original scientific article
received: 2005-05-02

UDC 581.9:582.26/.27(262.3-18)

DEVELOPMENT OF THE INVASIVE TURF-FORMING RED ALGAE *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS ON SUBTIDAL SHORES OF RIJEKA BAY (NORTHERN ADRIATIC SEA)

Claudio BATTELLI
University of Primorska, Faculty of Education of Koper, SI-6000 Koper, Cankarjeva 5
E-mail: claudio.battelli@guest.arnes.si

Milvana ARKO PIJEVAC
Natural History Museum Rijeka, HR-51000 Rijeka, Lorenzov prolaz 1, Croatia

ABSTRACT

Results of the study of subtidal macrobenthic flora, carried out in 1997 at Cape Oštro, Rijeka Bay, Croatia (northern Adriatic Sea), are presented. The investigation was based on seasonal sampling at different depths. Results indicated that the flora was strongly dominated by turf-forming algae. Overall, 37 macrobenthic algae (23 Rhodophycota or 62.2%, 6 Phaeophycota or 16.2% and 8 Chlorophycota or 21.6%) were identified. The invasive red filamentous alga Womersleyella setacea *(Hollenberg) R. E. Norris was recorded for the first time in this area. The impact of massive development of the turf–forming algae on the structure of algal assemblages is discussed.*

Key words: turf-forming algae, *Womersleyella setacea*, subtidal, northern Adriatic Sea, Rijeka Bay

SVILUPPO DI FELTRI DELL'ALGA ROSSA INVASIVA *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS NELL'INFRALITORALE DEL GOLFO DI FIUME (ALTO ADRIATICO)

SINTESI

Vengono presentati i risultati di un'indagine condotta nel 1997 sulla flora macrobentonica nell'infralitorale nei pressi di Punta Oštro, Golfo di Fiume, Croazia (Alto Adriatico). Lo studio si basa su rilievi stagionali svolti a diverse profondità. I risultati indicano che la flora è costituita da densi feltri algali. Nel corso della ricerca sono state identificate 37 specie di alghe macrobentoniche, di cui 23 Rhodophycota (62,2%), 6 Phaeophycota (16,2%) e 8 Chlorophycota (21,6%). Nel presente lavoro viene segnalata per la prima volta in quest'area la presenza dell'alga rossa filamentosa invasiva Womersleyella setacea *(Hollenberg) R. E. Norris. Sono discusse le conseguenze dell'estesa diffusione di tali feltri sulla struttura delle comunità algali.*

Parole chiave: feltri algali, *Womersleyella setacea*, infralitorale, Alto Adriatico, Golfo di Fiume

INTRODUCTION

More than 90 taxa of marine algae are known to have been introduced into the Mediterranean Sea, mostly by human activities (*i.e.* aquaculture, pollution, ballast waters, fishing nets), and at least nine of them are considered invasive (Verlaque, 1994; Boudouresque & Verlaque, 2002). Some of the most invasive introductions took place in the last 10-15 years and have caused substantial changes in the structure of benthic algal assemblages. One of the best examples of this phenomenon is represented by the massive development of dense algal turfs produced by filamentous species, in particular the red alga *Womersleyella setacea* (Hollenberg) R. E. Norris This species has been reported to produce thick turfs covering large portions of subtidal bottoms in several regions (Verlaque, 1989; Airoldi *et al.*, 1995; Athanasiadis, 1997; Patzner, 1998). The uncontrolled growth of turfs is considered an indicator of disturbance in the environment, with a negative impact on biodiversity (Barth & Fagan, 1990; Morand & Briand, 1996).

Many non-indigenous species of algae have been recorded in the northern Adriatic Sea (Orlando Bonaca, 2001), mostly on the Italian shores. Among them, the brown *Sargassum muticum* (Yendo) Fensholt (Gargiulo *et al.*, 1992) and *Undaria pinnatifida* (Harvey) Surigar (Rismondo *et al.*, 1993), the green *Codium fragile* subsp. *tomentosoides* (Van Goor) P.C. Silva (Godini & Avanzini, 1988), *Caulerpa taxifolia* (Vahl) C. Agardh (Žuljević & Antolić, 1998; Špan *et al.*, 1998), *Ulva scandinavica* Bliding (Battelli & Tan, 1998), and the red *Antithamnion pectinatum* (Montagne) Brauner *ex* Athanasiadis et Tittley (Curiel *et al.*, 1996) and *Polysiphonia morrowii* Harvey (Curiel *et al.*, 2002) are some of the most recent records. Comparatively, the eastern shores of the northern Adriatic Sea have not been severely affected by algal introductions so far. However, some algae reported elsewhere as highly aggressive invaders, such as *C. taxifolia*, *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, (Verlaque, 1994) and *W. setacea* (Sartoni & Rossi, 1998), have been recently recorded.

In 1996, an extensive growth of turf-forming algae was noted in the sublittoral area around Cape Oštro, north-eastern coast of Rijeka Bay, northern Adriatic Sea (Battelli & Arko Pijevac, 2003). The same phenomenon was subsequently recorded in other parts of Rijeka Bay, such as the Sepen cove and the submarine area of Sv. Marko islet (Jaklin & Arko Pijevac, 1997; Zahtila, 1999). Examination of samples collected in these areas indicated that algal turfs had been formed primarily by *W. setacea*. The benthic marine algae of the Kvarner Gulf have been studied sporadically (Munda, 1960; Rizzi Longo, 1972; Zavodnik *et al.*, 1981; Zavodnik & Zavodnik, 1982; Zavodnik, 1992; Zavodnik *et al.*, 1998) and no previous records of this phenomenon are available in the literature.

In this study, we report preliminary on the observations regarding the composition of algal assemblages, their bathymetric variation and the reproductive phenology of *W. setacea* in the area at Cape Oštro. The results presented constitute the first report on extensive development of algal turfs in the northern Adriatic and provide a background of knowledge that will be of great value for further investigations.

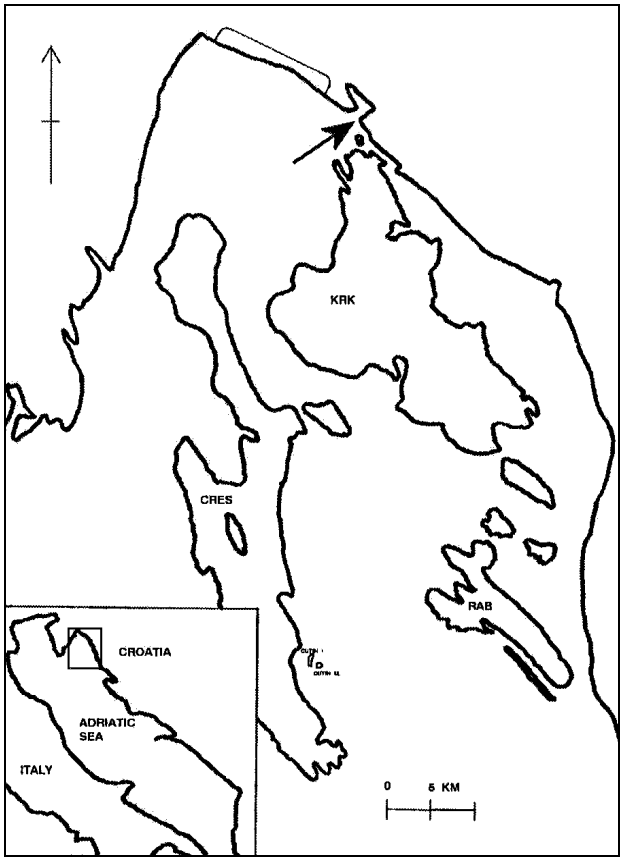

Fig. 1: Study area, Cape Oštro (north-eastern coast of Rijeka Bay).
Sl. 1: Raziskovano območje, Rt Oštro (severovzhodna obala Reškega zaliva).

MATERIAL AND METHODS

The study was carried out near Cape Oštro (north-eastern coast of Rijeka Bay) (43°16.152 N, 14°33.792 E) in 1997 (Fig. 1). The morphology of the area's bottom varies with depth; the substratum consists of carbonate rocks (limestone and dolomites) between 0 and 5 m, a mixture of rock and sand between 5 and 10 m, sand between 10 and 15 m, and muddy sand below 15 m.

Samples were collected at different depths (5, 10, 15 and 20 m) and in each season. Overall, 36 samples (8 in winter, 8 in summer, 8 in autumn and 12 in spring) were collected. Algae were removed from 100 cm^2 squares

and the percentage cover of each species was estimated for each date and for different depths (5 m, 10 m, 15 m and 20 m). The samples were preserved in 4% seawater-formalin solution and examined in the laboratory. The algal material is deposited in the Natural History Museum of Rijeka.

The algae were determined at the best possible level of taxonomic resolution; for *W. setacea* (Fig. 2), detailed observations of the reproductive phenology were also carried out. Algal nomenclature follows Ribera *et al.* (1992), Gallardo *et al.* (1993), and Gómez Garreta *et al.* (2001).

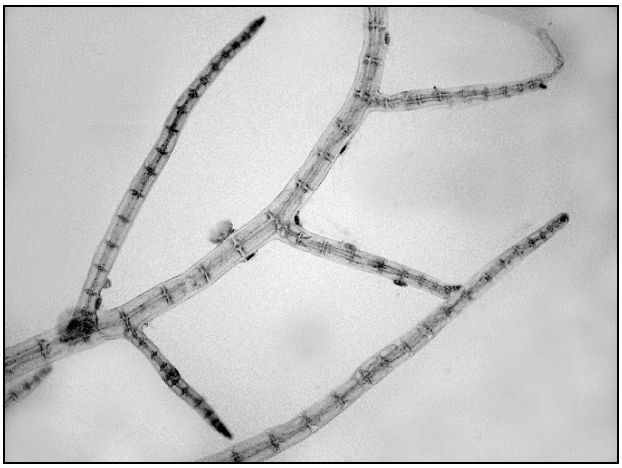

Fig. 2: Thallus of *Womersleyella setacea* ***(barr = 500 µm).***
Sl. 2: Steljka vrste *Womersleyella setacea* ***(merilo = 500 µm).***

RESULTS

Overall, 37 species of macrobenthic algae were identified (Tab. 1): 23 Rhodophycota (62.2%), 6 Phaeophycota (16.2%) and 8 Chlorophycota (21.6%).

At the time of the survey, the bottom of the surveyed area was colonized by macroalgal assemblages that appeared very poor in terms of species number. The investigated area was mostly colonized by turf-forming species overgrowing all types of substrata from 5 m to 20 m depth.

In terms of presence, the most common species were the green algae *Chaetomorpha linum* (O.F. Müller) Kützing and *Cladophora nigrescens* Zanardini *ex* Frauenfeld and the red alga *Womersleyella setacea*. The species *C. linum* dominated at a depth of 5 m, *C. nigrescens* at depths of 10 and 20 m, while the depth of 15 m was dominated by the red alga *W. setacea* (Tabs. 2, 3, 4, 5).

Tab. 1: Check list of macrobenthic algae at Cape Oštro (Rijeka Bay, northern Adriatic Sea).
Tab. 1: Seznam vrst makrobentoških alg pri Rtu Oštro (Reški zaliv, severno Jadransko morje).

Rhodophycota
Antithamnion cruciatum (C. Agardh) Nägeli
Boergeseniella fruticulosa (Wulfen) Kylin
Ceramium ciliatum (J. Ellis) Ducluzeau var. *robustum* (J. Agardh) Feldmann-Mazoyer
Ceramium tenerrimum (G. Martens) Okamura
Champia parvula (C. Agardh) Harvey
Chondria coerulescens (J. Agardh) Falkenberg
Dipterosiphonia rigens (C. Agardh) Falkenberg
Gelidium pusillum (Stackhouse) Le Jolis
Haliptilon virgatum (Zanardini) Garbary *et* H. V. Johansen
Halopithys incurva (Hudson) Batters
Herposiphonia secunda (C. Agardh) Ambronn f. *secunda*
Jania rubens (Linnaeus) J. V. Lamouroux
Laurencia sp.
Lophosiphonia obscura (C. Agardh) Falkenberg
Nitophyllum punctatum (Stackhouse) Greville
Polysiphonia atra Zanardini
Polysiphonia breviarticulata (C. Agardh) Zanardini
Polysiphonia opaca (C. Agardh) Moris & De Notaris
Polysiphonia polyspora (C.Agardh) Montagne
Polysiphonia stuposa Zanardini ex Kützing
Polysiphonia subulifera (C. Agardh) Harvey
Spyridia filamentosa (Wulfen) Harvey
Womersleyella setacea (Hollenberg) R. E. Norris
Phaeophycota
Cystoseira corniculata (Turner) Zanardini
Dictyota dichotoma (Hudson) J.V. Lamouroux var *dichotoma*
Dictyota fasciola (Roth) J.V.Lamouroux
Halopteris filicina (Grateloup) Kützing
Padina pavonica (Linnaeus) J. V. Lamouroux
Sphacelaria cirrosa (Roth) C. Agardh
Chlorophycota
Chaetomorpha linum (O. F. Mueller) Kützin
Cladophora coelothrix Kützing
Cladophora laetevirens (Dillwin) Kützing
Cladophora lehmanniana (Lindenberg) Kützing
Cladophora nigrescens Zanardini ex Frauenfeld
Cladophora prolifera (Roth) Kützing
Ulva clathrata (Roth) C. Agardh
Ulva laetevirens Areschoug

In terms of percentage cover, the most abundant species were the green algae *C. nigrescens* and the red alga *W. setacea*. During the study, the abundance of *C. nigrescens*, at different depths, was generally higher than *W. setacea*, although the average cover percentage of these two species showed different trends during the seasons. The cover percentage of *C. nigrescens* increased from a depth of 5 m to a depth of 10 m and then markedly decreased to a depth of 20 m. The fluctuation of the cover percentage of the red algae *W. setacea* showed a different trend: it increased slightly from a depth of 5 m to 15 m and then decreased at a depth of 20 m (Fig. 3).

Seasonal fluctuation of the cover percentage values showed that at all depths (5 m, 10 m, 15 m, 20 m), the abundance of *C. nigrescens* decreased in general from the winter to the summer and then increased in the autumn, while the abundance of *W. setacea* slightly decreased from the winter to the autumn at all depths (Fig. 4).

In spite of frequent sampling, *W. setacea* was never observed in a reproductive state.

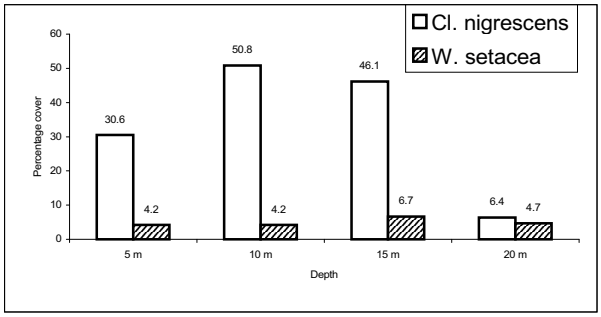

Fig. 3: Percentage covers of** C. nigrescens **and** W. setacea **at different depths.
Sl. 3: Odstotne pokrovne vrednosti vrst** C. nigrescens **in** W. setacea **na različnih globinah.

DISCUSSION

During the study, the invasive filamentous red alga *W. setacea* was recorded for the first time in Rijeka Bay. This species, originally described from a tropical locality and subsequently reported for other tropical regions, has recently become widespread in the Mediterranean Sea (Verlaque, 1989, 1994; Airoldi *et al.*, 1994; Rindi & Cinelli, 1995; Athanasiadis, 1997; Rindi *et al.*, 1999), and in the northern Adriatic Sea (Sartoni & Rossi, 1998).

The phenological observations suggest that the colonization of *W. setacea* proceeded by vegetative reproduction, which is so far the only form of reproduction known both in the field and in cultures of this species from various areas of the Mediterranean Sea (Airoldi *et al.*,1995; Rindi *et al.*, 1999; Rindi & Cinelli, 2000).

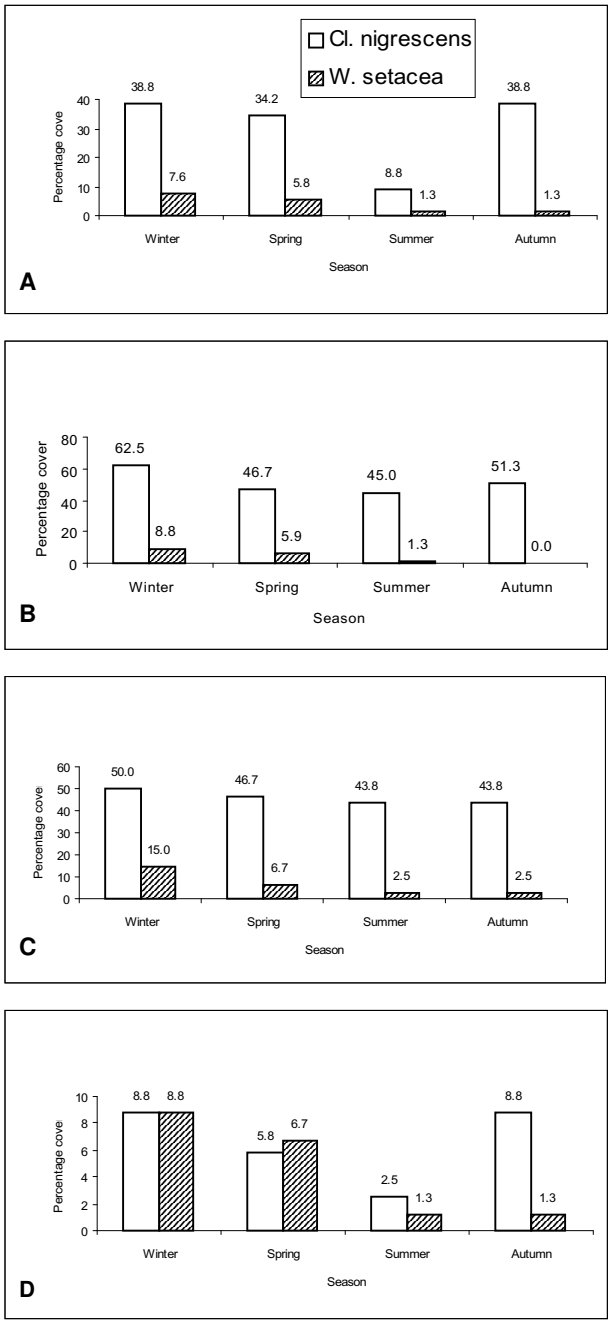

Fig. 4: Temporal fluctuation of mean cover of** C. nigrescens **and** W. setacea **at a depth of (A) 5 m, (B) 10 m, (C) 15 m and (D) 20 m.
Sl. 4: Sezonske variacije pokrovnih vrednosti vrst** C. nigrescens **in** W. setacea **na globini (A) 5 m, (B) 10 m, (C) 15 m in (D) 20 m.

The present results show that turfs of *W. setacea* can grow on all types of substratum (rock, sand and mud) and at different depths in the investigated area. Although *W. setacea* has been recorded in the Adriatic only re-

cently, the extensive development of this alga in Rijeka Bay reflects the fast and aggressive propagation already reported for the western Mediterranean Sea (Verlaque, 1989; Airoldi *et al.*, 1995; Athanasiadis, 1997; Rindi & Cinelli, 2000; Piazzi & Cinelli, 2001; Boudouresque & Verlaque, 2002).

Tab. 2: Algal species recorded in the study area at a depth of 5 m with average values*. (*Cover abundance values)
Tab. 2: Vrste alg na raziskanem območju na globini 5 m s pokrovnimi vrednostmi*. (*Vrednosti pokrovne gostote)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
A. cruciatum	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
B. fruticulosa	15.0	2.5	2.5	0.0	0.0	15.0	0.0	2.5	0.0
C. ciliatum v. *robustum*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
C. coerulescens	15.0	2.5	2.5	2.5	0.0	0.0	0.0	2.5	0.0
C. laetevirens	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	2.5
C. tenerrimum	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Ch. linum	0.1	2.5	0.1	0.1	2.5	0.1	0.1	0.1	0.1
Cl. coelothrix	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl. lehmanniana	0.0	0.0	0.1	0.0	15.0	0.0	2.5	0.0	0.0
Cl. nigrescens	62.5	15.0	0.0	87.5	15.0	15.0	2.5	62.5	15.0
Cl. prolifera	0.1	0.1	0.1	2.5	0.0	2.5	0.0	2.5	0.0
Cy. corniculata	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0
D. dichotoma	2.5	15.0	15.0	0.0	0.0	0.1	0.0	0.0	15.0
D. fasciola	2.5	0.1	0.1	0.0	15.0	0.1	15.0	2.5	15.0
D. rigens	0.0	0.0	2.5	0.0	2.5	2.5	15.0	2.5	0.0
G. pusillum	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H. filicina	0.0	0.1	0.0	0.0	0.0	2.5	0.0	0.0	0.0
H. incurva	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
H. secunda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
L. obscura	0.0	2.5	0.0	0.1	2.5	0.0	0.1	0.1	0.0
Laurencia sp.	0.0	0.0	15.0	2.5	15.0	15.0	15.0	15.0	0.0
N. punctatum	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. breviarticulata	0.0	0.0	2.5	0.1	0.1	2.5	2.5	2.5	0.1
P. opaca	0.1	2.5	0.0	0.1	0.1	0.0	0.1	2.5	0.0
P. polyspora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
P. stuposa	0.0	2.5	2.5	0.0	2.5	0.0	0.1	0.0	0.0
P. subulifera	0.0	15.0	2.5	0.0	0.1	0.0	0.0	0.0	2.5
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
Sp. cirrosa	0.1	0.1	0.0	0.0	2.5	0.1	2.5	2.5	0.0
W. setacea	0.1	15.0	15.0	0.0	2.5	0.1	2.5	0.0	2.5

*Cover abundance values / Vrednosti pokrovne gostote:

Class	% cover	Average values
+	<1%	0.1
1	1.1–5.0%	2.5
2	5.1–25.0%	15.0
3	25.1–50.0%	37.5
4	50.1–75.0%	62.5
5	75.1–100%	87.5

In the course of the survey, large-sized erect algae appeared to be rare. The high dominance of the turf-forming algae might negatively affect the development of some erect species, such as *Dictyota dichotoma* (Hudson) J. V. Lamouroux, *Dictyota fasciola* (Roth) J. V. Lamouroux, *Padina pavonica* (Linnaeus) J. V. Lamouroux and *Cystoseira corniculata* (Turner) Zanardini. This is in agreement with the studies carried out in other regions of the Mediterranean, which have shown that the monopolization of substratum by turf-forming filamentous algae can prevent the development of other macroalgae by overgrowth and accumulation of sediment, making the settlement of spores and the survival of juvenile stages impossible and thus reducing species diversity and equitability (Airoldi *et al.,* 1995; Morand & Briand, 1996; Airoldi & Virgilio, 1998; Piazzi & Cinelli, 2001).

The present observations, however, are based on a relatively short sampling period and do not allow for a formulation of relevant conclusions on the impact of these algal turfs in Rijeka Bay. Observations in a longer temporal span and studies based on an experimental approach, as carried out for other parts of the Mediter-

Tab. 3: Algal species recorded in the study area at a depth of 10 m with average values*. (*see Table 2)
Tab. 3: Vrste alg na raziskanem območju na globini 10 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
C. coerulescens	2.5	0.1	0.1	2.5	0.0	2.5	0.0	0.1	2.5
C. parvula	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ce. ciliatum v. *robustum*	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
Ce. tenerrimum	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Ch. linum	0.1	2.5	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Cl. laetevirens	0.0	37.5	15.0	0.0	0.0	2.5	0.0	0.0	0.0
Cl. lehmanniana	0.0	0.1	0.0	0.0	0.0	0.0	2.5	2.5	2.5
Cl. nigrescens	87.5	37.5	15.0	87.5	37.5	87.5	2.5	87.5	15.0
Cl. prolifera	2.5	0.0	0.0	0.0	2.5	2.5	2.5	0.0	0.5
Cy. corniculata	0.0	0.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0
D. dichotoma	0.0	0.1	0.1	2.5	0.0	0.0	0.0	0.0	0.0
D. fasciola	0.0	2.5	0.0	2.5	0.0	0.0	15.0	0.0	2.5
D. rigens	2.5	0.1	0.1	0.0	0.0	0.0	2.5	0.0	2.5
G. pusillum	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
H. filicina	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
H. incurva	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0
L. obscura	0.0	2.5	0.1	0.0	0.0	0.1	0.0	2.5	0.0
Laurencia sp.	0.0	0.1	0.0	2.5	0.1	0.0	0.1	0.0	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. breviarticulata	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
P. opaca	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1
P. polyspora	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
P. stuposa	0.0	0.0	0.0	0.0	0.1	0.0	2.5	0.0	0.0
P. subulifera	0.0	0.0	2.5	0.0	0.1	0.0	0.0	0.0	2.5
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
Sp. cirrosa	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
W. setacea	2.5	15.0	15.0	0.1	2.5	0.0	2.5	0.0	0.0

Tab. 4: Algal species recorded in the study area at a depth of 15 m with average values*. (*see Table 2)
Tab. 4: Vrste alg na raziskanem območju na globini 15 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
B. fruticulosa	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
C. coerulescens	0.0	2.5	2.5	0.1	0.0	2.5	0.0	2.5	0.0
Ce. tenerrimum	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ch. linum	0.1	2.5	2.5	0.1	2.5	0.1	0.0	0.1	0.1
Cl. nigrescens	62.5	37.5	37.5	87.5	15.0	87.5	0.0	87.5	0.0
Cl. laetevirens	0.0	15.0	15.0	0.0	0.0	0.1	15.0	2.5	0.0
Cl. lehmanniana	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.5
Cl. prolifera	2.5	0.1	2.5	2.5	0.1	0.0	0.0	0.0	0.1
Cy. corniculata	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0
D. dichotoma	0.0	0.1	0.0	0.1	0.0	0.0	15.0	0.0	0.0
D. rigens	0.0	0.1	0.0	0.0	0.0	0.0	2.5	0.0	2.5
H. incurva	0.1	2.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0
L. obscura	2.5	2.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Laurencia sp.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. atra	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. opaca	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P. sertularioides	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
P. stuposa	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.1
P. subulifera	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
S. cirrosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
S. filamentosa	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
W. setacea	15.0	15.0	15.0	2.5	2.5	2.5	2.5	2.5	2.5

ranean, will be necessary to understand better the effects of the development of algal turfs. It is therefore very important that the scientific institutions continue to monitor the distribution and persistence of turfs of *W. setacea* and their effects on the structure of subtidal assemblages.

Tab. 5: Algal species recorded in the study area at a depth of 20 m with average values*. (*see Table 2)
Tab. 5: Vrste alg na raziskanem območju na globini 20 m s pokrovnimi vrednostmi*. (*glej Tabelo 2)

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Nov	Dec
B. fruticulosa	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ce. ciliatum v. *robustum*	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Ch. linum	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
Cl. lehmanniana	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Cl. nigrescens	15.0	2.5	0.0	15.0	2.5	2.5	2.5	2.5	15.0
Cl. prolifera	2.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. dichotoma	0.0	0.0	2.5	0.0	15.0	0.1	0.1	0.1	0.0
D. rigens	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
H. filicina	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H. incurva	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
H. secunda	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laurencia sp.	0.0	0.1	0.0	0.0	15.0	2.5	0.1	2.5	0.0
P. atra	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. pavonica	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
P. stuposa	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
S. cirrosa	0.1	0.0	2.5	0.0	2.5	0.1	0.1	0.1	0.0
U. clathrata	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
W. setacea	2.5	15.0	2.5	15.0	2.5	2.5	0.0	0.0	2.5

ACKNOWLEDGEMENTS

We are grateful to Dr Fabio Rindi from the Martin Ryan Institute of Galway (Ireland) for his advice and help with the revision of the text. We wish to thank Dr Donatella Serio from the University of Catania (Italy) for her assistance in the determination of some algal species.

POJAVLJANJE GOSTIH PREVLEK INVAZIVNE RDEČE ALGE *WOMERSLEYELLA SETACEA* (HOLLENBERG) R. E. NORRIS V INFRALITORALU REŠKEGA ZALIVA (SEVERNO JADRANSKO MORJE)

Claudio BATTELLI
Univerza na Primorskem, Pedagoška fakulteta Koper, SI-6000 Koper, Cankarjeva 5
E-mail: claudio.battelli@guest.arnes.si

Milvana ARKO PIJEVAC
Prirodoslovni muzej Rijeka, HR-51000 Rijeka, Lorenzov prolaz 1, Hrvaška

POVZETEK

Članek obravnava rezultate raziskave morske makrobentoške flore alg infralitorala pri rtu Oštro, Reški zaliv (severno Jadransko morje). Študija, napravljena v letu 1997, temelji na sezonskem vzorčenju na različnih globinah (5, 10, 15 in 20 m). Rezultati kažejo, da je flora alg sestavljena predvsem iz gostih prevlek makrobentoških alg. Skupno je bilo določenih 37 alg, med katerimi je bilo 23 rdečih (62,2%), 6 rjavih (16,2%) in 8 zelenih (21,6%). Prikazana je časovna variacija pokrovnih vrednosti najbolj pogostih vrst (Cladophora nigrescens *Zanardini ex Frauenfeld in*

Womersleyella setacea *(Hollenberg) R. E. Norris). V članku je prvič zabeleženo pojavljanje rdeče nitaste alge* W. setacea *na tem območju, ki se tu pojavlja na vseh globinah in v vseh letnih časih, vendar nikoli v fertilni obliki. Dosedanje študije o vrsti* W. setacea *so pokazale, da se vrsta v Sredozemskem morju razmnožuje vegetativno in hitro širi po vseh vrstah podlage; zato se ta alga prišteva k invazivnim vrstam. Članek obravnava tudi posledice masivnega pojavljanja gostih prevlek makrobentoških alg na sestavo združb alg.*

Ključne besede: prevleke alg, *Womersleyella setacea,* infralitoral, severno Jadransko morje, Reški zaliv

REFERENCES

Airoldi, L., F. Rindi, L. Piazzi & F. Cinelli (1994): Distribuzione di *Polysiphonia setacea* (Rhodomelaceae, Rhodophyta) Hollenberg in Mediterraneo e possibili modalità di diffusione. Biol. Mar. Medit., 2, 343–344.

Airoldi, L., F. Rindi & F. Cinelli (1995): Structure, seasonal dynamics and reproductive phenology of a filamentous turf assemblage on a sediment influenced, rocky subtidal shore. Bot. Mar., 38, 227–237.

Airoldi, L. & M. Virgilio (1998): Responses of turf-forming algae to spatial variations in the deposition of sediments. Mar. Ecol. Prog. Ser., 165, 271–282.

Athanasiadis, A. (1997): North Aegean marine algae IV. *Womersleyella setacea* (Hollenberg) R. E. Norris (Rhodophyta, Ceramiales). Bot. Mar., 40, 473–476.

Barth, H. & L. Fagan (1990): Eutrophication-related phenomena in the Adriatic Sea and in other Mediterranean coastal zones. Commission of the European Communities water Pollution Research Report, 16 pp.

Battelli, C. & I. H. Tan (1998): *Ulva scandinavica* Bliding, (Chlorophyta): a new species for the Adriatic Sea. Annales Ser. Hist. Nat., 8(1), 121–124.

Battelli, C. & M. Arko Pijevac (2003): Structure and seasonal variations of a subtidal turf-dominated assemblage of the Oštro Cape (Rijeka Bay, Nothern Adriatic Sea). EMBS 38, Marine biodiversity. September 8–12, 2003, Aveiro, Portugal. Book of Abstracts. Universidade de Aveiro, Aveiro, p. 173.

Boudouresque, C. F. & M. Verlaque (2002): Alien marine organisms introduced by ships. CIESM Workshop Monographs no. 20, 6–9 November 2002, Istanbul, Turkey, p. 53–61.

Curiel, D., G. Bellemo & M. Marzocchi (1996): New records of marine algae in the Lagoon of Venice. G. Bot. Ital., 130, 651–707.

Curiel, D., G. Bellemo, B. La Rocca, M. Scattolin & M. Marzocchi (2002): First Report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea. Bot. Mar., 45, 66–70.

Gallardo, T., A. Gómez Garreta, M. A. Ribera, M. Cormaci, G. Furnari, G. Giaccone & C. H. Boudouresque (1993): Check-list of Mediterranean seaweeds. II. Chlorophyceae Wille s.l. Bot. Mar., 36(5), 399–421.

Gargiulo, G. M., F. De Masi & G. Tripodi (1992): *Sargassum muticum* (Yendo) Fernsholt (Phaeophyta, Fucales) is spreading in the Lagoon of Venice (Northern Adriatic Sea). G. Bot. Ital.,126, p. 259.

Godini, A. & A. Avanzini (1988): Una specie nuova per il Golfo di Trieste (Nord Adriatico): *Codium fragile* (Sur.) Hariot (Chlorophyta). Atti. Mus. Civ. Stor. Nat. Trieste, 41(2),197–203.

Gómez Garreta, A., T. Gallardo, M. A. Ribera, M. Cormaci, G. Furnari, G. Giaccone & C. F. Boudouresque (2001): Checklist of Mediterranean Seaweeds. III. Rhodophyceae Rabenh. 1. Ceramiales Oltm. Bot. Mar., 44, 425–460.

Jaklin, A. & M. Arko Pijevac (1997): Benthic biocoenoses of the Sv. Marko Islet (Rijeka bay). Period. Biol., 99(2), 219–228.

Morand, P. & X. Briand (1996): Excessive growth of macroalgae: a symptom of environmental disturbance. Bot. Mar., 39, 491–516.

Munda, I. M. (1960): On the seasonal distribution of benthic marine algae along the northeastern coast of the isle of Krk (Northern Adriatic). Nova Hedwigia, 2(1–2), 191–242.

Orlando Bonaca, M. (2001): A survey of the introduced non-indigenous species in the Northern Adriatic Sae. Annales Ser. Hist. Nat., 10(2), 149–158.

Patzner, R. A. (1998): The invasion of *Lophocladia* (Rhodomelaceae, Lophotalieae) at the northern coast of Ibiza (western Mediterranean Sea). Bol. Soc. Hist. Nat. Balears, 41, 75–80.

Piazzi, L. & F. Cinelli (2001): Distribution and dominance of two introduced turf-forming macroalgae on the coast of Tuscany, Italy, northwestern Mediterranean Sea in relation to different habitats and sedimentation. Bot. Mar., 44, 509–520.

Ribera, M. A., A. Gomez Garreta, T. Gallardo, M. Cormaci, G. Furnari & G. Giaccone (1992): Check-list of Mediterranean Seaweeds. I. Fucophyceae (Warming, 1884). Bot. Mar., 35, 109–130.

Rindi, F. & F. Cinelli (1995): Contribution to the knowledge of the benthic algal flora of the Isle of Alboran, with notes on some little-known species in the Mediterranean. Cryptogamie Algol., 16, 103–114.

Rindi, F. & F. Cinelli (2000): Phenology and small-scale distribution of some rhodomelacean red algae on a western Mediterranean rocky shore. Eur. J. Phycol., 35, 115–125.

Rindi, F., M. D. Guiry & F. Cinelli (1999): Morphology and reproduction of the adventive Mediterranean Rhodophyta *Polysiphonia setacea*. Hydrobiologia, 398/399, 91–100.

Rismondo, A., S. Volpe, D. Curiel & A. Solazzi (1993): Segnalazione di *Undaria pinnatifida* (Harvey) Suringar a Chioggia (Laguna di Venezia). Lavori Soc. Ven. Sci. Nat., 18, 328–330.

Rizzi Longo, L. (1972): Campionamenti di alghe bentoniche nel Quarnero. Atti Mus. Civ. Stor. Nat. Trieste, 28,147–166.

Sartoni, G. & S. Rossi (1998): New records for the benthic algal flora of the Northern Adriatic Sea. Flora Medit., 8, 9–15.

Špan, A., B. Antolić & A. Žuljević (1998): The genus *Caulerpa* (Caulerpales, Chlorophyta) in the Adriatic Sea. Rapp. Comm. int. Mer Médit., 35, 584–585.

Verlaque, M. (1989): Contribution à la flore des algues de Méditerranée: Espéces rare ou nouvelles pour les côtes Françaises. Bot. Mar., 32, 101–113.

Verlaque, M. (1994): Inventaire des plantes introduites en Méditerranée: origines et répercussions sur l'environnement et les activités humaines. Oceanol. Acta, 17(1), 1–23.

Zahtila, E. (1999): IV. Biomonitoring *in situ* eksponiranih morskih organizama. Izvještaj o praćenju utjecaja objekata DINA Omišalj na okoliš u 1999. godini. ZZJZ, Rijeka, p. 63–71.

Zavodnik, N. (1992): Prilozi morskoj flori i fauni lošinjske otočne skupine. I. Alge. Otočki ljetopis Cres-Lošinj, 8, 205–214.

Zavodnik, D. & N. Zavodnik (1982): Survey of benthic communities in the area of Osor (North Adriatic Sea). Acta Adriat., 23(1/2), 259–270.

Zavodnik, D., A. Špan, N. Zavodnik, A. Šimunović & B. Antolić (1981): Benthos of the western coast of the island Krk (Rijeka Bay, the North Adriatic Sea). Thalassia Jugosl., 17(3/4), 285–337.

Zavodnik, N., A. Jaklin & Ž. Labura (1998): Pojava tropske alge *Caulerpa taxifilia* u riječkom zaljevu. Prirodoslovna istraživanja riječkog područja. Prirodoslovni muzej Rijeka, Prirodoslovna bibilioteka, str. 717–722.

Žuljević, A. & B. Antolić (1998): Croatia. In: Proceeding of the workshop on invasive *Caulerpa* species in the Mediterranean. MAP Technical Report Series No. 125, p. 227–230.