott (= *Salicornia radicans* Sm), whose distribution is only on the Atlantic coast (Géhu & Biondi, 1994). Records of *Salicornietum perennis* already mentioned in Sardinia (Géhu *et al.*, 1984; Biondi, 1992) must then be related to *Sarcocornietum deflexae* association. In S'Ena Arrubia lagoon, this association is present in open and plane areas, along the western shore where it is subject to prolonged floods and summer drying up conditions. Consequently, soil is hyperhyaline.

Annual halophile vegetation

Pioneer communities of halophile therophytes distributed around the whole pond are present along the lagoon shores, in inland depressions, in old settling ponds, in glades of perennial halophile vegetation, in areas subject to prolonged floods and summer drying up.

*SUAEDO MARITIMAE-SALICORNIETUM PATULAE* (Tab. 5)

This peri-Mediterranean association was found in more inland areas, especially along the shores of settling ponds that now are out of use. It covers substrata slightly higher than other halophile therophyte formations and consequently it is drier in summer and, perhaps, saltier (Géhu *et al.*, 1984, Biondi, 1992).

In S'Ena Arrubia, it has topographic contacts with the halophile perennial vegetation of *Sarcocornietum fruticosae* association (Tab. 5, relevé 1 and 5; Tab. 6, relevé 4).

*SALICORNIETUM EMERICI* (Tab. 6)

In the inlet area, it grows in sites subject to floods for a long time and open to the sea or on settling pond bottoms, which are slightly wet in summer. It is an association already recorded for Sardinia: in Cagliari and Marceddì (Oristano) ponds (Géhu *et al.*, 1984).

*SALICORNIETUM VENETAE* (Tab. 7)

*Salicornietum venetae* association, mono-specific and characterised by the presence of the endemic *Salicornia veneta* Pignatti *et* Lausi, was found along the less high shores of the pond and along the side runoff canals near the inlet. It is often associated with organic matter deposits and highly eutrophic waters. The presence of this association states some chorologic problems, since *Salicornia veneta* was believed endemic in the North Adriatic lagoons (Lausi, 1969; Géhu *et al.*, 1984; Géhu & Biondi, 1995; Piccoli, 1995; Géhu & Biondi, 1996), whereas other species of glasswort found in S'Ena Arrubia have a peri- and Western Mediterranean distribution. The morphologic characteristics of some specimens found in S'Ena Arrubia coincide with those described for *S. veneta*, that is a tetraploid species, as *S. emerici*. *S. veneta* is very similar to *S. emerici*, from

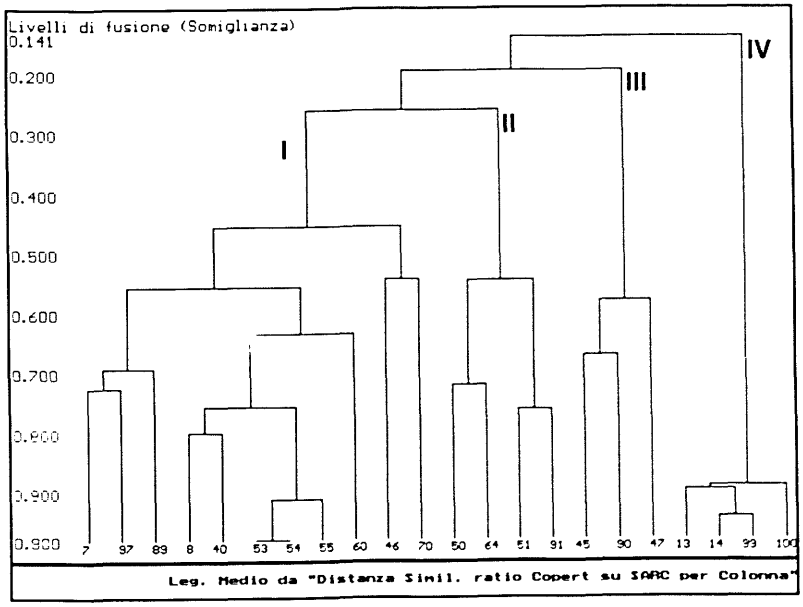


Fig. 2 – Dendrogram of relevés referred to *SALICORNIETEA FRUTICOSAE* class halophile vegetation (Tabs. 1, 2, 3 and 4): cluster I identifies *Cynomorio coccineae-Halimionetum portulacoidis* ass.; cluster II *Puccinellio festuciformis-Sarcocornietum fruticosae* ass.; cluster III *Puccinellio convolutae-Arthrocnemetum macrostachyi* ass.; cluster IV *Sarcocornietum deflexae* ass.

Tab. 4 - SARCOCORNIETUM DEFLEXAE (Br.-Bl. 1931) Lahondère, Géhu & Paradis 1992

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Number of relevé | 13 | 14 | 99 | 100 |
| | | Vegetation cover (%) | 100 | 100 | 100 | 95 |
| | | Surface (sqm) | 30 | 30 | 50 | 20 |
| | | Character species of the association | | | | |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott var. deflexa | 5.5 | 5.5 | 4.5 | 5.5 |
| | | Character species of superior unities | | | | |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | 2.3 | 1.1 | 1.1 | 1.2 |
| EURIMEDIT. | H ros | Limonium narbonense Miller | + | . | . | + |
| | | Other species | | | | |
| ANFI ATL. | G rhiz | Spartina juncea (Michx.) Willd. | . | +(0) | . | . |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | +(0) | +(0) | . | . |

Tab. 5 - SUEDO MARITIMAE - SALICORNIETUM PATULAE (Brullo & Furnari 1976) Géhu & Géhu-Franck 1984

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of relevé | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | Vegetation cover (%) | 90 | 90 | 90 | 90 | 100 | 80 | 100 |
| | | Surface (sqm) | 3 | 100 | 30 | 50 | 20 | 8 | 20 |
| | | Character species of the association | | | | | | | |
| STENOMEDIT | T scap | Salicornia patula Duval-Jouve | 5.5 | 5.5 | 5.5 | 5.5 | 4.5 | 3.4 | 1.1 |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | 1.2 | +.2 | . | . | . | 2.3 | 3.4 |
| | | Character species of superior unities | | | | | | | |
| STENOMEDIT | T scap | Salicornia emerici Duval-Jouve | 1.2 | 1.1 | + | . | 1.1 | . | . |
| | | Other species | | | | | | | |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott | + | . | . | . | 1.1 | . | . |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | (+.2) | . | . | . | 1.1 | . | . |
| CIRCUMBOR. | T scap | Atriplex patula L. | . | . | . | . | + | . | 1.2 |

Tab. 6 - SALICORNIETUM EMERICI (O. de Bolòs 1962) Brullo & Furnari 1976

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Number of relevé | 1 | 2 | 3 | 4 | 5 | 6 |
| | | Vegetation cover (%) | 90 | 98 | 90 | 100 | 90 | 75 |
| | | Surface (sqm) | 20 | 20 | 20 | 30 | 20 | 10 |
| | | Character species of the association | | | | | | |
| STENOMEDIT | T scap | Salicornia emerici Duval-Jouve | 5.1 | 4.4 | 4.4 | 4.4 | 5.5 | 4.5 |
| | | Character species of superior unities | | | | | | |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | 3.4 | 3.4 | 2.3 | 1.2 | . | . |
| STENOMEDIT | T scap | Salicornia patula Duval-Jouve | . | . | + | 1.2 | . | . |
| ENDEM. | T scap | Salicornia veneta Pign. et Lausi | . | . | + | + | . | . |
| | | Other species | | | | | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.(0) | 1.2 | (0).+ | . | . | . |
| PALEOTEMP. | T scap | Salsola soda L. | + | . | + | . | . | . |

Tab. 7 - SALICORNIETUM VENETAE Pign. 1966

| | | | | |
|---|---|---|---|---|
| | | Number of relevé | 1 | 2 |
| | | Vegetation cover (%) | 80 | 85 |
| | | Surface (sqm) | 4 | 5 |
| | | Character species of the association | | |
| ENDEM. | T scap | Salicornia veneta Pign. et Lausi | 4.5 | 4.5 |
| | | Character species of superior unities | | |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | . | 2.2 |
| | | Other species | | |
| CIRCUMBOR. | T scap | Atriplex patula L. | . | +.2 |

which it differs for its larger size and its ramification starting from the basis, near the collar. Considering the synecology of this association in our area, it is thought that it can also be a dystrophic population owing to the high trophic level of the lagoon waters.

Annual halonitrophile vegetation

*SALSOLETUM SODAE* (Tab. 8)

In the lagoon areas subject to periodical floods, i. e. near the inlet, characterised by substrata of organic matter, the growth of the paucispecific therophyte vegetation, dominated by *Salsola soda*, occurs. This association is found in several zones of the Mediterranean and in Sardinia (Camarda & Satta, 1995).

*PARAPHOLISO STRIGOSAE-HORDEETUM MARINI* (Tab. 9)

Outside the cingulum of halophile and mosaic vegetation, together with the *Schoeno nigricantis-Plantaginetum crassifoliae* association, on sandy accumulation soils, dry in summer and then subject to stamping, there is the therophyte vegetation flowering in spring and ascribed to this association. This was described for Mont Saint Michel bay (Géhu & de Foucault, 1977) and then it was also found in different ecological conditions on salty soils, such as Pliocene clayey soils giving origin to the Apennines gullies (Biondi *et al.*, 1990a; Pirone, 1995).

Hemicryptophyte halophile grasslands

On constantly wet soils, periodically flooded, several associations with dominance of hemicryptophytes, are found (Fig. 3). They indicate the salinity gradient variation and mark the transition from the merely halophile communities to the halophile and halo-tolerant ones.

*INULO CRITHMOIDIS-PASPALETUM VAGINATI* ass. nova (rel. typus n°5, Tab. 10)

*halimionetosum portucoidis* subass. nova (rel. typus n°66, Tab. 10)

*bolboschoenetosum maritimi* subass. nova (rel. typus n°25, Tab. 10)

On very wet substrata even during summer, on mud soils, this association dominated by *Paspalum vaginatum*, is present. *P. vaginatum* is a very invasive neophyte halophile. It was already recorded in Italy, in Versilia (Tuscany), where it colonises the marine littoral zone of *Cakiletum maritimae* as reported by Arrigoni (1990). This species was already present in S'Ena Arrubia lagoon in the sixties: in fact, there is a herbarium sample (SS!) of the year 1965 [*sub Paspalum paspalodes* (Michx) Scribner], while it is not mentioned in the publication of S'Ena Arrubia (Valsecchi, 1972). This plant was probably rare at that time and at the beginning of the following colonisation stage, which led now *P. vaginatum* to form dense populations in the north of the lagoon, near

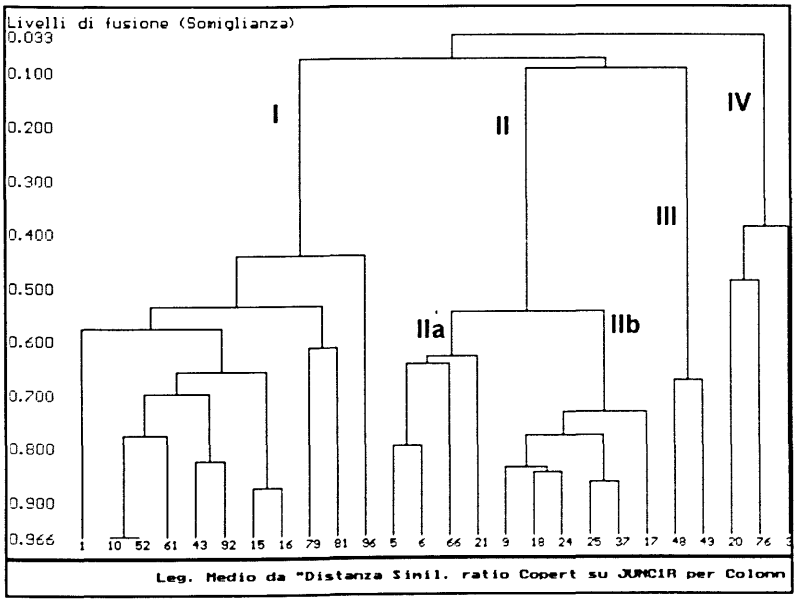


Fig. 3 – Dendrogram of relevés referred to *JUNCETEA MARITIMI* class halophile vegetation (tabs. 10, 11, 12 and 13): cluster I identifies *Junco maritimi-Spartinetum junceae* ass.; cluster II *Inulo crithmoidis-Paspaletum vaginati* ass. (subcluster IIa is the subass. *halimionetosum portulacoidis*; subcluster IIb is the subass. *bolboschoenetosum maritimi*); cluster III *Limonio narbonensis-Juncetum gerardii* ass.; cluster IV *Schoeno nigricantis-Plantaginetum crassifoliae* ass.

Tab.8 - SALSOLETUM SODAE Pign. 1953

| | | Number of relevé | 1 | 2 | 3 |
|---|---|---|---|---|---|
| | | Vegetation cover (%) | 70 | 70 | 90 |
| | | Surface (sqm) | 2 | 1 | 10 |
| | | Character species of the association | | | |
| PALEOTEMP. | T scap | Salsola soda L. | 4.5 | 4.5 | 4.4 |
| | | Other species | | | |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | . | . | 2.3 |
| EURASIAT. | H bienn | Aster tripolium L. | . | . | + |
| AVV. | T scap | Aster squamatus (Sprengel) Hieron. | . | . | 1.2 |

Tab.9 - PARAPHOLISO STRIGOSAE - HORDEETUM MARINI Géhu & de Foucault 1977

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 90 |
| | | Surface (sqm) | 10 | 8 |
| | | Character species of the association | | |
| MEDIT.ATL.(STENO) | T scap | Parapholis strigosa (Dumort.) Hubbard | 5.5 | 5.5 |
| | | Character species of superior unities | | |
| EURIMEDIT. | T scap | Plantago coronopus L. | . | 2.3 |
| MEDIT.ATL. | T scap | Catapodium marinum (L.) Hubbard | 1.3 | . |
| MEDIT.ATL.(STENO) | T scap | Sagina maritima G. Don | 1.1 | . |
| | | Other species | | |
| EURASIAT. | T scap | Sonchus oleraceus L. | . | +.2 |
| STENOMEDIT. | T scap | Cynosurus elegans Desf. | 1.2 | . |
| S-MEDIT. | G rhiz | Juncus subulatus Forsskal | 1.1 | . |
| PALEOTEMP. | H bienn | Centaurium erythraea Rafn | +.2 | . |
| STENOMEDIT. | G bulb | Aetheorrhiza bulbosa (L.) Cass. | 1.1 | + |
| EURIMEDIT. | T scap | Silene gallica L. | + | . |
| SW-MEDIT.-MONT. | T scap | Senecio delphinifolius Vahl | . | + |
| | T scap | Geranium sp. | + | . |

Tab. 10 - INULO CRITHMOIDIS - PASPALETUM VAGINATI ass. nova. (typus rel. 5)
subass. halimionetosum portulacoidis subass. nova (typus rel. 66)
subass. bolboschoenetosum maritimi subass. nova (typus rel. 25)

| | | Number of relevé | 5* | 6 | 66* | 21 | 9 | 18 | 24 | 25* | 37 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | Surface (sqm) | 15 | 15 | 10 | 50 | 20 | 25 | 50 | 50 | 50 | 25 |
| | | Character species of the association | | | | | | | | | | |
| COSMOP. | G rhiz | Paspalum vaginatum Swartz | 5.5 | 5.5 | 5.5 | 3.4 | 5.5 | 5.5 | 5.5 | 3.3 | 5.5 | 5.5 |
| MEDIT.ATL. | Ch suffr | Inula crithmoides L. | 2.2 | + | 2.2 | 3.4 | . | + | . | . | . | +.2 |
| EURASIAT. | H bienn | Aster tripolium L. | 1.2 | + | . | + | . | . | . | 1.1 | 1.2 | . |
| | | Character species of the subassociation | | | | | | | | | | |
| COSMOP. | G rhiz | Bolboschoenus maritimus (L.) Palla var. compactus Hoff. | . | . | . | | . | 1.1 | 1.2 | 1.2 | 2.3 | 3.4 |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | + | 1.2 | 2.2 | + | . | . | . | . | . | + |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | 1.2 | 2.2 | + | . | . | . | . | . | . | . |
| STENOMEDIT. | Ch succ | Arthrocnemum macrostachyum (Moric.) | . | 1.2 | . | . | . | . | . | . | . | . |
| | | Character species of superior unities | | | | | | | | | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.1 | 1.2 | . | 1.2 | 2.3 | 2.2 | 1.1 | 3.3 | 2.3 | 2.1 |
| | | Other species | | | | | | | | | | |
| CIRCUMBOR. | T scap | Atriplex patula L. | 1.2 | +.2 | . | + | 1.2 | + | 2.2 | 1.2 | 1.2 | + |
| PALEOTEMP. | T scap | Salsola soda L. | + | + | . | . | 1.1 | +.2 | + | . | + | . |

the inlet, and in more inland areas characterised by freshwater seepage. In the first zone reporting the presence of the suggested association, the *P. vaginatum* vegetation forms a mosaic with the therophyte halophile community of *Salicornietum emerici* association, covering areas that were formerly colonised by *Phragmites australis* and *Typha latifolia* reedswamps, the latter now completely extinct in the biotope. In the areas closer to the canals, directly connected to the inlet, the subassociation *halimionetosum*, in contact with the *Halimione portulacoides* vegetation, is found. In contrast, in inland areas, where the substratum is more flooded and less salty, due to the tributaries and drainage canals, the subassociation *bolboschoenetosum maritimi* is found.

*Paspalum vaginatum* vegetation was described for different coastal sites of the centre-northern Spain (Bueno Sanchez, 1997; Loidi *et al.*, 1997) as *Agrostio stoloniferae-Paspaletum vaginati* association, whereas in the centre-northern Mediterranean coasts of Iberian Peninsula this vegetation was described as *Astero squamati-Paspaletum vaginati* association (Bòlos, 1988; Perez Badia, 1997). The new association here described is different from the above-mentioned ones, because of its more halophile and less nitrophile floristic complex.

*LIMONIO NARBONENSIS-JUNCETUM GERARDII* (Tab. 11)

The *Juncus gerardi* association has a very localized on three shores where the humidity is always high and soil has a bigger granulometry and has few supplies of phreatic freshwater. This association, described in Corsica (Géhu & Biondi, 1994), is a geovicarious of other Atlantic, continental Europe and Pontic associations, always characterised by the presence of *J. gerardi*.

*JUNCO MARITIMAE-SPARTINETUM JUNCEAE* nom. inv. prop. (Tab. 12)

*Spartina juncea* association grows in more inland areas, all around the lagoon, always on sandy soil more or less wet because of the groundwater. It has a variable floristic suite, which allows identify the contacts with other associations of *Salicornietea fruticosae* class and with *Agropyretalia repentis* order. In this latter case, it is a matter of coenosis due to the fast sand colonisation of deposits derived from frequent strips carried out in order to restore canals and floodwalls near the inlet.

Bòlos (1962) described it in Barcelona zone as *Spartino-Juncetum maritimae*, whose name inversion is here proposed and for which the relevé n. 2, Tab. 54 is identified as lectotype. For this reason *Junco maritimi-spartinetum junceae* Biondi 1992 association, described in La Maddalena Archipelago and also recorded in Corsica (Géhu & Biondi, 1995), must be referred to it.

*SCHOENO NIGRICANTIS-PLANTAGINETUM CRASSIFOLIAE* (Tab. 13)

This hemicryptophyte association is found on soils that are wet in winter but relatively dry in summer. It was recorded in a number of Sardinian coastal zones (Camarda & Satta, 1995) and appears widely spread in Mediterranean, where it is often found in serious degradation conditions. This vegetation is extremely variable and easily damageable by the reclamation of coastal soils (Géhu & Biondi, 1995). In S'Ena Arrubia it is present on the south-western shore, in the shelter of modest and discontinuous residuals of the old dune bar, as demonstrated by the presence of few individuals of *Ephedra distachya* L. growing on slightly higher zones.

Halophile forest formation

*TAMARIX AFRICANA* community (Tab. 14)

Linear and not very deep small streams are present on the northern shore, sandwiched between modest soil dams and the perimeter road, and they are colonised by very reduced formations of a *Tamarix africana* short wood. This vegetation is very similar to that described for rivers in Sicily and indicated as *T. africana* community (Brullo & Spampinato, 1990).

**Freshwater and subhalophile lagoon vegetation**

Freshwater and subhalophile lagoon vegetation includes *Bolboschoenus maritimus* and *Phragmites australis* formations and strips of *Agropyron repens* grassland.

*ASTERO TRIPOLII-BOLBOSCHOENETUM MARITIMI* ass. nova (rel. typus n°1, Tab. 15)

*paspaletosum vaginati* subass. nova (rel. typus n° 8, Tab. 15)

The association identifies the subhalophile reedswamps present in areas flooded for a long time by waters still rich in salts, on mud soils, relatively deep, and it is distributed prevalently on the north and south-eastern shores, along which the freshwater canals start. This vegetation is dominated by *Bolboschoenus maritimus*, in its compact form of sessile spikes, linked with still merely brackish environments. The association is placed in large belts, often in chain contact with *Spartina juncea*

Tab. 11 - LIMONIO NARBONENSIS - JUNCETUM GERARDII Géhu & Biondi 1994

| | | | | |
|---|---|---|---|---|
| | | Number of relevé | 48 | 49 |
| | | Vegetation cover (%) | 100 | 100 |
| | | Surface (sqm) | 8 | 8 |
| | | Character species of the association | | |
| CIRCUMBOR. | G rhiz | Juncus gerardi Loisel. | 5.5 | 5.5 |
| | | Character species of superior unities | | |
| MEDIT.ATL. | H caesp | Carex extensa Good. | . | +.2 |
| MEDIT.ATL.(STENO) | Ch suffr | Inula crithmoides L. | . | 1.2 |
| EURASIAT. | H bienn | Aster tripolium L. | + | . |
| | | Other species | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.0 | 1.(0) |
| EURIMEDIT. | Ch succ | Sarcocornia fruticosa (L.) A. J. Scott | 1.2 | . |
| CIRCUMBOR. | Ch frut | Halimione portulacoides (L.) Aellen | + | . |
| EURIMEDIT. | H caesp | Agropyron elongatum (Host) Beauv. | . | +.2 |
| CIRCUMBOR. | T scap | Atriplex patula L. | 1.1 | . |

Tab. 12 - JUNCO MARITIMI - SPARTINETUM JUNCEAE O. de Bòlos 1962 nom. invert.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of relevé | 1 | 10 | 52 | 61 | 43 | 92 | 15 | 16 | 79 | 81 | 96 |
| | | Vegetation cover (%) | 100 | 100 | 100 | 100 | 90 | 90 | 100 | 100 | 100 | 100 | 100 |
| | | Surface (sqm) | 40 | 50 | 40 | 100 | 60 | 60 | 30 | 10 | 30 | 50 | 6 |
| | | Character species of the association | | | | | | | | | | | |
| ANFI ATL. | G rhiz | Spartina juncea (Michx.) Willd. | 5.5 | 5.5 | 5.5 | 5.5 | 4.4 | 4.4 | 5.5 | 5.5 | 4.5 | 3.3 | 5.5 |
| SUBCOSMOP. | G rhiz | Juncus maritimus Lam. | . | . | + | . | . | . | . | . | 1.2 | 4.4 | + |
| | | Other species | | | | | | | | | | | |
| STENOMEDIT. | G bulb | Aetheorrhiza bulbosa (L.) Cass. | 1.2 | . | . | . | + | 2.2 | . | . | . | . | 3.3 |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.1 | 2.2 | 2.2.0 | 2.2 | 1.(1) | 1.2 | 1.2 | . | 2.2 | + | . |
| MEDIT.ATL. | Ch suffr | Inula crithmoides L. | 4.4 | 1.2 | 1.2 | 1.2 | . | . | . | . | . | . | . |

Tab. 13 - SCHOENO NIGRICANTIS - PLANTAGINETUM CRASSIFOLIAE Br.-Bl. (1931) 1952

| | | | | | |
|---|---|---|---|---|---|
| | | Number of relevé | 20 | 76 | 3 |
| | | Vegetation cover (%) | 95 | 70 | 70 |
| | | Surface (sqm) | 10 | 10 | 30 |
| | | Character species of the association | | | |
| STENOMEDIT. | H ros | Plantago crassifolia Forsskal | 5.5 | 3.4 | 4.5 |
| SUBCOSMOP. | H caesp | Schoenus nigricans L. | . | . | + |
| | | Character species of superior unities | | | |
| SUBCOSMOP. | G rhiz | Juncus maritimus Lam. | 2.3 | . | . |
| EURIMEDIT. | H ros | Limonium narbonense Miller | 1.2 | 1.2 | . |
| | | Other species | | | |
| STENOMEDIT. | G bulb | Aetheorrhiza bulbosa (L.) Cass. | 2.2 | 1.2 | . |
| EURIMEDIT. | G rhiz | Limodorum abortivum (L.) Swartz | . | + | + |
| STENOMEDIT. | G bulb | Serapias cordigera L. | 1.2 | + | . |

or in mosaic distribution with halophile therophytes.

The association is found with a floristic suite of clearly halophile species. The constant presence of *Phragmites australis*, generally not very vital (relevés 2 and 4), points out the pre-existence of a freshwater reedswamps, which was replaced in the same areas by the current *Bolboschoenus maritimus* vegetation, owing to the high increase of salinity in the whole basin.

Where the water level decreases considerably during summer, with temporary drying up, *Paspalum vaginatum*, which distinguishes the *paspaletosum vaginati* subassociation, invades the association (Fig. 4).

In S'Ena Arrubia, this vegetation is vicarious of *Scirpetum compacto-littoralis* Br.-Bl (1931) 1952 em. Rivas.-Mart. *et al.* 1980, clearly less halophile, found in Sardinia, too (Camarda & Satta, 1995). However, it is believed that even this association might be present near the tributaries.

*SCIRPO-JUNCETUM SUBULATI* (Tab. 16)

This association is found in the more inland areas of south-eastern shore of the lagoon, where freshwater canals flow. It forms little islands of vegetation that often are brought into contact with *Junco maritimi-Spartinetum junceae* association. *Scirpo-Juncetum subulati* association was described in Camargue (Géhu *et al.*, 1992) and it is found in Corsica, (Géhu & Biondi, 1994). It is considered rare and vulnerable. Its spreading in S'Ena Arrubia lagoon seems strictly linked with the presence of modest inland depressions, flooded in winter and spring and dry in summer, so that considerable chloride concentrations are produced on the substratum.

*PHRAGMITETUM COMMUNIS* (Tab. 17)

On south-eastern shore, reached by the tributaries, freshwater reedswamps which can be ascribed to this association are placed in a compact front, in contact with *Astero tripolii-Bolboschoenetum maritimi* or *Junco maritimi-Spartinetum junceae* association.

*LOTO TENUIS-AGROPYRETUM REPENTIS* (Tab. 18)

On the southern shore, in a wide clayey plane terrace, one side delimited by the mean water canal, post-farming grasslands are present. They grow on soils with high groundwater, as demonstrated by the presence of *Agropyron repens* and *Althaea officinalis*. In these areas, *Phragmites australis*, *Juncus acutus* and *Carex otrubae* dominate the floristic combination when a considerable stagnation occurs.

*LEMNETUM MINORIS* (Tab.19)

The sporadic presence of mono-specific *Lemna minor* formations was found near the inlet of the low water canal: it was distributed in very sunny little meanders, near the pond border. In these little areas, water level and trophic variations are considerable and related to variations of seasonal capacity of both the freshwater canal and the tide. Therefore, it is a pioneer vegetation, linked with ephemeral environments and it is able to stand wide variations of environmental parameters, including those of anthropic origins (Scoppola, 1982). In S'Ena Arrubia lagoon, near the inlet canals, the presence of a stratum of

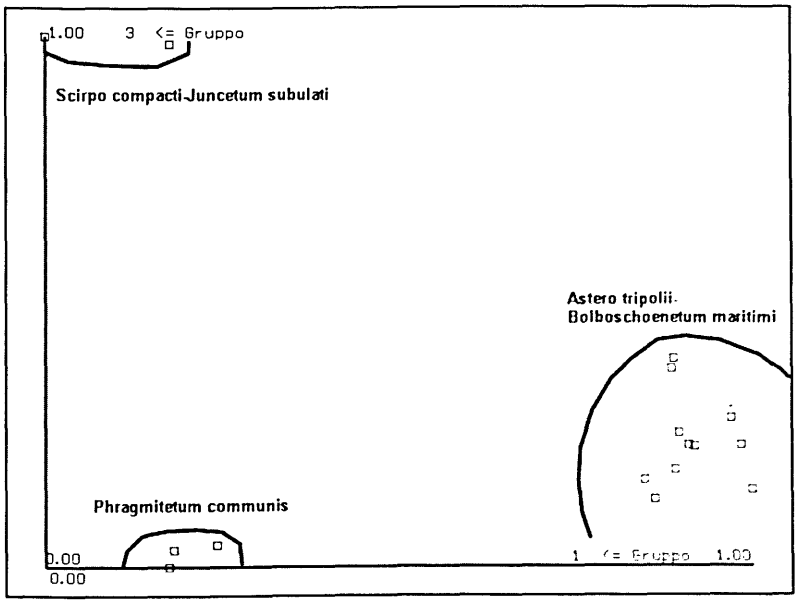


Fig. 4 – Dispersion diagram of freshwater and subhalophile vegetation of the class PHRAGMITI-MAGNOCARICETEA (Tabs. 15, 16 and 17)

Tab. 14 - TAMARIX AFRICANA community

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 90 | 80 |
| | | Surface (sqm) | 50 | 10 |
| W-STENOMEDIT. | P scap | Tamarix africana Poiret | 4.5 | 4.5 |
| | | Other species | | |
| STENOMEDIT. | G bulb | Aetheorrhiza bulbosa (L.) Cass. | 2.2 | +.2 |
| STENOMEDIT. | H scand | Convolvulus althaeoides L. | +.2 | +.2 |
| EURASIAT. | T scap | Avena fatua L. | +.2 | + |
| STENOMEDIT. | G rhiz | Asparagus acutifolius L. | + | +.2 |
| CIRCUMBOR. | G rhiz | Agropyron repens (L.) Beauv. | . | 1.1 |
| STENOMEDIT. | H caesp | Oryzopsis miliacea (L.) Asch. et Schweinf. | +.2 | . |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | . | + |
| PALEOTEMP. | H bienn | Daucus carota L. | . | + |

Tab. 15 -ASTERO TRIPOLII-BOLBOSCHOENETUM MARITIMI ass. nova (typus rel. 1)
subass. paspaletosum vaginati subass. nova (typus rel. 8)

| | | Number of relevé | 1* | 2 | 3 | 4 | 5 | 6 | 7 | 8* | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 90 | 100 | 100 | 100 | 80 | 100 | 98 | 100 | 100 |
| | | Surface (sqm) | 60 | 5 | 5 | 10 | 30 | 100 | 50 | 100 | 70 | 50 | 100 |
| | | Character species of the association | | | | | | | | | | | |
| COSMOP. | G rhiz | Bolboschoenus maritimus (L.) Palla var. compactus Hoff. | 4.5 | 1.1 | 5.5 | . | 1.1 | 1.2 | . | 3.3 | 3.4 | 2.3 | 4.4 |
| EURASIAT. | H bienn | Aster tripolium L. | 1.2 | 2.2 | 1.1 | 2.3 | 2.2 | 2.2 | 2.2 | 1.2 | 2.3 | + | 1.2 |
| | | Character species of the subassociation | | | | | | | | | | | |
| COSMOP. | G rhiz | Paspalum vaginatum Swartz | . | . | . | . | . | 4.5 | 3.4 | 2.3 | 1.2 | 1.2 | + |
| | | Character species of superior unities | | | | | | | | | | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 3.3 | 2.3.0 | 1.2 | 2.3.0 | 2.3 | 1.1 | 1.1 | 3.4 | 3.3 | 4.4 | 4.4 |
| | | Other species | | | | | | | | | | | |
| CIRCUMBOR. | T scap | Atriplex patula L. | 2.3 | 2.3 | . | 3.4 | 1.2 | 2.2 | 2.3 | 2.2 | 3.3 | 3.3 | 1.2 |
| COSMOP. | T scap | Suaeda maritima (L.) Dumort. | . | 3.3 | + | . | 3.4 | . | . | . | + | . | . |
| MEDIT.ATL.(STENO) | Ch suffr | Inula crithmoides L. | + | . | +.2 | . | . | . | . | 1.1 | . | . | . |

Tab. 16 - SCIRPO COMPACTI - JUNCETUM SUBULATI Géhu et al. 1992

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 |
| | | Surface (sqm) | 50 | 30 |
| | | Character species of the association | | |
| S-MEDIT. | G rhiz | Juncus subulatus Forsskal | 4.4 | 4.5 |
| | | Character species of superior unities | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.2 | 1.1 |
| | | Other species | | |
| EURASIAT. | H bienn | Aster tripolium L. | 2.2 | 1.2 |
| MEDIT.ATL. | Ch suffr | Inula crithmoides L. | 1.2 | 1.1 |
| EUROP. | H scap | Rumex hydrolapathum Hudson | + | + |

*Lemna gibba* and *Lemna minor* floating vegetation was already recorded (Valsecchi, 1972).

## Anthropogen vegetation

Merely anthropogen vegetation is present in marginal areas, farther from the lagoon and neighbouring with the perimeter roads, not directly affected by fresh or salty water supplies.

*RESEDO ALBAE-CHRYSANTHEMETUM CORONARII* (Tab. 20)

This association is found on soil accumulations consisting of scrappy material, on soils nitrified by anthropozoogen action and in uncultivated lands near the perimeter roads. It is a heliophilous and nitrophilous phytocoenosis dominated by *Chrysantemum coronarium*, which has a wide distribution in the entire western and centre Mediterranean and was already recorded in Sardinia (Biondi *et al.*, 1990; Biondi *et al.*, 1993).

*INULO VISCOSAE-ORYZOPSIETUM MILIACEAE* (Tab. 21)

It is present along the road borders, on little humps not trampled and periodically cut that delimit the ditches, on very dry and detritus soils. This vegetation consists of perennial great grasses, bushes of *Inula viscosa* and *Oryzopsis miliacea*. The association, widely spread in the entire centre-western Mediterranean (De Bolòs, 1975; Cantò *et al.*, 1986) was already found in Sardinia (Biondi *et al.*, 1993).

## Lagoon management and vegetation

The reclamation of areas around S'Ena Arrubia was performed by the opening of canals able to drain the freshwaters of surrounding soils and by the obstruction of the lagoon sea inlet: in the Seventies, this resulted in a considerable decrease of lagoon water salinity and had effect on vegetation. In 1972, Valsecchi pointed out the presence of a wide community of *Phragmites australis* (ascribed to a generic *Phragmitetum*), that colonised the shores without interruption together with *Typha latifolia* variant and with *Aster tripolium* halophile facies. Almost mono-specific *Typha latifolia* formations were also present near the canals: this species was not found anymore during the present research and for this reason it can be considered extinct in the biotope, together with many other freshwater species. Chronologically linked to this kind of vegetation are rooted or floating submerged aquatic plants communities that can be ascribed to *Potametalia* and *Lemnetalia* orders with: *Potamogeton crispus* L., *P. pectinatus* L., *Ceratophyllum demersum* L., *Myriophyllum verticillatum* L., *Lemna gibba* L., *L. minor*. Among them, only few small populations of *L. minor* were found during the present study.

Outside the reedswamp, *Scirpetum maritimi* was located, whereas the very halophile communities of perennial glassworts, also characterised by the presence of *Puccinellia festuciformis* (Host.) Parl (*sub P. distans* (L.) Parl.), lived in still more inland zones, "flooded only in winter and completely dry in the other months" (Valsecchi, 1972) (Fig. 5). After the building of a canal opened in the coastal dune and of another one running along the main axis of the lagoon as far as the freshwater inlet area, determined a remarkable inflow of sea waters and a fast removal of waters coming from the watershed: consequently, an increase of salinity occurs. The increase of mean salinity in water lagoon was also due, during the same years, to the change of the irrigation system in surrounding farming areas, from flowing to sprinkling, which caused a sudden fall of freshwater inputs in the lagoon. Within few years, this resulted in a considerable change: vegetation turned from freshwater into halophile.

In order to understand the importance of these variations, to compare several vegetation successions in relation to the changes of salinity conditions owing to the engineering works is significant (Fig. 6). Areas formerly covered by canebrakes on the northern shore are currently covered by *Inulo crithmoidis-Paspaletum vaginati* association: it is found on the outsider area in *bolboschoenetosum* subassociation. This can be explained as the persistence of *Phragmitetum* elements in a clear salinity crisis (Tab. 10). In these same areas, subject to erosion, halophile therophyte communities form mosaics. Strip works for building canals and subsequent accumulation of scrappy material have also promoted the spreading of the psammophile *Junco maritimi-Spartinetum junceae* association, with which the *Tamarix africana* shrub vegetation currently links up, under sub-halophile edaphic conditions. Transects relative to the zone near the inlet show that areas formerly covered by reedswamps are currently covered by halophile chamaephyte succession.

On the contrary, the halophile vegetation – represented by *Salicornietea*, *Thero-Suaedetea* and *Juncetea maritimi* classes – is prevalently distributed on the shores near the sea inlet. In the higher zones, perennial

Tab. 17 - PHRAGMITETUM COMMUNIS (Koch 1926) Schmale 1939

| | | Number of relevé | 1 | 2 | 3 |
|---|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 | 100 |
| | | Surface (sqm) | 100 | 50 | 30 |
| | | Character species of the association | | | |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 5.5 | 4.5 | 5.5 |
| PALEOTEMP. | H scand | Calystegia sepium (L.) R.Br. | 4.4 | 2.3 | 1.1 |

Tab. 18 - LOTO TENUIS- AGROPYRETUM REPENTIS Biondi, Vagge, Baldoni & Taffetani 1997

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 |
| | | Surface (sqm) | 40 | 30 |
| | | Character species of the association | | |
| CIRCUMBOR. | G rhiz | Agropyron repens (L.) Beauv. | 5.5 | 5.5 |
| SE-EUROP. | H scap | Althaea officinalis L. | 1.2 | 1.1 |
| PALEOTEMP. | H scap | Lotus tenuis W. et K. | 1.1 | 2.2 |
| | | Character species of superior unities | | |
| PALEOTEMP. | H scand | Calystegia sepium (L.) R.Br. | 2.2 | 1.2 |
| PALEOTEMP. | G rhiz | Convolvulus arvensis L. | + | 1.1 |
| | | Other species | | |
| EURIMEDIT. | H caesp | Juncus acutus L. | 2.2 | 1.1 |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 1.2 | + |
| EURIMEDIT.ATL. | H caesp | Carex otrubae Podp. | 1.2 | 2.2 |
| EURASIAT. | H scap | Rumex conglomeratus Murray | 1.1 | + |
| MEDIT.ATL.(EURI) | H scap | Oenanthe silaifolia Bieb. | + | + |

Tab. 19 - LEMNETUM MINORIS Oberdorfer ex Th. Muller & Gars 1960

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 50 | 70 |
| | | Surface (sqm) | 1 | 2 |
| | | Character species of the association | | |
| SUBCOSMOP. | I nat | Lemna minor L. | 2.2 | 3.3 |

Tab. 20 - RESEDO ALBAE - CHRYSANTHEMETUM CORONARII O. de Bòlos & Molinier 1958

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 100 | 100 |
| | | Surface (sqm) | 50 | 30 |
| | | Character species of the association | | |
| STENOMEDIT. | T scap | Chrysanthemum coronarium L. | 4.5 | 5.5 |
| | | Other species | | |
| | H bienn | Daucus carota L. ssp. maximus (Desf.) Ball | 2.2 | . |
| PALEOTEMP. | G rhiz | Convolvulus arvensis L. | 1.2 | . |
| EURIMEDIT. | T scap | Picris echioides L. (plantule) | 1.2 | . |
| EURASIAT. | T scap | Avena fatua L. | . | 1.2 |
| STENOMEDIT. | T scap | Hypochoeris achyrophorus L. | 1.2 | . |
| EURASIAT. | H scap | Rumex conglomeratus Murray | + | + |
| EURIMEDIT. | H bienn | Scolymus hispanicus L. | + | . |
| SUBCOSMOP. | T scap | Bromus hordeaceus L. | . | + |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | +.0 | . |

Tab. 21 - INULO VISCOSAE - ORYZOPSIETUM MILIACEAE (A. & O. de Bòlos 1950) O. de Bòlos 1957

| | | Number of relevé | 1 | 2 |
|---|---|---|---|---|
| | | Vegetation cover (%) | 90 | 100 |
| | | Surface (sqm) | 50 | 30 |
| | | Character species of the association | | |
| EURIMEDIT. | H scap | Inula viscosa (L.) Aiton | 4.5 | 3.3 |
| STENOMEDIT. | H caesp | Oryzopsis miliacea (L.) Asch. et Schweinf. | 1.2 | +.2 |
| | | Character species of the subassociation | | |
| CIRCUMBOR. | G rhiz | Agropyron repens (L.) Beauv. | . | 4.5 |
| SUBCOSMOP. | He | Phragmites australis (Cav.) Trin. | 2.3 | . |
| PALEOTEMP. | H bienn | Daucus carota L. ssp. maximus (Desf.) Ball | 1.1 | 1.1 |
| S-MEDIT. | H scap | Foeniculum vulgare Miller ssp. piperitum (Ucria) Coutinho | 2.2 | 2.2 |
| | | Other species | | |
| STENOMEDIT. | G bulb | Aetheorrhiza bulbosa (L.) Cass. | 1.2 | + |
| AVV. | T scap | Aster squamatus (Sprengel) Hieron. | + | 1.2 |
| PALEOTEMP. | G rhiz | Convolvulus arvensis L. | + | 1.2 |
| STENOMEDIT. | H scap | Reichardia picroides (L.) Roth | + | + |
| CIRCUMBOR. | H scap | Rumex acetosa L. | + | + |
| PALEOTEMP. | H scap | Cichorium intybus L. | + | + |

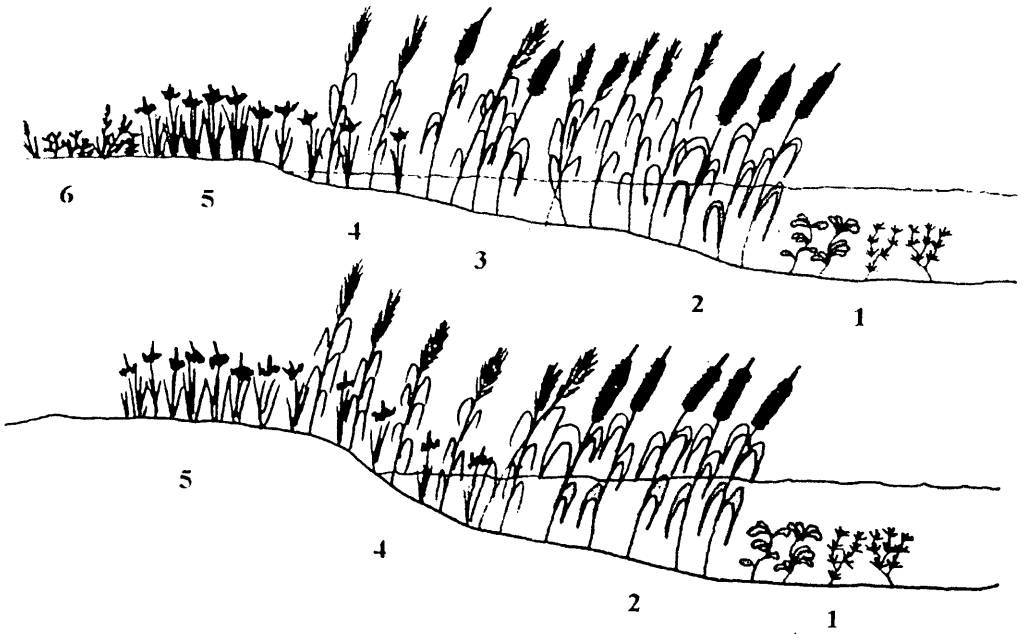


Fig. 5 - Patterns of vegetation distribution in 1972 in the northern (a) and in the western edge (b) of S'Ena Arrubia Lagoon, before human interventions that led to increase of water salinity. 1= submerged vegetation with *Myriophyllum* sp. and *Potamogeton crispus*; 2= *Typhetum latifoliae*; 3= *Phragmitetum*; 4= *Scirpetum compacto-littoralis*; 5= *Junco maritimi-Spartinetum junceae*; 6= *Puccinellio festuciformis-Sarcocornietum fruticosae* (reinterpreted and redrawn from Valsecchi, 1972)

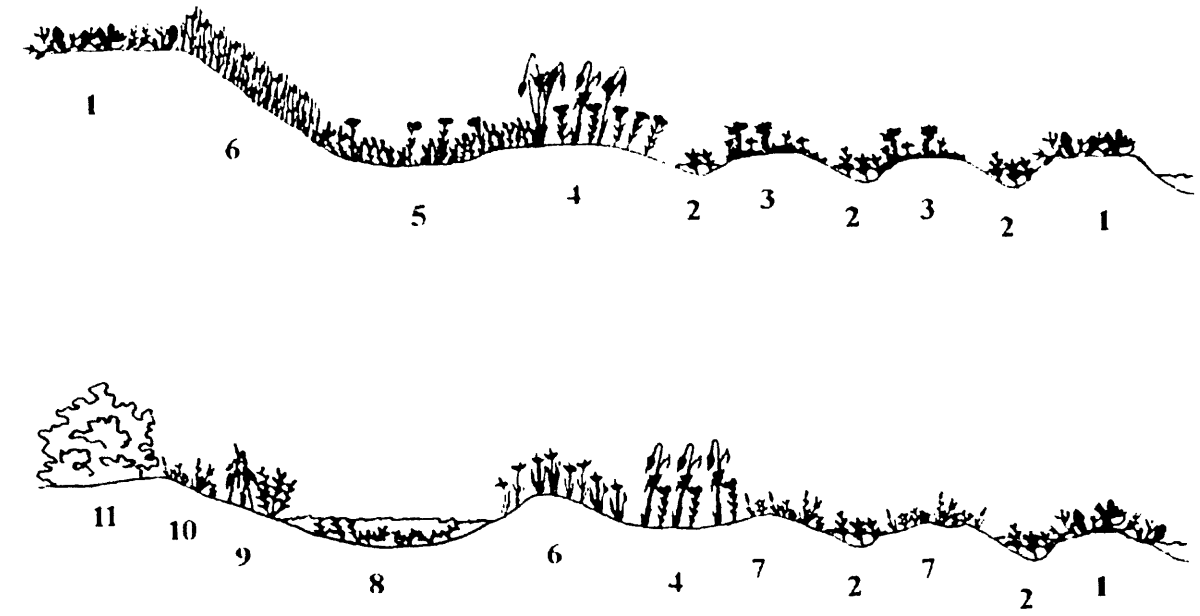


Fig. 6 - Current patterns of vegetation distribution in the northern (a) and in the western edge (b) of S'Ena Arrubia Lagoon. 1= *Cynomorio coccineae-Halimionetum portulacoidis*; 2= *Salicornietum emerici*; 3= *Inulo crithmoidis-Paspaletum vaginati*; 4= *Astero tripolii-Bolboschoenetum maritimi*; 5= *Inulo crithmoidis-Paspaletum vaginati bolboschoenetosum*; 6= *Junco maritimi-Spartinetum junceae*; 7= *Puccinellio festuciformis-Sarcocornietum fruticosae*; 8= *Sarcocornietum deflexae*; 9= *Puccinellio convolutae-Arthrocnemetum macrostachyi*; 10= *Schoeno nigricantis-Plantaginetum crassifoliae*; 11= *Myrto-Lentiscetum*

communities of *Salicornietea fruticosae* represent it, while in the areas flooded for a longer time the therophyte communities of *Thero-Suaedeta* dominate. Interesting aspects of perennial halophile vegetation are also present in more inland tablelands, which are affected by floods owing to topographic factors, perhaps corresponding with halophile formations mentioned by Valsecchi (1972). The biotope is currently deprived in *Puccinellia festuciformis*, maybe owing to the salinity increase. Communities of *Juncetea maritimi* class form more or less linear belts along all the shores, as regards anthropic sandy deposits or brackish depressions. Communities of *Phragmiti-Magnocaricetea* represent halo-tolerant and freshwater vegetation and they are dominant on the shores near the mouth of freshwater canals (north-east and south-east edges). The Halo-tolerant component, represented by *Astero tripolii-Bolboschoenetum maritimi* association, is very frequent spread in the areas formerly covered by *Phragmitetum* and indicates the transition towards the freshwater lagoon vegetation that is restricted near the canals.

**Syntaxonomic scheme**

*THERO-SUADETEA* Riv.-Mart. 1972
- *Thero-Salicornietalia europaeae* Tx. in Tx. & Oberdorfer ex Géhu *et* Géhu-Franck 1984
  - *Salicornion patulae* Géhu & Géhu-Franck 1984
    - *Suaedo maritimae-Salicornietum patulae* (Brullo & Furnari 1976) Géhu & Géhu-Franck 1984
    - *Salicornietum emerici* O. de Bolòs 1962 ex Brullo & Furnari 1976
    - *Salicornietum venetae* Pignatti 1966
- *Thero-Suaedetalia* Br.-Bl. & O. de Bolòs 1958
  - *Thero-Suaedion* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952
    - *Salsoletum sodae* Pignatti 1953

*SAGINETEA MARITIMAE* Westhoff, Van Leeuwen & Adriani 1962
- *Frankenietalia pulverulentae* Riv.-Mart. ex Castroviejo & Porta 1976
  - *Frankenion pulverulentae* Riv.-Mart. ex Castroviejo & Porta 1976
    - *Parapholiso strigosae-Hordeetum marini* Géhu & de Foucault 1977

*SALICORNIETEA FRUTICOSAE* Br.-Bl. & Tx. ex A. & O. Bolòs 1950
- *Salicornietalia fruticosae* Br.-Bl. 1933
  - *Salicornion fruticosae* Br.-Bl. 1933
    - *Salicornienion fruticosae* Rivas-Martìnez, Lousa, Diaz, Fernandez-Gonzalez & Costa 1990
      - *Sarcocornietum deflexae* (Br.-Bl. 1931) Lahondère, Géhu & Paradis 1992
      - *Puccinellio festuciformis-Sarcocornietum fruticosae* (Br.-Bl. 1928) J.M. Géhu 1976
      - *Cynomorio coccineae-Halimionetum portulacoidis* Biondi 1992
    - *Arthrocnemion glauci* Rivas-Martìnez & Costa 1984
      - *Arthrocnemenion glauci* Rivas-Martìnez 1980
        - *Puccinellio convolutae-Arthrocnemetum macrostachyi* (Br.-Bl. (1928) 1933) Géhu ex Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Géhu-Franck, Caniglia et Veri 1984

*JUNCETEA MARITIMI* Br.-Bl. in Br.-Bl. & Roussine & Nègre 1952
- *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934
  - *Juncion maritimi* Br.-Bl. ex Horvatic 1934

*Inulo crithmoidis-Paspaletum vaginati* ass. nova
*bolboschoenetosum maritimi* subass. nova
*halimionetosum portulacoidis* subass. nova
*Junco maritimi-Spartinetum junceae* nom. inv. prop. O. de Bolòs 1962
(= *Junco maritimi-Spartinetum junceae* Biondi 1992)
*Limonio narbonensis-Juncetum gerardii* Géhu & Biondi 1994
*Juncus maritimus community*
*Plantaginion crassifoliae* Br. Bl. 1993
*Schoeno nigricantis-Plantaginetum crassifoliae* Br.-Bl. in Br.-Bl., Roussine & Negre &1952

*NERIO-TAMARICETEA* Br.-Bl. & Bòlos 1958
*Tamaricetalia africanae* Br.Bl. & Bòlos 1958 em. Izco, Fernàndez & Molina 1984
*Tamaricion africanae* Br.Bl. & Bòlos 1958
*Tamarix africana* community

*LEMNETEA MINORIS* Tx. ex O. de Bòlos & Masclans 1955
*Lemnetalia minoris* Tx. ex O. de Bòlos & Masclans 1955
*Lemnion minoris* Tx. ex O. de Bòlos & Masclans 1955
*Lemnetum minoris* Oberdorfer ex Th. Müller & Gärs 1960

*PHRAGMITI-MAGNOCARICETEA* Klika in Klika & Novak 1941
*Scirpetalia compacti* Hejny in Holub., Hejny, Moravec et Neuhaüsl 1967 corr. Riv.-Mart. *et al.* 1980
*Scirpion compacto-littoralis* Riv.-Mart. in Riv.-Mart. *et al.* 1980
*Scirpo-Juncetum subulati* Géhu *et al.* 1992
*Astero tripolii-Bolboschoenetum maritimi* ass. nova
*paspaletosum vaginati* subass. nova
*Phragmitetalia* Koch 1926 em. Pignatti 1954
*Phragmition communis* Koch 1926
*Phragmitetum communis* (Koch 1926) Schmale 1939

*ARTEMISIETEA VULGARIS* Lohm., Prsg. & Tx. ex von Rochow 1951
*Agropyretalia repentis* Oberdorfer, Muller & Gors in Oberdorfer *et al.* 1967
*Bromo-Oryzopsion miliaceae* O. de Bolòs 1970
*Inulo viscosae-Oryzopsietum miliaceae* (A. & O. de Bolòs 1950) O. de Bolòs 1957
*Inulo viscosae-Agropyrion repentis* Biondi & Allegrezza 1996
*Loto tenuis-Agropyretum repentis* Biondi, Vagge, Baldoni & Taffetani 1997

*STELLARIETEA MEDIAE* Tx., Lohm. & Preising ex von Rochow 1951
*Sisymbretalia officinalis* J. Tx. in Lohmeyer *et al.* 1962 em. Riv.-Mart. *et al.* 1991
*Hordeion leporini* Br.-Bl. in Br.-Bl., Gajewski, Wraber & Walas 1936
*Resedo albae-Chrysanthemetum coronarii* O. de Bòlos & Molinier 1958

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## Sites and dates of relevés

Tab. 1: 1, 6 northern edge, peninsula (15/03/99); 2 western edge (11/11/99); 3 northern edge, peninsula (12/11/99); 4 southern edge, transition between halophile and halotolerant vegetation (20/06/99); 5 western edge, in front of pine wood (28/10/99); 7 eastern edge, in front of water-scooping house (20/06/99); 8, 9, 10 inlet area, near new fishermen house (28/10/99); 11 northern edge, inlet area, border of tanks (28/10/99).

Tab. 2: 12, 14 southern edge (20/06/99); 13 northern edge, peninsula (12/11/99).

Tab. 3: 15, 17 western edge (30/06/99); 16 inlet area, border of a dead canal (28/10/99); 18 northern edge, peninsula (12/11/99).

Tab. 4: 19, 21 southern edge (05/11/98); 20, 22 southern edge (11/11/99).

Tab. 5: 1 southern edge, lateral basin, perennially submerged linear annual vegetation (05/11/98); 2, 3 northern edge, inlet, between the new fishermen house and the road, first tank (28/10/99); 4, 6 northern edge, inlet, between the new fishermen house and the road, second tank (28/10/99); 5 western edge, bight (11/11/99); 7 northern edge, peninsula (12/11/99).

Tab. 6: 1, 3 northern edge, near fishermen house (05/11/98); 2 southern edge (28/10/99); 4, 5 northern edge, peninsula, depression around well (2/11/99); 6 northern edge, peninsula (12/11/99).

Tab. 7: 1 border of canal, inlet area (28/10/99); 2 inlet area, mosaic (10/5/99).

Tab. 8: 1 northern edge, inlet area, near new house, dry tank (28/10/99); 2 northern edge, near house (05/11/98); 3 northern edge, depression in the reclamation tank (28/10/99).

Tab. 9: 1 western edge, glades in the *Cynomorio coccineae-Halimionetum portulacoidis* (11/11/99); 2 western edge, therophytic meadow (06/11/98).

Tab. 10: 1, 2, 5 northern edge, near fishermen house, mosaic, on 1,5 m islets divided each other by linear depressions (05/11/98); 3 southern edge, (28/10/99); 4, 7, 8 northern edge, near the boats (10/05/99); 6, 10 northern edge, along the road near the gate (06/11/98); 9 southern edge, fishermen house, canal on the left, linear vegetation between *Phragmitetum communis* and *Suaedo maritimae-Salicornietum patulae*, (27/05/99); 11, 12 southern edge, linear vegetation between *Phragmitetum communis* and *Suaedo maritimae-Salicornietum patulae* (2/11/99).

Tab. 11: 1 eastern edge (20/06/99); 2 northern edge, in front of the gate (20/06/99).

Tab. 12: 1, 2, 12 northern edge, embankment between the canal and the house, well drained sandy soil, (05/11/98); 3, 4 inlet area (new house) (28/10/99); 5, 6 inlet area, the locks, on hoarded material (06/11/98); 7 southern edge, in front of the water-scooping house (20/06/99); 8 northern edge, peninsula (12/11/99); 9, 10 eastern edge, at the left of the fishermen house, before *Phragmitetum communis* (02/11/99); 11 western edge, bight (11/11/99).

Tab. 13: 1 western edge (06/11/98); 2 western edge (2/11/99); 3 southern edge, fishermen house, on burnt soil (27/05/99).

Tab. 14: 1, 2 northern edge, depression in the reclamation tank near road (2/11/99).

Tab. 15: 1, 6, 7, 8, 9, 11 northern edge (10/05/99); 2, 4 northern edge, peninsula (12/11/99); 3 eastern edge in front of water-scooping house, (20/06/99); 5 western edge (11/11/99); 10 southern edge, fishermen house, on the left of the canal, (27/05/99).

Tab. 16: 1, 2 northern edge, near the boats, in front of the *Junco maritimi-Spartinetum junceae* (10/05/99).

Tab. 17: 1, 2 southern edge, on the left of the mean water canal, interior area, dry soil (27/05/99); 3, 4 southern edge, on the left of the mean water canal, interior area, dry soil (2/11/99).

Tab. 18: 1, 2 eastern edge, at the right of the mean water canal outlet (20/06/99).

Tab. 19: 1, 2 eastern edge, in front of the water-scooping house (20/06/99).

Tab. 20: 1, 2 northern edge, near the road, reclamation tank (2/11/99).

Tab. 21: 1, 2 northern edge, reclamation tank, further the block-house (28/10/99).

## Sporadic species

Tab. 1: 2 *Aetheorrhiza bulbosa* (L.) Cass. 1.2; 3 *Rumex conglomeratus* Murray +, *Allium roseum* L. 1.1, *Asparagus acutifolius* L. +, *Juncus subulatus* Forsskal 1.2; 5 Agropyron pungens (Pers.) R. et S. +, *Cynosurus elegans* Desf. +, *Reichardia picroides* (L.) Roth +; 11 *Atriplex latifolia* Wahlenb. +, *Rumex conglomeratus* Murray +.

Tab. 5: 1 *Limonium narbonense* Miller +; 5 *Juncus subulatus* Forsskal 2.2, *Phragmites australis* (Cav.) Trin. 1.0, *Inula crithmoides* L. +.0.

Tab. 6: 4 *Aster tripolium* L. 1.1, *Limonium narbonense* Miller +, *Sarcocornia fruticosa* (L.) A. J. Scott +; 6 *Atriplex patula* L. +.

Tab. 10: 3 *Sarcocornia fruticosa* (L.) A. J. Scott +, *Salicornia emerici* Duval-Jouve +; 4 *Salicornia emerici* Duval-Jouve +, *Sonchus tenerrimus* L. +; 5 *Salicornia patula* Duval-Jouve +; 6 *Carex distans* L. +.2; 9 *Juncus subulatus* Forsskal +; 10 *Aster squamatus* (Sprengel) Hieron. +.

Tab. 12: 1 *Beta vulgaris* L. ssp. *maritima* (L.) Arcang. +, *Rumex pulcher* L. +; 4 *Aster tripolium* L. 1.2, *Sarcocornia fruticosa* (L.) A. J. Scott 1.2, *Atriplex patula* L. +, *Halimione portulacoides* (L.) Aellen 1.2; 5 *Anthemis maritima* L. 1.2, *Lotus cytisoides* L. +; 6 5 *Anthemis maritima* L. 1.2; 7 *Agropyron pungens* (Pers.) R. et S. +, *Calystegia sepium* (L.) R.Br. +; 9 *Agropyron repens* (L.) Beauv. 1.2, *Inula viscosa* (L.) Aiton 1.2, *Oenanthe lachenalii* Gmelin 1.2, *Althaea officinalis* L. +; 10 *Althaea officinalis* L. +, *Oenanthe lachenalii* Gmelin 2.2, *Paspalum vaginatum* Schwartz 1.2, *Juncus acutus* L. 1.2; 11 *Agropyron repens* (L.) Beauv. 2.2, *Juncus acutus* L. 1.2, *Daucus carota* L. ssp. *maximus* (Desf.) Ball +; 12 *Agropyron pungens* (Pers.) R. et S. 3.4.

Tab. 13: 1 *Halimione portulacoides* (L.) Aellen 1.2, *Orchis papilionacea* L. +.2, *Spartina juncea* (Michx.) Willd. +; 2 *Triglochin laxiflorum* Guss. +.2, *Cynosurus elegans* Desf. 2.2, *Trifolium angustifolium* L. +, *Asphodelus microcarpus* Salzm. et Viv. +, *Spiranthes spiralis* (L.) Koch +; 3 *Inula crithmoides* L. 1.2, *Juncus acutus* L. 1.2, *Juncus subulatus* Forsskal +.

Tab. 15: 1 *Halimione portulacoides* (L.) Aellen +; 2 *Salicornia emerici* Duval-Jouve 1.2; 3 *Agropyron elongatum* (Host) Beauv. 1.2, *Salicornia veneta* Pign. et Lausi +, *Polypogon monspeliensis* (L.) Desf. +; 5 *Salsola soda* L. +; 8 *Salsola soda* L. 1.2; 9 *Salsola soda* L. +.

Tab. 16: 1 *Paspalum vaginatum* Schwartz +, *Salicornia emerici* Duval-Jouve 1.2, *Suaeda maritima* (L.) Dumort. 1.2.

Tab. 18: 1 *Avena fatua* L. +.

Tab. 21: 1 *Thymelaea hirsuta* (L.) Endl. 1.2, *Cynosurus echinatus* L. 1.2, *Asparagus acutifolius* L. 1.1, *Sonchus oleraceus* L. +, *Beta vulgaris* L. ssp. *maritima* (L.) Arcang. +, *Rumex conglomeratus* Murray +, *Chondrilla juncea* L. +, *Eryngium campestre* L. +, *Cynodon dactylon* (L.) Pers. +.2, *Asparagus stipularis* Forsskal +.2, *Sonchus tenerrimus* L. +, *Verbascum sinuatum* L. +; 2 *Scolymus hispanicus* L. +, *Avena fatua* L. +.