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VEGETATION OF TALL RUSH SALTMARSHES *(JUNCETEA MARITIMAE)* AND SALTMARSH SCRUBS *(ARTHROCNEMETEA FRUTICOSAE)* ON THE SLOVENIAN SEACOAST

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ABSTRACT

Halophyte vegetation of Slovenian sedimentary seacoast was studied according to Braun-Blanquet method. 140 collected relevés were analysed by cluster analysis and five main clusters were separated. Relevés from the first, fourth and fifth clusters were further elaborated in this study. The Juncus maritimus*-dominated tall rush saltmarshes of the class* Juncetea maritimi *were classified within two associations:* Limonio-Puccinellietum *represented hygrophilous stands, exposed to tide, while the association* Juncetum maritimi-acuti *was represented with more closed stands with higher species richness, thriving on rather drier sites. Within the saltmarsh scrubs of the class* Arthrocnemetea fruticosi*, 3 associations, following the declining moisture/salinity gradient were recognized:* Puccinellio-Arthrocnemetum, Puccinellio-Halimionetum *and* Limonio-Artemisietum.

Key words: phytosociology, halophyte vegetation, classification, North Adriatic

VEGETAZIONE A GIUNCO DI ACQUE SALMASTRE *(JUNCETEA MARITIMAE)* E PRATERIE ALOFILE *(ARTHROCNEMETEA FRUTICOSAE)* SULLA COSTA SLOVENA

SINTESI

La vegetazione alofila della costa marina sedimentaria in Slovenia è stata studiata secondo il metodo di Braun-Blanquet. Centoquaranta rilievi *sono stati analizzati con l'aiuto della* analisi numeriche *e cinque grandi gruppi sono stati separati. I* rilievi *appartenenti al primo, quarto e quinto gruppo sono stati ulteriormente elaborati durante lo studio. La vegetazione di acque salmastre dominata da* Juncus maritimus*, della classe* Juncetea maritime*, è stata classificata in due associazioni:* Limonio-Puccinellietum *con banchi igrofili, esposti alla marea, e* Juncetum maritimi-acuti *con banchi più ristretti con una diversità di specie più alta, sprosperanti in siti piuttosto secchi. All'interno delle praterie alofile della classe* Arthrocnemetea fruticosi*, 3 associationi sono state riconosciute seguendo il gradiente umidità/salinità declinante:* Puccinellio-Arthrocnemetum, Puccinellio-Halimionetum *e* Limonio-Artemisietum.

Parole chiave: fitosociologia, vegetazione alofila, classificazione, Adriatico settentrionale

INTRODUCTION

The Slovenian short seacoast is under heavy pressure of urbanization, leisure activities and industry (Port of Koper). Its special feature is the geological bedrock, being the calcareous sandstone – Eocene flysch substrate. This substrate almost perfectly matches the territory of Slovenia; only a small part extends to the Italian territory. Flysch substrate results in dense hydrological system above ground due to its impenetrable properties. Three larger streams/rivers have their mouths in the Gulf of Trieste: the Rižana, Strunjanski potok and Dragonja. Alluvial deposits in the mouths resulted in salt–marshes, where different vegetation types probably occurred before human influence. After the Roman period and afterwards these alluvial coastal regions have been either conversed to salt pans either drained (Darovec, 1992). The present situation is only a transitional stage in abandonment and creation of new habitats on the seacoast. The dynamics have always been fast and enabled assemblages of different vegetation types on the seacoast. Abiotic conditions – shallow coast and large tide area – are in favour of assemblage of the various types of halophyte vegetation, probably similar to the natural types, developed before the human interference. The halophyte vegetation is interesting and important from the conservational perspective, as it is threatened by all factors mentioned above. Many coastal habitats with different types of halophyte vegetation are listed in Annexes of the EU Directive on the conservation of natural habitats and of wild fauna and flora (Council Directive 92/43/EEC, 1992).

Syntaxonomical classifications of the Slovenian halophyte vegetation are based on the relevés taken by M. Kaligarič in the years 1984–87 and in 1998 and 1999, published so far only for annual pioneer vegetation (*Salicornietea*) and *Spartina maritima*-dominated swards (*Spartinetea*) (Kaligarič & Škornik, 2006). Some of those relevés have been taken in consideration also within the last complete revision of the North Adriatic halophyte vegetation (Poldini *et al.*, 1999). This revision considered the global revision of Mediterranean halophyte vegetation by Géhu *et al.* (1984), Rivas-Martínez (1990), Géhu & Biondi (1995, 1996), Mucina (1997) and Géhu (1999). Recent studies of halophyte vegetation, to the exclusion of Tyrrhenian district (Latium), have been made by Iberite & Frondoni (1997) and Frondoni & Iberite (2002). Both consider the already revised syntaxonomy.

The first phytosociological assessment of the North Adriatic halophyte vegetation was made much earlier by Béguinot (1941). The most profound research was carried out by Pignatti (1966) and followed by Fornaciari (1968). The Pignatti's syntaxonomical scheme (*e.g.* macroassociation "*Limonietum venetum*") was adopted also for Slovenian halophyte vegetation in some short contributions about Sečoveljske soline (Kaligarič & Tratnik, 1981; Kaligarič & Wraber, 1988), Strunjan (Šajna & Kaligarič, 2005) and Škocjanski zatok (Kaligarič, 1997, 1998). The Pignatti's syntaxonomical units are also used for the threat status of halophyte flora and vegetation of the Slovenian seacoast (Kaligarič, 1996).

The elaboration of collected relevés from the Slovenian seacoast with classification methods and determination of major groups of vegetation (classes and orders) on the basis of classification methods and characteristic species has been carried out already by Kaligarič & Škornik (2006). The aim of this study was elaboration of the *Juncus maritimus*-dominated tall rush saltmarshes of the class *Juncetea maritimi* and the saltmarsh scrubs of the *Arthrocnemetea fruticosi* class.

MATERIAL AND METHODS

Study area

The Slovenian seacoast consists of flysch cliffs with scarce halophyte vegetation and sedimentary coast, mainly converted to salt pans or dried. In some parts, natural patches of coast still exist, while in other parts the sedimentary coast is even artificially enlarged (like soil deposits, etc.). In some parts (Sečoveljske soline), salt pans were abandoned and halophyte vegetation spread out. Locations (Fig. 1) were relevés have been sampled are: Sečoveljske soline (mouth of the Dragonja river, Fontanigge, Lera, San Giorggio channel), Strunjanske soline (Stjuža lagoon coast, salt pans), Škocjanski zatok, mud deposits and coastal grasslands near Sv. Katarina/Ankaran (Kaligarič & Škornik, 2006).

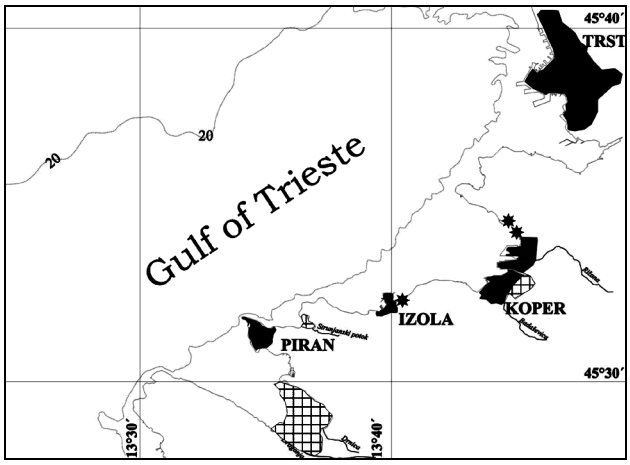

Fig. 1: Map of Slovenian seacoast with locations of the collected relevés of halophilous vegetation.
Sl. 1: Karta slovenske morske obale z lokalitetatmi popisov halofitne vegetacije.

Sampling methods

Using the standard Braun-Blanquet procedure (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1973; Dierschke, 1994), relevés were taken during the years 1984–87 and 1998–1999. In the initial procedure, all the relevés were classified using the SYN-TAX 2000 software package (Podani, 2001). A hierarchical classification algorithm (Complete linkage, Eucledian distance) based on quantitative data was employed. From the resulting dendrogram (Fig. 2), three clusters were elaborated in previous study (Kaligarič & Škornik, 2006); all the other clusters were elaborated within this study. Division to classes and orders were based on main clusters, further subdivision to associations was carried out with the help of characteristic species (their frequencies and dominance) of the syntaxa.

Taxonomic nomenclature followed Martinčič *et al.* (1999) except for taxon *Halimione portulacoides*, syntaxonomic nomenclature followed Poldini *et al.* (1999).

RESULTS AND DISCCUSION

Classification of the relevés

The 140 relevés were classified in 5 main clusters according to species composition and abundance, considering all the species of equal importance (Fig. 2). The most diverse was the first main cluster (No.1), which could be further divided into 7 sub-clusters (1A-1G). The first one (A, relevés 1–4) was represented by floristically poor *Salsola soda* dominated stands on dry trampled muddy soils with stones, where *Elytrigia atherica* and *Atriplex prostrata* indicate relatively dry conditions and lower salinity (Kaligarič & Škornik, 2006). This group of relevés was classified within the class *Cakiletea maritimae* (Kaligarič & Škornik, 2006). The third sub-cluster (1C, relevés 15–20) was characterized by dominance of grass *Spartina maritima*, and it was also elaborated in previous study (Kaligarič & Škornik, 2006). Other five sub-clusters (1B, 1D, 1F, 1G and part of 1E) were *Juncus maritimus*-dominated saltmarshes, relatively rich in various halophyte hygrophilous species. Among them were also halophytes such as *Phragmites communis* and characteristic species of the class *Juncetea maritimae*, *Carex extensa* and *Plantago cornuti,* which are not present in other halophilous vegetation types. These relevés (relevés 5–14 and 21–44) were classified within the class *Juncetea maritimi* (Kaligarič & Škornik, 2006).

The second main cluster (No. 2, relevés 45–67) and the third main cluster (No. 3, relevés 68–86), characterized by *Salicornia europaea*-dominated stands on mudflats or salt pans, were classified within the class *Thero-Salicornietea* and elaborated in the study by Kaligarič & Škornik (2006).

The fourth main cluster (No. 4, relevés 87–137) had many sub-clusters on a lower level of dissimilarity. The main characteristics were scarce presence of pioneer annual halophytes *(Salicornia and Suaeda)* and strong presence and dominance of halophilous scrubs: *Arthrocnemum macrostachyum, Halimione portulacoides, Limonium angustifolium, Artemisia caerulescens,* but also *Puccinellia palustris*, *Inula crithmoides*, and *Aster tripolium*. This perennial halophilous vegetation of relatively dry soil was spread predominately on abandoned salt pans or higher levels (above the tidal area). It was classified within the class *Arthrocnemetea fruticosi* (Kaligarič & Škornik, 2006).

The fifth main cluster with only 3 relevés (No. 5, relevés 138–140) represented *Juncus maritimus*-dominated salt grasslands near Sv. Katarina (Ankaran), which was classified within the class *Juncetea maritimi* (Kaligarič & Škornik, 2006), despite the presence of some non-halophytic species and its particular species richness.

Within this study, the clusters representing classes *Arthocnemetea, Juncetea* and *Cakiletea* will be further elaborated.

The syntaxa were determined mainly on the basis of cluster analysis (Fig. 2), but in some floristically very impoverished relevés the dominance of characteristic species was weighted over the automatic classification given by the expert system.

Vegetation of saltmarsh scrubs

Syntaxonomical classification of halophilous vegetation in the Mediterranean was very variable – from one class *(Salicornietea)* up to seven classes (Poldini *et al.*, 1999). On the basis of different studies across the Mediterranean, European coastal halophyte vegetation is classified in three classes. The vegetation of perennial halophytes – mainly succulent chamaephytes and nanophanerophytes, which form more or less densely vegetated saltmarsh scrubs, is classified as *Arthrocnemetea fruticosi*. The distribution of this class of vegetation is not limited to the Atlantic and Mediterranean coasts, but extends to the continental halophilous vegetation of North Africa and Asia. The order *Arthrocnemetalia fruticosi* has a Mediterranean and Atlantic distribution. Alliance *Arthrocnemion fruticosi* is the *Arthrocnemum fruticosum*-dominated vegetation within the area mentioned above.

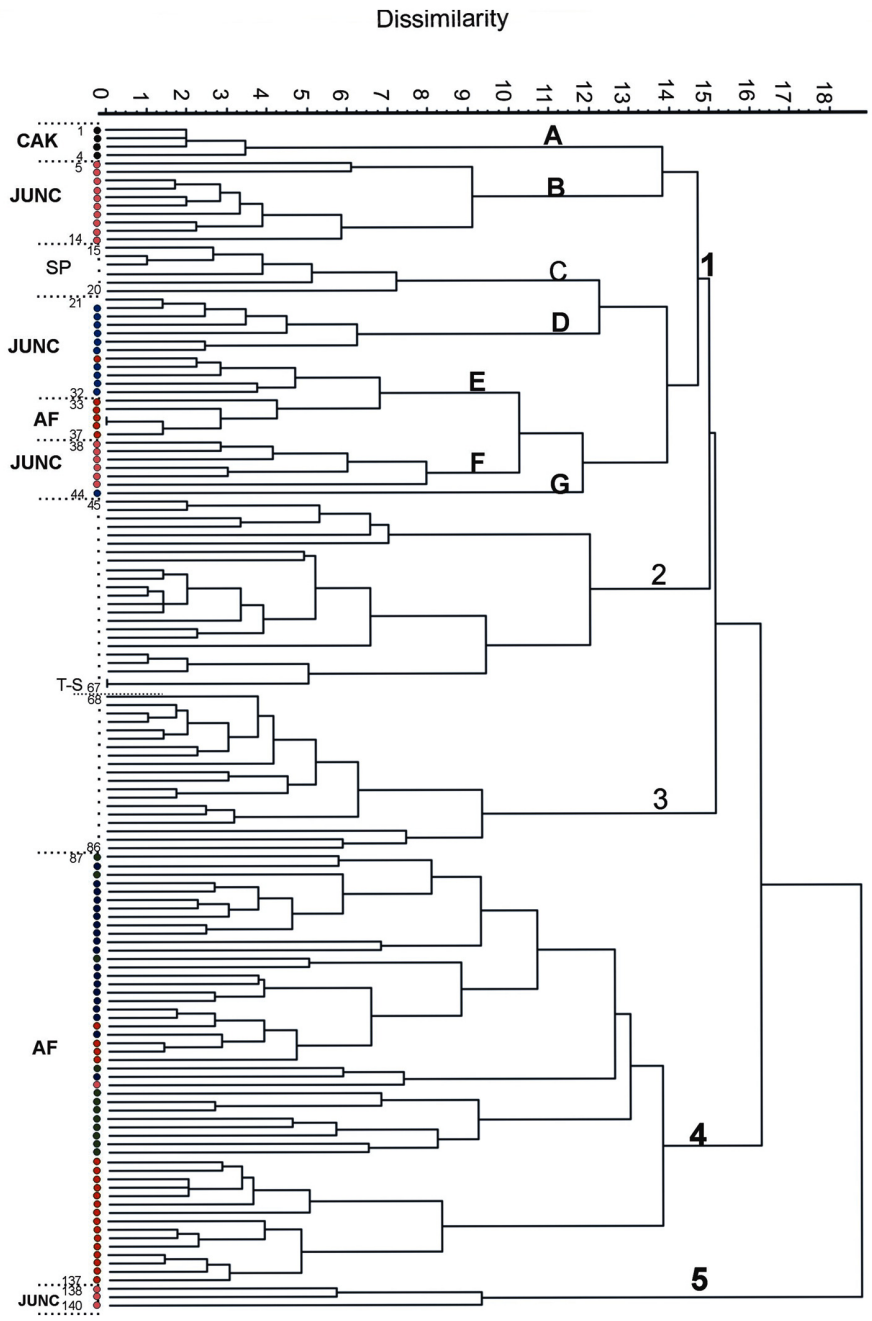

Fig. 2: Dendrogram: the result of hierarchical classification analysis for 104 relevés of halophilous vegetation of the Slovenian seacoast.
Legend: black circles – ass. *Salsoletum sodae****; pink circles – ass.*** *Juncetum maritime-acuti****; blue circles – ass.*** *Limonio narbonensis-Puccinellietum palustris****; orange circles – ass.*** *Puccinelio festuciformis-Arthrocnemetum perennis****; green circles – ass.*** *Limonio narbonensis-Artemisietum coerulescentis****; violet circles – ass.*** *Puccinellio festuciformis-Arthrocnemetum fruticosi.*
Sl. 2: Dendrogram: rezultat hierarhične klasifikacije 104 popisov halofitne vegetacije ob slovenski obali.
Legenda: črni krogci – as. *Salsolo kali-Cakiletum maritimae****; rožnati krogci – as.*** *Juncetum maritime-acuti****; modri krogci – as.*** *Limonio narbonensis-Puccinellietum palustris****; oranžni krogci – as.*** *Puccinelio festuciformis-Arthrocnemetum perennis****; zeleni krogci – as.*** *Limonio narbonensis-Artemisietum coerulescentis****; vijolični krogci – as.*** *Puccinellio festuciformis-Arthrocnemetum fruticosi.*

Association *Limonio narbonensis-Artemisietum coerulescentis* Horvatić (1933) 1934 corr. Gehu *et* Biondi 1996 (Tab. 1)

This is the driest association in the humidity/salinity gradient of perennial scrubs, with really dense vegetation cover, and highest species-richness in this series of syntaxa. The presence of halotolerant species, which penetrate from marginal areas outside salty soils, is also characteristic. It was described from Dalmatia by Horvatić in 1934 and registered many times in NE Italy (*e.g.* Poldini *et al.*, 1999). Halophytes with less extreme adaptations are characteristic of these stands, which could be explained with less extreme site conditions. The summer dry period is also characteristic.

On the Slovenian seacoast, this association occurs predominately in abandoned salt pans, on elevated sites, banks, and closed muddy surfaces with only temporary inundation.

Association *Puccinellio festuciformis-Halimionetum portulacoidis* Géhu, Biondi, Géhu Franck *et* Costa 1992 (Tab. 2)

This association was described by Ferrari *et al.* (1985) from Italy. It is characterized by dominance of *Halimione portulacoides*. Its position along the humidity/salinity gradient is the middle one, between the three associations of the order. It covers smaller surfaces, on better drained soils that the previous association. It develops on margins of abandoned salt pans; bottoms of banks, the presence of rougher granulation of soils (*e.g.* smaller parts of stony banks in salt pans) seem to promote the dominance of *Halimione portulacoides*. The vegetation is not as dense as in the previous association. This association had been previously at least partly classified as a subassociation *(halimionetosum)* of the macroassociation *"Limonietum venetum",* described by Pignatti (1952). This macroassociation was later divided into different units by Géhu *et al.* (1984) due to scientific and technical (nomenclatural) arguments.

Tab. 1: Analytical table of the association** Limonio narbonensis-Artemisietum coerulescentis **Horvatić (1933) 1934 corr. Géhu** et **Biondi 1996.
Legend: Cl –** Arthrocnemetea fruticosi **Br.-Bl.** et **R. Tx. 1943 corr. O. Bolós 1967; O –** Arthrocnemetalia fruticosi **Br.-Bl. 1931 corr. O. Bolós 1967; A –** Arthrocnemion fruticosi **Br.-Bl. 1931 corr O. Bolós 1967.
Tab. 1: Analitična tabela asociacije** Limonio narbonensis-Artemisietum coerulescentis **Horvatić (1933) 1934 corr. Géhu** et **Biondi 1996.
Legenda: Cl –** Arthrocnemetea fruticosi **Br.-Bl.** et **R. Tx. 1943 corr. O. Bolós 1967; O –** Arthrocnemetalia fruticosi **Br.-Bl. 1931 corr. O. Bolós 1967; A –** Arthrocnemion fruticosi **Br.-Bl. 1931 corr O. Bolós 1967.

Relevé number	87	89	99	112	115	116	117	118	119	120	121	122	
Original relevé number	54	65	62	55	56	57	58	59	60	64	61	63	**Fr. (%)**
Diagnostic species of the association													
Cl *Limonium angustifolium*	1	2	+	2	1	+	.	3	2	3	2	2	92
Cl *Artemisia coerulescens*	2	1	2	.	3	3	3	2	2	1	2	3	92
Diagnostic species of higher syntaxonomic units													
O *Halimione portulacoides*	4	2	3	2	3	1	+	+	+	1	+	+	100
Cl, A *Inula crithmoides*	+	+	1	3	+	.	+	+	1	1	+	1	92
Cl, O *Sarcocornia fruticosa*	1	1	3	2	.	.	.	.	.	.	.	+	42
Others													
Aster tripolium	+	.	1	.	+	+	+	+	.	.	2	.	58
Elytrigia atherica	+	.	+	.	.	.	+	+	.	1	+	.	50
Suaeda maritima	1	.	.	.	+	+	+	1	.	.	.	+	50
Puccinellia palustris	2	.	.	1	.	.	.	.	+	.	1	2	42
Elytrigia elongata	.	.	+	.	.	.	.	.	.	+	+	.	25
Melilotus albus	.	+	.	.	.	.	.	.	.	+	.	.	17
Dactylis glomerata	.	.	+	.	.	.	.	.	.	+	.	.	17
Arthrocnemum macrostachyum	.	.	.	.	.	.	.	.	+	.	.	.	8
Aster lynosiris	.	.	.	.	.	.	.	.	.	+	.	.	8
Atriplex prostrata	.	.	+	.	.	.	.	.	.	.	.	.	8
Lotus corniculatus	.	.	.	.	.	.	.	.	.	+	.	.	8
Phragmites australis	+	.	.	.	.	.	.	.	.	.	.	.	8
Salicornia europaea	.	.	.	.	.	.	.	.	.	.	.	+	8

Tab. 2: Analytical table of the association *Puccinelio festuciformis-Halimionetum portulacoidis* ***Géhu, Biondi. Géhu Franck*** *et* ***Costa 1992.***
Legend: Cl – *Arthrocnemetea fruticosi* ***Br.-Bl.*** *et* ***R. Tx. 1943 corr. O. Bolós 1967; O –*** *Arthrocnemetalia fruticosi* ***Br.-Bl. 1931 corr. O. Bolós 1967; A –*** *Arthrocnemion fruticosi* ***Br.-Bl. 1931 corr O. Bolós 1967.***
Tab. 2: Analitična tabela asociacije *Puccinelio festuciformis-Halimionetum portulacoidis* ***Géhu, Biondi. Géhu Franck*** *et* ***Costa 1992.***
Legenda: Cl – *Arthrocnemetea fruticosi* ***Br.-Bl.*** *et* ***R. Tx. 1943 corr. O. Bolós 1967; O –*** *Arthrocnemetalia fruticosi* ***Br.-Bl. 1931 corr. O. Bolós 1967; A –*** *Arthrocnemion fruticosi* ***Br.-Bl. 1931 corr O. Bolós 1967.***

Relevé number	88	90	91	92	93	94	95	96	97	98	100	101	102	103	104	105	106	108	
Original relevé number	72	73	75	76	83	77	79	80	78	82	71	66	67	68	74	69	81	70	**Fr. (%)**
Diagnostic species of the association																			
O *Halimione portulacoides*	3	3	4	4	3	3	2	2	3	3	2	4	3	3	3	2	2	2	100
Puccinellia palustris	2	+	+	+	+	+	+	+	.	1	+	+	+	1	+	+	.	+	89
Diagnostic species of higher syntaxonomic units																			
Cl, O *Sarcocornia fruticosa*	2	1	+	1	1	+	+	+	+	.	2	3	3	2	2	2	2	3	94
Cl *Limonium angustifolium*	+	1	1	+	+	+	+	1	+	.	+	1	+	+	+	1	1	+	94
Cl *Artemisia coerulescens*	1	.	+	+	.	+	.	.	.	.	1	.	.	.	.	.	.	+	33
A *Inula crithmoides*	.	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	22
Others																			
Aster tripolium	+	.	.	.	.	+	.	+	+	+	+	.	.	+	.	+	.	+	50
Elytrigia atherica	+	+	+	+	.	.	+	.	.	1	+	.	.	.	+	+	.	.	50
Suaeda maritima	.	.	.	.	+	+	+	+	2	+	+	.	1	+	.	.	.	.	50
Arthrocnemum macrostachyum	1	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	17
Juncus maritimus	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	6

Tab. 3: Analytical table of the association *Puccinellio festuciformis-Arthrocnemetum fruticosi* ***(Br.-Bl. 1928) Géhu 1976.***
Legend: Cl – *Arthrocnemetea fruticosi* ***Br.-Bl.*** *et* ***R. Tx. 1943 corr. O. Bolós 1967; O –*** *Arthrocnemetalia fruticosi* ***Br.-Bl. 1931 corr. O. Bolós 1967; A –*** *Arthrocnemion fruticosi* ***Br.-Bl. 1931 corr O. Bolós 1967.***
Tab. 3: Analitična tabela asociacije *Puccinellio festuciformis-Arthrocnemetum fruticosi* ***(Br.-Bl. 1928) Géhu 1976.***
Legenda: Cl – *Arthrocnemetea fruticosi* ***Br.-Bl.*** *et* ***R. Tx. 1943 corr. O. Bolós 1967; O –*** *Arthrocnemetalia fruticosi* ***Br.-Bl. 1931 corr. O. Bolós 1967; A –*** *Arthrocnemion fruticosi* ***Br.-Bl. 1931 corr O. Bolós 1967.***

Relevé number	28	33	34	35	36	37	107	109	110	111	113	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	
Original relevé number	90	91	92	93	94	95	107	101	108	104	89	84	88	85	105	109	86	87	96	98	99	106	97	100	102	103	**Fr. (%)**
Diagnostic species of the association																											
Cl, O *Sarcocornia fruticosa*	+	2	1	1	1	1	3	3	3	3	3	4	3	4	3	4	3	3	4	4	4	5	3	3	2	3	100
Puccinellia palustris	+	+	.	.	.	.	.	.	+	.	1	+	1	1	1	1	1	.	1	.	.	.	+	.	.	.	46
Diagnostic species of higher syntaxonomic units																											
Cl *Limonium narbonense*	4	4	4	3	3	3	1	+	+	1	4	2	2	3	3	3	3	3	.	.	.	+	+	+	+	1	88
O *Halimione portulacoides*	+	+	+	1	1	1	2	1	1	1	1	.	+	.	.	.	.	.	.	.	.	.	.	+	+	+	58
A *Inula crithmoides*	.	.	+	+	+	.	.	.	.	.	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	23
Cl *Artemisia caerulescens*	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12
Others																											
Aster tripolium	+	.	.	+	+	+	.	.	.	.	.	+	+	+	+	.	1	+	+	.	+	.	.	.	.	.	46
Suaeda maritima	.	1	.	+	+	+	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	+	.	.	.	+	35
Salicornia europaea	.	.	.	.	.	.	.	.	+	1	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	19
Phragmites australis	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	+	+	.	.	.	.	19
Elytrigia atherica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	4

Puccinellio festuciformis-Arthrocnemetum fruticosi **(Br.-Bl. 1928) Géhu 1976** (Tab. 3)

This association, formerly considered as one of the most widespread subassociations ("*arthrocnemetosum fruticosi*") of the "*Limonietum venetum*", is extremely humid, for very long time inundated along the humidity/salinity gradient of the three associations of the order. It has also the lower cover values. Water – predominately rainwater – stands in wintertime for longer periods, with no possibility to flow off. In the summer time it may dry up completely, especially within the abandoned salt pans of Sečoveljske soline, where one of the most abundant halophyte associations can be found. It is

characterized by dominance of *Sarcocornia fruticosa* and weak presence/cover of *Halimione portulacoides*. The rest of the floristic inventory is very similar to the previous association. Outside the Sečoveljske soline, patches of this association do not reach larger surfaces (a few square metres at the most). The association occurs on elevated sites in Strunjanske soline and Škocjanski zatok.

Vegetation of *Juncus maritimus* tall rush saltmarshes

The vegetation of coastal saltmarsh vegetation of the class *Juncetea maritimi* is characterized by the dominance of *Juncus maritimus* and other helophytes among halophytic species. These habitats are also supported by brackish water. The classis is further classified into the order *Juncetalia maritimi* and alliance *Juncion maritimi*, which is present on the North Adriatic coast with two suballiances: the (a) *Juncenion maritimi* is always characterized by dominance of *Juncus maritimus* and it is relatively rich with species of different syntaxa, from therophytes to scrubs, marshy halotolerant species to extreme succulents. Indicator species beside *J. maritimus* are *J. acutus*, which is currently not present on the Slovenian seacoast, *Plantago cornuti, Sonchus maritimus* and *Elytrigia elongata*. The suballiance *Puccinellienion festuciformis* is characterized by the strong presence of *Puccinellia palustris (=P. festuciformis)* and *Aster tripolium*. These stands are wet and frequently inundated.

Association *Juncetum maritimi-acuti* Horvatić 1934 (suballiance *Juncenion maritimi*) (Tab. 4)

Juncus maritimus is absolutely dominant perennial in this association, which also forms main physiognomic aspect of these habitats, being in the permanent contact with sea or brackish water. One group of the relevés is more hygrophilous and characterized by *Limonium angustifolium* and *Pucinellia palustris*. It covers smaller surfaces at the shores of the channels or lagoons, sometimes at closed habitats in depressions with accumulating water. Another group of relevés is characterised by the natural saltmarsh at Sv. Katarina (Ankaran), where the conditions are drier and more species occur, including the rare ones, like *Linum maritimum, Centaurium spicatum* and *Elytrigia elongata*.

Tab. 4: Analytical table of the association *Juncetum maritimi-acuti* ***Horvatić 1934.***
Legend: Cl – *Juncetea maritimi* ***Br.-Bl. 1952 em. Beeftink 1965; O –*** *Juncetalia maritimi* ***Br.-Bl. 1931; A –*** *Juncenion maritimi* ***Géhu*** *et* ***Biondi 1995.***
Tab. 4: Analitična tabela asociacije *Juncetum maritimi-acuti* ***Horvatić 1934***
Legenda: Cl – *Juncetea maritimi* ***Br.-Bl. 1952 em. Beeftink 1965; O –*** *Juncetalia maritimi* ***Br.-Bl. 1931; A –*** *Juncenion maritimi* ***Géhu*** *et* ***Biondi 1995.***

Relevé number	5	6	7	8	9	10	11	12	13	14	38	39	40	41	42	43	114	138	139	140	
Original relevé number	123	136	129	130	131	138	133	139	140	132	121	122	125	126	127	124	128	134	137	135	**Fr. (%)**
Diagnostic species of the association																					
Cl, O *Juncus maritimus*	3	3	3	4	4	4	3	3	4	5	4	3	3	2	2	2	1	4	3	4	100
Diagnostic species of higher syntaxonomic units																					
Cl *Limonium angu stifolium*	2	.	+	+	+	+	.	1	1	.	2	3	2	5	4	3	4	.	+	+	80
Cl, O *Puccinellia palustris*	2	2	+	+	.	.	.	+	.	.	+	+	.	+	+	2	+	.	.	.	55
Cl, O *Aster tripolium*	.	1	.	.	+	+	+	.	+	+	.	.	.	+	1	.	.	+	.	2	50
O *Carex extensa*	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	+	1	+	.	25
A *Plantago cornuti*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	3	3	3	20
A *Sonchus maritimus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	10
A *Elytrigia elongata*	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Others																					
Phragmites australis	.	+	.	.	+	.	+	+	+	2	.	.	.	+	.	2	.	1	+	2	55
Suaeda maritima	.	.	+	.	.	.	+	.	+	+	+	.	1	.	.	1	.	.	.	.	35
Inula crithmoides	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	2	.	.	1	30
Halimione portulacoides	.	+	.	.	.	+	.	.	.	.	.	+	+	+	.	.	1	.	.	.	30
Artemisia caerulescens	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	1	25
Elytrigia atherica	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	2	2	20
Salicornia europaea	.	.	+	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	.	.	20
Sarcocornia fruticosa	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	15
Bolboschoenus maritimus	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.	15
Centaureum spicatum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	10
Linum maritimum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	10
Holoschoenus maritimus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	5
Dittrichia viscosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	5

Tab. 5: Analytical table of the association *Limonio narbonensis-Puccinellietum palustris* ***(Pignatti 1966) Géhu*** *et* ***Scopp. 1984 in Géhu*** *et al.* ***1984.***
Legend: Cl – *Juncetea maritimi* ***Br.-Bl. 1952 em. Beeftink 1965; O –*** *Juncetalia maritimi* ***Br.-Bl. 1931; subA –*** *Puccinellienion festuciformis* ***(Géhu*** *et* ***Scopp. 1984 in Géhu, Scoppola, Caniglia, Marchiori*** *et* ***Géhu Franck 1984) Géhu*** *et* ***Biondi 1995.***
Tab. 5: Analitična tabela asociacije *Limonio narbonensis-Puccinellietum palustris* ***(Pignatti 1966) Géhu*** *et* ***Scopp. 1984 in Géhu*** *et al.* ***1984.***
Legenda: Cl – *Juncetea maritimi* ***Br.-Bl. 1952 em. Beeftink 1965; O –*** *Juncetalia maritimi* ***Br.-Bl. 1931; subA –*** *Puccinellienion festuciformis* ***(Géhu*** *et* ***Scopp. 1984 in Géhu, Scoppola, Caniglia, Marchiori*** *et* ***Géhu Franck 1984) Géhu*** *et* ***Biondi 1995.***

Relevé number	22	23	24	25	26	27	29	30	31	32	44	
Original relevé number	113	111	112	110	118	120	117	119	115	116	114	**Fr. (%)**
Diagnostic species of the association												
Cl *Limoniumangustifolium*	+	+	+	+	2	2	5	4	4	2	2	100
Cl, O, subA *Puccinellia palustris*	3	5	4	3	4	3	+	1	1	1	.	91
Diagnostic species of higher syntaxonomic units												
Cl, O *Aster tripolium*	+	.	.	+	+	+	+	+	.	.	4	64
Cl, O *Juncus maritimus*	.	.	.	.	1	+	+	.	+	+	.	45
O *Carex extensa*	.	.	.	.	.	.	.	.	.	.	+	9
Others												
Phragmites australis	.	.	.	.	+	+	.	+	.	.	+	36
Suaeda maritima	.	.	.	1	.	.	.	.	1	+	+	36
Salicornia europaea	+	.	.	.	.	.	+	.	.	+	.	27
Halimione portulacoides	.	.	1	.	.	.	.	.	.	.	.	9
Spartina maritima	.	.	.	.	+	.	.	.	.	.	.	9

Association *Limonio narbonensis-Puccinellietum palustris* (Pignatti 1966) Géhu *et* Scopp. 1984 in Géhu *et al.* 1984 (suballiance *Puccinellienion festuciformis*) (Tab. 5)

This association is characterized by combined domination of *Puccinellia palustris* and *Limonium angustifolium*. It appears in belts along the channel banks, lagoon margins, with high level of salt or brackish water. These stands are exposed to tidal oscillations and strong nutrient flow. *Juncus maritimus* is present, but not in all relevés. This association is in contact with syntaxa of the class *Spartinetea* on one side and syntaxa of the class *Arthrocnemetea* on the other side. The morphology of the dominant *Limonium angustifolium* species is different from drier sites, inhabited by *Arthrocnemetea* vegetation: here *Limonium* is taller and bigger. This species reaches its ecological optimum in two quite different habitats, classified in two different phytosociological classes.

CONCLUSIONS

The elaborated associations are presented in synoptic table (Tab. 6), where some *Salsola soda*-dominated stands are included and classified within the class *Cakiletea maritime*, provisionally treated in the rank of association *Salsoletum sodae*, due to the presence of only two *Cakiletea* characteristic species – *Salsola soda* and *Atriplex prostrata*. This anthropogenic stands with very small surfaces on the stony seashore or at the tops of the muddy dikes within some salt basins are very poor in species composition and therefore very hard to classify. This classification in the synoptic table is provisional only and it will not be further discussed in this treatise.

We could summarize that the two classes *Juncetea maritimae* and *Arthrocnemetea fruticosae* indeed differ ecologically, but further delimitation of the lower syntaxa (associations, namely) is based mostly on frequency and coverage of the species, *e.g. Arthrocnemum vs. Halimione vs. Artemisia* within the *Arthrocnemetea* classis, and *Limonium/Puccinellia* vs. *Juncus* and typical *Juncetea* inventory. Characteristic species for the two classes of halophilous vegetation are distributed more or less across all five (six) associations. It is very difficult to draw conclusions only on the basis of species presence and cover. The "understanding" of vegetation assemblage is beyond the species combinations and numerical classifications: it should be accompanied with ecological data (salinity, water potential, soil properties, nutrients etc) and functional plant traits (Kaligarič & Škornik, 2006). For a better understanding of the classification of respective vegetation types, Poldini *et al.* (1999) incorporated structural data (life form and growth form of plants) into his treatise. For causal understanding, where pure classification is only a starting point, an ecophysiological and morphological approach is needed.

Tab. 6: Synoptic table of the associations of the classes *Arthrocnemetea fruticosi, Juncetea maritimi* ***and*** *Cakiletea maritimae****. Values in the table correspond to the relative frequencies (in percentage) of the species in presented group of relevés.***
Legend: Li-Ar: *Limonio narbonensis-Artemisietum coerulescentis****; Pu-Ha:*** *Puccinellio festuciformis-Halimionetum portulacoidis****; Pu-Ar:*** *Puccinellio festuciformis-Arthrocnemetum fruticosi****; Ju ma:*** *Juncetum maritimi-acuti****; Li-Pu:*** *Limonio narbonensis-Puccinellietum palustris****; Sals:*** *Salsoletum sodae****; Di1-5: diagnostic species of ass.; Cl1:*** *Arthrocnemetea fruticosi****; Cl2:*** *Juncetea maritimi****; O1:*** *Arthrocnemetalia fruticosi****; O2:*** *Juncetalia maritimi****; subA2:*** *Puccinellienion festuciformis****.***
Tab. 6: Sinoptična tabela asociacij razredov *Arthrocnemetea fruticosi, Juncetea maritimi* ***in*** *Cakiletea maritimae****. Vrednosti v tabeli ustrezajo frekvencam (v odstotkih) pojavljanja vrst v predstavljenih skupinah popisov.***
Legenda: Li-Ar: *Limonio narbonensis-Artemisietum coerulescentis****; Pu-Ha:*** *Puccinellio festuciformis-Halimionetum portulacoidis****; Pu-Ar:*** *Puccinellio festuciformis-Arthrocnemetum fruticosi****; Ju ma:*** *Juncetum maritimi-acuti****; Li-Pu:*** *Limonio narbonensis-Puccinellietum palustris****; Sals:*** *Salsoletum sodae****; Di1-5: diagnostične vrste asociacij; Cl1:*** *Arthrocnemetea fruticosi****; Cl2:*** *Juncetea maritimi****; O1:*** *Arthrocnemetalia fruticosi****; O2:*** *Juncetalia maritimi****; subA2:*** *Puccinellienion festuciformis****.***

	Association	**Li-Ar**	**Pu-Ha**	**Pu-Ar**	**Ju ma**	**Li-Pu**	**Sals**
	Number of relevés	**12**	**18**	**26**	**20**	**11**	**4**
Diagnostic species of the associations							
Di1,Di5(Cl1, Cl2)	*Limonium angustifolium*	92	94	88	80	100	.
Di1, (Cl1)	*Artemisia caerulescens*	92	33	12	25	.	.
Di2(O1)	*Halimione portulacoides*	100	100	58	30	9	.
Di2,Di3,Di5(Cl2, O2, subA2)	*Puccinellia palustris*	.	89	46	55	91	33
Di3(Cl1, O1)	*Sarcocornia fruticosa*	42	94	100	15	.	.
Di4(Cl2, O2)	*Juncus maritimus*	.	6	.	100	45	.
Cl1 *Arthrocnemetea fruticosi* Br.-Bl. *et* R. Tx. 1943 corr O. Bolós 1967							
	Inula crithmoides	92	22	23	30	.	.
Cl2 *Juncetea maritimi* Br.-Bl. 1952 em. Beeftink 1965							
	Aster tripolium	58	50	46	50	64	.
	Carex extensa	.	.	.	25	9	.
	Plantago cornuti	.	.	.	20	.	.
	Sonchus maritimus	.	.	.	10	.	.
	Elytrigia elongata	25	.	.	5	.	.
Cl3 *Cakiletea maritimae* R. Tx. *et* Prsg. 1950							
	Salsola soda	.	.	.	.	.	100
	Atriplex prostrata	.	.	.	.	.	33
***Thero-Salicornietea* Pignatti ex Tx. In Tx. *Et* Oberdorfer 1958 corr. Tx.1974**							
	Salicornia europaea	8	.	19	20	27	33
	Suaeda maritima	50	50	35	36	.	.
***Spartinetea maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba *et* R. Tx. 1971**							
	Spartina maritima	.	.	.	.	9	.
Others							
	Puccinellia palustris	42	.	.	.	.	.
	Melilotus albus	17	.	.	.	.	.
	Dactylis glomerata	17	.	.	.	.	.
	Aster lynosiris	8	.	.	.	.	.
	Atriplex latifolia	8	.	.	.	.	.
	Lotus corniculatus	8	.	.	.	.	.
	Arthrocnemum macrostachyum	8	17	.	.	.	.
	Elytrigia atherica	50	50	4	20	.	66
	Phragmites australis	8	.	19	55	36	.
	Bolboschoenus maritimus	.	.	.	15	.	.
	Centaurium spicatum	.	.	.	10	.	.
	Linum maritimum	.	.	.	10	.	.
	Holoschoenus maritimus	.	.	.	5	.	.
	Dittrichia viscosa	.	.	.	5	.	.

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APPENDIX 1

Synoptic table of studied vegetation types:

Arthrocnemetea fruticosi Br.-Bl. *et* R. Tx. 1943 corr. O. Bolós 1967 (=*Sarcocornietea fruticosae* Br.-Bl. *et* R. Tx. 1943 corr. Castroviejo *et* Cirujano 1980)
Arthrocnemetalia fruticosi Br.-Bl. 1931 corr. O. Bolós 1967 (=*Sarcocornietea fruticosi* Br.-Bl. 1931 corr. Castroviejo *et* Cirujano 1980)
Artrhrocnemion fruticosi Br.-Bl. 1931 corr. O. Boloó 1967
- *Limonio narbonensis-Artemisietum coerulescentis* Horvatić (1933) 1934 corr. Géhu *et* Biondi 1996
- *Puccinellio festuciformis-Halimionetum portulacoidis* Géhu, Biondi, Géhu Franck *et* Costa 1992
- *Puccinellio festuciformis-Arthrocnemetum fruticosi* (Br.-Bl. 1928) Géhu 1976

Juncetea maritimi Br.-Bl. 1952 em. Beeftink 1965
Juncetalia maritimi Br.-Bl. 1931
Juncion maritimi Br.-Bl. 1931
Puccinellenion festuciformis (Géhu *et* Scopp. 1984 in Géhu, Scoppola, Caniglia, Marchiori *et* Géhu Franck 1984) Géhu *et* Biondi 1995
- *Limonio narbonensis-Puccinellietum palustris* (Pignatti 1966) Géhu *et* Scopp. 1984 in Géhu *et al.* 1984
- *Juncenion maritimi* Géhu *et* Biondi 1995
- *Juncetum maritimi-acuti* Horvatić 1934

Cakiletea maritimae R. Tx. *et* Prsg. 1950
Euphorbietalia peplis R. Tx. 1950
Thero-Suaedion splendentis Br.-Bl. 1931
- *Salsoletum sodae* Pignatti 1953

APPENDIX 2

Localities of relevés:

Table 1: **87, 89**: Sečovlje – Fontanigge, MTB: 0547/2; **99**: Ankaran, MTB: 0448/1; **112, 115, 116–119**: Sečovlje – Fontanigge, MTB: 0547/2; **120**: Ankaran, MTB: 0448/1; **121, 122**: Sečovlje – Fontanigge, MTB: 0547/2.
Table 2: **88, 90**: Sečovlje – Fontanigge, MTB: 0547/2; **91**: Koper–Škocjanski zatok, MTB: 0448/3 and 0448/4; **92–97**: Strunjan, MTB: 0447/4; **98, 100, 101**: Sečovlje – Fontanigge, MTB: 0547/2; **102, 103**: Strunjan, MTB: 0447/4; **104–106:** Sečovlje – Fontanigge, MTB: 0547/2; **108**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4.
Table 3: **28, 33–36**: Sečovlje – Fontanigge, MTB: 0547/2; **37**: Strunjan, MTB: 0447/4; **107, 109**: Sečovlje – Fontanigge, MTB: 0547/2; **110**: Strunjan, MTB: 0447/4; **111, 113**, **123–127**: Sečovlje – Fontanigge, MTB: 0547/2; **128**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4; **129, 130–133**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4; **134**: Strunjan, MTB: 0447/4; **135**: Sečovlje – Fontanigge, MTB: 0547/2; **136**: Strunjan, MTB: 0447/4; **137**: Sečovlje – Fontanigge, MTB: 0547/2.
Table 4: **5, 6, 7**: Sečovlje – Fontanigge, MTB: 0547/2; **8**: Strunjan, MTB: 0447/4; **9**: Sečovlje – Fontanigge, MTB: 0547/2; **10, 11**: Ankaran, MTB: 0448/1; **12**: Strunjan, MTB: 0447/4; **13**: Sečovlje – Fontanigge, MTB: 0547/2; **14**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4; **38**: Sečovlje – Fontanigge, MTB: 0547/2; **39**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4; **40, 41**: Sečovlje – Fontanigge, MTB: 0547/2; **42, 43**: Koper – Škocjanski zatok, MTB: 0448/3 and 0448/4; **114**, **138**: Sečovlje – Fontanigge, MTB: 0547/2; **139**, **140**: Ankaran, MTB: 0448/1.
Table 5: **22–27, 29, 30–32, 44**: Sečovlje – Fontanigge, MTB: 0547/2.

VEGETACIJA OBMORSKIH MOČVIRIJ Z OBMORSKIM LOČKOM *(JUNCETEA MARITIMAE)* IN HALOFITNIH TRAJNIC *(ARTHROCNEMETEA FRUTICOSAE)* NA SLOVENSKI OBALI

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POVZETEK

Na kratki slovenski morski obali prevladujejo flišni klifi, kjer je halofitna vegetacija zelo slabo razvita. Zelo raznolika pa je halofitna vegetacija na muljastih sedimentih, tako naravnih kot antropogenih ali tistih v opuščanju (soline). Med leti 1984–87 in 1998–1999 je bilo zbranih 140 popisov halofitne vegetacije po standardni Braun-Blanquetovi metodi. V pričujočem članku smo podrobneje analizirali in predstavili tiste popise, ki zajemajo vegetacijo razredov halofitnih trajnic- grmičkov in polgrmičkov – Arthrocnemetea fruticosae *in obmorskega ločkovja –* Juncetea maritimi-acuti. *Ob pomoči značilnih in dominantnih vrst v popisih smo identificirali 5 združb, in sicer v okviru prvega razreda tri združbe, ki sledijo gradientu vlažnosti/slanosti od najbolj suhih habitatov do najbolj zalitih v tem vrstnem redu:* Limonio narbonensis-Artemisietum coerulescentis, Puccinellio festuciformis-Halimionetum portulacoidis *in* Puccinellio festuciformis-Arthrocnemetum fruticosi. *Prva asociacija je najbolj sušna, dvignjena od vod, pojavlja se manj ekstremnih halofitov, značilna je vrsta* Artemisia caerulescens. *Sestoji so precej sklenjeni in vrstno pestri. V drugi je dominantna vrsta* Halimione portulacoides, *vegetacija je manj sklenjena, vrstno revnejša in zaseda manjše površine. V tretji asociaciji absolutno prevladuje vrsta* Sarcocornia fruticosa, *ki je najbolj namočena in ima najmanj sklenjeno vegetacijo. Za morska močvirja z vrsto* Juncus maritimus (J. acutus *manjka!) sta značilni dve asociaciji. Sestoji asociacije* Limonio narbonensis-Puccinellietum palustris *so razviti v pasovih ob obalah kanalov, lagun, v slani ali brakični vodi, so precej namočeni oziroma izpostavljeni plimovanju in dotoku hranil. Asociacijo označuje dominantnost vrst* Limonium angustifolium *ter* Puccinellia palustris *in je vrstno razmeroma revna. Asociacija* Juncetum maritimi-acuti *je vrstno pestrejša, označuje pa jo dominantnost obmorskega ločka. Nekaj popisov s prevladujočo vrsto* Salsola soda *je bilo klasificiranih kot* Salsoletum sodae, *ki sodi v razred* Cakiletea maritimae. *Sintezna tabela pokaže razlikovanje asociacij glede na dominantne vrste ter obstoj značilnic 2 (3) razredov halofitne vegetacije, kar je za uvrščanje v višje sintaksone v malovrstnih halofitnih sestojih vedno problematično. Zato se upoštevajo tudi nekatere strukturne značilnosti rastlin (življenjska oblika in oblika rasti), za globlje razumevanje pa je treba poznati tudi okoljske parametre in funkcionalne značilnosti rastlin.*

Ključne besede: fitosociologija, halofitna vegetacija, klasifikacija, severni Jadran

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