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► **To cite this version:**

Argyro Zenetos, Konstantinos Tsiamis, Marika Galanidi, Natacha Carvalho, Cátia Bartilotti, et al.. Status and Trends in the Rate of Introduction of Marine Non-Indigenous Species in European Seas. Diversity, 2022, 14 (12), pp.1077. 10.3390/d14121077 . hal-03921901

**HAL Id: hal-03921901**

**<https://hal.science/hal-03921901>**




Submitted on 4 Jan 2023

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## Article

# Status and Trends in the Rate of Introduction of Marine Non-Indigenous Species in European Seas

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**Citation:** Zenetos, A.; Tsiamis, K.; Galanidi, M.; Carvalho, N.; Bartilotti, C.; Canning-Clode, J.; Castriota, L.; Chainho, P.; Comas-González, R.; Costa, A.C.; et al. Status and Trends in the Rate of Introduction of Marine Non-Indigenous Species in European Seas. *Diversity* **2022**, *14*, 1077.  
<https://doi.org/10.3390/d14121077>

Academic Editor: Bert W. Hoeksema

Received: 1 November 2022

Accepted: 28 November 2022

Published: 6 December 2022

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**Abstract:** Invasive alien species are a major worldwide driver of biodiversity change. The current study lists verified records of non-indigenous species (NIS) in European marine waters until 2020, with the purpose of establishing a baseline, assessing trends, and discussing appropriate threshold values for good environmental status (GES) according to the relevant European legislation. All NIS records were verified by national experts and trends are presented in six-year assessment periods from 1970 to 2020 according to the European Union Marine Strategy Framework Directive. Altogether, 874 NIS have been introduced to European marine waters until 2020 with the Mediterranean Sea and North-East Atlantic Ocean hosting most of the introductions. Overall, the number of new introductions has steadily increased since 2000. The annual rate of new introductions reached 21 new NIS in European seas within the last six-year assessment period (2012–2017). This increase is likely due to increased human activities and research efforts that have intensified during the early 21st century within European Seas. As Europe seas are not environmentally, nor geographically homogenous, the setting of threshold values for assessing GES requires regional expertise. Further, once management measures are operational, pathway-specific threshold values would enable assessing the effectiveness of such measures.

**Keywords:** non-indigenous species; European seas; regional seas; MSFD; good environmental status; validation; uncertainties

## 1. Introduction

The introduction of marine Non-Indigenous Species (NIS) is widely perceived as one of the main threats to biological diversity next to habitat destruction at a global scale [1,2]. Invasive Alien Species (IAS) are a subset of NIS, which are of particular concern due to their ability to naturally reproduce in the recipient areas, spread rapidly, and threaten biological diversity in various ways, from reducing genetic variation and modifying gene pools, displacing, hybridizing or competing with local endemic or native species to altering habitat and ecosystem functioning [3–7]. It is essential to note that the term “invasive” may have various implications depending on the context. From a scientific perspective, “invasive” refers to the ability of the species to survive, reproduce and spread in the invaded region [8], whereas political frameworks, such as the EU Regulation (No 1143/2014) on the prevention and management of the introduction and spread of invasive alien species (IAS Regulation) often connect invasiveness to impact.

Marine NIS, and IAS in particular, are addressed by European Union (EU) policies, such as the EU Biodiversity Strategy 2020 (COM (2011) 244) target 5; the European Water Framework Directive (WFD) (2000/60/EC); the EU Marine Strategy Framework Directive (MSFD) (2008/56/EC) with a dedicated descriptor (D2 “*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems*”) and the IAS Regulation (No 1143/2014). Non-indigenous species is one of the 11 descriptors in the MSFD that refer to anthropogenic pressures on the marine environment of the EU [9]. In the latest MSFD update [9] among the criteria for assessing descriptor D2 on marine NIS, primary criterion D2C1 concerning new NIS introductions states that: “*The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period (6 years), measured from the reference year (2011) as reported for initial assessment under Article 8(1) of Directive 2008/56/EC, is minimised and where possible reduced to zero*”. Efforts to make this target more quantitative are ongoing [10–12], further encouraged by Target 6 of the first draft of the Convention on Biological Diversity (CBD) Post-2020 Global Biodiversity Framework, which stipulates at least a 50% reduction in the rate of new introductions [13]. However, to date, only the Baltic Marine Environment Protection Commission (Helsinki Convention, HELCOM) has set a numerical threshold of zero new NIS introductions through anthropogenic activities in the Baltic Sea [10]. At the EU level, Tsiamis et al. [14] suggested that the most suitable approach for setting the Good Environmental Status (GES) thresholds for criterion D2C1 would be a percentage reduction of new NIS introductions

for an assessment period compared to the previous six-year assessment period (baseline). Preferably, the more previous six-year cycles that are included in the assessment, the better (e.g., starting from the 1970s) since the inclusion of earlier assessment periods enables tracking down how management measures have changed the result of the assessment over time. Thus, as qualitative GES descriptions turn into quantitative targets, it is now more imperative than ever that information on NIS in European seas is as accurate and complete as possible to provide a sound baseline for future management.

The first compilation of marine NIS inventory in Europe was conducted by Streftaris et al. [15] and followed by an update in 2009 toward the SEBI2010 report [16]. In the same period, comprehensive data collection from a wide range of taxonomic groups through the EU-funded project Delivering Alien Species Inventories for Europe resulted in a European database [17]. The DAISIE database, which included recorded information on the impacts, pathways of introduction, and associated references, was integrated into the information system on Aquatic Non-Indigenous and Cryptogenic Species (AquaNIS) [18]. In parallel, the European Alien Species Information Network (EASIN) [19] has been developed by the European Commission's Joint Research Centre (JRC) aiming to facilitate the exploration of existing alien species information from a variety of distributed information sources through freely available tools and interoperable web services, compliant with internationally recognized standards. Updated information on NIS is provided by data partners and the editorial board of EASIN [20]. AquaNIS stores and disseminates information on NIS introduction histories, recipient regions, taxonomy, biological traits, impacts, and other relevant documented data. The system is continuously updated with new NIS records provided by registered data providers.

With the digital infrastructure in place and prompted by the increased demands placed by legislation, there is an increasing availability of national (e.g., Portugal) [21] and regional inventories of NIS (e.g., Baltic [22], Mediterranean [23], Black Sea [24]), which have been instrumental for analyzing trends and pathways of NIS introductions at national (e.g., Italy [25], Greece [26], Denmark [27], Belgium [28]), subregional (Macaronesia [29]), regional (Mediterranean [30], Baltic [22]), and global scales [31]. All these assessments have the shared ambition to assess the most updated status of NIS and provide a robust baseline for understanding trends in new NIS arrivals and pathways. Such knowledge is essential for the optimal implementation of existing policies and for evaluating policy effectiveness. Furthermore, knowledge is important to evaluate the need for new policies and management strategies. Updated and validated NIS inventories constitute a milestone for the implementation of the MSFD D2. Based on refined baseline inventories of NIS set by each EU Member State (MS), in the context of the MSFD and the updated data of EASIN, Tsiamis et al. [32] estimated that 787 non-indigenous taxa were found in EU marine and partially transitional waters (including Macaronesia) by the end of 2011. Further, Tsiamis et al. [14] updated the EASIN marine data at the national and MSFD subregional levels up to 31 December 2017. In the period of 2018–2020, not only have new NIS been identified in the European seas, but also new information has emerged on the taxonomic identity (e.g., as a consequence of recent taxonomic revision efforts), biogeographic origin, and distribution of NIS records, resulting in significant changes in both the status and distribution of several species. Now more than ever, it is crucial to reassess, revise and update the NIS inventories at all spatial assessment levels. In this context, the present work presents the most updated list of marine NIS introduced in the EU and surrounding waters validated by national experts and examines trends in these NIS introductions at European, regional, and subregional levels paving the way for the setting of threshold values for new NIS introductions in the context of the MSFD, and particularly of the primary criterion D2C1.

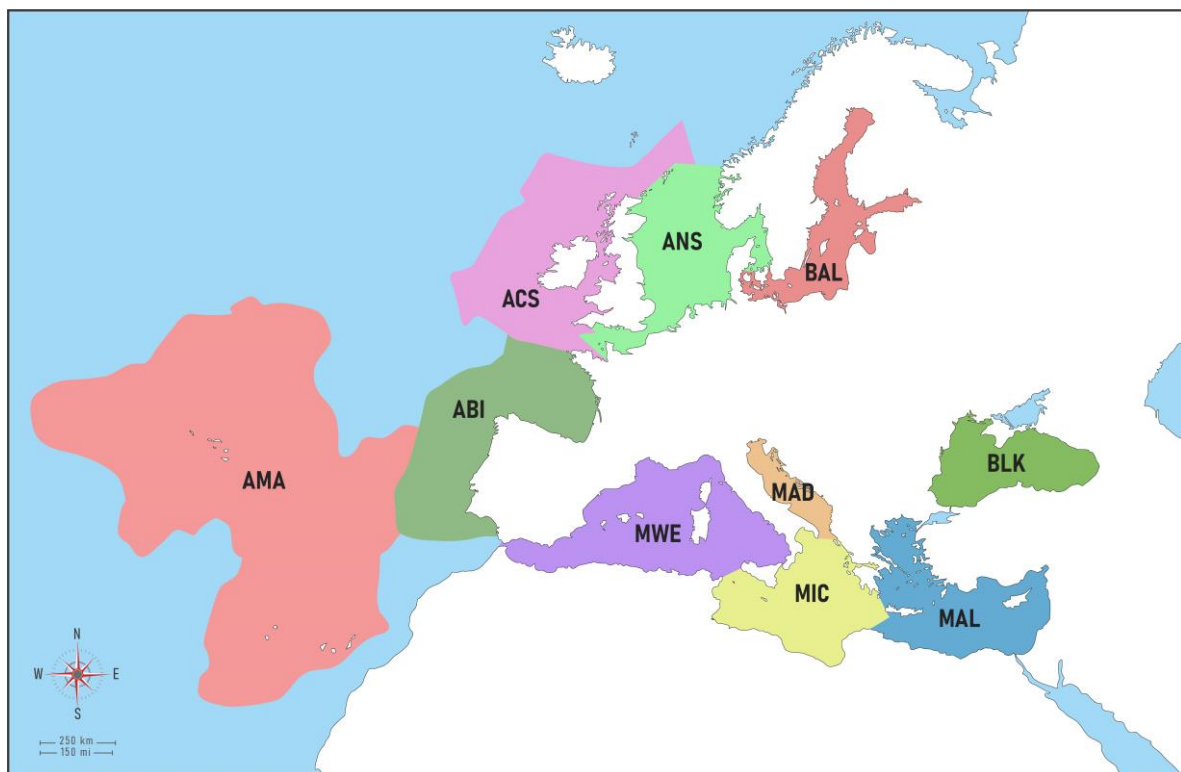
## 2. Methodology

The national inventories of EU countries submitted to JRC for the purposes of the 2012–2017 assessment cycle [33] formed the starting point for the revision process. They

were updated with published data from biodiversity and hot-spot campaigns, academic surveys, and citizen science project observations until December 2020 (reported until June 2022). For Norway, Albania, and Montenegro, local experts were invited. The subsequent validation of the revised lists with the contribution of national experts included several rounds of communication whereby many discrepancies were resolved, and several controversial species were agreed upon. Subsequently, the national data were aggregated at subregional, regional, and Pan-European levels. The species list includes every first novel report of species introduction, irrespective of the establishment status. In our analysis, we only considered the first new record of a NIS within a region/subregion. Duplicate records for any given species were removed to avoid overestimating new NIS records at all spatial levels. The number of species detected/observed per six-year cycles since 1970 was analyzed from these datasets.

### 2.1. Geographic Coverage

The study area included European marine waters surrounding EU countries, EU candidate countries (*Albania, Montenegro*), and Norway a country of the European Economic Area (EEA) all divided into regions and subregions (Figure 1, Table 1) as per the MSFD delineation [33]. Marine waters of the United Kingdom (UK), Turkey, and Russian Federation were not considered in this work, meaning that NIS records from these countries are not included.



**Figure 1.** European subregions (modified from Jensen et al. [34]). BAL = Baltic Sea, ANS = Greater North Sea, ACS = Celtic Seas, ABI = Bay of Biscay-Iberian Shelf, AMA = Macaronesia, MWE = Western Mediterranean, MIC = Central Mediterranean, MAD = Adriatic Sea, MAL = Eastern Mediterranean, BLK = Black Sea.

**Table 1.** Geographic coverage of new NIS introductions in the present study at regional and sub-regional levels. Abbreviation: ABI = Bay of Biscay and the Iberian Coast, ACS = Celtic Seas, ANS = Greater North Sea, AMA = Macaronesia, MWE = Western Mediterranean Sea, MIC = Ionian Sea and the Central Mediterranean Sea, MAD = Adriatic Sea, MAL = Aegean-Levantine Sea (Eastern Mediterranean Sea).

Regional Level	Subregional Level			
Baltic Sea (BAL)	<b>BAL</b> Denmark (In the Sound area of the Kattegat, the border follows the Øresund/Öresund bridge between Denmark and Sweden and in Copenhagen harbor, the border is defined by a lock just north of the bridge. On the west side of Sjælland, the border follows the OSPAR Convention boundary connecting Gniben Point on Sjællands Odde with Hasenore Head on the coast of Jutland), Estonia, Finland, Germany (Baltic Sea-side), Latvia, Lithuania, Poland, Sweden (Baltic Sea-side)			
North-East Atlantic Ocean (NEA)	<b>ANS</b> France (including Eastern English Channel, and a small area of the Western English Channel), Belgium, Netherlands, Germany, Denmark, Sweden, Norway up to 62° N (EEA country).	<b>ACS</b> Ireland and France (Western English Channel)	<b>ABI</b> Spain (mainland), Portugal (mainland), and France.	<b>AMA</b> Portugal (Azores, and Madeira) Spain (Canary Islands)
Mediterranean Sea (MED)	<b>WME</b> Spain, France, and Western Italy	<b>MIC</b> Western Greece (Ionian Sea), Ionian coasts of Italy, and Malta	<b>MAD</b> Adriatic coasts of Italy, Slovenia, Croatia, and Albania and Montenegro (EU candidates)	<b>MAL</b> Cyprus and Eastern Greece
Black Sea (BLK)	<b>BLK</b> Bulgaria and Romania			

The Baltic Sea (BAL) is here regarded as both a region and a subregion according to the MSFD delineation, and the same applies to the Black Sea (BLK). The North-East Atlantic (NEA) comprises four MSFD subregions, namely: (a) Greater North Sea (ANS) (b) Celtic Seas (ACS), (c) the Bay of Biscay and the Iberian Coast (ABI), and (d) Macaronesia (AMA). The ANS spans the Kattegat, the eastern English Channel, and a small part of the Western English Channel. It covers NIS in coastal and estuarine waters from seven countries including Norway (an EEA country). The Celtic Seas (ACS) are represented only by Ireland and the western English Channel waters of France. Macaronesia (AMA) is a complex of oceanic islands located in the NEA. The region comprises the archipelagos of the Azores (Portugal), Madeira (Portugal), Canary Islands (Spain), and Cabo Verde. For the present paper exclusively European Macaronesia (i.e., the Azores, Madeira, and Canary Islands), which is the European marine ecoregion within the Lusitanian province following the proposed classification in [35], was considered. The Mediterranean Sea (MED) includes four MSFD subregions: (a) the Western Mediterranean Sea (MWE); (b) the Ionian Sea and the Central Mediterranean Sea (MIC); (c) the Adriatic Sea (MAD); and (d) the Eastern Mediterranean Sea (MAL), encompassing the Aegean and Levantine basins.

## 2.2. Data Included

The most recent MSFD D2 evaluation recommendations [13] were largely followed for the inclusion of marine NIS in the present analyses. Accordingly, cryptogenic, and crypto-expanding species for the regions considered were removed from NIS lists and subsequent analyses. The terms cryptogenic and crypto expanding refer to uncertainties in the status of a species in relation to either their true native range [36] or true dispersion pathway (i.e., natural range expansion vs. human-mediated expansion) [14].

Species with insufficient information or new records unverified by experts or NIS with unresolved taxonomic status [32] were included in this study only after detailed scrutiny

by different experts and a general agreement that there is a strong indication that their presence and distribution pattern implies an introduction event. It is worth mentioning the case of the annelid *Laonome xeprovala*, by Bick and Bastrop in Bick et al., 2018, a species described from the Netherlands and subsequently found in other Dutch rivers, canals, and estuaries [37], as well as in the eastern part of the Baltic Sea, and identified originally as *Laonome calida* Capa, 2007 [38]. Previous literature suggests that North America's eastern coast is a potential native origin for *Laonome xeprovala*, although further clarification is still required [39].

It has been heavily debated in recent years whether parasitic NIS and pathogens (including disease agents) should be omitted from MSFD D2 since they are managed under the Aquatic Animal Health Directive (2006/88/EC) [32]. Overall, the JRC group agreed that these NIS should be reported in D2 criteria, but not considered when assessing against a GES threshold [14]. Aiming to produce results that are as representative and comparable as possible with future GES assessments, parasites and pathogens are listed in Table 2 but were not considered in the D2 trend and status analyses.

There are contrasting opinions among national NIS experts with regard to microscopic algae (phytoplankton) and to their native, cryptogenic, or NIS status, which is reflected in the literature [40] but also in the information systems of EASIN and AquaNIS. However, due to the high reproductive potential of phytoplankton and thus the high potential of spreading, it is important to have a gauge on phytoplankton expansion. The JRC invited the D2 NIS experts' network to contact phytoplankton experts across Europe, to set up a working group that could deliver a consolidated revision of phytoplankton NIS in European seas [14]. Given that further clarification is yet to be provided regarding the status of microalgae in Europe, they are listed in Table 2 but were not considered in the D2 trend and status analyses.

Oligohaline species are included if such species were found in estuarine or coastal systems of the marine region.

NIS spreading from one region/subregion to another through natural dispersal mechanisms (secondary introduction) is included in our analyses. Their introduction pathway was classified as UNAIDED. Such is the case of many Red Sea species that have invaded the eastern Mediterranean (known as Lessepsian immigrants) and are progressively moving to the central and western Mediterranean as well as to the Adriatic Sea. However, species that have undergone tropicalization processes (i.e., shifts in range distribution induced by climate change) [41] were not included as NIS, and thus not considered in these analyses.

With regards to partly native and partly cryptogenic species, here defined as species that are native or cryptogenic in one EU region while they are non-indigenous (i.e., introduced by humans), in another EU region, they were included in the analyses at regional and/or subregional level but not at the pan-European level. Such NIS notably include Mediterranean molluscan transported with shellfish movements to the North-East Atlantic and vice versa, as well as also sessile biota, such as tunicates. Species native within a subregion (e.g., North Sea) that have been anthropogenically transferred to another country within the same subregion, were not included in the subregional analysis, although they are regarded as NIS in the countries they have invaded. This also applies to countries with coastal areas in more than one regional sea (Denmark, France, Germany, Spain, and Sweden).

### 2.3. Detection Year

The year of introduction was based on the reported date of the first collection/detection. However, it is important to point out that this date does not necessarily reflect the actual year of introduction which may have occurred years or even decades earlier since most species are often overlooked in the early stages of the invasion process, e.g., the green alga *Codium fragile* that has spread rapidly throughout the globe from its native range in Japan and the North Pacific was first detected in Europe c. 1900 in the Netherlands but reported in 1955 [42]. In addition, the date of first detection/collection is not always documented. In such cases, the publication date was accepted as the first record date. Moreover, in cases

where only a time range has been supplied (e.g., 1986–1994), or the first record refers to a decade (e.g., the 1970s), the introduction date was set approximately as the average year for that given period (1990 and 1975, respectively).

### 3. Results

In total, 874 NIS were identified across European seas by December 2020 including 22 species of parasites and pathogens, and 50 species of microalgae (Table 2, Figure 2a). Of these 80% (701 taxa) were first reported in 1970. The vast majority of NIS are invertebrates (59%), followed by primary producers (algae and plants) (25%) and vertebrates (16%). Dissimilar proportions of all mentioned groups were evidenced across regions and subregions (Figure 3). While invertebrates dominate at all regional seas, the contribution of vertebrates (fishes) at the pan-European level is largely driven by the high contribution of Red Sea fish species in the Mediterranean Sea (Lessepsian immigrants) as opposed to their low presence in the NEA and Black Sea. Primary producers have a higher share in the NEA (29%) than the other regional seas (14–22%).

**Table 2.** List of NIS and their first year of detection at pan-European and regional levels. Group: VER = vertebrate, INV = invertebrate, PP = primary producer, INV/par = parasite, PP/micro = microalgae. BAL = Baltic Sea, NEA = North-East Atlantic Sea, MED = Mediterranean Sea, BLK = Black Sea. In bold, species detected since 1970. Asterisk denotes freshwater species detected in marine/estuarine environments.

Group	Species	Pan-European	BAL	NEA	MED	BLK
VER	<i>Ablennes hians</i> (Valenciennes, 1846)	2018			2018	
VER	<i>Abudefduf sexfasciatus</i> (Lacepède, 1801)	2017			2017	
VER	<i>Abudefduf vaigiensis</i> (Quoy & Gaimard, 1825)	2005			2005	
VER	<i>Abudefduf hoefleri</i> (Steindachner, 1881)	2014			2014	
INV	<i>Acanthaster planci</i> (Linnaeus, 1758)	2006			2006	
VER	<i>Acanthopagrus bifasciatus</i> (Forsskål, 1775)	2019			2019	
PP	<i>Acanthosiphonia echinata</i> (Harvey) A.M.Savoie & G.W.Saunders	2018			2018	
VER	<i>Acanthurus bahianus</i> Castelnau, 1855	2013		2013		
VER	<i>Acanthurus cfr gahhm</i> (Forsskål, 1775)	2019			2019	
VER	<i>Acanthurus coeruleus</i> Bloch & Schneider, 1801	2011		2013	2011	
VER	<i>Acanthurus sohal</i> (Forsskål, 1775)	2017			2017	
VER	<i>Acanthurus chirurgus</i> (Bloch, 1787)	2012		2013	2012	
INV	<i>Acartia</i> ( <i>Acanthacartia</i> ) <i>tonsa</i> Dana, 1849	1921	1921	1921	1986	1976
INV	<i>Acartia</i> ( <i>Acartiura</i> ) <i>omorii</i> Bradford, 1976	2004		2004		
INV	<i>Achelia sawayai</i> Marcus, 1940	2016			2016	
VER	<i>Acipenser baerii</i> Brandt, 1869	1960	1960	1985		
VER	<i>Acipenser gueldenstaedtii</i> Brandt & Ratzeburg, 1833*	1962	1962	2010		
VER	<i>Acipenser ruthenus</i> Linnaeus, 1758*	1887	1887			
VER	<i>Acipenser stellatus</i> Pallas, 1771	1999	1999			
VER	<i>Acipenser transmontanus</i> Richardson, 1836	1999		1999		
PP	<i>Acrochaetium catenulatum</i> M.A.Howe	1967		1967		



Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP	<i>Acrothamnion preissii</i> (Sonder) E.M.Wollaston	1968		2009	1968	
INV	<i>Actaeodes tomentosus</i> (H. Milne Edwards, 1834)	2013			2013	
INV	<i>Acteocina mucronata</i> (Philippi, 1849)	1991			1991	
INV	<i>Actumnus globulus</i> Heller, 1861	1978			1978	
PP	<i>Adelosina carinatastriata</i> (Wiesner)	2004		2004		
Pathogen	<i>Aerococcus viridans</i> Williams, Hirsch & Cowan	1961		1961		
PP	<i>Agardhiella subulata</i> (C.Agardh) Kraft & M.J.Wynne	1984		1989	1984	
PP	<i>Agarophyton vermiculophyllum</i> (Ohmi) Gurgel, J.N.Norris & Fredericq	1989	2003	1989	2008	
PP	<i>Aglaothamnion halliae</i> (Collins) Aponte, D.L.Ballantine & J.N.Norris	1960		1960	2016	
VER	<i>Agonus cataphractus</i> (Linnaeus, 1758)	2005			2005	
PP	<i>Ahnfeltiopsis flabelliformis</i> (Harvey) Masuda, 1993	1994			1994	
PP/micro	<i>Akashiwo sanguinea</i> (K.Hirasaka) G.Hansen & Ø.Moestrup	1982		1982		
VER	<i>Alepes djedaba</i> (Forsskål, 1775)	1960			1960	
PP/micro	<i>Alexandrium ostenfeldii</i> (Paulsen) Balech & Tangen	1986		1986		
PP/micro	<i>Alexandrium affine</i> (H.Inoue & Y.Fukuyo) Balech	1987		1987		
PP/micro	<i>Alexandrium leei</i> Balech	1991		1991		
PP/micro	<i>Alexandrium margalefii</i> Balech	2006		2006		
PP/micro	<i>Alexandrium taylori</i> Balech	1994			1994	
INV	<i>Aliculastrum cylindricum</i> (Helbling, 1779)	2020			2020	
INV/par	<i>Allolepidapedon fistulariae</i> Yamaguti, 1940	2005			2005	
INV	<i>Alpheus rapacida</i> de Man, 1908	1998			1998	
INV	<i>Amathina tricarinata</i> (Linnaeus, 1767)	2012			2012	
INV	<i>Ammothea hilgendorfi</i> (Böhm, 1879)	1979		2013	1979	
INV	<i>Ampelisca cavicoxa</i> Reid, 1951	2005		2005		
INV	<i>Ampelisca heterodactyla</i> Schellenberg, 1925	1986		1986		
INV	<i>Amphibalanus eburneus</i> (Gould, 1841)	1818		1872	1818	1933
INV	<i>Amphibalanus reticulatus</i> (Utinomi, 1967)	1977		1997	1977	
INV	<i>Amphibalanus variegatus</i> (Darwin, 1854)	1997		1997		
INV	<i>Amphinome rostrata</i> (Pallas, 1766)	1900		1900		
PP	<i>Amphistegina</i> cf. <i>papillosa</i> Said, 1949	2005			2005	
PP	<i>Amphistegina lessonii</i> d'Orbigny in Guérin-Méneville, 1832	2001			2001	
PP	<i>Amphistegina lobifera</i> Larsen, 1976	1959			1959	
INV	<i>Ampithoe valida</i> Smith, 1873	1985		1985	2000	
INV	<i>Anadara kagoshimensis</i> (Tokunaga, 1906)	1966		1993	1966	1981

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Anadara transversa</i> (Say, 1822)	1975		2016	1975	
INV/par	<i>Anguillicola crassus</i> (Kuwahara, Niimi & Itagaki, 1974)	1980	1988	1982	1980	
INV	<i>Anomia chinensis</i> Philippi, 1849	1974		1974		
INV	<i>Anoplodactylus californicus</i> Hall, 1912	1965			1965	
PP	<i>Anotrichium furcellatum</i> (J.Agardh) Baldock	1950		1950		
PP	<i>Antithamnion densum</i> (Suhr) M.Howe	1964		1964		
PP	<i>Antithamnion diminuatum</i> Wollaston	1989		1989		
PP	<i>Antithamnion hubbsii</i> E.Y.Dawson	1987		1989	1987	
PP	<i>Antithamnion amphigeneum</i> A.J.K.Millar	1992		1995	1992	
PP	<i>Antithamnionella ternifolia</i> (Hooker fil. & Harvey) Lyle	1910	2014	1910	1981	
INV	<i>Aoroides curvipes</i> Ariyama, 2004	2009		2009		
INV	<i>Aoroides semicurvatus</i> Ariyama, 2004	2009		2009		
INV	<i>Aoroides longimerus</i> Ren & Zheng, 1996	2013		2013	2015	
INV	<i>Apanthura addui</i> Wägele, 1981	1998			1998	
INV	<i>Aplidium antillense</i> (Gravier, 1955)	2004		2004		
INV	<i>Aplidium accareense</i> (Millar, 1953)	2012			2012	
VER	<i>Apogonichthyoides pharaonis</i> (Bellotti, 1874)	1964			1964	
INV	<i>Aquilonastra burtoni</i> (Gray, 1840)	2003			2003	
INV	<i>Arachnidium lacourti</i> d'Hondt & Faasse, 2006	1999	2015	1999		
INV	<i>Arachnoidella protecta</i> Harmer, 1915	1992			1992	
INV	<i>Arbopercula tenella</i> (Hincks, 1880)	1990			1990	
INV	<i>Arctapodema australis</i> (Vanhöffen, 1912)	1967			1967	
INV	<i>Arcuatula senhousia</i> (Benson, 1842)	1982		2002	1982	2002
INV	<i>Argopecten gibbus</i> (Linnaeus, 1758)	2016		2016		
INV	<i>Arhynchite arhynchite</i> (Ikeda, 1924)	2001			2001	
INV	<i>Arietellus pavoninus</i> Sars G.O., 1905	1967			1967	
VER	<i>Arothron hispidus</i> (Linnaeus, 1758)	2018			2018	
INV	<i>Artemia monica</i> Verrill, 1869	1972		1987	1972	
INV	<i>Ascidia curvata</i> (Traustedt, 1882)	2014		2014		
INV	<i>Ascidia interrupta</i> Heller, 1878	1990		1990		
INV	<i>Asclerocheilus ashworthi</i> Blake, 1981	2005		2005		
PP	<i>Ascophyllum nodosum</i> (Linnaeus) Le Jolis	2009			2009	
PP	<i>Asparagopsis taxiformis</i> (Delile) Trevisan de Saint-Léon (lineage 2)	1928		1928	1992	
PP	<i>Asparagopsis armata</i> Harvey	1880		1922	1880	
INV	<i>Asterocarpa humilis</i> (Heller, 1878)	2005		2005		
PP/micro	<i>Asteromphalus sarcophagus</i> Wallich, 1860	1993		1993		
INV	<i>Atactodea striata</i> (Gmelin, 1791)	1977			1977	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Atergatis roseus</i> (Rüppell, 1830)	2009			2009	
VER	<i>Atherinomorhus forskalii</i> (Rüppell, 1838)	1929			1929	
INV	<i>Atys angustatus</i> E. A. Smith, 1872	2017			2017	
INV	<i>Atys ehrenbergi</i> (Issel, 1869)	2016			2016	
INV	<i>Aurelia coerulea</i> von Lendenfeld, 1884	2002			2002	
INV	<i>Aurelia solida</i> Browne, 1905	2000			2000	
INV	<i>Austrominius modestus</i> (Darwin, 1854)	1944		1944	1990	
INV	<i>Axionice medusa</i> (Savigny in Lamarck, 1818)	1976			1976	
INV	<i>Baeolidia moebii</i> Bergh, 1888	2017			2017	
INV	<i>Balanus glandula</i> Darwin, 1854	2015		2015		
INV	<i>Balanus trigonus</i> Darwin, 1854	1887		1887	1927	
VER	<i>Balistoides conspicillum</i> (Bloch & Schneider, 1801)	2012			2012	
INV	<i>Bankia fimbriatula</i> Moll & Roch, 1931	1847		1847		
INV	<i>Barentsia ramosa</i> (Robertson, 1900)	1962		1962		
PP	<i>Batophora occidentalis</i> var. <i>largoensis</i> (Harvey) S.Berger & Kaeffer ex M.J.Wynne	2020			2020	
INV	<i>Beania maxilladentata</i> Ramalho, Muricy & Taylor, 2010	2013		2013		
INV	<i>Bemlos leptocheirus</i> (Walker, 1909)	2015			2015	
INV	<i>Beroe ovata</i> Bruguière, 1789	1997	2011	2013	2004	1997
INV	<i>Berthellina citrina</i> (Rüppell & Leuckart, 1828)	2019			2019	
PP/micro	<i>Biddulphia rhombus</i> (Ehrenberg) W.Smith	1983		1983		
PP/micro	<i>Biddulphia sinensis</i> Greville	1903	1904	1903		
INV	<i>Biflustra grandicella</i> (Canu & Bassler, 1929)	2016		2016		
INV	<i>Bispira polyomma</i> Giangrande & Faasse, 2012	2010		2010	2014	
INV	<i>Biuve fulvipunctata</i> (Baba, 1938)	1993			1993	
INV	<i>Boccardia proboscidea</i> Hartman, 1940	1996		1996	2014	
INV	<i>Boccardia semibranchiata</i> Guérin, 1990	1999		1999		
INV	<i>Boccardiella hamata</i> (Webster, 1879)	2001		2001		
Pathogen	<i>Bonamia exitiosa</i> Hine, Cochennac & Berthe	2006		2006	2007	
Pathogen	<i>Bonamia ostreae</i> Pichot, Comps, Tigé, Grizel & Rabouin	1978		1978	1990	
PP	<i>Bonnemaisonia hamifera</i> Hariot	1898	1900	1898	1932	
INV	<i>Bostrycapulus odites</i> Collin, 2005	1973			1973	
INV	<i>Botrylloides diegensis</i> Ritter & Forsyth, 1917	1999		1999	2004	
INV	<i>Botrylloides giganteum</i> (Pérès, 1949)	2003			2003	
INV	<i>Botrylloides niger</i> Herdman, 1886	2013		2013	2014	
INV	<i>Botrylloides violaceus</i> Oka, 1927	1991		1999	1991	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP	<i>Botryocladia wrightii</i> (Harvey) W.E.Schmidt, D.L.Ballantine & Fredericq	1978		2005	1978	
PP	<i>Botryocladia madagascariensis</i> G.Feldmann	1978			1978	
PP	<i>Botrytella parva</i> (Takamatsu) H.S.Kim	1996			1996	
INV	<i>Bougainvillia macloviana</i> Lesson, 1830	1895		1895		
INV	<i>Brachidontes exustus</i> (Linnaeus, 1758)	1977		1977		
INV	<i>Brachidontes pharaonis</i> (P. Fischer, 1870)	1960			1960	
INV	<i>Branchiommata bairdi</i> (McIntosh, 1885)	1998		2012	1998	
INV	<i>Branchiommata boholense</i> (Grube, 1878)	2004			2004	
INV	<i>Branchiommata luctuosum</i> (Grube, 1870)	1978		2015	1978	
VER	<i>Bregmaceros nectabanus</i> Whitley, 1941	2014			2014	
INV	<i>Bugulina simplex</i> (Hincks, 1886)	1982		1982		
INV	<i>Bugulina stolonifera</i> (Ryland, 1960)	1976		1976		
INV	<i>Bulla arabica</i> Malaquias & Reid, 2008	1998			1998	
INV	<i>Bursatella leachii</i> Blainville, 1817	1969			1969	
INV	<i>Calanopia elliptica</i> (Dana, 1849)	1891			1891	
INV	<i>Callinectes danae</i> Smith, 1869	1981			1981	
INV	<i>Callinectes pallidus</i> (de Rochebrune, 1883)	2013		2013		
INV	<i>Callinectes sapidus</i> Rathbun, 1896	1901	1951	1901	1947	1967
VER	<i>Callionymus filamentosus</i> Valenciennes, 1837	2003			2003	
INV	<i>Calyptospadix cerulea</i> Clarke, 1882	1940	2014		1978	1940
VER	<i>Cantherhines pullus</i> (Ranzani, 1842)	2015		2015		
INV	<i>Caprella mutica</i> Schurin, 1935	1985	2017	1985		
INV	<i>Caprella scaura</i> Templeton, 1836	1985		1985	1994	
VER	<i>Carassius auratus</i> (Linnaeus, 1758)	2012		2012		
VER	<i>Carassius gibelio</i> (Bloch, 1782)*	1800	1800			
INV	<i>Carijoa riisei</i> (Duchassaing & Michelotti, 1860)	2016		2016		
INV	<i>Carupa tenuipes</i> Dana, 1852	2009			2009	
INV	<i>Cassiopea andromeda</i> (Forsskål, 1775)	1903			1903	
PP	<i>Caulacanthus okamurai</i> Yamada	1999		1999	2002	
PP	<i>Caulerpa cylindracea</i> Sonder	1991		1997	1991	
PP	<i>Caulerpa lamourouxii</i> (Turner) C.Agardh	1956			1956	
PP	<i>Caulerpa taxifolia</i> (M.Vahl) C.Agardh	1984			1984	
PP	<i>Caulerpa taxifolia</i> var. <i>distichophylla</i> (Sonder) Verlaque, Huisman & Procaccini	2007			2007	
PP	<i>Caulerpa webbiana</i> Montagne	2002		2002		
INV	<i>Caulibugula zanzibariensis</i> (Waters, 1913)	2003		2003		
INV	<i>Cellana rota</i> (Gmelin, 1791)	2007			2007	
INV	<i>Celleporaria inaudita</i> Tilbrook, Hayward & Gordon, 2001	2007		2007		

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Celleporaria aperta</i> (Hincks, 1882)	1975			1975	
INV	<i>Celleporaria brunnea</i> (Hincks, 1884)	2007		2007	2010	
INV	<i>Celleporaria vermiformis</i> (Waters, 1909)	2015			2015	
INV	<i>Celleporella carolinensis</i> Ryland, 1979	1993			1993	
INV	<i>Celtodoryx ciocalyptoides</i> (Burton, 1935)	1996		1996		
INV	<i>Centropages furcatus</i> (Dana, 1849)	1988			1988	
VER	<i>Cephalopholis hemistiktos</i> (Rüppell, 1830)	2009			2009	
VER	<i>Cephalopholis taeniops</i> (Valenciennes, 1828)	2009		2009		
VER	<i>Cephalopholis nigri</i> (Günther, 1859)	2016			2016	
INV	<i>Cephalothrix simula</i> Iwata, 1952	2012		2012		
PP	<i>Ceramium atrorubescens</i> Kylin	1988		1988		
PP	<i>Ceramium sungminbooi</i> Hughey & Boo	2018		2018		
PP	<i>Ceramium tenuicorne</i> (Kützing) Waern	2011		2011		
PP	<i>Ceramium bisporum</i> D.L.Ballantine	1980			1980	
PP	<i>Ceramium strobiliforme</i> G.W.Lawson & D.M.John	1991			1991	
INV	<i>Ceratonereis mirabilis</i> Kinberg, 1865	1997			1997	
INV	<i>Cerithidium perparvulum</i> (Watson, 1886)	1995			1995	
INV	<i>Cerithiopsis pulvis</i> (Issel, 1869)	1985			1985	
INV	<i>Cerithiopsis tenthrenois</i> (Melvill, 1896)	1985			1985	
INV	<i>Cerithium scabridum</i> Philippi, 1848	1972			1972	
PP/micro	<i>Chaetoceros peruvianus</i> Brightwell	1981		1981		
PP/micro	<i>Chaetoceros rostratus</i> Ralfs	2003		2003		
PP/micro	<i>Chaetoceros bacteriastroides</i> G.H.H.Karsten	1996			1996	
PP/micro	<i>Chaetoceros concavicornis</i> Mangin	2011		2011		
PP/micro	<i>Chaetoceros pseudosymmetricus</i> Nielsen	2015			2015	
VER	<i>Chaetodipterus faber</i> (Broussonet, 1782)	2019			2019	
VER	<i>Chaetodon sanctaehelenae</i> Günther, 1868	1993		1993		
VER	<i>Chaetodon auriga</i> Forsskål, 1775	2015			2015	
VER	<i>Chaetodontoplus septentrionalis</i> (Temminck & Schlegel, 1844)	2015		2015		
INV	<i>Chaetopleura angulata</i> (Spengler, 1797)	1850		1850		
INV	<i>Chaetozone corona</i> Berkeley & Berkeley, 1941	1982		1996	1982	
INV	<i>Chama asperella</i> Lamarck, 1819	2007			2007	
INV	<i>Chama pacifica</i> Broderip, 1835	1998			1998	
VER	<i>Champsodon nudivittis</i> (Ogilby, 1895)	2012			2012	
INV	<i>Charybdis (Charybdis) japonica</i> (A. Milne-Edwards, 1861)	2006			2006	
INV	<i>Charybdis (Charybdis) feriata</i> (Linnaeus, 1758)	2004			2004	
INV	<i>Charybdis (Charybdis) hellerii</i> (A. Milne-Edwards, 1867)	1998			1998	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Charybdis (Charybdis) lucifera</i> (Fabricius, 1798)	2006			2006	
INV	<i>Charybdis (Goniohellenus) longicollis</i> Leene, 1938	1969			1969	
PP/micro	<i>Chattonella marina</i> (Subrahmanyam) Hara & Chihara	1974		1974		
VER	<i>Cheilodipterus novemstriatus</i> (Rüppell, 1838)	2015			2015	
INV	<i>Chelicorophium robustum</i> (G.O. Sars, 1895)	2018	2018			
INV	<i>Chelicorophium curvoispinum</i> (G.O. Sars, 1895)	1912	1921	1912		
VER	<i>Chlorurus rhakoura</i> Randall & Anderson, 1997	2017			2017	
PP	<i>Chondria pygmaea</i> Garbary & Vandermeulen	1974			1974	
PP	<i>Chondria curvilineata</i> F.S.Collins & Hervey	1981			1981	
PP	<i>Chondrus giganteus f. flabellatus</i> Mikami	1994			1994	
VER	<i>Chromis multilineata</i> (Guichenot, 1853)	2015		2015		
INV	<i>Chromodoris quadricolor</i> (Rüppell & Leuckart, 1830)	1982			1982	
INV	<i>Chrysaora achlyos</i> Martin, Gershwin, Burnett, Cargo & Bloom, 1997	2018			2018	
VER	<i>Chrysiptera cyanea</i> (Quoy & Gaimard, 1825)	2013			2013	
VER	<i>Chrysiptera hemicyanea</i> (Weber, 1913)	2017			2017	
PP	<i>Chrysonephos lewisii</i> (W.R.Taylor) W.R.Taylor	1988			1988	
INV	<i>Cingulina isseli</i> (Tryon, 1886)	1998			1998	
INV	<i>Ciona robusta</i> Hoshino & Tokioka, 1967	1901		2007	1901	
VER	<i>Cirrhitis atlanticus</i> Osório, 1893	2018		2018		
PP	<i>Cladophora patentiramea</i> (Montagne) Kützing	1991			1991	
INV	<i>Clavelina oblonga</i> Herdman, 1880	1929		1971	1929	
Pathogen	<i>Claviceps purpurea</i> (Fr.:Fr.) Tul.	1960		1960		
PP	<i>Clavulina cf. multicamerata</i> Chapman, 1907	2012			2012	
INV	<i>Clementia papyracea</i> (Gmelin, 1791)	1985			1985	
INV	<i>Clymenella torquata</i> (Leidy, 1855)	1977		1977		
INV	<i>Clytia gregaria</i> (Agassiz, 1862)	2017		2017		
INV	<i>Clytia hummelincki</i> (Leloup, 1935)	1996			1996	
INV	<i>Clytia linearis</i> (Thorneley, 1900)	1951		1983	1951	
PP	<i>Codium arabicum</i> Kützing	2006		2006		
PP	<i>Codium fragile subsp. fragile</i> (Suringar) Hariot	1895	1919	1895	1946	
PP	<i>Colaçonema codicola</i> (Børgesen) H.Stegenga, J.J. Bolton & R.J.Anderson	1926		1926	1952	
PP	<i>Colaçonema dasyae</i> (F.S.Collins) Stegenga, I.Mol, Prud'homme van Reine & Lokhorst	1951		1951		

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Coleusia signata</i> (Paul'son, 1875)	2005			2005	
PP	<i>Colpomenia peregrina</i> Sauvageau	1905		1905	1918	
INV	<i>Conomurex persicus</i> (Swainson, 1821)	1983			1983	
INV	<i>Corambe obscura</i> (A.E. Verrill, 1870)	1879		1879		1986
INV	<i>Corbicula fluminea</i> (O. F. Müller, 1774)	1978		1978		
INV	<i>Corella eumyota</i> Traustedt, 1882	2002		2002		
PP/micro	<i>Corymbellus aureus</i> J.C.Green	1992		1992		
PP	<i>Corynomorpha prismatica</i> (J.Agardh) J.Agardh	1990		1990		
PP	<i>Corynophlaea verruculiformis</i> (Y.-P.Lee & I.K.Lee) Y.-P.Lee	1994		1994		
INV	<i>Coryphellina rubrolineata</i> O'Donoghue, 1929	2008			2008	
INV	<i>Crassostrea rhizophorae</i> (Guilding, 1828)	1976		1976		
INV	<i>Crassostrea virginica</i> (Gmelin, 1791)	1861		1861		1974
INV	<i>Crepidacantha poissonii</i> (Audouin, 1826)	1982			1982	
INV	<i>Crepidula fornicata</i> (Linnaeus, 1758)	1902		1902	1957	
INV	<i>Crepidatella dilatata</i> (Lamarck, 1822)	2005		2005	2014	
INV	<i>Crisularia plumosa</i> (Pallas, 1766)	1937		1937		
INV	<i>Crisularia serrata</i> (Lamarck, 1816)	1902			1902	
PP	<i>Cryptonemia hibernica</i> Guiry & L.M.Irvine	1911		1911		
PP	<i>Cushmanina striatopunctata</i> (Parker & Jones, 1865)	1913			1913	
INV	<i>Cuthona perca</i> (Er. Marcus, 1958)	1976			1976	
INV	<i>Cycloscala hyalina</i> (G. B. Sowerby II, 1844)	1992			1992	
INV	<i>Cymodoce fuscina</i> Schotte & Kensley, 2005	2015			2015	
VER	<i>Cynoscion regalis</i> (Bloch & Schneider, 1801)	2009		2009		
VER	<i>Cyprinus carpio</i> (Linnaeus, 1758)*	1200	1200	1879		
PP	<i>Dasya sessilis</i> Yamada	1984		1989	1984	
PP	<i>Dasysiphonia japonica</i> (Yendo) H.-S.Kim	1984		1984	1998	
INV	<i>Dendostrea frons</i> (Linnaeus, 1758)	1983		1983		
INV	<i>Dendostrea folium</i> (Linnaeus, 1758)	2005			2005	
PP	<i>Derbesia rhizophora</i> Yamada	1984			1984	
INV	<i>Desdemona ornata</i> Banse, 1957	1983		1993	1983	
INV	<i>Diadema setosum</i> (Leske, 1778)	2010			2010	
INV	<i>Diadumene lineata</i> (Verrill, 1869)	1925	2011	1963	1925	1945
PP/micro	<i>Dicroerisma psilonereiella</i> F.J.R.Taylor & S.A. Cattell	1998		1998		
PP	<i>Dictyota cyanoloma</i> Tronholm, De Clerck, A.Gómez-Garreta & Rull Lluçh in Tronholm et al.	1935		2006	1935	
INV	<i>Didemnum perlucidum</i> Monniot F, 1983	2006		2006		

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Didemnum vexillum</i> Kott, 2002	1968		1968	2007	
INV	<i>Dikerogammarus villosus</i> (Sowinsky, 1894)	2015	2015			
INV	<i>Dikoleps micalii</i> Agamennone, Sbrana, Nardi, Siragusa & Germanà, 2020	2016			2016	
PP/micro	<i>Dinophysis sacculus</i> Stein	2004		2004		
INV	<i>Diodora funiculata</i> (Reeve, 1850)	2013			2013	
INV	<i>Diplosoma listerianum</i> (Milne Edwards, 1841)	1877			1877	
INV	<i>Dipolydora quadrilobata</i> (Jacobi, 1883)	2003				2003
INV	<i>Dipolydora socialis</i> (Schmarda, 1861)	2006		2006		
INV	<i>Dipolydora tentaculata</i> (Blake & Kudenov, 1978)	2005		2005		
PP	<i>Dipterosiphonia dendritica</i> (C.Agardh) F.Schmitz	1961		1961		
INV	<i>Dispio magna</i> (Day, 1955)	1982			1982	
PP/micro	<i>Dissodinium pseudocalani</i> (Gonnert) Drebes ex Elbrachter & Drebes	2003		2003		
INV	<i>Distaplia magnilarva</i> (Della Valle, 1881)	1929		1929		
INV	<i>Distaplia bermudensis</i> Van Name, 1902	1953		2006	1953	
INV	<i>Distaplia corolla</i> Monniot F., 1974	1971		1971		
INV	<i>Dodecaceria capensis</i> Day, 1961	1976			1976	
INV	<i>Dorvillea similis</i> (Crossland, 1924)	2014			2014	
INV	<i>Dreissena rostriformis bugensis</i> (Andrusov, 1897)	2014	2014			
VER	<i>Dussumieria elopsoides</i> Bleeker, 1849	2005			2005	
INV	<i>Dyspanopeus texanus</i> (Stimpson, 1859)	2015		2015		
INV	<i>Dyspanopeus sayi</i> (Smith, 1869)	1992		2007	1992	
INV	<i>Echinogammarus trichiatus</i> (Martynov, 1932)	2014	2014			
INV	<i>Ecteinascidia styeloides</i> (Traustedt, 1882)	1983			1983	
INV	<i>Ectopleura crocea</i> (Agassiz, 1862)	1895		1989	1895	
INV	<i>Edwardsiella lineata</i> (Verrill in Baird, 1873)	2010		2010		
PP	<i>Elachista</i> spp mentioned as <i>E. flaccida</i>	1993		1993		
VER	<i>Elates ransonnettii</i> (Steindachner, 1876)	2005			2005	
PP	<i>Elodea canadensis</i> Michx.*	1873	1873			
PP	<i>Elodea nuttallii</i> (Planch.) H.St.John	1991	1991	2006		
PP	<i>Elphidium striatopunctatum</i> (Fichtel & Moll, 1798)	1911			1911	
INV	<i>Elysia nealae</i> (Ostergaard, 1955)	2018			2018	
PP/micro	<i>Emiliana huxleyi</i> (Lohmann) W.W.Hay & H.P.Mohler	1989		1989		
INV	<i>Endeis biseriata</i> Stock, 1968	1979			1979	
INV	<i>Ensis leei</i> M. Huber, 2015	1978	1991	1978		
INV	<i>Eocuma dimorphum</i> Fage, 1928	1992		1992		
INV	<i>Eocuma sarsii</i> (Kossmann), 1880	1901			1901	



Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
VER	<i>Epinephelus fasciatus</i> (Forsskål, 1775)	2018		2018		
VER	<i>Epinephelus coioides</i> (Hamilton, 1822)	1998			1998	
VER	<i>Epinephelus malabaricus</i> (Bloch & Schneider, 1801)	2011			2011	
VER	<i>Epinephelus merra</i> Bloch, 1793	2004			2004	
VER	<i>Equulites klunzingeri</i> (Steindachner, 1898)	1955			1955	
INV	<i>Ergalatax junionae</i> Houart, 2008	1993			1993	
INV	<i>Eriocheir sinensis</i> H. Milne Edwards, 1853*	1912	1921	1912	1959	1997
INV	<i>Erugosquilla massavensis</i> (Kossmann, 1880)	1956			1956	
PP/micro	<i>Ethmodiscus punctiger</i> Castracane	1800	1979	1800		
VER	<i>Etrumeus golanii</i> DiBattista, Randall & Bowen, 2012	1999			1999	
INV	<i>Euchaeta concinna</i> Dana, 1849	1987			1987	
INV	<i>Eucheilota paradoxica</i> Mayer, 1900	1967			1967	
INV	<i>Euchone limnicola</i> Reish, 1959	2015		2015		
INV	<i>Euclidaris tribuloides</i> (Lamarck, 1816)	1998			1998	
INV	<i>Eudendrium carneum</i> Clarke, 1882	1950			1950	
INV	<i>Eudendrium merulum</i> Watson, 1985	1969			1969	
INV	<i>Eunaticina papilla</i> (Gmelin, 1791)	2020			2020	
INV	<i>Euplana gracilis</i> Girard, 1853	2002		2002		
INV	<i>Euplokamis dunlapae</i> Mills, 1987	2011		2011		
PP/micro	<i>Eupyxidicula turris</i> (Greville) S.Blanco & C.E. Wetzel	1983		1983		
INV	<i>Eurypanopeus depressus</i> (Smith, 1869)	2009				2009
INV	<i>Eurytemora americana</i> Williams, 1906	1938		1938		
INV	<i>Eurytemora carolleae</i> Aleksseev & Souissi, 2011	2011	2012	2011		
INV	<i>Eurytemora pacifica</i> Sato, 1913	2014		2014		
INV	<i>Eurythoe laevisetis</i> Fauvel, 1914	2011			2011	
INV	<i>Eusarsiella zostericola</i> (Cushman, 1906)	2012		2012		
INV	<i>Eusyllis kupfferi</i> Langerhans, 1879	1998			1998	
INV	<i>Euthymella colzumensis</i> (Jousseume, 1898)	2017			2017	
PP/micro	<i>Eutintinnus lusus-undae</i> (Entz)	2001				2001
INV	<i>Fauveliopsis glabra</i> (Hartman, 1960)	2007			2007	
INV	<i>Favorinus ghanensis</i> Edmunds, 1968	2020			2020	
INV	<i>Faxonius limosus</i> (Rafinesque, 1817)	2015	2015			
INV	<i>Fenestrulina malusii</i> (Audouin, 1826)	2011		2011		
INV	<i>Fenestrulina delicia</i> Winston, Hayward & Craig, 2000	2002		2002		
INV	<i>Ferosagitta galerita</i> (Dallot, 1971)	2011			2011	
PP/micro	<i>Fibrocapsa japonica</i> S.Toriumi & H.Takano	1924		1924		
INV	<i>Ficopomatus enigmaticus</i> (Fauvel, 1923)	1919	1939	1921	1919	1935

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Finella pupoides</i> A. Adams, 1860	1996			1996	
VER	<i>Fistularia petimba</i> Lacepède, 1803	2018			2018	
VER	<i>Fistularia commersonii</i> Rüppell, 1838	1999			1999	
INV	<i>Fistulobalanus albicostatus</i> (Pilsbry, 1916)	1973		1973		
INV	<i>Fulvia fragilis</i> (Forsskål in Niebuhr, 1775)	1983			1983	
VER	<i>Fundulus heteroclitus heteroclitus</i> (Linnaeus, 1766)	1970		1970	2005	
INV	<i>Gafrarium savignyi</i> (Jonas, 1846)	2005			2005	
INV	<i>Gammarus tigrinus</i> Sexton, 1939	1931	1975	1931		
PP	<i>Gelidium microdenticum</i> W.R.Taylor	2017		2017		
PP	<i>Gelidium vagum</i> Okamura	2010		2010		
VER	<i>Genyatremus cavifrons</i> (Cuvier, 1830)	2015		2015		
INV	<i>Glabropilumnus laevis</i> (Dana, 1852)	1956			1956	
INV	<i>Glycinde bonhourei</i> Gravier, 1904	2007			2007	
VER	<i>Gobiosoma bosc</i> (Lacepède, 1800)	2009		2009		
INV	<i>Godiva quadricolor</i> (Barnard, 1927)	1985			1985	
INV	<i>Goniadella gracilis</i> (Verrill, 1873)	1968		1968		
INV	<i>Goniobranchus annulatus</i> (Eliot, 1904)	2004			2004	
INV	<i>Goniobranchus obsoletus</i> (Rüppell & Leuckart, 1830)	2018			2018	
INV	<i>Gonioinfradens giardi</i> (Nobili, 1905)	2010			2010	
INV	<i>Gonionemus vertens</i> A. Agassiz, 1862	1700		1700	1918	
PP	<i>Goniotrichopsis sublittoralis</i> G.M.Smith	1975		1975	1989	
PP	<i>Gracilariopsis chorda</i> (Holmes) Ohmi	2010		2010		
INV	<i>Grandidierella japonica</i> Stephensen, 1938	2010	2010	2010	2013	
PP	<i>Grateloupia imbricata</i> Holmes	2005		2005		
PP	<i>Grateloupia asiatica</i> S.Kawaguchi & H.W.Wang	1984			1984	
PP	<i>Grateloupia patens</i> (Okamura) S.Kawaguchi & H.W.Wang	1994			1994	
PP	<i>Grateloupia subpectinata</i> Holmes	1978		1978	1990	
PP	<i>Grateloupia turuturu</i> Yamada	1982		1989	1982	
PP	<i>Grateloupia yinggehaiensis</i> H.W.Wang & R.X.Luan	2008			2008	
INV	<i>Guinearma alberti</i> (Rathbun, 1921)	2016		2016		
VER	<i>Gymnomuraena zebra</i> (Shaw, 1797)	2002		2002		
PP	<i>Gymnophycus hapsiphorus</i> Huisman & Kraft	2011		2011		
INV/par	<i>Gyrodactylus salaris</i> Malmberg, 1957	1975		1975		
PP/micro	<i>Gyrodinium corallinum</i> Kofoid & Swezy	2001		2001		
INV	<i>Halgerda willeyi</i> Eliot, 1904	1988			1988	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Haliclona (Halichoclona) vansoesti</i> de Weerd, de Kluijver & Gómez, 1999	2019			2019	
INV	<i>Halicylustus tenuis</i> Kishinouye, 1910	2010		2010		
PP	<i>Halimeda incrassata</i> (J.Ellis) J.V.Lamouroux	2011			2011	
INV	<i>Haliotis discus hannai</i> Ino, 1953	1985		1985		
INV	<i>Haloa japonica</i> (Pilsbry, 1895)	1992		1992	1992	
PP	<i>Halophila stipulacea</i> (Forsskål) Ascherson	1894			1894	
INV	<i>Haminella solitaria</i> (Say, 1822)	2016	2016	2020		
Pathogen	<i>Haplosporidium nelsoni</i> Haskin, Stauber & Mackin	1975		1975		
INV	<i>Heleobia charruana</i> (d'Orbigny, 1841)	2014		2014		
INV	<i>Heliacus implexus</i> (Mighels, 1845)	2019			2019	
INV	<i>Hemigrapsus sanguineus</i> (De Haan, 1835)	1999		1999	1999	2008
INV	<i>Hemigrapsus takanoi</i> Asakura & Watanabe, 2005	1993	2014	1993		
INV	<i>Hemimysis anomala</i> G.O. Sars, 1907*	1962	1962	1999	2007	
VER	<i>Hemiramphus far</i> (Forsskål, 1775)	1943			1943	
VER	<i>Heniochus acuminatus</i> (Linnaeus, 1758)	2014		2014		
VER	<i>Heniochus intermedius</i> Steindachner, 1893	2013		2013	2014	
INV	<i>Herbstia nitida</i> Manning & Holthuis, 1981	2002			2002	
INV	<i>Herdmania momus</i> (Savigny, 1816)	1998			1998	
PP	<i>Herposiphonia parca</i> Setchell	1997		2006	1997	
INV	<i>Hesperibalanus fallax</i> (Broch, 1927)	1976		1976	1976	
PP	<i>Heterostegina depressa</i> d'Orbigny, 1826	1988			1988	
INV	<i>Heterotentacula mirabilis</i> (Kramp, 1957)	1997			1997	
PP	<i>Hildenbrandia occidentalis</i> Setch.	2011		2011		
VER	<i>Hippocampus kuda</i> Bleeker, 1852	2014			2014	
INV	<i>Hippopodina feegeensis</i> (Busk, 1884)	1996			1996	
VER	<i>Holacanthus africanus</i> Cadenat, 1951	2017		2018	2017	
VER	<i>Holacanthus ciliaris</i> (Linnaeus, 1758)	2011			2011	
VER	<i>Holocentrus adscensionis</i> (Osbeck, 1765)	2016			2016	
INV	<i>Homarus americanus</i> H. Milne Edwards, 1837	1961	2007	1961	2018	
VER	<i>Huso huso</i> (Linnaeus, 1758)*	1962	1962			
PP	<i>Hydroclathrus tilesii</i> (Endlicher) Santiañez & M.J.Wynne	2006		2006		
INV	<i>Hydroides brachyacantha</i> Rioja, 1941	2015			2015	
INV	<i>Hydroides dirampha</i> Mörch, 1863	1981		1982	1981	
INV	<i>Hydroides elegans</i> (Haswell, 1883)	1868		1973	1868	
INV	<i>Hydroides ezoensis</i> Okuda, 1934	1968		1968		
INV	<i>Hydroides heterocera</i> (Grube, 1868)	1998			1998	
INV	<i>Hymeniacion gracilis</i> (Hentschel, 1912)	2017		2017		
INV	<i>Hypania invalida</i> (Grube, 1860)	1995		1995		

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Hypereteone heteropoda</i> (Hartman, 1951)	2017		2017		
PP	<i>Hypnea musciformis</i> (Wulfen) J.V.Lamouroux	2005		2005		
PP	<i>Hypnea anastomosans</i> Papenfuss, Lipkin & P.C.Silva	2008			2008	
PP	<i>Hypnea cervicornis</i> J.Agardh	2009			2009	
PP	<i>Hypnea cornuta</i> (Kützinger) J.Agardh	1894			1894	
PP	<i>Hypnea spinella</i> (C.Agardh) Kützinger	1977			1977	
PP	<i>Hypnea valentiae</i> (Turner) Montagne	1996		2006	1996	
INV	<i>Hypselodoris infucata</i> (Rüppell & Leuckart, 1830)	2002			2002	
INV	<i>Ianiropsis serricaudis</i> Gurjanova, 1936	2000		2000	2012	
INV	<i>Incisocalliope aestuarius</i> (Watling & Maurer, 1973)	1975		1975		
INV	<i>Indothais lacera</i> (Born, 1778)	1983			1983	
INV	<i>Isognomon aff. australicus</i> (Reeve, 1858)	2016			2016	
INV	<i>Isognomon legumen</i> (Gmelin, 1791)	2016			2016	
INV	<i>Isognomon radiatus</i> (Anton, 1838)	1996		1996		
INV	<i>Isolda pulchella</i> Müller in Grube, 1858	1994		1994		
INV	<i>Ixa monodi</i> Holthuis & Gottlieb, 1956	1999			1999	
INV	<i>Jasus lalandii</i> (H. Milne Edwards, 1837)	1980		1980		
PP	<i>Kapraunia schneideri</i> (Stuercke & Freshwater) A.M.Savoie & G.W.Saunders	2010		2010	2016	
PP/micro	<i>Karenia longicanalis</i> Z.B.Yang, I.J.Hodgkiss & Gerd Hansen	2008		2008		
PP/micro	<i>Karenia mikimotoi</i> (Miyake & Kominami ex Oda) Gert Hansen & Ø.Moestrup	1968	1980	1968		
PP/micro	<i>Karenia papilionacea</i> A.J.Haywood & K.A.Steidinger	1994		1994		
INV	<i>Koinostylochus ostreophagus</i> (Hyman, 1955)	1970		1970		
Pathogen	<i>Labyrinthula zosterae</i> D. Porter & Muehlst. in Muehlstein & Short	1930		1930		
VER	<i>Lactophrys triqueter</i> (Linnaeus, 1758)	1909			1909	
VER	<i>Lagocephalus guentheri</i> Miranda Ribeiro, 1915	1952			1952	
VER	<i>Lagocephalus sceleratus</i> (Gmelin, 1789)	2004			2004	
VER	<i>Lagocephalus suezensis</i> Clark & Gohar, 1953	2003			2003	
INV	<i>Lamprohaminoea ovalis</i> (Pease, 1868)	2001			2001	
INV	<i>Laonome xeprovala</i> Bick & Bastrop, in Bick et al., 2018	2012	2012	2016		2018
INV	<i>Latopilumnus malardi</i> (De Man, 1914)	1910		1910		
PP/micro	<i>Lauderia pumila</i> Castracane	1995				1995
PP	<i>Laurencia brongniartii</i> J.Agardh	1989		1989		
PP	<i>Laurencia caduciramulosa</i> Masuda & Kawaguchi	1991			1991	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP	<i>Laurencia okamurae</i> Yamada	1984			1984	
PP	<i>Leathesia marina</i> (Lyngbye) Decaisne	1905			1905	
INV	<i>Leiocapitellides analis</i> Hartmann-Schröder, 1960	2000			2000	
INV	<i>Leiochrides australis</i> Augener, 1914	2002			2002	
PP/micro	<i>Lennoxia faveolata</i> H.A.Thomsen & K.R.Buck	2007	2007			
INV	<i>Leonnates persicus</i> Wesenberg-Lund, 1949	2013			2013	
INV	<i>Lepidonotus tenuisetosus</i> (Gravier, 1902)	2007			2007	
INV	<i>Lepidonotus carinulatus</i> (Grube, 1870)	1984			1984	
INV	<i>Leucotina natalensis</i> E. A. Smith, 1910	1996			1996	
INV	<i>Limnodrilus profundicola</i> (Verrill, 1871)	2014	2014			
INV	<i>Limulus polyphemus</i> (Linnaeus, 1758)	1866		1866		
INV	<i>Linguimaera caesaris</i> Krapp-Schickel, 2003	1997			1997	
INV	<i>Linopherus canariensis</i> Langerhans, 1881	1997			1997	
INV	<i>Lioberus ligneus</i> (Reeve, 1858)	2019			2019	
PP	<i>Lithophyllum yessoense</i> Foslie	1994			1994	
PP	<i>Lomentaria flaccida</i> Tanaka	2002			2002	
PP	<i>Lomentaria hakodatensis</i> Yendo	1978		1984	1978	
PP	<i>Lophocladia lallemandii</i> (Montagne) F.Schmitz	1908			1908	
INV	<i>Lottia</i> sp.	2015			2015	
INV	<i>Lovenella assimilis</i> (Browne, 1905)	2007		2007		
INV	<i>Lumbrinerides crassicephala</i> (Hartman, 1965)	1994		1994		
INV	<i>Lumbrinerides neogesae</i> Miura, 1981	2002			2002	
INV	<i>Lumbrineris perkinsi</i> Carrera-Parra, 2001	1973			1973	
VER	<i>Lutjanus argentimaculatus</i> (Forsskål, 1775)	2019			2019	
VER	<i>Lutjanus griseus</i> (Linnaeus, 1758)	2018		2018		
VER	<i>Lutjanus jocu</i> (Bloch & Schneider, 1801)	2005			2005	
VER	<i>Lutjanus sebae</i> (Cuvier, 1816)	2010			2010	
VER	<i>Lutjanus fulviflamma</i> (Forsskål, 1775)	2013			2013	
INV	<i>Lysidice collaris</i> Grube, 1870	1961			1961	
PP	<i>Macrocystis pyrifera</i> (Linnaeus) C.Agardh	1972		1972		
INV	<i>Macromedaeus voeltzkowi</i> (Lenz, 1905)	1910		1910		
INV	<i>Macrophthalmus (Macrophthalmus) indicus</i> Davie, 2012	2009			2009	
INV	<i>Macrorhynchia philippina</i> Kirchenpauer, 1872	1982		1982		
INV	<i>Magallana angulata</i> (Lamarck, 1819)	1700		1700		
INV	<i>Magallana gigas</i> (Thunberg, 1793)	1700	2019	1700	1850	2010
INV	<i>Magallana rivularis</i> (Gould, 1861)	1994		1994		
INV	<i>Magallana sikamea</i> (Amemiya, 1928)	1994		1994		
INV	<i>Malleus regula</i> (Forsskål in Niebuhr, 1775)	1970			1970	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Marenzelleria arctica</i> (Chamberlin, 1920)	2004	2004			
INV	<i>Marenzelleria neglecta</i> Sikorski & Bick, 2004	1983	1983	1985		
INV	<i>Marenzelleria viridis</i> (Verrill, 1873)	1983	1985	1983		
INV	<i>Marginella glabella</i> (Linnaeus, 1758)	2009			2009	
INV	<i>Maritigrella fuscopunctata</i> (Prudhoe, 1978)	2014			2014	
INV	<i>Marivagia stellata</i> Galil & Gershwin, 2010	2019			2019	
INV	<i>Marphysa victori</i> Lavesque, Daffe, Bonifácio & Hutchings, 2017	1975		1975		
Pathogen	<i>Marteilia refringens</i> Grizel, Comps, Bonami, Cousserans, Duthoit & Le Pennec	1975		1975	1992	
INV	<i>Matuta victor</i> (J.C. Fabricius, 1781)	2018			2018	
PP/micro	<i>Mediopyxis helysia</i> Kühn, Hargreaves & Halliger	2003		2003		
INV	<i>Megabalanus tintinnabulum</i> (Linnaeus, 1758)	1764		1764	1971	
INV	<i>Megabalanus coccopoma</i> (Darwin, 1854)	1851		1851		
INV	<i>Melanella orientalis</i> Agamennone, Micali & Siragusa, 2020	2016			2016	
PP	<i>Melanothamnus flavimarinus</i> (M.-S.Kim & I.K.Lee) Díaz-Tapia & Maggs	2010		2010		
PP	<i>Melanothamnus harveyi</i> (Bailey) Díaz-Tapia & Maggs	1958	1982	2015	1958	
PP	<i>Melanothamnus japonicus</i> (Harvey) Díaz-Tapia & Maggs	2016			2016	
INV	<i>Melibe viridis</i> (Kelaart, 1858)	1970			1970	
INV	<i>Melita nitida</i> S.I. Smith in Verrill, 1873	1996	2010	1996		
INV	<i>Menaethius monoceros</i> (Latreille, 1825)	1978			1978	
INV	<i>Mercenaria mercenaria</i> (Linnaeus, 1758)	1861		1861	1964	
INV	<i>Mesanthura</i> cfr. <i>romulea</i> Poore & Lew Ton, 1986	2000			2000	
INV	<i>Metacalanus acutioperculum</i> Ohtsuka, 1984	1995			1995	
INV	<i>Metacirolana rotunda</i> (Bruce & Jones, 1978)	1998			1998	
INV	<i>Metapenaeopsis aegyptia</i> Galil & Golani, 1990	1996			1996	
INV	<i>Metapenaeopsis mogiensis consobrina</i> (Nobili, 1904)	1995			1995	
INV	<i>Metapenaeus monoceros</i> (Fabricius, 1798)	1961			1961	
INV	<i>Metaxia bacillum</i> (Issel, 1869)	1995			1995	
INV	<i>Microcosmus anchylodeirus</i> Traustedt, 1883	1980			1980	
INV	<i>Microcosmus squamiger</i> Michaelsen, 1927	1971		1992	1971	
INV	<i>Microcosmus exasperatus</i> Heller, 1878	2005		2005	2014	
VER	<i>Micropogonias undulatus</i> (Linnaeus, 1766)	1998		1998		
PP	<i>Miliolinella fichteliana</i> (d'Orbigny, 1839)	1911			1911	
INV	<i>Millepora alcicornis</i> Linnaeus, 1758	2004		2004		

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP	<i>Mimosina affinis</i> Millett, 1900	2012			2012	
INV	<i>Mitrella psilla</i> (Duclos, 1846)	2016			2016	
INV	<i>Mizuhopecten yessoensis</i> (Jay, 1857)	1979		1979		
INV	<i>Mnemiopsis leidyi</i> A. Agassiz, 1865	1986	2006	2001	1990	1986
INV	<i>Mnestia girardi</i> (Audouin, 1826)	1990			1990	
INV	<i>Moerisia inkermanica</i> Paltschikowa-Ostroumowa	1959	2018	1959		
INV	<i>Molgula occidentalis</i> Traustedt, 1883	2010		2010		
INV	<i>Monocorophium uenoi</i> (Stephensen, 1932)	2007		2007		
VER	<i>Morone saxatilis x Morone chrysops</i>	2019				2019
INV	<i>Mulinia lateralis</i> (Say, 1822)	2017		2017		
INV	<i>Murchisonellidae</i> T. L. Casey, 1904	2013	2013			
INV	<i>Mycale (Carmia) senegalensis</i> Lévi, 1952	2002		2002		
VER	<i>Mycteroperca tigris</i> (Valenciennes, 1833)	2018		2018		
INV/par	<i>Mycicola ostreae</i> Hoshina & Sugiura, 1953	1972		1972	1972	
INV	<i>Myra subgranulata</i> Kossmann, 1877	2004			2004	
INV/par	<i>Mytilicola orientalis</i> Mori, 1935	1977	2018	1977	1977	
INV	<i>Mytilopsis leucophaeata</i> (Conrad, 1831)	1835	1928	1835		
INV	<i>Naineris setosa</i> (Verrill, 1900)	2010			2010	
INV	<i>Namanereis littoralis</i> (Grube, 1872)	1991		1991		
INV	<i>Neanthes agulhana</i> (Day, 1963)	2007			2007	
PP	<i>Nemalion vermiculare</i> Suringar	2005			2005	
VER	<i>Nemipterus randalli</i> Russell, 1986	2014			2014	
INV	<i>Nemopsis bachei</i> L. Agassiz, 1849	1905		1905		
INV	<i>Neodexiospira brasiliensis</i> (Grube, 1872)	1982		1982		
PP	<i>Neogastroclonium subarticulatum</i> (Turner) L.Le Gall, Dalen & G.W.Saunders	2017		2017		
VER	<i>Neogobius melanostomus</i> (Pallas, 1814)	1990	1990	2004		
PP	<i>Neoizziella divaricata</i> (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman	1989		1989		
INV	<i>Neomysis americana</i> (S.I. Smith, 1873)	2010		2010		
INV	<i>Nereis jacksoni</i> Kinberg, 1865	1964			1964	
INV	<i>Nerita sanguinolenta</i> Menke, 1829	1969			1969	
INV	<i>Nippoleucon hinumensis</i> (Gamô, 1967)	2019	2019			
PP	<i>Nitophyllum stellato-corticatum</i> Okamura	1984			1984	
PP	<i>Nonionella</i> sp. T1/ <i>Nonionella stella</i>	2012		2012		
INV	<i>Notocochlis gualtieriana</i> (Récluz, 1844)	1978			1978	
INV	<i>Notomastus aberans</i> Day, 1957	1964			1964	
INV	<i>Notomastus mossambicus</i> (Thomassin, 1970)	1997			1997	
INV	<i>Novafabricia infratorquata</i> (Fitzhugh, 1973)	1985		2013	1985	
INV/par	<i>Nybelinia africana</i> Dollfus, 1960	2005			2005	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Obesogammarus crassus</i> (Sars G.O., 1894)*	1962	1962	2016		
INV	<i>Ocinebrellus inornatus</i> (Récluz, 1851)	1993		1993		
INV	<i>Odontodactylus scyllarus</i> (Linnaeus, 1758)	2009		2009		
INV	<i>Oithona davisae</i> Ferrari F.D. & Orsi, 1984	2000		2002	2000	2009
VER	<i>Oncorhynchus gorbuscha</i> (Walbaum, 1792)	1958	1958	1958		
VER	<i>Oncorhynchus kisutch</i> (Walbaum, 1792)*	1905	1984	1905		
VER	<i>Oncorhynchus mykiss</i> (Walbaum, 1792)*	1882	1882	1899		
PP	<i>Operculina ammonoides</i> (Gronovius, 1781)	1911			1911	
INV	<i>Ophiactis macrolepidota</i> Marktanner-Turneretscher, 1887	1998			1998	
INV	<i>Ophiactis savignyi</i> (Müller & Troschel, 1842)	1968			1968	
VER	<i>Ophioblennius atlanticus</i> (Valenciennes, 1836)	2017			2017	
INV	<i>Ophryotrocha japonica</i> Paxton & Åkesson, 2010	1999			1999	
INV	<i>Ophryotrocha diadema</i> Åkesson, 1976	2006			2006	
VER	<i>Oplegnathus fasciatus</i> (Temminck & Schlegel, 1844)	2009			2009	
VER	<i>Orthopristis chrysoptera</i> (Linnaeus, 1766)	2020			2020	
INV	<i>Oscilla galilae</i> Bogi, Karhan & Yokeş, 2012	2016			2016	
VER	<i>Ostorhinchus fasciatus</i> (White, 1790)	2014			2014	
Pathogen	<i>Ostracoblabe implexa</i> Born & Flahault	1951		1951		
INV	<i>Ostraea angasi</i> G. B. Sowerby II, 1871	1985		1985		
INV	<i>Ostrea equestris</i> Say, 1834	1995		1995		
INV	<i>Ostrea denselamellosa</i> Lischke, 1869	1982		1982		
INV	<i>Ostrea puelchana</i> d'Orbigny, 1842	1989		1989		
INV	<i>Oulastrea crispata</i> (Lamarck, 1816)	2012			2012	
INV	<i>Oxydromus humesi</i> (Pettibone, 1961)	2009		2009		
PP/micro	<i>Oxytoxum criophilum</i> Balech	2003		2003		
VER	<i>Oxyurichthys papuensis</i> (Valenciennes, 1837)	2010			2010	
INV	<i>Pachygrapsus gracilis</i> (de Saussure, 1857)	2013		2013		
PP	<i>Pachymeniopsis gargiuli</i> S.Y.Kim, Manghisi, Morabito & S.M.Boo	1968		2001	1968	
PP	<i>Pachymeniopsis lanceolata</i> (K.Okamura) Y.Yamada ex S.Kawabata	1982		2006	1982	
INV	<i>Pacifastacus leniusculus</i> (Dana, 1852)	2014	2014			
INV	<i>Pacificincola perforata</i> (Okada & Mawatari, 1937)	2001		2001		
PP	<i>Padina boergesenii</i> Allender & Kraft	1965			1965	
VER	<i>Pagrus major</i> (Temminck & Schlegel, 1843)	2004			2004	
INV	<i>Pagurus longicarpus</i> (Say, 1817)	2020		2020		
INV	<i>Palaemon macrodactylus</i> Rathbun, 1902	1998	2014	1998	2005	2002



Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Palola valida</i> (Gravier, 1900)	2014			2014	
VER	<i>Pampus argenteus</i> (Euphrasen, 1788)	1896			1896	
INV	<i>Panopeus occidentalis</i> Saussure, 1857	2015		2015		
PP	<i>Papenfussiella kuromo</i> (Yendo) Inagaki	1990		1990		
INV	<i>Paracalanus quasimodo</i> Bowman, 1971	2017		2017		
INV	<i>Paracaprella pusilla</i> Mayer, 1890	2010		2010	2011	
INV	<i>Paracerceis sculpta</i> (Holmes, 1904)	1981		1988	1981	
INV	<i>Paradella diana</i> (Menzies, 1962)	1985		1988	1985	
INV	<i>Paradyte</i> cf. <i>crinoidicola</i> (Potts, 1910)	1968			1968	
INV	<i>Paraleucilla magna</i> Klautau, Monteiro & Borojevic, 2004	2000		2006	2000	
INV	<i>Paralithodes camtschaticus</i> (Tilesius, 1815)	2008			2008	
INV	<i>Parametopella cypris</i> Holmes, 1905	2014			2014	
INV	<i>Paramysis (Mesomysis) intermedia</i> (Czerniavsky, 1882)	2008	2008			
INV	<i>Paramysis (Serrapalpis) lacustris</i> (Czerniavsky, 1882)	1962	1962			
INV	<i>Paranaïs frici</i> Hrabě, 1941	1970	1970			
VER	<i>Paranthias furcifer</i> (Valenciennes, 1828)	2011		2014	2011	
INV	<i>Paranthura japonica</i> Richardson, 1909	2005		2007	2005	
INV	<i>Parasmittina alba</i> Ramalho, Muricy & Taylor, 2011	2014		2014		
INV	<i>Parasmittina multiaviculata</i> Souto, Ramalhosa & Canning-Clode, 2016	2016		2016		
INV	<i>Parasmittina egyptiaca</i> (Waters, 1909)	2016			2016	
PP	<i>Parasorites orbitolitoides</i> Hofker, 1930	2016			2016	
INV	<i>Paratapes textilis</i> (Gmelin, 1791)	2004			2004	
INV/par	<i>Paratenuisentis ambiguus</i> (Van Cleave, 1921)	2001	2001			
VER	<i>Parexocoetus mento</i> (Valenciennes, 1847)	1955			1955	
VER	<i>Parupeneus forskali</i> (Fourmanoir & Guézé, 1976)	2014			2014	
INV	<i>Parvocalanus crassirostris</i> (Dahl F., 1894)	2009			2009	
PP	<i>Pegidia lacunata</i> McCulloch, 1977	2010			2010	
VER	<i>Pempheris rhomboidea</i> Kossmann & Räuber, 1877	1983			1983	
INV	<i>Penaeus aztecus</i> Ives, 1891	2012		2018	2012	
INV	<i>Penaeus hathor</i> (Burkenroad, 1959)	2012			2012	
INV	<i>Penaeus monodon</i> Fabricius, 1798	2011		2011		
INV	<i>Penaeus japonicus</i> Spence Bate, 1888	1972		1980	1972	
INV	<i>Penaeus pulchricaudatus</i> Stebbing, 1914	1961		1982	1961	
INV	<i>Penaeus semisulcatus</i> De Haan, 1844 [in De Haan, 1833–1850]	2016		2016		
PP/micro	<i>Peridiniella catenata</i> (Levander) Balech	1987	1987			

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP/micro	<i>Peridiniella danica</i> (Paulsen) Y.B.Okolodkov & J.D.Dodge	1901		1901		
PP/micro	<i>Peridinium quadridentatum</i> (F.Stein) Gert Hansen	2005	2008	2005		
INV	<i>Perinereis linea</i> (Treadwell, 1936)	2012			2012	
Pathogen	<i>Perkinsus chesapeaki</i> McLaughlin, Tall, Shaheen, El Sayed & Faisal	1992		1992	1992	
Pathogen	<i>Perkinsus olsenii</i> R.J.G.Lester & G.H.G.Davis	1983		1983		
INV	<i>Perophora multiclathrata</i> (Sluiter, 1904)	1983			1983	
INV	<i>Perophora viridis</i> Verrill, 1871	1971		1971		
INV	<i>Perophora japonica</i> Oka, 1927	1982		1982		
PP	<i>Petalonia binghamiseae</i> (J.Agardh) K.L.Vinogradova	1985		1985		
INV	<i>Petricolaria pholadiformis</i> (Lamarck, 1818)	1896	1927	1896	1985	
VER	<i>Petroscirtes ancyloдон</i> Rüppell, 1835	2004			2004	
INV	<i>Phallusia nigra</i> Savigny, 1816	2008			2008	
INV	<i>Phascolion convestitum</i> Sluiter, 1902	1977			1977	
INV	<i>Phascolosoma (Phascolosoma) scolops</i> (Selenka & de Man, 1883)	1975			1975	
INV	<i>Photis lamellifera</i> Schellenberg, 1928	1990			1990	
Pathogen	<i>Photobacterium damsela</i> Love, Teebken-Fisher, Hose, Farmer III, Hickman & Fanning	1992			1992	
PP	<i>Phrix spatulata</i> (E.Y.Dawson) M.J.Wynne, M.Kamiya & J.A.West	1992			1992	
INV	<i>Phyllorhiza punctata</i> Lendenfeld, 1884	2005		2018	2005	
VER	<i>Piaractus brachypomus</i> (Cuvier, 1818)	2013		2013		
PP	<i>Pikea californica</i> Harvey	1991		1991		
INV	<i>Pileolaria berkeleyana</i> (Rioja, 1942)	1977		2007	1977	
INV	<i>Pilumnopeus africanus</i> (de Man, 1902)	2013		2013		
INV	<i>Pilumnopeus vauquelini</i> (Audouin, 1826)	1963			1963	
INV	<i>Pilumnus minutus</i> De Haan, 1835 [in De Haan, 1833–1850]	2017			2017	
INV	<i>Pinctada fucata</i> (A. Gould, 1850)	2018			2018	
INV	<i>Pinctada radiata</i> (Leach, 1814)	1899		1998	1899	
VER	<i>Pinguipes brasiliensis</i> Cuvier, 1829	1990			1990	
INV/par	<i>Piscicola pojmanskae</i> Bielecki, 1994	2008	2008			
INV	<i>Pista unibranchia</i> Day, 1963	1997		2005	1997	
INV	<i>Plagusia squamosa</i> (Herbst, 1790)	1906			1906	
VER	<i>Planiliza haematocheila</i> (Temminck & Schlegel, 1845)	1972			1995	1972
PP	<i>Planispirinella exigua</i> (Brady, 1879)	1910			1910	
PP	<i>Planogypsina acervalis</i> (Brady, 1884)	1909			1909	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
VER	<i>Platycephalus indicus</i> (Linnaeus, 1758)	1978			1978	
PP	<i>Plocamium secundatum</i> (Kützing) Kützing	1991			1991	
INV	<i>Plocamopherus ocellatus</i> Rüppell & Leuckart, 1828	2015			2015	
VER	<i>Poecilopsetta beanii</i> (Goode, 1881)	1995		1995		
INV	<i>Polyandrocarpa zorritensis</i> (Van Name, 1931)	1974			1974	
INV	<i>Polycera hedgpethi</i> Er. Marcus, 1964	1986		2001	1986	
INV	<i>Polycerella emertoni</i> A. E. Verrill, 1880	1964		1981	1964	
INV	<i>Polycirrus twisti</i> Potts, 1928	1983			1983	
INV	<i>Polyclinum constellatum</i> Savigny, 1816	2014			2014	
INV	<i>Polydora colonia</i> Moore, 1907	1983		2018	1983	
INV	<i>Polydora triglanda</i> Radashevsky & Hsieh, 2000	2014		2014		
INV	<i>Polydora websteri</i> Hartman in Loosanoff & Engle, 1943	2014		2014		
PP	<i>Polyopes lancifolius</i> (Harvey) Kawaguchi & Wang	2008		2008		
PP	<i>Polysiphonia paniculata</i> Montagne	1967			1967	
PP	<i>Polysiphonia forfex</i> Harvey	2011		2011		
PP	<i>Polysiphonia morrowii</i> Harvey	1975		1975	1997	
PP	<i>Polysiphonia senticulosa</i> Harvey	1993		1993		
VER	<i>Pomacanthus imperator</i> (Bloch, 1787)	2016			2016	
VER	<i>Pomacanthus paru</i> (Bloch, 1787)	2015		2015		
VER	<i>Pomacanthus maculosus</i> (Forsskål, 1775)	1994		1994	2012	
VER	<i>Pomadasys stridens</i> (Forsskål, 1775)	1968			1968	
INV	<i>Pontogammarus robustoides</i> (Sars, 1894)*	1962	1962			
PP	<i>Porphyra umbilicalis</i> Kützing	1989	1989			
INV	<i>Portunus segnis</i> (Forskål, 1775)	1958			1958	
INV	<b>Potamocorbula amurensis</b> (Schrenck, 1862)	2018		2018		
INV	<i>Potamopyrgus antipodarum</i> (Gray, 1843)*	1801	1801	1887		
INV	<i>Potamothenis moldaviensis</i> Vejdovský & Mrázek, 1903	2008	2008			
INV	<i>Potamothenis bavaricus</i> (Oschmann, 1913)	2015	2015			
INV	<i>Potamothenis bedoti</i> (Piguet, 1913)	1915	1915			
INV	<i>Potamothenis heuscheri</i> (Bretscher, 1900)*	1960	1960			
INV	<i>Potamothenis vej dovskyi</i> (Hrabě, 1941)*	1967	1967			
inv	<i>Prionospio aluta</i> Maciolek, 1985	1994		1994		
INV	<i>Prionospio depauperata</i> Imajima, 1990	2018			2018	
INV	<i>Prionospio pulchra</i> Imajima, 1990	1989		1989	1991	
INV	<i>Proasellus coxalis</i> (Dollfus, 1892)	2011	2011			
INV	<i>Procamburus clarkii</i> (Girard, 1852)*	2000			2000	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Prokelisia marginata</i> (Van Duzee, 1897)	2011		2011		
PP/micro	<i>Prorocentrum gracile</i> Schütt	1989		1989		
INV	<i>Prosphaerosyllis longipapillata</i> (Hartmann-Schröder, 1979)	1997			1997	
VER	<i>Proterorhinus nasalis</i> (De Filippi, 1863)	2020	2020			
INV	<i>Protodorvillea biarticulata</i> Day, 1963	1975			1975	
INV	<i>Protoreaster nodosus</i> (Linnaeus, 1758)	1981			1981	
INV	<i>Psammacoma gubernaculum</i> (Hanley, 1844)	2009			2009	
PP/micro	<i>Pseudochattonella farcimen</i> (Riisberg I.)	1998	2001	1998		
PP/micro	<i>Pseudochattonella verruculosa</i> (Y.Hara & M.Chihara) S.Tanabe-Hosoi, D.Honda, S.Fukaya, Y.Inagaki & Y.Sako	1998	2015	1998		
INV/par	<i>Pseudodactylogyrus anguillae</i> (Yin & Sproston, 1948)	1982	1985	1982		
INV/par	<i>Pseudodactylogyrus bini</i> (Kikuchi, 1929)	1985	1985	1997		
INV	<i>Pseudodiptomus marinus</i> Sato, 1913	2007		2010	2007	
INV	<i>Pseudonereis anomala</i> Gravier, 1899	1969			1969	
PP/micro	<i>Pseudo-nitzschia australis</i> Frenguelli	1995		1995	2000	
PP/micro	<i>Pseudo-nitzschia multistriata</i> (Takano) Takano	1985		1985		
INV	<i>Pseudopolydora paucibranchiata</i> (Okuda, 1937)	1977		1982	1977	
VER	<i>Pteragogus trispilus</i> Randall, 2013	1992			1992	
VER	<i>Pterois miles</i> (Bennett, 1828)	2009			2009	
INV	<i>Ptilohyale littoralis</i> (Stimpson, 1853)	2009		2009		
INV	<i>Purpuradusta gracilis notata</i> (Gill, 1858)	1988			1988	
INV	<i>Pyrgulina pupaeformis</i> (Souverbie, 1865)	1995			1995	
INV	<i>Pyromaia tuberculata</i> (Lockington, 1877)	2016		2016		
PP	<i>Pyropia yezoensis</i> (Ueda) M.S.Hwang & H.G.Choi	1975		1984	1975	
PP	<i>Pyropia suborbiculata</i> (Kjellman) J.E.Sutherland, H.G.Choi, M.S.Hwang & W.A.Nelson	2010		2010	2014	
INV	<i>Pyrrunculus fourierii</i> (Audouin, 1826)	1995			1995	
INV	<i>Rangia cuneata</i> (G. B. Sowerby I, 1832)	1997	2011	1997		
INV	<i>Rapana venosa</i> (Valenciennes, 1846)	1956		1997	1973	1956
VER	<i>Rastrelliger kanagurta</i> (Cuvier, 1816)	2018			2018	
INV	<i>Rhinoclavis kochi</i> (Philippi, 1848)	1976			1976	
INV	<i>Rhithropanopeus harrisi</i> (Gould, 1841)	1936	1936	1950	1994	1948
PP/micro	<i>Rhizosolenia calcar-avis</i> Schultze	2009		2009		
INV	<i>Rhopilema nomadica</i> Galil, 1990	1995			1995	
INV	<i>Ringicula minuta</i> H. Adams, 1872	2019			2019	
INV	<i>Rissoina bertholleti</i> Issel, 1869	1985			1985	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Ruditapes philippinarum</i> (Adams & Reeve, 1850)	1973		1973	1980	
PP	<i>Rugulopteryx okamurae</i> (E.Y.Dawson) I.K.Hwang, W.J.Lee & H.S.Kim	2002		2015	2002	
PP	<i>Saccharina japonica</i> (J.E. Areschoug) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	1976		1980	1976	
INV	<i>Saccostrea cucullata</i> (Born, 1778)	2007		2007		
INV	<i>Saccostrea glomerata</i> (Gould, 1850)	1984			1984	
VER	<i>Salvelinus fontinalis</i> (Mitchill, 1814)*	1916		1916		
PP	<i>Sarconema filiforme</i> (Sonder) Kylin	1990			1990	
PP	<i>Sarconema scinaoides</i> Børgesen	1980			1980	
PP	<i>Sargassum muticum</i> (Yendo) Fensholt	1972		1972	1980	
VER	<i>Sargocentron rubrum</i> (Forsskål, 1775)	1943			1943	
VER	<i>Saurida lessepsianus</i> Russell, Golani & Tikochinski, 2015	1960			1960	
PP	<i>Scageliopsis patens</i> Wollaston	1989		1989		
VER	<i>Scarus ghobban</i> Forsskål, 1775	2010			2010	
VER	<i>Scatophagus argus</i> (Linnaeus, 1766)	2007			2007	
INV	<i>Schizoporella japonica</i> Ortmann, 1890	1976		1976		
INV	<i>Schizoporella pungens</i> Canu & Bassler, 1928	2010		2010		
VER	<i>Sciaenops ocellatus</i> (Linnaeus, 1766)	2016			2016	
INV	<i>Scolecopsis (Parascolecopsis) gilchristi</i> (Day, 1961)	1977			1977	
INV	<i>Scolecopsis korsuni</i> Sikorski, 1994	1994		1994		
INV	<i>Scolionema suvaense</i> (Agassiz & Mayer, 1899)	1950			1950	
VER	<i>Scomberomorus commerson</i> (Lacepède, 1800)	2008			2008	
INV	<i>Scyllarus caparti</i> Holthuis, 1952	1977			1977	
PP	<i>Scytosiphon dotyi</i> M.J.Wynne	1968		1991	1968	
VER	<i>Sebastes schlegelii</i> Hilgendorf, 1880	2008		2008		
INV	<i>Sebastiscus marmoratus</i> (Cuvier, 1829)	2016		2016		
INV	<i>Sepioteuthis lessoniana</i> Férussac [in Lesson], 1831	2009			2009	
INV	<i>Septifer cumingii</i> Récluz, 1848	2005			2005	
VER	<i>Siganus fuscescens</i> (Houttuyn, 1782)	2020			2020	
VER	<i>Siganus virgatus</i> (Valenciennes, 1835)	1975			1975	
VER	<i>Siganus luridus</i> (Rüppell, 1829)	1964			1964	
VER	<i>Siganus rivulatus</i> Forsskål & Niebuhr, 1775	1925			1925	
PP	<i>Sigmamiliolinella australis</i> (Parr, 1932)	2001			2001	
VER	<i>Sillago suezensis</i> Golani, Fricke & Tikochinski, 2013	2009			2009	
INV	<i>Sinelobus vanhaareni</i> Bamber, 2014	2006	2010	2006		
INV	<i>Sinezona plicata</i> (Hedley, 1899)	2019			2019	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Smaragdia souverbiana</i> (Montrouzier in Souverbie & Montrouzier, 1863)	1993			1993	
INV	<i>Smittina nitidissima</i> (Hincks, 1880)	2014			2014	
INV	<i>Smittoidea prolifica</i> Osburn, 1952	1995		1995		
PP	<i>Solieria filiformis</i> (Kützing) P.W.Gabrielson	1922			1922	
PP	<i>Sorites variabilis</i> Lacroix, 1941	1996			1996	
PP	<i>Spartina anglica</i> C.E. Hubbard	1924		1924		
PP	<i>Spartina densiflora</i> Brongn.	1986		1986		
PP	<i>Spartina patens</i> (Aiton) Muhl.	1986		1986		
PP	<i>Spartina alterniflora</i> Loisel	1806		1806		
PP	<i>Spermothamnion cymosum</i> (Harvey) De Toni	2010			2010	
INV	<i>Sphaeroma walkeri</i> Stebbing, 1905	1977		2015	1977	2004
PP	<i>Sphaerotrichia firma</i> (E.S.Gepp) A.D.Zinova	1981			1981	
INV	<i>Sphaerozius nitidus</i> Stimpson, 1858	2013			2013	
VER	<i>Sphyræna chrysotaenia</i> Klunzinger, 1884	1964			1964	
VER	<i>Sphyræna flavicauda</i> Rüppell, 1838	2003			2003	
INV	<i>Spirobranchus tetracerus</i> (Schmarda, 1861)	1970			1970	
PP	<i>Spiroloculina angulata</i> Cushman, 1917	1996			1996	
PP	<i>Spiroloculina antillarum</i> d'Orbigny, 1839	1911			1911	
INV	<i>Spirorbis (Spirorbis) marioni</i> Caullery & Mesnil, 1897	1974		1974	1977	
INV	<i>Spondylus spinosus</i> Schreibers, 1793	2001			2001	
PP	<i>Spongoclonium caribaeum</i> (Børgesen) M.J.Wynne	1967		1967	1974	
VER	<i>Spratelloides delicatulus</i> (Bennett, 1832)	2014			2014	
VER	<i>Stegastes variabilis</i> (Castelnau, 1855)	2014			2014	
INV	<i>Stenothoe georgiana</i> Bynum & Fox, 1977	2010		2011	2010	
VER	<i>Stephanolepis diaspros</i> Fraser-Brunner, 1940	1935			1935	
INV	<i>Sternodromia spinirostris</i> (Miers, 1881)	1969			1969	
INV	<i>Sticteulima lentiginosa</i> (A. Adams, 1861)	1995			1995	
INV	<i>Stomatella</i> sp.	2011			2011	
INV	<i>Streblospio gynobranchiata</i> Rice & Levin, 1998	2011				2011
INV	<i>Streblospio benedicti</i> Webster, 1879	1982		1982		
INV	<i>Styela plicata</i> (Lesueur, 1823)	1877		1989	1877	
INV	<i>Styela canopus</i> (Savigny, 1816)	2006		2006		
INV	<i>Styela clava</i> Herdman, 1881	1968	2017	1968	2005	2002
PP	<i>Stypopodium schimperi</i> (Kützing) M.Verlaque & Boudouresque	1990			1990	
INV	<i>Syllis hyllebergi</i> (Licher, 1999)	1972			1972	
INV	<i>Syllis pectinans</i> Haswell, 1920	1982		1982	2013	

Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
PP	<i>Symphyclocladia marchantioides</i> (Harvey) Falkenberg	1971		1971	1984	
PP	<i>Symphyclocladiella dendroidea</i> (Montagne) D.Bustamante, B.Y.Won, S.C.Lindstrom & T.O.Cho	1993		2005	1993	
INV	<i>Symplegma rubra</i> Monniot C., 1972	2014		2014		
INV	<i>Symplegma brakenhielmi</i> (Michaelsen, 1904)	2003			2003	
VER	<i>Synagrops japonicus</i> (Döderlein, 1883)	1987			1987	
INV	<i>Synaptula reciprocans</i> (Forsskål, 1775)	1967			1967	
VER	<i>Synchiropus sechellensis</i> Regan, 1908	2014			2014	
INV	<i>Synidotea laticauda</i> Benedict, 1897	1975		1975		
INV	<i>Syphonota geographica</i> (A. Adams & Reeve, 1850)	1999			1999	
INV	<i>Syrnola fasciata</i> Jickeli, 1882	1995			1995	
INV/par	<i>Taeniastrotos</i> sp.	1993		1993		
PP/micro	<i>Takayama tasmanica</i> de Salas, Bolch & Hallegraeff	2008		2008		
INV	<i>Telmatogeton japonicus</i> Tokunaga, 1933	1962	1962	1979		
INV	<i>Tenellia adpersa</i> (Nordmann, 1845)	2001		2001		
VER	<i>Terapon theraps</i> (Cuvier, 1829)	2007			2007	
INV	<i>Terebella ehrenbergi</i> Gravier, 1906	1952			1952	
INV	<i>Teredo bartschi</i> Clapp, 1923	2003		2003	2007	
INV	<i>Thalamita gloriensis</i> Crosnier, 1962	1977			1977	
INV	<i>Thalamita poissonii</i> (Audouin, 1826)	1969			1969	
PP/micro	<i>Thalassiosira nordenskiöldii</i> Cleve	1967				1967
PP/micro	<i>Thalassiosira hendeyi</i> Hasle & G.Fryxell	1978		1978		
PP/micro	<i>Thalassiosira tealata</i> Takano	1968		1968		
PP/micro	<i>Thecadinium yashimaense</i> S.Yoshimatsu, S.Toriumi & J.D.Dodge	2002		2002		
INV	<i>Thelepus japonicus</i> Marenzeller, 1884	2017		2017		
INV	<i>Theora lubrica</i> Gould, 1861	2001		2010	2001	
INV	<i>Timarete punctata</i> (Grube, 1859)	2006			2006	
INV	<i>Tonicia atrata</i> (G.B. Sowerby II, 1840)	1978		1978		
VER	<i>Torquigener flavimaculosus</i> Hardy & Randall, 1983	2006			2006	
INV	<i>Trachysalambria palaestinensis</i> (Steinitz, 1932)	1995			1995	
INV	<i>Tremoctopus gracilis</i> (Souleyet, 1852)	1937			1937	
INV	<i>Tricellaria inopinata</i> d'Hondt & Occhipinti Ambrogi, 1985	1982		1996	1982	
INV	<i>Triconia rufa</i> (Boxshall & Böttger, 1987)	2004			2004	
INV	<i>Triconia umerus</i> (Böttger-Schnack & Boxshall, 1990)	2004			2004	

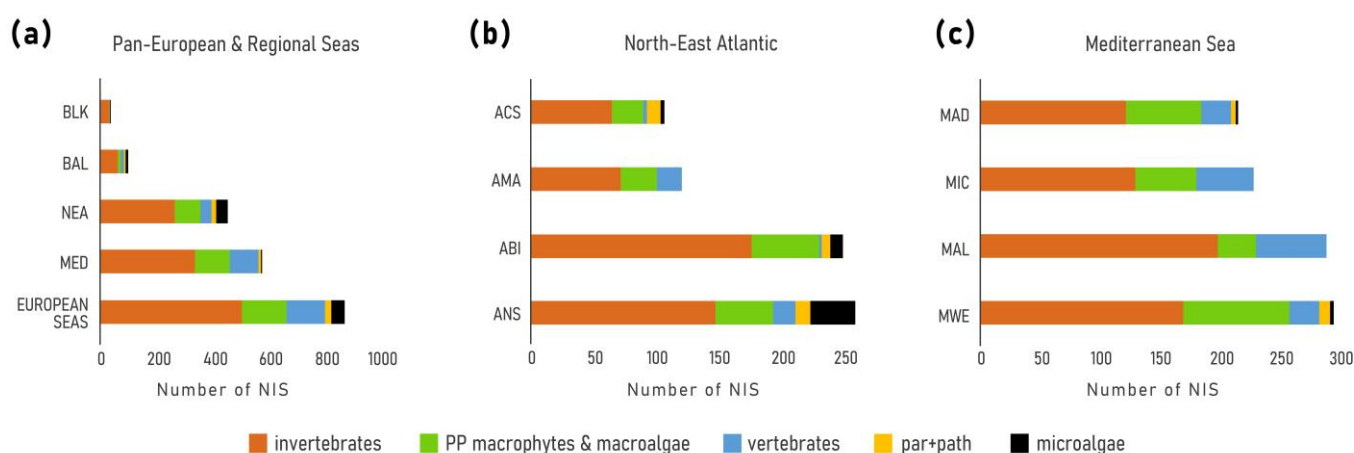
Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Tridentata marginata</i> (Kirchenpauer, 1864)	1980		1980	1990	
VER	<i>Tridentiger barbatus</i> (Günther, 1861)	2016		2016		
PP/micro	<i>Trieres mobiliensis</i> (J.W.Bailey) Ashworth & Theriot	1983		1983		
PP/micro	<i>Trieres regia</i> (M.Schultze) M.P.Ashworth & E.C.Theriot	1989		1989		
VER	<i>Trinectes maculatus</i> (Bloch & Schneider, 1801)	1984		1984		
PP/micro	<i>Triplos arietinus</i> (Cleve) F.Gómez	1992		1992		
PP/micro	<i>Triplos macroceros</i> (Ehrenberg) F.Gómez	1983		1983		
INV	<i>Trochus erithreus</i> Brocchi, 1821	1985			1985	
INV	<i>Tubastraea tagusensis</i> Wells, 1982	2017		2017		
INV	<i>Turbonilla edgarii</i> (Melvill, 1896)	1996			1996	
VER	<i>Tylerius spinosissimus</i> (Regan, 1908)	2004			2004	
VER	<i>Tylosurus crocodilus crocodilus</i> (Péron & Lesueur, 1821)	2003			2003	
PP	<i>Ulva australis</i> Areschoug	1984		1990	1984	
PP	<i>Ulva californica</i> Wille	2006		2006	2011	
PP	<i>Ulva gigantea</i> (Kützting) Bliding	2015		2015		
PP	<i>Ulva ohnoi</i> M.Hiraoka & S.Shimada	2011		2015	2011	
PP	<i>Ulvaria obscura</i> (Kützting) P.Gayral ex C.Bliding	1985			1985	
PP	<i>Umbraulva dangeardii</i> M.J.Wynne & G.Furnari	2014		2014		
PP	<i>Undaria pinnatifida</i> (Harvey) Suringar	1971		1975	1971	
PP	<i>Undella hadai</i> Balech	2004			2004	
VER	<i>Upeneus moluccensis</i> (Bleeker, 1855)	1947			1947	
VER	<i>Upeneus pori</i> Ben-Tuvia & Golani, 1989	2003			2003	
INV	<i>Urocaridella pulchella</i> Yokes & Galil, 2006	2018			2018	
PP	<i>Uronema marinum</i> Womersley	1989			1989	
INV	<i>Urosalpinx cinerea</i> (Say, 1822)	1960		1960		
INV	<i>Vallicula multiformis</i> Rankin, 1956	1998		1998		
VER	<i>Vanderhorstia mertensi</i> Klausewitz, 1974	2019			2019	
VER	<i>Variola louti</i> (Forsskål, 1775)	2018			2018	
PP	<i>Vaucheria longicaulis</i> Hoppaugh	2020		2020		
INV	<i>Viriola sp.[cf. bayani]</i> Jousseume, 1884	2016			2016	
INV	<i>Watersipora aterrima</i> (Ortmann, 1890)	1983		1983		
INV	<i>Watersipora subatra</i> (Ortmann, 1890)	1987		1987		
INV	<i>Watersipora arcuata</i> Banta, 1969	1990		1990	2013	
PP	<i>Womersleyella setacea</i> (Hollenberg) R.E.Norris	1986			1986	
INV	<i>Xanthias lamarckii</i> (H. Milne Edwards, 1834)	2013			2013	



Table 2. Cont.

Group	Species	Pan-European	BAL	NEA	MED	BLK
INV	<i>Xenostrobus securis</i> (Lamarck, 1819)	1991		2005	1991	
INV	<i>Yoldia limatula</i> (Say, 1831)	2019		2019		
INV	<i>Zafra savignyi</i> (Moazzo, 1939)	1995			1995	
INV	<i>Zafra selasphora</i> (Melvill & Standen, 1901)	1995			1995	
VER	<i>Zebrasoma flavescens</i> (Bennett, 1828)	2008			2008	
VER	<i>Zebrasoma xanthurum</i> (Blyth, 1852)	2015			2015	



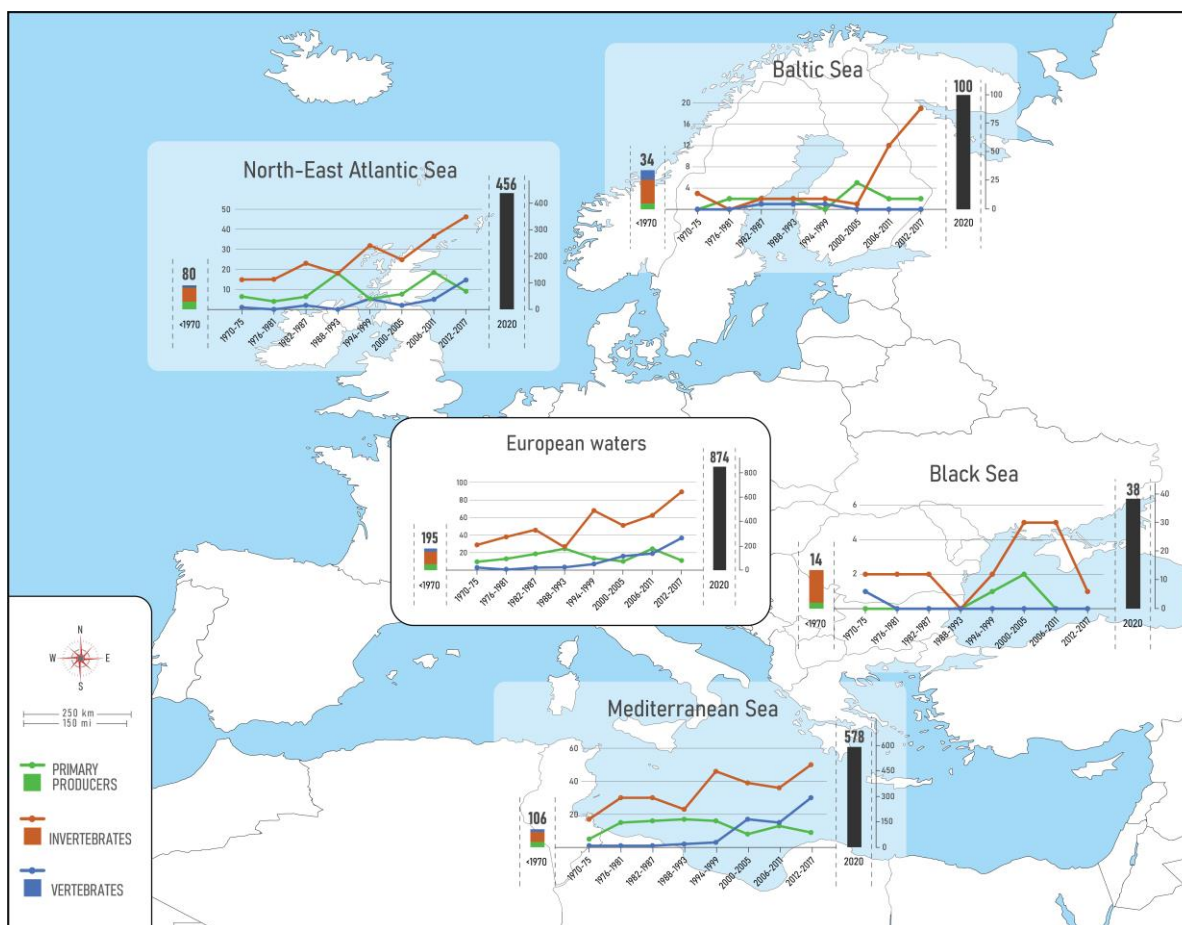
**Figure 2.** Number of NIS detected by December 2020. (a) European waters and regional Seas, (b) North-East Atlantic subregions: ANS = Greater North Sea, ABI = Bay of Biscay-Iberian Shelf, AMA = Macaronesia, ACS = Celtic Seas; (c) Mediterranean subregions: MWE = Western Mediterranean, MAL = Eastern Mediterranean, MIC = Central Mediterranean, MAD = Adriatic Sea.

The Baltic Sea dataset encompasses 100 NIS introductions (including 6 parasites and 9 microalgae), 34 of which were introduced before 1970. The major proportion of the introductions since 1970 have been invertebrates (42 species, ~83%), followed by primary producers (5 species, ~10%), and vertebrates (4 species, ~8%). Invertebrates consist of a wide range of benthic crustaceans, as well as pelagic zooplanktonic taxa, whereas primary producers include both, phytoplankton, and phytobenthic species. Vertebrate species include Ponto-Caspian sturgeons and gobies, as well as cultured salmonids.

456 NIS are known from the North-East Atlantic (NEA), 372 of which have been detected since 1970 (81%). The Greater North Sea (ANS) hosts 260 NIS including parasites and pathogens (Figure 4b), 193 of which (74%) have been observed since 1970. The NIS biota is dominated by invertebrates (154 taxa = 59%) and primary producers (macroalgae, microalgae, pathogens) 88 taxa (34%). The proportion of vertebrates (fish) is low (18 taxa = 7%), and mostly related to freshwater NIS expanding their distribution into estuarine coastal waters.

The Celtic Seas (ACS) host 107 NIS including parasites and pathogens (Figure 4b), 72 of which (67%) have been detected since 1970. The vast majority (69 taxa = 64%) are invertebrates, followed by primary producers (35 taxa = 33%) while vertebrates are represented only by three freshwater fishes that have been observed in Irish estuarine waters.

The Bay of Biscay and Iberian Shelf (ABI) subregion hosts 250 NIS, 215 of which (86%) have been introduced since 1970. Most of them are invertebrates (180 taxa = 72%), followed by primary producers (68 taxa = 27%) and vertebrates (2 taxa = 1%).



**Figure 3.** Status and trends in introduction of NIS in European seas. Bars depict the cumulative number of NIS, from historical times to 2020. Details for the status in 2020 (black bar) as in Figure 2. Lines show the trends in new NIS introductions per 6-year intervals from 1970 to 2017. Note: parasites/pathogens and microalgae were excluded from the trend analyses.

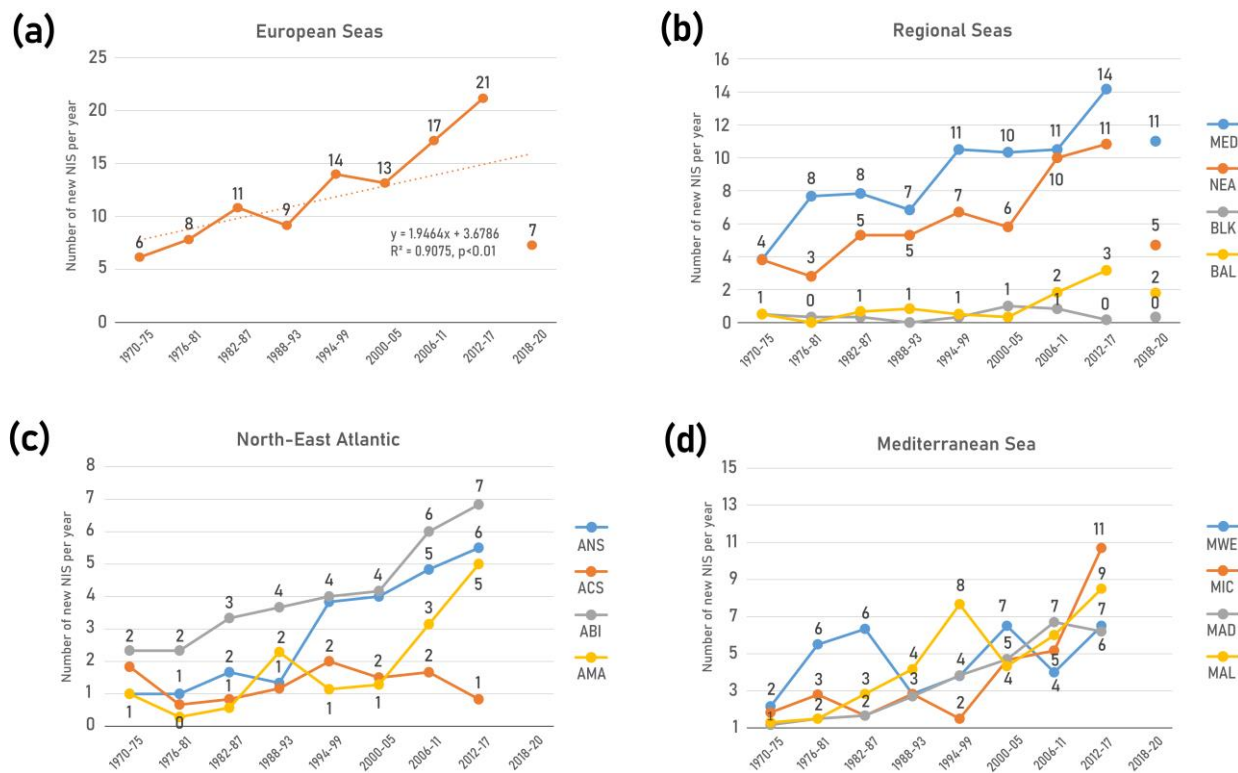
The Macaronesia (AMA) hosts 121 species, 109 (90%) introduced since 1970. Invertebrates dominate (72 taxa = 59%), followed by primary producers (29 taxa = 24%) and vertebrates (20 taxa = 17%).

The Mediterranean NIS list includes 578 species (473 = 83% since 1970) dominated by invertebrates (59%) (Figure 4a). Primary producers follow with approximately 23% of species among which macroalgae and Rhodophyta prevail. Vertebrates (103 taxa = 18%) are dominated by Red Sea (Lessepsian) fishes. The contribution of NIS groups varies among the Mediterranean subregions (Figure 2c). Primary producers have their largest representation in MWE and MAD (31–32%), introduced as contaminants in shellfish consignments in the major shellfish culture areas of the northern Adriatic and the French coast. On the other hand, the percentage of vertebrates is higher in MAL where they mostly arrived through the Suez Canal, and in MIC which receives naturally dispersing fish from MAL than all other subregions.

The EU part of the Black Sea (Bulgaria and Romania) hosts only 38 validated NIS out of a total of more than 110 NIS reported for the whole Black Sea. These are mostly invertebrates (33 species) with crustacean and molluscan species dominating. Only 24 NIS have been reported since 1970 including two microalgae.

In addition to the 874 NIS in European waters, 57 NIS detected in one regional sea are native or cryptogenic in at least one other regional Sea (Supplementary Table S1). These include macroalgae (18 taxa), mollusks (13 taxa), crustaceans (11 taxa), cnidarian (5 taxa), polychaetes (5 taxa), tunicates (2 taxa), bryozoan (1 taxon), Fish (1 taxon), and microalgae

(1 taxon). They have been transferred from the NEA to the MED and BLK Seas (more than 27 taxa), but also from the MED to the NEA (more than 22 taxa). Finally, six species have been transferred from the EU BLK waters to the BAL.



**Figure 4.** Annual rate of NIS introductions (6-year average) at different geographic levels: (a) European waters; (b) regional seas, (c) North-East Atlantic subregions: ABI = Bay of Biscay-Iberian Shelf, ACS = Celtic Seas, ANS = Greater North Sea, AMA = Macaronesia (d) Mediterranean subregions. MWE = Western Mediterranean, MIC = Central Mediterranean, MAD = Adriatic Sea, MAL = Eastern Mediterranean. Dotted line for the EU trend (Figure 4a) is a linear regression line. Note that the annual average for the final interval has been calculated for three years only.

Species classified as NIS in a country but partly native or cryptogenic within the subregion/region of the country were not included in the analyses, with some examples provided in Table 3. In contrast, species native in one subregion, but NIS in another subregion within the same MSFD region were not listed in Table 2 but are considered as NIS at the subregional level (Supplementary Table S2). They are mostly widespread native or cryptogenic species in the MED and NEA that have been classified as NIS in Macaronesia.

**Table 3.** Examples of partly native/cryptogenic species within the same region/subregion excluded from the analyses. For regions/subregions’ abbreviations see Table 1.

Group	Species	Region/Subregion Native	Country/Region Introduced
Dinoflagellates	<i>Procentrum lima</i> (Ehrenberg) F.Stein, 1878	NEA	Denmark/NEA
Macroalgae	<i>Asperococcus scaber</i> Kuckuck, 1899	NEA/ANS	Netherlands
Macroalgae	<i>Fucus distichus</i> subsp. <i>evanescens</i> (C.Agardh) H.T.Powell	NEA/ANS CRY in Norway	Sweden/NEA
Crustacea	<i>Necora puber</i> (Linnaeus, 1767)	NEA, MED	Sweden/NEA
Crustacea	<i>Pseudomyicola spinosus spinosus</i> (Raffaele & Monticelli, 1885)	NEA, MED	France/NEA

Table 3. Cont.

Group	Species	Region/Subregion Native	Country/Region Introduced
Crustacea	<i>Pilumnus spinifer</i> H. Milne Edwards, 1834	NEA, MED	Sweden/NEA
Mollusca	<i>Calliostoma zizyphinum</i> (Linnaeus, 1758)	NEA, MED	Netherlands
Mollusca	<i>Cymbium olla</i> (Linnaeus, 1758)	NEA/ABI	Spain/MED
Mollusca	<i>Tritia corniculum</i> (Olivi, 1792)	NEA, MED	Spain/NEA
Mollusca	<i>Tritia neritea</i> (Linnaeus, 1758)	MED, partly in ABI	France/NEA
Cnidaria	<i>Cereus pedunculatus</i> (Pennant, 1777)	NEA/ANS	Denmark/NEA
Porifera	<i>Suberites massa</i> Nardo, 1847	NEA/ANS	Netherlands
Porifera	<i>Haliclona (Haliclona) urceolus</i> (Rathke & Vahl, 1806)	NEA/ANS	Netherlands
Porifera	<i>Haliclona (Reniera) cinerea</i> (Grant, 1826)	NEA/ANS	Netherlands
Bryozoa	<i>Reptadeonella violacea</i> (Johnston, 1847)	NEA	Portugal

The trend in new NIS introductions per 6 year assessment periods varies among groups and regional seas (Figure 3). The upward trend observed for invertebrates at the pan-European level is evident in the BAL, NEA, and MED Seas but not in the BLK Sea.

Overall, the rate of new NIS introductions (excluding parasites, pathogens, and microalgae) at the Pan-European level has increased at what appears to be a linear trend since 1970 from six to 21 NIS per year (Figure 4a). While evident in most regional seas, the increase also obscures large regional differences such as the steep increase from the early 2000s to 2017 in the Baltic Sea (Figure 4b) and a decreasing trend in the Black Sea (Figure 4b) and the Celtic Seas (Figure 4c). Comparison with the latest assessment period (2018–2020) shows a decline in the annual average rate of new NIS introductions compared to the preceding trends in many regional seas. Thus, while the annual rate of NIS in the North-East Atlantic steadily increased since 1970, although with subregional differences, reaching 11 new NIS per year in the 2012–2017 period, the latest assessment period (2018–2020) indicated a decline to an average of five NIS per year (Figure 4b). The annual rate of new NIS in the Greater North Sea (ANS) increased rapidly in the 1994–1999 period and maintained the upward trend in the last assessment period reaching six new NIS per year (Figure 4c). In the Bay of Biscay and Iberian Shelf (ABI), a steady upward trend was observed until 2005, followed by a sharp increase in the following periods, reaching seven new NIS per year in the 2012–2017 period. A similar pattern to that of ABI was observed in Macaronesia where the annual rate reached five NIS/per year in the 2012–2017 period. The highest number of new NIS introductions in the Celtic Seas occurred in the assessment period 1994–2005 with two new NIS per year. A declining trend was observed in the last assessment periods. Only five invertebrates were detected in the 2012–2017 period, and none since 2017.

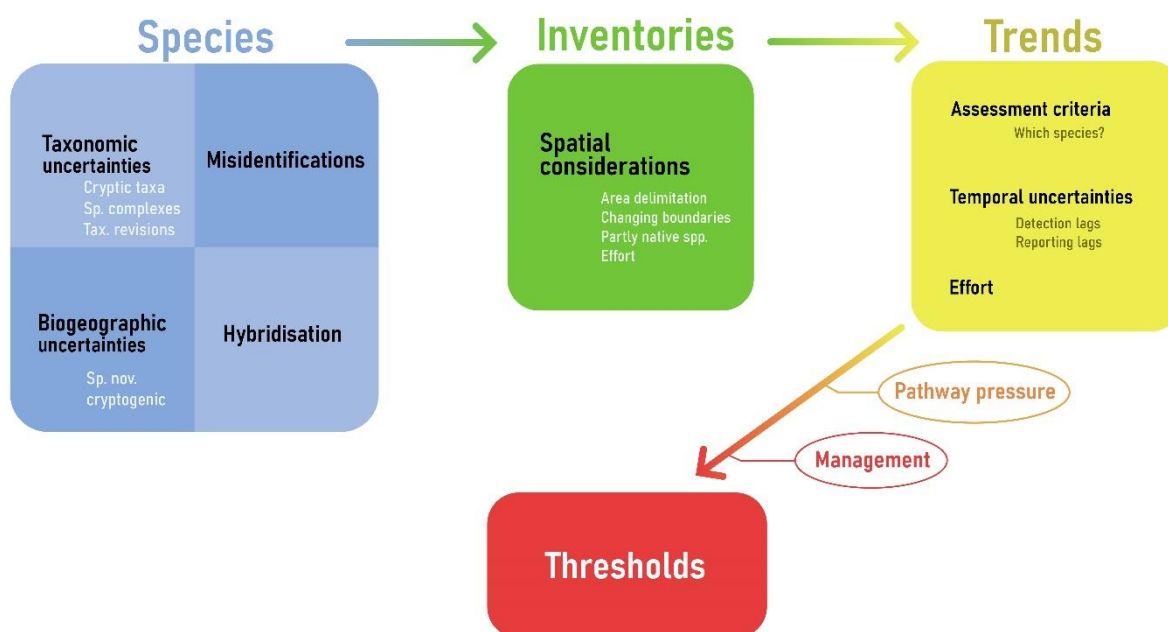
All analyses in the Mediterranean Sea are based on 460 NIS taxa observed for the first time since 1970. On an annual basis, the number of newly introduced NIS has increased in the Mediterranean since the late 1990's reaching 14 species per year in the period 2012–2017 (Figure 4b). This increasing trend is also observed at a subregional level for all regions but the MWE. Specifically, the annual new NIS rate calculated in the assessment period (2012–2017) reached 11 new NIS per year in the MIC, followed by nine in the MAL, seven in the MWE and six in the MAD (Figure 4d). In the MWE, the annual rate of NIS introductions fluctuates between two and seven species per year without any pronounced peaks or temporal trends. In contrast, a slight leveling off in the introductions rate appears in the MAD, while the rate of new NIS introductions presents a steeper increase in the MAL and MIC after the mid-2000s.

The rate of introductions in the BLK peaked in the 1994–2006 period reaching one new NIS per year but dropped in the following periods (Figure 4b). As many as six

species (18%) have expanded the geographic range from neighboring areas surrounding the Black Sea where they first invaded, while the presence of two NIS namely the oysters *Crassostrea virginica* and *Magallana gigas* is attributed to escape from confinement (oyster culture facilities).

#### 4. Discussion

With the current work, we aimed at establishing an updated status of NIS in European waters to provide a robust baseline for understanding trends in new NIS arrivals. The presented analyses documented an increasing trend in the annual rate of new NIS at all spatial levels until 2017 while highlighting some major regional differences both in the composition of xenodiversity and the temporal evolution of new NIS introductions at the subregional level, that can prove useful in further steps of setting thresholds for NIS trends indicators. Our findings are discussed in the context of spatial, temporal, species-specific and effort-related sources of uncertainty (Figure 5), which are primarily epistemic in nature (sensu [43,44]) i.e., they relate to measurement or systematic error, be it in species taxonomy, identification, and origin, in the spatial aspects of inventories or the temporal uncertainties associated with trends estimation. Subjective judgment may introduce additional uncertainty in determining species to include/exclude from management actions, such as cryptogenic species or functional groups addressed with different policy instruments. Finally, we provided an explicit account of partly native species in different management units, helping to resolve linguistic uncertainties stemming from a context-dependent definition of the terms alien/native.



**Figure 5.** Schematic diagram of the process of NIS trends calculation identifying sources of uncertainty (outlined in rectangles) as they propagate from species to inventories to trends. Additional considerations for threshold setting are indicated by oval outlines. Sp. complexes = species complexes, Tax. Revisions = taxonomic revisions. Sp.nov. = species novae.

##### 4.1. Validation of European NIS: A Challenging and Dynamic Task

One of the main challenges in establishing a robust and accurate baseline is addressing taxonomic or biogeographic uncertainties and incorporating new taxonomic information. To maintain a conservative viewpoint and avoid potential false positives, the authors agreed to exclude species that have raised uncertainties regarding (i) the known existence of cryptic species, (ii) recent taxonomic revisions, (iii) suspicions of possible errors for taxa belonging to species complex, and/or (iv) species that are possibly non-native but

only recently described and thus requiring further clarification about their status. Issues arising from cryptic species, taxonomic revision, and occurrence of species complexes were noticed in the NEA for the ascidians *Botrylloides schlosseri*, *Ciona intestinalis*, and the mussels *Mytilus galloprovincialis* and *Mytilus trossulus*.

*Botrylloides schlosseri* is an example of the problems associated with the identification of cryptic species complexes, which are common among widely distributed marine taxa [45]. An extensive study by Bock et al. [46] showed that several cryptic species of *B. schlosseri* coexist at a regional scale in northwestern Europe. Some are probably native (e.g., clade E in Brittany, France) while others are likely to be introduced, considering their near-global distribution (e.g., clade A in Brittany, France). The specimens of *B. schlosseri*, reported in the North-East Atlantic, could thus be either NIS or native species. Thus, overall, it seems more reasonable to assign *B. schlosseri* a cryptogenic status.

In the case of *Ciona intestinalis*, uncertainties stem from a recent extensive taxonomic revision [47]. Based on a series of morphological and molecular investigations (references in 47), this species name was shown to bring together two distinct species, namely *Ciona intestinalis* and *Ciona robusta*, which had previously been described as two distinct species but unfortunately synonymized in 1985. Until a recent taxonomic revision, *C. robusta* was known as *C. intestinalis* type A and *C. intestinalis* as *C. intestinalis* type B although the type was not always reported. Furthermore, since the taxonomic revision was announced in 2017, the use of the correct species name is questionable for our dataset ending in 2020. *C. robusta*, native to Asia, is the only *Ciona* species introduced, so far, to the North-East Atlantic (in the early 2000s) [48,49]. We, therefore, excluded records of *C. intestinalis* and retained only records of *C. robusta* or *C. intestinalis* type A, as the use of these names refers to the Pacific-origin species.

The situation is even more complicated with the *Mytilus edulis* species complex, which obscures three European accepted species *M. edulis*, *M. galloprovincialis* and *M. trossulus* that still hybridize and exchange genes at contact zones. In our list, we have two species reported as introduced in the North-East Atlantic, for which reports are questionable: *M.e galloprovincialis* and *M. trossulus*. The use of the species name *M. galloprovincialis* is insufficient to determine native vs. introduced status, as it covers two distinct lineages, one present in the Mediterranean Sea, and the other in the Atlantic [50]. As with *C. intestinalis* prior to its taxonomic revision, the name *M. galloprovincialis* does not allow us to determine the native or introduced status of specimens reported from the North-East Atlantic. In addition, the natural presence of the Atlantic lineage as enclosed population patches in Brittany, Wales, Scotland, and Northern Ireland is not always recognized by some specialists and is debated. In the case of *M. trossulus*, identification has most often been established using barcoding or metabarcoding based on the COI mitochondrial marker. However, in the absence of details regarding the reference sequence that was used for the taxonomic assignment, we face another problem here. Some of the reference data available in public databases are indeed from specimens collected in the Baltic Sea, where the mitochondrial genome of *M. trossulus* has been extensively introgressed (i.e., replaced) by that of *M. edulis*, which may lead to a false taxonomic assignment of a *M. edulis* specimen to *M. trossulus* [51]. In addition, recent work has shown that *M. edulis* carries a transmissible cancer of *M. trossulus* origin. Thus, molecular-based identification may lead to the assignment of *M. trossulus* or *edulis-trossulus* hybrids for *M. edulis* specimens with this cancer [52,53]. The so-called “Baltic *Mytilus trossulus*” actually differs distinctly in morphology, ecology and genetic characters from *M. trossulus*, i.e., a species described from the NE Pacific [54]. To resolve this, *Mytilus edulis balthicus* by Gittenberger and Gittenberger, 2021, has recently been described. In addition, to further the nomenclatorial stability within the *M. edulis* complex, the locus *typicus restrictus* of the nominal taxon *M. edulis* has been restricted to the North Sea off the Dutch coast [54].

The improvement of molecular methods in ecological studies has helped to shed some light on species’ origins and their actual distribution, (see for instance the case of *Tritia neritea* detailed in the next Section). However, at the same time, this may give rise

to some controversies until further studies finally provide unequivocal confirmation of status with more data. This is the case, for example, of the oyster *Ostrea stentina*, which was recently found to encompass two different genotypes, one of them belonging to the newly described *Ostrea neostentina* with type locality in Hong Kong [55]. A new distribution map of this genus has thus been constructed, with *O. stentina* present in both the MED and NEA regions, and *O. neostentina* only in the MED. New studies are taking place to confirm the native range, but, so far, regarding the present knowledge of historical records and taxonomical studies, the population of *O. stentina* present in the ABI subregion is considered introduced.

In addition, systematics is a dynamic field of research, as novel species are continuously being described; some of them possibly being novel introduced species. However, in the absence of further verification regarding their status, we did not include some of these species in our list. A case in point is that of the spaghetti worm *Terebella banksyi* nov. sp [56] newly described following its collection in 2017 in Arcachon Bay and found in farms or reefs of the Pacific oyster *Magallana gigas*. Similar uncertainty is occurring for the newly described colonial tunicate *Didemnum pseudovexillum* nov. sp [57], distinctive from the well-known invader *D. vexillum* by morphological traits and genetic characteristics and found only in marinas in the Celtic Seas (Brittany, France) and NW Mediterranean Sea (Spain). Considering the habitats (farms, marinas) and extensive range of *D. pseudovexillum* nov., it is likely that it had been introduced. However, further clarification would be needed to ascertain its introduced or cryptogenic status.

We included in the list of accepted species that arose following hybridization between a NIS and a native species. Hybridization between native and introduced species is very common in plants [58,59]. It has also been documented in marine species although being still poorly examined, and yet an important issue to consider for marine NIS management [6]. In coastal systems, this process is well-illustrated by cordgrass species from the *Spartina* genus [60,61]. For instance, *S. alterniflora* hybridized with the native species *S. maritima* after its introduction in the United Kingdom. This hybridization gave rise to *S. townsendii*, a sterile species, which then gave rise through polyploidization to *S. anglica*. The latter species is highly successful, displacing the native *S. maritima*, and is present in most of the ANS and locally in the western BAL. Thus, *S. anglica* is not per se introduced but is included in our list, because it would have never existed without the introduction of *S. alterniflora* in Europe.

Another cordgrass species, *Spartina versicolor* Fabre, has also a controversial taxonomic status. Although it was recorded as NIS in several European countries in the 19th and 20th centuries, it was considered synonymous with *Spartina patens*, due to morphological similarities [62,63] sampled several populations of *S. versicolor* in the Mediterranean, Atlantic, and North Africa saltmarshes and conducted cytogenetic and molecular analysis (microsatellite, nuclear and chloroplast DNA sequences) and compared it to North American *Spartina* species. Their results supported the hypothesis that all European and African populations of *S. versicolor* are, in fact, North American *S. patens*, introduced before or at the beginning of the nineteenth century. Due to potential hybridization within *Spartina* species, further investigations are needed to clarify any potential hybridizations between introduced species with the native ones (e.g., *S. maritima*).

#### 4.2. Issues with Assessing the Spatial Distribution of NIS in Europe's Seas

The NIS data-gathering process is not standardized (there is no consistent methodology) among EU Member States, which is a drawback and likely to generate bias and uncertainty in the assessment itself. In addition, biases may arise from the lack of dedicated surveillance programs. Not only studies focused on NIS introduction hot spots, such as ports and marinas or aquaculture facilities, but also the increment of monitoring programs to give responses to other MSFD descriptors increased the probability of finding newly introduced NIS during the surveys. However, it must be highlighted that several new records are introductions that most probably either went unnoticed in previous surveys

or from areas that were never previously investigated. Monitoring programs are also not equally implemented in all subregions, and only a few have specifically focused on NIS and cryptogenic species detection [14].

Therefore, data need to be updated continuously from other monitoring programs or scientific literature reporting NIS. For example, in the NEA region, subregions such as ANS or ACS have historically received more attention than ABI [64]. In several countries such as Spain, Portugal, and Denmark, there were no baseline studies for NIS until very recently and the list included in the last assessment period (2012–2017), can therefore be considered as a baseline for some countries.

Boundaries between sub-regions established for MSFD reports are also challenging. In particular, the ABI subregion boundaries, as the boundaries between ANS and ACS, very often raise questions when establishing the status of some species because the natural borders between water masses are not static at these human-established borders (Figure 1). The same holds for the MWE subregion. Its western limit finishes a few kilometers after the strait of Gibraltar making it difficult to establish proper frontiers between Mediterranean and Atlantic waters since the Mediterranean shows a high influence even until central Atlantic waters [65]. In this sense in the southern extension of the ABI subregion, being highly influenced by Mediterranean waters, some species whose native range extends in both NEA and MED regions can be found, giving them the category of partly native species in a subregion, but being NIS in a country of this same subregion (Table 3) or in another subregion of the same region. This is the case, for example, of the gastropod *Cymbium olla*, whose native range includes Algarve (southern Portugal) and the Gulf of Cadiz (southern Spain—Atlantic coast), which are part of the ABI subregion, but also Cadiz in the Alboran Sea site, which is in the MWE subregion. Therefore, *Cymbium olla*, which is partly native in the MWE subregion even in some other localities in the MWE, might be locally classified as NIS [66].

Species distribution and their possible expansion, are never contained within any human delineation of marine borders, making it difficult to categorize their status when it comes to classification at any bordering level (subregion, region, or Pan-European). This issue is particularly important for species spreading gradually, which might be considered either as a natural expansion or introduced by human activities. For example, the nassariid gastropod *Tritia neritea*'s native range includes the Mediterranean and the Black Sea, as well as all around the Iberian Peninsula (Hidalgo [67] as *Cyclops neriteum*), but since the 1970s, this gastropod has been extending its range along the coast of France since its first record in 1976 in Arcachon Bay [68]. Its presence almost exclusively in oyster farming areas and the genetic characteristics of the French populations (e.g., admixture of lineages found in different locations of the Mediterranean Sea that indicated multiple introductions [69]) finally concur to report this nassariid gastropod as a NIS, probably introduced by oyster cultures in France [70]. Therefore, it is considered partly native to the ABI subregion because of its native range in Portugal and Spain, and its later introduction in France (Table 3). Some cases such as *Tritia neritea*, exemplify the difficulty of sometimes categorizing species as either NIS, cryptogenic or native because of their life history, migratory and demographic history, influenced by paleoclimatic events in a longer time scale and more recently by human activities [69,71]. These processes determine the species' contemporary distribution, showing a patched map of native and introduced localities, even at local small scales [72].

Another example of a partly native species is that of the amphipod *Erichthonius didymus* (Krapp-Schickel, 2013), which was described in the Adriatic Sea from the Venice Lagoon (Italy). This recent description was rapidly followed by new records in Europe both in the Mediterranean and the Atlantic between 2013 and 2017 [73]. These observations, some of which date back to the year of description of the species, do not allow an unequivocal designation of the species as non-indigenous in the Bay of Biscay. However, the species is considered NIS in the ANS and the AMA, due to its presence in anthropogenically stressed sites, such as harbors/marinas and shellfish grounds [73].



#### 4.3. Trends Indicator

Across all taxonomic groups, the rate of new NIS introductions in EU waters has increased gradually since 1970 and reached an average of 21 NIS per year in the period 2012–2017. The same upward trend was noticed for the Baltic, North-East Atlantic, and the Mediterranean Sea, but was more evident in the Mediterranean and Baltic Seas. In contrast, a decreasing trend was seen in the Black Sea with only one new species detected in the last assessment periods (0.2–0.3 NIS per year). Low figures noticed in the periods of 1988–1993 and 2000–2005 are likely an artifact of varying monitoring and reporting efforts between the regions over these periods.

The high rate of annual Introductions from 2000–2005 was very likely associated with a growing research interest in NIS, rather than discrete episodic events leading to high levels of new introductions during these years. Indeed, the development of several dedicated projects (AquaNIS, DAISIE, EASIN) produced outputs with updates on the list of NIS.

The decreased annual rate of new NIS introductions in the period 2018–2020 at almost all geographic levels examined has recently been attributed to time lags in reporting [74] rather than a result of NIS intervention programs. Also, there are fewer sampling years in this last interval analyzed, which might entail larger variability in the annual rate. This provisional reduction of new NIS registered is furthermore not likely to be associated with the implementation of measures since no new programs of measures have been implemented yet (e.g., only three marine NIS, the fish *Plotosus lineatus*, the seaweed *Rugulopteryx okamurae*, and the crab *Eriocheir sinensis* (only partly marine), are in the EU list of Invasive Alien Species of Union concern) and the implementation of the Ballast Water Management Convention at the European level is still in progress [75]. The only exception is the Council Regulation (EC) No 708/2007 of 11 June 2007 concerning the use of alien and locally absent species in aquaculture that may have decreased the risk of novel species introduced for cultivation purposes, although not preventing transfer within each EU country's borders. A decrease in new NIS records in the last assessment period (2018–2020) for most regions might furthermore be explained by the homogeneity of marine NIS fauna since more and more species previously found exclusively in one of the countries are now found in more countries. Probably many species are expanding naturally from previously invaded countries.

The present upward trend in new NIS introductions to the Baltic Sea contradicts the previous D2C1 assessment, which indicated that the trend was decreasing since 2011 [76]. The discrepancy is very likely due to updated NIS records from several countries around the Baltic Sea. The latest assessment period in the present study covered only three years (2018–2020), but already five new NIS were recorded from the EU marine waters of the Baltic Sea during this time, suggesting that the ultimate HELCOM goal of zero new NIS introductions will not be reached, even though the rate of new NIS introductions has dropped to less than two new NIS per year. Overall, the current Baltic Sea analysis indicated that the number of new introductions has had a steep increase from the early 2000s to 2017. The increase may be due to growing scientific interest and promotion of citizen science projects [77], but it is evident that anthropogenic pressure through intensified shipping has steadily increased toward the marine environment of the Baltic Sea [78].

The NEA region encompasses several ecoregions, 4 sub-regions, and 10 different countries, making this region a very complex one for analyzing trends because of the heterogeneity in surveys and ecosystems. It is thus not surprising that quite a large number of species are reported as NIS within the region, and subregions (Figure 4b,c). Altogether the number of novel NIS has always been increasing, at least for invertebrates that are the most numerous NIS in this region (Figure 3). This is likely attributed to the continued increased maritime traffic in the region. Indeed, overall shipping density increased across the North-East Atlantic by 33.6% between 2013 and 2017 [79].

In comparison to the previous assessment [3,15,32], this work does not consider data from the UK waters. This leads to differences not only in the total number of NIS but

also in the trends indicator as first detection dates may be years earlier in neighboring non-EU countries.

An earlier assessment (over the period of 2003–2014) of NIS in the ANS, ACS, and the ABI subregions showed that the number of newly recorded NIS varied by year and region showing a relatively constant linear increase in the ANS only, but not so in the ACS and ABI [80]. In this study, an increasing trend was observed in all subregions but the ACS. The high number of NIS in the ABI in the 2012–2017 period (7 NIS/year) is partly attributed to intensive studies in port areas and marinas [81–83] in the framework of the implementation of the MSFD descriptor 2 or research projects dedicated to NIS surveys. Furthermore, the increase of studies based on genetic analyses within this last decade has helped to rapidly and accurately detect newly introduced species reassess some species that have been misidentified, and elaborate an updated checklist of NIS [84–86]. In addition to traditional genetic approaches, in recent years metabarcoding of environmental DNA had been proposed and is increasingly used as a new tool to improve NIS detection [87]. The approach is promising and effective although it needs to be used cautiously to avoid both false negatives (i.e., present, but undetected NIS) and false positives (i.e., NIS erroneously detected) [51]. NIS detection by these methods requires fit-to-purpose protocols and should not be based on molecular data obtained for general biodiversity assessments [88]. Either way, the data show that the increase seems to be stabilizing, indicating that it is a good time to set the baseline.

The increasing trend in introductions in ANS, which culminated in the 2012–2017 period with six NIS per year, appears to be slowing down in the last assessment period (2018–2020) with four new NIS per year, although future publications are expected to bring to light more NIS. During the period 2018–2020, in France, the number of records increased. However, this is the only French subregion with such an increase, thanks to dedicated surveys programs carried out in the Normandy region [86]; these reports are not new either for France or for ANS [89] (and references therein), suggesting a decrease of new species but an important dispersal between subregions.

In the ACS, the decrease is even more pronounced than in the ANS, with no novel NIS reported after 2017. As for the ANS, the difference from the previous assessment can be partly attributed to the geographic areas involved. In the previous assessment [76] the NIS of the United Kingdom in ACS were included in the analysis. Moreover, pathogens were also included. Additionally, in the Western English Channel (French and UK coastline), a research project (Interreg Marinexus project) dedicated to rapid assessment surveys of NIS in marinas, well-known introduction hotspots, was carried out over 2010–2017 [78], and provided novel reports for European waters (e.g., the ascidian *Asterocarpa humilis* [90]).

The AMA NIS list presented here represents an updated version of the list reported by Castro et al. [29] following similar criteria. As opposed to the current study, species that underwent tropicalization processes (see 29, 41) were considered one of the criteria for NIS attributes in Castro et al. [29] inventory. Most changes were made on macroalgae records for the Azores as more information on records, taxonomy, and distributional updates have been gathered and led to some changes. In addition, a few new records have been added as [29] included records only until 2020 whereas the present account includes records reported until summer 2022.

Comparisons with the full NIS inventory of the MED are somewhat hampered by the geographic coverage of the current study, which is limited to the EU waters of the Mediterranean (plus Albania and Montenegro). As a result, total numbers of new NIS, as well as annual introduction rates, appear to be reduced in comparison to, e.g., [30], especially for the eastern Mediterranean, as primary Lessepsian introductions restricted to the Levantine were outside the spatial scope of this study. Indicatively, the whole Mediterranean Sea hosts upward of 1000 validated NIS, 786 of which are in the MAL [12,23,91], compared with the 579 NIS present in the EU parts of these waters. As such, it is not surprising that the annual introduction rate in the central Mediterranean in the 2012–2017 period exceeds that of the eastern Mediterranean, as the accelerated sea warming rates

favor the spread of Indo-Pacific species already present in the Levantine [92]. On the other hand, the reduction in Transport-Contaminant species [76], which are more prevalent in the Adriatic and the western Mediterranean, may have contributed to the observed leveling off or decreasing NIS trends in these two subregions. For the Mediterranean Sea as a whole, there appear to be two “stepwise” increases in new NIS introductions, the first one in the late 1990’s, mostly driven by introductions in the MAL and likely related to sea surface warming [30,93], and the second in the 2012–2017 period. This last peak could partly reflect intensified research efforts, which the whole basin has undoubtedly experienced in the last decade [94] as already suggested for other regions and subregions of the NEA, and in line with comments by Bailey et al. [31]. In Slovenia, for example, the number of detected NIS has increased from 17 in 2012 to 57 in 2021, which is due to increased targeted research, mainly founded by the Ministry of Agriculture, Forestry and Food for the implementation of D2 in the country [95]. It also coincides with a sharp increase in the introduction rate of fouling species, notably in marinas and on leisure boats, at least in their detection and reporting [96,97]. Hence it is difficult to really evaluate the significance of these trends without considering a measure of “effort”, which again starkly exemplifies the need for standardized monitoring for any assessments to be meaningful.

Some of the earlier invading NIS in the BLK such as the blue crab *Callinectes sapidus* (Rathbun, 1896) appear to be established and spreading in the area over the years. *Callinectes sapidus* was first found on the Bulgarian coast of the Black Sea in 1967 [98], most likely transferred in ballast water but could have been spreading via the Marmara Sea from an invasive population in the northern Aegean. Six new records of the blue crab have been documented near the Bulgarian Black Sea coast since 2010. This is evidence of a recent expansion of the species in this part of the Black Sea. This expansion could be explained by the existence of an established population in the area and is confirmed by the capturing of an egg-bearing female in Varna Bay in 2005 [99]. It is anticipated that in the face of climate change the number of NIS in the EU areas of the BLK will increase in the near future due to the spreading (Unaided pathway) of NIS from the North Aegean Sea that has already invaded the BLK via the Sea of Marmara such as the marbled pine foot *Siganus rivulatus* [100,101]. Moreover, NIS recently introduced via vessels in the northeastern and southern Black Sea could spread unaided in the study area [102,103]. Such is the case of the polychaetes *Laonome xeprovala* that spread in the Danube Delta–Black Sea Ecosystem and *Marenzelleria neglecta* that was detected in 2021 in the same area [103].

#### 4.4. Uncertainties in Trends

Uncertainties in trends first rely on the uncertainty of the first date of the report (if not consistent across periods). The true introduction year of NIS may be different from the detection year. As an example, the Terebellid polychaete *Marphysa victori* was detected in 2016 and described in 2017 from French waters in the Arcachon Bay, with doubts already surrounding its true origin due to its presence in and close to oyster farms where *Magallana gigas* is cultivated [104]. This possibility was verified several years later. *Marphysa victori* is native to the Northwest Pacific [105], and it has undoubtedly been introduced as a contaminant with oyster transfers. However, it remains unproven if its introduction is a consequence of oyster importation from Japan. Between 1971 and 1975, about 1200 t of *Magallana gigas* spat collected from Sendai Bay (Japan) were introduced into Arcachon Bay. *Marphysa victori* has a substantial economic value as bait and is widely collected by recreational and professional fishermen. The number of worms collected in the lagoon (13 companies) could reach 1 million per year [104]. Reaching such densities within a year would be impossible. Thus 1975 was set as the most plausible year of its introduction.

Other examples include Mollusca species observations in EU waters around 80 years after their first detection in neighboring non-EU waters. Such are the cases of the gastropod *Berthellina citrina* (Rüppell & Leuckart, 1828), which was first reported in the MED from the Gaza Strip in 1940 [106], but only in 2019 in EU Mediterranean waters: Cyprus [107] or of

the bivalve *Gafrarium savignyi* (Jonas, 1846) with a first Mediterranean record in 1905 from Egypt [108] but an EU record in 2005 from Cyprus [109].

Various policy measures relevant to the Baltic Sea countries can result in uncertainties regarding the emergent reports of new NIS introductions. Trend analyses on new NIS introductions to the Baltic Sea, such as [22,27,110] may differ mainly due to the applied assessment principles, e.g., area of interest, and species included in the analyses. Baltic Sea delineation determined according to the EU MSFD differs from HELCOM delineation, and this often leads to NIS being reported, for example, from the Kattegat area, which is BAL according to the HELCOM delineation, but at the same time a part of the ANS according to the EU MSFD delineation. In addition, Russian coastal waters outside of St. Petersburg and Kaliningrad are obviously part of the Baltic Sea but are not included in assessments that refer to the marine waters of the EU.

Even more, pronounced discrepancies may be observed with pan-Mediterranean assessments due to the exclusion of non-EU Mediterranean countries in this study (see above). Regardless of administrative boundaries for EU policies, it is crucial that the marine environment is managed with sufficient harmonization between regional policies. Toward that end, the Contracting Parties to the Barcelona Convention—21 Mediterranean countries and the European Union—have recently developed and adopted the Integrated Monitoring and Assessment Programme for the Mediterranean region (IMAP) [111]. Within its framework and in accordance with the MSFD [9], GES for NIS in the Mediterranean was defined as the minimization of the introduction and spread of NIS linked to human activities, in particular for potential IAS, with the reduction in human-mediated introductions as the proposed State Target [112], a target that clearly needs to be further refined but seems far from achieved based on our latest data.

#### 4.5. Threshold Values

Qualitative GES assessments to date have been based on directional trends and, despite ongoing efforts [110], threshold values for the NIS trend indicator have not been set yet and neither have more specific recommendations been made for the magnitude of this reduction or the number of reporting cycles that will define the reference conditions [113].

Waiting for a value of the percentage reduction to be established at a European level, as suggested by [14], the French decree relating to the definition of GES states that GES is achieved if there is a significant decrease in the number of new NIS over two cycles at minimum. As visible in this work, the number of new NIS increased in all French marine subregions during the previous cycle (2012–2017), and the goal has therefore not been reached to date.

The identification and comprehension of impact thresholds on ABI marine native communities is required. ABI countries must collaborate more closely to implement common methodologies for MSFD implementation, particularly regarding non-indigenous species (D2) [114]. Furthermore, good coordination is required for the creation of an effective alert system. It is worth mentioning the risk-based approaches to good environmental status (RAGES) project, which attempted to establish reproducible, transparent, and standardized risk management decision procedures based on international best practices. The increase in the number of new NIS introductions in the period 2006–2017 seems to be stabilizing, indicating that it is a good time to set the baseline. This decrease in new NIS records might be explained by a biotic homogenization of the ABI marine NIS fauna since more and more species previously found exclusively in one of the countries are now found in all three ABI countries. Probably many species are expanding naturally from previously invaded countries.

In the Mediterranean Sea, preliminary analyses [12] indicated that threshold values should be established separately for each subregion and should be sought by examining the data of the last two decades, if not an even more recent period. Further work by Galanidi and Zenetos [30], based on breakpoint analysis of 1970–2017 NIS data, corroborated the validity of a subregional approach, demonstrating different temporal breakpoints in the

rate of NIS introductions per subregion, ranging from 1997 in the MAL, to 2000 in the MAD, 2003 in the MWE and 2012 in the MIC. They suggest that the mean introduction rate of these periods can be used to define threshold values but stress that GES target refinement and percentage reduction cannot proceed without careful consideration of management objectives and pathway pressure, as also pointed out in Tsiamis et al. [14].

Trends in the arrival of new NIS is a core indicator of the Baltic Marine Environment Protection Commission (Helsinki Convention, HELCOM), and the primary criterion D2C1 was assessed for the first time for a six-year assessment period (2011–2016) in 2018 [10]. The report listed new NIS and cryptogenic species for BAL over the assessment period. Contracting Parties of HELCOM have set a precautionary threshold to assess GES in relation to NIS. Zero new NIS introductions through anthropogenic activities to the Baltic Sea per six-year assessment period has been defined as the GES for NIS [10], and therefore one or more introductions to BAL would result in GES not being reached. Furthermore, it has been argued whether a reduction in new NIS introductions could be set as an intermediate objective if the goal of no new introductions cannot be reached. Even though a proportional reduction of new NIS introductions between the assessment periods would indicate temporary improvement of GES, the “zero tolerance policy” was chosen as the GES threshold to the BAL, because it is pragmatic, independent of earlier assessment periods, applicable even with uncertainties in relation to taxonomy and introduction pathways, and efficiently reflecting management measures [10,110].

#### 4.6. Concluding Remarks—The Way forward

Considering how dynamic biological invasions are, NIS inventories should be curated regularly, especially when used to inform policy, in order to minimize errors and avoid over- or under-estimating the state of invasions in a region [44]. While the validation process in this work explicitly addressed many of the taxonomic and spatial components of uncertainty in the EU NIS baseline, other issues remain unresolved, among which the lack of standardized monitoring needs to be urgently rectified both for the meaningful interpretation of results and for the refinement of the relevant indicators.

Regional and sub-regional analyses revealed that there are relatively strong variations in the number of new NIS introductions between the European seas, as well as among the subregions within the same region. Hence, it is natural that GES threshold values for the primary criterion D2C1 are discussed and decided under regional cooperation, as some regions have preferable conditions for a wider variety of species and thus tend to suffer from a higher number of introductions. In addition, NIS pathways are region-specific (e.g., the Suez Canal in the MED, shipping in the NEA). Shipping was found to be a likely vector for over half of NIS in European waters both through biofouling and ballast discharges [2], while biofouling, particularly of recreational vessels, appears to be an important driver for the homogenization of the alien biota in the Mediterranean. As such, a more detailed focus on quantitative measures of pathway pressure would help better elucidate the observed NIS patterns, inform target setting and evaluate GES achievement in relation to management. Considering that currently only aquaculture-related introductions are addressed with EU-wide legislation and that the BWMC is not expected to be fully implemented until 2024 at the earliest, expectations for percentage reduction should have a realistic temporal horizon and, if possible, promote management implementation for the remaining major introduction pathways. More specific national or local measures may be put in place to protect sectors or sensitive habitats, e.g., see [115] for additional measures related to shellfish culture in the Wadden Sea), pathways of species introductions however operate globally and should be managed at appropriate scales.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/d14121077/s1>, Table S1: Partly native or cryptogenic (CRY) species in European seas; Table S2: Species native/cryptogenic in one subregion, but NIS in another subregion.

**Author Contributions:** A.Z. and O.O.: conceptualization, review, and data collection. All authors: providing and validating national data, contribution with taxonomic expertise, interpretation of data. A.Z., O.O., M.G.: data analysis, writing the first draft of the manuscript. F.V. made significant contributions to early drafts of the manuscript. All authors wrote, revised, and contributed to the editing of the final manuscript. All authors have read and agreed to the published version of the manuscript.

**Funding:** A.Z. and O.O. were partially funded by the European Environment Agency, through ETC/ICM 2021. The authors from the National Institute of Biology (Slovenia) acknowledge the financial support of the Slovenian Research Agency (Research Core Funding No. P1-0237) and of the Ministry of Agriculture, Forestry and Food. F.V. is supported by the CNRS Institute for Ecology and Environment. This work benefited from results obtained during surveys carried out in the Interreg IVa Marinexus programme and the Aquanis2.0 (TOTAL Foundation) and MarEEE (i-site MUSE; French National Research Agency under the “Investissements d’Avenir” programme ANR-16-IDEX-0006) projects allocated to FV. This is publication ISEM 2022-296. A.C.C.’s work was partially funded by FEDER funds through the Operational Programme for Competitiveness Factors—COMPETE and by Portuguese National Funds through FCT (Foundation for Science and Technology) under the UID/BIA/50027/2020 and POCI-01-0145-FEDER-006821. P.C. is supported by 2020.01797.CEECIND and (UIDB/04292/2020), granted by Fundação para a Ciência (FCT) e Tecnologia. RR’s work is funded by GI4Sado—IPS RD project. C.B.’s work is partially supported by programme MarBIS—Marine Biodiversity Information System financed through the Portuguese Government. Other support was provided by the Marine and Environmental Sciences Centre (MARE) financed by Portuguese National Funds through FCT/MCTES (UIDB/04292/2020), and by the project LA/P/0069/2020 granted to the Associate Laboratory ARNET. The Portuguese assessment benefited from the contribution of all the Portuguese experts working group on marine NIS. Authors from SLU acknowledge funding from The Swedish Agency for Sea and Water Management.

**Institutional Review Board Statement:** Not Applicable.

**Data Availability Statement:** The data availability statement for this manuscript is already described in the results section and the Supplementary Materials.

**Acknowledgments:** The outcome of the present study was improved through cooperation within the Joint Working Group on Ballast and Other Ship Vectors under the International Council for the Exploration of the Seas (ICES), Intergovernmental Oceanographic Commission of Unesco and International Maritime Organization, as well as the ICES Working Group on Introductions and Transfers of Marine Organisms. The authors thank Nicholas Jason Xentidis for preparing the figures.

**Conflicts of Interest:** The authors declare no conflict of interest.

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