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New records and range expansion of alien fish and macroalgae in Greek waters (south-east Ionian Sea)

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*Three lessepsian fish immigrants—*Siganus luridus, Siganus rivulatus *and* Fistularia commersonii*—as well as two alien macroalgae—*Stypopodium schimperi *and* Asparagopsis taxiformis*—are reported for the first time from the Messiniakos Gulf (south-east Ionian Sea, Greece). Findings of* S. schimperi *and* A. taxiformis *correspond to their westernmost records from Greek waters. Direct field observations showed that* S. luridus *has established a permanent population, the first to be mentioned in the Ionian Sea taken as a whole. The results increase the total number of marine aliens of the studied area to 14 species, enhancing the assumption that the south-east Ionian Sea is a hot spot on the way of lessepsian species spreading to the west.*

Keywords: alien, fish, macroalgae, lessepsian, Ionian Sea, Mediterranean Sea

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INTRODUCTION

Introduction of alien species to new ecosystems is considered a major threat to ecosystem's biodiversity, structure and function (Courchamp *et al.*, 2003; Boudouresque, 2005). It is estimated that more than 790 alien species have been introduced into the Mediterranean Sea until today, most of which correspond to benthos and fish species (Zenetos *et al.*, 2007). The majority of these have an Indo-Pacific origin; more than 300 Indo-Pacific species of macrophytes, invertebrates and fish (Galil, 2000) have migrated from the Red Sea into the eastern Mediterranean Sea since the opening of the Suez Canal in 1869. This massive aquatic invasion was given the name of 'lessepsian migration' (Por, 1978). Marine biologists have justifiably focused on biology and ecology of alien species and their spreading across the Mediterranean coasts, considering the undisputed effects of their invasion on native marine communities and ecosystems as well as on catch composition in commercial fisheries (Goren & Galil, 2005; Harmelin-Vivien *et al.*, 2005).

In the Greek seas, a large increase of alien marine species introductions during the last years is observed for mollusca (Zenetos *et al.*, 2005), fish (Corsini-Foka & Economidis, 2007), macroalgae (Tsiamis *et al.*, 2008) and other marine biota (Pancucci-Papadopoulou *et al.*, 2005a). The increasing rate at which invasions are reported in Greece may result from a multiplicity of interactions, such as the intensive research on the marine biota and increased anthropogenic activities over the last years, e.g. aquaculture, international trade and tourism favour the unintentional introduction of aliens (Carlton, 1996). In addition, global warming and the tropicalization scenario (Occhipinti-Ambrogi, 2007) cannot be ruled out as contributing factors enhancing the opportunities for the introduction of exotic marine species. This phenomenon seems to accelerate the northward expansion and biomass increase of thermophilic species (meridionalization), including non-indigenous tropical and subtropical species (Bianchi & Morri, 2003). Marine alien species in Greek waters reached the number of 128 in 2005, with the highest number of species present in the south-east Aegean Sea (69), decreasing significantly to the north and to the west, so that only 30 aliens have been recorded from the Ionian Sea (Pancucci-Papadopoulou *et al.*, 2005b). Their restricted distribution in the Ionian Sea is probably due to lack of published information and the low shipping traffic in the region (Pancucci-Papadopoulou *et al.*, 2005a).

Taking into consideration that the Ionian Sea belongs to the same biogeographical area as the south Aegean Sea (Bianchi & Morri, 2000), the quest for new records of the spreading of alien species in the Greek seas logically turns to the west. The Messiniakos Gulf lies in the south-east Ionian Sea, so it is assumed to be a hot spot area, situated on the path of marine alien species' westwards expansion. Nevertheless, in this area recent studies have focused on alien zoobenthic species (Kambouroglou & Nikolaidou, 2006; Thessalou-Legaki *et al.*, 2006) but there is little information regarding phytobenthos (Tsirika *et al.*, 2003) and alien fishes (ELNAIS, 2008).

The aim of this paper is to contribute to the monitoring of alien species' range expansion in Greek waters, providing new records of fish and macroalgae and describing their current status along the coasts of the south-east Ionian Sea.

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MATERIALS AND METHODS

Description of the area

The Ionian Sea is an arm of the Mediterranean Sea, south of the Adriatic Sea. It is bounded by southern Italy, including Calabria, Sicily and the Salento Peninsula to the west and by south-western Albania and the west coasts of Greece to the east. The south-east Ionian Sea mainly includes the Messiniakos Gulf, which is considered as the link of the Aegean Sea to the Ionian Sea.

Sampling

Sampling of fish was done mostly by spear while free diving and complementary gillnets of 18, 22, 30 and 36 mm mesh size at landing, thanks to the cooperation of local professional fishermen. Sampling by spear was carried out through 2006–2008 on a monthly basis, at depths ranging from 0–18 m and from 0–150 m off the coast, on rocky substrate with plenty of crevices and holes and sometimes in close proximity to *Posidonia oceanica* (L.) Delile meadows. On each sampling day and location the sea surface temperature and salinity were recorded with a precision of 0.1°C and 0.1 psu respectively, using a conductivity hand-held meter. After capture, specimens were preserved frozen at −20°C.

For macroalgae seven sampling locations at the upper infralittoral zone were chosen along the rocky shores of the Messiniakos Gulf. Two seasonal samplings were carried out for each location, one during autumn 2006 and the other one during spring 2008. Samples were collected by free diving from almost horizontal rocky surfaces, 50 cm below the lowest water level. Quadrats of 400 cm^2 (20 cm × 20 cm) were scraped off at each site ('destructive' sampling). All samples were preserved in formalin until further analysis in the laboratory.

Species identification

The fish were identified to species level following Fischer *et al.* (1987) and *FishBase* (Froese & Pauly, 2008).

When it comes to macroalgae, formalin fixed samples were carefully analysed in the Phytobenthos Laboratory of the Hellenic Centre of Marine Research (HCMR), by identifying species presence and by estimating their vertically projected coverage. For the classification of macroalgae the following Mediterranean Sea check-lists were used: Ribera *et al.* (1992) for Fucophyceae, Gallardo *et al.* (1993) for Chlorophyta, and Athanasiadis (1987) and Gómez-Garreta *et al.* (2001) for Rhodophyta.

Fish morphometrics

Total length (LT) of each individual fish was measured to the nearest mm, while total body weight (WT) was recorded to the nearest g. Meristic features were counted and morphometric measurements were taken with a calliper on defrosted specimens of *Siganus rivulatus*, Forsskål 1775 and *Fistularia commersonii*, Rüppel 1835 and also on a subsample of 121 defrosted specimens of *Siganus luridus*, Rüppel 1829, selected to cover a broad size-range.

RESULTS

Lessepsian fish

Three lessepsian fish immigrants were recorded from the study area (Figure 1): the dusky spinefoot *Siganus luridus*, in large numbers, the marbled spinefoot *Siganus rivulatus* and the blue-spotted cornetfish *Fistularia commersonii*.

Two hundred and ninety-eight specimens of *Siganus luridus* were captured by spear during 47 days of sampling from January 2006 to June 2008, ranging from 90–278 mm

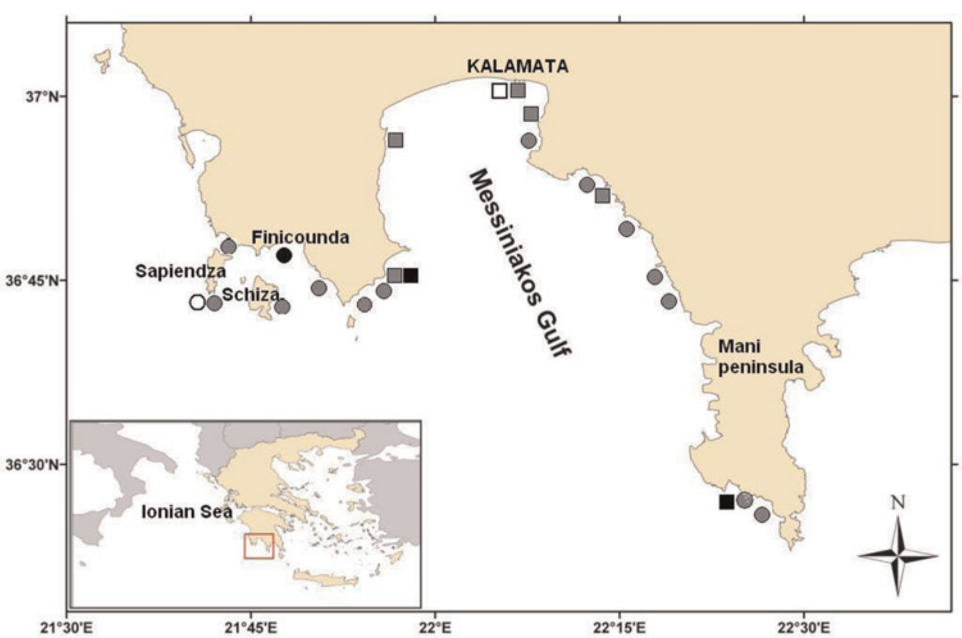

Fig. 1. Sampling sites in the Messiniakos Gulf: circles for fish (white, *Siganus rivulatus*; grey, *S. luridus*; black, *Fistularia commersonii*) and quadrats for macroalgae (white, *Asparagopsis taxiformis*; grey, *Caulerpa racemosa* var. *cylindracea*; black, *Stypopodium schimperi*).

in total length and from 9–382 g in total body weight. Observations in the field during sampling confirmed the presence of *S. luridus* (Figure 2) at 13 different coastal sites of the Messiniakos Gulf all the year round. Most specimens were observed and captured at depths often less than 10 m, although some of them were caught down to a depth of 18 m. Surface temperatures varied throughout the year and from site to site from 15°C (January–March 2007) to 28.6°C (August 2006), while surface salinity ranged from 32.1 psu to 40.9 psu. Individuals of *S. rivulatus* and *Fistularia commersonii* were not observed directly in the field, neither caught by spear.

Gillnets of 18, 22, 30 and 36 mm mesh size provided additional information on the presence of two more lessepsian fish immigrants: a single specimen of *Fistularia commersonii* (Figure 3) of 907 mm LT and 292 g WT was caught by gillnets of 22 mm mesh size at a depth of 7–8 m from Finicounda on 15 January 2008, and one specimen of *Siganus rivulatus* of 225 mm LT and 140 g WT (Figure 4) was caught by gillnets of 30 mm mesh size at a depth of 17–23 m from Sapiendza Island on 25 May 2008. Furthermore, 243 *S. luridus* specimens were captured by gillnets of 18, 30 and 36 mm mesh size from the Islands of Schiza and Sapiendza.

Considering meristic features of the dusky spinefoot (N = 121), all specimens had a XIV-10 dorsal fin type, with the first dorsal spine horizontally orientated, looking frontward and I-3-I pelvic fin type. The pectoral fin consisted of 15–16 yellowish soft rays. The anal fin structure displayed worth-mentioning variability: 116 of them had the usual type of VII-9 reported from *FishBase* (Froese & Pauly, 2008), but five specimens exhibited differentiated types: VI-10 and VIII-9 in two specimens each and VIII-8 in one specimen. The marbled spinefoot exhibited the following meristic features: dorsal fin XIV-10, anal fin VII-9, pectoral fin 0-16 and pelvic fin I-3-I. For the bluespotted cornetfish the dorsal type was 0-15, anal type 0-14, pelvic type 0-6 and pectoral 0-14.

Data from morphometric measurements expressed as % of total length (LT) for the two siganids and as % of standard length (LS) for the bluespotted cornetfish are presented in Table 1.

Fig. 3. *Fistularia commersonii* specimen of 907 mm LT caught in the south-east Ionian Sea.

Macroalgae

A total of 125 macroalgal taxa were identified in the studied area, which is approximate to a past study of the area (Tsirika *et al.*, 2003). Red algae dominate with 81 representatives, whereas the brown and green algae participate with 24 and 20 representatives respectively. The vegetation of the rocky substrate of the studied site is mainly characterized by species of the genus *Cystoseira* C. Agardh, which play a role of canopy algae and constitute important communities for both algal and fish populations. Other common macroalgal species include the brown alga *Sphacelaria cirrosa* (Roth) C. Agardh and the red algae *Ceramium* spp., *Herposiphonia secunda* (C. Agardh) Ambronn and *Jania rubens* (Linnaeus) Lamouroux.

Among all identified species 3 of them are considered as aliens: the green alga *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, the brown alga *Stypopodium schimperi* (Buchinger *ex* Kützing) Verlaque & Boudouresque (Figure 5) and the red alga *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon (Figure 6), from which the two latter are reported from the Ionian Sea for the first time. A few thalli of *S. schimperi*

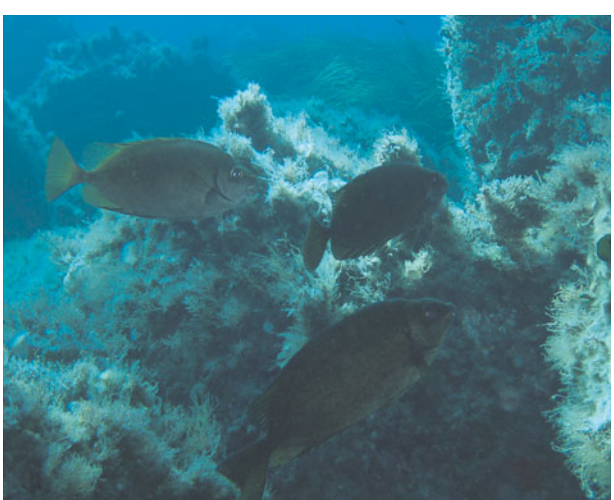

Fig. 2. *Siganus luridus* school from the south-east Ionian Sea.

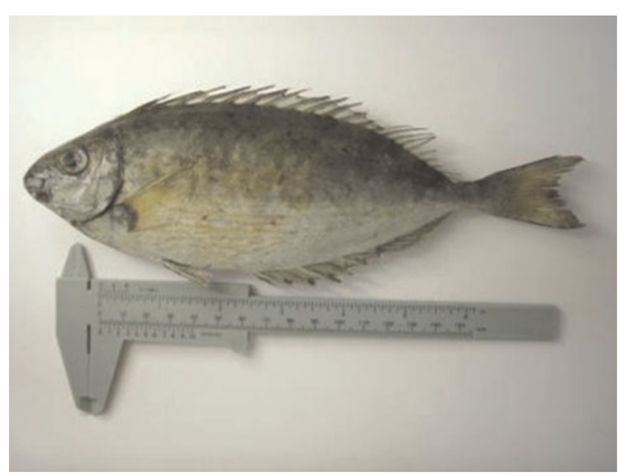

Fig. 4. *Siganus rivulatus* specimen of 225 mm LT caught in the south-east Ionian Sea.

Table 1. Morphometric characters of *Fistularia commersonii*, *Siganus rivulatus* and *Siganus luridus* from the south-east Ionian Sea.

	F. commersonii	*S. rivulatus*	*S. luridus**
Total length (LT)	907	225	195 ± 40
		% LT	
Standard length (LS)	743	84.4	84.5 ± 1.41
	% LS		
Head length (LH)	35.9	17.8	18.5 ± 0.97
Head height	3.6	15.1	18.6 ± 1.10
Body height	3.2	29.3	33.9 ± 2.02
Prepectoral length	36.7	17.3	17.7 ± 1.00
Predorsal length	83.2	20.4	21.9 ± 1.27
Preanal length	83.2	43.6	44.1 ± 1.86
Prepelvic length	51.1	25.8	26.3 ± 1.20
Pectoral fin length	4.2	16.0	5.8 ± 0.35
Dorsal fin base	3.6	57.8	58.5 ± 1.98
Dorsal fin height	2.3	8.9	12.0 ± 0.78
Anal fin base	4.3	37.3	35.5 ± 1.39
Anal fin height	3.4	8.9	10.3 ± 0.72
Caudal peduncle height	5	4.5	5.2 ± 0.28
		% LH	
Head width	3.9	52.3	52.8 ± 2.27
Eye maximum diameter	3.0	27.0	30.2 ± 2.28
Eye minimum diameter	1.5	22.0	27.4 ± 2.41
Preorbital length	26.2	46.0	42.0 ± 2.81
Interorbital width	2.4	41.5	41.9 ± 1.51
Postorbital length	6.7	37.5	35.9 ± 2.49

LT, LS in mm; *mean ± standard deviation.

were recorded only at the outer Messiniakos Gulf during spring 2008, while in the inner coasts the species was absent (Figure 1). In addition, a single thallus of the haploid gametophytic stage of *A. taxiformis* was found in the inner Messiniakos Gulf (Kalamata's main port) in spring 2008 (Figure 1). At the same area, a few individuals of the diploid tetrasporophytes of *A. taxiformis* were found as epiphytes on other macroalgae. Finally, *C. racemosa* var. *cylindracea* was found during autumn 2006 and spring 2008, and it was present at most sampling stations (Figure 1), occasionally through high abundances. Among the identified taxa, it is the only alien macroalga that exhibits invasive behaviour in Messiniakos Gulf.

Fig. 5. *Stypopodium schimperi* from the outer Messiniakos Gulf (south-east Ionian Sea).

Fig. 6. *Asparagopsis taxiformis* from the port of Kalamata (south-east Ionian Sea).

DISCUSSION

Alien fish

According to the CIESM (Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée) Atlases of Alien species (Galil *et al.*, 2002; Golani *et al.*, 2002; Zenetos *et al.*, 2003), an exotic species is considered to be established in a new area as soon as it is recorded from either different localities or twice (three times regarding fish) in different periods, while alien species are identified as having been recorded only once (no more than twice for fish): they are presumed to be not-established in the basin. Nevertheless, the characterization of an allochthonous species as 'established' or 'alien' in a new environment depends on the size of the latter, defined by the aims of the study. What is referred to as 'established' in the Mediterranean Sea as a whole may have not been recorded even once from several parts. In practice, it is more significant for conservation biology to monitor the establishment of new populations of marine aliens on a smaller geographical scale, since they may have a considerable impact either on local ecosystems and communities or on small scale commercial fisheries.

The blue-spotted cornetfish *Fistularia commersonii* is one of the most recently recorded lessepsian fish (Golani, 2000). It is referred to as a 'lessepsian sprinter' (Karachle *et al.*, 2004), due to its rapid range extension to the north and west, now including the whole Levantine, the Aegean Sea and the central and western Mediterranean Sea (Golani *et al.*, 2006; Corsini-Foka & Economidis, 2007; Sánchez-Tocino, 2007). This is the second record of *F. commersonii* from the Ionian Sea—the first was off Corfu Island in 2007 (ELNAIS, 2008)—so it could be described as 'alien' in this area, following the CIESM's terminology of exotic species. Yet, more records and/or data on its reproduction in the wild from this area are prerequisites to ensure the existence of an established population.

The first record of the two siganids from the Mediterranean Sea was in 1927 by Steinitz (1927) for *Siganus rivulatus* and in 1956 for *Siganus luridus* (Ben Tuvia, 1964). Since then, both species have been well established along the coasts of the Levantine Sea and have invaded the Central Mediterranean Sea (Azzurro & Andaloro, 2004; Charfi-Cheikhrouha, 2004; Castriota & Andaloro, 2005; Corsini-Foka & Economidis, 2007), on some occasions dominating the herbivorous fish community in terms of abundance and biomass (Papaconstantinou *et al.*, 1988; Harmelin-Vivien *et al.*, 2005).

This is the first record of *Siganus rivulatus* from the south-east Ionian Sea and the second from the Ionian Sea taken as a whole (Golani *et al.*, 2002). Therefore, the marbled spinefoot is considered to be a non-established alien in this area. This finding connects the established populations of the south-east and south Aegean Sea (Papaconstantinou *et al.*, 1988; Peristeraki *et al.*, 2006), to the records of the Adriatic Sea, where two specimens were reported by Dulčić & Pallaoro (2004). At first glance, it seems peculiar why this species has not established populations in the south-east Ionian Sea area, where its congeneric *S. luridus* is very abundant (present study). The answer might hide in the question itself: it is possible that the latter species outcompetes the former, occupying an available niche for an additional herbivorous species in the novel environment. Even though the feeding habits of these two siganids have been repeatedly studied in both the Red Sea and the eastern Mediterranean Sea, there are no data quantitatively comparing their diets and assessing whether an overlap in use of food resources exists between them and to what extent (Bariche, 2006).

Kaspiris (1976) recorded one single specimen of *Siganus luridus* from the Patraikos Gulf, east Ionian Sea, yet this was not enough to support the finding of an established population. Based on the large number of specimens observed directly in the field and caught almost on a monthly basis from 2006–2008, one can say with certainty that the presence of *S. luridus* in the south-east Ionian Sea is not only the first record of the species in the particular area, but also is proof of a well-established population for the first time in the Greek part of the Ionian Sea. Local fishermen informed us that the dusky spinefoot has become a significant part of their net catches in shallow waters since 2000. Then, how could we explain its previous record by Kaspiris? Following the considerations of Por (1978), we assume that pioneers of the dusky spinefoot had settled small populations at first in the Ionian Sea which escaped scientific attention. Significant populations were built-up later and that brought their existence to light. It is most likely that the dusky spinefoot arrived at the south-east Ionian Sea extending its distribution probably from established populations from the Cyclades Islands in the south Aegean Sea (Corsini-Foka & Economidis, 2007) or alternatively from Crete (Tingilis *et al.*, 2003; Golani *et al.*, 2004) via Antikythera Island, where many specimens were caught in August 2000 (Damalas & Megalofonou, unpublished data). We suppose that range expansion is mediated by larval drift and/or by active migration. The scenario of eggs being transported by currents seems controversial. According to Popper *et al.* (1979), its eggs are not pelagic but adhesive and sink slowly to the bottom. On the contrary, Lakkis *et al.* (2004) recognized *S. luridus* eggs and larvae among plankton sampled off the coast of Syria, while in the CIESM *Atlas of Exotic Fishes* (Golani *et al.*, 2002), *S. luridus* is cited as a species with both eggs and larvae planktonic.

Por (1978) predicted that the expansion of lessepsian immigrants in the Mediterranean Sea would be limited by temperature, with this limit being sought at the 16°C isotherm of minimum winter surface temperature. The dusky spinefoot might be less sensitive to low temperature than expected, since we observed it as abundant with a seawater temperature of 15°C during winter and early spring. The present study also showed that it is tolerant of a fairly wide range of changes in salinity, from 32.1–40 psu, which is in accord with Ben-Tuvia (1964) and Popper & Gundermann (1975).

The maximum depth where the dusky spinefoot was met on the coral reefs of Aqaba in the Red Sea (Bouchon-Navaro & Harmelin-Vivien, 1981) was only 6 m. According to Harmelin-Vivien *et al.* (2005), on the rocky coast of Lebanon *Siganus luridus* was recorded from the surface down to 40 m depth, but exhibited higher densities in shallow waters of less than 12 m depth. Our observations agree with the latter, confirming the enlargement of the species' ecological niche to deeper waters, compared to the Red Sea populations. This could be explained by the lack of competition from native herbivores in the eastern Mediterranean Sea (Harmelin-Vivien *et al.*, 2005), an argument which is further supported by the findings of Azzurro *et al.* (2007). The authors proved that there is a resource partitioning concerning food between *S. luridus* and its most suspected native competitor *Sarpa salpa* (Linnaeus, 1758) in the Central Mediterranean Sea.

All three fish immigrants of the present study are considered to have invasive behaviour in other parts of the eastern Mediterranean Sea (Streftaris & Zenetos, 2006). The bluespotted cornetfish is a higher order carnivore, often feeding on species of significant commercial importance for fisheries, such as *Mullus surmuletus* Linnaeus 1758 and is considered abundant in the south-east Aegean (Corsini-Foka *et al.*, 2002; Kalogirou *et al.*, 2007). The two *Siganus* species are the most abundant herbivorous fish in shallow coastal waters across the Levantine, and comprise much of the fish biomass along its rocky habitats (Harmelin-Vivien *et al.*, 2005). Only *S. luridus* could be considered invasive in the south-east Ionian Sea for now, thanks to its abundance. Yet, in this area it is discarded as by-catch in fisheries, despite the fact that elsewhere in the eastern Mediterranean Sea it is of moderate commercial importance for inshore fisheries. Characterized as a browser (Ogden & Lobel, 1978), *S. luridus* is an additional consumer of algae in the south-east Ionian Sea, probably exerting a significant impact on the structure of the local algal community.

Alien macroalgae

The brown alga *Stypopodium schimperi* is a lessepsian immigrant which has been introduced into the eastern Mediterranean Sea since the early 1990s (Nizamuddin & Godeh, 1989; Verlaque & Boudouresque, 1991). In Greece, it was reported only in the south Aegean Sea, from Milos Island (Sartoni & De Biasi, 1999) and Rhodes Island (Tsiamis *et al.*, 2007). Its finding in the present study corresponds to the most western record in Greece. Although it exhibits invasive behaviour along the coasts of Levantine (Boudouresque & Verlaque, 2002), no invasive behaviour was detected until today for any Greek marine area (Tsiamis *et al.*, 2008). However, north-western expansion in the Ionian Sea as well as towards the inner Messiniakos Gulf is expected during the next years.

Two cryptic taxa seem to coexist under the name of *Asparagopsis taxiformis* in the Mediterranean Sea: a taxon described in 1813 from Alexandria by Delile (1813) and confined to the eastern Mediterranean basin—Egypt, Lebanon, Syria and likely Libya—(Ní Chualáin *et al.*, 2004) and another one, more recently introduced into the Mediterranean Sea, and exhibiting an invasive behaviour in the western basin—Algeria, Balearic Islands, France, western Italy, Sicily, Tunisia—(Ballesteros & Rodriguez-Prieto, 1996; Barone *et al.*, 2003; Flagella *et al.*, 2003; Ní Chualáin *et al.*, 2004). Recent molecular results showed that the first taxon appears to be of Atlantic provenance, via the Strait of Gibraltar, whereas the second taxon probably colonized the Mediterranean from the Indo-Pacific, most likely via the Suez Canal (Andreakis *et al.*, 2004, 2007; Ní Chualáin *et al.*, 2004). The Mediterranean distribution of the two taxa appears to be closely related to their lower survival temperature—17°C and 9–11°C for the Atlantic and the Indo-Pacific taxon, respectively (Ní Chualáin *et al.*, 2004). Since the seawater temperatures of the Messiniakos Gulf get down to 15°C during winter, it is probable that the specimen of *A. taxiformis* which was found in the studied site corresponds to the invasive Indo-Pacific strain.

In Greece, *Asparagopsis taxiformis* was found only recently in the central and south Aegean Sea (Tsiamis & Panayotidis, 2007). Its finding in the south-east Ionian Sea corresponds to the most western record of this species in Greece. Although it was found only in the inner Messiniakos Gulf, at Kalamata's port, north-western expansion is expected in the near future.

When it comes to *Caulerpa racemosa* var. *cylindracea*, recent molecular studies indicate that this green alga has been probably introduced into the Mediterranean Sea from south-west Australia, probably through aquarium trade and/or intentional introduction (Verlaque *et al.*, 2003). It was first found in Libya during the early 1990s (Nizamuddin, 1991) and since then it has been spreading extremely rapidly along the whole Mediterranean basin, probably through shipping (fouling and ballast waters; Verlaque *et al.*, 2003), occupying diverse substrata, various depths, polluted and unpolluted areas, revealing, thus, a strong invasive behaviour (Piazzi *et al.*, 2005). Similar behaviour is also

Table 2. Alien marine species reported from the Messiniakos Gulf (south-east Ionian Sea) until today.

Group	Species	Status in the Messiniakos Gulf	Origin	Vector	First record	Source
Phytobenthos	**Macroalgae**					
	Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon	Alien	Indo-Pacific	Suez Canal	2008	Present study
	Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman et Boudouresque	Established	South-west Australia	Aquarium trade/ intentional act	2002	Tsirika *et al.*, 2003
	Stypopodium schimperi (Buchinger ex Kützing) Verlaque et Boudouresque	Established	Red Sea	Suez Canal	2008	Present study
	Womersleyella setacea (Hollenberg) R.E. Norris	Alien	Indo-Pacific	Shipping	2002	Tsirika *et al.*, 2003
	Seagrasses					
	Halophila stipulacea (Forsskål) Ascherson	Established	Red Sea	Suez Canal	1958	Pérès & Picard, 1958
Zoobenthos	**Crustaceans**					
	Percnon gibbesi H. Milne-Edwards, 1853	Established	Tropical Atlantic	Shipping/via larval transport	2004	Thessalou-Legaki *et al.*, 2006
	Molluscs					
	Aplysia dactylomeda (Rang, 1828)	Alien	Circumtropical	Suez Canal/shipping	2005	Zenetos *et al.*, 2007
	Pinctada radiata Leach, 1814	Alien	Red Sea	Suez Canal/ aquaculture	2004	Katsanevakis *et al.*, 2008
	Strombus persicus Swainson, 1821	Alien	Indo-Pacific	Shipping	2001	Gibert, 2001
	Polychaeta					
	Pseudonereis anomala Gravier, 1900	Alien	Red Sea	Suez Canal/shipping	2003	Kambouroglou & Nikolaidou, 2006
Fish	*Fistularia commersonii* Rüppel, 1835	Alien	Indo-Pacific–Red Sea	Suez Canal	2008	Present study
	Siganus luridus Rüppel, 1829	Established	Indo-Pacific–Red Sea	Suez Canal	2000	According to fishermen
	Siganus rivulatus Forsskål, 1775	Alien	Indo-Pacific–Red Sea	Suez Canal	2008	Present study
	Sphoeroides pachygaster	Alien	Atlantic	Via Gibraltar	2008	ELNAIS, 2008

known from the Greek coasts; however, its direct impact on the native biota has not yet been documented in the eastern Mediterranean Sea (Tsiamis *et al*., 2008). In the Messiniakos Gulf this taxon was first found by Tsirika *et al.* (2003) who mentioned a more significant expansion at deep than at shallow water. Today, its presence in the studied area seems to be stable.

Among the identified macroalgae in the south-east Ionian Sea, only *Caulerpa racemosa* var. *cylindracea* exhibits invasive behaviour. This belongs to the 9 most invasive marine macrophytes listed for the Mediterranean Sea (Boudouresque & Verlaque, 2002), which are known to displace the indigenous flora, reduce community biodiversity, and modify the basic ecological characteristics of the native benthic ecosystems through the disruption of the trophic food webs, and thus resulting in negative consequences on human activities, such as fisheries and tourism (Schaffelke & Hewitt, 2007).

CONCLUSIONS

It is of great interest to record any new trophic relationships among alien marine organisms as well as between aliens and native species in a marine area. There is evidence that *Siganus luridus* consumes *Caulerpa racemosa* along the Middle East coast (Bariche, 2006), while *Fistularia commersonii* feeds on fry of the family Siganidae (Popper & Gundermann, 1975) among other taxa of prey. Groupers feed mainly on siganids in Israeli waters (Galil, 2007). In that case, the ecosystem itself probably finds balance into a new level.

The finding of five new alien species in the studied site (*Fistularia commersonii*, *Siganus rivulatus*, *Siganus luridus*, *Stypopodium schimperi* and *Asparagopsis taxiformis*) increases the total number of alien marine species of the Messiniakos Gulf to 14 species (Table 2). The majority of those are lessepsian immigrants originating in the Red Sea, enhancing the assumption that Messiniakos Gulf is a hot-spot area on the way of lessepsian immigrants spreading from the eastern to the western basin. The Suez Canal is the main vector for the alien species of the south-east Ionian Sea, while other significant vectors include shipping (fouling and ballast waters), probably due to the influence of Kalamata's main port.

The north-western spread of alien marine species of the south-east Ionian Sea as well as the introduction of new aliens in the area is prospective in the next few years. Taking for granted that the influx of alien species has brought up impressive changes in the marine communities and ecosystems of other parts of the eastern Mediterranean Sea, their spreading in the Greek waters towards the northern coasts of both the Ionian Sea and Aegean Sea should be monitored, while more knowledge about their biology and ecology would be helpful to suggest an appropriate management plan.

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