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Benthic biocoenoses of the Sv. Marko Islet (Rijeka Bay)

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INTRODUCTION

Natural researches into the sea-bottom of the Rijeka Bay and the whole Kvarner Gulf commenced in the second half of the 19th century. Many authors undertook investigations of the aquatorium flora and fauna *(7, 9, 12, 14, 20, 28, 29)*. Research work was continued during the World War II *(3, 5, 13, 15, 17, 26, 27, 30)*. At the present time biocoenological researches are carried out by using, apart from classic sampling methods on a sediment bottom, the method of direct observations by means of SCUBA-diving equipment on a hard bottom of littoral stations *(4, 10, 31, 32)*.

Although the Rijeka Bay and the Kvarner area are relatively well researched, the sea-bottom of the Sv. Marko Islet has remained almost uninvestigated *(21)*. Gamulin-Brida et al. *(4)* worked out a station in the Voz bay of the island of Krk (KR-23), not very far from the islet. In their researches Zavodnik et al. *(33)* worked out just one station in the northern part of the islet (RI-18). The reasons for ignoring the islet of Sv. Marko during the biocoenological researches could be attributed to its small area and its position so close to the island of Krk and the mainland, from which it is separated only by narrow channels.

Area of investigation

Sv. Marko is an irregular triangle-shaped islet, located along the north-eastern coast of the Krk island (Figure 1). The main part of the islet consists of paleogenic and cretaceous carbonate rocks *(23)*. In the south-western part, facing the Krk island, the layers of paleogene flysch are set in the basic rocky mass *(2)*.

Although the surface of the islet is markedly rugged, there are no visible signs of abrasion processes in the carbonate littoral zone. Due to highly pure limestone, the process of bioerosion is evident *(6, 19)*. In shallower parts (up to 10 m depth) the undersea slopes are mainly rocky, with no sediment layer. In deeper parts the slopes begin to be covered with rough detritic sand which gradually changes into fine sand. The plain bottom of the Tihi channel consists of fine sand, more or less muddy, depending on intensity of near-bottom sea currents.

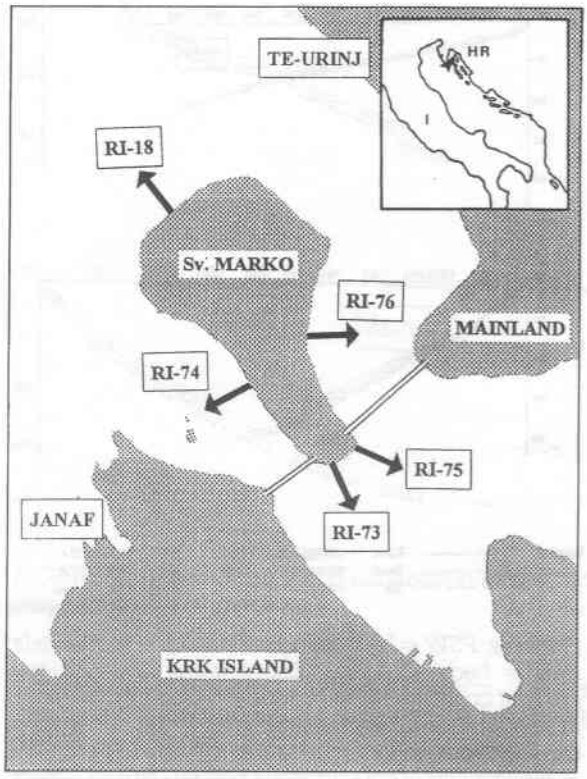


FIGURE 1. *Investigation area. The transects are indicated by arrows and station numbers.*

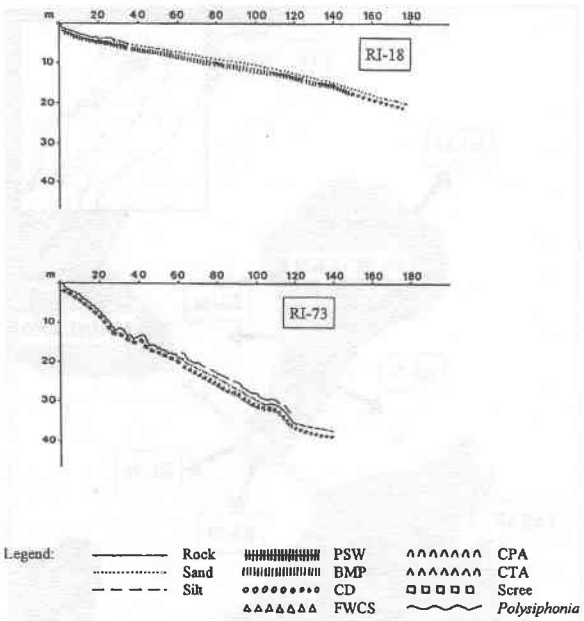
In the flysch zone there is a beach formed by drifts from higher unconsolidated parts of the steep slope. The littoral and sublittoral zones consist of movable materials subject to hidrodynamic influence of the sea. The effects are intensified by sea streams, especially distinct on the account of the narrow passage between the islet and the riff in the middle of the channel.

While constructing the bridge and the road to link up the mainland with Sv. Marko and Krk in late seventies, large quantities of materials from the south-western part of the islet were discarded toward the sea, completely

covering the autochthonous communities of the terrestrial slope and the sea-bottom of the southern side of the islet up to a depth of 20 m.

METHODOLOGY

The researches had been performed at five stations during the period from July 1994 to December 1995. These stations are: RI-18 (north-western coast), RI.73 (south coast), RI-74 (south-western coast), RI-75 (south-eastern coast) and RI-76 (eastern coast) (Figure 2). When planning the stations we tried to comprise the whole islet evenly; the designations of the above mentioned stations were added to previous researches done in the area *(33)*.



Symbols: PSW = biocoenosis of photophilic seaweds; BMP = beds of marine phanerogams;CD = biocoenosis of coastal detritic bottom; FWCS = biocoenosis of fine well calibrated sands; CPA = biocoenosis of coralligenous bottom - praecoralligenous aspect; CTA = biocoenosis of coralligenous bottom - typical aspect; SC = biocoenosis of scree

FIGURE 2. *Bottom profile and distribution of benthic communities at transects.*

At each station we marked, by means of a measuring rope, a transect perpendicularly to the coast from the sea surface to approximately 40 m depth. We investigated the benthic communities using the method of direct observations and SCUBA-diving equipment. *In situ* observations and notes are completed with photodocumentation.

The most common species were determined in the field. The species that required more detailed analysis were stored for precise determination. The collected fauna material was conserved in 4% buffered formol solution; the algae were stored at -2°C. Determination was carried out in the Laboratory for Ecology and Systematics of the "Ruđer Bošković" Institute, Center for Marine Research Rovinj. A part of collected and determined species was stored in collections and herbarium of the Rovinj Laboratory and the Natural History Museum of Rijeka.

The evaluated number of specimens was designated according to degrees : R = rare single individuals, + = common species, C = abundant species, CC = dense population, numerically prevailing species. On the basis of field notes and material determination we found out the benthic communities along every transect, according to the classification of Pérès and Picard *(18)*.

RESULTS

RI-18 (Figure 2)

A station on the northwestern coast of the islet of Sv. Marko is facing the Rijeka Bay. The coast is rocky and gently slopes to the sea. Numerous specimens of the small periwinkle *Littorina neritoides* are found in the supralittoral zone and the red seaweed *Catenella caespitosa* is common in crevices. In the mediolittoral zone the barnacle *Chthamalus stellatus* populates up to 70% of the rocky surface *(33)*.

The upper part of the infralittoral up to 4 m depth forms a rocky bottom with outstanding stones overgrown by photophilic algae (*Cystoseira amantacea* var. *spicata*, *Dictyota dichotoma* var. *intricata*, *Padina pavonica*, *Acetabularia acetabulum*). Among them, especially in shaded basal stratum, some sciaphilous algae (*Halimeda tuna*, *Dasycladus vermicularis*, *Peyssonnelia squamaria*, *Vidalia volubilis*) are found quite often. The epiphytic *Wrangelia penicillata* covers up to 60% of algae thalli in the first depth meter.

The bottom at the depth from 5 to 27 m is sandy. In a shallower part the seagrass *Cymodocea nodosa* grows in individual small tufts among which the specimens of the common sargassum *Sargassum vulgare* are prominent. In deeper part there is a well developed seagrass bed in which, among macrofauna species, the sea-squirt *Phallusia mammilata*, the annelid worm *Sabella spallanzanii* and sea-cucumbers *Holothuria tubulosa* and *H. forskali* are prevailing.The seagrass bed ends at the depth of 15 m and there appears *Cystoseira corniculata* ssp. *laxior*. Along the transect we also found the common octopus *Octopus vulgaris*.

RI-73 (Figure 2)

A station on the south coast of the Sv. Marko islet. The coast is steep, an artificial scree up to the depth of 17 m was created during construction works. The bottom is mainly bare, algae cover only 20% of its surface (*Peyssonnelia squamaria*, *P. polymorpha*, *Laurencia obtusa*, *Wrangelia penicillata*, *Cladophora* sp.). The hydrozoan population of *Eudendrium* sp. is well developed. Specimens of boring sponges *Cliona cellata* and *C. viridis*, the sea-snail *Bittium reticulatum*, the annelid

worm *Pomatoceros triqueter*, the flat encrusting bryozoan *Cryptosula pallasiana*, as well as sea-squirts *Phallusia fumigata* and *Microcosmos sulcatus*, are very common. Half of the bottom-surface, formed by big pebbles, is overgrown with the red alga *Polysiphonia* sp. up to 20 m depth. The silty-sand bottom, 20 - 30 m deep, is completely covered by a layer of the red algae *Polysiphonia* spp., 3-5 cm thick. On bigger stones that slid down from the upper terrestrial part, we can find specimens of the yellow gorgonian *Eunicella cavolinii*, the golden sponge *Verongia aerophoba*, the Noah's ark *Arca noae* and sciaphilous algae *Peyssonnelia rubra* and *Phyllophora nervosa*. Up to a depth of 35 m the layer of *Polysiphonia* spp. still covers 50% of the bottom. From 36 m depth on there is no algal cover and the bottom is bare. On uncovered parts of silty and sandy bottoms we found a female of the spiny crab *Maja squinado*, sponges *Tethya lyncurium*, echiurid worms *Bonellia viridis*, red starfishes *Echinaster sepositus* and golden anemones *Condylactis aurantiaca*. On thinly scattered stones, there are red algae *Peyssonnelia rubra*, *P. squamaria* and *Phymatolithon calcareum*, as well as the sponge *Axinella verrucosa* with the anthozoans *Parazoanthus axinellae* and red the-squirt *Halocynthia papillosa*.

RI-74 (Figure 3)

A station on the southwestern coast of the islet of Sv. Marko where is a beach extending along the coast. The splash zone is densely settled by the small periwinkle *Littorina neritoides*. Clumps of the blue-green alga *Rivularia atra* are noticeable, too. In the zone of the tides there are found settlements of barnacles *Chthamalus stellatus* and *Ch. montagui*, as well as snails *Patella caerulea*, *Monodonta turbinata* and *M. articulata*.

The upper infralittoral up to 2 m depth consists of broad shelf gently inclined, made of edged stones, as those found at the scree. Algae cover approximately a half of the complete bottom surface (*Padina pavonica*, *Anadyomene stellata*, *Laurencia obtusa*, *Dictyota dichotoma* var. *intricata*, *Cystoseira crinita*). Very common are the small snails *Bittium reticulatum*, the endolithic bivalve molluscs *Gastrochaena dubia* and sea-urchins *Arbacia lixula* and *Paracentrotus lividus*. A steep slope of rough sand that follows, gets finer in deeper parts. Along the slope rare stony blocks scattered around are overgrown whith seaweeds *Cystoseira corniculata* ssp. *laxior*, *Dictyota dichotoma* var. *intricata* and *D. linearis*. Quite common are colonies of tiny hydroids *Eudendrium* sp. with the slug *Flabellina affinis* feeding and depositing egg-masses on them. On the sandy slope the most abundant are the sea-stars *Astropecten aranciacus*, *Echinaster sepositus* and *Marthasterias glacialis*. Between 20 and 35 m depth the slope is less inclined, sand is slightly muddy and a lot of suspended material is present in the water column. In the middle of the channel, at the depth of 35 m, free-lying patches of algae *Vidalia volubilis* i *Polysiphonia* spp. cover about 20% of the sea-floor. Among the macrofauna species we noticed numerous individuals of the black sea-cucumber *Holothuria forskali*, the Mediterranean feather-star

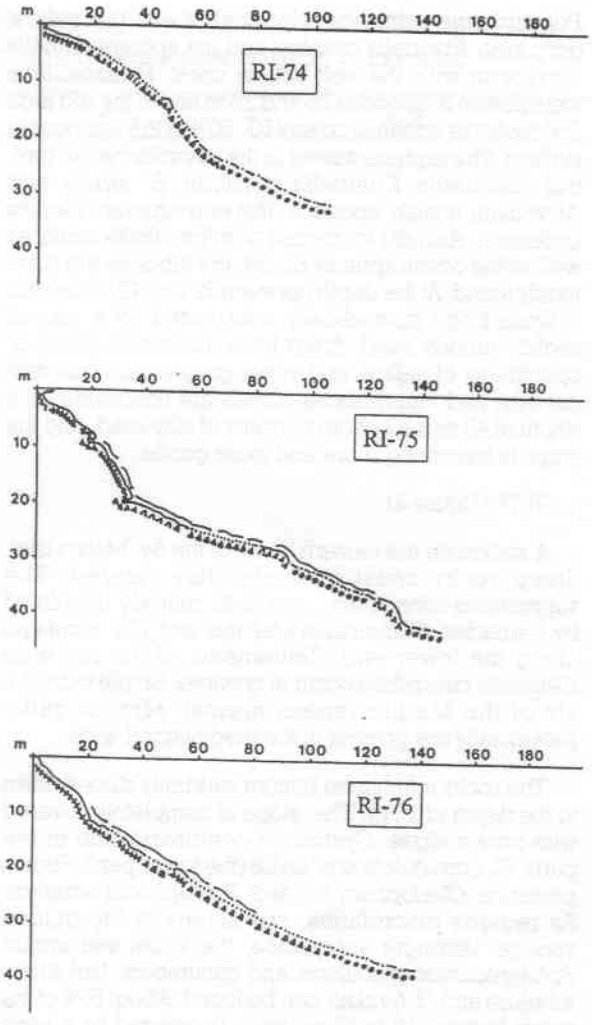


FIGURE 3. Bottom profile and distribution of benthic communities at transects.

Antedon mediterranea, the annelid worm *Sabella spallanzanii* and one single colony of the white gorgonian *Eunicella stricta*.

RI-75 (Figure 3)

A station on the rocky and steep southeastern coast of the islet of Sv. Marko. In the supralittoral zone the population of the barnacle *Chthamalus depressus* is well developed, and in the mediolittoral zone *Ch. stellatus* and *Ch. montagui* are dominant. In a lower part of the intertidal zone small clumps of the Mediterranean mussel *Mytilus galloprovincialis* are found.

The uppermost part of the infralittoral step is formed by an overhanging rock full of holes of the date mussel *Lithophaga lithophaga*. The population of the hydroid *Eudendrium* sp. is very dense. Typical are algae *Corallina officinalis*, *Peyssonnelia squamaria*, *Amphiroa rigida*, *Cladophora laetevirens*, as well as *Polysiphonia sertularioides* and *P. subulifera*. At the depth of 10 m the sea-bottom is completely covered with the red alga

Polysiphonia adriatica. Noticeable are the yellow gorgonian *Eunicella cavolinii* and the sponge *Axinella verrucosa* with the soft yellow coral *Parazoanthus axinellae* on it. Between 25 and 35 m depth the red alga *Polysiphonia adriatica* covers 50 - 90% of the sea-bottom surface. The representatives of the macrofauna are rare, but cnidarians *Eunicella cavolinii*, *E. stricta* and *Alcyonium acaule*, sponges *Tethya lyncurium*, *Geodia cydonium*, *Axinella verrucosa* and *Acanthella acuta*, as well as the cotton spinner *Holothuria tubulosa* are commonly found. At the depth between 39 and 42 m, there is a stone ridge sporadically interrupted by a dike of slightly muddy sand. Apart from numerous sponges, specimens of yellow and violet gorgonians *Eunicella cavolinii* and *Paramuricea clavata* are noticeable. At a depth of 45 m the bottom consists of silty sand, and the slope is becoming more and more gentle.

RI-76 (Figure 3)

A station on the eastern coast of the Sv. Marko islet. Steep rocky coast is moderately rugged. The supralittoral zone is 0.5 - 1 m high, densely populated by barnacles *Chthamalus stellatus* and *Ch. montagui* along the lower end. Settlements of the red alga *Catenella caespitosa* occur in crevices. Single individuals of the Mediterranean mussel *Mytilus galloprovincialis* are present in the mediolittoral zone.

The rocky infralittoral bottom suddenly slopes down to the depth of 10 m. The slope is completely covered with brown algae *Cystoseira compressa* (the upper part), *C. corniculata* ssp. *laxior* (the lower part), *Padina pavonica*, *Cladophora* sp. and *Polysiphonia adriatica*. As regards macrofauna, specimens of the golden sponge *Verongia aerophoba*, the violet sea-urchin *Sphaerechinus granularis*, and cucumbers *Holothuria tubulosa* and *H. forskali* can be found. About 50% of the sandy bottom, 16 to 27 m deep, is covered by a layer stratum of the red alga *Polysiphonia adriatica*. We noticed colonies of the stone-coral *Cladocora caespitosa*, as well as specimens of the solitary coral *Balanophyllia europaea*. On fine and slightly muddy sand, 27 to 39 m deep, old subfossil and fresh testae of the irregular urchin *Spatangus purpureus*, as well as shells of bivalves *Pecten jacobaeus*, *Laevicardium oblongum* and *Acanthocardia echinata* are commonly found. From a depth of 40 m on the slope gradually continues toward the central part of the channel.

DISCUSSION

We consider these results as preliminary for many reasons. Researches were not carried out during all seasons, and the number of stations is sufficient for covering each sides of the islet are by one transect only.

Zones of supralittoral, mediolittoral and infralittoral analysed in this area are in compliance with commonly known and accepted vertical distribution. However, elements of circalittoral biocoenosis are sporadically found in a shallower infralittoral zone. Such enclaves are obviously caused by the bottom configuration with special microrelief characteristics (overhanging rocky walls, crevices, lower parts of loose stones and boulders) and by shadow in the basal stratum of dense *Cystoseira* settlements. But, we also believe that the phenomenon is strongly influenced by the water column overloaded with suspended material of unknown origin that decrease the quantity of light penetrating depth *(11)*.

We think that it is necessary to point out the finding of the submarine well-like formation in the northeastern part of the islet, between stations RI-18 and RI-76. The entrance is about 150 m far from the coastal line at the depth of 14 m, but it is too narrow for SCUBA-divers to get in. Such underwater "wells" are geologically "dead" channels of former active water springs. They are usually found along the western Istrian coast, and their common feature is that they slope down almost vertically. Researches into Mediterranean caves showed that such extreme biotopes were settled by very particular macrofauna, comparable to that from deep sea-floors *(24, 25)*.

In the submarine area of the islet of Sv. Marko we have found altogether 47 taxa of macroalgae, two species of blue-green algae, 1 phanerogam and 101 macrofauna species (Table I). According to the current data, the benthos of Sv. Marko does not differ from other locations of the Rijeka Bay and Kvarner, although there are a few interesting characteristics.

A community of supralittoral rocks in the Adriatic is featured by the small periwinkle *Littorina neritoides* and the barnacle *Chthamalus depressus*. Among three stations (RI-74, RI-75 and RI-76), where the supralittoral was more throughly analysed in the course of these researches, *Ch. depressus* was found only at station RI-75. Zavodnik et al. *(33)* also mentioned *Ch. depressus* at the station RI-18. It is interesting that at station RI-76 the supralittoral step is only 0.5 to 1 m high, although the coast is directly exposed to the influence of the northeastern wind "bora". Even more surprisingly, the supralittoral *Ch. depressus* was not found during our researches. Two typical mediolittoral species of barnacles *Chthamalus stellatus* and *Ch. montagui* were found at stations RI-74, RI-75 and RI-76. Zavodnik et al. *(33)* mentioned *Ch. stellatus* at station RI-18, but the presence of *Ch. montagui* should be checked out.

The intertidal zone is characterized by a biocoenosis of mediolittoral rocks with gastropod species *Patella rustica*, *P. caerulea* and *Monodonta turbinata* at stations RI-74, RI-75 and RI-76. The Mediterranean mussel *Mytilus galloprovincialis* occurs individually or in small clumps at stations RI-75 and RI-76, where a surface layer of fresh water is visible with the naked eye. The brown fucoid alga *Fucus virsoides*, an endemic Adriatic species, is typical for the lower horizon of the mediolittoral step in the North Adriatic *(35)*. Although Zavodnik et al. *(33)* recorded *F. virsoides* at station RI-18, we did not find it during our research. The calcareous alga *Phymatolithon lenormandii*, that takes part in formation of mediolittoral "cornishes" in the middle Adriatic, is found at stations RI-75 and RI-76. The belt-like settlement of *P. lenormandii*, 15 - 29 cm wide, is especially well developed at station RI-76.

TABLE 1

Preliminary list of marine plant and animal species at transects in the coastal zone of the Sv. Marko islet.

	RI-18	RI-73	RI-74	RI-75	RI-76
RODOPHITA					
Ceramium rubrum (Huds.) C.Ag.		+			
Wrangelia penicillata C.Ag.	+	+			
Laurencia obtusa (Huds.) Lamour.		+	+	+	+
Laurencia paniculata (C.Ag.) J.Ag.			+		
Laurencia papillosa (Forsk.) Grev.	+				
Laurencia pinnatifida (Gmel.) Lam.		+			
Polysiphonia adriatica Schiff.	+			+	+
Polysiphonia fruticulosa (Wulf.) Spreng.	+				
Polysiphonia sertularioides (Gratel.) J.Ag.				+	
Polysiphonia subulifera (C.Ag.)				+	
Polysiphonia sp.		+	+		
Vidalia volubilis (L.) J.Ag.	+		+		+
Amphiroa rigida Lamour.				+	
Corallina officinalis L.				+	
Jania rubens (L.) Lam.	+				
Lithophyllum incrustans Phil.		+		+	
Phymatolithon calcareum (Pall.) Adey et McKibbin		+			
Phymatolithon lenormandii (Aresh.) Adey				+	+
Spongites fruticulosa Kütz.		+	+	+	
Catenella caespitosa (Wither.) L. Irvine					+
Peyssonnelia polymorpha (Zanard.) Schlitz		+		+	
Peyssonnelia rubra (Grev.) J.Ag.	+	+	+	+	+
Peyssonnelia squamaria (Gmel.) Dec.	+	+	+	+	+
Phyllophora nervosa (De Condolle) Grev. ex J.Ag.		+			
Hildembrandtia rubra (Sommerf.) Menegh.			+		
PHAEOPHYTA					
Dictyota dichotoma var. *intricata* (C.Ag.) Grev.	+		+	+	+
Dictyota linearis (C.Ag.) Grev.	+		+		
Padina pavonica (L.) Thivy	+		+		+
Cystoseira amantacea var. *spicata* (Erceg.) Giacc.	+				
Cystoseira compressa (Esp.) Gerl. et Nizam.					+
Cystoseira corniculata ssp. *laxior* Erceg.	+		+		+
Cystoseira crinita Bory			+		
Sargassum vulgare C.Ag.	+				
Sphacellaria cirrosa (Roth) C.Ag.	+	+	+	+	
CHLOROPHYTA					
Bryopsis duplex De Notaris	+				
Codium bursa (L.) C.Ag.		+	+	+	+
Codium adherens C.Ag.				+	
Codium tomentosum Stack.					+
Flabellia petiolata (Turra) Nizam.			+		+
Halimeda tuna (El. et Solan.) Lam.	+				
Anadyomene stellata (Wulf.) C.Ag.	+		+		
Cladophora laetevirens (Dillw.) Kütz.				+	
Cladophora prolifera (Roth) Kütz.	+				
Cladophora sp.		+			+
Valonia utricularis (Roth) C.Ag.			+		
Acetabularia acetabulum (L.) Silva	+				+
Dasycladus vermicularis (Scop.) Krass.	+			+	
CYANOPHYTA					
Rivularia atra Roth			+	+	
Rivularia mesenterica Thur.				+	
SPERMATOPHYTA					
Cymodocea nodosa (Ucria) Asch.	+				
PORIFERA					
Geodia cydonium (Jameson)				+	
Tethya lyncurium (Linnaeus)		+		+	
Spirastrella cunctatrix O. Schmidt		+			
Cliona viridis (O. Schmidt)		+	+	+	

TABLE 1
(Continued)

	RI-18	RI-73	RI-74	RI-75	RI-76
Cliona cellata Grant		+	+		
Axinella verrucosa (Esper)		+		+	
Axinella cannabina (Esper)				+	
Acanthella acuta (O. Schmidt)				+	
Petrosia ficiformis (Poiret)				+	
Cacospongia sp.					+
Verongia aerophoba (O. Schmidt)	+	+	+	+	+
CNIDARIA					
Eudendrium sp.		+	+	+	+
Cerianthus membranaceus (Spallanzani)	+				
Parazoanthus axinellae (O. Schmidt)		+		+	
Condylactis aurantiaca (Delle Chiaje)	+	+	+		+
Actinia equina (Linnaeus)			+	+	+
Anemonia sulcata (Pennant)			+		
Cereus pedunculatus (Pennant)			+		
Cladocora caespitosa (Linnaeus)				+	
Balanophyllia europaea (Risso)	+		+		+
Alcyonium acaule (Kükenthal)				+	
Parerythropodium corraloides (Pallas)				+	
Eunicella cavolinii (Koch)		+		+	
Eunicella stricta (Bertoloni)			+	+	+
Paramuricea clavata (Risso)				+	
MOLLUSCA					
Patella caerulea Linnaeus			+	+	+
Patella rustica Linnaeus				+	+
Haliotis tuberculata lamellosa Lamarck			+		+
Gibula divaricata Linnaeus			+		+
Monodonta articulata Lamarck			+		+
Monodonta turbinata (Von Born)			+	+	+
Cerithium rupestre Risso			+		
Cerithium vulgatum Bruguière			+		
Bittium reticulatum (Da Costa)	+	+	+	+	+
Littorina neritoides (Linnaeus)			+	+	+
Serpulorbis arenaria (Linnaeus)			+	+	
Hexaplex trunculus (Linnaeus)	+				
Tylodina perversa (Gmelin)		+	+		
Discodoris atromaculata (Bergh)				+	
Dendrodoris grandiflora (Rapp)			+		
Flabellina affinis (Gmelin)		+	+		+
Coryphella lineata (Loven)		+		+	
Arca noae Linnaeus	+	+	+		
Mytilus galloprovincialis Lamarck				+	+
Lithophaga lithophaga (Linnaeus)				+	+
Pecten jacobaeus (Linnaeus)	+				+
Acanthocardia echinata (Linnaeus)					+
Laevicardium oblongum (Gmelin)	+				+
Gastrochaena dubia (Pennant)	+	+	+	+	+
Hiatella arctica Linnaeus					+
Octopus vulgaris Cuvier	+				
SIPUNCULA					
Phascolosoma granulatum (Leuckart)	+				
ECHIURA					
Bonellia viridis (Rolando)	+	+		+	
ANNELIDA					
Lanice conchylega (Pallas)			+		
Sabella pavonina (Savigny)		+			
Sabella spalanzani (Gmelin)	+		+		
Filograna implexa Berkeley			+		
Pomatoceros triquter Linnaeus		+	+	+	
Protula sp.		+		+	+

TABLE 1
(Continued)

	RI-18	RI-73	RI-74	RI-75	RI-76
CRUSTACEA					
Chtamalus stellatus (Poli)			+	+	+
Chtamalus depressus (Poli)				+	
Chtamalus montagui Southward			+	+	+
Palaemon cf. *serratus* (Pennant)	+	+	+		+
Maja crispata Risso				+	
Maja squinado (Herbst)		+			
Pachygrapsus marmoratus (Fabricius)			+	+	+
Eriphia verrucosa (Forskål)				+	+
Ligia italica Fabricius			+	+	
BRYOZOA					
Cryptosula pallasiana (Moll)		+			
Reptandeonella violacea (Johnston)			+		
ECHINODERMATA					
Antedon mediterranea Lamarck		+	+		
Holothuria forskali Delle Chiaje			+		+
Holothuria tubulosa Gmelin	+	+		+	+
Arbacia lixula (Linnaeus)			+		
Paracentrotus lividus (Lamarck)			+	+	
Sphaerechinus granularis (Lamarck)	+	+			+
Spatangus purpureus O.F. Müller	+				+
Astropecten aranciacus (Linnaeus)	+		+		+
Echinaster sepositus (Retzius)	+	+	+		+
Marthasterias glacialis (Linnaeus)		+	+	+	
TUNICATA					
Clavelina lepadiformis (O.F. Müller)				+	
Distoma adriatica Drasche				+	
Phallusia mammilata (Cuvier)	+				
Phallusia fumigata Grube	+	+	+		+
Halocynthia papillosa (Linnaeus)	+	+		+	
Microcosmus sulcatus Coquebert		+	+	+	
PISCES					
Scyliorhinus stellaris (Linnaeus)				+	
Serranus hepatus (Linnaeus)	+	+		+	+
Diplodus vulgaris (Saint Hillaire)			+	+	
Sarpa salpa (Linnaeus)				+	
Spicara sp.		+		+	
Chromis chromis (Linnaeus)		+		+	+
Coris julis (Linnaeus)	+	+		+	+
Gobius bucchichi Steindachner	+		+		
Lipophrys dalmatinus (Steindachner & Kolombatoviæ)				+	+
Aidablennius sphynx (Valenciennes)					+
Parablennius rouxi (Cocco)					+
Parablennius sanguinoletus (Pallas)			+		+
Trypterigium tripteronotus (Risso)				+	+
Atherina sp.				+	
Scorpaena porcus Linnaeus				+	

A community of photophilic algae with species of genus *Cystoseira*, as well as *Laurencia obtusa*, *Dictyota dichotoma* var. *intricata*, *Padina pavonica* occur in the upper infralittoral zone on a solid substrate. The epiphytic red alga *Wrangelia penicillata* is very significant for the summer aspect. Among important animal species there are spread the golden sponge *Verongia aerophoba* and sea-urchins *Paracentrotus lividus*, *Arbacia lixula* and *Sphaerechinus granularis*.

In the infralittoral zone at station RI-73 the sea-bottom is stony and loose, formed by material slid from the land side. We can talk about a sea-scree which main characteristic is unconsolidated edged stones on the slope and 60 - 75% inclination. The complete slope is unstable and only a slight disturbance could be sufficient for stones to cave in depth. Considering the bottom as the main ecological factor, some species, normally concurring in other biocoenoses, are regarded as typical here. The

organisms tolerating bottom movements are represented in a larger number, like boring sponges *Cliona viridis* and *C. cellata*, the snail *Bittium reticulatum*, the endolithic bivalve *Gastrochaena dubia*, the sedentary polychaete *Pomatoceros triqueter* and the encrusting bryozoan *Cryptosula pallasiana*. On the bottom algae are rarely found, only the species of short or flat thallus (*Cladophora* spp., *Peyssonnelia squamaria*) are recorded. Common concurring species are sea-cucumbers *Holothuria tubulosa* and *H. forskali*, as well as the sea-egg *Microcosmus sulcatus*. According to our data, we believe that it is possible to establish the scree as a distinct biocoenosis of movable stony bottom of an infralittoral step. We recorded it at station RI-73, up to 75° inclined, at a depth from 0 to 19 m.

The initial part of the RI-73 transect is a stony bottom, also consisting of edge stones (scree elements), but with minimally inclined substrate and populated by species typical of a photophilic algae community.

Therefore, our opinion is that the bottom inclination, apart from unconsolidated compound bottom elements, is one of main factors to define ruderal biocoenosis of the scree.

Namely, a bottom with similar characteristics is found in the littoral zone of the power-plant TE-Urinj and the tankers loading berth JANAF in the Omišalj Bay (Figure 1). During construction works the original steep coast was covered by material discarded from land. We assume that fine sediment was flushed away by the sea and only bigger and smaller unconsolidated crushed stones remained. Due to relatively short time period, the biogenic establishment of stones and substrate consolidation have not occurred yet. On such secondary bottoms, the community is poor in species, animal organisms are prevailing, while the floristic component is very indigent. Natural "screes" (the south coast of the entrance into the Raša Bay, the eastern coast of the Cres Island,..., all in broad Kvarner region) differ significantly from the above described "antropogenic" ones, made by man in scree gradation. Since the material had been caved in during a long time period, it was verticaly sorted by size. In deeper areas rough sand turns into bigger pebbles and bigger stones form the bottom of the slope.

The biocoenosis of fine well-sorted sand with the seagrass *Cymodocea nodosa* is developed in the upper infralittoral of station RI-18. Only at this station we noted specimens of the common sargassum *Sargassum vulgare* within the *Cymodocea* bed. The most important Mediterranean phanerogam *Posidonia oceanica* was not noticed during our research. Zavodnik et al. *(33)* some 25 years ago recorded a complex community of *Posidonia* meadow at the very same station. On all bottom types of infralittoral steps at stations RI-73, RI-75 and RI-76, 60 to 100% of surface, depending on depth, is covered by a red algae layer of the *Polysiphonia* species. Algae of the genus *Polysiphonia* were noticed at stations RI-18 and RI-74 as well, but in a much smaller quantity. The largest covering rate and thickness of an alga layer was observed at the depth from 20 - 25 m, where the amount of the day light was reduced due to highly suspended particles density in the water column.

Algae grow as epibionts, covering not only "bare" rocky, stony and all types of sedimentary bottoms, but also various organisms (*Codium bursa*, *Tethya lyncurium*, *Microcosmus sulcatus*). The largest part of their thalli is not accreted to the substratum, but is freely lying on the surface. That is why in this paper we used the expression "layer", trying to describe the phenomenon morphologically as exact as possible. Under the algae layer the sediment is completely black at some bottom areas, indicating a lack of oxygen and appearance of anoxic conditions. Besides at the above mentioned stations, an identical phenomenon was recorded at stations RI-71 (the Scott Bay), RI-72 (the Oštro Cape) and RI-77 (the Voz Cape) too (Jaklin and Arko-Pijevac, unpublished data). All quoted stations are facing the Tihi Channel which separates the Krk island (with the Sv. Marko islet) from the mainland (Figure 1).

The biomass of the described layer is very high, because the algae wet weight exceeds even 6 kg/m^2 at some places (Jaklin & Arko-Pijevac, unpublished data). At this moment we cannot conclude for certain what are the causes that lead to the "bloom" of the red algae genus *Polysiphonia*. We only know that this is not a short-time, ephemeral phenomenon, since such layer could be found in various seasons. Consequently, we can conclude that the layer is present throughout the year with probable oscillations conditioned by abiotic environmental factors. Therefore, we consider that the phenomenon deserves much more attention in future researches. More records of their spread are required, as well as data on physical-ecologic factors in order to get an answer to the question "WHY?". We should like to emphasize that nothing similar had been recorded in the literature on biocoenoses of the eastern Adriatic coast by now.

At the first impression similar phenomenon was described in the world literature. An excessive macrophitic algae development reflecting the eutrophication at the coastal areas has been recorded wordwide *(16)*. But, in distinction from the sea-bottom of the Tihi Channel, described localities are markedly shallow (lagoons or estuaries), with weak water exchange and direct inflow of untreated waste waters. Species mainly belong to genera of *Ulva*, *Enteromorpha*, *Chaetomorpha*, *Cladophora*, *Gracilaria* and *Porphyra*.

At places where the layer of *Polysiphonia* spp. is thinner we noted sciaphilic algae of genus *Peyssonnelia*, *Vidalia volubilis* and *Flabellia petiolata*. We found elements of a coastal detrital bottom biocoenosis with species of *Pecten jacobaeus*, *Laevicardium oblongum* and *Acanthocardia echinata* at stations RI-18, RI-75 and RI-76 at the depth from 17 to 40 m.

At station RI-75, on a stony ridge in the circalittoral zone at the depth between 39 and 42 m, we recorded a biocoenosis of coralligenous bottoms with species of *Paramuricea clavata*, *Eunicella cavolinii*, *Parazoanthus axinellae*, *Axinella verrucosa*, *Acanthella acuta* and *Halocynthia papillosa*. At shaded and overhanging places in the upper infralittoral zone and in crevices in the mid-infralittoral zone we also noted a praecoralligenous aspect of this community.

The violet gorgonian *Paramuricea clavata* is the biggest Adriatic representative of Gorgonia. Pax and Müller *(17)* mentioned in their paper on the Adriatic Anthozoa fauna only one location (the island of Vis) and considered the species as very rare in the Adriatic. Recently, using SCUBA-diving equipment in biological marine researches, we found out that *P. clavata* is a common sea inhabitant. It was noted by Špan et al. *(22)* for the area of the Lokrum island, by Belamarić *(1)* and Grubelić *(8)* for the group of Kornati islands and also by Zavodnik and Zavodnik *(34)* for the Brseč area. It is also recorded in the southern part of Dugi otok and in the aquatorium of islands of Prvić, Goli and Grgur (Jaklin, unpublished data). Accordingly, as a result there occurs that so far our station RI-75 is the northernmost known location of *Paramuricea clavata* in the Adriatic.

It is interesting that the population of hydrozoa *Eudendrium* sp. is well developed at all stations in the upper infralittoral zone. The exception is station RI-18 facing the Rijeka Bay, because of the weakest sea-currents, as we assume.

With further researches and additional stations we should be able to make an accurate map showing the spread of individual biocoenoses on the sea-bottom of the Sv. Marko islet. Šegulja and Lovrić *(21)*, describing floristic components of the Sv. Marko islet, mentioned *Cystoseiretum barbatae* as facies of the *Cystoseirion crinitae* assembly. Zavodnik et al. (33) found the species of *Cystoseira barbata* at station RI-18, what is more they described it as very common. During our researches the species of *C. barbata* has not been found on the sea-bottom of the Sv. Marko islet.

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ABSTRACT

Benthic biocoenoses of the Sv. Marko Islet (Rijeka Bay)

Background and purpose: *Researches of marine flora and fauna of the Rijeka Bay and the whole Kvarner Gulf have been going on for a century and a half. Despite numerous sampling locations in the coastal, open-water and channel zone of the region, the submarine littoral of the Sv. Marko islet remained almost unexplored. Because of the fact, our goal is to describe some biocoenological features of this "blank" area.*

Materials and methods: *From 1994 to 1995* in situ *observations were performed at five different localities, at one transect station, from the sea level to a depth of approximately 40 m. The method of direct observations and collections by SCUBA diving was applied from coastal rocks to the muddy-sandy bottom of the infralittoral zone. Additional underwater photo documentation was taken with intent to complete the field and laboratory data.*

Results and conclusions: *In the submarine area of the islet of Sv. Marko we have found all together 47 taxa of macroalgae, two species of blue-green algae, 1 phanerogam species and 101 macrofauna species. According to the current data, the benthic communities of Sv. Marko are rich and diverse, but do not differ from other locations of the Rijeka Bay and Kvarner region. An exception is the excessive growth of red algae* Polysiphonia *spp. that cover comprehensive parts of a bottom surface at some localities. A thick layer of algae obviously reduces the water near-bottom circulation, causing anoxic conditions beneath the layer. Such phenomenon was neither recorded during previous researches in the Kvarner nor was noticed in the biocoenologic literature of the eastern Adriatic coast. We believe that there are reasons for establishment of the distinct ruderal biocoenosis of movable stony bottom of infralittoral step. The inclination of the unconsolidated bottom is one of main factors leading to the development of the particular scree community. We consider the present research just as preliminary because of the minimal number of stations which were visited and investigated only once. The well-like submarine cave between stations RI-18 and RI-76 has remained completely uninvestigated.*

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