Updated records and range expansion of alien marine macrophytes in Greece (2009)

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Abstract

In the present study the list of alien marine macrophytes already recorded on Greek coasts has been revised in the light of recent studies and new observations. In comparison to 2008, the total number consists of 32 taxa, and the classification as established, casual and debatable species has been modified, with a total of 14, 5 and 13 species respectively. An interesting increase in established species from 9 taxa in 2008 to 14 taxa in 2009 is noted. With 23 taxa listed, Rhodobionta is the best represented group, followed by Chlorobionta (4 taxa) and Chromobionta (4 taxa), while seagrasses (Streptobionta) are represented by only one species. Several new records, one new entry and two putative additions are considered here, while two other taxa previously assumed introduced are excluded from the list of aliens.

Keywords: Alien; Invasive species; Marine macrophytes; Greece; Mediterranean.

Introduction

The introduction of alien marine species is considered to be one of the greatest threats to the marine environment at the dawn of the 21st century (SCHMITZ & SIMBER-LOFF, 1997; CARLTON, 2000). Alien species, especially those showing invasive behavior, can induce biodiversity losses, alterations to an ecosystems' structure and

functions, and even result in negative socioeconomic effects in coastal areas (BOUDOURESQUE & VERLAQUE, 2005; WALLENTINUS & NYBERG, 2007).

Alien species have puzzled the scientific community over recent decades, since there has been an uncontested increase in introductions worldwide, especially in Europe (CARLTON, 2002; STREFTARIS *et al.*, 2005; GALIL, 2008, 2009). This increase is

attributed mainly to intensive human activities in the marine environment (shipping, aquaculture, fisheries, tourism, etc.) since the 1960's (BOUDOURESQUE & VERLAQUE, 2005). Therefore, today there are several scientific programs focusing on alien species, such as CIESM: atlas of exotic species, www.ciesm.org/atlas, and DAISIE: Delivering Alien Invasive Species Inventories for Europe, http://www.europe-aliens.org/.

Among alien species, alien marine macrophytes represent one of the most important groups (SCHAFFELKE et al., 2006), especially in Europe and Australia (WALLE-NTINUS, 2002; HEWITT et al., 2007). In the Mediterranean Sea, more than 110 taxa of alien marine macrophytes have been hitherto recorded, most of which originate from the Indo-Pacific Ocean, and are introduced into the Mediterranean Sea through aquaculture, shipping, and via the Suez Canal (BOUDOURESQUE & VERLAQUE, 2002; CORMACI et al., 2004; HEWITT et al., 2007; MINEUR et al., 2007; VERLAQUE et al., 2007, in press; ZENETOS et al., 2008). Several alien marine macrophytes, such as Caulerpa taxifolia (M. Vahl) C. Agardh (THIBAUT & MEINESZ, 2004) and Caulerpa racemosa var. cylindracea (Sonder) Verlaque, Huisman et Boudouresque (KLEIN & VERLAQUE, 2008), exhibit invasive behavior and have a severe impact not only on the native algal and/or macrophytic communities but also on human activities (SCHAFFELKE & HEWITT, 2007; WILLIAMS & SMITH, 2007).

In Greece, there has been a sharp increase in alien marine macrophytes over the last four decades (TSIAMIS *et al.*, 2008), as well as the augmentation of other alien marine organisms, such as fish and benthic invertebrates (ZENETOS *et al.*, 2005; CORSINIFOKA & ECONOMIDIS, 2007). However, there is still information missing and there

are many gaps in our knowledge of alien marine macrophytes in Greece; this is due to the immensely long coastline and lack of research programs focusing on the subject.

The aim of the present study is to contribute to the knowledge of alien marine macrophytes in the Greek seas, since Greece represents an important geographical link between the Levantine Sea, the Black Sea, the Adriatic Sea and the Western Mediterranean basin. To the last published list of alien marine macrophytes from the Greek coasts (TSIAMIS *et al.*, 2008), we add new records, pointing out revised species and debatable cases, as well as giving detailed maps of their current range expansion in the Greek seas.

Methods

The list reported in the review paper by TSIAMIS et al. (2008, Table 1) was used as primary basis for the present work. According to that list, 31 alien macrophytic species had been recorded on Greek coasts until 2007, of which 9 were classified as 'established', 8 as 'casuals' and 14 as 'debatable' cases. Since then, field samplings focusing on alien marine macrophytes have been carried out along various Greek coasts, in both the Ionian and the Aegean Seas, aiming at an updated expansion range of alien macrophytes. Consequently, new entries and additional records of alien taxa have been included in this study, giving an updated list with records up to August 2009. Location, date, and collection data for the new records are given for each established alien species. In addition, the list has been critically reviewed and several records have been revised. For example, some previously assumed debatable taxa have now been moved to the established category, while some other records are now considered as excluded from the list of aliens. Moreover,

Table 1

Alien marine macrophytes in Greece classified as established (E) and casual (C). Taxon: CHL= Chlorobionta, CHR= Chromobionta, RHO= Rhodobionta, STR= Streptobionta. Taxa in Bold correspond to new entries for the list and to changes in the status since TSIAMIS et al. (2008, Table 1). D=debatable.

Group	Status		
		2008	2009
RHO	Antithamnionella elegans (Berthold) J.H. Price et D.M. John	D	Е
RHO	Asparagopsis armata Harvey ^a	Е	Е
RHO	Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon	D	Е
RHO	Bonnemaisonia hamifera Hariot b	C	C
CHL	Caulerpa racemosa var. cylindracea (Sonder) Verlaque,	Е	Е
	Huisman et Boudouresque		
CHL	Caulerpa racemosa var. lamourouxii f. requienii (Montagne)	C	Е
	Weber van Bosse		
RHO	Ceramium strobiliforme G.W. Lawson et D.M. John	C	C
RHO	Chondria curvilineata F.S. Collins & Hervey c	D	C
CHL	Codium fragile (Suringar) Hariot subsp. fragile d	Е	Е
CHR	Colpomenia peregrina Sauvageau	Е	Е
STR	Halophila stipulacea (Forsskål) Ascherson	Е	Е
RHO	Hypnea cornuta (Kützing) J. Agardh	C	Е
RHO	Hypnea spinella (C. Agardh) Kützing	Е	Е
RHO	Laurencia caduciramulosa Masuda et Kawaguchi	D	C
RHO	Lophocladia lallemandii (Montagne) F. Schmitz	Е	Е
RHO	Neosiphonia harveyi (J. Bailey) MS. Kim, HG. Choi,	-	С
	Guiry & G.W. Saunders		
RHO	Sarconema scinaioides Børgesen	С	Е
CHR	Stypopodium schimperi (Buchinger ex Kützing)	Е	Е
	Verlaque et Boudouresque		
RHO	Womersleyella setacea (Hollenberg) R.E. Norris	Е	Е

^a Most records are based only on a 'Falkenbergia' life-history phase arbitrarily attributed to "F. rufolanosa", the sporophyte of A. armata.

alien species considered previously not introduced as well as unpublished records by regional experts have been also included in this study, thus giving a more precise view of alien marine macrophytes in Greece.

Following the same classification

(TSIAMIS et al., 2008), alien macrophytes have been grouped into four broad categories according to their establishment success, namely 'established' (permanent, self-maintaining populations), 'casual' (recorded only once), 'debatable' (insufficient

^b Only the tetrasporophyte phase was found (SKOUFAS & TSIRIKA, 2003).

^c Misidentified as *C. collinsiana* M.A. Howe (ATHANASIADIS, 1987). Although ATHANASIADIS's material was not re-examined, his description agrees with *C. curvilineata* and not with *C. collinsiana*.

^d Synonym of Codium fragile subsp. tomentosoides (van Goor) P.C. Silva.

information, highly probable records requiring confirmation, and cryptic introductions) and 'excluded' (native species, misidentifications). Updated range expansion maps are given for the established and casual alien taxa, taking into account both our own and already published records for each taxon (only some references of interest are cited due to space limitations). On the other hand, debatable and excluded species are briefly discussed, with, however, special attention paid to new entries and revised cases.

Results

By August 2009, the total number of alien marine macrophytes recorded on Greek coasts (32 taxa) had slightly increased when compared to TSIAMIS *et al.* (2008) (31 taxa); moreover, the proportion of each

category differs with 14 established (E), 5 casual (C) and 13 debatable (D) species (Tables 1 & 2). With 23 taxa listed, Rhodobionta is the best represented group, followed by Chlorobionta (4 taxa) and Chromobionta (4 taxa), while seagrasses (Streptobionta) are represented by only one species. One new entry (C) and two putative additions (D) are considered here, while three other taxa previously assumed casuals (TSIAMIS et al., 2008) are now considered as debatable. Moreover, there are also two taxa previously assumed introduced and are now excluded from the list of aliens. Distribution records and range expansion are given for each established (Fig. 1) and casual (Fig. 2) alien marine macrophyte in Greece. Location, date, and collecting data for the new records are given for each established alien species (Table 3).

Table 2
Alien marine macrophytes in Greece classified as debatable. Taxon: CHL= Chlorobionta, CHR= Chromobionta, RHO= Rhodobionta. Taxa in Bold correspond to new entries for the list.

TAXON	SPECIES	COMMENT
RHO	Acanthophora nayadiformis (Delile) Papenfuss	native (or) cryptic introduction
RHO	Anotrichium okamurae Baldock?	native (or) cryptic introduction
RHO	Antithamnionella spirographidis (Schiffner)	needs confirmation
	E.M. Wollaston	
RHO	Ceramium bisporum D.L. Ballantine	needs confirmation
RHO	Chondria coerulescens (J. Agardh) Falkenberg	native (or) cryptic introduction
RHO	Chondria pygmaea Garbary & Vandermeulen	highly probable presence, needs observation
RHO	Ganonema farinosum (J.V. Lamouroux)	native (or) cryptic introduction
	K.C. Fan et Yung C. Wang	
RHO	Hypnea valentiae (Turner) Montagne ^a	needs confirmation
CHR	Padina boryana Thivy b	needs confirmation
RHO	Polysiphonia atlantica Kapraun et J.N. Norris	high risk of confusion with Mediterranean species
RHO	Polysiphonia fucoides (Hudson) Greville	native (or) cryptic introduction
CHR	Pylaiella littoralis (Linnaeus) Kjellman c	needs confirmation
CHL	Ulva fasciata Delile	native (or) cryptic introduction

^a from Casual to Debatable compared to TSIAMIS et al., 2008

^b from Casual to Debatable compared to TSIAMIS et al., 2008

^c from Casual to Debatable compared to TSIAMIS et al., 2008

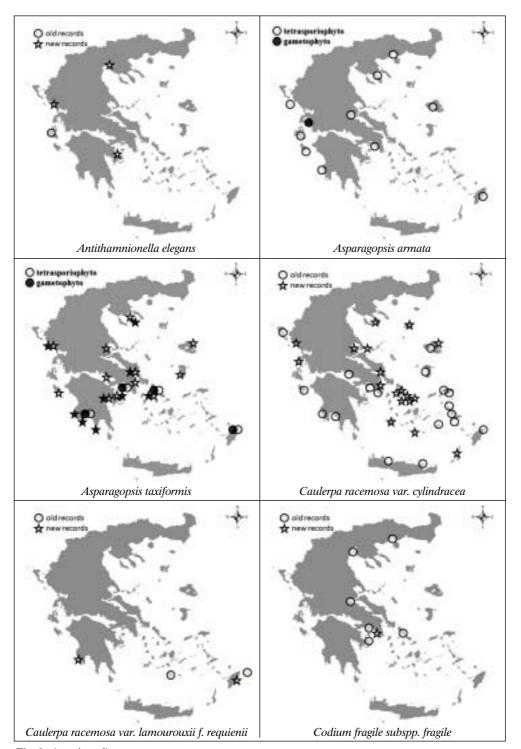


Fig. 1: (continued)

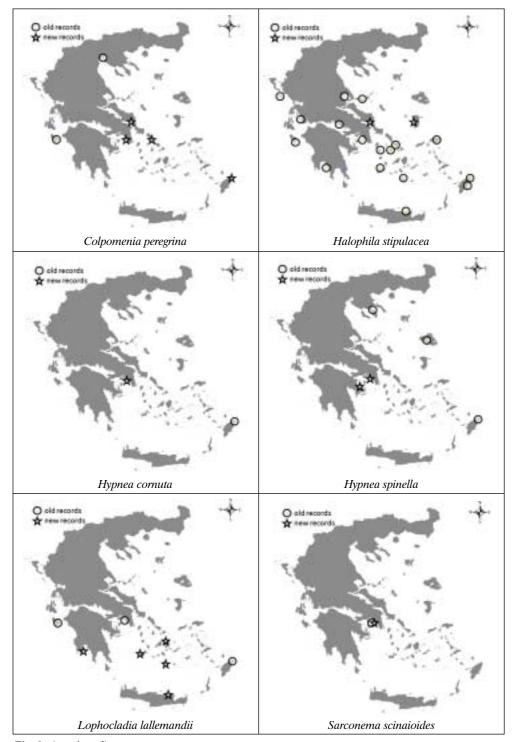


Fig. 1: (continued)

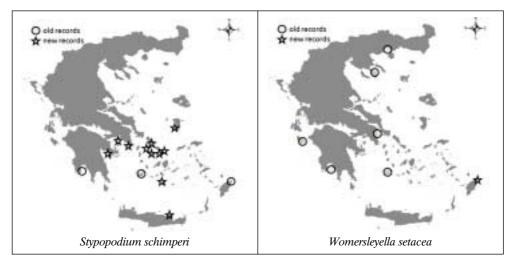


Fig. 1 (continued): Distribution records and range expansion of established alien marine macrophytes in Greece until 2009. Both old (published) and new records are given.



Fig. 2: Casual alien marine macroalgae in Greece until 2009.

Table 3

Data for the new records of established alien marine macrophytes in Greece up to August 2009.

Pilos Port	Taxon	Location	Depth	Substrate	Date	Collector
elegans Parga port Sclonda, Epidauros Gulf Im epiphyte January 2009 K. Tsiamis epiphyte January 2009 K. Tsiamis epiphyte October 2006 N. Tsiamis epiphyte October 2006 N. Tsiamis epiphyte September 2008 K. Tsiamis epiphyte September 2008 K. Tsiamis epiphyte September 2008 N. Tsiamis epiphyte November 2008 N. Tsiamis epiphyte November 2008 N. Tsiamis epiphyte January 2009 N. Tsiamis epiphyte January 2009 N. Tsiamis epiphyte January 2009 N. Tsiamis epiphyte March 2009 N. Tsiamis epiphyte March 2009 N. Tsiamis epiphyte March 2009 N. Tsiamis epiphyte January 2009 N. Tsiamis epiphyte March 2009 N. Tsiamis epiphyte Mar	Antithamnionalla	Neoi Epivates, Thermaikos Gulf	1m	epiphyte	July 2007	K. Tsiamis
Selonda, Epidauros Gulf		Parga port	1m	epiphyte	October 2008	K. Tsiamis
*Vourrourou, Sithonia 2m epiphyte August 2007 K. Tsiamis *Keri, Zakinthos Isl. 1m epiphyte September 2008 K. Tsiamis *Nies, Pagasitikos Gulf 2m epiphyte September 2008 K. Tsiamis *Nies, Pagasitikos Gulf 2m epiphyte September 2008 K. Tsiamis *Scoinias, Attiki 1m epiphyte November 2008 K. Tsiamis *Exoinias, Attiki 1m epiphyte November 2008 K. Tsiamis taxiformis *Vourlias, Argolikos Gulf 1-3m epiphyte Procky January 2009 K. Tsiamis *Evolution of tetrasporophytic phace found Nauplio port, Argolikos Gulf 1m rocky February 2009 K. Tsiamis *Skala Kydonion, Lesvos Isl. 1m epiphyte March 2009 G. Bardama Pilos Port 1m rocky April 2009 G. Bardama Aliveri, Evoikos Gulf 1-2m epiphyte procky June 2009 K. Tsiamis Gerolimenas, Messiniakos Gulf 1-2m rocky June 2009 K. Tsiamis Gerolimenas, Messiniakos Gulf 1-2m rocky June 2009 K. Tsiamis Gerolimenas, Messiniakos Gulf 1-2m rocky June 2009 K. Tsiamis Naar Pyrgi, Chios Isl. 2m rocky June 2009 M. Salomidi Nar Pyrgi, Chios Isl. 2m rocky July 2009 M. Salomidi Karpathos Isl., port 1m rocky August 2009 S. Katsaneva Kimolos Isl., port 1m rocky August 2006 M. Salomidi Karpathos Isl., port 1m rocky August 2006 M. Salomidi Karpathos Isl., port 1m rocky August 2006 M. Salomidi Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis racemosa var. Sixiamis, Attiki 1-15m rocky June 2009 K. Tsiamis rocky November 2008 K. Tsiamis rocky August 2008 K. Tsiamis rocky November 2008 K. Tsiamis rocky June 2009 K. Tsiamis rocky J	cuguns	Selonda, Epidauros Gulf	1m	epiphyte	January 2009	K. Tsiamis
*Keri, Zakinthos Isl.		*Antikyra, Korinthiakos Gulf	1m	epiphyte	October 2006	K. Tsiamis
*Nies, Pagasitikos Gulf Parga port Im epiphyte November 2008 K. Tsiamis Science Scienc		*Vourvourou, Sithonia	2m	epiphyte	August 2007	K. Tsiamis
Parga port		*Keri, Zakinthos Isl.	1m	epiphyte	September 2008	K. Tsiamis
*Sxoinias, Attiki Im epiphyte November 2008 K. Tsiamis taxiformis *Vourlias, Argolikos Gulf Im epiphyte January 2009 K. Tsiamis Nauplio port, Argolikos Gulf Im rocky February 2009 K. Tsiamis Place found *Skala Kydonion, Lesvos Isl. Im epiphyte March 2009 K. Tsiamis Porto Coufo, Sithonia I-3m rocky June 2009 K. Tsiamis Gerolimenas, Messiniakos Gulf I-2m rocky June 2009 K. Tsiamis Gyaros Isl. Im rocky July 2009 M. Salomidi Karpathos Isl., port Im rocky July 2006 M. Salomidi Karpathos Isl., port Im rocky August 2009 S. Katsaneva Agia Paraskevi, Skiathos Isl. Im rocky August 2008 K. Tsiamis Moudros bay, Limnos Isl. Im rocky August 2008 K. Tsiamis Poros, Leukada Isl. Im rocky August 2008 K. Tsiamis Rocky August 2008 K. Tsiamis Poros, Leukada Isl. Im rocky August 2008 K. Tsiamis Parga port Im rocky August 2008 K. Tsiamis Rocky Algust 2008 K. Tsiamis Poros, Leukada Isl. Im rocky August 2008 K. Tsiamis Rocky August 2008 K. Tsiamis Rocky August 2008 K. Tsiamis Parga port Im rocky August 2008 K. Tsiamis Rocky Algust 2009 K. Tsiamis Rocky Algust 2008 K. Tsiamis Rocky Algust 2009		*Nies, Pagasitikos Gulf	2m	epiphyte	September 2008	K. Tsiamis
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*Vourlias, Argolikos Gulf		*Sxoinias, Attiki	1m	epiphyte	November 2008	K. Tsiamis
* = only the tetrasporophytic phace found Nauplio port, Argolikos Gulf phace found Nauplio port, Argolikos Gulf *Skala Kydonion, Lesvos Isl.	Asparagopsis	Selonda, Epidauros Gulf	1-3m	epiphyte/rocky	January 2009	K. Tsiamis
tetrasporophytic phace found **Skala Kydonion, Lesvos Isl.** Im epiphyte March 2009 K. Tsiamis Koroni port Im rocky April 2009 G. Bardama Pilos Port Im rocky April 2009 G. Bardama Aliveri, Evoikos Gulf I-2m epiphyte/rocky June 2009 K. Tsiamis Gerolimenas, Messiniakos Gulf I-2m rocky June 2009 K. Tsiamis Gyaros Isl. Near Pyrgi, Chios Isl. 2m rocky July 2009 M. Salomidi Karpathos Isl., port Im rocky July 2009 M. Salomidi Karpathos Isl., port Im rocky August 2006 M. Salomidi Karpathos Isl., port Im rocky August 2006 K. Tsiamis Korthi, Andros Isl. Im rocky August 2006 K. Tsiamis Korthi, Andros Isl. Im rocky August 2008 K. Tsiamis Moudros bay, Limnos Isl. Im rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Saoinias, Attiki I-15m rocky November 2008 K. Tsiamis Saoinias, Attiki I-15m rocky June 2009 K. Tsiamis Tristinika, Sithonia Im rocky June 2009 K. Tsiamis Gyaros Isl. Im rocky June 2009 K. Tsiamis Tristinika, Sithonia Im rocky June 2009 K. Tsiamis Gyaros Isl. Im rocky June 2009 M. Salomidi Kaldera, Santorini Isl. I-3m Rocky August 2009 M. Salomidi Kaldera, Santorini Isl. I-3m Rocky August 2009 K. Tsiamis	taxiformis	*Vourlias, Argolikos Gulf	1m	epiphyte	January 2009	K. Tsiamis
phace found Koroni port Pilos Port Porto Coufo, Sithonia Gerolimenas, Messiniakos Gulf Near Pyrgi, Chios Isl. Kimolos Isl., port Agia Paraskevi, Skiathos Isl. Moudros bay, Limnos Isl. Moudros bay, Limnos Isl. Caulerpa racemosa var. cylindracea Koroni port Porto Coufo, Sithonia Porto Coufo, June 2009 Porto Coufo, Sithonia Porto Coufo, Sithonia Porto Coufo, June 2009 Porto Coufo, Sithonia Porto Coufo, June 2009 Porto Coufo, Sithonia Porto Coufo, June 2009 Porto Coufo, June 2009 Porto Coufo, Porto	* = only the	Nauplio port, Argolikos Gulf	1m	rocky	February 2009	K. Tsiamis
Pilos Port	tetrasporophytic	*Skala Kydonion, Lesvos Isl.	1m	epiphyte	March 2009	K. Tsiamis
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Karpathos Isl., port 1m rocky August 2006 A. Zenetos Agia Paraskevi, Skiathos Isl. 1m rocky August 2006 K. Tsiamis Korthi, Andros Isl. 1m epiphyte June 2008 K. Tsiamis Moudros bay, Limnos Isl. 1m rocky August 2008 S. Orfanidis Poros, Leukada Isl. 1m rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Parga port 1m rocky October 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis Skala Kydonion, Lesvos Isl. 1-3m rocky March 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Gyaros Isl. 1-15m rocky June 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky August 2009 K. Tsiamis			2m	rocky	August 2009	S. Katsanevakis
Agia Paraskevi, Skiathos Isl. 1m rocky August 2006 K. Tsiamis Korthi, Andros Isl. 1m epiphyte June 2008 K. Tsiamis Moudros bay, Limnos Isl. 1m rocky August 2008 S. Orfanidis Poros, Leukada Isl. 1m rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Parga port 1m rocky October 2008 K. Tsiamis Parga port 1m rocky November 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis racemosa var. Skala Kydonion, Lesvos Isl. 1-3m rocky March 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky August 2009 K. Tsiamis		Kimolos Isl., port	1m	rocky	July 2006	M. Salomidi
Korthi, Andros Isl. 1m epiphyte June 2008 K. Tsiamis Moudros bay, Limnos Isl. 1m rocky August 2008 S. Orfanidis Poros, Leukada Isl. 1m rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Parga port 1m rocky October 2008 K. Tsiamis Parga port 1m rocky November 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis racemosa var. Skala Kydonion, Lesvos Isl. 1-3m rocky March 2009 K. Tsiamis Cylindracea Aliveri, Evoikos Gulf 1m rocky June 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Gyaros Isl. 1-15m rocky July 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky August 2009 K. Tsiamis			1m	rocky	August 2006	A. Zenetos
Moudros bay, Limnos Isl. 1m rocky August 2008 S. Orfanidis Poros, Leukada Isl. 1m rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Parga port 1m rocky October 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis Skala Kydonion, Lesvos Isl. 1-3m rocky March 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Gyaros Isl. 1-15m rocky June 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky August 2009 K. Tsiamis		Agia Paraskevi, Skiathos Isl.	1m	rocky	August 2006	K. Tsiamis
Poros, Leukada Isl. 1m rocky August 2008 K. Tsiamis Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis Parga port 1m rocky October 2008 K. Tsiamis Sxoinias, Attiki 1-15m rocky November 2008 K. Tsiamis Skala Kydonion, Lesvos Isl. 1-3m rocky March 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Gyaros Isl. 1-15m rocky July 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky August 2009 K. Tsiamis		Korthi, Andros Isl.	1m	epiphyte	June 2008	K. Tsiamis
Nies, Pagasitikos Gulf 2m sandy/rocky September 2008 K. Tsiamis		Moudros bay, Limnos Isl.	1m	rocky	August 2008	S. Orfanidis
CaulerpaParga port1mrockyOctober 2008K. TsiamisSxoinias, Attiki1-15mrockyNovember 2008K. Tsiamisracemosa var.Skala Kydonion, Lesvos Isl.1-3mrockyMarch 2009K. TsiamiscylindraceaAliveri, Evoikos Gulf1mrockyJune 2009K. TsiamisTristinika, Sithonia1mrockyJune 2009K. TsiamisGyaros Isl.1-15mrockyJuly 2009M. SalomidiKaldera, Santorini Isl.1-3mRocky /August 2009K. Tsiamis		Poros, Leukada Isl.	1m	rocky	August 2008	K. Tsiamis
Caulerpa racemosa var.Sxoinias, Attiki1-15m rockyNovember 2008 November 2008 March 2009 March 2009 M. TsiamiscylindraceaAliveri, Evoikos Gulf Tristinika, Sithonia1m rocky 1m rockyJune 2009 June 2009 June 2009 M. TsiamisGyaros Isl.1-15m rockyJuly 2009 July 2009 M. Salomidi Kaldera, Santorini Isl.1-3m Rocky / August 2009August 2009 K. Tsiamis		Nies, Pagasitikos Gulf	2m	sandy/rocky	September 2008	K. Tsiamis
racemosa var.Skala Kydonion, Lesvos Isl.1-3mrockyMarch 2009K. TsiamisCylindraceaAliveri, Evoikos Gulf1mrockyJune 2009K. TsiamisTristinika, Sithonia1mrockyJune 2009K. TsiamisGyaros Isl.1-15mrockyJuly 2009M. SalomidiKaldera, Santorini Isl.1-3mRocky /August 2009K. Tsiamis		Parga port	1m	rocky	October 2008	K. Tsiamis
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Tristinika, Sithonia 1m rocky June 2009 K. Tsiamis Gyaros Isl. 1-15m rocky July 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky / August 2009 K. Tsiamis	racemosa var.	Skala Kydonion, Lesvos Isl.	1-3m	rocky	March 2009	K. Tsiamis
Gyaros Isl. 1-15m rocky July 2009 M. Salomidi Kaldera, Santorini Isl. 1-3m Rocky / August 2009 K. Tsiamis	cylindracea	Aliveri, Evoikos Gulf	1m	rocky	June 2009	K. Tsiamis
Kaldera, Santorini Isl. 1-3m Rocky / August 2009 K. Tsiamis		Tristinika, Sithonia	1m	rocky	June 2009	K. Tsiamis
		Gyaros Isl.	1-15m	rocky	July 2009	M. Salomidi
aninhuta		Kaldera, Santorini Isl.	1-3m	Rocky /	August 2009	K. Tsiamis
epipiiyte				epiphyte		
Rinia, Dilos Isl., 1-15m rocky August 2009 S. Katsaneva		Rinia, Dilos Isl.,	1-15m	rocky	August 2009	S. Katsanevakis
		Tragonisi, Mikonos Isl.			August 2009	S. Katsanevakis
Aspro & Stroggili, Syros Isl. 1-15m rocky August 2009 S. Katsaneva		Aspro & Stroggili, Syros Isl.	1-15m	rocky	August 2009	S. Katsanevakis
		Tinos Isl., south coasts			August 2009	S. Katsanevakis

(continued)

Table 3 (continued)

Taxon	Location	Depth	Substrate	Date	Collector
Caulerpa	Sapienza Isl., Messiniakos Gulf	50m	rocky	April 2009	K. Tsiamis
racemosa var.	Ladiko, Rhodes Isl.	2-3m	rocky	July 2009	K. Tsiamis
lamourouxii					
Codium fragile	Glyfada, Saronikos Gulf	0,5m	rocky	July 2009	K. Tsiamis
subsp. fragile					
	Apollakia, Rhodes Isl.	1m	rocky	June 1994	P. Panayotidis
Colpomenia	Andros Isl., port	1m	rocky	June 2008	K. Tsiamis
peregrina	Aliveri, Evoikos Gulf	1m	epiphyte	June 2009	K. Tsiamis
	Vouliagmeni, Saronikos Gulf	0,2m	rocky	August 2009	K. Tsiamis
Halophila	Aliveri, Evoikos Gulf	3m	sandy	June 2009	K. Tsiamis
stipulacea	Elinta, Chios Isl.	5m	sandy	August 2009	S. Katsanevakis
Hypnea cornuta	Agios Kosmas, Saronikos Gulf	0,2m	epiphyte	June 2007	K. Tsiamis
Пуриси согнии	Agios Kosmas, Saronikos Gulf	0,2m	sandy	August 2009	K. Tsiamis
Hypnea spinella	Agios Kosmas, Saronikos Gulf	0,5m	epiphyte	June 2006	K. Tsiamis
Hypnea spineua	Selonda, Epidauros Gulf	0,5m	epiphyte	January 2009	K. Tsiamis
	Tsigrado, Milos Isl.	1m	rocky	July 2007	K. Tsiamis
Lophocladia	Koukouras, Messiniakos Gulf	1m	rocky	July 2008	K. Tsiamis
lallemandii	Naxos Isl., port	1m	rocky	October 2008	V. Roussis
	Istron, Crete Isl.	1m	rocky	October 2008	V. Roussis
	Red beach, Santorini	1m	rocky	August 2009	K. Tsiamis
Sarconema	Agios Kosmas, Saronikos Gulf	0,2m	rocky-sandy	September 2008	K. Tsiamis
scinaioides					
	Korthi, Andros Isl.	2m	rocky	June 2008	K. Tsiamis
	Istron, Crete Isl.	1m	rocky	September 2008	V. Roussis
	Aigina Isl., Saronikos Gulf	1-26m	rocky	1	M. Salomidi
	Vourlias, Argolikos Gulf	1m	rocky	January 2009	K. Tsiamis
Stypopodium	Glaronisi, Gyaros Isl.	1-15m	rocky	July 2009	M. Salomidi
schimperi	Legraina, Attiki	2-5m	rocky	July 2009	K. Tsiamis
Serial Perio	Thirasia, Santorini Isl.	0,5m	rocky	August 2009	K. Tsiamis
	Chios Isl., west coasts	0-10m	rocky	August 2009	S. Katsanevakis
	Rinia Isl, Cyclades	0-15m	rocky	August 2009	S. Katsanevakis
	Tragonisi, Mikonos Isl.	0-15m	rocky	August 2009	S. Katsanevakis
	Aspro & Stroggili, Syros Isl.	0-15m	rocky	August 2009	S. Katsanevakis
Womersleyella	Rhodes Port, Rhodes Isl.	1m	epiphyte	January 2006	K. Tsiamis
setacea					

New entries and putative additions

Anotrichium okamurae Baldock?
In 1939, the Mediterranean range of

Anotrichium furcellatum J. Agardh, a species described from Amalfi in Naples (AGARDH, 1842, as *Griffithsia furcellata*), seemed to be expanding so rapidly that FELDMANN-

MAZOYER & MESLIN (1939) queried whether the species now present was really the one described by J. Agardh. The scenario of expansion of this species in the Mediterranean Sea resembles that of Asparagopsis taxiformis and Caulerpa racemosa. In the present case two taxa have probably been confused under the name of A. furcellatum: the native taxon described from Naples and a species (A. okamurae) originally described from Japan, probably introduced from the Pacific at an unknown time and exhibiting an invasive behaviour (A. okamurae originally described from Japan; OKAMURA 1934, as Monospora tenuis) (VERLAQUE et al., in press). In Greece, where A. furcellatum was frequently recorded in the Ionian and Aegean Seas, three hypotheses have to be considered: either we have the native taxon, or the introduced species, or both taxa. Pending new information, the Greek records of A. furcellatum are provisionally attributed to A. okamurae ? as a debatable case (Table 2).

<u>Chondria pygmaea</u> Garbary & Vandermeulen (not yet observed but presence highly probable)

GARBARY & VANDERMEULEN (1990) first described Chondria pygmaea from Eilat in the Red Sea as an epiphyte on the seagrass Halophila stipulacea (Forsskål) Ascherson. In the Mediterranean Sea, C. pygmaea was found among the epiflora of the introduced H. stipulacea each time it was studied (CORMACI et al., 1992; ALONGI et al., 1993; KASHTA & PIZZUTO, 1995; RINDI et al., 1999). Considering the wide distribution of the introduced seagrass in Greece (Fig. 1), the occurrence of C. pvgmaea in this region is highly probable. Pending confirmation by observation, we provisionally range C. pygmaea in the debatable category (Table 2).

Neosiphonia harveyi (J. Bailey) M.-S. Kim, H.-G. Choi, Guiry & G.W. Saunders

This species was first described as Polysiphonia harveyi from the NW Atlantic (USA, Connecticut, BAILEY, 1848). It is presently considered to be widespread in the world, and is regarded as introduced in the Atlantic Ocean and the Mediterranean Sea (MAGGS & STEGENGA, 1999; CHOI et al., 2001; VERLAQUE et al., in press). Based on an analysis of rbcL sequences, MCIVOR et al. (2001) concluded that Japan is its native region. In the Mediterranean Sea, Neosiphonia harveyi is more common in the western basin than in the eastern basin. In Greece, the species has been reported only once from the Gulf of Thessaloniki (C. MAGGS, pers. com. in VERLAQUE et al., in press) (Table 1, casual category).

Revised species, now considered as debatable

There are three species, originally considered as casuals (TSIAMIS *et al.*, 2008), which have been revised and now considered as debatable:

Hypnea valentiae (Turner) Montagne

Hypnea valentiae has been originally described from the Red Sea (TURNER, 1809, as Fucus valentiae). Its introduction into the Mediterranean Sea was unequivocally identified for the first time in 1996 in France (Thau Lagoon), and successively in Italy (Venice and Mar Piccolo di Taranto) (VERLAQUE et al., in press). In Greece, H. valentiae was first recorded in 1894 from Rhodes Island (REINBOLD, 1898), but it turned out to be a misidentification of *H. cornuta* (Kützing) J. Agardh. More specifically, REINBOLD (1898) wrote: 'Die exemplare zeigten die für diese art characteristischen spinulae stellulaeformes.', that is: 'The specimens bear the characteristic stellate spines of the species'. Such stellate spines, which never occur in *H. valentiae*, are typical of *H. cornuta*. However, there are several other records of *H. valentiae* from Greece (BOGDANOS & DIAPOULIS, 1984; DIAPOULIS & HARITONIDIS, 1987), but in the absence of detailed specimen descriptions and the complex taxonomy of the genus we cannot consider these data as sufficient to establish the presence of *H. valentiae* in Greece. Therefore, pending new observations, we consider *H. valentiae* as debatable in Greece.

Padina boryana Thivy

The records of this species from Amorgos, Attica and Crete in Greece (see NIZAMUDDIN, 1981, as *Padina tenuis* Bory de Saint-Vincent) remain unconfirmed. Pending new observations, the occurrence of *P. boryana* in Greece should be considered as debatable.

Pylaiella littoralis (Linnaeus) Kjellman

There are only two records of this alga in Greece: one in the Aegean Sea (ANAGNOSTIDIS, 1968, with reservation), which probably corresponds to a misidentification of an *Ectocarpus* species (A. ATHANASIADIS, pers. com.), and one in the Ionian Sea (SCHNETTER & SCHNETTER, 1981). Moreover, according to VERLAQUE *et al.* (in press) several populations of this species could be native in the Mediterranean Sea. Therefore, pending new observations in Greece, *P. littoralis* should be considered as debatable.

Excluded species

Chorda filum (Linnaeus) Stackhouse

According to GERLOFF & GEISSLER (1974) and ATHANASIADIS (1987), the single record of *Chorda filum* from Lesvos

Island in the N. Aegean Sea (CANDARGY, 1899) is probably based on a misidentification. We agree with their remark.

Neosiphonia sphaerocarpa (Børgesen) M.S. Kim et I.K. Lee

Originally described from St. Thomas (Virgin Islands) in the Caribbean Sea (BØRGESEN, 1918, as Polysiphonia sphaerocarpa) and presently distributed worldwide in warm seas, Neosiphonia sphaerocarpa was first recorded in the Mediterranean Sea in 1970 from Tunisia (BEN ALAYA, 1970, misspelled P. sphaerocaspa), and successively in Corsica (VERLAQUE, 1989, as P. sphaerocarpa), the Balearic Islands (BALLE-STEROS, 1992), and Milos Island in Greece (LAZARIDOU, 1994). CORMACI et al. (2004) considered N. sphaerocarpa to be introduced. However, the species is distributed worldwide and molecular data are needed to locate its place of origin. Moreover, the identification of the species is not easy. Consequently the absence of N. sphaerocarpa in the Mediterranean prior to 1970 could simply mean that it was overlooked or mistaken for another *Polysiphonia* species. Pending further investigations, we provisionally consider this species as native in the Mediterranean Sea.

Discussion

Distribution and dynamics

Since TSIAMIS et al. (2008), a large expansion has been observed for most established alien species, reaching 68 new distribution records on various Greek coasts (Table 3). The most rapid and broadest expansion was observed for Asparagopsis taxiformis, a red alga with an heteromorphic diplohaplontic life cycle, including a gametophytic and a tetrasporophytic phase,

the latter known as 'Falkenbergia' phase. A. taxiformis was found recently in Greece (TSIAMIS & PANAYOTIDIS, 2007), but since then it has exhibited rapid spread, especially in the South Aegean Sea. It is often found on shallow rocky bottoms, through low to high abundance. As far as its origin is concerned, at least two cryptic taxa of different origin (Atlantic and Indo-pacific origin) coexist under the name of A. taxiformis in the Mediterranean Sea (ANDREAKIS et al., 2004, 2007; NÍ CHUALÁIN et al., 2004). On the basis of their low survival rates in winter temperatures the Greek populations probably belong to the invasive Indo-Pacific strain (BARDAMASKOS et al., 2008). The sister species, A. armata, may have a broader distribution in Greece, but as the majority of Greek records refer to the Falkenbergia phase, which is nearly indistinguishable from the Falkenbergia phase of A. taxiformis (NÍ CHUALÁIN et al., 2004), these records could actually either correspond to A. taxiformis or A. armata.

Caulerpa racemosa var. cylindracea is by far the most common alien marine macrophyte in Greece, presenting an extensive spread along the majority of the Greek coasts. This warm-temperate Caulerpa, originating from SW Australia (VERLAQUE et al., 2003), can be found in various types of bottom, from surface down to a depth of 40 m, in both polluted and pristine sites. It often exhibits high abundances near ports and fishing harbors. Conversely, the sister taxon C. racemosa var. lamourouxii f. requienii has a very restricted distribution, found only four times in Greece. Its distribution requires further consideration since this taxon can be easily confused with C. racemosa var. cylindracea. Its discovery in the Ionian Sea represents the westernmost distribution record in the Mediterranean Sea, revealing a possible recent westward expansion of the taxon during recent years.

Populations of Codium fragile subsp. fragile, originating from the N. Pacific Ocean (CARLTON & SCANLON, 1985), are relatively restricted in Greece, found only at specific sites but usually in high abundance. Most sites where it is observed are located near ports and polluted environments. It can be found on shallow rocky bottoms. The Indo-Pacific brown alga Colpomenia peregrina is known in Greece only through very few local records, although its distribution could be wider since it can be easily confused with the native species C. sinuosa (Mertens ex Roth) Derbès & Solier. The pantropical red alga Hypnea spinella also exhibits a restricted distribution with very low abundance, found usually near ports as an epiphyte on other macrophytes. Moreover, the Lessepsian immigrant Hypnea cornuta is very rare in Greece, found only twice in the Aegean Sea: in 1894 in Rhodes Isl. (Reinbold 1898, as H. valentiae) and after about one century (in 2007) in the Saronikos Gulf by the authors.

The Lessepsian seagrass Halophila stipulacea shows a wide distribution in Greece. however, it is absent from the far N. Aegean Sea, probably because of the lower seawater temperature. It can be found on sandy bottoms at various depths, usually with the native seagrass Cymodocea nodosa (Ucria) Ascherson. Occasionally, it can be abundant. The Lessepsian red alga Lophocladia lallemandii, has spread extensively during recent years in Greece, mainly in the S. Aegean Sea. It is usually found as an epiphyte during summer, especially at a depth of several meters. Similarly, Stypopodium schimperi, another Lessepsian immigrant, has exhibited a rapid expansion in the Aegean Sea recent years (see also KATSANEVAKIS & TSIAMIS, in press),

revealing a gradual immigration from the Levantive Sea towards the Western Mediterranean basin. It grows on rocky bottoms, from surface to several meters depth.

Although it had been found in Greece only once (SCHNETTER & SCHNETTER, 1981) up till now, the red alga *Antithamnionella elegans* was detected three times during the last year: once in the Ionian Sea and twice in the Aegean Sea, all cases sterile and near shipping traffic, reflecting a possible spread of the species during recent years by vegetative propagation. In addition, the Lessepsian red alga *Sarconema scinaioides*, which was reported from Greece only in the Saronikos Gulf in the early 1980's (DIAPOULIS *et al.*, 1985), was re-found at

the same location after about 30 years, in 2008 (see also TSIAMIS *et al.*, 2009); thus, revealing an established population in the area which still survives after 3 decades. Finally, the Indo-Pacific red alga *Womersleyella setacea*, found in various locations in both the Aegean and the Ionian Seas, seems to have been stable in Greece since 2007. The taxon is usually found at a depth of several meters.

In total, all established alien macrophytes (14 taxa) have been found in the S. Aegean Sea, most of them being present in the Saronikos Gulf. Similarly, most records of established alien species come from the South Aegean Sea, while the fewest come from the North Aegean Sea (Fig. 3). These findings

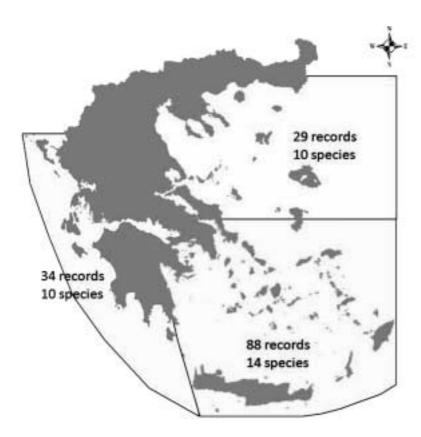


Fig. 3: Records of established alien marine macrophytes in Greece until 2009.

reflect (i) the more extensive surveys on alien marine macrophytes in the S. Aegean Sea (the Saronikos Gulf, Rhodes Island); (ii) the role of Piraeus port, which is the largest port in Greece, as a major site for introduction via shipping; and (iii) the role of the South Aegean Sea as migration route for the Lessepsian species coming from the Levantine coast (see also PANCUCCI-PAPADOPOULOU *et al.*, 2005).

Finally, we note an interesting increase in established species, from 9 taxa in 2008 (TSIAMIS et al., 2008) to 14 taxa in 2009. This is because of new records and findings, leading to the inclusion of originally casual (Caulerpa racemosa var. lamourouxii f. requienii, Hypnea cornuta, Sarconema scinaioides) and debatable species (Antithamnionella elegans, Asparagopsis taxiformis) in the established category. Thus, established alien marine macrophytes in Greece exhibit higher abundance than originally thought.

Impact on benthic assemblages

The direct impact has not been documented yet for any alien marine macrophyte in Greece. However, there are several cases where losses of biodiversity and alterations of communities are evident, especially in the case of the invasive alien taxa. In such cases there is displacement of the native flora and monopolization of substrates by the alien invaders. Caulerpa racemosa var. cylindracea often exhibits such behavior, especially in stressed ecosystems, as well as in rather deep sandy bottoms. Codium fragile subsp. fragile and Asparagopsis taxiformis display invasive behavior exclusively in cases of ports and harbors, where nitrophilous Chlorobionta, such as Ulva spp., also thrive. This supports the view that invasive species are favored in ecosystems already disturbed by human activities (OCCHIPINTI-AMBROGI & SAVINI, 2003; DUNSTAN & JOHNSON, 2007; VALENTINE *et al.*, 2007).

An invasive behavior was also observed for *Womersleyella setacea*, but only once, in the N. Aegean Sea in the middle 1990's (ATHANASIADIS, 1997); however, similar cases could have been overlooked due to its rather deep habitat. In addition, there are also indications of invasive behavior of the seagrass *Halophila stipulacea* on sandy bottoms due to its high abundances; however, no displacement of native species due to *H. stipulacea* has hitherto been reported in the Mediterranean Sea.

Finally, invasive behavior of the brown alga *Stypopodium schimperi* is known along the Levantine coasts (BOUDOURESQUE & VERLAQUE, 2002), although such behavior was not observed for any Greek site, at least not until July 2009, when extremely high abundances and occasionally monopolization of the substrate were detected in Rhodes Island.

Until now, in Greece, there is not any scientific proof of a negative impact of the invasive marine macrophytes on human activities, such as fisheries and tourism, although a few local cases have been reported where fishermen blamed invasive species, such as *Codium fragile* subsp. *fragile*, for the reduction of fish abundance.

Conclusion

In conclusion, there are at least 14 alien marine macrophytes that are established in Greece. Most of them are still in progress along the Greek coasts, and further expansion, as well as new introductions, can be expected in the near future. Taking into account that the arrival of invasive alien species has brought about severe changes in the marine communities in other parts of the

Mediterranean Sea (BOUDOURESQUE & VERLAQUE, 2002; SCHAFFELKE & HEWITT, 2007), the spread of these aliens along the Greek coasts, especially from the South Aegean Sea towards both the Ionian and the North Aegean Sea, should be monitored. Moreover, more knowledge about their biology, ecology and impact on the native communities would be helpful to elucidate more aspects of alien introductions.

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References

- AGARDH, J.G., 1842. *Algae maris Mediterranei et Adriatici, observationes in diagnosin specierum et dispositionem generum.* Paris: Fortin, Masson et Cie, X + 164 pp.
- ALONGI, G., CORMACI, M. & PIZZUTO, F., 1993. La macroflora epifita delle foglie di *Halophila stipulacea* (Forssk.) Aschers. del Porto di Catania. *Biologia Marina Mediterranea, Suplemento al Notiziario SIBM*, 1: 287-288.
- ANAGNOSTIDIS, K., 1968. *Untersuchungen über die Salz- und Süβwasser- Thiobioconosen (Sulpuretum) Griechenlands.*PhD thesis, Aristotle University of Thessaloniki, Thessaloniki, Greece, 457 pp.

- ANDREAKIS, N., PROCACCINI, G. & KOOISTRA, W., 2004. Asparagopsis taxiformis and Asparagopsis armata (Bonnemaisoniales, Rhodophyta): genetic and morphological identification of Mediterranean populations. European Journal of Phycology, 39: 273-283.
- ANDREAKIS, N., PROCACCINI, G., MAGGS, C. & KOOISTRA, W.H.C.F., 2007. Phylogeography of the invasive seaweed *Asparagopsis* (Bonnemaisoniales, Rhodophyta) reveals cryptic diversity. *Molecular Ecology*, 16 (11): 2285-2299.
- ATHANASIADIS, A., 1987. A survey of the seaweeds of the Aegean Sea with taxonomic studies on species of the tribe Antithamniae (Rhodophyta). PhD thesis, University of Göterbog, Göterbog, Sweden, 174 pp.
- ATHANASIADIS, A., 1997. North Aegean Marine Algae IV. *Womersleyella setacea* (Hollenberg) R.E. Norris (Rhodophyta, Ceramiales). *Botanica Marina*, 40 (1-6): 473-476.
- BAILEY, J.W., 1848. Continuation of the list of localities of algae in the United States. *American Journal of Sciences*, Series 2, 6: 37-42.
- BALLESTEROS, E., 1992. Contribució al coneixement algológic de la Mediterrània Espanyola. IX. Espècies interessants de les Illes Balears. *Folia Botanica Miscelanea*, 8: 77-102.
- BARDAMASKOS, G., TSIAMIS, K., PANAYOTIDIS, P. & MEGALO-FONOU, P., 2008. New records and range expansion of alien fishes and macroalgae in Greek waters (SE Ionian Sea). *JMBA2 - Biodiversity Records*, 2: 1-9.
- BEN ALAYA, H., 1970. Flore marine de Tunisie. I. Liste préliminaire des algues du golfe de Tunis. *Bulletin de l'Institut National Scientifique et Technique*

- d'Océanographie et de la Pêche de Salammbô, 1 (4) : 205-212.
- BOGDANOS, K. & DIAPOULIS, A., 1984. Contribution to the study of zoobenthos and phytobenthos of Mesologhi lagoon. *Thalassographica*, 7: 39-52.
- BØRGESEN, F., 1918. The marine algae of the Danish West Indies. Part 3. Rhodophyceae (4). *Dansk Botanisk Arkiv*, 3: 241-304.
- BOUDOURESQUE, C.-F. & VERLAQUE, M., 2002. Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. *Marine Pollution Bulletin*, 44 (1): 32-38.
- BOUDOURESQUE, C.F. & VERLAQUE, M., 2005. Nature conservation, Marine Protected Areas, sustainable development and the flow of invasive species to the Mediterranean Sea. *Travaux scientifiques du Parc national de Port-Cros*, 21: 29-54.
- CANDARGY, P.C., 1899. La végétation marine de l'île de Lesbos (Mytilène). Ph. D. Thesis, University of Paris.
- CARLTON, J.T., 2000. Global change and biological invasions in the oceans. p. 31-53. In: *Invasive Species in a Changing World*, H.A. Mooney & R.J. Hobbs (eds), Island Press, Washington.
- CARLTON, J.T., 2002. Bioinvasion ecology: Assessing invasion impact and scale. p. 7-19. In: *Invasive Aquatic Species of Europe. Distribution, Impacts and Management*, E. Leppäkoski, S. Gollasch & S. Olenin (eds), Kluwer Academic Publishers, Dordrecht.
- CARLTON, J.T. & SCANLON, J.A., 1985. Progression and dispersal of introduced alga: *Codium fragile* ssp. *tomentosoides* (Chlorophyta) on the Atlantic coast of North America. *Botanica Marina*, 28 (4): 155-165.
- CHOI, H.-G., KIM, M.-S., GUIRY, M.D.

- & SAUNDERS, G.W., 2001. Phylogenetic relationships of *Polysiphonia* (Rhodomelaceae, Rhodophyta) and its relatives based on anatomical and nuclear small-subunit rDNA sequence data. *Canadian Journal of Botany*, 79 (12): 1465-1476.
- CORMACI, M., FURNARI, G., ALONGI, G., DINARO, R. & PIZZUTO, F., 1992. On the occurrence in Sicily of three Florideophyceae new to the Mediterranean Sea. *Botanica Marina*, 35 (5): 447-449.
- CORMACI, M., FURNARI, G., GIACCONE, G. & SERIO, D., 2004. Alien Macrophytes in the Mediterranean Sea: A review. Recent Research Developments in Environmental Biology, India, 1: 153-202.
- CORSINI-FOKA, M. & ECONOMIDIS, P.S., 2007. Allochthonous and vagrant ichthyofauna in Hellenic marine and estuarine waters. *Mediterranean Marine Science*, 8 (1): 67-89.
- DIAPOULIS, A. & HARITONIDIS, S., 1987. Marine algae of the west Greek coasts. *Acta Adriatica*, 28: 85-101.
- DIAPOULIS, A., VERLAQUE, M., HUVE, P. & BOUDOURESQUE, C.F., 1985. Sur la présence du genre *Sarconema* (Solieraceae, Rhodophyta) en Grèce. *Vie Milieu*, 35 (1): 57-59.
- DUNSTAN, P.K. & JOHNSON, C.R., 2007. Mechanisms of invasions: can the recipient community influence invasion rates? *Botanica Marina*, 50 (5-6): 361–372.
- FELDMANN-MAZOYER, G. & MESLIN, R., 1939. Note sur le *Neomonospora furcellata* (J. Ag.) comb. nov. et sa naturalisation dans la Manche. *Revue Générale de Botanique*, 51: 193-203.
- GALIL, B.S., 2008. Alien species in the Mediterranean Sea—which, when, where, why? *Hydrobiologia*, 606 (1): 105-116.

- GALIL, B.S., 2009. Tacking stock: inventory of alien species in the Mediterranean Sea. *Biological Invasions*, 11 (2): 359-372.
- GARBARY, D.J. & VANDERMEULEN, H., 1990. *Chondria pygmaea* sp. nov. (Rhodomelaceae, Rhodophyta) from the Gulf of Aqaba ('Aquaba'), Red Sea. *Botanica Marina*, 33 (4): 311-318.
- GERLOFF, J. & GEISSLER, U., 1974. Eine revidierte Liste der Meeresalgen Griechenlands. *Nova Hedwigia*, 22: 721-793.
- HEWITT, C.L., CAMPBELL, M.L. & SCHAFFELKE, B., 2007. Introductions of seaweeds: accidental transfer pathways and mechanisms. *Botanica Marina*, 50 (5-6): 326–337.
- KASHTA, L. & PIZZUTO, F., 1995. Sulla presenza di *Halophila stipulacea* (Forsskål) Ascherson (Hydrocharitales, Hydrocharitaceae) nelle coste dell'Albania. *Bollettino delle sedute dell'Accademia Gioenia di Scienze Naturali, Catania*, 28 (349): 161-166.
- KATSANEVAKIS, S. & TSIAMIS, K., (in press). Records of alien marine species in the shallow coastal waters of Chios Island (2009). Mediterranean Marine Science, 10 (2): 99-107.
- KLEIN, J. & VERLAQUE, M., 2008. The *Caulerpa racemosa* invasion: A critical review. *Marine Pollution Bulletin*, 56 (2): 205-225.
- LAZARIDOU, E.S., 1994. Systematics, bionomy and ecological study of the marine phytobenthos of the Milos Island (Cyclades). PhD Thesis, Thessaloniki University, Thessaloniki, Greece, 297 pp.
- MAGGS, C.A. & STEGENGA, H., 1999. Red algal exotics on North Sea coasts. *Helgoländer Meeresuntersuchungen*, 52: 243-258.
- MCIVOR, L., MAGGS, C.A., PROVAN, J. & STANHOPE, M.J., 2001. *rbc*L sequences reveal multiple cryptic in-

- troductions of the Japanese red alga *Polysiphonia harveyi. Molecular Ecology*, 10 (4): 911-919.
- MINEUR, F., BELSHER, T., JOHNSON, M.P., MAGGS, C.A. & VERLAQUE, M., 2007. Experimental assessment of oyster transfers as a vector for macroalgal introductions. *Biological Conservation*, 137 (2): 237-247.
- NI CHUALÁIN, F., MAGGS, C.A., SAUNDERS, G.W. & GUIRY, M.D., 2004. The invasive genus *Asparagopsis* (Bonnemaisoniaceae, Rhodophyta): molecular systematics, morphology and ecophysiology of *Falkenbergia* isolates. *Journal of Phycology*, 40 (6): 1112-1126.
- NIZAMUDDIN, M., 1981. Contribution to the marine algae of Libya. Dictyotales. *Bibliotheca Phycologica*, 54: 1-122.
- OCCHIPINTI-AMBROGI, A & SAVINI, D., 2003. Biological invasions as a component of global change in stressed marine ecosystems. *Marine Pollution Bulletin*, 46 (5): 542-551.
- OKAMURA, K., 1934. *Icones of Japanese algae*. Vol. 7 pp. 19-48 (English), 17-44 (Japanese), Plates CCCXI-CCCXXV. Tokyo.
- PANCUCCI-PAPADOPOULOU, M.A., ZENETOS, A., CORSINI-FOKA, M.A. & POLITOU, C.Y., 2005. Update of marine aliens in Hellenic waters. *Mediter*ranean Marine Science, 6 (2): 147-158.
- REINBOLD, T., 1898. Meeresalgen von der Insel Rhodos. *Hedwigia*, 37: 87-90.
- RINDI, F., MALTAGLIATI, F., ROSSI, F., ACUNTO, S. & CINELLI, F., 1999. Algal flora associated to a *Halophila stipulacea* (Forssk.) Aschers. (Hydrocharitaceae) stand in Western Mediterranean. *Oceanologica Acta*, 22 (4): 421-429.
- SCHAFFELKE, B. & HEWITT, C.L., 2007. Impacts of introduced seaweeds. *Botanica Marina*, 50 (5-6): 397-417.

- SCHAFFELKE, B., SMITH, J.E. & HEWITT, C.L., 2006. Introduced macroalgae a growing concern. *Journal of Applied Phycology*, 18 (3-5): 529-541.
- SCHMITZ, D.C. & SIMBERLOFF, D., 1997. Biological invasions: a growing threat. *Issues in Science and Technology*, 13 (4): 33-40.
- SCHNETTER, R. & SCHNETTER, M.L., 1981. Marine Benthosalgen von Kephalinia (Jonische Inseln). *Bibliotheca Phycologica*, 51: 111-152.
- SKOUFAS, G. & TSIRIKA, A., 2003. Preliminary results of the epibiotic flora on *Eunicella singularis* (Gorgonacea) colonies from the north Aegean Sea. p. 244. In: *Proceedings of the Second Mediterranean Symposium on Marine Vegetation*, Athens, December 2003.
- STREFTARIS, N., ZENETOS, A. & PAPATHANASIOU, E., 2005. Globalisation in marine ecosystems: the story of non-indigenous marine species across European seas. *Oceanography and Marine Biology: An Annual Review*, 43: 419-453.
- THIBAUT, T. & MEINESZ A., 2004. Cauler-pa taxifolia: 18 years of infestation in the Mediterranean Sea. pp.287-298. In: Aquatics Invasions in the Black, Caspian, and Mediterranean Seas, edited by H. Dumont, T.A. Shiganova, U. Niermann, The Netherlands, Kluwer Academic Publishers.
- TSIAMIS, K. & PANAYOTIDIS, P., 2007. First record of *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon (Rhodophyta: Florideophyceae: Bonnemaisoniales: Bonnemaisoniaceae) in Greece. *Aquatic Invasions*, 2 (4): 435-438.
- TSIAMIS, K., PANAYOTIDIS, P. & ZENETOS, A., 2008. Alien marine macrophytes in Greece: a review. *Botanica Marina*, 51 (4): 237-246.

- TSIAMIS, K., DIAPOULIS, A. & PANAYOTIDIS, P., 2009. On the enigmatic occurrence of the alien alga *Sarconema scinaioides* Børgesen (Gigartinales, Rhodophyta) in the Mediterranean Sea. *Phycologia*, 48 (Suppl.): 26.
- TURNER, D., 1809. Fuci sive plantarum fucorum generi a botanicis ascriptarum icones descriptiones et historia. Fuci, or coloured figures and descriptions of the plants referrred by botanists to the genus Fucus. Vol. 2. Arch, London, 162 pp.
- VALENTINE1, J.P., MAGIEROWSKI, R.H. & JOHNSON, C.R., 2007. Mechanisms of invasion: establishment, spread and persistence of introduced seaweed populations. *Botanica Marina*, 50 (5-6): 351-360.
- VERLAQUE, M., 1989. Contribution to the marine algal flora of the Mediterranean: rare or new species for the French coasts. *Botanica Marina*, 32 (2): 101-113.
- VERLAQUE, M., DURAND, C., HUISMAN, J.M., BOUDOURESQUE, C.F. & PARCO, Y., 2003. On the identity and origin of the Mediterranean invasive *Caulerpa racemosa* (Caulerpales, Chlorophyta). *European Journal of Phycology*, 38 (4): 325-339.
- VERLAQUE, M., RUITTON, S., MINEUR, F. & BOUDOURESQUE, C.F., 2007. CIESM atlas of exotic macrophytes in the Mediterranean Sea. Rapports de la Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee (Monaco), 38, p. 14.
- VERLAQUE, M., RUITTON, S., MINEUR, F. & BOUDOURESQUE, C.F. (in press). 4. Macrophytes. In: CIESM Atlas of Exotic Species in the Mediterranean, edited by F. Briand, CIESM Publishers, Monaco.
- WALLENTINUS, I., 2002. Introduced marine algae and vascular plants in Euro-

- pean aquatic environments. p. 27-52. In: *Invasive aquatic species of Europe. Distribution, impacts and management.* E. Leppäkoski, S. Gollash & S. Olenin (eds), Kluwer Academic Publishers, Dordrecht, The Netherlands.
- WALLENTINUS, I. & NYBERG, C.D., 2007. Introduced marine organisms as habitat modifiers. *Marine Pollution Bulletin*, 55 (7-9): 323-332.
- WILLIAMS, S.L. & SMITH, J.E., 2007. A global review of the distribution, taxonomy, and impacts of introduced seaweeds. *Annual Review of Ecology, Evolution and Systematics*, 38: 327-359.
- ZENETOS, A., KOUTSOUMBAS, D. & VARDALA-THEODOROU, E., 2005. Origin and vectors of introduction of exotic molluscs in Greek Waters. *Belgian Journal of Zoology*, 135 (Suppl. 1): 279-286.
- ZENETOS, A., MERIC, E., VERLAQUE, M., GALLI, P., BOUDOURESQUE, C.-F., GIANGRANDE, A., CINAR, M.E. & BILECENOGLU, M., 2008. Additions to the annotated list of marine alien biota in the Mediterranean with special emphasis on Foraminifera and Parasites. *Mediterranean Marine Science*, 9 (1): 119-164.