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Review

Who's Next? Non-Indigenous Cnidarian and Ctenophoran Species Approaching to the Italian Waters

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Abstract: The aims of the present paper were to review the knowledge about the Mediterranean non-indigenous species of the taxa Cnidaria and Ctenophora (CC NIS), to screen the risk of 98 species for their potential invasiveness in the Mediterranean Sea and their approach to the Italian waters. Of these, 38% are well established in the basin, 4% are known for their invasiveness, 44% are casual, 11% have a taxonomic status unresolved, and 3% are included in the category "cryptogenic". The biodiversity CC NIS of the Mediterranean Sea has changed considerably in the last two decades and 27 out of 98 Mediterranean CC NIS are present in the Italian waters. Fifteen CC NIS, some equipped with high invasive potential, should be regarded as good candidates to become future immigrants of the Italian waters. Anticipatory NIS forecast based on biogeographical and ecological analyses may provide a useful tool for targeted management of the CC NIS issue and for the assessment of the second descriptor of Good Environmental Status. On the other hand, conservation and management of marine ecosystem should be based on the conservation of the essential environmental conditions for the functioning of these ecosystems instead of the contamination or eradication of alien species.

Keywords: non-indigenous Cnidaria and Ctenophora; pathways; ecological trends; Mediterranean Sea; Italian waters

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1. Introduction

Marine non-indigenous species (NIS) represent a potential risk to the host environments [1,2] inducing ecosystem alterations often with socioeconomic effects in coastal areas [3–5].

Dispersal and invasion of species in new habitats have occurred throughout the history of marine life, but an important point is the fast rate at which invasions are recently taking place facilitated by anthropic activities [6]. The rate of introduction and the spread of invasive alien species increased rapidly in recent decades, so that these species are now considered one of the first anthropogenic threats for the marine communities [7–9]. Worldwide revisions and inventories highlight that biological diversity consists of both long-term native species and NIS that in some regions can contribute to local biodiversity with up to more than half of all the species [10]. Today, more than 980 alien species have been counted in the most invaded marine region of the world situated between Spanish and Middle East Mediterranean waters [1]. The best-known Mediterranean invasions are linked to macroalgae with negative impacts on native communities, biodiversity reduction, and ecological relationships alteration [11–14].

Mediterranean NIS have been examined by the scientific community through spatial and temporal patterns flanked by revision or species inventories [1,5,6,15–27]. Moreover, breaking of ecological barriers and excavating of canals promoted invasions of marine NIS leading to inclusion of the Mediterranean Sea into the Indo-Pacific region [28]. In the last decades, climate change affects the vulnerability of the region to biological invasions [29–31], influencing native species' geographical and depth ranges [32,33] or the possibility that these species may be replaced by NIS [34,35]. Changing climate is leading indeed the Mediterranean Sea into a new stage characterized by an increase in the number of NIS with warm water affinities [16,36].

Several studies have covered the native distribution range of the Mediterranean marine NIS, but most of them have examined it only at country or regional level [2,37–39]. Only a few studies have provided a large-scale estimate of the native distribution of NIS across the Mediterranean and the other European Seas [1,27,40]. Furthermore, the revolution of Good Environmental Status (GES), 11 descriptors of the European Marine Strategy Framework Directive, introduced a new approach to define the status of the environment considering the effects of the putative causes of impact on the living component [33].

In this study, the Mediterranean non-indigenous species of the taxa Cnidaria and Ctenophora (CC NIS) have been considered as a good proxy for changes in biodiversity in the plankton and in the benthos, because of their structuring and functional roles. They inhabit all aquatic ecosystems displaying a wide array of life-cycle strategies with potential negative impacts on biodiversity, ecosystem, tourism, fisheries, fish farms, and power plants. Their native distribution and the main introduction pathways have been examined jointly to time trends of species introductions in relation to the prevailing native distribution areas. Moreover, evaluation of their invasiveness, also through the analysis of some case studies, could allow anticipatory NIS forecast based on biogeographical and ecological analyses of the CC NIS identified as good candidates to become future immigrants of the Italian waters that, to date, host more than 160 marine and brackish NIS along its coastline [39].

2. Materials and Methods

An inclusive bibliographic survey was performed to gather data for this review (indexed and non-indexed journals, checklists, on-line databases, and grey literature). Taxonomically, our survey is based on the extensive revision of the information found in the World Register of Marine Species [41]. Only CC NIS detected in marine and brackish waters were considered.

We identified Mediterranean CC NIS by examining records from the 19th century to 2020 to trace their origin, date, method of introduction, current distribution and establishment status, and global distribution. A database with more than 18,200 records was organized to provide the following information: species, family, collector, life-cycle phase, reproductive state, location, date of collection, publication year of the article, substrate type, water depth, synonymy, and cited references.

The following data (Supplementary Materials) are provided for each CC NIS:

- establishment success in the Mediterranean Sea according to Zenetos et al. [15]: established (widely recorded at some sites), invasive (able to disseminate from their area of initial introduction), casual (few records), cryptogenic (species with no definite evidence of their native or introduced status), questionable (species with taxonomic status unresolved), unknown;
- first record in the Mediterranean Sea (date, locality, reference: the date and location of the first observation) of each species in the Mediterranean Sea were extracted from the literature; if possible, the actual date of first record was reported, along with its publication date;
- native distribution range: following the global marine biogeographic realms proposed by Spalding et al. [42];
- distribution per Mediterranean subregion (following MSFD, Marine Strategy Framework Directive, 2017) [43]: Aegean-Levantine Sea, Ionian Sea and the Central Mediterranean Sea, Adriatic Sea, Western Mediterranean Sea;
- extra-Mediterranean distribution;
- the taxonomic position of each species (Class, Order, Family);
- the primary pathway(s) of introduction in Europe based on CBD [44]: indicating the frequency if low (L), medium (M) or high (H);
- possible notes;

– code of the main pathway(s) of introduction: A (aquaculture), G (range expansion through the Strait of Gibraltar), Lp (Lessepsian), S (shipping), U (unknown).

Temporal trends of CC NIS introductions in the Mediterranean Sea per 5-year intervals have been performed for the time period 1950–2014, whose native distribution corresponds to at least one of the five most important realms of the Mediterranean CC NIS' native distribution ranges (Temperate Northern Atlantic, Central Indo-Pacific, Western Indo-Pacific, Tropical Atlantic, Temperate Australasia). Due to the time lag between observation date of a new CC NIS and its subsequent reporting, temporal trends only reports up to 2014 were taken into consideration.

Finally, CC NIS have been investigated through the evaluation of their invasiveness (depending on the species ability to rapidly conquer new spaces, spread and generate various impacts) by identifying the possible future immigrants of the Italian waters, and considering also the distribution of CC NIS already established in the Italian seas through the following steps: (1) summarize the data about CC NIS in the Italian waters; (2) determine the origin regions for the CC invaders; (3) analyze CC biodiversity data in each region; (4) determine of new potential Italian invaders according to the data about CC invasive species in neighboring regions (information extracted from Supplementary Materials).

3. Results

Most CC NIS are concentrated in the Aegean-Levantine region (61 species, 38%) followed by the Western Mediterranean Sea (59 species, 36%), Adriatic Sea (22 species, 14%), and Ionian Sea and Central Mediterranean Sea (20 species, 12%). Most CC NIS, established in one or more Mediterranean subregion [43], have their native distribution range in the following Indo-Pacific realms: Central Indo-Pacific (20 species, 21%), Western Indo-Pacific (19 species, 19%), Temperate Australasia (6 species, 6%), and Tropical Eastern-Pacific (2 species, 2%). On the other hand, the Temperate Northern Atlantic (27 species, 28%) and the Tropical Atlantic (10 species, 10%) constitute also important realms of Mediterranean NIS native distributions (Figure 1, Supplementary Materials). Very few CC NIS have their native distribution in the Temperate Northern Pacific (3 species, 3%), Temperate South Africa (2 species, 2%), Temperate South America (2 species, 2%), and Southern Ocean (4 species, 4%); 3 species have an unknown origin (3%). More biogeographical details of the CC NIS with native distribution in each MSFD Mediterranean subregion are provided in Supplementary Materials.

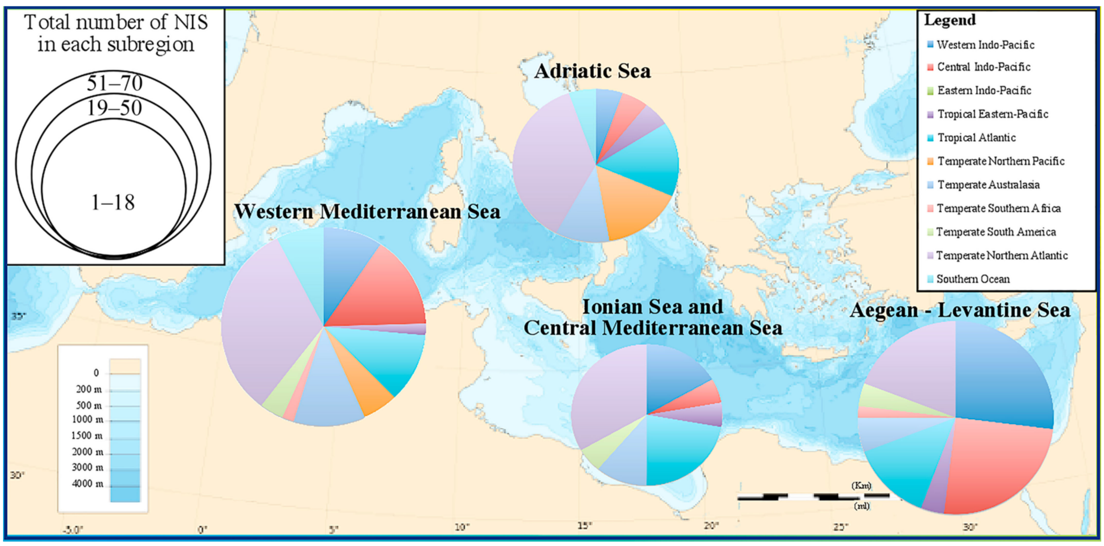

Figure 1. Proportion of the major native distribution ranges of CC NIS (following Spalding et al. [42] for biogeographic realms classifications) in the Mediterranean subregions. The size of each pie chart represents the total number of NIS primarily introduced in a subregion.

Of the 98 CC NIS, 38% are well established in the basin, 4% are known for their invasiveness, 44% are casual, 11% have a taxonomic status unresolved, and 3% are included in the category "cryptogenic".

The analysis has shown different patterns of the most important pathways among the native distribution realms (Figure 2).

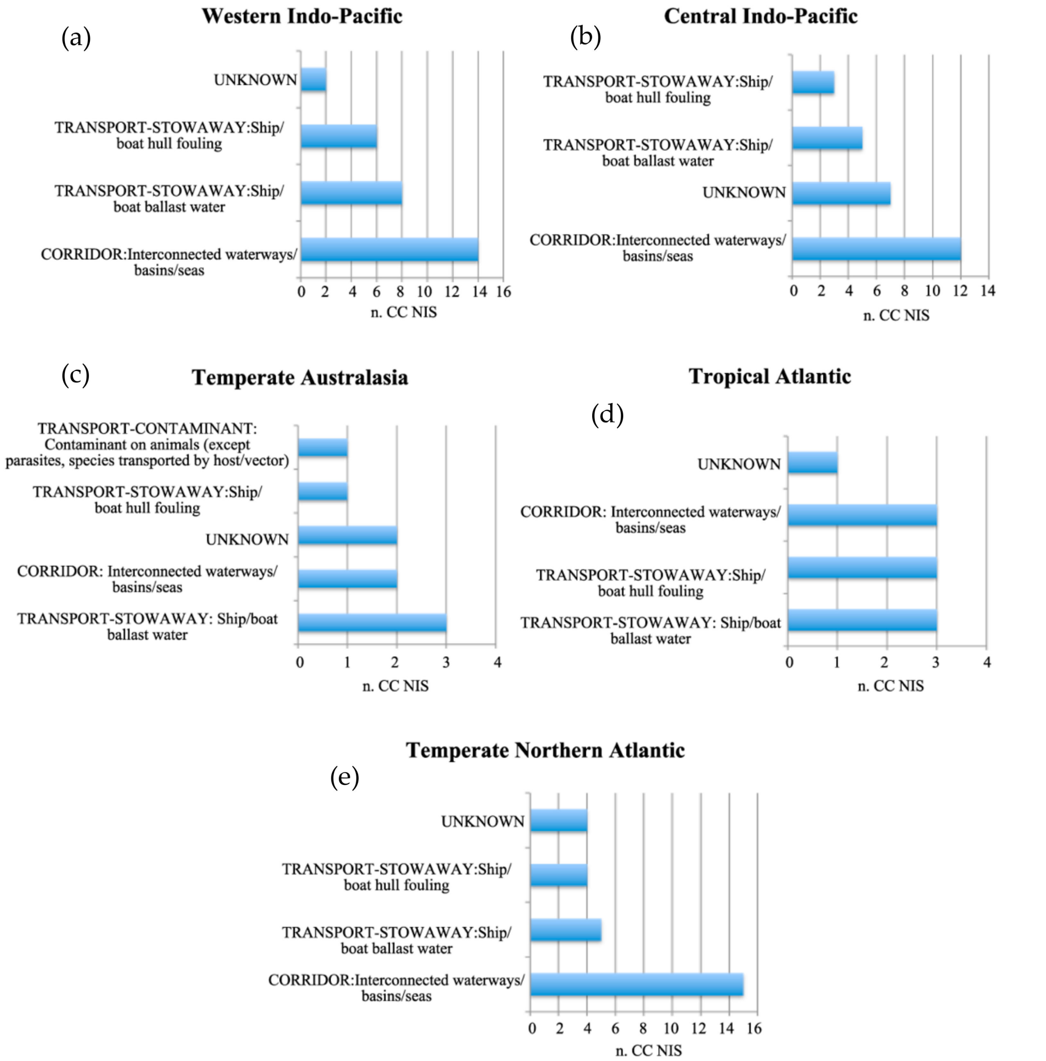

Figure 2. Number of CC NIS introduced in the Mediterranean Sea through primary introduction pathways, based on CBD [44] scheme associated with each of five major realms of Mediterranean CC NIS's native distribution: (**a**) Western Indo-Pacific, (**b**) Central Indo-Pacific, (**c**) Temperate Australasia, (**d**) Tropical Atlantic, (**e**) Temperate Northern Atlantic. Several species are linked to more than one pathway.

CC NIS with native distribution in the Western and Central Indo-Pacific have been introduced into the Mediterranean Sea mostly through "Corridor: interconnected waterways/basins/Seas", corresponding to the Suez Canal. On the other hand, CC NIS with native distribution in the Temperate Australasia have been introduced mainly through shipping, including both "Transport-stowaway: ship/boat ballast water" (hereafter referred to as shipping-ballast) and "Transport-stowaway: ship/boat hull fouling" (hereafter referred to as shipping-fouling). "Transport-contaminant: contaminant on animals (except parasites, species transported by host/vector)" (hereafter referred to as aquaculture-contamination) concerns a few CC NIS with Temperate Australasia native realm. Finally, most CC NIS with native distribution in the Tropical Atlantic are associated with shipping (both ballast and fouling) and with "Corridor: interconnected waterways/basins/Seas". Similarly, CC

NIS related to the Temperate Northern Atlantic realm are mainly linked to interconnection across the Strait of Gibraltar and shipping-ballast/fouling.

Up to 1980–1984, temporal analysis revealed an overall increasing trend of new CC NIS introductions with native distribution in the realms: Western and Central Indo-Pacific, Temperate Australasia, Tropical Atlantic, and Temperate Northern Atlantic. After this period, most of them present a constant or decreasing trend, less for CC NIS introduced from the Indo-Pacific and Temperate Northern Atlantic (Figure 3).

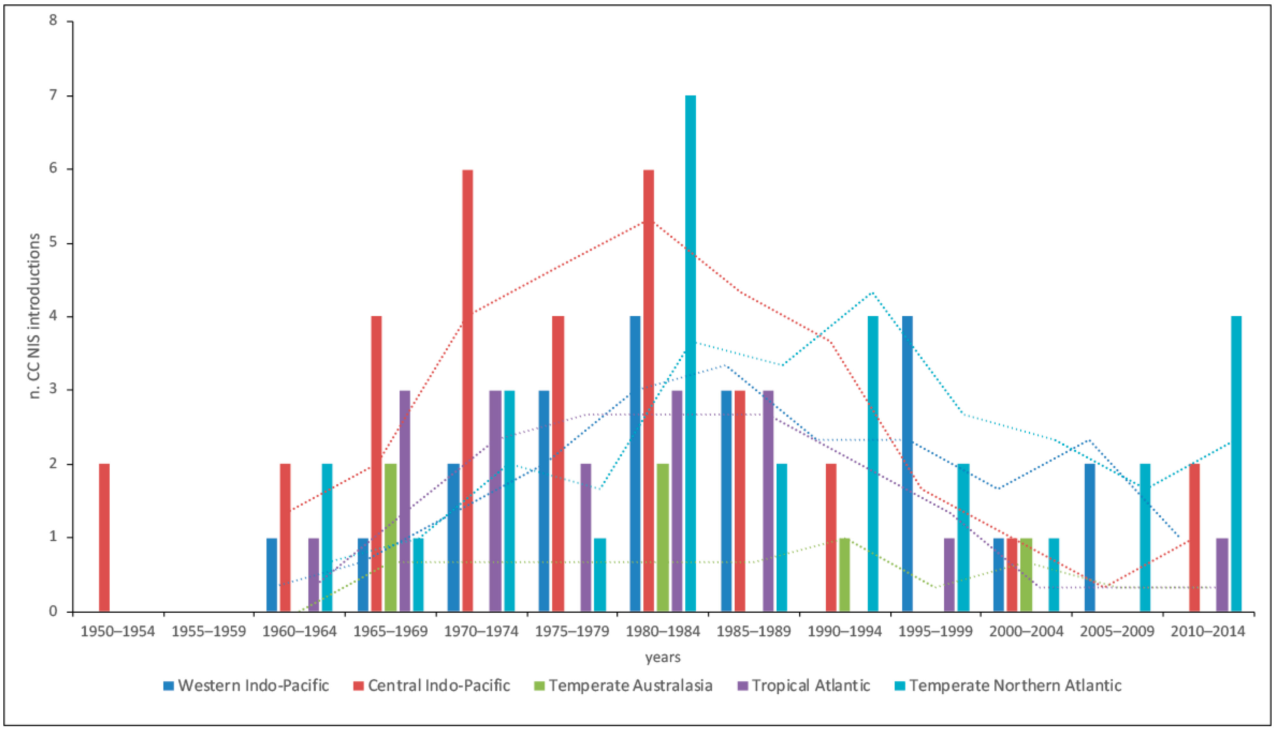

Figure 3. Temporal trends of new marine CC NIS introductions in Europe per 5-year intervals, whose native distribution corresponds to at least one of the five most important realms of Mediterranean CC NIS' native distribution ranges for the time period 1950–2014 (dashed lines: mobile averages over 3-year period).

3.1. Cnidaria and Ctenophora Potential Invaders of the Italian Waters

Among the most invasive species, *Mnemiopsis leidyi* A. Agassiz, 1865 and *Rhopilema nomadica* Galil, Spanier & Ferguson, 1990 have been recently reported in the Italian waters [45–49]. Other CC NIS (15 species), well established in some areas of the Mediterranean basin (some of these equipped with invasive potential), could soon reach the Italian waters (Table 1).

Table 1. Cnidaria potential invaders of the Italian waters.

Taxa	Origin	Main Way of Introduction	Distribution in Mediterranean Sea and Records	Last Record (Locality and Year)	Probable Invasiveness
Hydrozoa					
Dynamena quadridentata (Ellis & Solander, 1786)	Tropical Atlantic	Suez Canal (Lessepsian species)	Levant Sea [50]	Lebanon coast (2004)	++
Eucheilota paradoxica Mayer, 1900	Tropical Atlantic	Unknown	Croatian coast [51], Alborán Sea [52], Levant Sea [53–55], French coast [56,57], Tunisian coast [58,59], Algerian coast [60]	Tunisian coast (2015)	++

Table 1. *Cont.*

Taxa	Origin	Main Way of Introduction	Distribution in Mediterranean Sea and Records	Last Record (Locality and Year)	Probable Invasiveness
Eucheilota ventricularis McCrady, 1859	North temperate Atlantic	Suez Canal (Lessepsian species)	Levant Sea [53–55,61]	Lebanon coast (1989)	+
Haliscera bigelowi *Kramp*, 1947	Tropical eastern Pacific	Unknown	Croatian coast [51,62], Alborán Sea [63], Spanish coast [64–68], Tunisian coast [59,69]	Tunisian coast (2015)	++
Macrorhynchia philippina Kirchenpauer, 1872	Central Indo-Pacific	Suez Canal (Lessepsian species)	Lebanon coast [50,70,71], Levantine coast of Turkey [72], Suez Canal [22], Aegean Sea [73]	Suez Canal (2014)	+++
Moerisia carine Bouillon, 1978	Central Indo-Pacific	Suez Canal (Lessepsian species)	Levant Sea [53–55]	Lebanon coast (1989)	+
Olindias singularis Browne, 1905	Central Indo-Pacific	Suez Canal (Lessepsian species)	Egyptian Mediterranean coast [74]	Egyptian Mediterranean coast (extending from Alexandria in the east to Sidi Barani in the west) (2001)	++
Plumularia pulchella Bale, 1882	Temperate Australasia	Unknown	Alborán Sea [65], Spanish coast [75–77], Egyptian Mediterranean waters [78]	Egyptian Mediterranean waters (1977)	+
Sertularia marginata (Kirchenpauer, 1864)	Western Indo-Pacific	Suez Canal (Lessepsian species)	Levant Sea [50,79–82], Alborán Sea [83]	Alborán Sea (2012)	+++
Sertularia tongensis (Stechow, 1919) as *S. thecocarpa*	Western Indo-Pacific	Suez Canal (Lessepsian species)	Levant Sea [50]	Lebanon coast (2004)	++
Tetrorchis erythrogaster Bigelow, 1909	Tropical eastern Pacific	Unknown	Beyrouth [53–55,61,84]	Lebanon coast (1982)	+
Gymnangium montagui (Billard, 1912)	Temperate North Atlantic	Espansion natural range	French coast [85], Alborán Sea [86]	Strait of Gibraltar and nearly areas (1993)	++
Scyphozoa					
Cotylorhiza erythraea Stiasny, 1920	Western Indo-Pacific	Suez Canal (Lessepsian species)	Levant Sea [87]	Israel coast (2015)	+++
Marivagia stellata Galil & Gershwin, 2010	Western Indo-Pacific	Shipping (ballast waters) (Lessepsian species)	Levant Sea [88–91]	Syrian coast (2015), Lebanese waters (2015)	+++
Anthozoa					
Oulastrea crispata (Lamarck, 1816)	Central Indo-Pacific	Unknown	Corsica [92]	Corsica (2014)	++

+: low; ++: medium; +++: high.

Figure 4 shows the distribution of CC NIS in the Italian seas. The majority of CC NIS are concentrated in the South (16 species) and Central Tyrrhenian Sea (9 species), in the Ligurian Sea (14 species) and in the North Adriatic Sea (9 species).

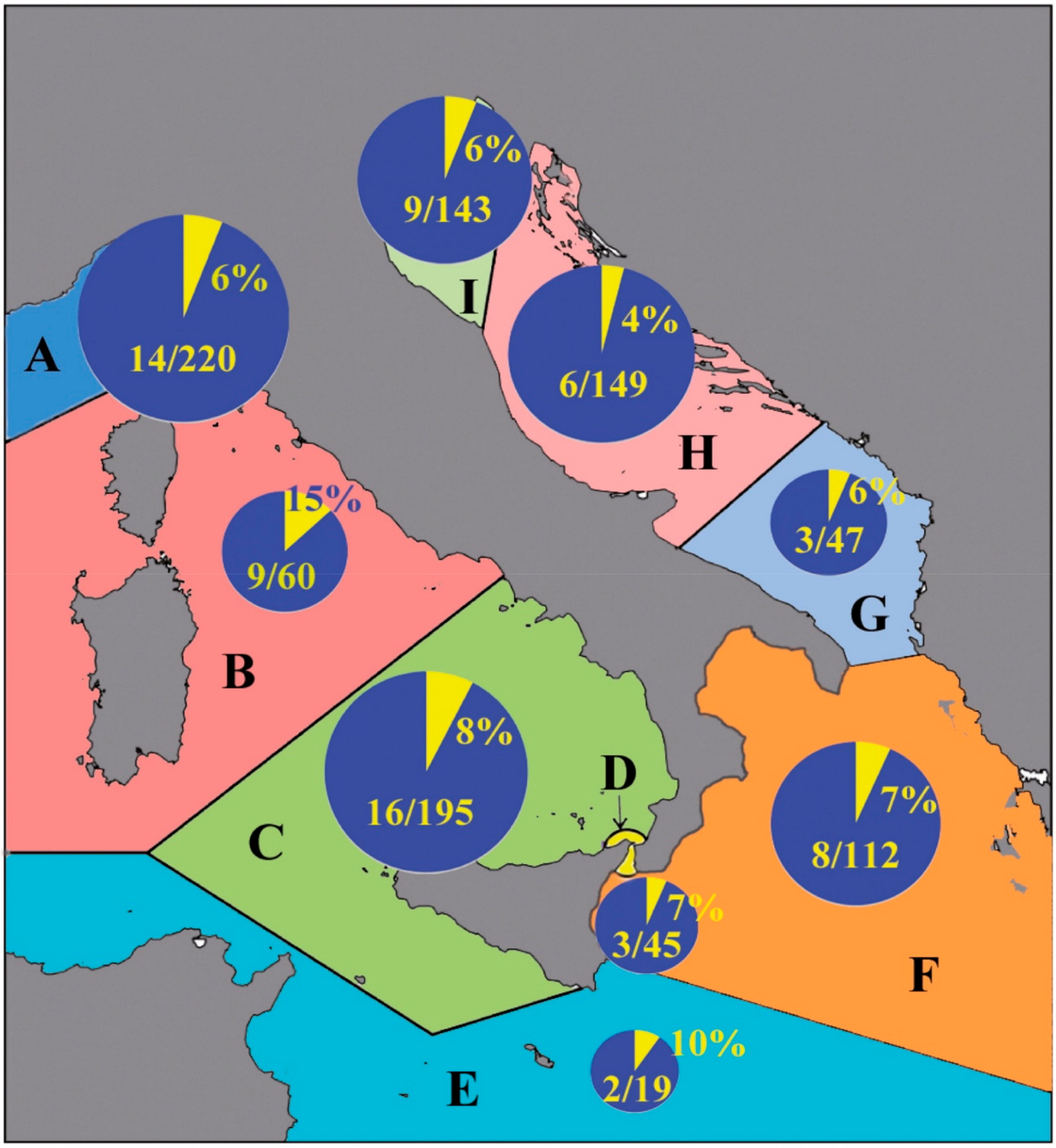

Figure 4. Distribution of CC NIS in each biogeographic area within the Italian Seas following Bianchi [93]. (**A**) Ligurian Sea; (**B**) central Tyrrhenian Sea; (**C**) south Tyrrhenian Sea; (**D**) Strait of Messina; (**E**) south-eastern tip of Sicily, Pelagie Islands; (**F**) Ionian Sea; (**G**) south Adriatic Sea; (**H**) central Adriatic Sea; (**I**) north Adriatic Sea. For each sector, CC NIS percentage and CC NIS number/Cnidaria and Ctenophora total number are shown.

3.2. *Oculina patagonica*, a Positive Alien Species?

In 1966, *Oculina patagonica* de Angelis, 1908 has been registered for the first time in the Mediterranean waters (Savona, Italy) [94,95]. This species expanded its presence, being found in Alicante (Spain, 1973), Egypt (1981) and in the Eastern Mediterranean (1992), as well as in the Croatian waters in 2011 [95]. Recently, it has been detected also in the Sicilian coasts (Giovanni Giallongo personal observation), suggesting an invasive trend in the Italian waters. Its widespread presence is due to its capacity to adapt to harsh conditions and almost to every kind of substrate [96], in vertical or horizontal surfaces and in a wide depth range [97]. Artificial substrata are especially suitable for this invasive species [95,98], which seems to have little problems even in polluted conditions [99,100].

Probably one of the keys to understand the successful invasion of this anthozoan is related to its early sexual reproduction (1–2 years, [95]) and the bailout propagation of the species [99]. Gametogenesis is fast, taking five months in the case of female colonies and three months in the case of male colonies [101], similar to the parasitic alcyonarian *Alcyonium coralloides* [102]. This kind of reproduction may be an advantage in a fast-changing sea in which cnidarians may have problems in the stabilization of their populations due to climate change [103]. However, another potential advantage in the species expansion is the relationship with sea urchins and the erosion of the hard bottom substrate [100]. It has been shown that, in seven years (2003–2010), the population density increased between 172–276% [100], concurrently with an increase in abundance of the *Arbaxia lixula* and *Paracentrotus lividus* sea urchins. The surface eroded by the sea urchins is not suitable for most of the sessile species, but it seems to be an ideal substrate for *Oculina patagonica* expansion.

The presence of the sea urchins seems to be an essential point for the invasive species, which takes advantage of the absence of the macroalgae in shallow waters. However, one interesting point is that, once settled, *O. patagonica* may share the space with new incoming algae that are not grazed by the sea urchins [100]. So, in a certain sense, we are in front of a facilitator species, which in some way partially "protects" some of the autochthonous benthic algae from the excessive sea urchin grazing. The system recovers and may also enhance biodiversity on some occasions due to the presence of this eco-engineering species [104]. *O. patagonica* is thus a good monitored example of how a NIS may partially transform the habitat.

4. Discussion and Conclusions

The Mediterranean Sea is widely colonized by marine NIS hosting the highest number of them in the world [5]. Mediterranean cnidarian biodiversity is changing, and seawater warming is impacting marine ecosystems, but as highlighted by Bianchi et al. [105], an accurate evaluation of changes requires the availability of long-term biological data series.

The Mediterranean high number of CC NIS is mainly linked to the presence of the Lessepsian immigrants, heavy shipping traffic (fouling and ballast waters), but also to the long history of marine monitoring [1,2,15–18,40,106].

According to Galil et al. [28] and Tsiamis et al. [1], the patterns concerning the Mediterranean CC NIS native distribution differ among the Mediterranean marine subregions, following the history and traits of the dominating primary pathways of introduction in each subregion. In fact, the vast majority of the marine Mediterranean CC NIS have their native distribution in the Central and Western Indo-Pacific mostly associated with their introductions into the Mediterranean Sea through the Suez Canal [16,25,40]. As a result, 38% of all the Mediterranean CC NIS primary introductions were reported first in the Aegean-Levantine Sea. On the other hand, CC NIS reported first from the Western Mediterranean Sea have their native distribution mainly in the Temperate Northern Atlantic (28%) as pathway of introduction the entrance through the Strait of Gibraltar and shipping (ballast/fouling) traffic [86,107,108]. Other species of Mediterranean CC NIS have their native distribution in the Tropical Atlantic (10%) and Temperate Australasia (6%) with shipping (both ballast and fouling) as most responsible pathway for their introductions into the Mediterranean basin. On the other hand, very few Mediterranean CC NIS are associated to the Southern Ocean (4%), possibly due to climate differences and the limited pathways presence in this marine realm.

A surge in the records in the 1980s reflects probably the publication of the results of specific programs in the Levant Sea (see Galil [109] for more details). Moreover, the increase in shipping transported CC NIS may be attributed to the increase in shipping volume throughout the Mediterranean basin resulting in new shipping routes, a result of a significant shift in global economy trends. In the same way, the increase in commercial introductions follows the increase of shellfish production in aquaculture facilities [110].

According to several researchers [1,23–25], during the last years an overall negative trend in species introductions is noted in the Mediterranean Sea. However, the observed general decrease in NIS introductions should be considered with caution because could be attributed to the time lag between the observation date of a NIS and its subsequent reporting [1,111,112]. Moreover, this decrease should be attributed to the fewer introductions of CC NIS associated with aquaculture-contamination [17] and shipping, presumably due to compulsory measures implemented at a national or European level [113,114], and the recent adoption by the International Maritime Organization (IMO) of the "International Convention for the Control and Management of Ships' Ballast Water and Sediments" (BWM Convention). The approval of the guidance of the Marine Environment Protection Committee [115] should be encouraged since it concerns the shipping that has an important role in the CC NIS introductions [1,116–119]. We must consider also the permanence and spread of existing CC NIS, and their role in the ecosystem functioning. Is not only a matter of 'new introduced species', but also which role they may have in the habitat composition, energy fluxes and biogeochemical cycles in the near future [103].

According to the CC NIS invasiveness, and the distance from a region where their introductions were registered, three of the fifteen CC NIS potential invaders of the Italian waters (Table 1) deserve special attention.

The first species, *Macrorhynchia philippina* Kirchenpauer, 1872, native of the southern Pacific Ocean region, is one of the alien hydroid species most widely spread and well established in the Levant Sea [70,120]. This Lessepsian invader, found in shallow waters, can create dense populations and has been recorded also in the Aegean Sea introduced by shipping [70,121] being characterized by a high invasive potential. It is now a worldwide species in all tropical and sub-tropical oceans [108] and there are also records from temperate regions [122]. *M. phylippina* is a stinging species and the increase of its density and abundance in the Mediterranean basin could have a negative impact on local economies [70,121].

The second species, *Oulastrea crispata* (Lamarck, 1816), a non-indigenous zooxanthellate scleractinian coral, has been found in shallow water on the west coast of Corsica [92]. It is a species native on near-shore coral reefs in the central Indo-Pacific and a successful colonizer being able to settle on a wide variety of substrata and utilizes various reproductive strategies. Being widespread in temperate and subtropical waters, it is likely that it will be able to find a suitable temperature regime in the Mediterranean basin for further range expansion due to the "tropicalization" of this area [105].

Finally, the third species, *Eucheilota paradoxica* Mayer, 1900 is native of the tropical Atlantic region and its medusa stage has been recorded near the Italian coasts (along the Croatian coast [51] and the French coast [56,57] in the '70s and '90s, respectively), while the most recent records occurred along the African coasts [60].

Another aspect to consider is the spatial scale. According to several authors [123,124], the biodiversity of native and exotic species is often negatively correlated at small scale, but positively related at large scale. At broader spatial scale the complexity of natural community environments reduces the resistance to the spread of NIS provided by high species richness [125,126]. Recently, research on positive or neutral effects of NIS has received particular attention even if, generally, their positive impacts may be underestimated [5,127–130]. In fact, there are many examples in the literature regarding the NIS introduction accounting its effects on diversity, structure and functioning of marine ecosystems [124,131–134] where the problem is magnified because complex life cycles facilitate connectivity among distant environments. An assessment of ecological and economic impacts is still lacking in the marine environment [135–138]. In European seas an attempt to treat the impact of NIS on biodiversity and ecosystem functioning was addressed by Katsanevakis et al. [5]. The authors found most of the ecological services (food provision, water purification, recreation and tourism) were negatively impacted by the presence of NIS. The results of a few macro-ecological studies [124,139] have revealed the presence of positive relationships between alien and native species richness in marine environments focusing attention on some large-scale features. These factors, not detectable by studies carried out on a single species or habitat, can contribute toward the development to a more complete understanding of the impacts of alien species from an ecosystem perspective [124,140,141]. Moreover, the general perception that NIS are a threat to biodiversity is true [142,143] but it should be considered that in most cases the time of investigation has not been long enough to clarify their real effects on the habitat composition and functioning [139,144]. On the one hand, the impact of NIS on biodiversity cannot be generalized because they cause different effects at several spatial and temporal scales [13,124,145–151] being difficult to predict the fate of NIS in new habitat [152]. On the other hand, there is the possibility that some endangered species could also benefit from their transport towards different environments. In fact, considering that some invaders could survive better than endemic species in changing habitats that may compensate the decrease in the number of species caused by climate change and may act as 'reservoirs of diversity' [139,153]. According to Davis et al. [154], the 'practical value of the native-versus-alien species dichotomy' in conservation is setting. As suggested by Giangrande et al. [139], therefore, it is essential to distinguish early NIS from naturalized species defining a temporal baseline that can be used for this purpose.

The monitoring bias is another issue that should not be neglected: inevitably more NIS primary introductions in the Mediterranean Sea have been reported for well-known taxonomic groups (e.g., mollusks, fish, macroalgae) [133,155–157]. In addition, more focused studies are needed to examine pathway-introduction of most Mediterranean CC NIS because for the majority of introductions the pathway certainty is not sufficient, with the exception of the Lessepsian immigrants.

The information concerning the pathways could indeed be useful for CC NIS management per marine subregion according to the MSFD, directing where priority should be given to avoid new introductions. Furthermore, risk screening of the potential invasiveness of non-native species in the Mediterranean Sea can aid managers in making informed decisions on targeting species for management [158].

The study of new arrivals at an ecosystem level should involve interdisciplinary synergism and accurate analysis of species distribution. This requires international cooperation to define issues of provenance and to assess possible risks related to commercial exchanges [139].

In conclusion, as suggested by Corriero et al. [124] and Buonocore et al. [120], from a conservation point of view, diverse marine communities have unquestioned conservation and ecological value, and provide economic benefits such as diving experiences, nursering effect, shelter of fisheries biomass, carbon sequesters. Therefore, two different models should be distinguished during marine monitoring, the first aimed at promptly reporting the arrival of NIS in hot spots of introduction and the second at evaluating the success of these species in marine communities. Finally, according to Ekebom [159] and considering the unpredictability of the invasions processes, methods to detect impacts should be improved by implementing mensurative and experimental studies at different spatial and temporal scales.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/w13081062/s1.

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