SCHEDA

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TITOLO: Spreading of alien macroalgae in the Venice Lagoon, the Italian hotspot of non-indigenous species: biodiversity and standing crop.

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SPREADING OF ALIEN MACROALGAE IN THE VENICE LAGOON, THE ITALIAN HOTSPOT OF NON-INDIGENOUS SPECIES: BIODIVERSITY AND STANDING CROP

DIFFUSIONE DI MACROALGHE ALIENE NELLA LAGUNA DI VENEZIA, IL PUNTO CALDO ITALIANO DI SPECIE ALLOCTONE: BIODIVERSITÀ E BIOMASSA

Abstract *- Alien macroalgae are a constant concern for coastal areas, especially for the transitional systems of the northern Adriatic Sea. A revision of the taxa in the Venice Lagoon, the Italian hotspot of non-indigenous species (NIS), shows that, currently, the number of algal introductions is 31, and this number is growing steadily. On the basis of macrophyte distribution recorded during the last five years we estimated that the total NIS standing crop is ca. 147 ktonnes, i.e. 32% of the total macroalgal standing crop measured in late spring 2014 (ca. 456 ktonnes). The most abundant species are the invasive* Gracilaria vermiculophylla *(ca.66 ktonnes),* Agardhiella subulata *(37 ktonnes) and* Hypnea flexicaulis *(28 ktonnes). These species grow mainly free-floating and colonise mostly the soft substrata of the lagoon. Other two invasive species, which grew attached to hard substrata are* Sargassum muticum *and* Undaria pinnatifida*, but they showed a biomass significantly lower. Recent studies on* Gracilaria vermiculophylla *showed that, in turbid and confined areas rich in nutrients, this species is able to replace all the other species. Contrary to what it is believed, its presence has a positive effect on the environment because, in confined areas replace Ulvaceae, avoiding or reducing a rapid biomass collapse and the triggering of hypo-anoxic crises. In addition, the presence of NIS increases the biodiversity of the lagoon because the most abundant species have a seasonal distribution only.*

Key-words: *alien macroalgae, standing crop,* Gracilaria vermiculophylla, *biodiversity, Venice Lagoon.*

Introduction - All studies on alien species aim to update the taxonomic lists of new arrivals, their origins, the introduction vectors, their spread and the possibility to control or eradicate them. This is also the case of macrophytes (Sfriso and Marchini, 2014; Marchini *et al.*, 2015). In this paper the updating of alien macroalgae in the lagoon of Venice is presented together with their standing crop which was estimated by maps carried out in the whole basin. Moreover, it is reported a case of positive effect on the environment of an invasive species.

Materials and methods - The distribution of the most common taxa was determined by analysing the NIS records during several surveys carried out in the whole lagoon in summer and autumn 2010 (29 sites), 2011 (118 sites), 2014 (88 sites) and in a confined area placed between the historical centre of Venice and the industrial area of Porto Marghera in 2015 (150 sites). For some taxa we referred also to the observations carried out during the implementation of project Life12 Nat/IT/000331-SeResto. The information on the annual growth rates and biomass production of *Undaria pinnatifida* (Harvey) Suringar, *Sargassum muticum* (Yendo) Fensholt and *Gracilaria vermiculophylla* (Ohmi) Papenfuss was obtained in the studies of Sfriso and Facca (2013) and Sfriso and Sfriso (2017). The estimation of the standing crop was

determined by calculating the lagoon surface colonised by each species according to the surveys carried out for the application of the WFD (2000/60/EC) and the mean biomass present during the sampling.

Tab. 1 - Macroalgal NIS in Venice Lagoon and standing crop estimation.
Macroalghe non indigene nella laguna di Venezia e stima della biomassa.

Tab. 1 - Macroalgal NIS in Venice Lagoon and standing crop estimation

N°	Taxon	First record	Estimated standing crop	
1	*Gracilaria vermiculophylla* (Ohmi) Papenfuss	2008	66383	Tonnes
2	*Agardhiella subulata* (C. Agardh) Kraft & M.J. Wynne	2003	36714	Tonnes
3	*Hypnea flexicaulis* Y.Yamagishi & M.Masuda	2009	28305	Tonnes
4	*Sargassum muticum* (Yendo) Fensholt	1992	4826	Tonnes
5	*Scytosiphon dotyi* M. J. Wynne	1996	4774	Tonnes
6	*Solieria filiformis* (Kützing) Gabrielson	2003	3767	Tonnes
7	*Polysiphonia morrowii* Harvey	1999	517	Tonnes
8	*Polysiphonia schneideri* Stuercke & Freshwater	2017	398	Tonnes
9	*Ulvaria obscura* (Kützing) Gayral	2000	323	Tonnes
10	*Melanothamnus japonicus* (Harvey) Díaz-Tapia & Maggs	2017	272	Tonnes
11	*Undaria pinnatifida* (Harvey) Suringar	1992	143	Tonnes
12	*Grateloupia turuturu* Yamada	1989	87	Tonnes
13	*Uronema marinum* Womersley	2008	8.1	Tonnes
14	*Antithamnion hubbsii* E.Y.Dawson	1994	3.1	Tonnes
15	*Codium fragile* subsp. *fragile* (Suringar) Hariot	1978	1.25	Tonnes
16	*Grateloupia yinggehaiensis* H.W.Wang et R.X.Luan in D.Zhao *et al.*	2008	6.6	kg
17	*Lomentaria hakodatensis* Yendo	2000	5.6	kg
18	*Colaconema codicola* (Børgesen) H.Stegenga, J.J.Bolton, & R.J.Anderson	1978	0.5	kg
19	*Antithamnionella elegans* (Berthold) J.H.Price & D.M.John	1980	<0.5	kg
20	*Antithamnionella spirographidis* (Schiffner) E.M. Wollaston	1995	<0.5	kg
21	*Aglaothamnion feldmanniae* Halos	2003	<0.5	kg
22	*Botrytella parva* (Takamatsu) Kim	1996	+	
23	*Heterosiphonia japonica* Yendo	1999	+	
24	*Pyropia yezoensis* (Ueda) M.S.Hwang & H.G.Choi in Sutherland et al.	2010	+	
25	*Leathesia marina* (Lyngbye) Decaisne	1996	+	
26	*Bonnemaisonia hamifera* Hariot	1995	+	
27	*Halothrix lumbricalis* (Kützing) Reinke	1992	+	
28	*Spermothamnion cymosum* (Harvey) De Toni	2010	+	
29	*Aglaothamnion halliae* (Collins) Aponte, D.L. Ballantine & J.N. Norris	2016	+	
30	*Ulva australis* Areschoug	2011	?	
31	*Ulva californica* Wille in F.S. Collins, Holden & Setchell	2011	?	
Alien standing crop			**146521**	Tonnes
Total mean standing crop (spring 2014).			**456000**	Tonnes
% Alien standing crop			**32**	

Results - On the whole lagoon surface (soft + hard substrata), the total NIS biomass was estimated to be ca. 146,521 tonnes fw (Tab. 1). *Gracilaria vermiculophylla* accounted for 45.3% of the total biomass. In addition, the other taxa with a biomass >1% (*i.e.* 1467 tonnes) were *Agardhiella subulata* (C. Agardh) Kraft *et* Wynne (25.1%), *Hypnea flexicaulis* Y. Yamagishi & M. Masuda (19.3%), *Sargassum muticum* (3.29%), *Scytosiphon dotyi* M.J. Wynne (3.26%) and *Solieria filiformis* (Kützing) P.W. Gabrielson (2.57%). These six species accounted for 98.8% of the total NIS biomass. Other 9 taxa, ranged from 1.25 to 517 tonnes fw, whereas 8 taxa were sampled only occasionally (biomass >0.5 kg fw). Finally, 2 species which were recorded only recently and are difficult to determine morphologically, showed a biomass that cannot be easily quantified. Among NIS the invasive *G. vermiculophylla*, a species that grew mostly unattached in the confined soft substrata of the lagoon, was the most widespread species (66,383 tonnes) whereas *Codium fragile* subsp. *fragile* (Suringar) Hariot, although this species is also considered invasive was uncommon (1.25 tonnes). Despite the high number of NIS, many of these are very rare, others are of high ecological value and have no impact on biodiversity which, on the contrary, is enriched. As for *G. vermiculophylla* the first record dated back to May 2008 in the confined area placed in the western part of the industrial area of Porto Marghera at the Teneri salt marshes. Two years later that species colonized great part of this area with a biomass up to 8-10 kg fw m^{-2}. In 2011 *G. vermiculophylla* spread also in Valle

Millecampi and Valle di Brenta in the southern lagoon but some samples were also recorded near the Venice airport in the northern part of the Lagoon. In 2014 that species colonized all the confined areas of the lagoon. In that year, the spread of *G. vermiculophylla* was particularly massive in the northern side of the bridge that connects Venice to the mainland replacing almost completely *U. rigida*. The presence of this species in 2014 and in the successive years prevented the anoxic crisis that in 2013 affected that area with the decomposition of ca. 10,000 tonnes of biomass in a few days and the troubles that caused to the population of Venice on the night of the Redeemer Feast (Bastianini *et al.,* 2013). Since 2014 *G. vermiculophylla,* and *Agardhiella subulata* in a minor extent, and the native *Gracilariopsis longissima* and *Gracilaria gracilis* colonized all that area hampering the growth of Ulvaceae. That area is very turbid and these Rhodophyceae, and in particular *G. vermiculophylla* were able to grow where the other macroalgae were hampered by high sediment resuspension and phytoplankton blooms. Contrary to the Ulvaceae, which rapidly collapse when water temperature exceeds 25-26 °C, *G. vermiculophylla* also resists at temperatures higher than 30 °C for long periods and degrades it very slowly without triggering anoxic crises.

Conclusions - The standing crops of alien macroalgae that have invaded the bottoms of the Venice Lagoon are presented for the first time. Despite the high number of NIS, only some taxa were abundantly spread in the lagoon. They are mostly species able to live free-floating. Some of these, such as *Gracilaria vermiculophylla,* showed also a positive impact on the environment, replacing Ulvaceae and preventing the triggering of anoxic crises. On the whole the biodiversity resulted enriched without negative impact on the other species because they are prevalently seasonal species. The only negative effect was given by *Sargassum muticum*, *Undaria pinnatifida* and *Agardhiella subulata* because they grew massively around the historical centre of Venice and the city of Chioggia and when thalli detached from the banks of canals hindered the navigation of small boats. However, from the economical point of view all these three taxa could be a source for their phycocolloid content which is used as thickeners and stabilizers in the food, pharmaceutical and cosmetic industries. In addition, *Undaria* is widely used in the eastern countries for soup preparation and contains fucosan, a pigment used in cosmetics as a slimming product (Sfriso et *al.*, 2017).

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