

Note on recolonisation by furoid algae *Cystoseira* spp. and *Fucus virsoides* in the North Adriatic Sea

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In the northern Adriatic Sea a general rarefaction and withdrawal of dense settlements of furoid algae characteristic for shallow hard bottoms and well illuminated habitats in the past decennia have been traditionally explained to direct pollution effects and advanced eutrophication phenomena in the area. A recent recolonisation of furoid settlements suggests that a long-term natural fluctuation of marine vegetation has been caused prior to a direct human impact.

Key Words: furoid brown algae, *Cystoseira* spp., *Fucus virsoides*, Northern Adriatic, standing crop, recolonisation

INTRODUCTION

Furoid brown algae, especially *Cystoseira* species, are characteristic taxa in Mediterranean shallow waters climax communities occurring on rocky bottom between the surface and the depth of about 20 metres. In the coastal waters of the central and northern Adriatic *Cystoseira* species usually predominated by standing crop and canopy cover (ŠPAN, 1969). However, during the last few decades considerable changes have been observed in the northern Adriatic seaweed associations (MUNDA, 1972, 1973, 1993, 2000; ZAVODNIK N., 1977). Settlements of *Cystoseira* species and *Fucus virsoides* became more rare or even disappeared at many sites and were replaced by other algal populations. The main cause for these changes was generally attributed to increased pollution and eutrophication (GOLUBIĆ, 1968; KATZMANN, 1972; GIACCONE and RIZZI-LONGO, 1974; MUNDA, 1974, 1993, 2000; PIGNATTI and De CRISTINI, 1976). Settlements of *Fucus* and *Cystoseira* became recently once again more abundant in

some northern Adriatic sites, in spite of a continuous input of noxious effluents entering the northern Adriatic, frequent and severe eutrophic conditions, and related phenomena (e.g., phytoplankton blooms followed by mucilage and hypoxic conditions in bottom layers) (DEGOB-BIS *et al.*, 1995, 1999). The aim of our research was to assess recent changes in coastal settlements of selected furoid algae.

STUDY AREAS

Field studies were carried out, in the spring and summer of 1998 and 1999, at two north Adriatic shore sites: at the Faborsa cove near Rovinj at the western coast of the Istrian Peninsula and at the Haludovo Beach near Malinska on the Krk Island (Fig. 1).

The Faborsa cove is partly exposed to westerly winds and wave actions. The tidal rocks are occupied with a belt-like canopy of *Fucus virsoides*. Between the sea surface and the depth of about 2 metres, the rocky bottom is covered by

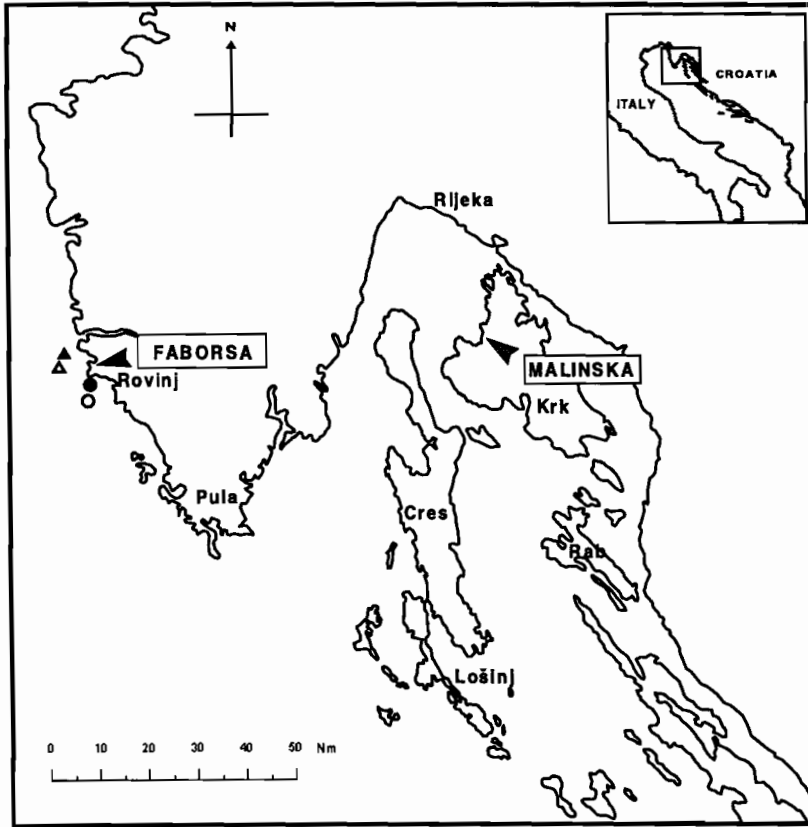


Fig. 1. Study areas

dense settlements of *Cystoseira barbata* and *Cystoseira compressa*, sheltering rich turf-like algal undergrowth of the bed-rock. At the depth of 4 metres, the sandy sediment appears. It is occupied by *Cymodocea nodosa* meadow.

At the Haludovo study site, settlements of *Fucus virsoides* occur only on detached cliffs while *Cystoseira compressa* and *Cystoseira crinita* have a patchy distribution on the rocky shore and the outcrops emerging from the sandy bottom. *Cystoseira barbata* was not found at this locality.

At both study sites, the annual surface temperature varies within more than 14°C: between 6°C and 10°C in winter and occasionally, more than 24°C in summer.

MATERIALS AND METHODS

The study was carried on at two sites of similar and comparable environmental conditions (Fig. 1). Studies of algal settlements in the

Faborsa cove have started several decades ago (Table 1) and for this site we dispose of a large number of data. On the other hand, the locality Haludovo near Malinska (Krk Island) lacks of historical data as the first studies have been undertaken upon the invasion of *Caulerpa taxifolia* a few years ago (1995). At both sites research was done once a month in the late spring and summer of 1998 and 1999, i.e. in the period of most luxurious growth of fucoid algae.

The littoral fringe, i.e. the eulittoral zone and upper belt of the sublittoral zone were studied taking into account the dominant macroalgal vegetation, specifically the covering rates of *Fucus virsoides* and *Cystoseira* species. Algae were harvested by hand using a 25x25 cm metal frame. Three replicates per survey were analysed for biomass and expressed in g wet weight per square meter.

RESULTS AND DISCUSSION

The marine flora of the Istrian peninsula and Rovinj environs in particular was well known yet one century ago (FOSLIE, 1905; SCHIFFNER, 1916; VATOVA, 1928; MUNDA, 2000). Soon local alterations of flora (and fauna) were noted at localities under domestic sewage and industrial effluents impact (STEUER, 1910). But detailed studies on alternations and successions in marine vegetation and pollution monitoring have not been performed until the beginning of 1960's (LOTHAR, 1967; GOLUBIĆ, 1968).

Results of our recent studies and the relevant literature data from the Rovinj area are summarised in Table 1. Advanced alterations of the standing crop of brown algae over the last four decades are evident. For comparison purposes, data from Haludovo beach at Malinska (Krak Island) were also considered.

The standing crop of the dominant fucoid algae recorded in the Rovinj area in the 1960's showed a marked decline and even the local disappearance of seaweeds in the following decade. Besides increased pollution impact in the shallow North Adriatic (ŠTIRN *et al.*, 1972; GHIRARDELLI *et al.*, 1973; GIORDANI SOIKA and PERIN, 1974), this event coincided also with a population explosion of littoral sea urchins, especially *Paracentrotus lividus* (VUKOVIĆ, 1982; IVEŠA, 1998). However, more recently, a decrease in sea urchin population was noted (unpublished results) and wide previously barren areas of the rocky bottom became colonised by large seaweed, *Cystoseira* species in particular. It is interesting to note that alga recolonisation also occurred in the tidal zone, which has never been exposed to browsing of sea urchins. The recently recorded stand-

Table 1. Biomass of littoral fucoid algae during last 40 years near Rovinj (Faborsa and Škaraba coves, Banjole, Crveni otok and Figarola islets) and present records from Haludovo beach (Malinska, Krak Island)

(g wet wt m⁻²)

Authors	Species	1960-1969	1970-1975	1998-1999	Locality	
Zavodnik, D., 1967.	<i>Cystoseira barbata</i>	7500			Figarola	
Munda, I., 1979.		3000-5500			Faborsa	
Zavodnik, N., 1977.			480		Faborsa	
Zavodnik, N., 1983.			200-300		Faborsa	
Present record					1456-8371	Faborsa
Zavodnik, D., 1967.	<i>Cystoseira compressa</i>	4332			Banjole	
Zavodnik, N., 1977.			2780		Banjole	
Present record				685-9924	Faborsa	
Present record				556-11836	Haludovo	
Zavodnik, D., 1967.	<i>Cystoseira amentacea</i> var. <i>spicata</i>	9375			Škaraba Škaraba	
Munda, I., 1973.		1700-4900				
Zavodnik, N., 1977.			216-547			
Munda, I., 1979.	<i>Cystoseira crinita</i>	2200-2700			Crveni otok	
Present record				563-3622	Haludovo	
Zavodnik, D., 1967.	<i>Fucus virsoides</i>	4750			Figarola	
Munda, I., 1973.		1555-5450			Faborsa	
Zavodnik, N., 1973.		3000			Faborsa	
Zavodnik, N., 1977.				200		Faborsa
Present record					2688-3518	Faborsa
Present record					1320-3103	Haludovo

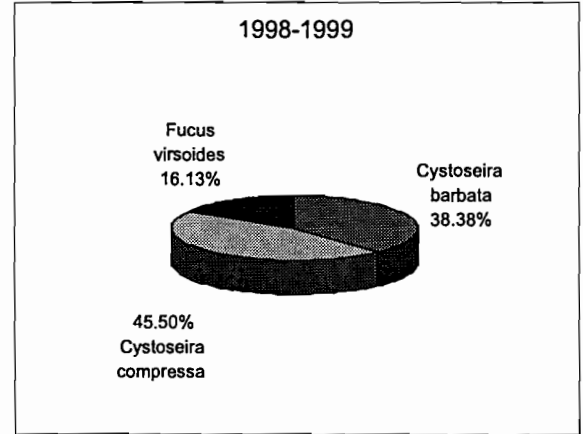
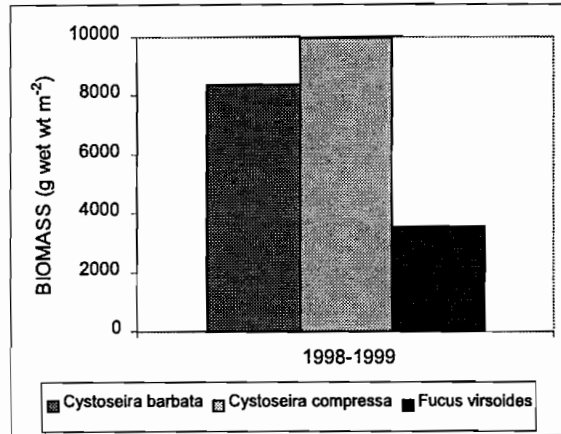
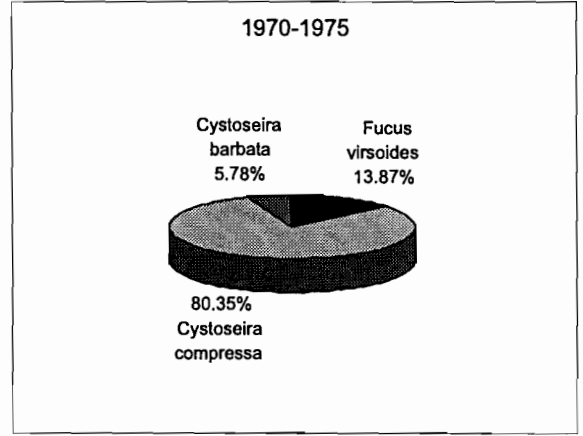
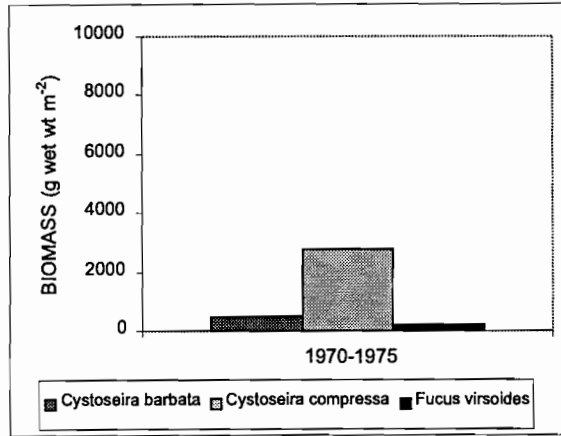
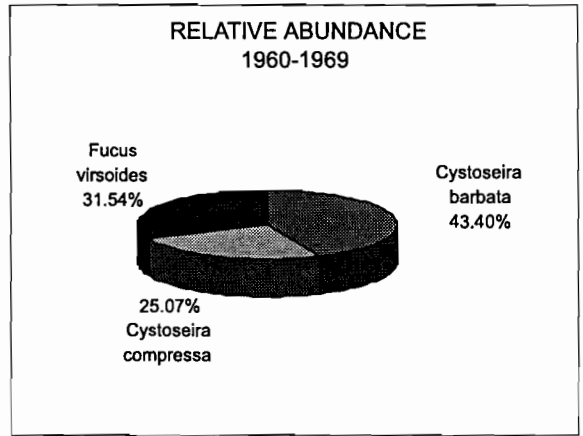
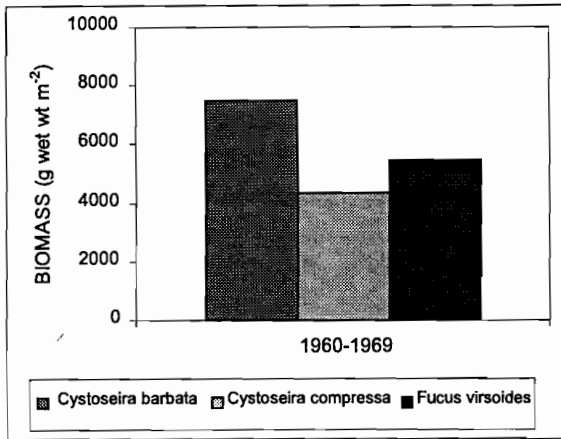


Fig. 2. The amount of average biomass for the main investigated species in the Faborsa Cove

Fig. 3. Relative distribution of the biomass among the main investigated species in the Faborsa Cove

ing crop of about 3000 g wet wt m⁻² of *Fucus virsoides* in Faborsa cove and of about 10 000 g.wet.wt m⁻² of *Cystoseira compressa* in the tidal pools and till 1m depth in studied areas

indicate an expressive recovery of these species. On the shallow infralittoral rocky bottom in Faborsa cove at 0-3 m depth, the biomass of the newly colonised *Cystoseira barbata* exceeded

7350 g wet wt m⁻² (Fig. 3). This standing crop is fully comparable with data recorded in the mid-1960's (Table 1). However, *Cystoseira amenata* var. *stricta* and *C. crinita* that were fairly abundant around Rovinj in the past became absent from most sites visited recently. The amount of average biomass of investigated dominant furoid species and its relative distribution in the Faborsa cove in the 1960's, 1970's and February 1999 is shown in Figs. 2 and 3.

The dominant brown algae studied at Faborsa are perennial but flourish in the spring. The seasonal epiflora accompanying the brown algae is rich and is composed of a number of genera, notably *Ceramium*, *Polysiphonia*, *Champia*, *Ectocarpus*, *Hinckia*, *Cladophora* and others. The undergrowth of large algae consists of seasonal and perennial species, such as *Ulva laetevirens*, *Scytosiphon lomentaria*, *Liebmannia leveillei*, *Dictyopteris polypodi-*

oides, and encrusted *Corallina officinalis*. In summer periods patchy appearance of *Laurencia paniculata* and various *Gelidium* species, as well as intensive growth of *Wrangelia penicillata* and *Padina pavonica* was observed.

At Haludovo Beach, the standing crop of *Fucus virsoides* exceeded 1300 and 2200 g wet wt m⁻² in March and June 1998, respectively. In 1999 the values for *Cystoseira crinita* were in the range of 1320 and 2210 g wet wt m⁻². It is interesting to note that the latter species was absent from the Faborsa site. At the depth of 0-1 metre, about 12000 g wet wt m⁻² of *Cystoseira compressa* was recorded, what is three times more then found in mid-1960's at the Banjole islet near Rovinj (ZAVODNIK, 1967).

The biomass and the relative abundance of the three dominant furoid species at Haludovo are shown in Fig. 4.

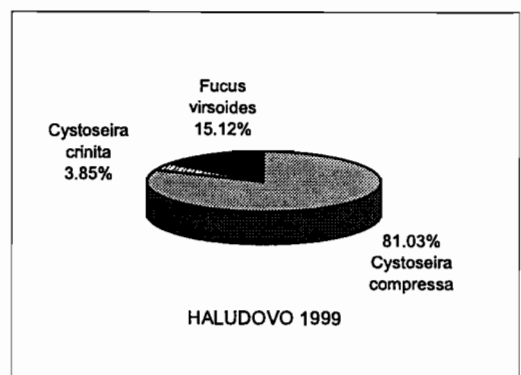
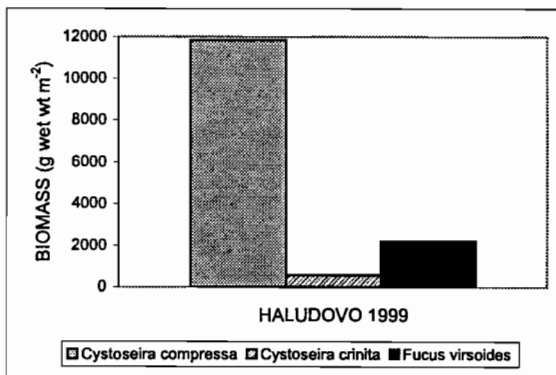
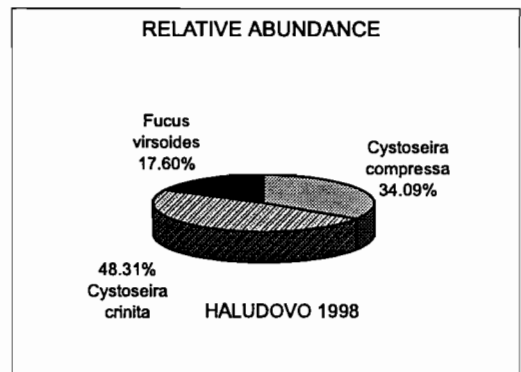
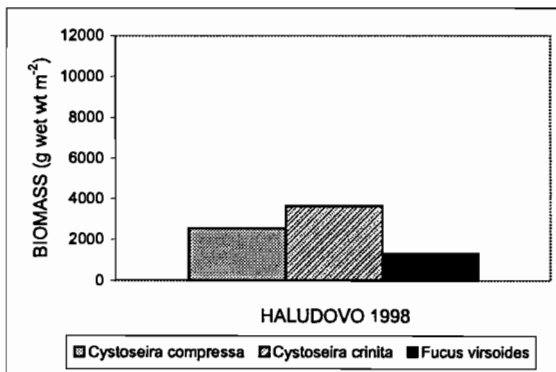


Fig.4. The biomass and relative abundance of three dominant furoid species at Haludovo in 1999

CONCLUSIONS

Abundant growth of *Fucus* and *Cystoseira* species, as well as of the epiflora and the undergrowth associated with these species, was observed at investigated areas. Algal standing crop was most abundant in the spring in particular, and declined towards the end of the summer due to high sea temperatures.

According to studies carried out in the course of the past forty years, it is supposed that remarkable variations in *Cystoseira* species and *Fucus virsoides* standing crop in the area first of

all were reasoned by natural environmental conditions and not by direct anthropogenic impacts.

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Bilješka o rekolonizaciji fukoidnih alga *Cystoseira* spp. i *Fucus virsoides* u sjevernom Jadranu

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SAŽETAK

Tijekom prošlih desetljeća u sjevernom Jadranu, ustanovljeno je opće razrijeđenje i nestajanje gustih naselja fukoidnih algi značajnih za plitka i dobro osvijetljena kamenita dna što se objašnjavalo onečišćenjem mora i uznapredovalom eutrofikacijom. Sadašnja rekolonizacija naselja ukazuje da se više radi o dugotrajnoj prirodnoj fluktuaciji morske vegetacije nego o utjecajima čovjeka.

Ključne riječi: fukoidne smeđe alge, *Cystoseira* spp., *Fucus virsoides*, sjeverni Jadran, standing crop, rekolonizacija
