

RECURRENCE OF *SARGASSUM VULGARE* C. AGARDH IN SLOVENIAN
COASTAL WATERS (ADRIATIC SEA)

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ABSTRACT

Perennial species from the genus *Sargassum* are considered to be indicators of high environmental quality and are therefore used in the assessment of the Ecological Status of Mediterranean coastal waters according to the European Water Framework Directive (WFD, 2000/60/EC). Over the past three decades a significant decline in *Sargassum* populations has been reported in the Gulf of Trieste, as well as in other Adriatic and Mediterranean areas. In Slovenian coastal waters the presence of *Sargassum* spp. had not been confirmed since 1980, after a severe decline due to overgrazing by the sea urchin *Paracentrotus lividus*. Recently, however, some thalli of *S. vulgare* were found in Piran Bay. The recurrence of this species is discussed in the paper, as well as the possible causes that led to the non-recovery in its populations in last decades in Slovenian coastal waters.

Key words: *Sargassum vulgare*, new data, non-recovery of populations, Gulf of Trieste, Mediterranean Sea

RICOMPARSA DI *SARGASSUM VULGARE* C. AGARDH IN ACQUE COSTIERE SLOVENE
(MARE ADRIATICO)

SINTESI

Specie perenni del genere *Sargassum* sono considerate indicatrici di elevata qualità ambientale e vengono quindi utilizzate nella valutazione dello stato ecologico delle acque costiere del Mediterraneo secondo la Direttiva Europea Quadro sulle Acque (WFD 2000/60/CE). Nel corso degli ultimi tre decenni è stato più volte segnalato un rilevante calo nelle popolazioni di *Sargassum* nel Golfo di Trieste, così come in altre zone dell'Adriatico e del Mediterraneo. Nelle acque costiere slovene la presenza di specie del genere *Sargassum* non è più stata confermata dopo il 1980, a seguito di un forte calo dovuto all'eccessivo pascolo del riccio di mare *Paracentrotus lividus*. Recentemente, alcuni talli di *S. vulgare* sono stati trovati nella baia di Pirano. Nell'articolo viene discussa la ricomparsa di questa specie, così come le possibili cause che hanno portato al mancato recupero delle sue popolazioni negli ultimi decenni nelle acque costiere slovene.

Parole chiave: *Sargassum vulgare*, nuovi dati, mancato recupero delle popolazioni, Golfo di Trieste, mare Mediterraneo

INTRODUCTION

Worldwide the genus *Sargassum* includes a large number of species, with a great morphological variability and extensive geographic and depth distribution (Špan, 2005). In contrast, in the Mediterranean Sea the genus *Sargassum* is represented by a relatively small number of taxa, since only six species were reported in the check-list of brown seaweeds (Ribera *et al.*, 1992). Of those species, only three occur along the eastern Adriatic coast (Antolić *et al.*, 2010): *S. acinarium* (Linnaeus) Setchell, *S. vulgare* C. Agardh, and *S. hornschurchii* C. Agardh. They were also reported for Slovenian coastal waters during the seventies of the last century (Avčin *et al.*, 1973; Matjašič *et al.*, 1975; Vukovič, 1980). However, the macroalgal belt off the Slovenian coast experienced a severe decline due to overgrazing by the sea urchin *Paracentrotus lividus* (Lamarck, 1816) in the seventies (Vukovič, 1982; Turk & Vukovič, 1994). Virtually all infralittoral vegetation was consumed by this echinoderm, and it took decades for the flora to recover. Species from the genus *Cystoseira* recovered quite well, while *Sargassum* species didn't recover at all. Also Curiel *et al.* (2008) and Falace *et al.* (2010) reported a significant decrease in perennial species indicators of high environmental quality (like *Cystoseira* spp. and *Sargassum* spp.) over the past three decades for the Venice Lagoon and for the Italian part of the Gulf of Trieste, respectively; this was mainly a result of anthropogenic disturbances. Species from both genera have relatively large thalli compared to the average size of other Mediterranean seaweeds, and their canopies provide suitable habitats for a large number of other algal and animal species (Ballesteros *et al.*, 1998; Orlando-Bonaca *et al.*, 2008a; Pitacco *et al.*, 2014). Those species are therefore used in the assessment of the Ecological Status of Mediterranean coastal waters according to the European Water Framework Directive (WFD, 2000/60/EC) (Ballesteros *et al.*, 2007; Orfanidis *et al.*, 2001, 2011). Moreover, species from the genera *Cystoseira* (except *Cystoseira compressa*) and *S. hornschurchii* are included in Annex II (List of endangered or threatened marine species in the Mediterranean) of the Barcelona Protocol concerning Specially Protected Areas and Biological Diversity (UNEP, Decision IG.21/6; entry into force: 30 March 2014).

From 2006 to date, species from the genus *Sargassum* were never found in any macroalgal samples regularly collected in Slovenian coastal waters twice per year. Benthic macroalgae were sampled in the upper infralittoral belt (depth range from 1 to 4 m) at 53 sites (Fig. 1) selected in order to assess the ecological status of macroalgal communities, as required by the WFD (Orlando-Bonaca *et al.*, 2008b; Orlando-Bonaca & Lipej, 2009; *unpubl. data*). Additionally, macroalgae were surveyed from the water surface down to 10 m depth in order to characterize benthic macro- and micro-habi-

tat types (Lipej *et al.*, 2007, 2008). The sampling depth range of macroalgae was recently broadened to the lower infralittoral belt (from 4 to 8 m) to assess the environmental status of the sea, as required by the Marine Strategy Framework Directive (2008/56/EC) (Orlando-Bonaca *et al.*, 2012a, 2012b).

Surprisingly, some thalli of *S. vulgare* were unexpectedly found in Piran Bay in 2012, during a scuba survey that was not part of any monitoring program, and the species became much more abundant in 2014. The aim of this paper is to provide data about the recurrence of this species, describe the collected thalli, and discuss the possible causes that led to the non-recovery in last decades of populations of *S. vulgare* in Slovenian coastal waters.

MATERIAL AND METHODS

The Slovenian coastal sea (that covers the southern part of the Gulf of Trieste) is a shallow semi-enclosed gulf with a maximum depth of ca. 33 m. Its diverse coastline is approximately 46.7 km long (Fig. 1). In recent decades the Slovenian natural shoreline has been modified by many human activities, like urbanisation, intensive hinterland farming and massive tourism. Nowadays, less than 18 % of the coastline is in its natural state (Turk, 1999). The coastal sea has also suffered from

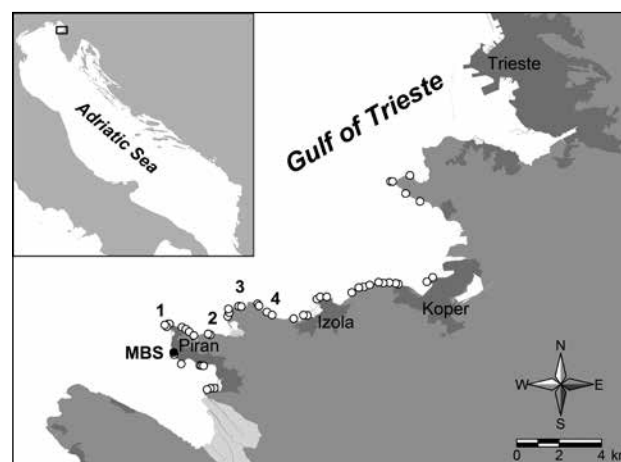


Fig. 1: Slovenian coastal waters and 53 sampling sites for macroalgae in the upper infralittoral belt (white dots) and the MBS site (black dot) where *Sargassum vulgare* was found. 1: Cape Madona Nature Monument, 2: Fiesa-Pacug area, 3: Strunjan Nature Reserve, 4: Bele Skale.

Sl. 1: Slovenske obalne vode in 53 vzorčnih mest za makroalge v zgornjem infralitoralnem pasu (bele točke) ter mesto MBS (črna točka), kjer so bile najdene steljke vrste *Sargassum vulgare*. 1: Naravni spomenik Rt Madona, 2: območje Fiesa-Pacug, 3: Naravni rezervat Strunjan, 4: Bele Skale

many anthropogenic impacts such as intensive fishing, sewage outfalls and mariculture (Francé & Mozetič, 2006; Mozetič *et al.*, 2008; Grego *et al.*, 2009).

In May 2012, during a scuba diving survey in Piran Bay (in front of the Marine Biology Station of the National Institute of Biology), some thalli of *S. vulgare* were found in the upper infralittoral rocky belt. In May 2014 it was observed that the species became much more abundant. The area covered by the species was photographed, its extension was measured and some samples were taken to the laboratory. Species identification was carried out in accordance with Špan (2005). It was planned to collect thalli of *S. vulgare* once per month in the summer period, for a complete morphological analysis. Samples were again collected in June 2014. Thalli were examined under a microscope in order to find any reproduction branches, with fertile cryptosomata (conceptacles) with reproductive organs (oogonia and antheridia). Unfortunately, during the scuba diving surveys in July and August 2014, only small flattened plates (holdfast, rhizoid), and caespitose stipes (central axis, cauloid) of *S. vulgare* were present, while erect branches and phylloclades (blades) were missing.

RESULTS AND DISCUSSION

In front of the Marine Biology Station in Piran (MBS in Fig. 1) thalli of *S. vulgare* were found growing among thalli of *Cystoseira compressa* (Esper) Gerloff & Nizamuddin (Fig. 2), in an area approximately 100 m × 5 m, in a depth range from 1.2 to 2.5 m. The alga was growing on sandstone boulders approx. half a meter wide and half a meter tall. Other abundant algal species

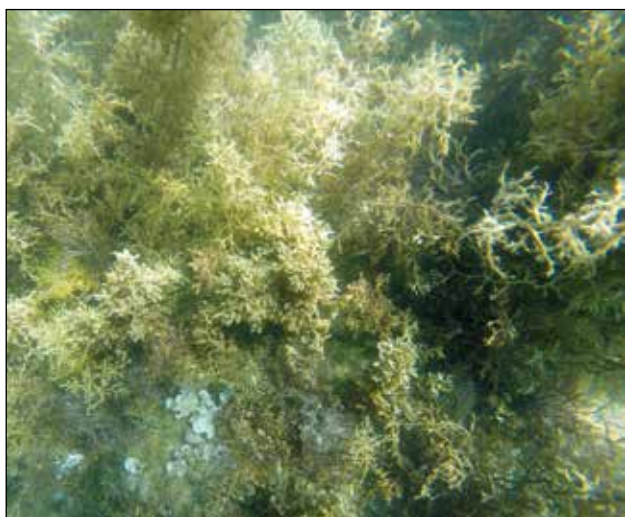


Fig. 2: Thalli of *S. vulgare* growing among thalli of *Cystoseira compressa*, in a depth range from 1.2 to 2.5 m.
Sl. 2: Steljke vrste *S. vulgare*, ki rastejo med steljkami vrste *Cystoseira compressa*, v globinskem razponu 1,2–2,5 m

were *Padina pavonica* (Linnaeus) Thivy and *Dictyota dichotoma* (Hudson) J. V. Lamouroux.

Specimens of *S. vulgare* were characterized by a high density of all parts of the thallus (secondary branches, phylloclades, and bladders (aerocysts)) (Fig. 3). None presented reproduction branches with conceptacles. The thalli were on average 20 cm in height. Two or three stipes were found growing from the holdfast of each thalli, the central of them having around 3 primary branches at the tip. Those branches had around 15 short secondary branches, with many phylloclades. Longer phylloclades (3–4 cm) were found in lower parts of primary branches, while shorter phylloclades (1–2 cm) were in the upper parts of thalli. Their edges were frequently wave-like. Aerocysts were numerous, egg-shaped and often had flattened elongation on the top.

According to Špan (2005), the most intensive development of annual thallus parts (branches and phylloclades) of *S. vulgare* takes place in winter and spring, so branches reach their maximum lengths approximately at the end of May. This means that thalli collected in Slovenian waters probably had reached their maximum development and height. In the central-southern Adriatic Sea, conceptacles of *S. vulgare* are known to be fully ripe in June and July (Špan, 2005). Since our samples from June 2014 did not present reproduction branches, we were planning to search for them in July and August 2014. Unfortunately, in both months large schools of *Sarpa salpa* (Linnaeus, 1758) were observed feeding on the vegetation cover in the sampled area and thalli of *S. vulgare* (and also *C. compressa*) were almost completely eaten. Usually in July thalli of *C. compressa* are still densely ramified, while the fall of older branches occurs at the end of summer/beginning of autumn (Fal-

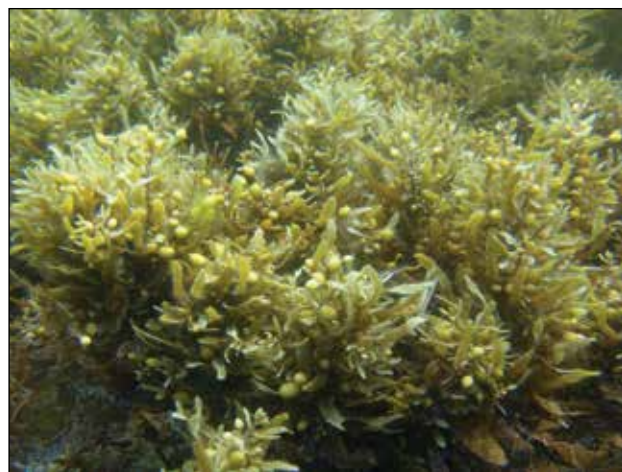


Fig. 3: Thalli of *S. vulgare* were characterized by a high density of secondary branches, phylloclades, and aerocysts.
Sl. 3: Steljke vrste *S. vulgare* z visoko gostoto sekundarnih vej, filoidov in plavalnih mehurjev (aerocist)

ace *et al.*, 2005). The sparid *S. salpa* is well known for its herbivorous diet (Verlaque, 1990; Havelange *et al.*, 1997; Tomec *et al.*, 2000; Vergés *et al.*, 2009; Steele *et al.*, 2014). Moreover, Azzurro *et al.* (2007) analyzed gut contents of some herbivorous fish and reported that 27 taxa of benthic algae were identified in the stomach of *S. salpa*, with a predominance of *S. vulgare*.

Along the eastern Adriatic coast, *S. vulgare* was recorded from Strunjan (Avčín *et al.*, 1973) to the Molunat Peninsula and to the outermost Adriatic islands (Špan, 2005). However, no data is available about the density of populations reported. After the overgrazing by *P. lividus* in the seventies, infralittoral vegetation in Slovenian coastal waters recovered and nowadays is rather homogeneously classified into two *Cystoseiretum crinitae* subassociations: *Halopithetosum incurvae* and *Cystoseiretosum compressae*, and into *Cystoseiretum barbatae* association (Orlando-Bonaca *et al.*, 2008b). Communities dominated by late-successional species of the genera *Cystoseira* are indicative of a quite pristine state, especially along the coastline from Bele Skale (near Izoła, see Figure 1) to Piran, where the Ecological Status according to macroalgae was assessed as “high” (Orlando-Bonaca *et al.*, 2008b). This coastal belt was previously defined as very important from the nature-conservation point of view (Turk, 1999), since it comprises also two MPAs (Cape Madona Nature Monument, Strunjan Nature Reserve) and some non-protected areas (like Fiesa and Pacug) with an exceptional richness of habitat types and fish assemblages (Orlando-Bonaca & Lipej, 2005;

Orlando-Bonaca *et al.*, 2008a). Therefore, at least along this part of the Slovenian coastal belt where *Cystoseira* species recovered very well, reasons for the non-recovery of *Sargassum* species in last decades remain quite unclear. Thibaut *et al.* (2005) reported the total collapse of the genus *Sargassum*, accompanied by a decline in the number of *Cystoseira* species off the north-western Mediterranean coast of France. Among causes leading to this decline they listed chemical pollution from agriculture, increased water turbidity, overgrazing by sea urchins and *S. salpa*, and habitat destruction (Thibaut *et al.*, 2005). Those factors probably also played an important role in the non-recovery of the genus *Sargassum* in Slovenian coastal waters but, in our judgment, the disappearance of *S. vulgare* thalli in the early summer 2014 can be attributed primarily to overgrazing by schools of *S. salpa*. We assume that this fish consumed *S. vulgare* thalli before the start of fructification. However, since the vegetative period of this species extends year-round (Špan, 2005), further scuba surveys are planned in order to find and collect new thalli of this species. We intend to continue the study of *S. vulgare* morphology, its reproductive cycle and ecology in Slovenian coastal waters and possibly to clarify the causes that are leading to the non-recovery of *Sargassum* species.

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PONOVNO POJAVLJANJE VRSTE *SARGASSUM VULGARE* C. AGARDH V SLOVENSKEM OBALNEM MORJU (JADRANSKO MORJE)

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POVZETEK

Trajnice iz rodu *Sargassum* veljajo za indikatorske vrste visoke kakovosti okolja in se zato uporabljajo pri oceni ekološkega stanja sredozemskih obalnih voda v skladu z evropsko Okvirno vodno direktivo (WFD, 2000/60/ES). V zadnjih treh desetletjih so raziskovalci večkrat poročali o pomembnem upadu populacij teh vrst tako v Tržaškem zalivu kot tudi v drugih jadranskih in sredozemskih območjih. V slovenskih obalnih vodah prisotnost vrst iz rodu *Sargassum* ni bila več potrjena po letu 1980, po hudemu padcu zaradi prekomerne pašne morskega ježka *Paracentrotus lividus*. V Piranskem zalivu so bile nedavno najdene steljke navadne sargaške alge (*S. vulgare*), ki so rasle med steljkami cistozir (*Cystoseira compressa*), v globinskem razponu med 1,2 in 2,0 m. Žal so bile na raziskanem območju v poletnih mesecih opažene salpe (*Sarpa salpa*) med pašo, ki so skoraj v celoti pojedle vse steljke omenjenih trajnic. Članek obravnava ponovno najdbo vrste *S. vulgare* kakor tudi možne vzroke, ki so privedli do neokrevanja njenih populacij v zadnjih desetletjih v slovenskih obalnih vodah.

Ključne besede: *Sargassum vulgare*, novi podatki, neokrevanje populacij, Tržaški zaliv, Sredozemsko morje

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