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Research Article

Alien marine macrophytes in transitional water systems: new entries and reappearances in a Mediterranean coastal basin

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Abstract

Three alien macrophytes, *Ascophyllum nodosum*, *Colpomenia peregrina* and *Polysiphonia morrowii,* are reported for the first time from the Mar Piccolo of Taranto (southern Italy, Mediterranean Sea). Two other species, *Agardhiella subulata* and *Codium fragile* subsp. *fragile* that were not, or were sporadically, detected in the basin since their first record in 1987 and 2002, respectively, were also recorded. In the Mar Piccolo, there appears to be a close link between establishment of alien species and the regular import of shellfish for direct sale. To limit the flow of accidental species introductions, a continuous and rigorous control of all the economic activities performed along the coast is recommended through the enforcement of effective laws and an early detection of new introductions.

Key words: *Ascophyllum nodosum; Colpomenia peregrina*; marine macrophytes; Mar Piccolo; Mediterranean Sea; *Polysiphonia morrowii*; shellfish transfer

Introduction

Transitional water systems (TWS) (i.e. estuaries, coastal lagoons) are traditionally exploited for their resources, including fisheries and aquaculture activities (Pérez-Ruzafa et al. 2011). Human pressures in these systems have, in the long term, resulted in degraded water quality, destruction of habitats, a serious depletion of marine biodiversity, and (especially in the last 30 years) large numbers of invasions by alien species (Lotze et al. 2006). As far as the Mediterranean Sea is concerned, about 1000 alien marine species are listed, of which there are 128 macrophytes (Zenetos et al. 2010; 2012). The introduction of alien macrophyte species has been particularly pronounced into transitional water systems, especially in the Western Mediterranean Basin (Zenetos et al. 2010; 2012).

The Mar Piccolo of Taranto (Ionian Sea, southern Italy) is a Mediterranean transitional water system long used for human activities. In particular, shellfish farming (mussels and oysters) was the main economic activity up to the second half of the 1950's (Caffio 2009). Starting in the 1980's, to satisfy the increasing market demands, the import of shellfish from both Mediterranean and extra-Mediterranean countries began. In 2011 and 2012, the destruction of most of mussel production of the First Inlet plants (see Figure 1) due to dioxin and PCB contaminations required massive importations to meet consumer demands. In 2013, the First Inlet mussel processing plants were moved to the near Mar Grande (Figure 1).

The first alien marine macrophytes were observed in the Mar Piccolo shortly after the onset of shellfish imports in the 1980's and the number of species detected had increased to 10 by the end of 2010 (Perrone and Cecere 1994; Cecere and Petrocelli 2009; Gravili et al. 2010; Cecere et al. 2011). Some of alien species were recorded sporadically [e.g. *Codium fragile* (Suringar) Hariot subsp. *fragile, Grateloupia minima* P.L. Crouan & H.M. Crouan, *Osmundea oederi* (Gunnerus) G.Furnari and *Womersleyella*

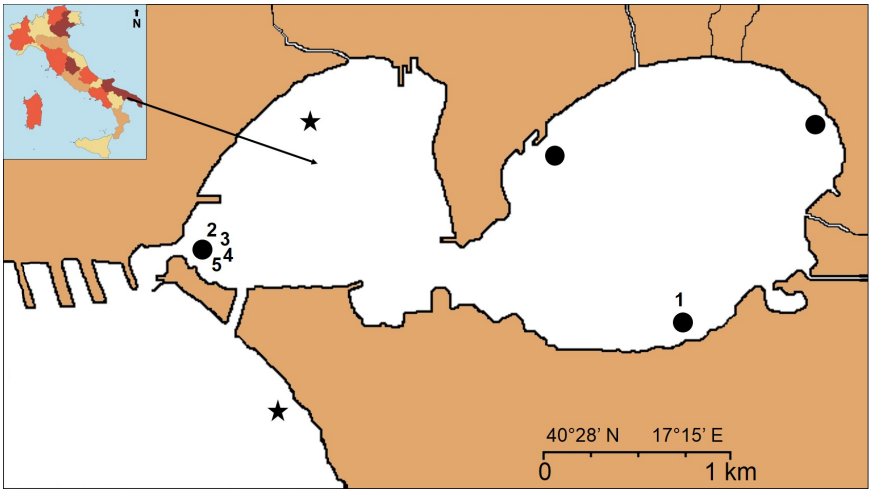

Figure 1. The Mar Piccolo of Taranto - Location of monitored stations (•) and alien marine macrophytes: 1. *Agardhiella subulata*; 2. *Ascophyllum nodosum*; 3. *Codium fragile* subsp. *fragile;* 4. *Colpomenia peregrina*; 5. *Polysiphonia morrowii*. (★) Location of mussel plants in the First Inlet before 2013 and in the Mar Grande starting from 2013.

setacea (Hollenberg) R.E. Norris,]; some formed transitory but well developed populations [e.g. *Agardhiella subulata* (C. Agardh) Kraft *et* M.J. Wynne, *Solieria filiformis* (Kützing) Gabrielson and *Undaria pinnatifida* (Harvey) Suringar], and the final group formed permanent populations exhibiting fluctuating abundances [e.g. *Caulerpa racemosa* (Forsskål) J. Agardh var. *cylindracea* (Sonder) Verlaque, Huisman *et* Boudouresque, *Grateloupia turuturu* Yamada and *Hypnea cornuta* (Kützing) J. Agardh]. However, none of the species listed ever showed noxious invasive behaviour.

The regular monitoring of the marine flora of the Mar Piccolo specifically designed to detect alien flora, began in December 2000 and was carried out monthly at four stations until the end of 2010 (Figure 1). Since 2011, due to the lack of funds, a seasonal monitoring activity was started. This study reports the detection of new non-native macrophytes, plus two species that re-appeared, in Mar Piccolo between 2011 and 2012.

Materials and methods

The Mar Piccolo of Taranto (40°28'N; 17°15'E) (Northern Ionian Sea) is a semi-enclosed embayment showing lagoon-like features. It has a surface area of 20.72 km² and is divided by two promontories into two smaller basins: the First Inlet with a maximum depth of 12 m and the Second Inlet which has a maximum depth of 8 m (Figure 1). Hard substrates are mostly artificial while the natural substrate is sandy near the shore and muddy in the central zone. The lagoon-like features of the Mar Piccolo are mainly due to the presence of several submarine freshwater springs and a few small rivers entering the two inlets. The two basins are subject to strong human pressures such as urban, industrial, and agricultural pollution as well as aquaculture, military shipping, and commercial fishing. The salinity ranges from 34.3 to 37.7 while seawater temperature ranges from 7.1°C to 33.6°C (Alabiso et al. 1997).

From 2011 to winter 2013, seasonal surveys were carried out at four stations in the Mar Piccolo of Taranto where alien marine species were previously observed (Figure 1). Marine macrophytes were hand-collected and brought to the laboratory for study under stereo and light microscopes (Leica Microsystems®, Wetzlar, Germany). Photomicrographs were made using a Nikon Coolpix 4500 (Nikon, Tokyo, Japan). Afterwards, some thalli were preserved in 2.5% formaldehyde-seawater and others were dried as voucher specimens that are stored in the Herbarium of the Istituto Sperimentale Talassografico of Taranto (TAR) (Table 1).

Results

Two exotic species, *Agardhiella subulata* and *Codium fragile* subsp. *fragile*, which had not been observed in the Mar Piccolo since the end of 1990s and 2009, respectively, were found again in 2011. Three additional exotic species, *Ascophyllum nodosum* (Linnaeus) Le Jolis, *Colpomenia peregrina* Sauvageau, and *Polysiphonia morrowii* Harvey were detected for the first time in 2012.

Table 1. Material deposited in the Herbarium of the Istituto Sperimentale Talassografico of Taranto (TAR).

Species	Finding	Specimen / photo
Agardhiella subulata	Mar Piccolo, 13.10.1989	53R TAR
	Mar Piccolo, 03.12.1989	60R TAR
	Mar Piccolo, 28.06.2011	135R TAR
	Mar Piccolo, 24.05.2012	136R TAR, female gametophyte
Ascophyllum nodosum	Mar Grande, 25.07.2009	44F TAR, specimens unattached
	Mar Grande, 01.03.2011	51F TAR, specimens unattached
	Mar Piccolo, 28.05.2012	Photos, specimens attached
Colpomenia peregrina	Mar Piccolo, 24.04.2012	56F TAR
	Mar Piccolo, 28.05.2012	Formalin preserved thallus
Codium fragile subsp. *fragile*	Mar Piccolo, 16.07.2002	Formalin preserved thallus
	Mar Piccolo, 25.07.2009	35C TAR
	Mar Piccolo, 21.07.2011	Formalin preserved thallus
	Mar Piccolo, 28.05.2012	Formalin preserved thallus
Polysiphonia morrowii	Mar Piccolo, 21.05.2012	Formalin preserved thallus
	Mar Piccolo, 26.02.2013	148R TAR

Figure 2. *Agardhiella subulata*. Unattached thallus collected in June 2011. Photograph by E. Cecere and A. Petrocelli.

Unattached individuals of *Agardhiella subulata* (Rhodophyta, Gigartinales, Solieriaceae) were found at 1 m depth in June 2011, entangled with *Gracilaria bursa-pastoris* (S.G. Gmelin) P.C. Silva (Figure 2). Thalli were dark red, very robust, terete throughout, with a diameter of axes up to 5 mm. Main branches were percurrent, densely and alternately branched to 3–4 orders, sometimes

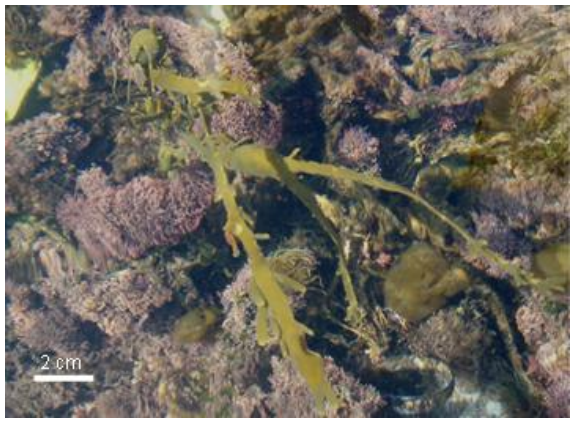

Figure 3. *Ascophyllum nodosum*. Attached thallus observed in June 2012. Photograph by E. Cecere and A. Petrocelli.

pyramidal in shape, with branches tapered at the basis and acuminate to rounded at the apex. These characters agree well with the description of specimens previously found in the region (Perrone and Cecere 1994). Some individuals were irregularly branched due to many regenerations and proliferations caused by heavy grazing. Only female and male gametophytes were collected, no tetrasporophytes were observed. New findings occurred also in March and December 2012 in the same station. *Agardhiella subulata* was collected in a zone where both local and imported molluscs are packed before selling (Figure 1).

Sparse thalli of *Ascophyllum nodosum* (Ochrophyta, Fucales, Fucaceae) were found settled on pebbles and fishing nets down to 50 cm depth in June 2012 (Figure 3). Thalli, greenish in colour, reached a maximum height of 30 cm, growing together with *Amphiroa beauvoisii* J.V.

Figure 4. *Codium fragile* subsp. *fragile*. Attached thallus observed in July 2011. In the frame, utricles with pointed apex (arrows). Photograph by E. Cecere and A. Petrocelli.

Figure 5. *Colpomenia peregrina*. Attached thallus observed in April 2012. In the frame, sporangia without cuticle (arrow). Photograph by E. Cecere and A. Petrocelli.

Lamouroux, *Corallina* sp., *Dasya rigidula* (Kützing) Ardissone and *Dictyota dichotoma* (Hudson) J.V. Lamouroux var. *intricata* (C. Agardh) Greville. No reproductive structures were observed. No thalli were found during the two following seasonal surveys (August and December). *Ascophyllum nodosum* was found in a zone characterised by the presence of numerous mussel retail shops, and where other alien macrophytes (e.g. *C. fragile*, *G. turuturu*, *U. pinnatifida*) were previously observed (Figure 1).

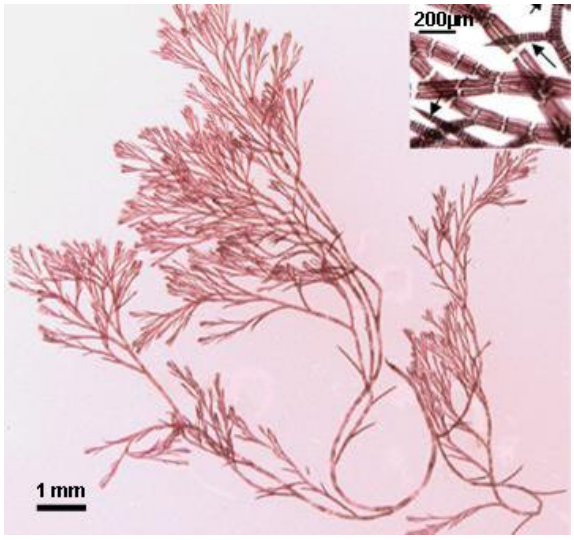

Figure 6. *Polysiphonia morrowii*. Thallus collected in March 2012, as an epiphyte on *Dictyota dichotoma*. In the inset, note the pointed branchlets (arrows). Photograph by E. Cecere and A. Petrocelli.

A few thalli of *Codium fragile* subsp. *fragile* (Chlorophyta, Bryopsidales, Codiaceae), up to 8 cm high, were observed on a few rocks in July 2011 (Figure 4). Specimens were bottle-green, generally isolated, settled at ca 1 m depth, and free of epiphytes. The presence of mucronate utricles confirmed the identification of the species (Silva 1955). New thalli were observed in May-June 2012. *C. fragile* subsp. *fragile* was found in an area where the fish market and several mollusc retail shops were present (Figure 1).

Small isolated, brownish and saccate thalli of *Colpomenia peregrina* (Ochrophyta, Ectocarpales, Scytosiphonaceae) were found in March-April 2012 (Figure 5), settled on pebbles, together with *Amphiroa beauvoisii*, *Corallina* sp., *Dictyota dichotoma* var. *intricata*, *Lomentaria clavellosa* (Lightfoot *ex* Turner) Gaillon, *Padina* sp., *Scytosiphon lomentaria* (Lyngbye) Link and *Ulva rigida* C. Agardh. No reproductive structures were present. More aggregated thalli collected in April and May 2012 were fertile, with plurilocular sporangia without cuticle, which allowed the correct identification (Clayton 1975). No thalli were observed in June 2012. *Colpomenia peregrina* was found in a zone characterised by the presence of numerous mussel retail shops as was the case for *A. nodosum* and *P. morrowii* (Figure 1).

Two tufts of *Polysiphonia morrowii* (Rhodophyta, Ceramiales, Rhodomelaceae), dark red in

colour, were collected in March 2012 (Figure 6), in the same benthic assemblage as *C. peregrina*. Tufts, up to 4 cm high, were characterised by the uncorticated axes with 4 periaxial cells; unicellular rhizoids in open connection with the periaxial cells, and by the ultimate branchlets sharply pointed at apex. No reproductive structures were observed. New thalli were found attached on sparse pebbles in February 2013. *Polysiphonia morrowii* was found in a zone characterised by the presence of numerous mussel retail shops as was the case for *A. nodosum* and *C. peregrina* (Figure 1).

Discussion

Marine alien species can be introduced into new environments by means of a variety of vectors. One of the most important vectors of introduction is the trade in living organisms (Minchin 2007). Indeed, unintentional introduction of marine aliens often happens for hitchhiking species, which are joined to the target species in various ways, e.g., used as packing material, as epibionts or hidden between the imported organisms, attached to packages, or carried into the palleal cavity of shellfish (Olson 2001). As far as the marine macrophytes are concerned, the trade of shellfish (mainly oysters and mussels) is considered to be a major vector of introduction in Europe and in the Mediterranean Sea (44% and 46% of the total, respectively) (Wallentinus 2002; Zenetos et al. 2010). Among the Mediterranean coastal lagoons, the Mar Piccolo of Taranto, with 13 alien macrophytes, is only surpassed by the Thau Lagoon (58 alien species; Boudouresque et al. 2011) and the Lagoon of Venice (37 alien species; Sfriso et al. 2009).

Agardhiella subulata is commonly distributed along the eastern coast of the USA, Caribbean Sea and Latin America. The species was also reported in India and South Korea (Guiry and Guiry 2013). In Great Britain and the Netherlands, *A. subulata* is considered to be alien and most likely unintentionally introduced by shellfish importation (Farnham and Irvine 1979; Wolff 2005). In the Mediterranean Sea, it was first reported in the Thau Lagoon in 1984 (Ben Maiz 1986; misidentified as *Solieria chordalis*), then in the Mar Piccolo of Taranto at the end of the 1980's together with *Solieria filiformis* (Perrone and Cecere 1994) - both species being dominant in unattached macrophyte assemblages, mainly in summer, up to the end of the 1990's (Cecere et al. 1992). Afterwards, their populations drastically declined and probably disappeared. The present occurrence of *A. subulata* in the Mar Piccolo likely resulted from new introductions. Like in the Lagoon of Venice (Curiel and Marzocchi 2010), the Thau Lagoon (Boudouresque et al. 2011) and the Cape Peloro Lagoon (Sicily) (Manghisi et al. 2010), the most likely vector of introduction is the importing of shellfish.

Ascophyllum nodosum is a cold-temperate North-Atlantic species (North America and Europe) (Guiry and Guiry 2013). Unattached thalli of *A. nodosum* were first observed in the Mar Grande of Taranto in July 2009, in the vicinity of an experimental aquaculture site for *Crassostrea gigas* (Petrocelli and Cecere 2010). The attached individuals discovered in 2012 in the Mar Piccolo are the first for the Mediterranean Sea. The only previous European case of introduction was on the trestles of *C. gigas* farms in the Wadden Sea (Reise 1998). Like in San Francisco Bay, where it was eradicated twice, the species was likely imported as packing material (Miller et al. 2011). Since its upper, long-term, temperature tolerance does not exceed 24–25 °C (Keser et al. 2005), and the seawater temperature in the Mar Piccolo is far higher in summer (up to 33.6 °C; Alabiso et al. 1997), its naturalization seems unlikely. *Ascophyllum nodosum* is itself, however, a potential vector for other non-native macrophytes and invertebrates (Crawford 2001; Miller et al. 2004).

Codium fragile subsp. *fragile* is a cold-temperate North-Pacific species that has been introduced worldwide (Provan et al. 2008). The oldest European collection dates from 1845 in Ireland (Provan et al. 2008), then the species spread along the NE Atlantic coast and into the Mediterranean Sea. In the mid-1950's, it appeared along the NW Atlantic coast , in the 1970's in New Zealand, and at the end of the last century in Australia and Chile, where it became a serious pest for aquaculture activities (Provan et al. 2008, Bridgwood 2010). Its first introduction into the Mediterranean Sea probably dates from the World War II and presumably was due to military shipping (Verlaque 1994). In the Mar Piccolo, since July 2002 when two first attached thalli were found, *C. fragile* was observed sporadically: in summer 2003, June 2009, July 2011, and May and June 2012 (Cecere and Petrocelli 2009, and unpublished data). This succession of introduction-extinction events might be associated with continuous shellfish importations, as observed near Piran (Slovenia) (Orlando-Bonaca 2010). The high seawater temperature in summer (up to 33.6°C) might

explain the failure to naturalize because the species requires a temperature range of 10–24°C for growth and reproduction (Bridgwood 2010).

Colpomenia peregrina is a cold-temperate Pacific species (Asia, North America and Australia) (Guiry and Guiry 2013). At the beginning of the 20th century, it was introduced to France via the import of the American oyster *Crassostrea virginica* (Gmelin 1791) (Farnham 1980). Afterwards it spread throughout Britain, the rest of Europe, Africa, North and Central America (Guiry and Guiry 2013). In the Mediterranean Sea, it was first reported in the Thau Lagoon in 1918 (Verlaque 2001). In the Mar Piccolo, *C. peregrina* was only observed from March to May 2012, but thalli were fertile before disappearing in summer, so the development of new generations can be expected, as was observed in Japan (Kogame and Yamagishi 1997).

Polysiphonia morrowii is a temperate, North-Pacific, species (Japan, China, Korea and Russia) reported as alien in Australia, New Zealand, and Europe (Guiry and Guiry 2013). It is very close to *P. senticulosa* Harvey, another North Pacific taxon reported from the Northern Europe (Stegenga et al. 2007). No fertile thalli were found in the Mar Piccolo but our material was tentatively attributed to *P. morrowii* because all the Mediterranean and NE Atlantic populations previously studied belonged to this species (Verlaque 2001, Curiel et al. 2002, Geoffroy et al. 2012). In the Mediterranean Sea, it was first collected in 1997 in the Thau Lagoon and in 1999 in the Lagoon of Venice (Verlaque 2001, Curiel et al. 2002). Its introduction with oyster imports from the NW Pacific is the most probable hypothesis. In the Mar Piccolo, *P. morrowii* was only observed in March 2012 and February 2013, maybe because its natural growth period is short (from February to May in Korea; Kim et al. 2004). *Polysiphonia morrowii* is considered as potentially invasive (Geoffroy et al. 2012), so a careful monitoring of the species in the Mar Piccolo is advisable.

These new findings, their proximity with shellfish retail shops and the frequent observations of shellfish immersions in the natural environment (E. Cecere and A. Petrocelli, unpublished data) well support the hypothesis of introductions via the import of Japanese oysters *C. gigas*, mussels *Mytilus* spp., or Japanese clams *Ruditapes philippinarum* (Adams & Reeves) (Crocetta and Colamonaco 2010).

Shellfish importing is a major vector of introduction of marine macrophytes and the less precautionary procedures for the shellfish importing are applied the more unintentional introductions of associated aliens increase (Minchin 2007). In this respect, the importing of live seafood for immediate consumption must be looked at more carefully because organisms going directly to market are not subjected to the same sanitary controls that are required for those destined to aquaculture activities (Chapman et al. 2003). This could be the case for the *Codium fragile* (Suringar) Hariot subsp. *atlanticum* (A.D. Cotton) P.C. Silva, recently discovered at Marina of Pisa (Tyrrhenian Sea) where several firms import seafood for local restaurants (Petrocelli et al. 2012). Relatively simple aquaculture practices already used to eliminate parasites (e.g. hot water or brine treatments) can markedly reduce the risk of macrophyte introduction (Mineur et al. 2007).

Until now, in the Mar Piccolo of Taranto, no negative impacts due to establishment of alien macrophytes have been detected. However, the attention level must remain high because it is well known that an alien species can become invasive after a long period of quiescence (Simberloff and Gibbons 2004). Since in the Mar Piccolo of Taranto the importation of shellfish appears as a major and continuous way of introduction of aliens, we recommend: 1. A continuous monitoring of aliens already observed in the basin as well as of potential sites of introduction (aquaculture facilities) to early detect any new entry; 2. A continuous and careful control of the economic activities performed in the basin, punishing the non-observance of the current laws; 3. Information campaigns towards sea-users (e.g. shellfish farmers, fishermen, scuba divers, yachtsmen) and the general public, to acquaint them of the problem and of the best practices for avoiding unintentional introductions.

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References

Alabiso G, Cannalire M, Ghionda D, Milillo M, Leone G, Caciorgna O (1997) Particulate matter and chemical-physical conditions of an inner sea: the Mar Piccolo in Taranto. A new statistical approach. *Marine Chemistry* 58: 373–388, http://dx.doi.org/10.1016/S0304-4203(97)00063-7

Ben Maiz N (1986) Flore algale (Rhodophyta, Phaeophyceae, Chlorophyceae, Bryopsidophyceae) de l'étang de Thau (Hérault). PhD Thesis, Université Aix-Marseille II, Marseille, France, 354 pp

Boudouresque CF, Klein J, Ruitton S, Verlaque M (2011) Biological invasion: the Thau Lagoon, a Japanese biological island in the Mediterranean Sea. In: Ceccaldi HJ, Dekeyser I, Girault M, Stora G (eds), Global Change: Mankind-Marine Environment Interactions. Proceedings of the 13th French-Japanese Oceanography Symposium. Springer, Dordrecht, The Netherlands, pp 151–156

Bridgwood S (2010) *Codium fragile* ssp. *fragile* (Suringar) Hariot summary document. Department of Fisheries, Western Australia. Fisheries Research Report No 202, 12 pp

Caffio F (2009) Molluschicoltura a Taranto ai primi del Novecento. In: Cecere E, Mellea S (eds), Frammenti di mare. Taranto e l'antica molluschicultura. Stampa Sud S.p.A., Mottola (TA), Italy, pp 36–68

Cecere E, Petrocelli A (2009) The Mar Piccolo of Taranto. In: Cecere E, Petrocelli A, Izzo G, Sfriso A (eds), Flora and Vegetation of the Italian Transitional Water Systems. CoRiLa, Stampa Multigraf, Spinea, Venezia, Italy, pp 195–227

Cecere E, Saracino OD, Fanelli M, Petrocelli A (1992) Presence of a drifting algal bed in the Mar Piccolo basin, Taranto (Ionian Sea, Southern Italy). *Journal of Applied Phycology* 4: 323–327, http://dx.doi.org/10.1007/BF02185789

Cecere E, Petrocelli A, Portacci G, Mineur F, Verlaque M (2011) *Grateloupia minima* (Rhodophyta, Gigartinales) in the Thau Lagoon and in the Mar Piccolo of Taranto: first report for the Mediterranean Sea. *Bollettino dei Musei e degli Istituti Biologici dell'Università di Genova* 73: 78

Chapman JW, Miller TW, Coan EV (2003) Live seafood species as recipes for invasion. *Conservation Biology* 17: 1386–1395, http://dx.doi.org/10.1046/j.1523-1739.2003.01016.x

Clayton MN (1975) A study of variation in Australian species of *Colpomenia* (Phaeophyta, Scytosiphonales). *Phycologia* 14: 187–195, http://dx.doi.org/10.2216/i0031-8884-14-4-187.1

Crawford SE (2001) Live rockweed (*Ascophyllum*) used as a shipping medium for the live transport of marine baitworms from Maine. In: Paust BC, Rice AA (eds), Marketing and shipping live aquatic products. Proc. of the 2nd Int. Conference and Exhibition, November 1999, Seattle, WA, University of Alaska Sea Grant, AK-SG-01-03, Fairbanks, pp 95–97

Crocetta F, Colamonaco G (2010) *Percnon gibbesi* (Crustacea: Decapoda) and *Aplysia dactylomela* (Mollusca: Gastropoda) in the Taranto Gulf (Italy, Ionian Sea): new populations incoming. *Marine Biodiversity Records*, http://dx.doi.org/10.1017/S1755267209990765

Curiel D, Marzocchi M (2010) Stato delle conoscenze nella laguna di Venezia di due *alien species: Undaria pinnatifida* e *Sargassum muticum. Lavori della Società Veneta di Scienze Naturali* 35: 93–106

Curiel D, Bellemo G, La Rocca B, Scattolin M, Marzocchi M (2002) First report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea. *Botanica Marina* 45: 66–70, http://dx.doi.org/10.1515/BOT.2002.008

Farnham WF (1980) Studies on aliens in the marine flora of southern England. In: Price JH, Irvine DEG, Farnham WF (eds), The shore environment, volume 2: ecosystems. Academic Press, London, UK, pp 875–914

Farnham WF, Irvine LM (1979) Discovery of members of the red algal family Solieriaceae in the British Isles. *British Phycological Journal* 14: 123

Geoffroy A, Le Gall L, Destombe C (2012) Cryptic introduction of the red alga *Polysiphonia morrowii* Harvey (Rhodomelaceae, Rhodophyta) in the North Atlantic Ocean highlighted by a DNA barcoding approach. *Aquatic Botany* 100: 67–71, http://dx.doi.org/10.1016/j.aquabot.2012.03.002

Gravili C, Belmonte G, Cecere E, Denitto F, Giangrande A, Guidetti P, Longo C, Mastrototaro F, Moscatello S, Petrocelli A, Piraino S, Terlizzi A, Boero F (2010) Non-indigenous species along the Apulian coast, Italy. *Chemistry and Ecology* 26: 121–142, http://dx.doi.org/10.1080/02757541003627654

Guiry MD, Guiry GM (2013) *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 14 February 2013

Keser M, Swenarton JT, Foertch JF (2005) Effects of thermal input and climate change on growth of *Ascophyllum nodosum* (Fucales, Phaeophyceae) in eastern Long Island Sound (USA). *Journal of Sea Research* 54: 211–220, http://dx.doi.org/10.1016/j.seares.2005.05.001

Kim MS, Yang EC, Mansilla A, Boo SM (2004) Recent introduction of *Polysiphonia morrowii* (Ceramiales, Rhodophyta) to Punta Arenas, Chile. *Botanica Marina* 47: 389–394, http://dx.doi.org/10.1515/BOT.2004.053

Kogame K, Yamagishi Y (1997) The life history and phenology of *Colpomenia peregrina* (Scytosiphonales, Phaeophyceae) from Japan. *Phycologia* 36: 337–344, http://dx.doi.org/10.2216/i0031-8884-36-5-337.1

Lotze HK, Lenihan HS, Bourque BJ, Bradbury RH, Cooke RG, Kay MC, Kidwell SM, Kirby MX, Peterson CH, Jackson JBC (2006) Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312: 1806–1809, http://dx.doi.org/10.1126/science.1128035

Manghisi A, Morabito M, Bertuccio C, Le Gall L, Couloux A, Cruaud C, Genovese G (2010) Is routine DNA barcoding an efficient tool to reveal introductions of alien macroalgae? A case study of *Agardhiella subulata* (Solieriaceae, Rhodophyta) in Cape Peloro lagoon (Sicily, Italy). *Cryptogamie, Algologie* 31: 423–433

Miller AW, Chang AL, Cosentino-Manning N, Ruiz GM (2004) A new record and eradication of the north Atlantic alga *Ascophyllum nodosum* (Phaeophyceae) from San Francisco Bay, California, USA. *Journal of Phycology* 40: 1028–1031, http://dx.doi.org/10.1111/j.1529-8817.2004.04081.x

Miller KA, Aguilar-Rosas LE, Pedroche FF (2011) A review of non-native seaweeds from California, USA and Baja California, Mexico. *Hidrobiológica* 21: 365–379

Minchin D (2007) Aquaculture and transport in a changing environment: overlap and links in the spread of alien biota. *Marine Pollution Bulletin* 55: 302–313, http://dx.doi.org/10.1016/j.marpolbul.2006.11.017

Mineur F, Belsher T, Johnson MP, Maggs CA, Verlaque M (2007) Experimental assessment of oyster transfers as a vector for macroalgal introductions. *Biological Conservations* 137: 237–247, http://dx.doi.org/10.1016/j.biocon.2007.02.001

Olson AM (2001) Do live marine products serve as pathways for the introduction of nonindigenous species? In: Paust BC, Rice AA (eds), Marketing and shipping live aquatic products: Proceedings of the Second International Conference and Exhibition, November 1999, Seattle, WA, University of Alaska Sea Grant, AK-SG-01-03, Fairbanks, pp 243–246

Orlando-Bonaca M (2010) New records of non-indigenous algal species in Slovenian coastal waters. *Annales, Series Historia Naturalis* 20: 143–150

Pérez-Ruzafa Á, Marcos C, Pérez-Ruzafa IM (2011) Recent advances in coastal lagoons ecology: evolving old ideas and assumptions. *Transitional Waters Bulletin* 5: 50–74

Perrone C, Cecere E (1994) Two solieriacean algae new to the Mediterranean: *Agardhiella subulata* and *Solieria filiformis* (Rhodophyta, Gigartinales). *Journal of Phycology* 30: 98–108, http://dx.doi.org/10.1111/j.0022-3646.1994.00098.x

Petrocelli A, Cecere E (2010) Biodiversity and mollusc transfer: need of observance of the laws to avoid alien seaweeds introduction. *Biologia Marina Mediterranea* 17: 175–176

Petrocelli A, Portacci G, Cinelli F, Cecere E (2012) Nuovi "alieni" nei mari italiani. Riunione Annuale del Gruppo per l'Algologia della Società Botanica Italiana, Abstract book, Ischia (NA) 9–10 November 2012: 25 (http://www.societabotanic aitaliana.it/uploaded/1714.pdf)

Provan J, Booth D, Todd NP, Beatty GE, Maggs CA (2008) Tracking biological invasions in space and time: elucidating the invasive history of the green alga *Codium fragile* using old DNA. *Diversity and Distributions A Journal of Conservation Biogeography* 14: 343–354

Reise K (1998) Pacific oysters invade mussel beds in the European Wadden Sea. *Senckenbergiana maritima* 28: 167–175, http://dx.doi.org/10.1007/BF03043147

Sfriso A, Curiel D, Rismondo A (2009) The Lagoon of Venice. In: Cecere E, Petrocelli A, Izzo G, Sfriso A (eds), Flora and Vegetation of the Italian Transitional Water Systems. CoRiLa, Stampa Multigraf, Spinea, Venezia, Italy, pp 17–80

Silva PC (1955) The dichotomous species of *Codium* in Britain. *Journal of the Marine Biological Association UK* 34: 565–577, http://dx.doi.org/10.1017/S0025315400008821

Simberloff D, Gibbons L (2004) Now you see them, now you don't! - population crashes of established introduced species. *Biological Invasions* 6: 161–172, http://dx.doi.org/10.1023/B:BINV.0000022133.49752.46

Stegenga H, Karremans M, Simons J (2007) Zeewieren van de voormalige oesterputten bij Yerseke. *Gorteria* 32: 125–143

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

Verlaque M (2001) Checklist of the macroalgae of Thau Lagoon (Hérault, France), a hot spot of marine species introduction in Europe. *Oceanologica Acta* 24: 29–49, http://dx.doi.org/10.1016/S0399-1784(00)01127-0

Wallentinus I (2002) Introduced marine algae and vascular plants in European aquatic environments. In: Leppakoski E, Gollasch S, Olenin S (eds), Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 27–52, http://dx.doi.org/10.1007/978-94-015-9956-6_4

Wolff WJ (2005) Non-indigenous marine and estuarine species in the Netherlands. *Zoologische Mededelingen* 79: 3–116

Zenetos A, Gofas S, Verlaque M, Çinar M, García Raso E, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglia C, Siokou I, Violanti D, Sfriso A, San Martín G, Giangrande A, Katağan T, Ballesteros E, Ramos Esplá A, Mastrototaro F, Ocaña O, Zingone A, Gambi MC, Streftaris N (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science* 11: 381–493, http://dx.doi.org/10.12681/mms.87

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, García Raso JE, Çinar ME, Almogi-Labin A, Ates AS, Azzurro E, Ballesteros E, Bianchi CN, Bilecenoglu M, Gambi MC, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle PK, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci-Papadopoulou MA, Ramos Esplá A, Salas C, San Martín G, Sfriso A, Streftaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. *Mediterranean Marine Science* 13: 328–352, http://dx.doi.org/10.12681/mms.327