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A comparative analysis of alien plant species along the Romanian Black Sea coastal area. The role of harbours

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Abstract Previous studies have found a higher proportion of alien plant species along the coastal area of the Black Sea. The goals of the present study were to assess the role of two harbours as gateways and reservoirs for alien plant species, to compare the structure and invasion pattern of the alien plants recorded there, and test methods useful for effective monitoring programs. We inventoried 12 sites along the western Black Sea coast from the harbour of Sulina in the north to Cape Kaliakra in the south. Each site was visited at least three times each. A more intensive survey was done in the two harbours targeted by our study: Constanța and Sulina. The proportion of neophytes was higher in the harbours (representing about one third of the total plant species) and lower in coastal protected areas (with an average proportion of 6.7%). Species accumulation curves and estimators of species richness indicated that while the plant inventory was not complete, invasive alien species (IAS) were adequately inventoried. Harbours act not only as gateways for IAS but also as reservoirs, facilitating their acclimatization and naturalization. The use of species accumulation curves and estimators of species richness are useful tools in designing and evaluating simple monitoring programs based on repeated inventories. Our study has stressed the importance of monitoring not only coastal waters but also green areas in harbours for the early detection of IAS.

Keywords Harbour · Alien species · Neophyte · Monitoring · Romania

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Introduction

For hundreds of years, humans have been introducing plants, animals, and other organisms around the world, in a relatively slow process of globalizing the Earth's biota (DiCastri 1989). More recently, the pace of this process has increased with modern trade, travel, and technology, so that biological invasions have become a consequence of globalization that facilitates and intensifies the spread of invasive alien species (IAS). Human-driven biotic invasions have already caused wide alteration of the Earth's biota, changing the structure of native communities, disrupting evolutionary processes, and causing reductions in the abundance of native species, including the extinction of many of them (Mack et al. 2000). These alterations constitute a threat to global biodiversity, second in impact only to the direct destruction and fragmentation of habitats (Cogălniceanu 2007).

The consequences of biological invasions are often so severe that they must be curbed and new invasions prevented (Mack et al. 2000). Prevention/exclusion is less costly than post-entry control and obviously has little or no detrimental effects. The main concern is to identify the species that should be prevented from entering and the areas of high risk of invasion. Early detection and rapid assessment can limit the damage and allow for efficient control methods. Therefore monitoring programs are required in areas of high risk (Lodge et al. 2006) or along transfer routes. The investigation of the transfer routes, the

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identification of the introduction routes, and the estimates of probability for successful settlement of the species suspected of becoming invasive are important fields of future studies (Occhipinti Ambrogi 2001).

Carlton (2001) identified a variety of anthropogenic vectors for introductions of marine alien species, the most important being commercial shipping. Ships can transport alien species either in the ballast water, as hull fouling and as solid ballast (e.g. sand, rocks, soil etc.). Terrestrial plant species can also benefit from this transportation route. Some cargoes provide excellent means for the transportation of seeds or even entire plants (food and animal feed, minerals, coal, sand, solid ballast etc.). Despite its importance the management of solid ballast has received little attention.

There are two important harbours on the Romanian Black Sea coast: Sulina in the north, located at the mouth of the Danube, a major harbour since the 19th and beginning of the 20th century (Fig. 1), and Constanța, the largest port at the Black Sea (Fig. 2). Both ports are connected to inland waterways: Sulina by the Danube and Constanța by the Danube-Black Sea canal. They are thus connected to the Trans-European Network for Transport that provides a 1,980 km navigation route that links the Danube, Oder and Elbe rivers (Galil and Minchin 2006), while the Rhine–Main–Danube Canal connects the Black Sea to the North Sea and Atlantic Ocean.

The western Black Sea coastal area between Sulina (Romania) and Cape Kaliakra (Bulgaria) covers a variety of coastal habitats, with different degrees of human impact. Several important protected areas are also located in the area (Danube Delta Biosphere Reserve in Romania, and Durankulak and Shabla in Bulgaria). The coastline has a

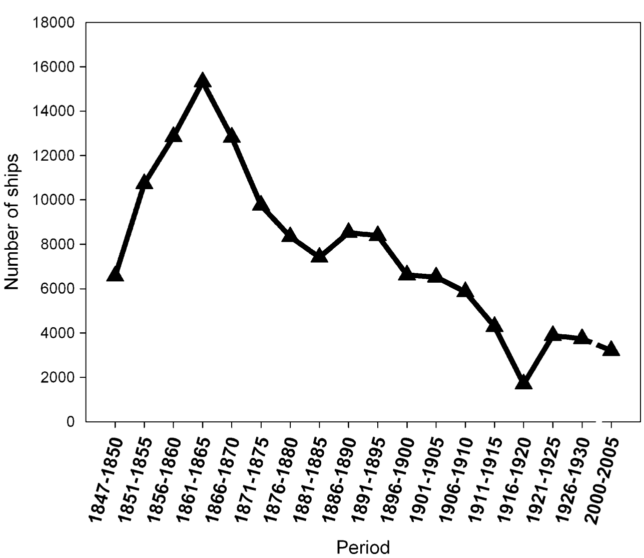

Fig. 1 Number of ships transiting Sulina during 1847–1930 and 2000–2005 (Commission Européenne du Danube 1931; National Institute of Statistics 2008)

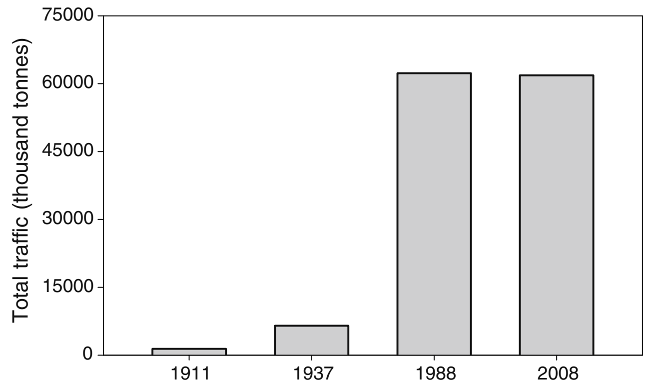

Fig. 2 Increase in the total traffic in Constanța harbour during the last century (Administration of Constantza Port 2009)

higher proportion of alien plants when compared to the inland (Anastasiu et al. 2009). The goals of the present study were to (1) assess the role of the two harbours as gateways and reservoirs for alien plant species, (2) compare the structure and invasion pattern of the alien plants recorded in the two harbours, and (3) test methods useful for effective monitoring programs.

Materials and methods

Location

The Romanian Black Sea coast area is part of the region of Dobrudja, representing the northern limit of the Balkan region. Its limits are the Danube River and Delta in the west and north and the Black Sea in the east. Our study was focused on the coastal area between Sulina (Romania) in the north and Cape Kaliakra (Bulgaria) in the south, along a stretch of coastline 265 km long. Vegetation inventories were conducted in 12 sites, of which nine along the Romanian coastline and three in Bulgaria. Six of these sites were located in protected areas, and were included as control sites. The sites included in our study were under different levels of human impact, ranging from tourism resorts to protected areas, including strictly protected areas with restricted access (Table 1 and Fig. 3).

The two harbours included in the study differ in area, traffic intensity and historical development. Constanța harbour has a total area of 3,626 ha, of which 1,784 land (49%), with 28.5 km of quay constructed and 37 km under construction, and 132 berths, with 150 additional ones under construction (Administration of Constantza Port 2009). The main town in the region is Constanța, with a population of 304,279 inhabitants (National Institute of Statistics 2008). The port of Constanța (which includes within its administration the smaller port of Midia) is a container hub for the Black Sea area, with 80% of the

Table 1 Location, area and human impact of the twelve sites sampled in the present study

No	Site	Location	Area (ha)	Human impact
1	Sulina harbour	45.15N; 29.67 E	600	Moderate
2	Sachalin Island (Danube Delta Biosphere Reserve)[a]	44.83N; 29.60E	400	Low
3	Chituc Sand dunes[a]	44.42–44.47N; 28.76–28.80 E	2,300	Low
4	Midia harbour	44.33–44.34N; 28.63–28.67 E	834 of which 234 land	Moderate
5	Năvodari	44.31N; 28.62 E	25	Moderate
6	Constanța harbour	44.12–44.17N; 28.65 E	3,626 of which 1,784 land	High
7	Agigea Sand Dunes[a]	44.08N; 28.64 E	25	Low
8	Eforie Sud	44.04N; 28.64 E	2	Moderate
9	Tuzla	44.01N; 28.66 E	2	Low
10	Durankulak (Bulgaria)[a]	43.67N; 28.56 E	446	Low
11	Shabla (Bulgaria)[a]	43.58N; 28.57 E	1,463	Low
12	Cape Kaliakra [a](Bulgaria)	43.37N; 28.46 E	287	Low

[a] Protected area

containerized cargo handled in Constanța having a different final destination. The number of containers transiting the port has increased seven-fold since 2003. Constanța harbour has grown in importance in time, increasing 45 times during the last hundred years (Fig. 1). Its growth was due both to spatial development, the area covered increasing constantly, and to increased in-port facilities.

Sulina harbour has a total area of 100 ha, of which 25 ha is land. With four berths its annual cargo tonnage was 1,400,000 tons in 2008 (Fig. 2). Sulina was historically a major port at the Danube, a gateway between the hinterland ports of Galați and Sulina and upstream to Vienna, and the Black and Mediterranean Seas (Commission Européenne du Danube 1931). It had a maximum population of around 15,000 inhabitants around 1920 and presently has 4,593 inhabitants (National Institute of Statistics 2008).

Vegetation inventory

All 12 sites included in our study were visited repeatedly, at least three times each. A more intensive survey was done in the two harbours targeted by our study: Constanța and Sulina.

The monitoring of vegetation within Constanța Harbour started in 2004 and was continued in 2008 and 2009. In total, nine inventories were made during the period May–September, each involving prolonged visits in the port. Sulina harbour was visited three times during July–September 2009. To assess the invasion status and residence time, we adopted the terminology and definitions recommended by Richardson et al. (2000) and Pyšek et al. (2004). Thus, invasive plants (referred hereafter as alien invasive species or IAS) are defined as a subset of naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from the parent plants, and thus have the potential to spread over a large area. For Central and Eastern Europe, archaeophytes are the species introduced into the flora of a country before cca 1,500, while neophytes are the species introduced after that year (Pyšek et al. 2004). We included in our analysis only neophytes, often being difficult to establish the status of archaeophytes. A list of vascular plant taxa was compiled based on field records (see Annex). Native species were identified according to Ciocârlan (2009). For each alien plant taxon we registered: family, life form, native range, way of introduction and invasive status. The nomenclature of recorded taxa follows Flora Europaea (Tutin et al. 1993, 1964–1980).

Data analysis

Based on the presence-absence data matrix we computed incidence-based estimators of species richness using Spade 3.1 (Chao and Shen 2003) for the homogeneous model estimator, ICE, Chao 2, Jackknife 1 and 2 and EstimateS 8.0 (Colwell 2009) for Bootstrap estimator. EstimateS was used for computing species accumulation curves. The GIS mapping and analysis was performed in ESRI ArcGIS Desktop 9.3.1.

Results

We inventoried 1,086 plant taxa during the study. Of these, 927 were considered native species and 159 were neophytes, of which 60 were invasive alien species (IAS), 24 were naturalized and 75 were only occasional present in the area (Table 2 and Fig. 3). The proportion of neophytes

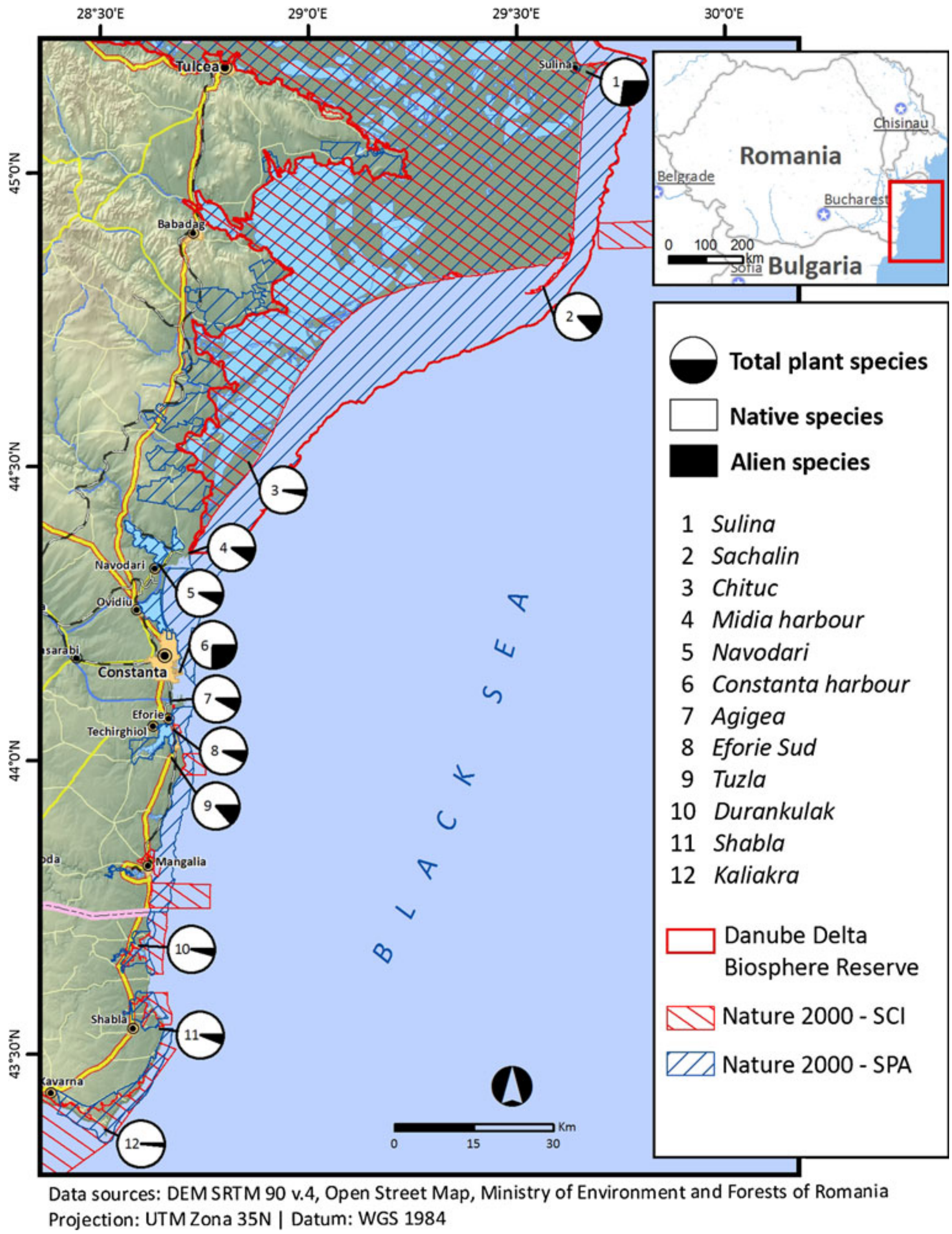

Fig. 3 Proportion of neophyta along the study sites located on the coastline between Sulina and Cape Kaliakra

appeared to be correlated with the human impact, being higher in the harbours and lower in protected areas. Neophytes represented about one third of the total plant species within the two main harbours, while in protected areas their average proportion was 6.7%.

Sulina harbour

The neophytes identified in Sulina originate mostly from ornamental and forestry (i.e. casual species). Most probably IAS in the area originated inland and were brought by shipping. Most IAS were previously reported in other parts of the country before reaching Sulina. The only exception was the duckweed fern *Azolla filiculoides*, spread by migrating waterfowl. Two species were already cited in the 19th century *Heliotropium curassavicum* and *Petunia parviflora* (Kanitz 1879–1881), but have not become invasive since.

Constanța harbour

We inventoried 491 plant species, of which 42 were invasive (10% of the total plant species richness and almost 40% of neophytes). The average number of plant species

Table 2 Number of native, neophyte and IAS plants inventoried within the twelve sites

No	Site	Area (ha)	Number of vascular plants	Number of native plants	Number of neophytes	Density of neophytes per ha	Ratio neophytes/native species × 100	Percentage of neophytes (%)
1	Sulina	600	352	257	95	0.158	37.0	27.0
2	Sachalin[a]	400	92	80	12	0.03	15.0	13.0
3	Chituc[a]	2,300	310	299	11	0.005	3.7	3.5
4	Midia harbour	234	167	150	17	0.073	11.3	10.2
5	Năvodari	25	104	96	8	0.32	8.3	7.7
6	Constanța harbour	1,784	426	317	109	0.06	34.4	25.8
7	Agigea[a]	25	153	140	13	0.52	9.3	8.5
8	Eforie Sud	2	52	48	4	2	8.3	7.7
9	Tuzla	2	52	45	7	3.5	15.6	13.5
10	Durankulak[a]	446	274	262	12	0.027	4.6	4.4
11	Shabla[a]	1,463	176	166	10	0.007	6.0	5.7
12	Kaliakra[a]	287	351	345	6	0.021	1.7	1.7

[a] Protected area

recorded in Constanța harbour during a single visit was 181.1±54.3, range 108–269. Figure 4 presents the frequency distribution of plant species inventoried in Constanța harbour during the study period. The high proportion of species inventoried during only one or two visits suggests a high species turnover in time and a still incomplete inventory, which implies that additional visits will allow the identification of new, previously not inventoried species. To assess this we computed a species accumulation curve (SAC), also known as a collector's curve (Fig. 5). The SACs do not reach a plateau indicating that the inventory was still incomplete even after nine repeated visits, thus further analyses were required, like computing estimators of species richness to assess the total number of species. The estimators of species richness were computed separately for all plant species inventoried and separately for neophyte and IAS (Table 3). The results indicated a much higher number of plant species expected, the highest increase being within the total number of species and neophytes. The inventory of IAS was almost complete due to their wide-spread distribution and ease of observation. The probability of finding new IAS is low, but more neophytes and native species are expected, including newly introduced species. Since the harbour has a highly heterogeneous and dynamic spatial structure, with large areas under construction, zones of restricted access that were not sampled and areas with different intensity of activities, we delimited 11 priority areas (Fig. 6). These

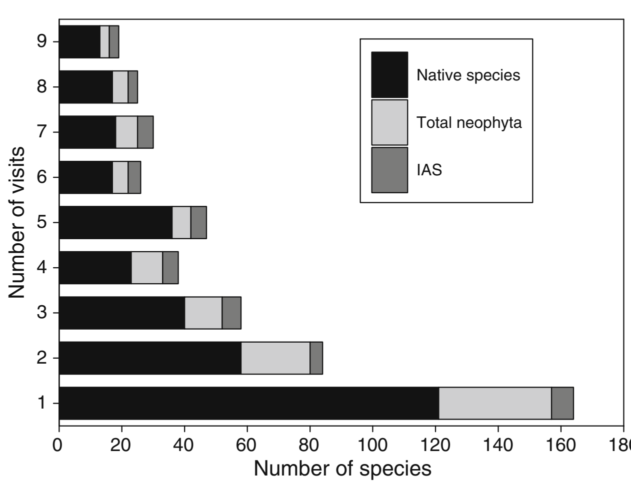

Fig. 4 The frequency distribution of plant species inventoried in Constanța harbour during the nine visits

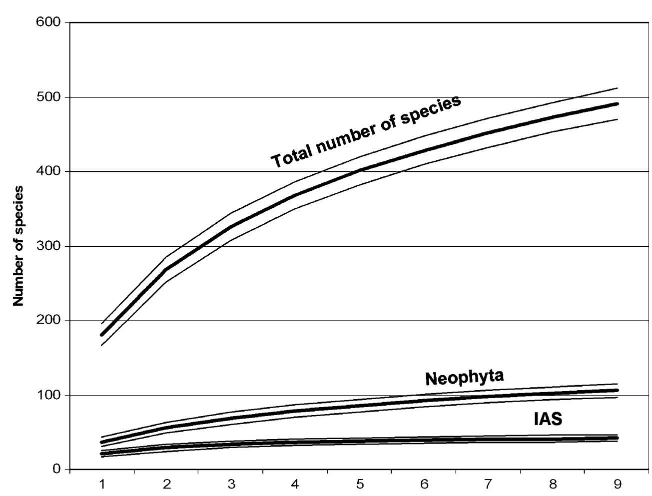

Fig. 5 Species accumulation curves for the total number of species, neophyta and IAS inventoried in Constanța harbour

Table 3 Estimators of species richness computed with the program Spade (Chao and Shen 2003) and EstimateS (Colwell 2009). For each estimator the estimated number of species, standard error and confidence interval are presented

Estimator	Total	Neophyta	IAS
No species inventoried	491	106	42
Homogeneous model	637±22.5 (599.8–688.8)	137.5±10.2 (123.0–164.4)	46.6±3.3 (43.3.–58.3)
ICE	614.4±10.2 (595.9–636.1)	131.8±4.6 (124.2–142.6)	45.9±1.9 (43.6–51.6)
Chao 2	630.8±29.2 (584.2–700.6)	130.3 ±11.0 (116.5–162.6)	45.7±4.3 (42.6–64.4)
Jackknife 1	636.8±16.6 (607.7–673.1)	138±7.8 (126–157.2)	48.2±3.4 (44.3–59.1)
Jackknife 2	707.1 ±26.7 (660.9–766.0)	151±12.5 (132.4–182.7)	50.9±5.5 (44.9–69.1)
Bootstrap	558.3	121.1	45

areas were selected for further monitoring based on accessibility, percentage of green area, proportion of IAS inventoried etc. (Table 4).

When comparing the composition of neophytes in the two harbours, out of a total of 149 species, 37 species were present only in Sulina and 54 only in Constanţa. Only ten species of neophytes reported from the study area were not present in the two harbours. For some neophytes the date of first sighting was available from literature records and allowed to estimate the dynamics of introductions in time (Fig. 7).

Discussion

Our results are consistent with the general opinion that human activities have a major influence on the dispersal of exotic plants (Mack and D'antonio 1998). Harbours act not only as gateways for IAS but also as reservoirs. The two studied harbours can be considered as critical transition zones between land, freshwater habitats and the sea (sensu Levin et al. 2001). The high invasion rates result from the high propagule pressure and from the high disturbance rates that contribute to the successful establishment by new invaders. Due to the weak boundaries and the dispersal corridors represented by highways, railways and or canals there is a constant spillover of neophytes into the surrounding areas. Our study has shown that neophytes were mostly contained within highly degraded and human-dominated ecosystems. Vilà and Pujadas (2001) found that the parameters that best explained the density of alien plants were the human development index and imports. Since our study was limited to harbours we could not verify this assumption.

While the importance of ballast water (e.g. International Global Ballast Water Management Programme) and hull fouling (Drake and Lodge 2007) have received extensive attention, dry ballast received less attention. For example, it was estimated that a wooden sailing vessel in 1750 could have carried 120 marine organisms fouling, boring into or nestling on the hull; and a further 30 associated with dry ballast and the anchor chain (Carlton 1999). Early wooden vessels were frequently loaded with dry ballast to adjust buoyancy and increase stability (Minchin et al. 2009). The cord grass *Spartina maritima* was probably introduced to South Africa along with dry ballast (Griffiths et al. 2009). To curb the growing number of alien aquatic species transport through ballast water, the International Maritime Organization (IMO) began developing a binding instrument for control of ships' ballast water control in 1997 to avoid unilateral responses by individual states in such an international industry. The International Convention for the Control and Management of Ships' Ballast Water and Sediments was finally adopted in February 2004. It aims to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments (Shine 2007). No legal measures were considered until now for solid ballast.

Managing the vectors carrying alien species can only reduce the risks of invasions, but not prevent it. Ongoing monitoring can help by quickly detecting a new invasion, thus allowing for timed control efforts and higher probability of success in eliminating it. An important component of any monitoring program is its sensitivity (i.e. the probability that it would detect a target species if present). While the detection of even a single individual of a target species indicates that the survey area is not free of that species, its absence cannot be ascertained despite any number of negative surveys. Monitoring costs can be reduced by targeting habitats preferred or likely to have the greatest population size (Hayes et al. 2005).

There is a high turnover of plant species within Constanţa harbour that explain the incomplete inventory after nine visits. For example, a number of neophytes like *Amaranthus palmeri*, *Amaranthus rudis*, *Amaranthus tamariscinus*, *Persicaria pensylvanica*, *Cardiospermum halicacabum*, *Senna obtusifolia*, *Sesbania exaltata*, *Biscutella auriculata*, *Solanum rostratum*, *Solanum carolinense*, *Ipomoea hederacea*, *Ipomoea lacunosa*, *Ipomoea quamoclit*, *Datura stramonium* var. *tatula*, *Setaria faberi*, *Sida spinosa*, *Salsola collina* were reported by Costea (1996). They probably originate from shipping, especially from cereal trade. Some species were not inventoried afterwards (e.g. *Sida spinosa, Cardiospermum halicacabum, Senna obtusifolia, Salsola collina*

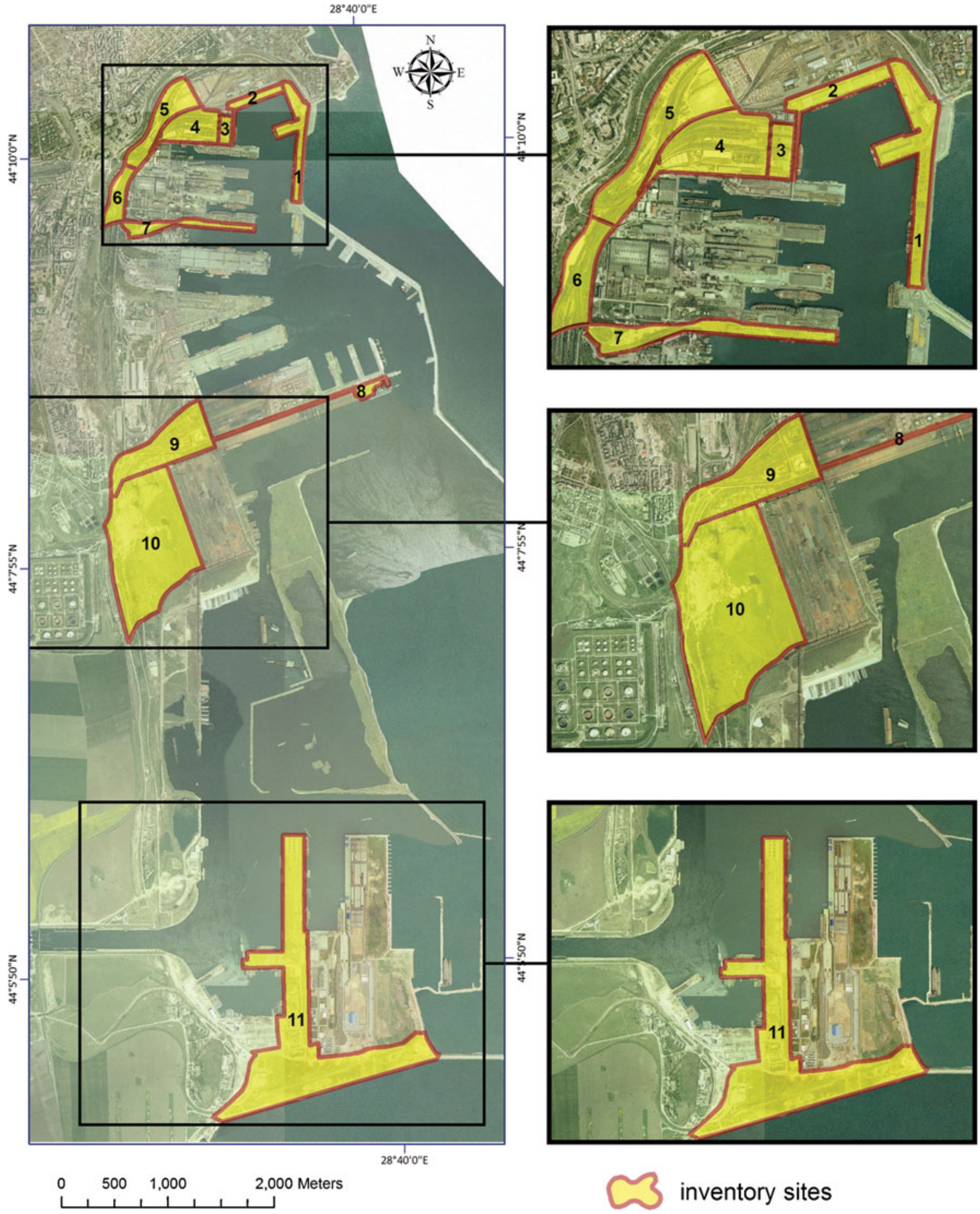

Fig. 6 Zonation of the Constanța harbour for monitoring purposes

etc.) while others became naturalized in the meantime (e.g. *Amaranthus palmeri, Ipomoea hederacea, Ipomoea lacunosa, Solanum carolinense*). Two additional species (*Chloris barbata* and *Bromus willdenowii*) were reported from the Constanta harbour (Anastasiu and Negrean 2008, Anastasiu et al. 2009). Since they are not ornamental plants they most probably were transported jointly with cereal containers.

Our repeated surveys allowed us to test several methods of species richness measures. We recommend the use of species accumulation curves and estimators of species richness that can prove a useful tool in designing

Table 4 Main characteristics of the eleven zones delimited for monitoring in the harbour of Constanța (see also Fig. 6)

Study zone	Perimeter (m)	Area (ha)	Total number of plant species	Native plant species	Neophyta
1	3042	13	148	148	36
2	1921	5	106	106	31
3	795	3	30	30	10
4	1977	16	137	137	36
5	2414	18	112	112	30
6	1531	9	57	57	11
7	2698	10	47	47	10
8	3790	5	91	91	7
9	2935	33	59	59	15
10	4140	89	108	108	25
11	9871	121	154	154	40

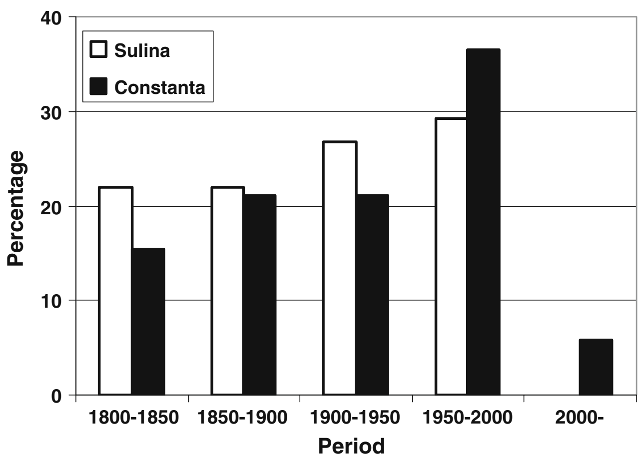

Fig. 7 Frequency distribution of neophyta according to the reported date of introduction. Sample size n=41 Sulina and n=52 for Constanta

and evaluating simple monitoring programs based on repeated inventories. Our study focused on neophytes has stressed the importance of monitoring not only coastal waters but also green areas in harbours for IAS. Since alien species soon after entering the harbours can be easily contained and even eradicated, early detection systems are required.

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Annex

List of neophytes recorded along the Black Sea shore from Sulina to Cape Kaliakra between 2004–2009

No.	Non-indigenous taxa	Family	Life form	Native range	Way of introduction	Invasive status
1.	*Acer negundo*	Sapindaceae	PhM	Am	d (orn)	I
2.	*Acorus calamus*	Araceae	H	As	d (med)	N
3.	*Aesculus hippocastanum*	Sapindaceae	PhM	EuS-E	d (orn)	C
4.	*Ailanthus altissima*	Simaroubaceae	PhM	As	d (orn)	I
5.	*Alcea rosea*	Malvaceae	H	Med	d (orn)	I
6.	*Alopecurus myosuroides*	Poaceae	T	EuW,S&C	a	I
7.	*Amaranthus albus*	Amaranthaceae	T	AmN	a	I
8.	*Amaranthus blitoides*	Amaranthaceae	T	AmN	a	I
9.	*Amaranthus caudatus*	Amaranthaceae	T	AmN	d	C
10.	*Amaranthus crispus*	Amaranthaceae	T	AmS	a	I
11.	*Amaranthus emarginatus*	Amaranthaceae	T	Trop	a	I
12.	*Amaranthus hybridus*	Amaranthaceae	T	AmN	a	I
13.	*Amaranthus palmeri*	Amaranthaceae	T	AmN	a	N
14.	*Amaranthus powellii*	Amaranthaceae	T	AmN&S	a	I
15.	*Amaranthus retroflexus*	Amaranthaceae	T	AmN	a	I
16.	*Amaranthus rudis*	Amaranthaceae	T	AmN	a	N

(continued)

No.	Non-indigenous taxa	Family	Life form	Native range	Way of introduction	Invasive status
17.	*Ambrosia artemisiifolia*	Asteraceae	T	AmN	a	I
18.	*Ambrosia trifida*	Asteraceae	T	AmN	a	I
19.	*Amorpha fruticosa*	Fabaceae	PhN	AmN	d (orn, for)	I
20.	*Anethum graveolens*	Apiaceae	T	AsSW, India	d (food)	C
21.	*Antirrhinum majus*	Plantaginaceae	T	Med	d (orn)	C
22.	*Apium graveolens* subsp. *graveolens*	Apiaceae	TH	EuW&S	a	N
23.	*Armoracia rusticana*	Brassicaceae	H	EuSE&AsW	d (food)	N
24.	*Artemisia annua*	Asteraceae	T	AsC&SW	a	I
25.	*Asclepias syriaca*[a]	Apocynaceae	H	AmN	d (meliferous)	I
26.	*Atriplex hortensis*	Amaranthaceae	T	As	d (food)	C
27.	*Avena sativa s.l.*	Poaceae	T	unknown	d (food)	C
28.	*Azolla filiculoides*	Azollaceae	HH	AmN	a	I
29.	*Bassia scoparia*	Amaranthaceae	T	RussiaE&S	a	I
30.	*Bidens frondosa*	Asteraceae	T	AmN	a	I
31.	*Brachyactis ciliata*	Asteraceae	T	As	a	I
32.	*Brassica rapa* subsp. *oleifera*	Brassicaceae	T-TH	cult.	d (ind)	C
33.	*Brassica rapa* subsp. *sylvestris*	Brassicaceae	T-TH	Med	a	C
34.	*Bromus madritensis*	Poaceae	T	EuW&S, AfrN	a	C
35.	*Bromus rigidus*	Poaceae	T	Med	a	C
36.	*Bromus willdenowii*	Poaceae	T	AmS	a	C
37.	*Calendula officinalis*	Asteraceae	T-H	Med	d (orn, med)	C
38.	*Celosia argentea* var. *cristata*	Amaranthaceae	T	Trop	d (orn)	C
39.	*Chamomilla suaveolens*	Asteraceae	T	Am,As	a	I
40.	*Chenopodium ambrosioides*	Amaranthaceae	T	AmTrop	a	I
41.	*Chenopodium botrys*	Amaranthaceae	T	Sm	a	C
42.	*Chloris barbata*	Poaceae	T	AmTrop	a	C
43.	*Citrullus lanatus*	Cucurbitaceae	T	AfrNW	d (food)	C
44.	*Cleome spinosa*	Brassicaceae	T	AmS	d (orn)	C
45.	*Cladium mariscus* subsp. *martii*	Cyperaceae	H	AsC&Med	a	N
46.	*Commelina communis*	Commelinaceae	H	As	d (orn)	N
47.	*Consolida ajacis*	Ranunculaceae	T	Med	d (orn)	C
48.	*Conyza canadensis*	Asteraceae	T	AmN	a	I
49.	*Coreopsis tinctoria*	Asteraceae	T	AmN	d (orn)	C
50.	*Cucumis sativus*	Cucurbitaceae	T	As	d (food)	C
51.	*Cucurbita pepo*	Cucurbitaceae	T	AmC	d (food)	C
52.	*Cuscuta campestris* subsp. *campestris*	Convolvulaceae	T	AmN	a	I
53.	*Cuscuta suaveolens*	Convolvulaceae	T	AmS	a	N
54.	*Cydonia oblonga*	Rosaceae	PhM	AsSW	d (food)	C
55.	*Cymbalaria muralis*	Plantaginaceae	H	Med	d (orn)	N
56.	*Cyperus odoratus*	Cyperaceae	T-H	Trop	a	I
57.	*Datura innoxia*	Solanaceae	T	AmC	d (orn)	C
58.	*Datura stramonium*	Solanaceae	T	Am	a	I
59.	*Eclipta prostrata*	Asteraceae	T	AmTrop	a	I
60.	*Elaeagnus angustifolia*	Elaeagnaceae	PhN	AsTemp	d (orn, for)	I
61.	*Eleusine indica*	Poaceae	T	Trop	a	I
62.	*Elodea nuttallii*	Hydrocharitaceae	HH	AmN	a	I
63.	*Erigeron annuus* subsp. *annuus*	Asteraceae	TH	AmN	a	I
64.	*Euphorbia maculata*	Euphorbiaceae	T	AmN	a	I
65.	*Fallopia aubertii*	Polygonaceae	PhLi	As	d (orn)	C
66.	*Ficus carica*	Moraceae	PhN	Med	d (food)	C
67.	*Foeniculum vulgare*	Apiaceae	T-H	Med	d (arom)	C

(continued)

No.	Non-indigenous taxa	Family	Life form	Native range	Way of introduction	Invasive status
68.	*Fragaria × ananassa*	Rosaceae	H	cult.	d (food)	C
69.	*Fraxinus americana*	Oleaceae	PhM	AmN	d (orn)	I
70.	*Fraxinus pennsylvanica*	Oleaceae	PhM	AmN	d (orn)	I
71.	*Gaillardia pulchella*	Asteraceae	T	AmN	d (orn)	C
72.	*Galinsoga parviflora*	Asteraceae	T	AmS	a	I
73.	*Gleditsia triacanthos*	Fabaceae	PhM	AmN	d (orn, for)	I
74.	*Gomphrena globosa*	Amaranthaceae	T	AmS	d (orn)	C
75.	*Helianthus annuus*	Asteraceae	T	Am	d (food)	C
76.	*Helianthus tuberosus*	Asteraceae	H	AmN	d (orn, food)	I
77.	*Heliotropium curassavicum*	Boraginaceae	H	AmS	a	N
78.	*Hemerocallis fulva*	Hemerocallidaceae	H	As	d (orn)	C
79.	*Hibiscus syriacus*	Malvaceae	PhN	AsE&S	d (orn)	C
80.	*Hordeum distichon*	Poaceae	T	unknown	d (food)	C
81.	*Hordeum marinum*	Poaceae	T	EuW&S	a	C
82.	*Hordeum vulgare*	Poaceae	T	unknown	d (food)	C
83.	*Impatiens balsamina*	Balsaminaceae	T	As(IndiaE)	d (orn)	C
84.	*Ipomoea hederacea*	Convolvulaceae	T	AmTrop	a	N
85.	*Ipomoea lacunosa*	Convolvulaceae	T	AmN	a	N
86.	*Ipomoea purpurea*	Convolvulaceae	T	AmTrop	d (orn)	C
87.	*Iris germanica*	Iridaceae	G	Med	d (orn)	C
88.	*Iva xanthifolia*	Asteraceae	T	AmN	a	I
89.	*Juniperus virginiana*	Cupressaceae	PhN	AmN	d (orn)	C
90.	*Koelreuteria paniculata*	Sapindaceae	PhM	As(China)	d (orn)	C
91.	*Lemna minuta*	Araceae	Hd	Am	a	I
92.	*Lepidium virginicum*	Brassicaceae	T-TH	AmN	a	I
93.	*Lonicera japonica*	Caprifoliaceae	PhLi	AsE	d (orn)	C
94.	*Lycium barbarum*	Solanaceae	PhN	As	d (orn)	I
95.	*Lycopersicon esculentum*	Solanaceae	T	AmS	d (food)	C
96.	*Maclura pomifera*	Moraceae	PhM	AmN	d (orn)	C
97.	*Malus domestica*	Rosaceae	PhM	AsC	d (food)	C
98.	*Medicago sativa* subsp. *sativa*	Fabaceae	T	Med	d (fodder)	N
99.	*Mentha×piperita*	Lamiaceae	H	cult.	d (med, arom)	N
100.	*Mentha spicata*	Lamiaceae	H	EuW&S	d (med, arom)	N
101.	*Mirabilis jalapa*	Nyctaginaceae	H	AmTrop	d (orn)	C
102.	*Morus alba*	Moraceae	PhM	As(China)	d (ser)	I
103.	*Nicotiana alata*	Solanaceae	T	AmS	d (orn)	C
104.	*Oenothera biennis*	Onagraceae	TH	AmN	d (orn)	N
105.	*Oenothera erythrosepala*	Onagraceae	TH	AmN	d (orn)	I
106.	*Oxalis corniculata*	Oxalidaceae	H	AmN&C	a	I
107.	*Oxalis europaea*	Oxalidaceae	H	AmN, AsE	a	I
108.	*Oxalis stricta* [syn. *O. dillenii*]	Oxalidaceae	T-H	AmN	a	I
109.	*Panicum capillare*	Poaceae	T	AmN	a	I
110.	*Panicum dichotomiflorum*	Poaceae	T	AmN	a	N
111.	*Parthenocissus inserta*	Vitaceae	PhLi	AmN	d (orn)	I
112.	*Parthenocissus tricuspidata*	Vitaceae	PhLi	AmN	d (orn)	N
113.	*Perilla frutescens*	Lamiaceae	T	As	d (orn)	C
114.	*Petroselinum crispum*	Apiaceae	TH	Med	d (arom)	N
115.	*Petunia×atkinsiana*	Solanaceae	T	cult.	d (orn)	C
116.	*Petunia parviflora*	Solanaceae	T-H	AmS	a	N
117.	*Phalaris canariensis*	Poaceae	T	Canare	d (fodder)	C
118.	*Phytolacca americana*	Phytolaccaceae	H	AmN	d (tinct)	I

(continued)

No.	Non-indigenous taxa	Family	Life form	Native range	Way of introduction	Invasive status
119.	*Polygonum orientale*	Polygonaceae	T	AsE&SE	d (orn)	C
120.	*Portulaca grandiflora*	Portulacaceae	T	AmS	d (orn)	C
121.	*Prunus armeniaca*	Rosaceae	PhM	AsW	d (food)	C
122.	*Prunus cerasus*	Rosaceae	PhM	EuSE&AsW	d (food)	C
123.	*Prunus persica*	Rosaceae	PhM	As(China)	d (food)	C
124.	*Raphanus sativus*	Brassicaceae	T-TH	unknown	d (food)	C
125.	*Ribes aureum*	Grossulariaceae	PhN	AmN	d (orn)	N
126.	*Ricinus communis*	Euphorbiaceae	T	AfrTrop	d (orn)	C
127.	*Robinia pseudacacia*	Fabaceae	PhM	AmN	d (orn, for)	I
128.	*Salvia splendens*	Lamiaceae	T	AmS	d (orn)	C
129.	*Satureja hortensis*	Lamiaceae	T	Med	d (arom)	C
130.	*Setaria faberi*	Poaceae	T	AsE	a	N
131.	*Sedum sarmentosum*	Crassulaceae	Ch	As	d (orn)	C
132.	*Sicyos angulatus*	Cucurbitaceae	T	AmN	d (orn)	I
133.	*Solanum carolinense*	Solanaceae	H	AmN	a	N
134.	*Solanum triflorum* subsp. *ponticum*	Solanaceae	T	AmN	a	I
135.	*Solanum tuberosum*	Solanaceae	T	AmS	d (food)	C
136.	*Solidago canadensis*[a]	Asteraceae	H	AmN	d (orn)	I
137.	*Solidago gigantea* subsp. *serotina*[a]	Asteraceae	H	AmN	d (orn)	I
138.	*Sophora japonica*	Fabaceae	PhM	AsE	d (orn)	C
139.	*Sorbaria sorbifolia*	Rosaceae	PhN	As	d (orn)	C
140.	*Sorghum dochna* var. *technicum*	Poaceae	T	AsS	d (fodder)	C
141.	*Sorghum halepense*	Poaceae	H	AfrN,AsSW	a	I
142.	*Tagetes patula*	Asteraceae	T	Am	d (orn)	C
143.	*Tamarix tetrandra*	Tamaricaceae	PhN	EuSE&AsSW	d (orn)	C
144.	*Tanacetum indicum*	Asteraceae	Ch	As	d (orn)	C
145.	*Tanacetum parthenium*	Asteraceae	H	Med	d (orn)	C
146.	*Tecoma radicans*	Bignoniaceae	PhLi	AmN	d (orn)	C
147.	*Tradescantia virginiana*	Commelinaceae	H	AmN	d (orn)	C
148.	*Trigonella caerulea*	Fabaceae	T	Med	d (fodder)	C
149.	*Triticum aestivum*	Poaceae	T	As	d (food)	C
150.	*Ulmus pumila*	Ulmaceae	PhM	As	d (orn)	I
151.	*Vallisneria spiralis*	Hydrocharitaceae	HH	Trop	d (acv)	I
152.	*Veronica persica*	Plantaginaceae	T	As	a	I
153.	*Vinca major*	Apocynaceae	H	Med	d (orn)	C
154.	*Viola×wittrockiana*	Violaceae	T	cult.	d (orn)	C
155.	*Vitis vinifera*	Vitaceae	PhLi	AsSW, Med	d (drink)	N
156.	*Xanthium spinosum*	Asteraceae	T	AmS	a	I
157.	*Xanthium strumarium* subsp. *italicum*	Asteraceae	T	Med	a	I
158.	*Zea mays*	Poaceae	T	Am	d (food, fodder)	C
159.	*Zinnia elegans*	Asteraceae	T	AmN	d (orn)	C

Life form: *Ch* Chamaephytae, *G* Geophyte, *H* Hemicryptophyte, *Hd* Hydrophyte, *PhEp* Epiphyte, *PhLi* Liana, *PhM* Macrophanerophyte, *PhN* Nanophanerophyte, *T* Therophyte, *TH* Hemitherophyte

Origin: *Af* Africa, *Am* America, *As* Asia, *Eu* Europe, *Trop* Tropical, *Med* Mediterranean, *Sm* Submediterranean, *N* North, *E* East, *S* South, *W* West, *C* Centre (central)

Way of introduction: *a* accidental, *d* deliberate, *orn* ornamental; *food* human food, *for* forestry, *med* medicinal, *arom* aromatic, *tinct* tinctorial, *ser* sericiculture

Invasive status: *I* invasive, *N* naturalized, *C* casual

[a] invasive species in Romania, but only escaped from cultivation to Sulina (casual)

References

Administration of Constantza Port (2009) Constantza port handbook, pp 07–08

Anastasiu P, Negrean G (2008) New alien plants to Romania. Analele Univ. din Craiova. Seria Agricultură, Montanologie, Cadastru 38/B: 1–10

Anastasiu P, Negrean G, Samoilă C, Făgăraş M, Cogălniceanu D (2009) A major gateway and reservoir for alien plant species—Constanța Harbour (Romania). Acta Horti Bot Bucur 36:1–25

Carlton JT (1999) The scale and ecological consequences of biological invasions in the world's oceans. In: Sandlund OT, Schei PJ, Viken A (eds) Invasive species and biodiversity management. Kluwer Academic Publishers, Dordrecht, pp 195–212

Carlton JT (2001) Introduced species in US coastal waters: environmental impacts and management priorities. Pew Oceans Commission, Arlington

Chao A, Shen T-J (2003) Program SPADE (Species Prediction And Diversity Estimation). Program and User's Guide. http://chao.stat.nthu.edu.tw. Accessed 26 September 2010

Ciocârlan V (2009) Flora Ilustrată a României. Pteridophyta et Spermatophyta, 2nd edn. Edit. Ceres, Bucureşti, pp 1140

Cogălniceanu D (2007) Biodiversity, 2nd edn. Verlag Kessel, Remagen-Oberwinter, Germany, p 126

Colwell RK (2009) EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.2. User's Guide and application. http://purl.oclc.org/estimates. Accessed 26 September 2010

Commission Européenne du Danube (1931) La Commission Européenne du Danube et son oeuvre de 1856 à 1931. Imprimerie Nationale, Paris

Costea M (1996) The recording of some new adventive taxa for Romania in the harbour Constanța. Rev Roum Biol Veg 41:91–96

DiCastri F (1989) History of biological invasions with special emphasis on the Old World. In: Drake JA, Mooney HJ, DiCastri F et al (eds) Biological invasions: a global perspective. Chichester, Wiley

Drake JM, Lodge DM (2007) Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. Aquat Invasions 2:121–131

Galil BS, Minchin D (2006) Chapter 4: snakes and ladders: navigable waterways as invasion corridors. In: Davenport J, Davenport JL (eds) The ecology of transportation: managing mobility for the environment, pp 71–75

Griffiths CL, Mead A, Robinson TB (2009) A brief history of marine bio-invasions in South Africa. Afr Zool 44:241–247

Hayes KR, Cannon R, Neil K, Inglis G (2005) Sensitivity and cost considerations for the detection and eradication of marine pests in ports. Mar Pollut Bull 50:823–834

Kanitz A (1879–1881) Plantas Romaniae hucusque cognitas enumerate. MNL, Cluj

Levin LA, Boesch DF, Covich A, Dahm C, Erséus C, Ewel KC, Kneib RT, Moldenke A, Palmer MA, Snelgrove P, Strayer D, Weslawski JM (2001) The function of marine critical transition zones and the importance of sediment biodiversity. Ecosystems 4:430–451

Lodge DM, Williams S, MacIsaac HJ, Hayes KR, Leung B, Reichard S, Mack RN, Moyle PB, Smith M, Andow DA, Carlton JT, McMichael S (2006) Biological invasions: recommendations for U.S. policy and management. Ecol Appl 16:2035–2054

Mack MC, D'Antonio CM (1998) Impacts of biological invasions on disturbance regimes. TREE 13:195–198

Mack RN, Simberloff D, Lonsdale WM, Evans H, Clout M, Bazzaz F (2000) Biotic invasions: Causes, epidemiology, global consequences and control. Issues in Ecology, No 5, Ecological Society of America.

Minchin D, Gollasch S, Cohen AN, Hewitt CL, Olenin S (2009) Characterizing vectors of marine bioinvasions. In: Rilov G, Crooks JA (eds) Biological invasions in marine ecosystems. Springer, Berlin, pp 109–116

National Institute of Statistics (2008) Statistical yearbook 2008. http://www.insse.ro. Accessed 26 September 2010

Occhipinti Ambrogi A (2001) Transfer of marine organisms: a challenge to the conservation of coastal biocoenoses. Aquatic Conserv: Mar Freshw Ecosyst 11:243–251

Pyšek P, Richardson DM, Rejmánek M, Webster GL, Williamson M, Kirschner J (2004) Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon 51(1):131–143

Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ (2000) Naturalization and invasion of alien plants: concepts and definitions. Divers Distrib 6:93–107

Shine C (2007) Invasive species in an international context: IPPC, CBD, European Strategy on Invasive Alien Species and other legal instruments. Bulletin OEPP/EPPO Bulletin 37:103–113

Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (eds) (1964–1980) Flora Europaea, vol 1–5. Cambridge University Press, Cambridge

Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA (eds, assist. by J.R. Akeroyd & M.E. Newton; appendices ed. by R.R. Mill), (1993). Flora Europaea. 2nd ed., vol. 1. Psilotaceae to Platanaceae. Cambridge University Press, Cambridge

Vilà M, Pujadas J (2001) Land use and socio economic correlates of plant invasions in European and North African countries. Biol Conserv 100:397–401