

HALOPHILE VEGETATION OF THE SLOVENIAN SEACOAST: *THERO-SALICORNIETEA* AND *SPARTINETEA MARITIMAE*

Mitja KALIGARIČ^{*,**} et Sonja ŠKORNIK^{*}

Abstract

Halophile vegetation of the Slovenian sedimentary seacoast have been sampled with the standard Braun-Blanquet procedure. All the 140 collected relevés have been classified using the SYN-TAX 2000 software. The resulting dendrogram separated 5 well-defined clusters, characterized by different dominant species. Two well separated clusters have been further elaborated in this study. The floristically-poor association *Suaedo maritimae-Salicornietum patulae* Brullo et Funari ex Géhu et Géhu Franck 1984 tend to form monodominated stands with *Salicornia europaea* s.l. on mudflat hypersaline stands. The association *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928, with high abundance of *Suaeda maritima* occupy smaller surfaces on drier stands. Both were classified within halophile annual swards of the class *Thero-Salicornietea*. *Spartina maritima*-dominated perennial halophyte saltmarshes are represented with association *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973 (class *Spartinetea maritimae*), which colonizes muddy islets, perturbed by high tide and sea turbulence and supports brackish water, which should be rich in nutrients.

Key words: phytosociology, halophile vegetation, classification, North Adriatic, *Thero-Salicornietea*, *Spartinetea maritimae*.

Izveček

S standardno Braun-Blanquetovo metodo smo vzorčili halofitno vegetacijo na sedimentni morski obali v Sloveniji. Vseh 140 zbranih popisov je bilo klasificiranih s pomočjo programa SYN-TAX 2000. Nastali dendrogram je ločil 5 dobro definiranih šopov, okarakteriziranih z različnimi dominantnimi vrstami. Dva dobro ločena šopa sta bila nadalje obdelana v tej študiji. Floristično revna asociacija *Suaedo maritimae-Salicornietum patulae* Brullo et Funari ex Géhu et Géhu Franck 1984 teži h graditvi enovrstnih sestojev z vrsto *Salicornia europaea* s. l. na muljastih hipersalinih rastiščih. Asociacija *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928 z visoko abundanco vrste *Suaeda maritima* zaseda manjše površine na bolj suhih rastiščih. Obe smo uvrstili v razred halofitnih enoletnic *Thero-Salicornietea*. Obmorska močvirja z dominantno vrsto *Spartina maritima* predstavljajo asociacijo *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973 (razred *Spartinetea maritimae*), ki kolonizira muljaste otočke, izpostavljene plimovanju in valovanju, in dobro prenašajo brakično vodo, ki mora biti bogata s hranili.

Ključne besede: fitocenologija, halofitna vegetacija, klasifikacija, Severni Jadran, *Thero-Salicornietea*, *Spartinetea maritimae*.

1. INTRODUCTION

Slovenia has only 46 km of seacoast, which is under the pressure of urbanization, tourism and industry (part of Koper). Its peculiarity is the geological substrate. With some exceptions, it consists of calcareous sandstone – Eocene flysch substrate. This

substrate is almost perfectly matching with the territory of Slovenia, only a part, in the Muggia/Milje peninsula and bay are lying predominantly in Italy. Flysch substrate results in a dense hydrological system above ground due to its impenetrable properties. Three streams/rivers have their mouths in the Gulf of Trieste. Alluvial deposits on the mouths

* Department of Biology, University of Maribor, SI-2000 Maribor, Koroška 160, Slovenia, mitja.kaligarc@uni-mb.si, sonja.skornik@uni-mb.si

** ZRS Koper, Institute for biodiversity studies, Garibaldijeva 1, SI-6000 Koper, Slovenia

resulted in salt-marshes, where probably different vegetation types occurred before human influence. After the Roman period and later, these alluvial coastal regions had been either converted to salt pans or drained (Darovec 1992). Nowadays, the situation is only a transitional stage in abandonment and creation of new habitats on the seacoast. Abiotic conditions – shallow coast and large tide area – are in favor 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, for being threatened by all factors mentioned above. Almost all coastal habitats with different types of halophyte vegetation are listed in Annexes of the EU Directive Habitat 92/43 (1992) (“Conservation of natural habitats and of wild fauna and flora”).

Syntaxonomical classifications of the Slovenian halophyte vegetation are based on the relevés taken by M. Kaligarič in the years 1984–87 and years 1998 in 1999, not published so far. Some of those relevés have been taken into consideration also within the last revision of the North Adriatic halophyte vegetation (Poldini et al. 1999). This revision considers already the global revision of Mediterranean halophyte vegetation by Géhu et al. (1984), Rivas-Martínez (1990), Géhu et Biondi (1995, 1996), Mucina (1997) and Géhu (1999). Recent studies of halophyte vegetation, but in the Tyrrhenian district (Latium) have been done by Iberite et Frondoni (1997) and Frondoni et Iberite (2002). Both consider already the revised syntaxonomy.

The history of phytosociological assessment in the North Adriatic was started much earlier by Béguinot (1941). The most profound research was undertaken by Pignatti (1966) and followed by Fornaciari (1968). Poldini's syntaxonomical scheme (e.g. macroassociation “*Limonietum venetum*”) was adopted also for Slovenian halophyte vegetation in some short contributions about conservational issues of Sečoveljske soline (Kaligarič et Tratnik 1981, Kaligarič et Wraber 1988), Strunjan (Šajna et Kaligarič 2005) and Škocjanski zatok (Kaligarič 1997, 1998). The description of Pignatti's syntaxonomical units is given also within the threat status of halophyte flora and vegetation of the Slovenian seacoast (Kaligarič 1996).

No analytical or synthetical phytosociological tables from Slovenian halophyte vegetation have been published so far, especially considering the last revision of Poldini et al. (1999). The main aims of the present study are: 1. Elaboration of collected

relevés from the Slovenian seacoast with classification methods. 2. Determination of major groups of vegetation (classes and orders) on the basis of classification methods and characteristic species. 3. Elaboration of the two most distinguishable classes: pioneer annual swards of the class *Thero-Salicornietea* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx. 1974 and brackish perennial stands with *Spartina maritima* of the class *Spartinetea maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971.

2. METHODS

2.1 Study area

The Slovenian flysch seacoast is predominantly – where still in natural form – composed of cliffs. Bellow the cliffs halophyte vegetation is scarce. The sedimentary coast was converted to salt pans or dried, and in some parts the sedimentary coast is artificially enlarged (soil deposits, salt pans etc.). On the other hand, some salt pans were abandoned and halophyte vegetation spread out. Locations of larger surfaces of halophyte vegetation (Figure 1), where the relevés have been sampled, are the following: Sečoveljske soline (mouth of Dragonja, Fontanigge, Lera, San Giorgio channel), Strunjanske soline (Sjuža lagoon coast, salt pans), Škocjanski zatok, mud deposits and coastal grasslands near Sv. Katarina/Ankaran.

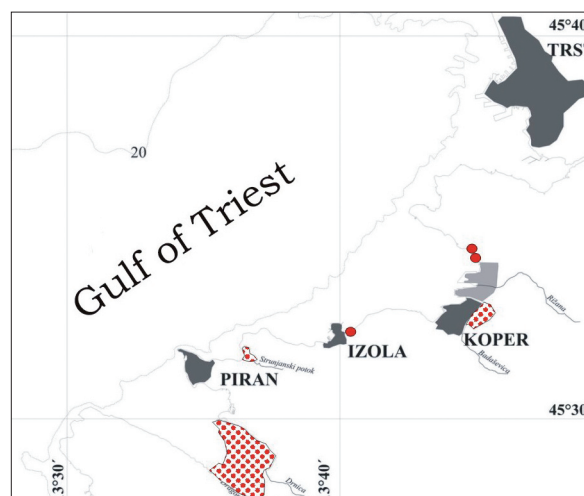


Figure 1: Map of Slovenian Seacoast with locations of the collected relevés of halophyte vegetation.

Slika 1: Karta slovenske morske obale z lokalitetami popisov halofitne vegetacije.

2.2 Sampling methods

During the years 1984–87 and 1998–1999 phytosociological relevés were taken. They were compiled using the standard procedure of the Braun-Blanquet approach (Braun-Blanquet 1964; Westhoff et al. 1973; Dierschke 1994), with combined cover/abundance scale. The phytosociological relevés were classified using the SYN-TAX 2000 software (Podani 2001). A hierarchical classification algorithm (Complete linkage, Euclidian distance) based on quantitative data was employed. The resulting dendrogram separated 5 well-defined clusters, characterized by different dominant species. Further subdivision was carried out with the help of character species.

2.3 Nomenclature

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

3. RESULTS AND DISCUSSION

3.1 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 (Figure 2). The most diverse is the first main cluster (No.1). It could be further divided in 5 sub-clusters (1A–1E): The first one (A, relevés 1–4) is represented by floristically poor *Salsola soda* dominated stands on dry trampled muddy soils with stones. Species *Elytrigia atherica* and *Atriplex prostrata* indicate relatively dry conditions and lower salinity. Such stands could be classified within the *Cakiletea maritimae* R. Tx. et Prsg. 1950 class. The third sub-cluster (1C, relevés 15–20) is characterized by dominance of grass *Spartina maritima*. Abundant species are also *Puccinellia palustris* and *Limonium angustifolium*. This group of 6 relevés from the mouth of the Dragonja and coast of San Giorgio channel in Sečovlje represent the only relevés with *Spartina maritima*-dominated stands in Slovenia. Such stands, occurring on brackish waters with high nutrient flux (mouths!), are clearly identified with *Spartinetea maritimae* class. The remaining

three sub-clusters (1B, 1D and 1E) are *Juncus maritimus*-dominated saltmarsh stands, relatively rich with various halophyte species, among them are also helophytes such as *Phragmites communis* and character species *Carex extensa* and *Plantago cornuti*, not present in other halophilous vegetation types. These relevés (relevés 5–14 and 21–44) are classified within the *Juncetea maritimi* Br.-Bl. 1952 em. Beetink 1965 class.

The second main cluster (No. 2, relevés 45–67) is characterized by sparsely vegetated *Salicornia europaea*-dominated stands on mudflats of salt pans, artificially made mud deposits or shallow sedimentary coasts. This vegetation is characterized by annuals *Salicornia europaea* and *Suaeda maritima* (the latter being less abundant) and perennial grass *Puccinellia palustris*. It covers large surfaces, but frequently consisting of only a few species (sometimes monocultures of glassworts). It was classified within the class *Thero-Salicornietea* annual halophyte vegetation.

Relevés from the third main cluster (No. 3, relevés 68–86) have similar characteristics to the previous group. They have the same dominant species but the stands are denser, with monodominant *Suaeda maritima* and less abundant *Salicornia europaea*. Other present species are characteristic for drier and/or trampled stands: e.g. *Elytrigia atherica*, *Salsola soda*, *Parapholis incurva*, *Inula crithmoides* and *Atriplex prostrata*. These stands contain many more species than the previous, *Salicornia*-dominated stands. Also this cluster is classified within the *Thero-Salicornietea* class.

The fourth main cluster (No. 4, relevés 87–137) has many sub-clusters at a lower level of dissimilarity. But the main trait is 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*, also *Puccinellia palustris*, *Inula crithmoides* and *Aster tripolium*. This low shrubby vegetation of relatively dry muddy soil is spread predominantly on abandoned salt pans or higher levels (away from the tide area) of the sedimentary coast. It is classified within the class *Arthrocnemetea fruticosi* Br.-Bl. et R. Tx. 1943 corr. O. Bolós 1967.

The fifth main cluster consists of only 3 relevés (No. 5, relevés 138–140) and represents a very specific situation. These are stands of *Juncus maritimus*-dominated salt grasslands near Sv. Katarina (Ankaran), classified within the *Juncetea maritimi* class. These grasslands are particularly species-rich (the

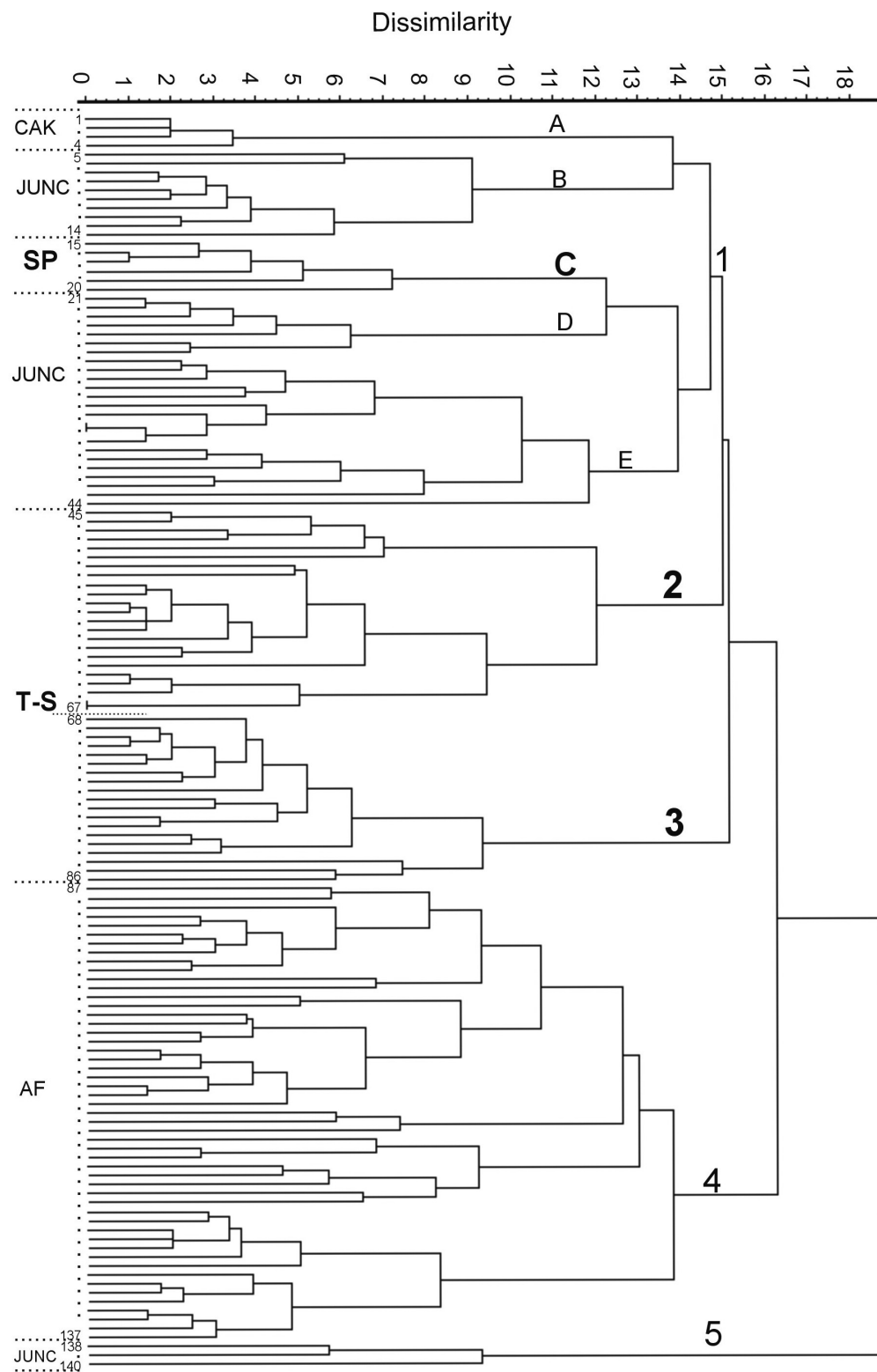


Figure 2: Dendrogram – the result of the hierarchical classification analysis for 104 relevés of halophyte vegetation of the Slovenian seacoast.

Slika 2: Dendrogram – rezultat hierarhične klasifikacije 104 popisov halofitne vegetacije ob slovenski obali.

most species rich among collected relevés) with halophytes and halotolerant species. Only here occur species like *Linum maritimum*, *Centaureum spicatum*, *Holoschoenus vulgaris* and *Sonchus maritimus*. The separate clustering of this group of relevés is therefore satisfactorily explained.

Within this study only the second and the third main clusters, with relevés representing the class *Thero-Salicornietea*, and third sub-cluster (1C) of the first main cluster with relevés classified within the class *Spartinetea maritimae*, will be further elaborated and discussed.

3.2 Vegetation of annual pioneer halophyte swards

Syntaxonomical classification of halophilous vegetation in the Mediterranean was very variable – from one class (*Salicornietea* Br.-Bl. 1939) 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 annual pioneer vegetation of different glassworts on sandy to muddy soils, poor in nutrients, is classified as *Thero-Salicornietea*. Within the Northern Adriatic only order *Thero-Salicornietalia* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx 1974 and alliance *Salicornion patulae* Géhu et Géhu Franck 1984 are present and represented with four associations (Poldini et al. 1999). Association *Salicornietum venetae* Pignatti 1966 is endemic due to endemic species *Salicornia veneta* and ecologically characteristic for “barene” – shallow muddy islets in the lagoon, a completely natural habitat. Another association, *Pholiuro-Spergularietum marginatae* Pignatti (1953) 1966, is characterised by *Parapholis incurva* and *Spergularia marginata*, both species being rare in Slovenia and occurring only in small patches, mainly in anthropogenically-driven micro-habitats (e.g. halophilous ruderal stands or margins of salt pans). The fragments of this association were found in Ankarana – Sv. Katarina and at the banks of San Giorgio channel in Seča, but not sampled. The other two associations, *Suaedo maritimae-Salicornietum patulae* Brullo et Funari ex Géhu et Géhu Franck 1984 and *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928 are *Salicornia europaea*-dominated and *Suaeda maritima*-dominated stands, as separately clustered in the dendrogram on Figure 2.

3.2.1 Association *Suaedo maritimae-Salicornietum patulae* Brullo et Funari ex Géhu et Géhu Franck 1984 (Table 1)

This, most widespread annual glasswort association in the Mediterranean (Frandoni et Iberite 2002), is characterized by species *Salicornia patula*. Since in Slovenia the taxonomy of genus *Salicornia* is still not cleared, we use the taxon *Salicornia europaea* in the broadest sense after »Mala flora Slovenije« (Martinčič et al. 1999). But there is a high probability that the most widespread annual glasswort which forms monodominant stands is taxon *Salicornia patula*. In table 1 the relevés 61 and 62 (present in dendrogram!) were not included, due to the high presence of *Puccinellia palustris* and weak presence of *Salicornia europaea*: that combination leads us out of the framework of a “salicornietum”.

On the Slovenian seacoast this association occurs predominantly in salt pans, closed muddy surfaces with extreme salinity. Due to homogenous conditions, the surface could reach quite a large extent. It could support periodically very dry conditions (summer) and it is flooded during high tide or rain periods (autumn, spring). These extreme conditions lead to almost monodominant stands. In moister and less salt conditions the grass *Puccinellia palustris* reaches higher cover values. The occurrence of *Suaeda maritima* alternates with *Puccinellia palustris*. It is a quite frequent species, but plants remain tall and poorly branched. *Suaeda maritima* doesn't reach high cover values as well.

3.2.2 Association *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928 (Table 2)

This association was described from southern France (Braun-Blanquet 1951). Some authors classify it within the *Thero-Salicornietea* (Ferrari et al. 1985, Poldini et al. 1999), some of them within the *Cakiletea* (Géhu et Biondi 1994, Biondi 1998). Our classification (Figure 2) clustered these relevés close to stands of the *Suaedo maritimae-Salicornietum patulae* association, within the same main cluster.

Characteristic of this association is high abundance and cover value of species *Suaeda maritima*. The form without *Bassia* is the most widespread and could be interpreted also as facies with *Suaeda maritima*. The plant architecture of this species is different than in the previous one: plants are taller fully branched and generally well developed. The

stands are not so extreme in environmental parameters, *Salicornia* occurs, but less abundantly. The number of species, belonging to different classes, including *Cakiletea*, is higher. Nevertheless this association is incompletely developed within the Northern Adriatic, due to the absence of two characteristic species: *Cressa cretica* is completely missing, *Bassia hirsuta* has become rare north of Ravenna (Poldini et al. 1999) and it is completely missing on the Slovenian seacoast.

3.3 *Spartina maritima*-dominated perennial halophyte saltmarshes

The first relevés of *Spartina maritima*-dominated stands from the Mediterranean were taken by Pignatti (1952). Outside the Atlantic, this species is limited only to sedimentary coasts with low salinity of the Northern Adriatic from the Lagoon of Venice to Istria. Pignatti (1966) classified those stands within the order of halophilous scrubs (order *Limonio-Salicornietea*), but all recent classifications distinguish a separate class *Spartinetea maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971, which includes North American and European *Spartina*-dominated saltmarshes. The presence of *Spartina maritima* in the Northern Adriatic is a biogeographic peculiarity. The only stands in the Adriatic and Mediterranean are very alike to Atlantic coasts: low winter temperatures of sea water, foggy winter periods with close-to-zero temperatures, shallow sedimentary coast and relatively high tide amplitude (Mosetti et Bajc 1972). But there exists a possibility that it was accidentally brought from the Atlantic with ships of »*La serenissima*«'s very active business with Atlantic Europe (after Géhu et al. 1984, Poldini et al. 1999). The floristically poor, but very distinctive stands of *Spartina maritima* are classified within one association – *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973.

3.3.1 Association *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973 (Table 3)

Spartina maritima is the absolutely dominant perennial in this association. *Limonium angustifolium* and *Puccinellia palustris* are also frequent, other species occur only sporadically. The stands are completely natural within the areas of North Adriatic lagoons

(Venice, Grado). This association colonizes first the stable muddy islets, perturbed by high tide, sea turbulence etc. It supports brackish water, which should be rich in nutrients. Therefore it is characteristic also for estuaries. On Slovenian seacoast it occurs along the San Giorgio channel in Seča and the mouth of the Dragonja river, where the environmental conditions are close-to natural with the above-mentioned characteristics. It occurs also in the shallow muddy coast of Debeli rtič near the border with Italy. Due to strong lateral clonal spread of *Spartina stricta*, possible fragmentation of ramets and dispersal by sea currents, it should be very interesting to find out how patches and/or populations are matching with genotypes.

4. CONCLUSIONS

The three associations are represented in the synoptic table (Table 4). We could conclude that associations are defined mostly through dominant species (*Salicornia europaea*, *Suaeda maritima* and *Spartina maritima*) and the absence (rather presence!) of certain taxa. Characteristic species for the four classes of halophile vegetation are distributed across all the three 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. Already Poldini et al. (1999) incorporated into understanding also structural data (life form and growth form of plants). For deeper understanding beyond classification and description, a functional approach is needed – a challenge for further research.

5. ACKNOWLEDGMENTS

The research for this paper was funded by the program group "Biodiversity" (P1-0078), the research project "Biodiversity gradient in relation to biogeographic, altitudinal and ecological factors" (J1-6577) and research project "Mapping of Sečoveljske soline and cultivation of autochthonous glassworts" (L1-7001-006), the first two headed by B. Kryštufek, the last one by J. Nečimer and M. Regvar, all receiving grants from the Slovenian Research Agency.

6. POVZETEK

Halofitna vegetacija ob slovenski morski obali: *Thero-salicornietea* in *Spartinetea Maritimae*

Na kratki slovenski morski obali (sl. 1) prevladujejo flišni klifi z le pičlo razvito halofitno vegetacijo ob kamniti obali. Zelo raznolika pa je halofitna vegetacija na muljastih sedimentih, tako naravnih kot antropogenih ali tistih v opuščanju (soline). Halofitna vegetacija je namreč zelo dinamična v času in prostoru, saj se okoljske razmere, ki jo pogojujejo, zaradi človekovega vpliva vseskozi spreminjajo. Popisi, zbrani med leti 1984–1987 in 1998–1999, do sedaj še niso bili klasificirani niti objavljeni. Klasificirali smo jih s pomočjo hierarhične klasifikacijske analize iz programskega paketa SYN-TAX 2000 (Podani 2001). Dendrogram (sl. 2) je pokazal 5 lepo definiranih šopov, okarakteriziranih z različnimi dominantnimi vrstami. En šop predstavlja vegetacijo halofitnih travnic, dva šopa pa halofitne pionirske enoletnice z dominirajočim osočnikom ali lobodko. Četrty šop so morska močvirja z dominantnim obmorskim ločjem. V ta šop so se uvrstili tudi sestoji, ki jih sestavlja obmorsko metličje. Peti šop pa so izolirani popisi halofitnih travnikov pri Ankaranu. V tem članku obravnavamo popise enoletnih halofitov, ki težijo k monodominantnim in floristično revnim sestojem in pripadajo razredu *Thero-Salicornietea* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx. 1974, ter popise z dominantno vrsto *Spartina maritima*, ki pripadajo razredu *Spartinetea maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971.

Suaedo maritimae-Salicornietum patulae Brullo et Furnari ex Géhu et Géhu-Franck 1984 (tabela 1)

Pionirska vegetacija halofitnih enoletnic na poplavljenih muljastih poljih je zelo ekstremen življenjski prostor, revne mineralne sestave in podvržen spreminjanju vodnih razmer. Prevladuje pionirska vrsta navadni osočnik, manj je obrežne lobodke. Značilna je za bolj vlažne dele solin in druge plitvine.

Suaedo maritimae-Bassietum hirsutae Br.-Bl. 1928 (tabela 2)

To je floristično osiromašena združba, kjer dominira obrežna lobodka, osočnika pa je manj. Vrstna sestava je bogatejša kot v prejšnji asociaciji, lobodka pa doseže optimalno velikost in razvejnost.

Limonio-Spartinetum maritimae (Pignatti 1966) Beeft. et Géhu 1973 (tabela 3)

Ta vegetacija je označena z dominantno vrsto *Spartina maritima*, ki je tipična atlantska vrsta z disjunkcijo v Severnem Jadranu. Porašča muljaste otočke v coni plimovanja, v Sloveniji pa je vezana na obrežje in/ali ustje Dragonje in kanala San Giorgio v Seči (tudi na Debelem rtiču). Na pojavljanje ugodno vplivata odprt sistem (plimovanje, dotok nutrientov) in brakična voda.

Tabela 4 prikazuje razlikovanje asociacij glede na dominantne vrste ter prisotnost značilnic 4 razredov halofitne vegetacije, kar je za uvrščanje v višje sintaksone v malovrstnih haloftnih sestojih vedno problematično. Že Poldini et al. (1999) je upošteval nekatere strukturne značilnosti rastlin (življenjsko obliko in obliko rasti), za globlje razumevanje pa je potrebno poznati tudi okoljske parametre in funkcionalne značilnosti rastlin, kar je vzpodbuda za nadaljnje raziskave.

7. REFERENCES

- Béguinot, A. 1941: La vita delle piante vascolari. In: La laguna di Venezia. Ferrari, Venezia, 3, p.5, t. 9 (2): 1–369.
- Biondi, E. 1998: Diversità fitocenotica degli ambienti costieri italiani. Boll. Mus. Civ. St. Nat. Venezia 49: 39–105.
- Braun-Blanquet, J. 1951: Les Groupements Végétaux de la France Méditerranéenne. Centre National de la recherche scientifique (service de la Carte des Groupements Végétaux) et Direction de la carte des Groupements Végétaux de l'Afrique du Nord, 297 pp + 16.
- Braun-Blanquet, J. 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde, Springer Verlag, Wien New York.
- Darovec, D. 1992: Pregled zgodovine Istre. Knjižnica Annales, 1. Ponatis. Koper: Zgodovinsko društvo za južno Primorsko. Primorske novice, 88 pp.
- Dierschke, H. 1994: Pflanzensoziologie: Grundlage und Methode. Stuttgart, Ulmer.
- Ferrari, C., Gerdol R. & Piccoli F. 1985: The halophilous vegetation of the Po Delta (northern Italy). Vegetatio 61: 5–14.
- Fornaciari, G. 1968: Aspetti floristici e fitosociologici della Laguna di Grado e del suo litorale. Atti Accad. Sci. Lett. Arti Udine 6: 5–199.
- Frondoni, R. & Iberite, M. 2002. The halophile vegetation of the sedimentary coast of Lazio (cen-

- tral Tyrrhenian District, Italy). *Plant Biosystems* 136(1): 49–67.
- Géhu, J. M. 1999: Schéma synsystématique des principales classes de végétations littorales sédimentaires européennes avec références à d' autres territoires holoarctiques. *Ann. Bot. (Roma)* 56(1): 5–52.
- Géhu, J.M., Costa, M., Scoppola, A., Biondi, E., Marchiori, S., Peris, J. B., Franck, J., Canglia, G. & Veri, L. 1984: Essai synsystématique et synchronologique sur les végétations littorales italiennes dans un but conservatoire. *Doc. Phytosoc. N.S.* 8: 393–474.
- Géhu, J. M. & Biondi, E. 1994: **Végétation du littoral** de la Corse: essai de synthèse phytosociologique. *Braun-Blanquetia* 13: 1–149.
- Géhu, J.M. & Biondi, E. 1995: Essai de typologie phytosociologique des habitats et des végétations halophiles des littoraux sédimentaires periméditerranéens halophiles des littoraux sédimentaires périméditerranéens et thermo-atlantiques. *Fitosociologia* 30: 201–212.
- Géhu, J.M. & Biondi, E. 1996: Synoptique des associations végétales du littoral adriatique italien. *Giorn. Bot. Ital.* 130 (1): 257–270.
- Iberite, M. & Frondoni, R. 1997: Contributo alla conoscenza della vegetazione del Parco Nazionale del Circeo: le comunità a salicornie annuali. *Fitosociologia* 34: 121–125.
- Kaligarič, M. 1996 : Threat status of halophyte flora and vegetation. In: Gregori, J. (ed.) *Narava Slovenije, stanje in perspektive*, Društvo ekologov Slovenije. Zbornik prispevkov o naravni dediščini Slovenije, Ljubljana: 113–121.
- Kaligarič, M. 1997: Rastlinstvo Škocjanskega zatoka – deset let kasneje. *Falco (Koper)* 11: 11–12.
- Kaligarič, M. 1998: Botanični pogled na možne ureditve naravnega rezervata Škocjanski zatok. *Ann. Ser. hist. nat.* 8 (13): 131–142.
- Kaligarič, M. & Tratnik, M. 1981: Ohranimo Sečoveljske soline. *Proteus* 44: 122–126.
- Kaligarič, M. & Wraber, T. 1988: Obmorski lan in klasnata tavžentroža v Sloveniji nista izumrla. *Proteus* 50: 372–373.
- Martinčič, A., Wraber, T., Jogan, N., Ravnik, V., Podobnik, A., Turk, B. & Vreš, B. 1999: Mala flora Slovenije. Ključ za določanje praprotnic in semenk. Tretja, dopolnjena in spremenjena izdaja, Tehniška založba Slovenije, Ljubljana.
- Mosetti, F. & Bajc, D. 1972: Una relazione empirica tra l'ampiezza dell'acqua alta a Venezia e la distribuzione della pressione atmosferica sull' Adriatico. *Boll. Geofis. Teor. Appl.* 21 (1/2): 39–42.
- Mucina, L. 1997: Conspectus of classes of European vegetation. *Folia Geobot. Phytotax.* 32: 117–172.
- Pignatti, S. 1952: Introduzione allo studio fitosociologico della Pianura Veneta orientale con particolare riguardo alla vegetazione litoranea. *Arch.Bot.* 28 (4): 265–329.
- Pignatti, S. 1966: La vegetazione alofila della laguna veneta. *Mem. Ist. Veneto Sci. Lett. Arti, Cl. Sci. Mat. Nat.* 33 (1): 3–147.
- Podani, J. 2001: SYN-TAX 2000. Computer Programs for data analysis in ecology and systematics. *Budapest*.
- Poldini, L., Vidali, M. & Fabiani, M.L. 1999: La vegetazione del litorale sedimentario del Friuli-Venezia Giulia (NE Italia) con riferimenti alla regione alto-adriatico. *Studia Geobotanica*, 17: 3–68.
- Rivas-Martinez, S. 1990: Sintaxonomia de la classe *Thero-Salicornietea* en Europe occidental. *Ecol. Medit.* 16: 359–364.
- Šajna N. & Kaligarič, M. 2005: Vegetation of the Stjuža coastal lagoon in Strunjan landscape park (Slovenia): a draft history, mapping and conservation evaluation. *Annales Ser. Hist. Nat.* (in print).
- Westhoff, V. & van der Maarel, E. 1973: The Braun-Blanquet approach. In: Whittaker, R.H. (ed.): *Ordination and classification of communities*. *Handb. Veg. Sci.* 5: 56–172.

Recieved 2. 2. 2006

Revision recieved 25. 5. 2006

Accepted 2. 6. 2006

Table 1: Analytical table of the association *Suaeda maritima*-*Salicornietum patulae* Brullo et Furnari ex Géhu et Géhu Franck 1984Tabela 1: Analitična tabela asociacije *Suaeda maritima*-*Salicornietum patulae* Brullo et Furnari ex Géhu et Géhu Franck 1984

Relevé number	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	63	64	65	66	67	Fr. (%)
Original relevé number	11	12	13	30	34	14	15	25	16	23	20	21	22	33	24	31	17	19	18	28	29	
Relevé surface (m2)	60	100	60	30	50	60	80	40	100	70	30	20	60	60	50	100	40	60	50	70	60	
coverage (%)	60	60	70	70	60	50	60	80	70	60	60	40	40	60	20	50	50	80	50	60	60	
Diagnostic species of the association																						
Cl, O, A <i>Salicornia europaea</i>	3	4	3	3	2	4	+	+	.	+	+	+	.	+	.	1	2	1	1	+	3	100
Diagnostic species of higher syntaxonomic units																						
Cl, O, A <i>Suaeda maritima</i>	4	3	3	3	4	+	+	.	.	+	+	+	.	+	.	1	2	1	1	+	3	76
Others																						
<i>Limonium angustifolium</i>	+	+	+	2	1	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	38
<i>Puccinellia palustris</i>	.	.	.	+	.	.	2	2	2	+	.	.	.	.	.	+	.	.	.	.	.	38
<i>Aster tripolium</i>	+	.	2	+	.	.	.	.	.	.	.	.	1	.	.	.	1	.	+	+	.	33
<i>Halimione portulacoides</i>	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	28
<i>Phragmites australis</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	13
<i>Sarcocornia fruticosa</i>	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14
<i>Elytrogia atherica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	5
<i>Puccinellia fasciculata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	5
<i>Salsola soda</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	5
<i>Spergularia media</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	5

Legend (legenda):Cl – *Thero-Salicornietea* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx. 1974O – *Thero-Salicornietalia* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx 1974A – *Salicornion patulae* Géhu et Géhu Franck 1984

Table 2: Analytical table of the association *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928Tabela 2: Analitična tabela asociacije *Suaedo maritimae-Bassietum hirsutae* Br.-Bl. 1928

Relevé number	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	Fr (%)
Original relevé number	35	38	39	40	42	52	41	46	47	36	37	48	49	43	45	44	50	51	53	
Relevé surface (m2)	30	40	60	30	30	20	50	40	60	40	70	20	40	30	40	40	60	70	30	
coverage (%)	80	70	70	80	80	80	40	80	70	60	70	70	70	50	50	80	70	60	60	
Diagnostic species of the association																				
Cl, O, A <i>Suaeda maritima</i>	4	3	3	5	5	5	3	5	4	3	4	4	4	3	3	3	3	4	3	100
Diagnostic species of higher syntaxonomic units																				
Cl, O, A <i>Salicornia europaea</i>	+	1	1	+	.	.	.	+	.	.	.	.	+	.	.	.	+	.	.	37
Others (ostale)																				
<i>Aster tripolium</i>	+	+	.	.	.	+	.	+	+	+	+	.	.	.	.	3	2	+	1	58
<i>Atriplex prostrata</i> subsp. <i>prostrata</i>	+	+	1	+	.	.	.	.	.	.	.	.	.	1	1	2	+	.	.	42
<i>Elytrigia atherica</i>	+	+	.	.	.	.	.	.	.	.	.	+	1	.	.	.	2	.	+	32
<i>Limonium angustifolium</i>	.	.	+	.	.	.	.	.	+	+	+	.	.	.	.	.	+	.	+	32
<i>Halimione portulacoides</i>	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	+	.	26
<i>Salsola soda</i>	.	.	.	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.	.	26
<i>Inula crithmoides</i>	.	.	.	.	.	.	.	.	+	1	.	.	+	+	.	.	.	.	.	21
<i>Puccinellia palustris</i>	1	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	21
<i>Spergularia media</i>	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	21
<i>Artemisia caerulescens</i>	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	16
<i>Sarcocornia fruticosa</i>	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	16
<i>Phragmites australis</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	16
<i>Parapholis incurva</i>	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	11
<i>Dactylis glomerata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	5

Legend (legenda):Cl – *Thero-Salicornietea* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx. 1974O – *Thero-Salicornietalia* Pignatti ex Tx. in Tx. et Oberdorfer 1958 corr. Tx 1974A – *Salicornion patulae* Géhu et Géhu Franck 1984

Table 3: Analytical table of the association *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973**Tabela 3:** Analitična tabela asociacije *Limonio-Spartinetum maritimae* (Pignatti 1966) Beeft. et Géhu 1973

Relevé number	15	16	17	18	19	20	Fr
Original relevé number	5	7	10	9	6	8	(%)
Relevé surface (m2)	20	30	10	20	20	30	
Coverage (%)	80	90	80	80	70	80	
Diagnostic species of the association							
Cl. O. A <i>Spartina maritima</i>	4	5	4	3	3	4	100
<i>Limonium angustifolium</i>	1	.	+	2	1	+	83
Others (ostale)							
<i>Puccinellia palustris</i>	.	1	+	2	+	+	83
<i>Aster tripolium</i>	.	.	.	+	1	.	33
<i>Suaeda maritima</i>	.	.	+	1	.	.	33
<i>Sarcocornia fruticosa</i>	+	.	.	.	.	.	16
<i>Phragmites australis</i>	.	.	.	1	.	.	16

Legend (legenda):Cl – *Spartinetea maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971O – *Spartinetalia maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971A – *Spartinion maritimae* (R. Tx. 1961) Beeft., Géhu, Ohba et R. Tx. 1971

Table 4: Synoptic table of the associations of the classes *Thero-Salicornietea* and *Spartinetea maritimae*. Values in the table correspond to the relative frequencies (in percentage) of the species in presented group of relevés.

Tabela 4: Sintetična tabela asociacij razreda *Thero-Salicornietea* in *Spartinetea maritimae*.

Vrednosti v tabeli ustrezajo frekvenkam (v odstotkih) pojavljanja vrst v predstavljenih skupinah popisov.

	Association Number of relevés	Sm-Sp 23	Sm-Bh 19	Li-Sp 6
Ass. char. and diff. species				
Ch1(CI1, O1, A1)	<i>Salicornia europaea</i>	100 (3-5)	37 (+-1)	.
Ch2(CI1, O1, A1)	<i>Suaeda maritima</i>	70 (+-4)	100 (3-5)	33 (+-1)
Ch3(CI2, O2, A2)	<i>Spartina maritima</i>	.	.	100 (3-5)
D3(AF)	<i>Limonium angustifolium</i>	35 (+-2)	32 (+)	83 (+-2)
<i>Arthrocnemetea fruticosi</i> Br.-Bl. et R. Tx. 1943 corr O. Bolós 1967				
	<i>Sarcocornia fruticosa</i>	9 (+-1)	16 (+-1)	16 (+)
	<i>Halimione portulacoides</i>	26 (+-2)	26 (+)	.
	<i>Inula crithmoides</i>	.	21 (+-1)	.
	<i>Artemisia caerulescens</i>	.	16 (+)	.
<i>Juncetea maritimi</i> Br.-Bl. 1952 em. Beeftink 1965				
	<i>Puccinellia palustris</i>	35 (+-2)	21 (+-1)	83 (+-2)
	<i>Aster tripolium</i>	30 (+-2)	58 (+-3)	33 (+-1)
	<i>Elytrigia atherica</i>	4 (+)	32 (+-2)	.
<i>Cakiletea maritimae</i> R. Tx. et Prsg. 1950				
	<i>Spergularia marina</i>	.	21 (+)	.
	<i>Salsola soda</i>	4 (1)	26 (+)	.
	<i>Atriplex prostrata</i> subsp. <i>prostrata</i>	.	42 (+-2)	.
Others (ostale)				
	<i>Phragmites australis</i>	13 (+)	16 (+-1)	16 (1)
	<i>Puccinellia fasciculata</i>	4 (1)	.	.
	<i>Spergularia media</i>	4 (+)	11 (+)	.
	<i>Parapholis incurva</i>	.	.	.
	<i>Dactylis glomerata</i>	.	5 (+)	.

Legend (legenda):

Sm-Sp: *Suaedo maritimae*-*Salicornietum patulae*

Sm-Bh: *Suaedo maritimae*-*Bassietum hirsutae*

Li-Sp: *Limonio-Spartinetum maritimae*

Ch1-3: Ass. char. species (značilnice asociacij)

D: differential species (razlikovalnice asociacij)

CI1: *Thero-Salicornietea*

CI2: *Spartinetea maritimae*

O1: *Thero-Salicornietalia*

O2: *Spartinetalia maritimae*

A1: *Salicornion patulae*

A2: *Spartinion maritimae*