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risk-based approaches to good environmental status

WP3: APPLICATION OF RISK-BASED APPROACH TO NON-INDIGENOUS SPECIES (DESCRIPTOR 2)

Deliverable 3.4 – Sub-regional risk assessment for Descriptor 2

Version 1

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Contents

Introduction

This document constitutes the Deliverable 3.4 – Sub regional risk assessment for Descriptor 2 (D2) of task 3.4 - "Perform risk assessment". The methodology set in the previous steps was used to perform the assessment on D2, in order to determine if there is a risk of not achieving Good Environmental Status (GES). A particular focus will be placed on data regarding major drivers, which act as pathways for non-indigenous species (NIS) including maritime transport, recreational yachting and aquaculture. Deliverable 3.1 (D3.1; Bartilotti et al. 2020a) reported the available information on non-indigenous, cryptogenic and data-deficient species (definitions according to Tsiamis et al. 2019), hereinafter referred as NIS, occurring in two sub-regions of the North-East Atlantic Ocean region defined under the Marine Strategy Framework Directive (MSFD) and considered in the RAGES project: the Bay of Biscay and the Iberian Coast (ABI), and the Macaronesia (AMA). Deliverable 3.2 (D3.2; Bartilotti et al. 2020b) defined the risk context, including the management objectives, assessment scales and risk parameters and categories. In addition, a list of potential pressures was defined as relevant criteria elements for the assessment of GES, which includes the NIS with known adverse effects highlighting those classified as having high impact in the European Alien Species Information Network (EASIN). This database provides technical and scientific support to the relevant European Union policies on biodiversity. Deliverable 3.3 (D3.3; Bartilotti et al. 2020c) defined risk criteria and aggregation methods, and elaborated risk scales for D2 risk evaluation.

Figure 1 summarises the steps required for the application of a Risk-Based Approach (RBA) to NIS developed under the RAGES project.

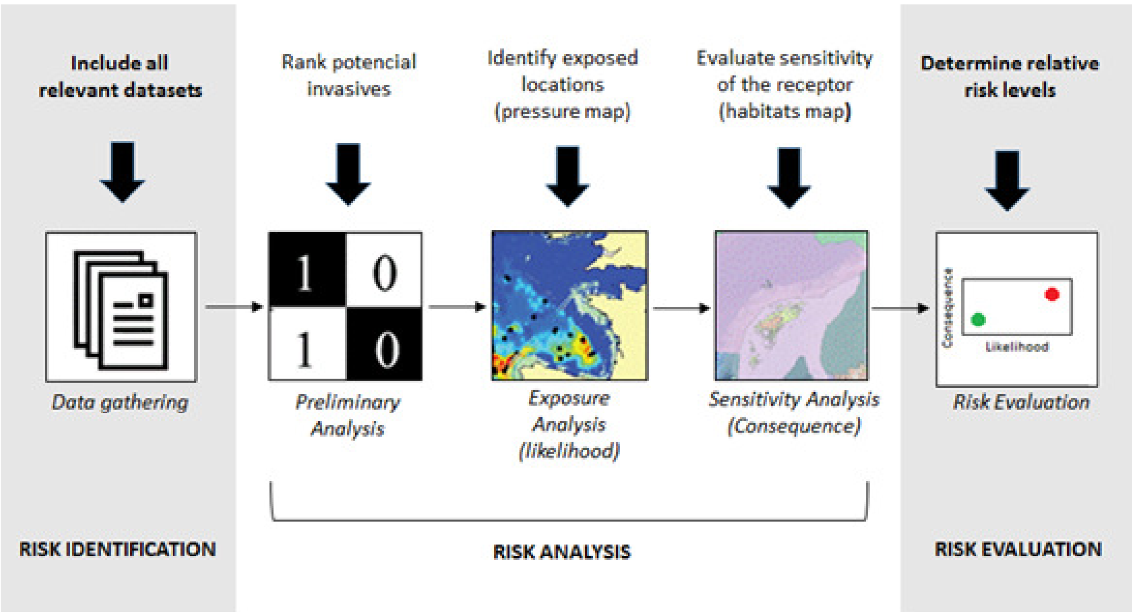

Figure 1. Diagrammatic representation of the work required under step 2 (Risk Identification), step 3 (Risk Analysis) and step 4 (Risk Evaluation) of the RAGES Risk-Based Approach, with a link to the three main steps of the ISO 31000 (2009).

Assessment scale

The focus of this risk assessment was the two MSFD sub-regions of the North-East Atlantic Ocean region, ABI and AMA. Within the sub-regional areas, each Member State (MS) divided their subdivisions in Marine Reporting Units (MRUs) taking into account their ecological and environmental characteristics. In the ABI sub-region, six MRUs were established: one in France (Bay of Biscay-BoB), two in Spain (North Atlantic-NA and South Atlantic-SA) and three in Portugal (Northwest-A, Southwest-B, and South-C). The AMA sub-region was divided in three MRUs, coincident with the three archipelagos of the two MS: two in Portugal (Azores and Madeira) and one in Spain (Canary Islands) (Figure 2).

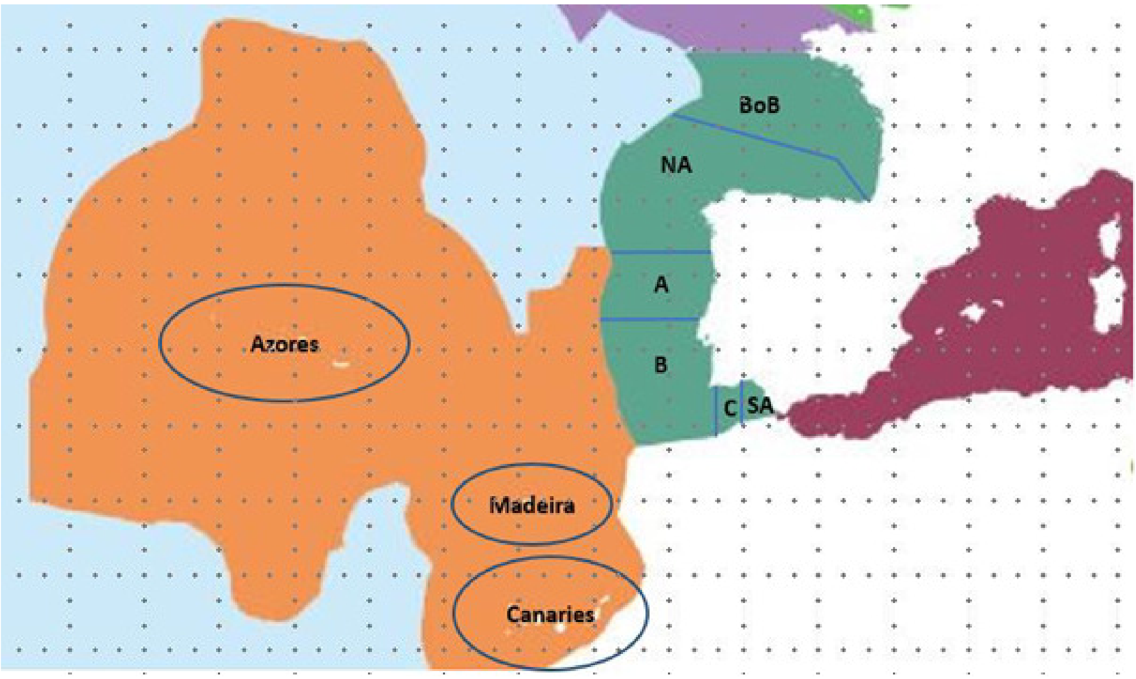

Figure 2. Delimitation of the MRUs. ABI sub-region: France, BoB - Bay of Biscay, Spain, NA - North Atlantic and SA - South Atlantic, and Portugal, A - Northwest, B - Southwest and C - South. AMA sub-region: the Portuguese archipelagos of the Azores and Madeira, and the Spanish archipelago of the Canary Islands.

Preliminary analysis

In order to provide a ranked list of NIS, a preliminary risk assessment using a pilot Horizon-Scanning (HS) exercise was conducted for the sub-regions of ABI and AMA. The HS involved three steps:

1. Composition of taxonomic groups and consultation of the participants: participants were invited to analyse a list of NIS for each taxonomic group;

2. Risk scoring process and initial ranking results: the risk scoring process defined in D3.3 was applied in the evaluation of the NIS records. The output of the risk scoring process produced an initial ranking for all NIS records, i.e., including, in some cases, different evaluations for the same NIS by different participants;

3. Review and validation of the HS results: the initial ranking of the NIS records was revised and amended in order to provide a final ranked list of NIS, i.e., including one single evaluation per NIS, therefore, removing conflicting results for the same NIS.

The ranked list of NIS (revised and amended) was compared with the list of NIS provided in D3.2, i.e., NIS with known adverse impacts highlighting those reported as high impact species in EASIN, in order to assess the potentiality of the HS approach to capture high impacting NIS. Moreover, a list of species not included in the HS is provided.

Finally, an alternative decision-support system for ranking NIS was applied using the ELECTRE III method, to assess the potential influence of the prioritization method on the ranked list of NIS derived from the HS approach.

Horizon-scanning approach

Composition of taxonomic groups and consultation of the participants

In this report, the information compiled in D3.1 (Bartilotti et al. 2020a) provided a reference base to perform the HS. Contributions to the risk scoring process were received from different institutions, including Patrimoine Naturel (PatriNat, France), the Centre of Marine Sciences (CCMAR, Portugal) and the Portuguese Institute for Sea and Atmosphere (IPMA). Participants (researchers both internal and external to RAGES) evaluated a subset of 342 NIS records, corresponding to 188 NIS. In total, eight taxonomic groups were considered: Annelida, Arthropoda, Chordata, Cnidaria, Ctenophora, Mollusca, Myzozoa and Ochrophyta. The species assessed included 36 Annelida, 59 Arthropoda, 54 Chordata, 18 Cnidaria, 1 Ctenophora, 10 Mollusca, 6 Myzozoa and 4 Ochrophyta. Some of the participants chose to evaluate only part of the NIS within the taxonomic group, for which they consider to have a better knowledge. The number of participants contributing to the HS exercise for each taxonomic group is summarized in Table 1. It is worth mentioning that the decision to score solely a subset of the species compiled in D3.1, was driven by the short time available to complete the work under Task 3.4 (to meet the project deadlines), which in turn was a limiting factor for the number of participants in the exercise.

Table 1. Taxa assessed by the participants in the risk scoring exercise.

Phylum	Class	Order	Vernacular	Number of participants
Annelida	Polychaeta		Polychaetes, polychaete worms	3
Arthropoda	Hexanauplia	Sessilia	Barnacles	2
	Malacostraca	Amphipoda	Amphipods, sand hopers, beach hopers	3
		Cumacea	Cumaceans, hooded shrimps	3
		Decapoda	Decapods (crabs, prawns, shrimps, lobsters, crayfish)	3
		Isopoda	Isopods, pillbugs	3
		Mysida	Mysid shrimps, opossum shrimps	3
		Tanaidacea	Tanaids	3
Chordata	Ascidiacea		Sea squirts	1
	Actinopterygii		Ray-finned fishes	2
Ctenophora	Tentaculata		Comb jellies	2
Cnidaria	Anthozoa		Anthozoans	2
	Hydrozoa		Hydrozoans, hydroids, hydromedusae	2
Mollusca	Gastropoda (part)		Gastropods, snails and slugs	3
	Bivalvia (part)		Bivalves	3
Myzozoa	Dinophyceae		Dinoflagellates	1
Ochrophyta (part)	Bacillariophyceae		Diatoms	1
	Raphidophyceae			1

Risk scoring process and initial ranking results

The risk scoring process followed the methodology set out in D3.3 (Bartilotti et al. 2020c). To guide the participants in performing the exercise and to explain to them how the scoring process works, a provisional spreadsheet template was provided including eight sections: (1) Read me, (2) Instructions, (3) Background information, Scoring, (4) Introduction pathways, (5) Risk-scoring table, (6) Risk-scoring example, (7) Glossary and (8) Questions and comments.

This pilot exercise raised a number of issues brought out by the participants, which led to the further review of the HS methodology developed in D3.3. For this reason, the revised and updated approach is provided in version 2 of D3.3 (Bartilotti et al. 2020c). In addition, the spreadsheet template was modified in order to make the process as accurate as possible. The risk-scoring table included in the spreadsheet template contains the following parameters: likelihood of introduction, establishment, spread, and potential adverse impacts. Each parameter is associated with risk categories, which reflect criteria that are considered relevant to the invasion process. In total, eight risk categories were defined to contribute to score calculation: number of introduction pathways, life cycle duration, reproductive rate, environmental tolerance to salinity and temperature, dispersal ability and potential environmental and socioeconomic negative impacts (Bartilotti et al. 2020c).

In the initial ranking results, 232 records (133 species) were evaluated for the ABI sub-region, of which 22 records (9%) were classified as “Top priority”, 81 records as “Alert” (35%) and 129 records as “Less concern” (56%). In the AMA sub-region, 110 records (76 species) were evaluated, with 20 records (18%) considered as “Top priority”, 47 records as “Alert” (43%) and 43 records (39%) classified as “Less Concern”. The results of the risk scoring process and the initial ranked list of NIS records for ABI and AMA sub-regions are available in Supplementary Information (Table S1).

Definitions of the risk categories are given in Box 1.

BOX 1 - Risk Classifications

TOP PRIORITY

Species that rank above the mean of the maximum risk score, with high confidence.

ALERT

Species that rank above the mean of the maximum risk score, with low to medium confidence or species that rank below the mean risk with low to medium confidence.

LESS CONCERN

Species that rank below the mean of the maximum risk score, with high confidence.

Note: Species that do not fall into the top priority category, but that are considered of high risk by the experts may be included in the top priority list.

The initial ranking results revealed a number of conflicting classifications, i.e., the same NIS was classified in different priority classes (e.g., Top priority and Alert) as a result of the risk scoring performed by different participants. The results for the ABI and AMA sub-regions are illustrated in Figure 3.

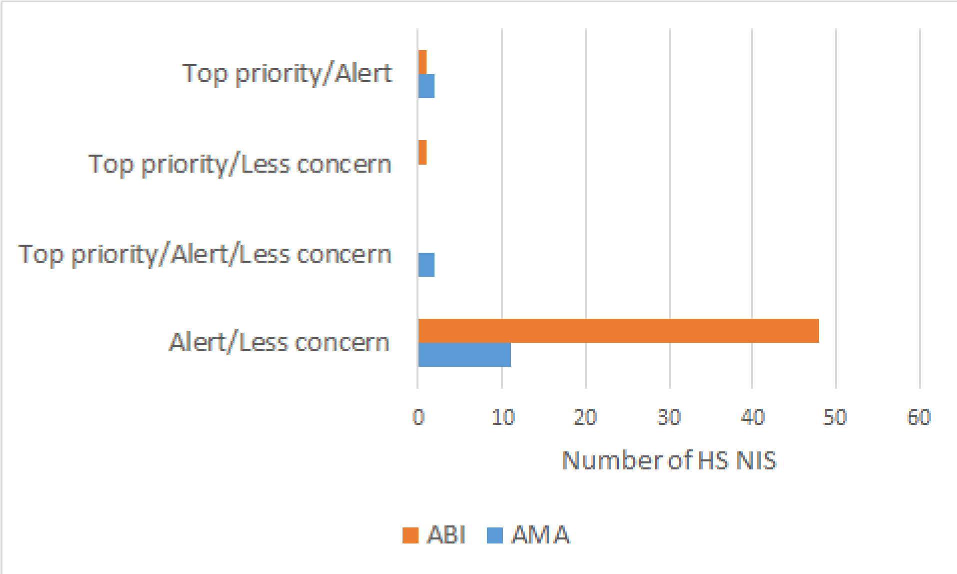

Figure 3. Number of HS NIS classified in different priority classes in the preliminary HS exercise.

In the ABI, only two NIS out of the 133 reported for this sub-region, received conflicting classifications as "Top priority" and "Alert" or "Top priority" and "Less concern"; those are *Penaeus japonicus* and *Procambarus clarkii*, respectively. In the AMA, two NIS, *Branchiomma bairdi* and *Sabella spallanzanii*, were classified in three priority classes, while *Hydroides elegans* and *Spirorbis (Spirorbis) marioni* received two different evaluations, being classified as either "Top priority" or "Alert". A high number of NIS were classified as "Alert" and "Less concern", 48 in the ABI and 11 in the AMA sub-region.

Review and validation of the HS results

As mentioned previously, consensual risk scoring was not achieved for some species. Disagreements were identified in scores and confidence levels as well, for all risk categories. The categories "likelihood of establishment" and "potential negative impacts" had slightly higher number of disagreements than the other ones. It is worth mentioning that several scores (particularly in the sub-category "number of introduction pathways") did not consider the information provided by the NIS checklist produced in Deliverable 3.1 and provided to the participants in the HS exercise.

To address conflicting risk scoring, consensus workshops were planned, to provide the participants in the exercise with an opportunity to analyse and discuss their decisions and eventually reach a consensus. Unfortunately, the risk scoring was a very time-consuming process. Taking into consideration the short time left to complete the HS exercise, holding those workshops was not deemed viable.

To overcome this constraint a simple rule of thumb was set out, under which the choices over conflicting scores would be based on the best available information, i.e., peer-reviewed studies, technical-scientific reports, and quality assurance databases, and be precautionary. All conflicting species scoring were then reviewed and amended (where necessary), in order to better harmonize the assessments and reduce, as much as possible, bias in the classifications.

In the absence of the consensus workshops the analyses and decisions were carried out by one single assessor. The choices were determined primarily by the information about the potential negative impacts of the species. The number of consensual scorings per species was also accounted for. Species without known adverse impacts were reclassified as "Less concern". Species with known adverse impacts, species considered of Union and/or Member States concern, species with conflicting or absent information about adverse impacts were reclassified as "Alert", except one species that was reclassified as "Top Priority", since this classification was the more consensual one among the participants in the HS exercise.

After the revision, 18 NIS were considered of top priority in the ABI (Table 2) and 14 NIS in the AMA (Table 3) sub-regions. The complete list with the HS results for each decision is provided in Appendix 1.

Table 2. Top priority NIS list obtained after the revision of the scores for the ABI sub-region. Ranking list of NIS in descending order according to overall scores.

Phylum	**Class**	**Species**
Chordata	Ascidiacea	*Botrylloides violaceus* Oka, 1927
Arthropoda	Malacostraca	*Rhithropanopeus harrisii* (Gould, 1841)
Arthropoda	Malacostraca	*Eriocheir sinensis* H. Milne Edwards, 1853
Arthropoda	Hexanauplia	*Austrominius modestus* (Darwin, 1854)
Arthropoda	Hexanauplia	*Amphibalanus amphitrite* (Darwin, 1854)
Arthropoda	Hexanauplia	*Amphibalanus improvisus* (Darwin, 1854)
Arthropoda	Hexanauplia	*Megabalanus tintinnabulum* (Linnaeus, 1758)

Chordata	Ascidiacea	*Botryllus schlosseri* (Pallas, 1766)
Chordata	Ascidiacea	*Styela clava* Herdman, 1881
Cnidaria	Hydrozoa	*Blackfordia virginica* Mayer, 1910
Mollusca	Bivalvia	*Ruditapes philippinarum* (Adams & Reeve, 1850)
Chordata	Ascidiacea	*Ciona robusta* Hoshino & Tokioka, 1967
Chordata	Ascidiacea	*Didemnum vexillum* Kott, 2002
Chordata	Ascidiacea	*Microcosmus squamiger* Michaelsen, 1927
Chordata	Ascidiacea	*Styela plicata* (Lesueur, 1823)
Arthropoda	Hexanauplia	*Balanus trigonus* Darwin, 1854
Annelida	Polychaeta	*Ficopomatus enigmaticus* (Fauvel, 1923)
Mollusca	Gastropoda	*Ocinebrellus inornatus* (Récluz, 1851)

Table 3. Top priority NIS list obtained after the revision of the scores for the AMA sub-region. Ranking list of NIS in descending order according to overall scores.

Phylum	**Class**	**Species**
Chordata	Ascidiacea	*Botrylloides violaceus* Oka, 1927
Chordata	Ascidiacea	*Polyandrocarpa zorritensis* (Van Name, 1931)
Arthropoda	Hexanauplia	*Austrominius modestus* (Darwin, 1854)
Arthropoda	Hexanauplia	*Amphibalanus amphitrite* (Darwin, 1854)
Chordata	Ascidiacea	*Botryllus schlosseri* (Pallas, 1766)
Chordata	Ascidiacea	*Ciona intestinalis* Linnaeus, 1767
Chordata	Ascidiacea	*Styela clava* Herdman, 1881
Annelida	Polychaeta	*Hydroides elegans* (Haswell, 1883)
Chordata	Ascidiacea	*Clavelina oblonga* Herdman, 1880
Chordata	Ascidiacea	*Microcosmus squamiger* Michaelsen, 1927
Chordata	Ascidiacea	*Styela plicata* (Lesueur, 1823)
Arthropoda	Hexanauplia	*Balanus trigonus* Darwin, 1854
Annelida	Polychaeta	*Ficopomatus enigmaticus* (Fauvel, 1923)

Cnidaria	Anthozoa	*Exaiptasia diaphana* (Rapp, 1829)

In the ABI sub-region, among the top 18 NIS that received the highest score are seven ascidians, seven arthropods (two crabs and five barnacles), two molluscs (one bivalve and one gastropod), one hydrozoan and one polychaete worm. The gastropod *Ocinebrellus inornatus* classified as "Less concern" was moved to the top priority list as it is considered as posing a high potential risk (e.g., Fey et al. 2010, Afonso, 2011, Lutzen et al. 2012). Moreover, it is considered a species of MS concern (https://easin.jrc.ec.europa.eu/spexplorer/search/searchpaged). In Portugal, this NIS is mentioned in the published list of invasive species (Decree Law No. 92/2019). In the AMA sub-region, 14 NIS were ranked as top priority in the final list, of which eight sea squirts, three arthropods (three barnacles), one anthozoan and two polychaete worms. This information is detailed in Appendix 1.

Comparison of the HS results and the NIS list compiled in D3.2

The comparison of the final list of NIS derived from the HS with the list of NIS provided in D3.2, i.e., NIS with known adverse impacts highlighting those reported as high impact species in EASIN, led to the following conclusions:

- In the ABI sub-region all species ranked as “Top priority” are included in the list of NIS with known adverse impacts, and 67% of them are reported as high impact species. From the species ranked as “Alert”, 55% are reported as species with adverse impacts and 39% are classified as high impact species, whereas 45% have no known adverse impacts and 24% are not reported in EASIN. Finally, 61% of the “Less concern” NIS issued from the HS exercise, correspond to the species with no reported adverse effects and no high impacts. Only 18% of these NIS are reported as high impact species, while 13% are not reported in EASIN.
- In the AMA sub-region, all “Top priority” NIS correspond to NIS with known adverse impacts, 57% being also considered as high impact NIS and 7% not reported in EASIN. Regarding NIS ranked as “Alert”, 57% correspond to NIS with known adverse impacts and 43% have no reported adverse impacts; only 7% are considered high impact species. It is worth highlighting that most (68%) of the “Alert” NIS are not reported in EASIN. Among the HS “Less concern” NIS, only 38% have no reported adverse impacts, whereas 62% do, and 9% are also high impact species. As for the “Alert” category, most of the “Less concern” NIS (74%) are not reported in EASIN.

These results suggest that the current HS approach is able to capture and prioritize most of the high-impacting NIS. Moreover, the system provides a rank of the remaining species (as “Alert” or “Less Concern”), which may not pose an immediate threat but cannot be disregarded, in particular the established ones, in the framework of a dedicated monitoring programme. This information is available in Appendix 1.

Nonetheless, comparisons with other ranking approaches should provide more information regarding the consistency of these results.

Review of the NIS list not included in the HS exercise

To provide more information for risk management decisions, a list of NIS that were not evaluated in the HS exercise, is provided, with reference to known adverse effects and highlighting those with high impacts reported in EASIN. In the ABI, a total of 101 NIS was not included in the exercise, of which 51 NIS have known adverse effects, with 28 being reported as high impact in EASIN. A summary of the results for the ABI sub-region is provided in Table 4 and Table 5.

Table 4. Summary results of NIS not evaluated in the HS exercise in the ABI sub-region.

Phylum	**Number of NIS**
Arthropoda*	3
Bryozoa	13
Cercozoa	3
Chlorophyta	7
Mollusca**	26
Nematoda	1
Ochrophyta	5
Platyhelminthes	2
Porifera	1
Rodophyta	37
Tracheophyta	3

** Copepoda*
*** 12 Bivalvia; 12 Gastropoda; 1 Polyplacophora; 1 Vetigastropoda*

Table 5. Summary results of NIS with known adverse effects in the ABI sub-region.

Phylum	Class	Total	High Impact	No High Impact
Arthropoda	Copepoda	3	3	-
Bryozoa	Gymnolaemata	5	3	2
Cercozoa	Ascetosporea	3	2	1
Chlorophyta	Ulvophyceae	5	1	4
Mollusca	Bivalvia	10	5	5
Mollusca	Gastropoda	4	1	3
Nematoda	Chromadorea	1	1	-
Ochrophyta	Phaeophyceae	3	2	1
Platyhelminthes	Monogenea	2	2	-
Porifera	Demospongiae	1	-	1
Rhodophyta	Florideophyceae	11	5	6
Tracheophyta	Magnoliopsida	3	3	-
Total		**51**	**28**	**23**

From the 51 NIS with known adverse impacts not evaluated in the HS exercise only seven (three reported as high impact species) are recorded in all MS and MRUs: the red algae *Agarophyton vermiculophyllum*, *Anotrichium furcellatum*, *Antithamnionella spirographidis*, *Asparagopsis armata* (high impact) and *Melanothamnus harveyi*, the brown alga *Sargassum muticum* (high impact) and the bryozoan *Bugula neritina* (high impact).

In the AMA, a total of 194 NIS was not included in the exercise, of which 80 NIS have known adverse effects with 18 being reported as high impact in EASIN. A summary of the results for the AMA sub-region is provided in Tables 6 and 7.

Table 6. Summary results of NIS not evaluated in the HS exercise in the AMA sub-region.

Phylum	Number of NIS
Bryozoa	69
Chlorophyta	14

Cnidaria	1
Ctenophora	1
Echinodermata	1
Entoprocta	1
Mollusca*	18
Myzozoa	1
Ochrophyta	12
Phoronida	3
Porifera	7
Rodophyta	66

*** 8 Bivalvia; 11 Gastropoda*

Table 7. Summary results of NIS with known adverse effects in the AMA sub-region.

Phylum	**Class**	**Total**	**High Impact**	**No High Impact**
Bryozoa	Gymnolaemata	20	2	18
Bryozoa	Stenolaemata	1	-	1
Chlorophyta	Ulvophyceae	6	3	3
Cnidaria	Myxozoa	1	-	1
Ctenophora	Tentaculata	1	-	1
Echinodermata	Echinoidea	1	-	1
Mollusca	Bivalvia	6	2	4
Mollusca	Gastropoda	6	1	5
Myzozoa	Dinophyceae	1	1	-
Ochrophyta	Phaeophyceae	3	2	1
Porifera	Calcarea	1	-	1
Porifera	Demospongiae	5	-	5
Rodophyta	Florideophyceae	28	7	21

Total		**80**	**18**	**62**

From the 80 NIS with known adverse impacts not evaluated in the HS exercise nine (three reported as high impact species) are recorded in all MS and MRUs, of which six bryozoans, *Bugula neritina* (high impact), *Bugulina fulva*, Bugulina *simplex*, *Bugulina stolonifera*, *Reptadeonella violacea* and *Schizoporella errata*, one sponge, *Paraleucilla magna* and two red algae, *Asparagopsis armata* and *Asparagopsis taxiformis,* both reported as high impact species. The complete list of NIS not included in the current HS exercise is given in Appendix 2.

Application of an alternative decision-support system for ranking NIS

In order to assess the potential influence of the prioritization method on the HS results we used the ELECTRE III as an alternative method to rank species in function of the risk they represent as NIS, for the two regions ABI and AMA separately. The method ELECTRE III allows ranking actions or objects, in the present case NIS, according to several criteria scored by the user, but using a different principle: systematic pairwise ordinal comparisons of all NIS under each criterion, instead of calculating scores.

Data used were the risk scoring of the same eight parameters as used in the HS exercise described above: number of introduction pathways, life cycle duration, reproductive rate, environmental tolerance to salinity and temperature, dispersal ability and potential adverse environmental and socioeconomic impacts. A ninth parameter was created to include confidence level or uncertainty in the score of parameters. This parameter is defined as the average of all confidence scores that were set by experts for each criterion. When no data for confidence were available, the minimum possible score was adopted (score 1 = low confidence), to have a precautionary approach.

Finally, two alternatives for this comparison have been developed: with the inclusion of confidence and without the inclusion of confidence, therefore eight parameters have been considered for the first approach and nine for the second.

The ELECTRE III method requires setting weights that, contrary to multicriteria scoring, are not used for the calculation of a weighted sum but reflect the relative confidence in preferences made on each criterion during pairwise comparisons. Weights were chosen similarly to those used in the HS exercise. When a confidence score was included, the parameters related to risk scoring were allocated a 50% weight and the confidence score was also set to 50% in ELECTRE by default. A summary of the ELECTRE III method is presented in Box 2. The detailed description of the method is given in D3.3 (Bartilotti et al. 2020c).

BOX 2 - ELECTRE III Method

The ELECTRE III approach provides the comparison of actions scored for different criteria defined by the user. This approach could consider ordinal or qualitative criteria. In our case study, actions are NIS and criteria used are the same as those used by the HS approach. ELECTRE III uses an aggregation algorithm, separated in two phases:

- Comparison of all actions by pairs (A, B), using evaluations and weighting of criteria, in order to test the hypothesis of "surpassing relation" between two actions; action A is at least as good as action B. The surpassing relation is reflexive but not transitive.
- Ranking actions based on these comparisons.

Actions are compared by pairs and all pairs are characterized by a surpassing relation. This relation is not fully accepted or rejected but the degree of credibility of the relation is assessed following two indexes: the compliance index and the discordance index.

- The compliance index indicates the importance of the affirmation of surpassing relation between two actions. The higher the index, the clearer the affirmation of surpassing is, i.e., the higher the index, the clearer the affirmation that A is at least as good as action B.
- The discordance index: the higher the index, the more discordant actions A and B are.

Relations between actions are defined by threshold of indifference, preference and veto that need to be set up for each criterion.

- Indifference (i): this threshold defines the estimated non-significant difference between two evaluations.
- Preference (p): this threshold defines the difference between two evaluations, which indicates that one option is preferred over the other.
- Veto (v): this threshold defines the difference between two evaluations, which indicates that the action with the lower evaluation cannot be ranked better at the end than the other action, whatever the relations for the other criteria are.

Results obtained and presented hereafter must be read as follows: parameters are set in a way that NIS associated to the rank 1 in ELECTRE represent the highest risk among all NIS.

Comparison of the HS approach and ELECTRE III without confidence scores

In this approach, ranks obtained with ELECTRE III (without the confidence parameter) are compared with the "overall risk score" (also without confidence), in which higher scores denote higher risks, obtained for each NIS with the HS approach. The comparison has been carried out for the two MSFD sub-regions ABI and AMA (Tables 8 - 11). HS overall scores vary from 270 to 10 for NIS in ABI and AMA and ranks for ELECTRE III vary between 1 and 25 (with many NIS ranking ex-aequo).

Table 8. Comparison of ranking results (NIS ranks from 1 to 5) and the “overall risk score” for the ABI sub-region obtained by the HS approach without confidence scores.

Species	**Final rank (ELECTRE III)**	**Overall risk score (HS results)**
Botrylloides violaceus Oka, 1927	1	270
Rhithropanopeus harrisii (Gould, 1841)	1	270
Eriocheir sinensis H. Milne Edwards, 1853	1	270
Botryllus schlosseri (Pallas, 1766)	2	180
Styela clava Herdman, 1881	2	180
Blackfordia virginica Mayer, 1910	2	180
Ruditapes philippinarum (Adams & Reeve, 1850)	2	180
Acartia (Acanthacartia) tonsa Dana, 1849	3	90
Mnemiopsis leidyi Agassiz, 1865	3	90
Monocorophium uenoi (Stephensen, 1932)	3	120
Ciona intestinalis (Linnaeus, 1767)	4	120
Austrominius modestus (Darwin, 1854)	5	234
Amphibalanus amphitrite (Darwin, 1854)	5	234
Amphibalanus improvisus (Darwin, 1854)	5	234
Megabalanus tintinnabulum (Linnaeus, 1758)	5	234
Didemnum vexillum Kott, 2002	5	156
Microcosmus squamiger Michaelsen, 1927	5	156
Cordylophora caspia (Pallas, 1771)	5	156
Nemopsis bachei L. Agassiz, 1849	5	90
Eucheilota menoni Kramp, 1959	5	90
Ecteinascidia turbinata Herdman, 1880	5	90
Rapana venosa (Valenciennes, 1846)	5	90
Jassa marmorata Holmes, 1905	5	90

Table 9. Comparison of ranking results (NIS ranks from 20 to 25) and “overall risk score” for the ABI sub-region obtained by the HS approach, without confidence scores.

Species	Final rank (ELECTRE III)	Overall risk score (HS results)
Molgula occidentalis Traustedt, 1883	20	22
Eocuma dimorphum Fage, 1928	21	27
Lumbrinerides crassicephala (Hartman, 1965)	21	40
Distaplia corolla Monniot F., 1974	21	22
Limnoria quadripunctata Holthuis, 1949	22	27
Namanereis littoralis (Grube, 1872)	22	20
Mercenaria mercenaria (Linnaeus, 1758)	22	18
Fistularia petimba Lacepède, 1803	23	18
Acanthurus monroviae Steindachner, 1876	23	18
Diodon eydouxii Brisout de Barneville, 1846	23	18
Dipolydora tentaculata (Blake & Kudenov, 1978)	24	18
Acipenser baerii Brandt, 1869	25	10

Table 8 illustrates the case of NIS belonging to the top 5 first ranks and Table 9 illustrates the case of NIS belonging to the last 5 ranks. Ranking results obtained with ELECTRE III are consistent with "overall risk scores" estimated with the HS approach. In fact, NIS from ranks 1 to 5 are also NIS with the highest values for the overall risk score and NIS from ranks 20 to 25 are also NIS with lowest values for the overall risk score.

Table 10. Comparison of ranking results (NIS ranks from 1 to 5) and "overall risk score" for the AMA sub-region obtained by the HS approach, without the confidence parameter.

Species	Final rank (ELECTRE III)	Overall risk score (HS results)
Botrylloides violaceus Oka, 1927	1	270
Botryllus schlosseri (Pallas, 1766)	2	180
Styela clava Herdman, 1881	2	180
Ciona intestinalis (Linnaeus, 1767)	3	180
Polyandrocarpa zorritensis (Van Name, 1931)	4	234
Austrominius modestus (Darwin, 1854)	5	234
Amphibalanus amphitrite (Darwin, 1854)	5	234
Styela plicata (Lesueur, 1823)	5	156
Clavelina dellavallei (Zirpolo, 1925)	5	90

Clavelina lepadiformis (Müller, 1776)	5	90
Diplosoma listerianum (Milne Edwards, 1841)	5	90

Table 11. Comparison of ranking results (NIS ranks from 17 to 21) and "overall risk score" for the AMA sub-region obtained by the HS approach, without the confidence parameter.

Species	**Final rank (ELECTRE III)**	**Overall risk score (HS results)**
Pomacanthus maculosus (Forsskål, 1775)	17	54
Prognathodes marcellae (Poll, 1950)	17	54
Sphaeroma walkeri Stebbing, 1905	17	30
Perinereis cultrifera (Grube, 1840)	17	44
Ctenodrilus serratus (Schmidt, 1857)	18	44
Tubularia indivisa Linnaeus, 1758	19	54
Alloeocarpa loculosa Monniot C., 1974	19	22
Distaplia bermudensis Van Name, 1902	19	54
Distaplia magnilarva (Della Valle, 1881)	19	54
Symplegma rubra Monniot C., 1972	19	22
Pileolaria berkeleyana (Rioja, 1942)	19	22
Cephalopholis nigri (Günther, 1859)	20	18
Millepora alcicornis Linnaeus, 1758	21	14

Tables 10 and 11 illustrate, for the AMA sub-region, the comparison of results provided by ELECTRE with "overall risk scores". As for the ABI sub-region similar conclusions are observed: first ranks are occupied with NIS with high "overall risk scores" and inversely final ranks are NIS with low "overall risk scores".

Default values for preference, indifference and veto thresholds were set by project members. Sensitivity tests were performed for the ELECTRE results, by varying these thresholds in realistic proportions (i.e., no extreme variations). With such a realistic variation of thresholds, the ranks obtained showed no difference with the initial ranking results. With a wider variation of thresholds, notably for the veto threshold, ranking results are modified more significantly, but the value of the veto threshold for this latter test was not realistic. These tests confirm the robustness of the ELECTRE results regarding these parameters.

In conclusion, for the two sub-regions ABI and AMA the results obtained with the method ELECTRE III are coherent with the values of the overall risk score and validate the HS approach to risk and the “overall risk score” used."

Comparison of the HS approach and ELECTRE III with confidence scores

When the confidence parameter is included, ranks obtained with ELECTRE are compared with the HS results, which are in this case: “Top priority”,"Alert” and “Less concern”.

In order to test the impact of the degree of confidence in the confidence scoring, we also carried out (for ABI sub-region only) a sensitivity analysis of ELECTRE III results by changing the default weight of the confidence parameter (50%), to two contrasting values (10% and 90%). The results are presented in Table 12.

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Table 12. Full comparison of the ranks obtained with ELECTRE III and HS results for the ABI sub-region (with different sensitivities to confidence).

Species	**Rank (ELECTRE III) Default confidence score weight 50%**	**HS results**	**Species**	**Final rank (ELECTRE III) confidence score weight 90%**	**HS results**	**Species**	**Final rank (ELECTRE III) confidence score weight 10%**	**HS results**
Clytia linearis (Thorneley, 1900)	1	Alert	*Asclerocheilus ashworthi* Blake, 1981	1	Alert	*Botrylloides violaceus* Oka, 1927	1	Top Priority
Asclerocheilus ashworthi Blake, 1981	2	Alert	*Nemopsis bachei* L. Agassiz, 1849	2	Alert	*Rhithropanopeus harrisii* (Gould, 1841)	2	Top Priority
Monocorophium uenoi (Stephensen, 1932)	2	Less Concern	*Monocorophium uenoi* (Stephensen, 1932)	2	Less Concern	*Eriocheir sinensis* H. Milne Edwards, 1853	2	Top Priority
Botrylloides violaceus Oka, 1927	3	Top Priority	*Botrylloides violaceus* Oka, 1927	3	Top Priority	*Blackfordia virginica* Mayer, 1910	3	Top Priority
Brachynotus sexdentatus (Risso, 1827)	3	Less Concern	*Blackfordia virginica* Mayer, 1910	3	Top Priority	*Asclerocheilus ashworthi* Blake, 1981	3	Alert
Nemopsis bachei L. Agassiz, 1849	4	Alert	*Clytia linearis* (Thorneley, 1900)	3	Alert	*Clytia linearis* (Thorneley, 1900)	3	Alert
Blackfordia virginica Mayer, 1910	4	Top Priority	*Eucheilota menoni* Kramp, 1959	4	Alert	*Monocorophium uenoi* (Stephensen, 1932)	3	Less Concern
Eucheilota menoni Kramp, 1959	4	Alert	*Rhithropanopeus harrisii* (Gould, 1841)	5	Top Priority	*Styela clava* Herdman, 1881	4	Top Priority
Rhithropanopeus harrisii (Gould, 1841)	5	Top Priority	*Eriocheir sinensis* H. Milne Edwards, 1853	5	Top Priority	*Nemopsis bachei* L. Agassiz, 1849	4	Alert
Eriocheir sinensis H. Milne Edwards, 1853	6	Top Priority	*Aoroides longimerus* Ren & Zheng, 1996	5	Less Concern	*Botryllus schlosseri* (Pallas, 1766)	5	Top Priority
Ciona robusta Hoshino & Tokioka, 1967	6	Top Priority	Cordylophora caspia (Pallas, 1771)	6	Alert	*Ruditapes philippinarum (Adams & Reeve, 1850)*	5	Top Priority

Filellum serratum (Clarke, 1879)	6	Alert	*Ciona intestinalis* (Linnaeus, 1767)	6	Less Concern	*Ciona intestinalis* (Linnaeus, 1767)	5	Less Concern
Cordylophora caspia (Pallas, 1771)	7	Alert	*Lumbrinerides crassicephala* (Hartman, 1965)	6	Less Concern	*Brachynotus sexdentatus* (Risso, 1827)	5	Less Concern
Mnemiopsis leidyi Agassiz, 1865	7	Less Concern	*Styela clava* Herdman, 1881	7	Top Priority	*Mnemiopsis leidyi* Agassiz, 1865	6	Less Concern
Procambarus clarkii (Girard, 1852)	7	Top Priority	*Ciona robusta* Hoshino & Tokioka, 1967	7	Top Priority	*Acartia (Acanthacartia) tonsa* Dana, 1849	7	Less Concern
Dyspanopeus sayi (Smith, 1869)	8	Alert	*Grandidierella japonica* Stephensen, 1938	7	Less Concern	*Procambarus clarkii* (Girard, 1852)	8	Top Priority
Austrominius modestus (Darwin, 1854)	8	Top Priority	*Procambarus clarkii* (Girard, 1852)	8	Top Priority	*Eucheilota menoni* Kramp, 1959	8	Alert
Amphibalanus amphitrite (Darwin, 1854)	8	Top Priority	*Hydroides dianthus* (Verrill, 1873)	8	Alert	*Austrominius modestus* (Darwin, 1854)	9	Top Priority
Amphibalanus improvisus (Darwin, 1854)	8	Top Priority	*Penaeus japonicus* Spence Bate, 1888	8	Alert	*Amphibalanus amphitrite* (Darwin, 1854)	9	Top Priority
Megabalanus tintinnabulum (Linnaeus, 1758)	8	Top Priority	*Botrylloides leachii* (Savigny, 1816)	8	Less Concern	*Amphibalanus improvisus* (Darwin, 1854)	9	Top Priority
Styela clava Herdman, 1881	8	Top Priority	*Streblospio benedicti* Webster, 1879	8	Less Concern	*Megabalanus tintinnabulum* (Linnaeus, 1758)	9	Top Priority
Gonionemus vertens A. Agassiz, 1862	8	Alert	*Brachynotus sexdentatus* (Risso, 1827)	8	Less Concern	*Cordylophora caspia* (Pallas, 1771)	9	Alert
Maeotias marginata (Modeer, 1791)	8	Alert	*Exaiptasia diaphana* (Rapp, 1829)	9	Alert	*Ecteinascidia turbinata* Herdman, 1880	9	Less Concern
Limnoria tripunctata Menzies, 1951	9	Alert	*Ecteinascidia turbinata* Herdman, 1880	9	Less Concern	*Jassa marmorata* Holmes, 1905	9	Less Concern
Ciona intestinalis (Linnaeus, 1767)	9	Less Concern	*Mnemiopsis leidyi* Agassiz, 1865	9	Less Concern	*Didemnum vexillum* Kott, 2002	10	Top Priority

Acartia (Acanthacartia) tonsa Dana, 1849	9	Less Concern	*Jassa marmorata* Holmes, 1905	9	Less Concern	*Microcosmus squamiger* Michaelsen, 1927	10	Top Priority
Hydroides dianthus (Verrill, 1873)	9	Alert	*Palaemon macrodactylus* Rathbun, 1902	9	Less Concern	*Styela plicata* (Lesueur, 1823)	10	Top Priority
Eurytemora pacifica Sato, 1913	9	Less Concern	*Botryllus schlosseri* (Pallas, 1766)	10	Top Priority	*Hydroides dianthus* (Verrill, 1873)	10	Alert
Oithona davisae Ferrari F.D. & Orsi, 1984	10	Less Concern	*Ruditapes philippinarum* (Adams & Reeve, 1850)	10	Top Priority	*Rapana venosa* (Valenciennes, 1846)	10	Less Concern
Fistulobalanus albicostatus (Pilsbry, 1916)	10	Less Concern	*Hemigrapsus takanoi* Asakura & Watanabe, 2005	10	Alert	*Molgula manhattensis* (De Kay, 1843)	10	Less Concern
Lumbrinerides crassicephala (Hartman, 1965)	10	Less Concern	*Acartia (Acanthacartia) tonsa* Dana, 1849	10	Less Concern	*Magallana gigas* (Thunberg, 1793)	10	Less Concern
Botryllus schlosseri (Pallas, 1766)	11	Top Priority	*Austrominius modestus* (Darwin, 1854)	11	Top Priority	*Grandidierella japonica* Stephensen, 1938	10	Less Concern
Ruditapes philippinarum (Adams & Reeve, 1850)	11	Top Priority	*Amphibalanus amphitrite* (Darwin, 1854)	11	Top Priority	*Hemigrapsus takanoi* Asakura & Watanabe, 2005	11	Alert
Hemigrapsus takanoi Asakura & Watanabe, 2005	11	Alert	*Amphibalanus improvisus* (Darwin, 1854)	11	Top Priority	*Dyspanopeus sayi* (Smith, 1869)	11	Alert
Penaeus japonicus Spence Bate, 1888	12	Alert	*Megabalanus tintinnabulum* (Linnaeus, 1758)	11	Top Priority	*Ianiropsis serricaudis* Gurjanova, 1936	11	Alert
Diodon eydouxii Brisout de Barneville, 1846	12	Alert	*Hydroides ezoensis* Okuda, 1934	11	Alert	*Botrylloides leachii* (Savigny, 1816)	11	Less Concern
Aoroides longimerus Ren & Zheng, 1996	12	Less Concern	*Dyspanopeus sayi* (Smith, 1869)	11	Alert	*Streblospio benedicti* Webster, 1879	11	Less Concern
Grandidierella japonica Stephensen, 1938	12	Less Concern	*Gonionemus vertens* A. Agassiz, 1862	11	Alert	*Eurytemora pacifica* Sato, 1913	11	Less Concern
Ecteinascidia turbinata Herdman, 1880	12	Less Concern	*Maeotias marginata* (Modeer, 1791)	11	Alert	*Oithona davisae* Ferrari F.D. & Orsi, 1984	11	Less Concern

Jassa marmorata Holmes, 1905	12	Less Concern	*Sabella spallanzanii* (Gmelin, 1791)	11	Less Concern	*Fistulobalanus albicostatus* (Pilsbry, 1916)	11	Less Concern
Hydroides ezoensis Okuda, 1934	12	Alert	*Metasychis gotoi* (Izuka, 1902)	11	Less Concern	*Ciona robusta* Hoshino & Tokioka, 1967	12	Top Priority
Fistularia petimba Lacepède, 1803	13	Alert	*Styela plicata* (Lesueur, 1823)	12	Top Priority	*Balanus trigonus* Darwin, 1854	12	Top Priority
Acanthurus monroviae Steindachner, 1876	13	Alert	*Diadumene cincta* Stephenson, 1925	12	Alert	*Gonionemus vertens* A. Agassiz, 1862	12	Alert
Botrylloides leachii (Savigny, 1816)	13	Less Concern	*Filellum serratum* (Clarke, 1879)	12	Alert	*Maeotias marginata* (Modeer, 1791)	12	Alert
Streblospio benedicti Webster, 1879	13	Less Concern	*Eurytemora pacifica* Sato, 1913	12	Less Concern	*Palaemon macrodactylus* Rathbun, 1902	12	Less Concern
Palaemon macrodactylus Rathbun, 1902	13	Less Concern	*Oithona davisae* Ferrari F.D. & Orsi, 1984	12	Less Concern	*Ficopomatus enigmaticus* (Fauvel, 1923)	13	Top Priority
Boccardia semibranchiata Guérin, 1990	14	Less Concern	*Fistulobalanus albicostatus* (Pilsbry, 1916)	12	Less Concern	*Limnoria tripunctata* Menzies, 1951	13	Alert
Balanus trigonus Darwin, 1854	14	Top Priority	*Didemnum vexillum* Kott, 2002	13	Top Priority	*Penaeus japonicus* Spence Bate, 1888	13	Alert
Pseudodiaptomus marinus Sato, 1913	14	Less Concern	*Microcosmus squamiger* Michaelsen, 1927	13	Top Priority	*Filellum serratum* (Clarke, 1879)	13	Alert
Asterocarpa humilis (Heller, 1878)	14	Alert	*Arcuatula senhousia* (Benson, 1842)	13	Alert	*Ocinebrellus inornatus* (Récluz, 1851)	13	Less Concern
Molgula manhattensis (De Kay, 1843)	14	Less Concern	*Rapana venosa* (Valenciennes, 1846)	13	Less Concern	*Exaiptasia diaphana* (Rapp, 1829)	14	Alert
Magallana gigas (Thunberg, 1793)	14	Less Concern	*Paradella dianae* (Menzies, 1962)	13	Less Concern	*Synidotea laticauda* Benedict, 1897	14	Alert
Chaetozone corona Berkeley & Berkeley, 1941	14	Less Concern	*Pseudo-nitzschia multistriata* (Takano) Takano, 1995	13	Less Concern	*Pseudo-nitzschia multistriata* (Takano) Takano, 1995	14	Less Concern

Exaiptasia diaphana (Rapp, 1829)	14	Alert	*Molgula manhattensis* (De Kay, 1843)	13	Less Concern	*Pseudodiaptomus marinus* Sato, 1913	14	Less Concern
Diadumene cincta Stephenson, 1925	14	Alert	*Magallana gigas* (Thunberg, 1793)	13	Less Concern	*Diamysis lagunaris* Ariani & Wittmann, 2000	14	Less Concern
Paracerceis sculpta (Holmes, 1904)	15	Less Concern	*Diamysis lagunaris* Ariani & Wittmann, 2000	13	Less Concern	*Paracerceis sculpta* (Holmes, 1904)	15	Less Concern
Arcuatula senhousia (Benson, 1842)	15	Alert	*Ficopomatus enigmaticus* (Fauvel, 1923)	14	Top Priority	*Callinectes sapidus* Rathbun, 1896	15	Less Concern

Regardless of the weight given to the confidence score, top priorities appear consistent between the two methods in spite of some exceptions. There are 13 NIS classified as "top priority" in the 10 first ranks when 10% weight is given to the confidence score, 11 when the weight is 50% and 9 when the weight is 90%. There is overall less consistency between the two classifications when the confidence parameter weight is high (90%).

The comparison of NIS classified in the last ranks obtained with ELECTRE III and the HS exercise does not show major inconsistencies. Last ranks in ELECTRE III results are globally occupied by NIS classified in the group "Less concern" whatever the weight accorded to confidence.

We can therefore conclude that the HS and ELECTRE results are overall consistent in identifying species that are top priorities or of less concern, with some exceptions (see Appendix 1 for comparisons).

Individual discrepancies between results show that the way uncertainties (confidence score) are addressed in the prioritization scheme has an important effect**.** The main difference in this respect between the two methods is that ELECTRE always considers in our setting that uncertainty is an aggravating risk factor, whatever the level of risk, whereas in the HS exercise, the confidence level is associated to the overall score to yield the final risk classification, i.e, top priority, alert or less concern. Rather than being regarded as a concern, the discrepancies found for some species are an opportunity to have a second look with experts to confirm or modify their final recommendations for those same species.

Sensitivity tests for ELECTRE were also performed including confidence scores and by varying the preference, indifference and veto thresholds in realistic proportions (no extreme variation of thresholds). With a small variation of thresholds, the ranks obtained showed very little differences from the initial ranking results. This test confirms the robustness of the ELECTRE results.

Finally, we also compared the HS exercise with ELECTRE, only for the alternative 50% weight accorded to the confidence parameter for the top priorities in the AMA sub-region (Table 13).

Table 13. Comparison of the results obtained with ELECTRE III including uncertainty (with 50% weight accorded to the confidence parameter) with the HS results for the AMA sub-region.

Species	**Final rank (ELECTRE III)**	**HS results**
Botrylloides violaceus Oka, 1927	1	Top Priority
Plagusia depressa (Fabricius, 1775)	1	Alert
Styela clava Herdman, 1881	2	Top Priority
Sparus aurata Linnaeus, 1758	2	Alert
Sphaeroma serratum (Fabricius, 1787)	2	Alert
Botryllus schlosseri (Pallas, 1766)	3	Top Priority
Ectopleura crocea (Agassiz, 1862)	3	Alert
Macrorhynchia philippina Kirchenpauer, 1872	3	Alert
Clavelina dellavallei (Zirpolo, 1925)	3	Less Concern
Ciona intestinalis Linnaeus, 1767	4	Top Priority
Hydroides elegans (Haswell, 1883)	4	Top Priority
Eurythoe complanata (Pallas, 1766)	4	Less Concern
Phyllodoce mucosa Örsted, 1843	4	Less Concern
Polyandrocarpa zorritensis (Van Name, 1931)	5	Top Priority
Clavelina oblonga Herdman, 1880	5	Top Priority
Clavelina lepadiformis (Müller, 1776)	5	Less Concern
Diplosoma listerianum (Milne Edwards, 1841)	5	Less Concern
Styela plicata (Lesueur, 1823)	6	Top Priority
Tesseropora atlantica Newman & Ross, 1976	6	Alert
Sabella spallanzanii (Gmelin, 1791)	6	Less Concern
Microcosmus squamiger Michaelsen, 1927	7	Top Priority
Perforatus perforatus (Bruguière, 1789)	7	Alert
Aoroides longimerus Ren & Zheng, 1996	7	Alert
Branchiomma bairdi (McIntosh, 1885)	8	Alert
Branchiomma luctuosum (Grube, 1870)	8	Alert
Pilumnus spinifer H. Milne Edwards, 1834	8	Alert
Aplidium glabrum (Verrill, 1871)	8	Less Concern
Perophora viridis Verrill, 1871	8	Less Concern
Polyclinum aurantium Milne Edwards, 1841	8	Less Concern

Pyura tessellata (Forbes, 1848)	8	Less Concern
Botrylloides leachii (Savigny, 1816)	8	Less Concern
Austrominius modestus (Darwin, 1854)	9	Top Priority
Amphibalanus amphitrite (Darwin, 1854)	9	Top Priority
Exaiptasia diaphana (Rapp, 1829)	9	Top Priority
Spirorbis (Spirorbis) marioni Caullery & Mesnil, 1897	9	Alert
Cystodytes dellechiajei (Della Valle, 1877)	9	Alert
Jassa marmorata Holmes, 1905	9	Less Concern
Ficopomatus enigmaticus (Fauvel, 1923)	10	Top Priority
Caprella scaura Templeton, 1836	10	Less Concern
Paracerceis sculpta (Holmes, 1904)	10	Less Concern
Perinereis cultrifera (Grube, 1840)	10	Less Concern
Balanus trigonus Darwin, 1854	11	Top Priority
Kirchenpaueria halecioides (Alder, 1859)	11	Alert
Ligia oceanica (Linnaeus, 1767)	11	Alert
Monodactylus sebae (Cuvier, 1829)	11	Alert
Tanais dulongii (Audouin, 1826)	11	Less Concern
Ctenodrilus serratus (Schmidt, 1857)	11	Less Concern
Pennaria disticha Goldfuss, 1820	12	Alert
Obelia dichotoma (Linnaeus, 1758)	12	Alert
Alexandrium minutum Halim, 1960	12	Less Concern
Molgula plana Monniot C., 1971	13	Alert
Pomacanthus maculosus (Forsskål, 1775)	13	Alert
Prognathodes marcellae (Poll, 1950)	13	Alert
Pycnoclavella taureanensis Brunetti, 1991	13	Alert
Argyrosomus regius (Asso, 1801)	13	Alert
Dicentrarchus labrax (Linnaeus, 1758)	13	Alert
Amphibalanus eburneus (Gould, 1841)	13	Less Concern
Cephalopholis nigri (Günther, 1859)	14	Alert
Sphaeroma walkeri Stebbing, 1905	14	Less Concern

Ascidia interrupta Heller, 1878	14	Less Concern
Perophora listeri Wiegman, 1835	14	Less Concern
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	14	Less Concern
Tubularia indivisa Linnaeus, 1758	15	Alert
Botrylloides niger Herdman, 1886	15	Less Concern
Didemnum perlucidum Monniot F., 1983	15	Less Concern
Styela canopus (Savigny, 1816)	15	Less Concern
Symplegma brakenhielmi (Michaelsen, 1904)	15	Less Concern
Distaplia corolla Monniot F., 1974	16	Less Concern
Protula tubularia (Montagu, 1803)	16	Less Concern
Eudistoma angolanum (Michaelsen, 1914)	17	Less Concern
Pileolaria berkeleyana (Rioja, 1942)	17	Less Concern
Alloeocarpa loculosa Monniot C., 1974	18	Alert
Millepora alcicornis Linnaeus, 1758	19	Alert
Symplegma rubra Monniot C., 1972	19	Less Concern
Distaplia bermudensis Van Name, 1902	20	Less Concern
Distaplia magnilarva (Della Valle, 1881)	20	Less Concern

The same overall outcome as in the ABI sub-region appears to hold for the AMA sub-region; the comparison of results obtained with ELECTRE III and with the HS exercise does not show major inconsistencies. First ranks in ELECTRE III results are globally occupied by NIS classified in the groups “Top priority” or “Alert”, and the last ranks in ELECTRE III results are globally occupied by NIS classified in the group “Less concern”. Nevertheless, there are some discrepancies, namely some species that are classified in the group “Less concern” and obtained a high rank with ELECTRE III (e.g., *Clavelina dellavallei*). For those species, this could be an opportunity to have a second look with experts to confirm or modify their final recommendations.

Ranking results obtained with ELECTRE III and those obtained by the HS approach are generally coherent for the two sub-regions, ABI and AMA, whether uncertainty is considered or not through confidence scores, and confirm their robustness. Nevertheless, despite this coherence at a global level, the comparative analysis highlights a stark difference for some species, with some being considered top priority by one approach and not by the other. These differences show the importance of caution when results are used and interpreted and can point to species for which further expert analysis would be warranted.

Exposure Analysis

Identification of pathway activity hotspots

For the exposure assessment, it is important to identify the areas where new introductions (i.e., new records) are more likely to occur, such as marinas, ports, terminals and aquaculture facilities in order to target 'hotspots' for monitoring (assessment of D2C1 - number of newly introduced NIS). The first step in this process was the compilation of the number of ports, marinas, recreational ports and aquaculture facilities for each sub-region and Marine Reporting Unit (MRU) in each Member State (MS). Information regarding the main ports was retrieved from the European Marine Observation and Data Network (EMODnet). The quantity and spatial distribution of other port areas were examined and compiled from Keller et al. (2011), the port authorities' websites, and Google Satellite Images (Google, 2021). Data regarding the distribution of aquaculture facilities were acquired from different sources. Information for Portugal and Spain was obtained through reports and interactive maps published by the respective Governments. The distribution of the aquaculture facilities in France was retrieved from EMODnet services. This information is summarized in Table 14.

Table 14. Number of commercial ports, marinas, recreational ports and aquaculture facilities across ABI and AMA sub-regions.FR/BoB: France, Bay of Biscay MRU; ES/NA and SA: Spain, North Atlantic and South Atlantic MRUs and PT/A-NW, B-SW and C-S: Portugal, A - Northwest, B - Southwest and C - South MRUs.

MSFD Sub-region	**MS/MRU**	**Main ports [a]**	**Marinas and other commercial and recreational ports**	**Aquaculture facilities**
ABI	FR/BoB	4	59[b]	129[a]
ABI	ES/NA	11	60[b]	4829[e]
ABI	ES/SA	2	10[b]	57[e]
ABI	PT/A-NW	4	7[c]	93[c]
ABI	PT/B-SW	3	16[c]	87[c]
ABI	PT/C-S	2	11[c]	1090[c]
AMA	ES/Canary	2	36[d]	14[e]
AMA	PT/Azores	9	12[c]	2[c]
AMA	PT/Madeira	3	5[c]	2[c]

[a] *Retrieved from https://www.emodnet-humanactivities.eu/view-data.php*

[b] Keller et al. (2011)
[c] Retrieved from https://www.dgrm.mm.gov.pt/
[d] Retrieved from https://puertoscanarios.es
[e] Retrieved from https://servicio.pesca.mapama.es/acuivisor/

Shipping data were acquired from a freely available processed dataset downloaded from the EMODnet portal. The data came from Automatic Identification System (AIS) vessel tracking records and are provided as the average *ship hours per square km per month* (Falco et al. 2019). Overall, the dataset contains information of several vessel types including cargo, passenger, fishing, and recreational boats. For this project, we analysed AIS shipping data for the year 2017, which was the only dataset available at the time of analysis, though data for subsequent years have become available since that time. Specific shipping data gathered for each port area were retrieved from 2018. The geographical area for which the shipping data were considered was defined by the 200 m isobath in the ABI sub-region, which delimits the continental shelf (https://www.un.org/Depts/los/clcs_new/continental_shelf_description.htm).

The shipping density in the geographical assessment areas for both sub-regions is illustrated in Figure 4.

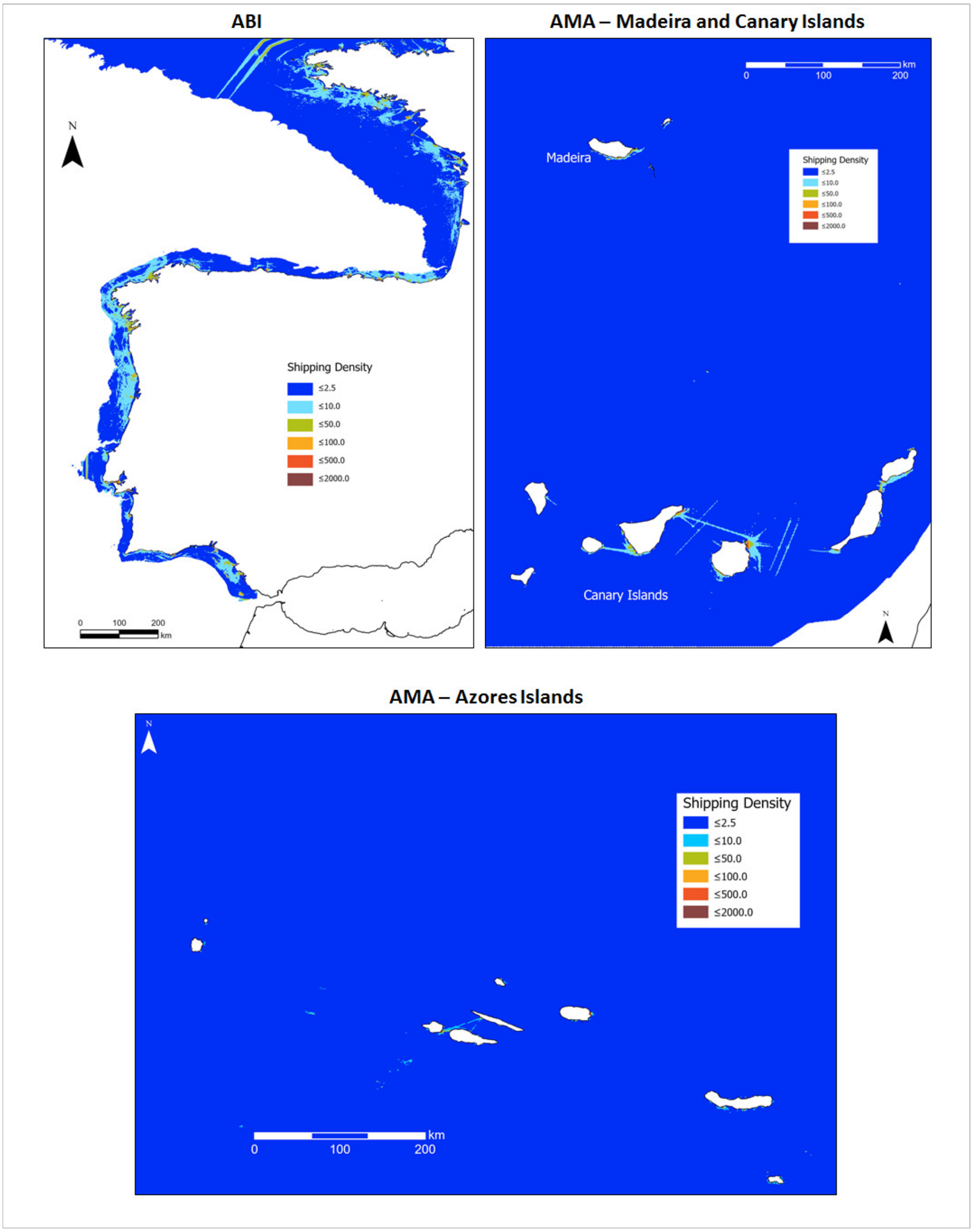
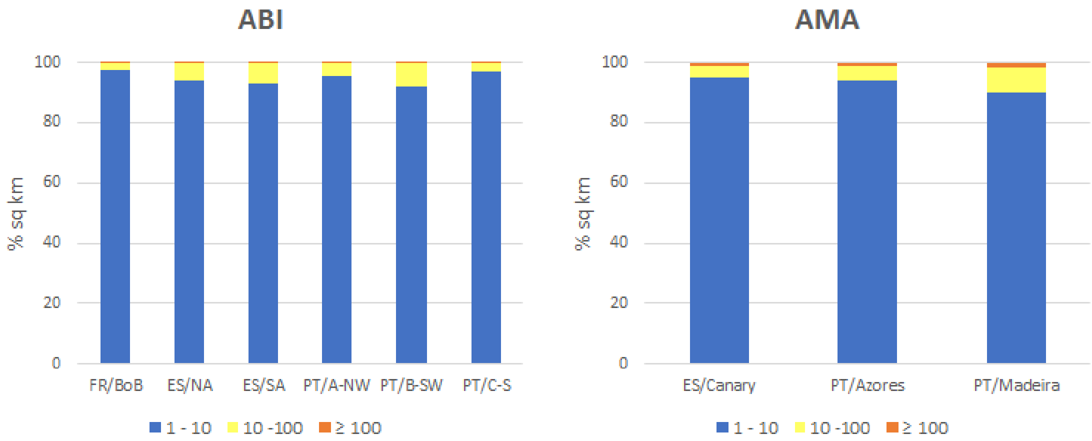


Figure 4. Map illustrating the shipping density data in ABI and AMA sub-regions.

A detailed analysis of the shipping dataset obtained for the year 2017 indicated that the majority of the ABI and AMA sub-regions has little or no shipping traffic (less than 1h of vessel density/km^2/month). Therefore, to better capture the differences between the two sub-regions, the areas where the shipping densities were lower than 1hr per month were removed from the analysis. The differences in the shipping densities across the MRUs within the ABI and AMA sub-regions are shown in Figure 5.



Total area ≥ 1h (km²)								
FR/BoB	ES/NA	ES/SA	PT/A-NW	PT/B-SW	PT/C-S	ES/Canary	PT/Azores	PT/Madeira
30.983	31.615	6.786	18.329	14.718	5.423	6.309	1.066	536

Figure 5. Distribution of the shipping density in ship hours categories for each MRU, within the ABI and AMA sub-regions (showing the data where the average shipping density was higher than one hr/km^2/month). The area analysed for each MRU is also shown. FR/BoB: France, Bay of Biscay MRU; ES/NA and SA: Spain, North Atlantic and South Atlantic MRUs and PT/A-NW, B-SW and C-S: Portugal, A - Northwest, B - Southwest and C - South MRUs.

To assess the location of pathway activity hotspots, the shipping density information was gathered for all port areas within each MRU, including commercial ports, marinas, recreational ports and terminals. The information retrieved corresponds to the highest average shipping density registered in one square kilometer per month within the port area in 2018. The list of all ports and associated geographical coordinates, as well as the vessel density data are provided in Supplementary Information (Table S2). The intensity of the shipping density (in ship hours categories) across the ports of each MRU of the ABI and AMA sub-regions is shown in Figure 6. In the ABI sub-region, ports of the Bay of Biscay (France) and the Iberian Coast (Spain North Atlantic - ES/NA and Portugal Southwest - PT/B-SW) display the highest shipping traffic, with respectively 32, 33 and 17 ports receiving over 500h//km^2/month. In the AMA sub-region, the busiest ports are in the Canary Islands, where the ship hours exceed 500h//km^2/month in 17 ports.

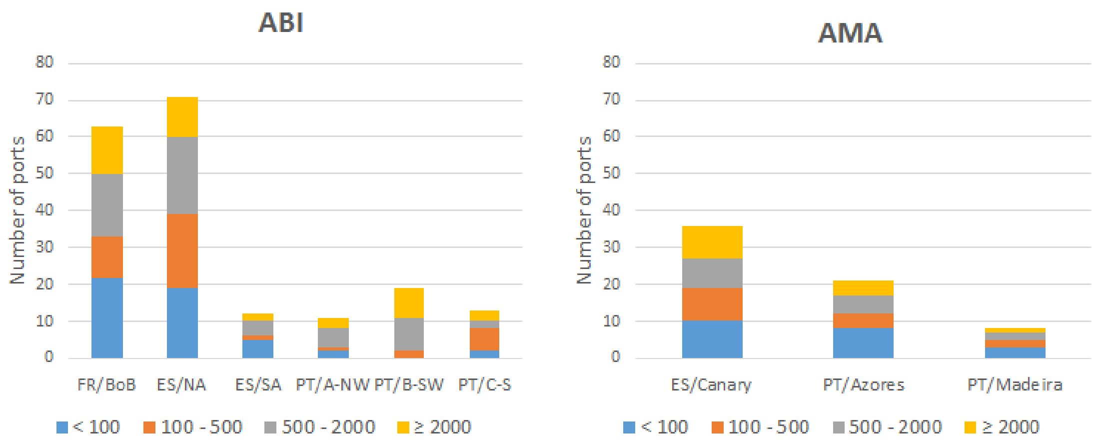


Figure 6. Distribution of the shipping density in ship hours categories for all ports of the MRUs in the ABI and AMA sub-regions (showing the data where the average shipping density was higher than one hr/km²/month). FR/BoB: France, Bay of Biscay MRU; ES/NA and SA: Spain, North Atlantic and South Atlantic MRUs and PT/A-NW, B-SW and C-S: Portugal, A - Northwest, B - Southwest and C - South MRUs.

The location of pathway activity hotspots was mapped for the ABI (Figure 7) and AMA sub-regions (Figure 8 and 9). The maps created for both sub-regions used GPS coordinates collected for all ports, marinas, recreational ports, as well as the location of aquaculture facilities retrieved from different websites (see Table 5). This information is also publicly available through interactive maps in the following websites: https://www.google.com/maps/d/edit?mid=1nVz_vt91OKphVqqARluEgiaecZRNBmNf&usp=sharing (ABI - Hotspots) and https://www.google.com/maps/d/edit?mid=10IBdnQ00644j1_ZhXBR- QkUYPu5T9tVN&usp=sharing (AMA - Hotspots), allowing viewers to assess shipping and aquaculture data in specific areas.

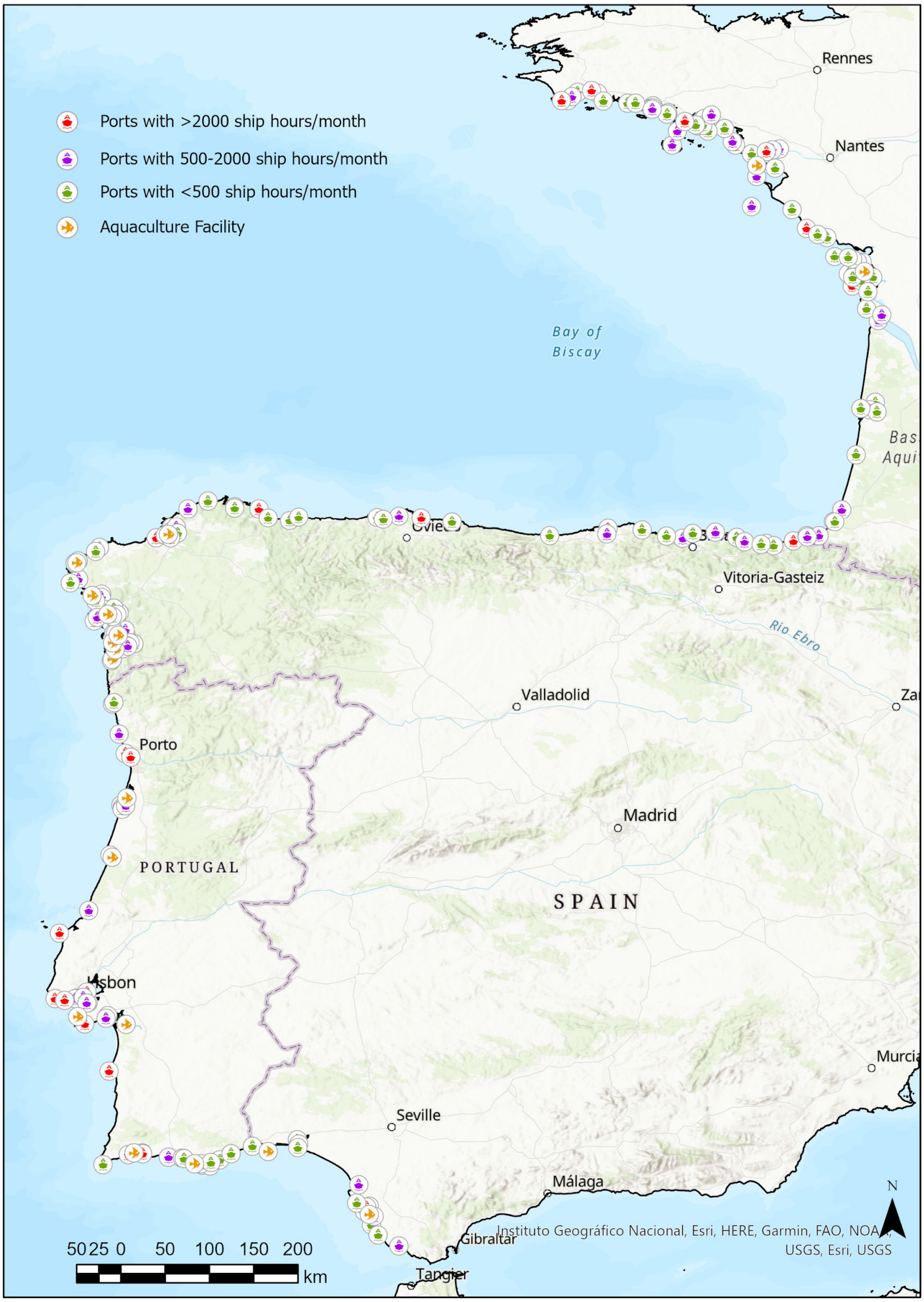


Figure 7. Pathway activity hotspots map illustrating shipping and aquaculture data retrieved for the ABI sub-region. Ship symbols were colour graded according to the average shipping hours they receive per km^2 per month. Ports receiving less than 500 hr/km^2/month are labeled in green, between 500 and 2000 hr/km^2/month are labelled in purple and ports receiving over 2000h are

labelled in red. The orange fish symbol represents the aquaculture areas including over 10 facilities.

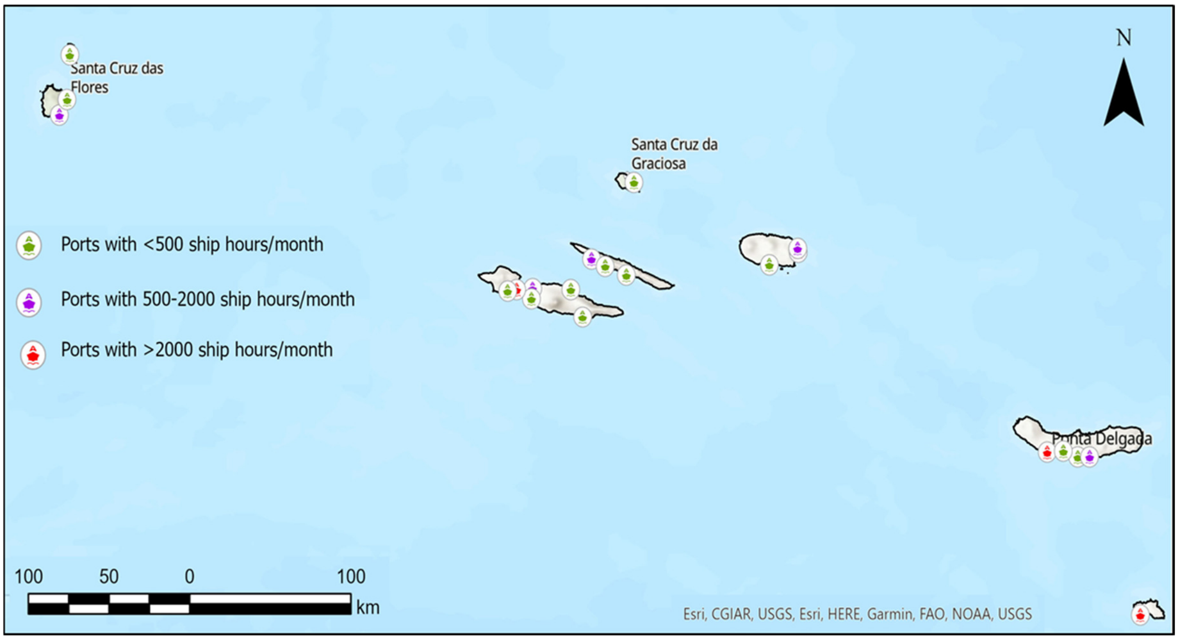


Figure 8. Pathway activity hotspots map illustrating shipping data retrieved for the PT/Azores MRU within the AMA sub-region. Ship symbols were colour graded according to the average shipping hours they receive per km^2 per month. Ports receiving less than 500 hr/km^2/month are labeled in green, between 500 and 2000 hr/km^2/month are labelled in purple and ports receiving over 2000 hr/km^2/month are labelled in red.

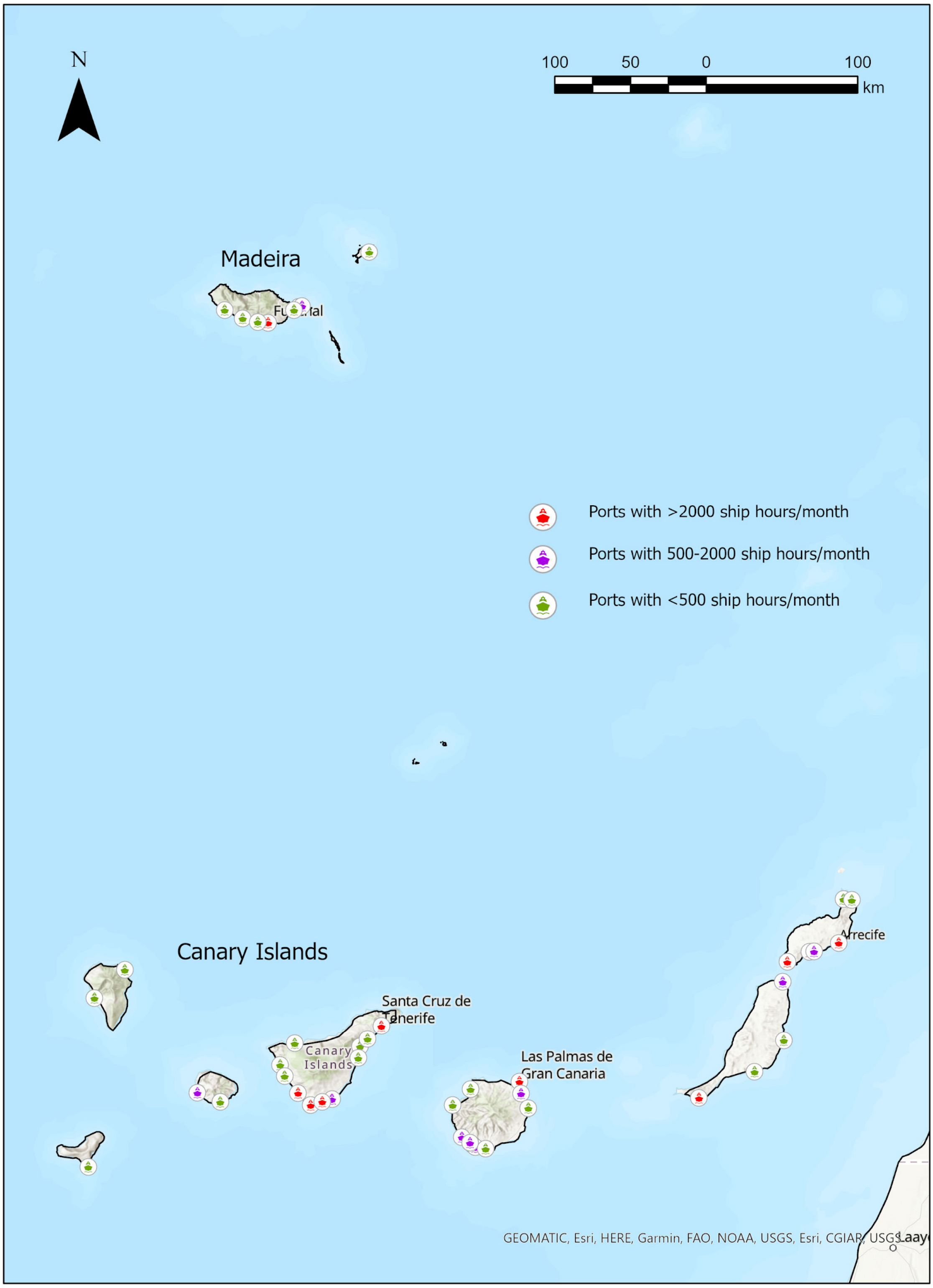


Figure 9. Pathway activity hotspots map illustrating shipping data retrieved for the PT/Madeira and ES/CanaryMRUs within AMA sub-region. Ship symbols were colour graded according to the average shipping hours they receive per km^2 per month. Ports receiving less than 500 $hr/km^2/month$ are labeled in green, between 500 and 2000 $hr/km^2/month$ are labelled in purple and ports receiving over 2000 $hr/km^2/month$ are labelled in red.

Among the 189 ports assessed in the ABI and the 69 ports assessed in the AMA, 98 and 29 ports respectively, receive over 500hr of shipping per km^2 per month. Regarding the aquaculture activities, the areas with the highest number of facilities in the ABI are located in the ES/NA MRU, mostly on the northwest coast of Spain (Galicia), where fish and shellfish farming are the main activities (FAO, 2017). In Portugal, the PT/C-S MRU displays the highest number of facilities located mainly in Ria Formosa, where the aquaculture production consists primarily of marine finfish and bivalves. The aquaculture activity in the AMA sub-region is associated with cage fish farming systems in the Canary and Madeira Archipelagos, while in the Azores this sector is in an early stage of research, development, and innovation (Png-Gonzalez et al. 2019). Due to the low number of aquaculture facilities in this sub-region, the aquaculture areas were not included as hotspots of introduction.

Risk Evaluation

The aim of the risk evaluation is to estimate the levels of risk (high, medium, low) associated with NIS and their introduction pathways. The risk of new introductions was assessed by estimating which NIS are more likely to be introduced based on their biological traits and probable introduction pathways. In the case of the HS approach, the information was obtained from the likelihood of introduction score [number of introduction pathways x (life cycle + reproductive rate)]. These scores can be graphed against the number of MRUs where NIS are established across the sub-region.

The information regarding the distribution of NIS allows us to assess how widespread the NIS are across the sub-regions. Figure 10 shows the number of NIS listed through the current HS, that are reported in one or more MRUs within the sub-region. It is possible to observe that a considerable number of NIS is reported as present in only one MRU. However, six NIS are found in all MRUs of the ABI, of which three are classified as top-priority (*Austrominius modestus, Amphibalanus amphitrite and Ruditapes philippinarum*; see Appendix 1). In the AMA sub-region, two top-priority NIS (*Botryllus schlosseri* and *Microcosmus squamiger*) are reported in the three MRUs.

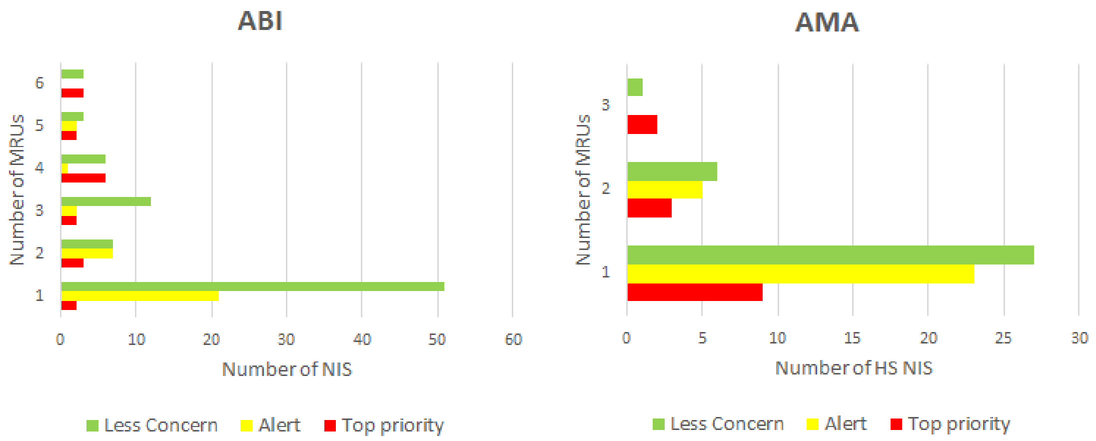


Figure 10. Number of MRUs, where NIS listed through the current HS and classified in different priority classes have been reported.

To assess the risk of introduction at national scale it is useful to distinguish between NIS already introduced in the MRUs within the sub-region and NIS currently absent but likely to arrive (Figure 11).

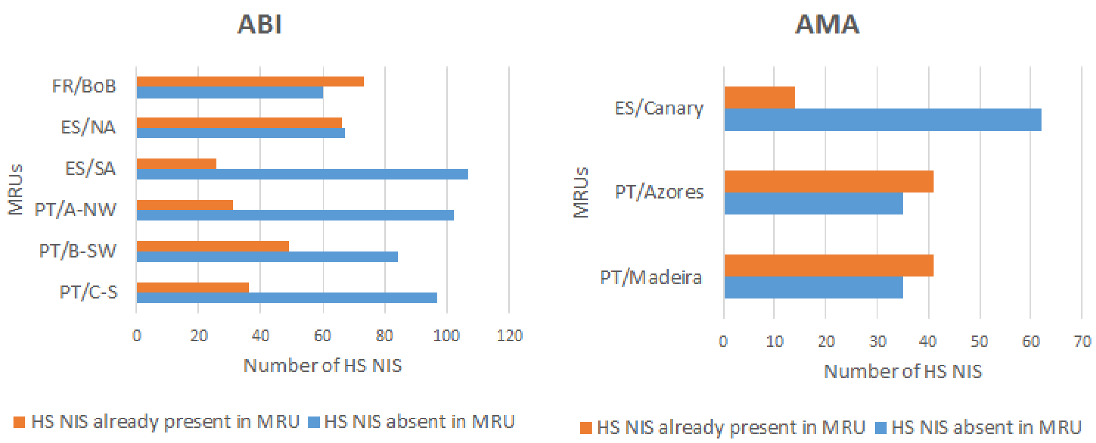


Figure 11. Number of NIS listed through the current Horizon Scanning, which are already introduced or still absent in each MRU.

A significant number of HS NIS are absent in four MRUs within the ABI, namely ES/SA (107), PT/A-NW (102), PT/C-S (97) and PT/B-SW (84), while in the AMA, the ES/Canary is the MRU with the highest number of HS NIS still absent but likely to arrive (62).

Moreover, the NIS population status within the sub-region (established, not established, and undetermined) should be taken into consideration, when assessing the level of risk of new introductions (Figure 12).

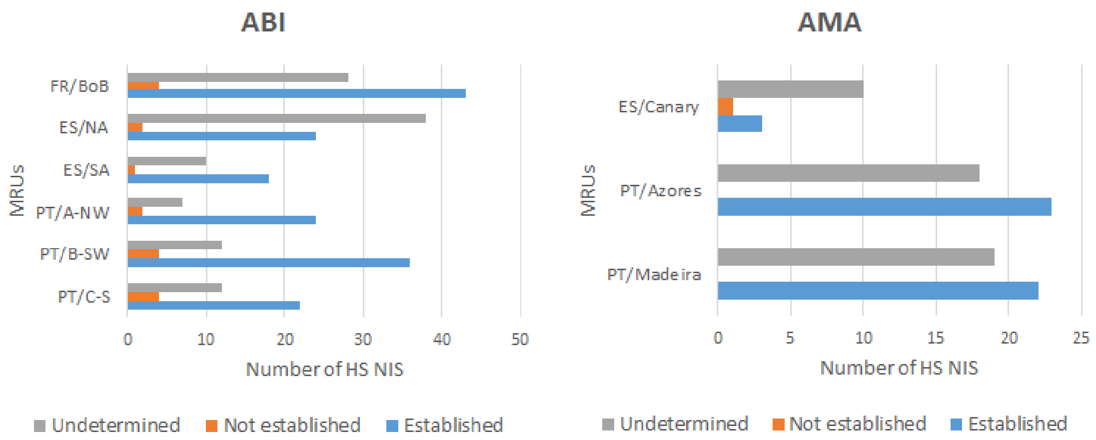


Figure 12. Number of HS NIS according to their population status in each MRU of the ABI and AMA sub-regions.

In the ABI, FR/BoB presents the highest number of established HS NIS (43), followed by PT/B-SW (36). In the AMA, the highest number of established HS NIS is found in the Portuguese archipelagos of Azores (23) and Madeira (22). It is worth noting the high proportion of NIS that have their population status undetermined, mostly in ABI FR/BoB and ES/NA MRUs, and in the three AMA MRUs, which suggests a significant lack of knowledge.

Risk evaluation - case studies

In order to illustrate how this methodology can be applied to different assessment areas, case studies were conducted for the MRUs of ABI and AMA. The HS results associated with the information on species spatial distribution allow us to identify which NIS are currently absent in each MRU. In addition, the information on NIS population status allows assessing which NIS are established, not established and undetermined in the sub-region (Appendix 1). For example, ten top priority NIS with established populations in the ABI were not found in the Portuguese Northwest MRU (PT/A-NW). Therefore, the HS approach provided a short list of NIS that can be prioritized for the risk of introduction. Out of the 18 top-priority NIS in the ABI, 11 were suitable to assess the risk of introduction. In the AMA, of the 14 top-priority NIS, 10 are suitable for the risk assessment.

A graphical representation of these data allows the assessor to identify the risk level associated with each HS NIS (Figures 13 - 18).

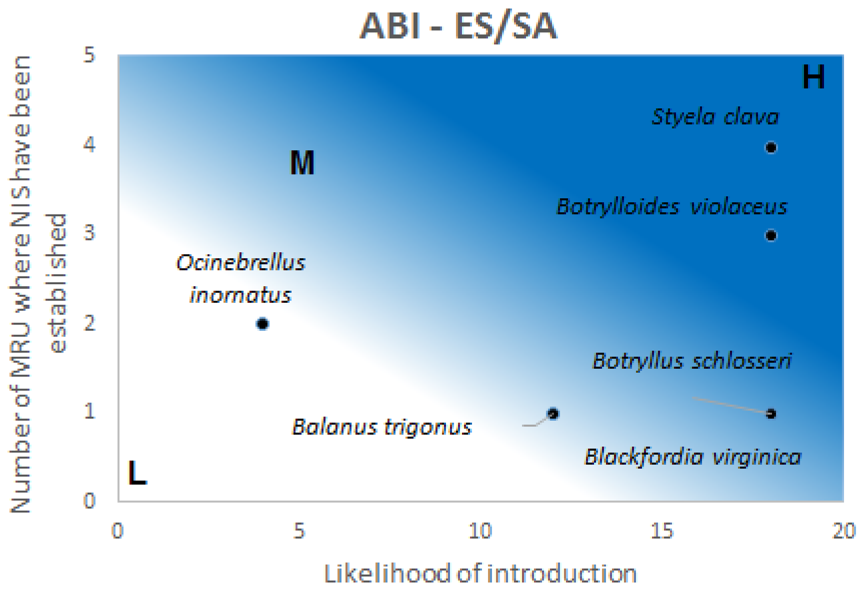


Figure 13. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the ES/SA MRU within the ABI can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

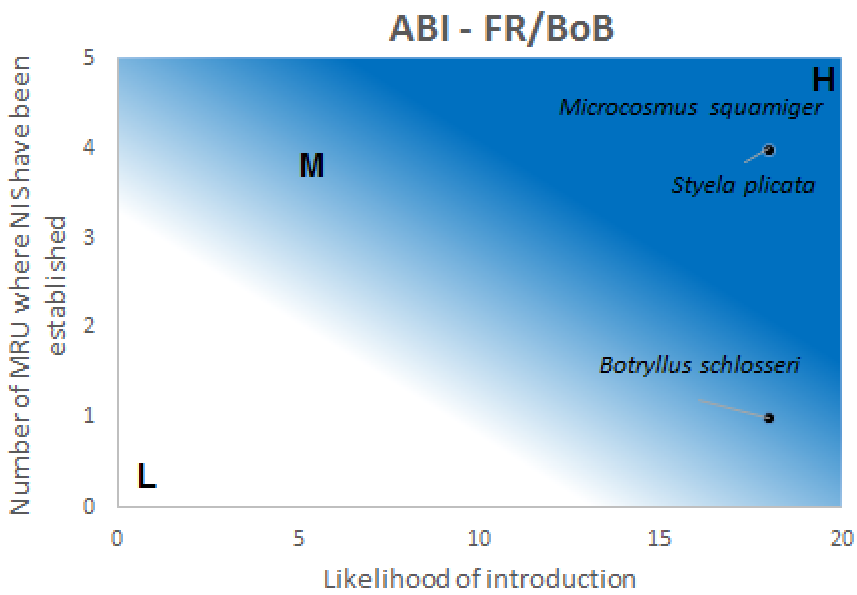


Figure 14. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the FR/BoB MRU within the ABI can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

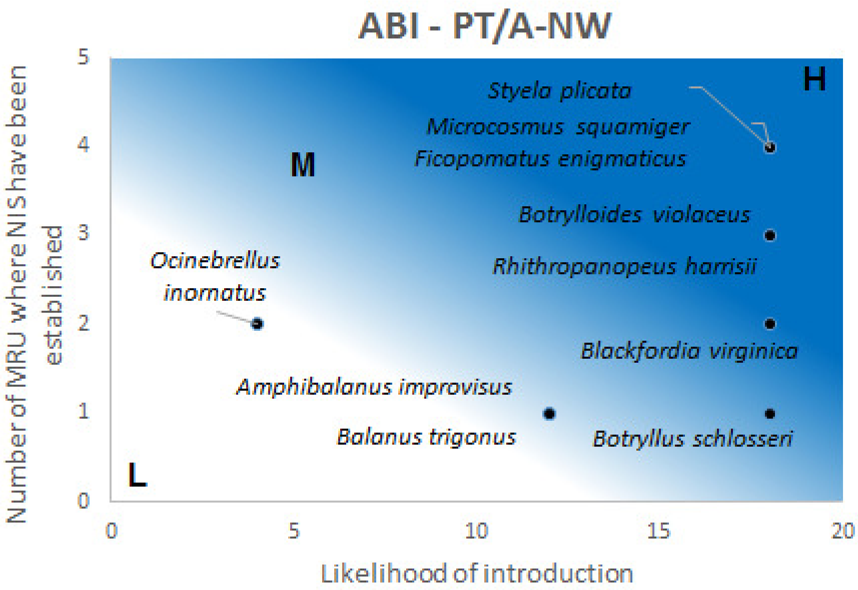


Figure 15. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the PT/A-NW MRU within the ABI can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

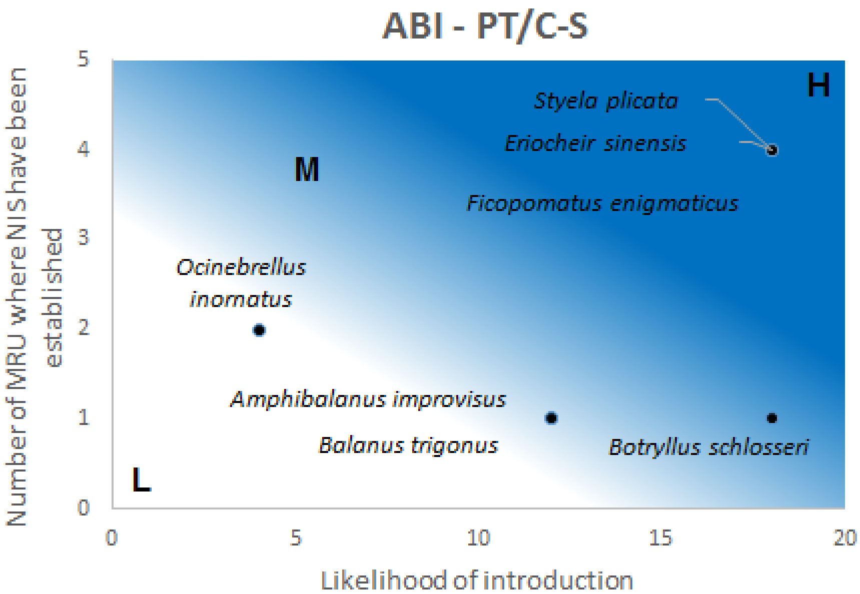


Figure 16. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the PT/C-S MRU within the ABI can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

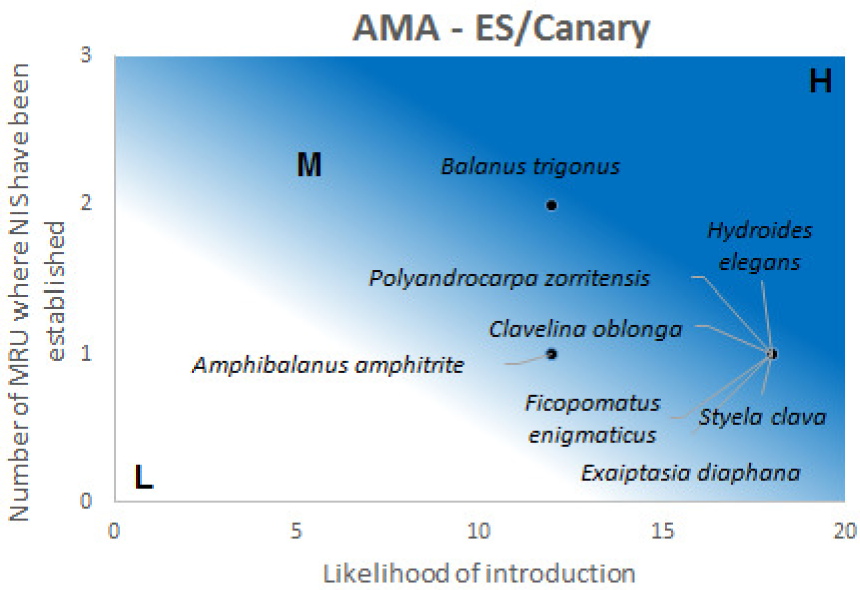


Figure 17. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the ES/Canary MRU within the AMA can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

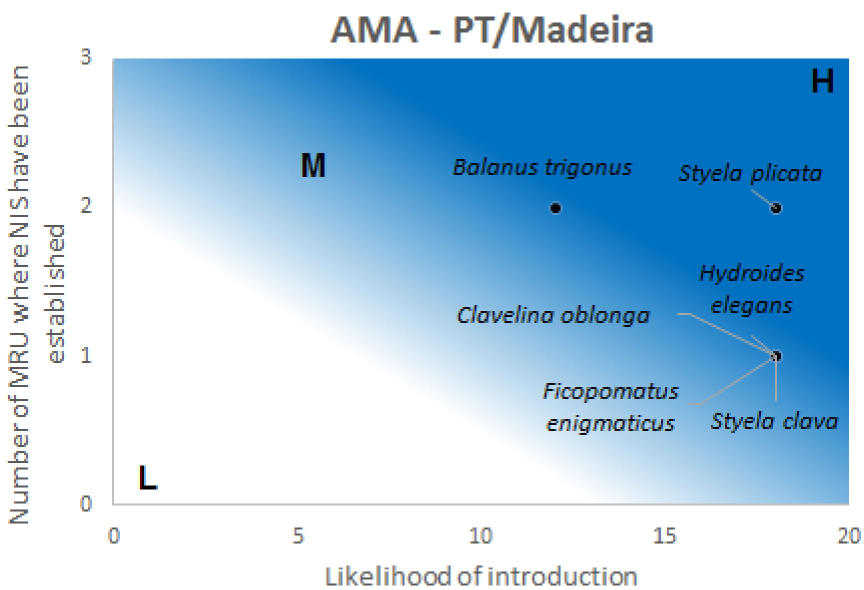


Figure 18. Case study illustrating how the results of the current Horizon Scanning and the spatial distribution of established NIS in the PT/Madeira MRU within the AMA can be graphed to assist risk evaluation. L: Low risk; M: Medium risk; H: High risk.

It should be noted that specific thresholds for the categorization of risk were not defined and the colour shades were added to the figures solely as an example. Also, the risk evaluation was not performed for ES/NA, since no top priority NIS with established populations in the ABI, were identified as absent in this MRU. Similarly, graphs were not shown for PT/B-SW and PT/Azores, as just one NIS classified as top priority was reported to be absent in these MRUs. *Ciona robusta*, ranked at the top in the ABI list, has an unknown pathway of introduction, and therefore, was not included in the analysis.

Other relevant information can be incorporated into the risk evaluation by the assessor, as appropriate. For instance, the presence of established NIS in the neighbouring MRUs might contribute to an increased risk. One example is represented by the NIS *Botrylloides violaceus*, absent in ES/SA and reported in the PT/C-S MRU.

Furthermore, the information about the probable introduction pathways (ballast water, fouling and aquaculture) may be useful in the development of prevention plans. For instance, among the NIS most easily managed at the pre-border stages are species introduced by aquaculture activities (Minchin, 2014). All NIS identified in these case studies are associated with at least two introduction pathways with the exception being *Ocinebrellus inornatus,* which is associated with aquaculture and *Balanus trigonus*, associated with fouling. This information can be found in Appendix 1.

In this study, the major pathways identified as key in the introduction of NIS into the ABI and AMA sub-regions were maritime transport (ballast waters and fouling) and aquaculture activities (Bartilotti et al. 2020a). The intensity of pathway activity is represented in a multivariable chart, where the proportion of ports (including commercial ports, marinas, recreational ports and terminals), displaying shipping densities over 500h/km^2/month were plotted against the number of established NIS in each MRU. The number of aquaculture facilities in each MRU is illustrated by the size of the circle (Figure 19).

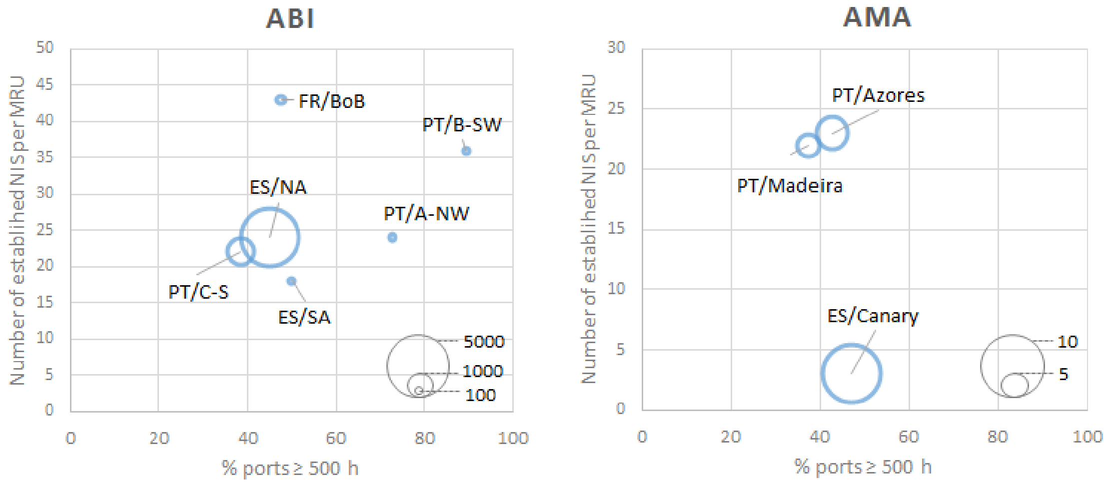


Figure 19. Graphs illustrating how the results of the intensity of the pathway activity versus the number of established NIS per MRU can be mapped to assist the risk evaluation. The size of the circle is proportional to the number of aquaculture facilities in each MRU.

In the ABI sub-region, 17 out of the 19 ports of the PT/B-SW MRU display high shipping traffic, where the number of ship hours per km^2 per month was over 500. This MRU has a significant number of established NIS in comparison with most of the MRUs within the ABI. In the AMA sub-region, it is possible to observe that the ES/Canary MRU has the highest proportion of busiest ports and aquaculture facilities. However, this MRU has the lowest number of established NIS reported in the sub-region.

The risk evaluation associated with the intensity of pathway activity should ideally combine information acquired from shipping data and aquaculture facilities. However, considering the differences in the number of aquaculture facilities reported for each MRU, the graphical representation of this information would underestimate the risk in most areas. For instance, aquaculture data indicate 4829 facilities in the ES/NA MRU and 1090 in the PT/C-S MRU, while the remaining areas have less than 129 (see Table 5). These charts, therefore, enable the instant visualization of the risk associated with aquaculture activities, while allowing assessors to evaluate the relative risk of introduction across the MRUs of the sub-region. Nonetheless, assessors should refer to the maps created for ABI and AMA sub-regions in order to gather more accurate information regarding the areas at higher risk of introduction.

Final remarks and recommendations

In this report, we demonstrated the application of the Risk Based Approach (RBA) developed by RAGES to non-indigenous species (D2). The scope of the RBA was the ABI and AMA sub-regions, with particular focus on their MRUs. To perform the risk assessment, we worked through the main steps set out in D3.3 (Bartilotti et al. 2020c) in order to assess the risk levels associated with NIS and their introduction pathways. As such, the main outputs of this work were: (1) the development of a Horizon-Scanning approach to identify NIS that should be of high priority for risk assessment, combining species biological traits and information on previously known negative environmental and socioeconomic impacts and (2) identification of areas at higher risk of NIS introduction, through the assessment of shipping density in coastal areas and the distribution of aquaculture facilities.

Development of the horizon scanning approach

The HS approach developed here attempts to meet the proposed recommendations set out for risk assessments of NIS (Roy et al. 2018). A range of attributes, including compilation of data on the biological traits of NIS, invasion history and distribution range, and characteristics relevant to the invasion process such as likelihood of introduction, establishment, spread and potential environmental and socioeconomic adverse impacts, were considered in this framework. In this sense, this work benefited from a comprehensive NIS reference base compiled in D3.1 (Bartilotti et al. 2020a). The NIS data included their distribution (native and introduced), population status, probable pathways of introduction, socioeconomic and environmental impacts, life cycle, EASIN check and other references, such as peer-reviewed literature, scientific-technical reports and quality assurance databases, therefore, allowing participants to have rapid access to the relevant information they needed for the HS exercise (i.e., NIS scoring). These data were later proven very useful, as the exercise could be nearly completed by any trained assessor with access to the reference base, reducing the need for expert elicitation at this initial phase. Indeed, engaging the participation of experts on NIS scoring was a challenging task. Despite the changes made to the spreadsheet template to improve clarity and the time spent in the process, the combination of a structured evidence-based approach through the involvement of a panel of experts at the end of the process was considered the best option to perform the HS exercise. However, it could not be performed in this current exercise, as previously explained (short time available to assemble a panel of experts). To ensure the application of this methodology, it is essential that Member States undertake a regular review and report of NIS data. Moreover, clear guidance on best practices to follow when convening a panel of experts is still a pressing need toward a more effective approach.

Ultimately, the HS exercise included relevant scoring criteria associated with the invasion process history coupled with confidence levels to increase the reliability of judgments, following recommendations to improve transparency in the risk assessments

(Mastrandea et al. 2011; Mathews et al. 2017). The NIS scoring revealed a good level of consistency among assessors, which is expected in protocols with three score levels, compared to those with five or more levels (Gonzalez-Moreno et al. 2019). Despite that, a few inconsistencies between risk classifications were found for a subset of NIS. Most differences were easily solved through the revision of the NIS data (base of reference provided in D3.1) and literature review. However, it was observed that the system failed to prioritize four NIS in the ABI sub-region, all with known high negative environmental and socioeconomic impacts. That is the case of *Ocinebrellus inornatus, Callinectes sapidus*, *Palaemon macrodactylus* and *Ciona intestinalis,* whose risk classification was underestimated. *C. sapidus*, *O. inortatus* and *P. macrodactylus* have in common a single probable introduction pathway, which translates into a score of 1 (lower risk scenario) and *C. intestinalis* has an unknown introduction vector (score = 2). In this framework, the introduction pathway score and the impact scores (environmental + socioeconomic) are multiplied to yield the overall score, while the remaining scores are additives (Bartilotti et al. 2020c). Therefore, the introduction pathway score combined with other low-risk scores led to an overall score below the cut-off value (mean value set to 140), with high confidence level, ranking the species as 'Less concern'. These results point out some of the difficulties surrounding the definition of cut-off values in semi-quantitative approaches, where slightly different judgements of available data can lead to different risk outcomes. This issue, however, remains to be tackled and further research is still required on this topic (Verbrugge et al. 2012).

Similarly, the definition of the guidelines to score potential environmental and socioeconomic impacts was acknowledged as difficult. The current approach proposes the assessment of the potential impacts based on the previous documented adverse effects reported for NIS, as the assessment of the magnitude of the impacts, i.e., levels of impacts from minimal to massive, can be very hard to estimate. The shortfall of this approach would be in turn the underestimation of the risk of NIS assigned to a single negative impact, which could be rather massive. Moreover, we adopted a more conservative approach, whereby only the potential negative impacts were considered in the HS exercise, as in general this information is crucial to inform decision makers of the potential risks. However, the prioritization of the Manila clam, *Ruditapes philippinarum* in the HS, triggered a few discussions on whether positive impacts should be considered in the HS exercises. This NIS is acknowledged by its socioeconomic benefits, being an important cultivated species in Spain (Apromar, 2020) and France (Flassch & Leborgne, 1994), and intensively harvested in Portugal (Maia et al. 2014, Moura et al. 2017). Indeed, the European Union legislation aiming at the prevention of introduction and spread of invasive species (Regulation 1143/2014, Art. 5, 1) states that risk assessments should include "a description of the known uses for the species and social and economic benefits deriving from those uses". This information was compiled and reported in D.3.1 (Bartilotti et al. 2020a) and should be made available to decision-makers when they are balancing the outcome of the risk assessment of adverse impacts against social and economic benefits (Roy et al. 2018, Verbrugge et al. 2019). It is important to note that while impacts on biodiversity and ecosystem services are recommended to be the core focus of a Horizon Scanning exercise, there is still a lack of information to allow for a scientifically well-informed assessment (Roy et al. 2019).

The difficulties concerning the treatment of the uncertainties, mostly related to the interpretation of data deficiencies (i.e., unknown or insufficient information) were also observed in the HS and ELECTRE III results. In the ELECTRE method, the lack of information, when uncertainty is included in the analysis, is considered an aggravating factor, which may lead to the overestimation of the threat posed by data deficient species. One example is represented by the data-deficient NIS *Plagusia depressa,* ranked at the top in AMA. On the other hand, data-deficient species may be underestimated in the HS approach as is the case of *Brachynotus sexdentatus* classified as "Less concern" in the ABI, which lacks information for five of the eight risk categories. In both cases, the risk classification cannot be reliably addressed due to the lack of information. These results pinpoint the need to improve clarity and transparency regarding the proportion of existing knowledge gaps for each species.

Another issue was the inclusion of oligohaline species. In the French Bay of Biscay MRU *Corbicula fluminea* and *Procambarus clarkii* were not considered in the D2 assessment since they occur exclusively in their inland systems (Bartilotti et al. 2020b). However, these oligohaline species can be found also in transitional waters, with records reported in other MS (e.g., Gutiérrez-Yurrita et al. 1999, Ilarri et al. 2014). For this reason, these NIS were considered in the final HS NIS list.

These limitations highlight the importance of expert-elicitation and consensus building approaches to derive final decisions on the top-priority NIS, and with precautionary approaches applied when deemed appropriate (Roy et al. 2015, Gonzalez-Moreno et al. 2019).

Assessment of the risk of introduction

The application of the RBA was focused on the assessment of the risk of introduction associated with NIS and their introduction pathways. To this end, the risk levels were estimated by assessing which NIS are more likely to be introduced based on their biological traits and introduction pathways. Additionally, information regarding areas where a higher number of established NIS have been reported combined with the intensity of the pathway activity were used to spot areas at higher risk of new introductions. These results will aid the risk management of NIS in the marine environment through the following decision tools:

- List of ranked NIS associated with their distribution, population status and probable pathways of introduction, providing components to identify those to target for early prevention efforts. Combining the ranked list of NIS and their distribution across the MRUs, areas at higher risk of introduction for specific NIS might be identified. Also, the risk assessment can be extended in various ways. For instance, when assessing the risk of new NIS incursions, assessors may consider the presence of NIS in neighboring locations and the bioclimatic similarities (e.g., salinity and temperature) between the current distribution of NIS and possible points of entrance. Moreover, depending on the management objectives (e.g., risk of establishment), the information on NIS population status can be used for targeting those NIS reported as not established or with undetermined population status.

- Map of the coastal areas at higher risk of new NIS introductions. Combining the information on shipping densities and the distribution of aquaculture facilities with the number of NIS established in the area, assessors might identify the susceptible areas to new NIS incursions. The pressure maps can be promptly used to inform surveillance and monitoring of the introduction pathways in those areas.

The pathway assessment proposed in this work enables the visualization of hotspots of introduction and the assessment of the relative risks across the MRUs within the sub-region. However, a more comprehensive analysis is required to better understand the risk associated with shipping traffic. Further work should distinguish the shipping densities between different types of vessels (e.g., commercial shipping, recreational boats), in order to identify those ships carrying ballast water systems. Furthermore, the discrimination of vessels operating in international voyages from those vessels transiting exclusively within MS borders, i.e., coastal domestic vessels, will provide relevant information to assess the risks of new NIS arrivals (Chan et al. 2011, Tidbury et al. 2015). For instance, commercial ships exhibit a high degree of variation in ballast water operations that affect both the quantity and quality of propagule supply, i.e density or total number of organisms or vegetative structures capable to establish self-sustaining populations. This may vary as a function of the type of vessel and its ballast discharge procedures, the source region, or the duration of the voyage (Verling et al. 2005). Moreover, the characterization of the propagule supply may influence the definition of management strategies, since the "International Convention for the Control and Management of Ships' Ballast Water and Sediments", entered into force in 2017, establishing the maximum quantity of organisms that can be discharged from ballast tanks (IMO, 2004).

In addition, similar vessel densities found between commercial and recreational ports and marinas may affect the perception of risks. Commercial shipping can provide more opportunities for NIS introductions, through ballast water and hull fouling pathways. Yet, similar vessel densities may occur in recreational ports also. For example, one of the highest vessel densities (near 10000 hr/km^2/month) was observed in Cascais marina on the southwest coast of Portugal (PT/B-SW), while close values (9000 hr/km^2/month) are observed in the port of Leixões, one of the main commercial ports located on the northwest coast of Portugal (PT/A-NW). For this reason, the risk posed by recreational boats should not be overlooked. This activity represents one of the major pathways contributing to NIS introductions, as recreational boats can travel long distances and their low speed make them suitable for fouling species (Minchin, 2006, Murray et al. 2011). Moreover, the risk of NIS introduction and establishment can be increased by recreational boats, due to mooring time at the marinas (Murray et al. 2011). Recreational boats have been implicated in the introduction of several species such as algae, mussels, barnacles and ascidians (Murray et al. 2011, Ulman et al. 2018). For example, the solitary ascidian *Styela clava* and the colonial ascidians *Botryllus schlosseri* and *Botrylloides violaceus*, which are among the top-priority NIS identified in this work, were the most observed NIS in marina surveys conducted by Murray et al. (2011).

To assess the risk associated with aquaculture, we aimed to quantify the number of facilities in the coastal areas of both sub-regions. The information retrieved corresponds to the number of culture systems established in the area, such as culture ponds, tanks and floats. This facilitates the identification of areas where the intensity of the aquaculture pathway is likely to be high. However, a proper evaluation of the risks associated with aquaculture activities requires a better understanding of routine movements and trading patterns between facilities, which can be assessed, for example, through the number of imports (Tidbury et al. 2015, Grosholz et al. 2015). For instance, bivalve culture, the main marine aquaculture activity in France, Spain and Portugal, is frequently dependent on imported seeds (FAO, 2017). The unintentional introduction of the Chinese mitten crab *Eriocheir sinensis*, and the Japanese oyster drill *Ocinebrellus inortatus*, for example, have been associated with the contamination of imported aquaculture stocks (Afonso, 2011, Minchin, 2014, Grosholz et al. 2015). Also, the importation of the Pacific cupped oyster *Magallana gigas* and the Manila clam *Ruditapes philippinarum* for farming purposes, were deemed responsible for the introduction of the largest number of NIS in Europe, including invertebrates and algae, often attached to packaging material, fouling the shells, or parasitizing bivalve tissues (Savini et al. 2010).

Unlike the other pathways, aquaculture can be more effectively controlled at pre-border and border stages (Minchin, 2014). These capacities are underpinned by legislation. At EU level, the aquaculture Regulation provides an example of a continuum of prevention, monitoring and response obligations linked to intentional introductions via this activity (Shine et al. 2010). It is important, however, that MS enforce routine border inspections and ensure that all appropriate measures (including relevant monitoring) are put in place to prevent new NIS introductions via this pathway. Moreover, the implementation of measures to prevent escapes or accidental releases are also important to reduce the risk associated with NIS (Png-Gonzalez et al. 2019).

It is important to highlight that a considerable number of NIS is not reported in EASIN, particularly in the AMA sub-region, indicating that efforts must be made to update this database on a regular basis, considering its legal competencies regarding the information and data on alien species in the framework of the European Union policies on biodiversity. Indeed, studies have shown that due to gaps in information systems, MS must make decisions using risk assessments built on limited data and information, leading to the application of the precautionary principle in the light of scientific uncertainty (Shine et al. 2010). These gaps need to be addressed by future research in order to strengthen and harmonize the risk assessment protocols among EU Member States. Robust and reliable information regarding NIS and their introduction pathways are critical to support decision-making and to ensure that resources and investments in prevention and early detection are allocated appropriately. Therefore, the regular review and refinement of NIS data as well as the regular assessment of the arrival pathways and their activity patterns (maximum time required of 6 years, following Article 17 of the MSFD for the updating of the marine strategies by each MS), will contribute towards more effective prevention plans and measures. Furthermore, efforts should be made by all EU Member States, to make this information readily accessible to risk managers in an efficient and structured manner.

It is important to note that the NIS data used for this study correspond to the compiled information collated and reported by December 2017 under the framework of the MSFD. The shipping data was acquired in the same year, corresponding to the most recent and complete available information by the time the project commenced. However, further information on shipping density for specific ports was retrieved in 2018. Considering the growing expansion of human activities in the marine environment, which are likely to affect trade and transport movements within the EU, new data must be incorporated to improve the accuracy of the risk assessment. This will allow for an optimization of monitoring efforts, in order to effectively prevent new NIS introductions.

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Appendix 1- Ranked list of NIS for the ABI and AMA sub-regions

Ranking results for a subset of NIS evaluated through the current Horizon-Scanning for the sub-region of Bay of Biscay and the Iberian Coast (ABI) and their associated overall scores, overall confidence level and classification. The distribution and population status of NIS by Member State (MS) and Marine Reporting Unit (MRU) and the probable introduction pathways are also shown. NIS with known adverse effects are shown in bold black and those with high impacts reported in EASIN are in bold red.. The classifications adjusted according to the revision are highlighted in red and yellow under the "Classification" column. Population status: E - Established; NE - Not Established; U – Undetermined. Introduction pathways: A – Aquaculture; B - Ballast water; F – Fouling; U - Unknown.

Phylum	Class	Species	Overall score	Overall confidence level	Classification	Population status						Probable introduction pathways
						FR	ES		PT			
						BoB	NA	SA	A-NW	B-SW	C-S	
Chordata	Ascidiacea	***Botrylloides violaceus*** **Oka, 1927**	270	High	Top Priority	E	U			E	E	A,F
Arthropoda	Malacostraca	***Rhithropanopeus harrisii*** **(Gould, 1841)**	270	High	Top Priority	U	U	E		E	E	A, B, F
Arthropoda	Malacostraca	***Eriocheir sinensis*** **H. Milne Edwards, 1853**	270	High	Top Priority	E	U	E	E	E		A, B, F
Arthropoda	Hexanauplia	***Austrominius modestus*** **(Darwin, 1854)**	234	High	Top Priority	E	E	U	E	E	NE	B, F
Arthropoda	Hexanauplia	***Amphibalanus amphitrite*** **(Darwin, 1854)**	234	High	Top Priority	U	E	E	E	E	E	A, B, F
Arthropoda	Hexanauplia	***Amphibalanus improvisus*** **(Darwin, 1854)**	234	High	Top Priority	U	E	U				A, B, F
Arthropoda	Hexanauplia	***Megabalanus tintinnabulum*** **(Linnaeus, 1758)**	234	High	Top Priority	U				U		B, F
Chordata	Ascidiacea	***Botryllus schlosseri*** **(Pallas, 1766)**	180	High	Top Priority		U			E		A, B, F
Chordata	Ascidiacea	***Styela clava*** **Herdman, 1881**	180	High	Top Priority	E	E		E	E		A, B, F
Cnidaria	Hydrozoa	***Blackfordia virginica*** **Mayer, 1910**	180	High	Top Priority	U	U	U		E	NE	B, F
Mollusca	Bivalvia	***Ruditapes philippinarum*** **(Adams & Reeve, 1850)**	180	High	Top Priority	E	E	E	E	E	NE	A
Chordata	Ascidiacea	***Ciona robusta*** **Hoshino & Tokioka, 1967**	156	High	Top Priority	E						U
Chordata	Ascidiacea	***Didemnum vexillum*** **Kott, 2002**	156	High	Top Priority	U	U				U	B, F
Chordata	Ascidiacea	***Microcosmus squamiger*** **Michaelsen, 1927**	156	High	Top Priority		E	E		E	E	B, F
Chordata	Ascidiacea	***Styela plicata*** **(Lesueur, 1823)**	156	High	Top Priority		E	E		E	E	B, F

Arthropoda	Hexanauplia	***Balanus trigonus* Darwin, 1854**	156	High	Top Priority	U	U			E		F
Annelida	Polychaeta	***Ficopomatus enigmaticus* (Fauvel, 1923)**	156	High	Top Priority	E	E	E		E		A, B, F
Annelida	Polychaeta	***Hydroides dianthus* (Verrill, 1873)**	156	Medium	Alert	U						A, B, F
Cnidaria	Hydrozoa	***Cordylophora caspia* (Pallas, 1771)**	156	Medium	Alert	E		E		E	NE	B, F
Cnidaria	Anthozoa	*Diadumene cincta* Stephenson, 1925	132	Medium	Alert	E						U
Arthropoda	Malacostraca	*Synidotea laticauda* Benedict, 1897	108	Medium	Alert	E		E			U	B, F
Cnidaria	Anthozoa	*Asclerocheilus ashworthi* Blake, 1981	104	Medium	Alert	U						U
Arthropoda	Malacostraca	***Exaiptasia diaphana* (Rapp, 1829)**	104	Medium	Alert	E	E					U
Cnidaria	Hydrozoa	*Nemopsis bachei* L. Agassiz, 1849	90	Medium	Alert	E						U
Cnidaria	Hydrozoa	*Eucheilota menoni Kramp, 1959*	90	Medium	Alert		U					B, F
Arthropoda	Malacostraca	***Monocorophium sextonae* (Crawford, 1937)**	81	Medium	Alert	E	U					U
Arthropoda	Malacostraca	*Dyspanopeus sayi* (Smith, 1869)	78	Medium	Alert	U						U
Cnidaria	Hydrozoa	***Gonionemus vertens* A. Agassiz, 1862**	78	Medium	Alert	E				U		A, B, F
Cnidaria	Hydrozoa	***Maeotias marginata* (Modeer, 1791)**	78	Medium	Alert	E					U	B, F
Arthropoda	Malacostraca	*Ianiropsis serricaudis* Gurjanova, 1936	72	Medium	Alert	U						U
Arthropoda	Malacostraca	***Monocorophium acherusicum* (Costa, 1853)**	66	Medium	Alert		NE					U
Annelida	Polychaeta	***Hemigrapsus takanoi* Asakura & Watanabe, 2005**	65	Medium	Alert	U	U					B
Cnidaria	Hydrozoa	*Clytia linearis* (Thorneley, 1900)	60	Low	Alert		E					B, F
Cnidaria	Hydrozoa	***Hydroides ezoensis* Okuda, 1934**	52	Medium	Alert	E		E		E	E	A
Chordata	Ascidiacea	*Asterocarpa humilis* (Heller, 1878)	52	Medium	Alert	E						U
Mollusca	Bivalvia	***Arcuatula senhousia* (Benson, 1842)**	44	Medium	Alert	E			U	U		A
Arthropoda	Malacostraca	*Limnoria tripunctata* Menzies, 1951	44	Medium	Alert					U	U	F
Arthropoda	Malacostraca	***Caprella mutica* Schurin, 1935**	39	Medium	Alert		U					F
Arthropoda	Malacostraca	***Penaeus japonicus* Spence Bate, 1888**	30	Medium	Alert	U			E	E		A
Arthropoda	Malacostraca	*Limnoria quadripunctata* Holthuis, 1949	27	Medium	Alert				NE			F
Cnidaria	Hydrozoa	*Filellum serratum* (Clarke, 1879)	26	Low	Alert		U					B

Arthropoda	Malacostraca	***Homarus americanus* H. Milne Edwards, 1837**	22	Medium	Alert	U						A
Arthropoda	Malacostraca	***Percnon gibbesi* (H. Milne Edwards, 1853)**	22	Medium	Alert					NE		B
Chordata	Actinopterygii	***Fistularia petimba* Lacepède, 1803**	18	Low	Alert		U					U
Chordata	Actinopterygii	*Acanthurus monroviae* Steindachner, 1876	18	Low	Alert					U	U	U
Chordata	Actinopterygii	*Diodon eydouxii* Brisout de Barneville, 1846	18	Low	Alert			NE				U
Chordata	Actinopterygii	*Acipenser baerii* Brandt, 1869	10	Medium	Alert	U						U
Mollusca	Bivalvia	***Corbicula fluminea* (O. F. Müller, 1774)**	132	High	Less Concern		E	E	E	E	E	B
Chordata	Ascidiacea	**_Ciona intestinalis_* (Linnaeus, 1767)**	120	High	Alert					U		U
Arthropoda	Malacostraca	*Monocorophium uenoi* (Stephensen, 1932)	120	High	Less Concern	E						U
Arthropoda	Malacostraca	*Paracerceis sculpta* (Holmes, 1904)	108	High	Less Concern			E				B, F
Arthropoda	Copepoda	*Eurytemora pacifica* Sato, 1913	104	High	Less Concern	U						U
Arthropoda	Copepoda	*Oithona davisae* Ferrari F.D. & Orsi, 1984	104	High	Less Concern		E					U
Arthropoda	Hexanauplia	*Fistulobalanus albicostatus (Pilsbry, 1916)*	104	High	Less Concern	U						U
Chordata	Ascidiacea	*Ecteinascidia turbinata* Herdman, 1880	90	High	Less Concern		U	U				B, F
Arthropoda	Copepoda	***Acartia (Acanthacartia) tonsa* Dana, 1849**	90	High	Less Concern	E	E	E	E	E	E	B
Ctenophora	Tentaculata	***Mnemiopsis leidyi* Agassiz, 1865**	90	High	Less Concern	E						U
Mollusca	Gastropoda	***Rapana venosa* (Valenciennes, 1846)**	90	High	Less Concern	U	U					B, A
Arthropoda	Malacostraca	*Jassa marmorata* Holmes, 1905	90	High	Less Concern		E					B, F
Arthropoda	Malacostraca	*Brachynotus sexdentatus* (Risso, 1827)	88	High	Less Concern	NE						U
Arthropoda	Malacostraca	***Procambarus clarkii* (Girard, 1852)**	78	High	Less Concern				E	E	E	A
Arthropoda	Malacostraca	*Paradella dianae* (Menzies, 1962)	78	High	Less Concern			E				B, F
Chordata	Ascidiacea	***Corella eumyota* Traustedt, 1882**	78	High	Less Concern	E	E		E	E		A, F
Chordata	Ascidiacea	*Perophora japonica* Oka, 1927	78	High	Less Concern	E	U					A, F
Arthropoda	Hexanauplia	*Amphibalanus eburneus* (Gould, 1841)	78	High	Less Concern	U					U	U
Cnidaria	Anthozoa	*Diadumene lineata* (Verrill, 1869)	78	High	Less Concern	E	U	U				A, F
Chordata	Actinopterygii	***Fundulus heteroclitus heteroclitus* (Linnaeus, 1766)**	78	High	Less Concern			E			E	A

Arthropoda	Malacostraca	*Ampelisca heterodactyla* Schellenberg, 1925	66	High	Less Concern		U			U	U	B, F
Ochrophyta	Bacillariophyceae	***Pseudo-nitzschia multistriata* (Takano) Takano, 1995**	66	High	Less Concern				U			U
Ochrophyta	Raphidophyceae	***Fibrocapsa japonica* S.Toriumi & H.Takano, 1973**	66	High	Less Concern		U					B
Annelida	Polychaeta	*Goniadella gracilis* (Verrill, 1873)	66	High	Less Concern	E	U		E	E	E	B, F
Annelida	Polychaeta	*Isolda pulchella* Müller in Grube, 1858	66	High	Less Concern				E	E	E	B, F
Mollusca	Bivalvia	***Mya arenaria* Linnaeus, 1758**	66	High	Less Concern	E	U		E	E		B
Mollusca	Gastropoda	***Ocinebrellus inornatus** (Récluz, 1851)**	66	High	Top Priority	E				E		A
Arthropoda	Malacostraca	*Ampelisca cavicoxa* Reid, 1951	66	High	Less Concern		U					B, F
Chordata	Ascidiacea	*Botrylloides leachii* (Savigny, 1816)	60	High	Less Concern		U					U
Annelida	Polychaeta	*Streblospio benedicti* Webster, 1879	60	High	Less Concern	E						U
Chordata	Ascidiacea	***Molgula manhattensis* (De Kay, 1843)**	60	High	Less Concern	E	U		E	E		B, F
Mollusca	Bivalvia	***Magallana gigas* (Thunberg, 1793)**	60	High	Less Concern	E	E	U	E	E	E	A, F
Arthropoda	Malacostraca	*Grandidierella japonica* Stephensen, 1938	60	High	Less Concern	E						U
Arthropoda	Malacostraca	*Aoroides longimerus* Ren & Zheng, 1996	56	High	Less Concern	E						U
Myzozoa	Dinophyceae	***Karenia mikimotoi* (Miyake & Kominami ex Oda) Gert Hansen & Ø.Moestrup, 2000**	54	High	Less Concern		U	U				B
Myzozoa	Dinophyceae	***Gymnodinium catenatum* H.W.Graham, 1943**	54	High	Less Concern		E	U	E	E	E	B, A
Myzozoa	Dinophyceae	*Gymnodinium microreticulatum* C.J.S.Bolch, Negri & G.M.Hallegraeff, 1999	54	High	Less Concern				E	E	E	U
Myzozoa	Dinophyceae	***Ostreopsis ovata* Fukuyo, 1981**	54	High	Less Concern						U	U
Myzozoa	Dinophyceae	***Ostreopsis siamensis* Schmidt, 1901**	54	High	Less Concern					U		U
Arthropoda	Malacostraca	*Aoroides curvipes* Ariyama, 2004	52	High	Less Concern	E						U
Arthropoda	Malacostraca	***Callinectes sapidus** Rathbun, 1896**	52	High	Alert	NE	U	E		E	E	B
Arthropoda	Malacostraca	*Melita nitida* Smith, 1873	52	High	Less Concern	E						U
Arthropoda	Malacostraca	*Incisocalliope aestuarius* (Watling & Maurer, 1973)	52	High	Less Concern	U						U
Arthropoda	Malacostraca	*Paranthura japonica* Richardson, 1909	52	High	Less Concern	U						U
Arthropoda	Malacostraca	*Hexapleomera robusta* (Moore, 1894)	52	High	Less Concern		E					U
Arthropoda	Copepoda	*Pseudodiaptomus marinus* Sato, 1913	52	High	Less Concern	E	U		E			B

Chordata	Ascidiacea	*Botrylloides diegensis* Ritter & Forsyth, 1917	48	High	Less Concern	E						U
Arthropoda	Malacostraca	***Palaemon macrodactylus**** **Rathbun, 1902**	45	High	Alert	E	U	U		U	U	B
Annelida	Polychaeta	***Boccardia semibranchiata*** **Guérin, 1990**	44	High	Less Concern		U					U
Arthropoda	Malacostraca	*Aoroides semicurvatus* Ariyama, 2004	44	High	Less Concern	E						U
Ochrophyta	Bacillariophyceae	***Biddulphia sinensis*** **Greville, 1866**	44	High	Less Concern	U			U	U		U
Ochrophyta	Phaeophyceae	*Pleurosigma simonsenii* Hasle, 1990	44	High	Less Concern	U						U
Annelida	Polychaeta	*Chaetozone corona* Berkeley & Berkeley, 1941	44	High	Less Concern	E						U
Annelida	Polychaeta	*Lumbrinerides acuta* (Verrill, 1875)	44	High	Less Concern		U					U
Annelida	Polychaeta	*Neodexiospira brasiliensis* (Grube, 1872)	44	High	Less Concern	U						U
Arthropoda	Malacostraca	*Paracaprella pusilla* Mayer, 1890	44	High	Less Concern			E				F
Annelida	Polychaeta	*Lumbrinerides crassicephala* (Hartman, 1965)	40	High	Less Concern				U			U
Annelida	Polychaeta	*Sabella spallanzanii* (Gmelin, 1791)	40	High	Less Concern		U					F
Arthropoda	Malacostraca	*Diamysis lagunaris* Ariani & Wittmann, 2000	30	High	Less Concern				E			U
Chordata	Actinopterygii	*Cynoscion regalis* (Bloch& Schneider, 1801)	30	High	Less Concern				E	E	E	B
Annelida	Polychaeta	***Boccardiella ligerica*** **(Ferronnière, 1898)**	30	High	Less Concern		U					B
Annelida	Polychaeta	*Polydora cornuta* Bosc, 1802	30	High	Less Concern				U			B
Annelida	Polychaeta	*Pseudopolydora paucibranchiata* (Okuda, 1937)	30	High	Less Concern	NE	E			E		B
Mollusca	Gastropoda	***Crepidula fornicata*** **(Linnaeus, 1758)**	30	High	Less Concern	E	E		U			A, B, F
Arthropoda	Malacostraca	*Eocuma dimorphum* Fage, 1928	27	High	Less Concern		U					B
Arthropoda	Malacostraca	*Ampithoe valida* Smith, 1873	26	High	Less Concern	E			E			B
Arthropoda	Malacostraca	*Caprella scaura* Templeton, 1836	26	High	Less Concern			E		E	E	F
Chordata	Ascidiacea	*Styela canopus* (Savigny, 1816)	26	High	Less Concern						U	B
Arthropoda	Branchiopoda	*Artemia franciscana* Kellog, 1906	26	High	Less Concern				U	U	U	B
Arthropoda	Hexanauplia	*Hesperibalanus fallax* (Broch, 1927)	26	High	Less Concern	U					U	F
Annelida	Polychaeta	*Boccardia polybranchia* (Haswell, 1885)	26	High	Less Concern	U						A
Annelida	Polychaeta	***Boccardia proboscidea*** **Hartman, 1940**	26	High	Less Concern		U					A

Annelida	Polychaeta	*Metasychis gotoi* (Izuka, 1902)	26	High	Less Concern	E			E	E	E	F
Annelida	Polychaeta	***Prionospio pulchra* Imajima, 1990**	26	High	Less Concern		E		E	E	E	A
Annelida	Polychaeta	***Potamopyrgus antipodarum* (Gray, 1843)**	26	High	Less Concern	NE	U	U	E	E	E	B, F
Arthropoda	Malacostraca	*Jasus lalandii* (H. Milne Edwards, 1837)	22	High	Less Concern					U		B
Annelida	Polychaeta	***Desdemona ornata* Banse, 1957**	22	High	Less Concern	U	U			E	E	B
Chordata	Ascidiacea	*Distaplia corolla* Monniot F., 1974	22	High	Less Concern					NE		F
Chordata	Ascidiacea	***Molgula occidentalis* Traustedt, 1883**	22	High	Less Concern					NE		U
Annelida	Polychaeta	*Sigambra parva* (Day, 1963)	22	High	Less Concern		E					B
Annelida	Polychaeta	*Syllis pectinans* (Day, 1963)	22	High	Less Concern		E					B
Annelida	Polychaeta	***Pileolaria berkeleyana* (Rioja, 1942)**	22	High	Less Concern	U						F
Annelida	Polychaeta	***Pista unibranchia* Day, 1963**	22	High	Less Concern		NE					B
Annelida	Polychaeta	*Namanereis littoralis* (Grube, 1872)	20	High	Less Concern		U					B
Annelida	Polychaeta	***Dipolydora tentaculata* (Blake & Kudenov, 1978)**	18	High	Less Concern		E					B
Mollusca	Bivalvia	***Mercenaria mercenaria* (Linnaeus, 1758)**	18	High	Less Concern	E	U		NE	NE		B

*Classification of the species was modified following the revision of the scores.

Ranking results for a subset of NIS evaluated through the current Horizon Scanning for the sub-region of Macaronesia (AMA) and their associated overall scores, overall confidence levels and classifications. The distribution and population status of NIS by Member State (MS) and Marine Reporting Unit (MRU) and probable introduction pathways are also shown. NIS with known adverse effects are shown in bold black and those with high impacts reported in EASIN are in bold red. Population status: E - Established; NE - Not Established; U - Undetermined. Introduction pathways: A - Aquaculture; B - Ballast water; F - Fouling; T - Aquarium Trade; U - Unknown.

Phylum	Class	Species	Overall score	Overall confidence level	Classification	Population status			Probable introduction pathways
						PT		ES	
						Azores	Madeira	Canary Islands	
Chordata	Ascidiacea	***Botrylloides violaceus* Oka, 1927**	270	High	Top Priority		U		A, F
Chordata	Ascidiacea	***Polyandrocarpa zorritensis* (Van Name, 1931)**	234	High	Top Priority		E		A, F
Arthropoda	Hexanauplia	***Austrominius modestus* (Darwin, 1854)**	234	High	Top Priority		U		A, B, F
Arthropoda	Hexanauplia	***Amphibalanus amphitrite* (Darwin, 1854)**	234	High	Top Priority	E	U		A, B, F
Chordata	Ascidiacea	***Botryllus schlosseri* (Pallas, 1766)**	180	High	Top Priority	E	E	U	A, B, F
Chordata	Ascidiacea	***Ciona intestinalis* Linnaeus, 1767**	180	High	Top Priority	U			A, B, F
Chordata	Ascidiacea	***Styela clava* Herdman, 1881**	180	High	Top Priority	E			B, F
Annelida	Polychaeta	***Hydroides elegans* (Haswell, 1883)**	162	High	Top Priority	E			B, F
Chordata	Ascidiacea	***Clavelina oblonga* Herdman, 1880**	156	High	Top Priority	E			B, F
Chordata	Ascidiacea	***Microcosmus squamiger* Michaelsen, 1927**	156	High	Top Priority	E	U	U	B, F
Chordata	Ascidiacea	***Styela plicata* (Lesueur, 1823)**	156	High	Top Priority	E		E	B, F
Arthropoda	Hexanauplia	***Balanus trigonus* Darwin, 1854**	156	High	Top Priority	E	E		B, F
Annelida	Polychaeta	***Ficopomatus enigmaticus* (Fauvel, 1923)**	156	High	Top Priority	E			B, F
Cnidaria	Anthozoa	***Exaiptasia diaphana* (Rapp, 1829)**	156	High	Top Priority		E		A, B, F
Cnidaria	Hydrozoa	***Ectopleura crocea* (Agassiz, 1862)**	198	Medium	Alert	E	U		A, B, F
Cnidaria	Hydrozoa	***Macrorhynchia philippina* Kirchenpauer, 1872**	198	Medium	Alert		U		F
Annelida	Polychaeta	***Branchiomma bairdi* (McIntosh, 1885)**	156	Medium	Alert		E		A, B, F
Annelida	Polychaeta	***Branchiomma luctuosum* (Grube, 1870)**	156	Medium	Alert	E			B, F
Chordata	Actinopterygii	***Sparus aurata* Linnaeus, 1758**	156	Medium	Alert		U	U	A
Cnidaria	Hydrozoa	***Kirchenpaueria halecioides* (Alder, 1859)**	132	Medium	Alert	E	E		B, F

Annelida	Polychaeta	***Spirorbis (Spirorbis) marioni* Caullery & Mesnil, 1897**	132	Medium	Alert	E	U		B, F
Arthropoda	Hexanauplia	***Perforatus perforatus* (Bruguière, 1789)**	117	Medium	Alert	E			B, F
Arthropoda	Malacostraca	*Ligia oceanica* (Linnaeus, 1767)	108	Medium	Alert	E			B, F
Arthropoda	Hexanauplia	*Tesseropora atlantica* Newman & Ross, 1976	104	Medium	Alert	U			U
Arthropoda	Malacostraca	*Plagusia depressa* (Fabricius, 1775)	96	Medium	Alert	U			U
Arthropoda	Malacostraca	*Pilumnus spinifer* H. Milne Edwards, 1834	80	Medium	Alert	U			U
Arthropoda	Malacostraca	*Aoroides longimerus Ren & Zheng, 1996*	78	Medium	Alert	E			A, F
Chordata	Ascidiacea	*Molgula plana* Monniot C., 1971	66	Medium	Alert	U			B, F
Cnidaria	Hydrozoa	***Pennaria disticha* Goldfuss, 1820**	66	Low	Alert		E		F
Arthropoda	Malacostraca	*Sphaeroma serratum* (Fabricius, 1787)	60	Medium	Alert	U			U
Cnidaria	Hydrozoa	***Tubularia indivisa* Linnaeus, 1758**	54	Medium	Alert	U			B, F
Chordata	Actinopterygii	*Pomacanthus maculosus* (Forsskål, 1775)	54	Medium	Alert			NE	T
Chordata	Actinopterygii	*Prognathodes marcellae* (Poll, 1950)	54	Medium	Alert			U	U
Chordata	Ascidiacea	*Cystodytes dellechiajei* (Della Valle, 1877)	52	Medium	Alert	U		U	U
Cnidaria	Hydrozoa	***Obelia dichotoma* (Linnaeus, 1758)**	44	Low	Alert		U		A
Chordata	Ascidiacea	***Pycnoclavella taureanensis* Brunetti, 1991**	26	Medium	Alert		E		F
Chordata	Ascidiacea	*Alloeocarpa loculosa* Monniot C., 1974	22	Medium	Alert	U			B
Chordata	Actinopterygii	***Argyrosomus regius* (Asso, 1801)**	22	Medium	Alert			E	A
Chordata	Actinopterygii	***Dicentrarchus labrax* (Linnaeus, 1758)**	22	Medium	Alert			U	A
Chordata	Actinopterygii	*Monodactylus sebae* (Cuvier, 1829)	22	Medium	Alert			U	U
Chordata	Actinopterygii	*Cephalopholis nigri* (Günther, 1859)	18	Low	Alert			U	O*
Cnidaria	Hydrozoa	***Millepora alcicornis* Linnaeus, 1758**	14	Medium	Alert		U		F
Arthropoda	Malacostraca	***Sphaeroma walkeri* Stebbing, 1905**	30	High	Less Concern		E		B
Annelida	Polychaeta	***Sabella spallanzanii* (Gmelin, 1791)**	120	High	Less Concern	U			B, F
Annelida	Polychaeta	***Eurythoe complanata* (Pallas, 1766)**	88	High	Less Concern		E		U
Chordata	Ascidiacea	***Clavelina dellavallei* (Zirpolo, 1925)**	90	High	Less Concern		E		B, F

Chordata	Ascidiacea	***Clavelina lepadiformis* (Müller, 1776)**	90	High	Less Concern	E	E		B, F
Chordata	Ascidiacea	***Diplosoma listerianum* (Milne Edwards, 1841)**	90	High	Less Concern		E	U	A, F
Arthropoda	Malacostraca	***Caprella scaura* Templeton, 1836**	78	High	Less Concern	E	E	E	A, B, F
Arthropoda	Malacostraca	***Paracerceis sculpta* (Holmes, 1904)**	78	High	Less Concern	E	E		A, B, F
Chordata	Ascidiacea	*Aplidium glabrum* (Verrill, 1871)	78	High	Less Concern		U		A, F
Chordata	Ascidiacea	***Perophora viridis* Verrill, 1871**	78	High	Less Concern	U			B, F
Chordata	Ascidiacea	***Polyclinum aurantium* Milne Edwards, 1841**	78	High	Less Concern	U			B, F
Chordata	Ascidiacea	***Pyura tessellata* (Forbes, 1848)**	78	High	Less Concern	U			B, F
Arthropoda	Hexanauplia	***Amphibalanus eburneus* (Gould, 1841)**	78	High	Less Concern	E			B, F
Chordata	Ascidiacea	***Ascidia interrupta* Heller, 1878**	66	High	Less Concern	U			B, F
Chordata	Ascidiacea	*Botrylloides niger* Herdman, 1886	66	High	Less Concern		U		A, F
Chordata	Ascidiacea	***Didemnum perlucidum* Monniot F., 1983**	66	High	Less Concern		U		A, F
Chordata	Ascidiacea	***Distaplia corolla* Monniot F., 1974**	66	High	Less Concern	E	E		B, F
Chordata	Ascidiacea	*Distaplia bermudensis* Van Name, 1902	54	High	Less Concern		U		A, F
Chordata	Ascidiacea	***Distaplia magnilarva* (Della Valle, 1881)**	54	High	Less Concern		E		B, F
Myzozoa	Dinophyceae	***Alexandrium minutum* Halim, 1960**	54	High	Less Concern	E			B
Arthropoda	Malacostraca	*Tanais dulongii* (Audouin, 1826)	52	High	Less Concern	U			U
Annelida	Polychaeta	***Phyllodoce mucosa* Örsted, 1843**	52	High	Less Concern		U		U
Annelida	Polychaeta	*Ctenodrilus serratus* (Schmidt, 1857)	44	High	Less Concern		E		U
Annelida	Polychaeta	*Perinereis cultrifera* (Grube, 1840)	44	High	Less Concern	U			U
Chordata	Ascidiacea	*Botrylloides leachii* (Savigny, 1816)	30	High	Less Concern		U	U	F
Arthropoda	Malacostraca	*Jassa marmorata* Holmes, 1905	30	High	Less Concern	U			B
Chordata	Ascidiacea	*Perophora listeri* Wiegman, 1835	26	High	Less Concern		E		F
Chordata	Ascidiacea	*Styela canopus* (Savigny, 1816)	26	High	Less Concern		U		F
Chordata	Ascidiacea	***Symplegma brakenhielmi* (Michaelsen, 1904)**	26	High	Less Concern		E		F
Chordata	Ascidiacea	*Eudistoma angolanum* (Michaelsen, 1914)	24	High	Less Concern	U	U		F

Annelida	Polychaeta	*Protula tubularia* (Montagu, 1803)	24	High	Less Concern		E		F
Chordata	Ascidiacea	*Symplegma rubra* Monniot C., 1972	22	High	Less Concern		E		F
Chordata	Actinopterygii	***Diplodus vulgaris*** **(Geoffroy Saint-Hilaire, 1817)**	22	High	Less Concern	E			U
Annelida	Polychaeta	***Pileolaria berkeleyana*** **(Rioja, 1942)**	22	High	Less Concern		U		F

**other: tropicalization*

Appendix 2 – List of NIS not evaluated through the Horizon-Scanning exercise for the ABI and AMA sub-regions

List of NIS that were not included in the Horizon-Scanning exercise for the sub-region of Bay of Biscay and the Iberian Coast (ABI) and their distribution and population status by Member State (MS) and Marine Reporting Unit (MRU). Probable introduction pathways are also shown. NIS with known adverse effects are shown in bold black and those with high impacts reported in EASIN are in bold red. Population status: E - Established; NE - Not Established; U - Undetermined. Introduction pathways: A - Aquaculture; B - Ballast water; F - Fouling; U - Unknown.

Phylum	Class	Species	Population status						Probable introduction pathways
			FR	ES		PT			
			BoB	NA	SA	A-NW	B-SW	C-S	
Arthropoda	Copepoda	***Myicola ostreae*** **Hoshina & Sugiura, 1953**	U					E	U
Arthropoda	Copepoda	***Mytilicola intestinalis*** **Steuer, 1902**	E						U
Arthropoda	Copepoda	***Mytilicola orientalis*** **Mori, 1935**	E						U
Bryozoa	Gymnolaemata	*Amathia verticillata* (delle Chiaje, 1822)				E	E	E	A, B
Bryozoa	Gymnolaemata	***Bugula neritina*** **(Linnaeus, 1758)**	U	U	U	E	E	E	F
Bryozoa	Gymnolaemata	*Bugulina fulva* (Ryland, 1960)					E	E	F
Bryozoa	Gymnolaemata	*Bugulina simplex* (Hincks, 1886)	U						U
Bryozoa	Gymnolaemata	*Bugulina stolonifera*	U	U		U	U		F
Bryozoa	Gymnolaemata	*Caulibugula zanzibariensis* (Waters, 1913)	U						U
Bryozoa	Gymnolaemata	*Celleporaria brunnea* (Hincks, 1884)	U				NE	NE	B
Bryozoa	Gymnolaemata	*Crisularia plumosa* (Pallas, 1766)					U		F
Bryozoa	Gymnolaemata	***Schizoporella errata*** **(Waters, 1878)**		E			U	U	A, B, F
Bryozoa	Gymnolaemata	*Reptadeonella violacea* (Johnston, 1847)				U	U		U
Bryozoa	Gymnolaemata	***Tricellaria inopinata*** **d'Hondt & Occhipinti Ambrogi, 1985**	E	E	E	E	E		A, F
Bryozoa	Gymnolaemata	***Victorella pavida*** **Saville-Kent, 1870**	E						U
Bryozoa	Gymnolaemata	*Watersipora subtorquata* (d'Orbigny, 1852)	U				E	E	F
Cercozoa	Ascetosporea	***Bonamia exitiosa*** **Hine, Cochennac & Berthe, 2001**		U					A

Cercozoa	Ascetosporea	***Bonamia ostreae* Pichot, Comps, Tigé, Grizel & Rabouin, 1980**		E	E				A
Cercozoa	Ascetosporea	***Marteilia refringens* Grizel, Comps, Bonami, Cousserans, Duthoit & Le Pennec, 1974**		E	E				A
Chlorophyta	Ulvophyceae	***Codium arabicum* Kützing, 1856**				*	*	*	F
Chlorophyta	Ulvophyceae	***Codium fragile* (Suringar) Hariot, 1889**	E						U
Chlorophyta	Ulvophyceae	***Codium fragile subsp. fragile* (Suringar) Hariot, 1889**	U	E	U		E	E	A, B, F
Chlorophyta	Ulvophyceae	*Kornmannia leptoderma* (Kjellman) Bliding, 1969	U						U
Chlorophyta	Ulvophyceae	***Ulva australis* Areschoug, 1854**	E	E		E		E	A, F
Chlorophyta	Ulvophyceae	***Ulvaria obscura* (Kützing) P.Gayral ex C.Bliding, 1969**	E						A, B
Chlorophyta	Ulvophyceae	*Umbraulva dangeardii* M.J.Wynne & G.Furnari, 2014		E					U
Mollusca	Bivalvia	***Anadara kagoshimensis* (Tokunaga, 1906)**		U					A, B
Mollusca	Bivalvia	*Anomia chinensis* Philippi, 1849	U						U
Mollusca	Bivalvia	***Crassostrea rhizophorae* (Guilding, 1828)**	U						U
Mollusca	Bivalvia	***Crassostrea virginica* (Gmelin, 1791)**	U						U
Mollusca	Bivalvia	***Ensis leei* M. Huber, 2015**		E					B
Mollusca	Bivalvia	*Mytilopsis leucophaeata* (Conrad, 1831)			E				B, F
Mollusca	Bivalvia	***Mizuhopecten yessoensis* (Jay, 1857)**	U						B, F
Mollusca	Bivalvia	***Ostrea angasi* G. B. Sowerby II, 1871**	U						U
Mollusca	Bivalvia	***Ostrea puelchana* d'Orbigny, 1842**	U						U
Mollusca	Bivalvia	***Petricolaria pholadiformis* (Lamarck, 1818)**	U	U					U
Mollusca	Bivalvia	***Theora lubrica* Gould, 1861**		E					B
Mollusca	Bivalvia	***Xenostrobus securis* (Lamarck, 1819)**		E	U				A
Mollusca	Gastropoda	*Bivetiella cancellata* (Linnaeus, 1767)		U					B
Mollusca	Gastropoda	*Corambe obscura (A. E. Verrill, 1870)*	U						U
Mollusca	Gastropoda	***Crepipatella dilatata* (Lamarck, 1822)**		E					A, B, F
Mollusca	Gastropoda	*Gibbula albida* (Gmelin, 1791)	E	U	U				A
Mollusca	Gastropoda	*Gracilipurpura rostrata (Olivi, 1792)*		U					A, F

Mollusca	Gastropoda	***Haloa japonica* Pilsbry, 1895**		E	U				A, B, F
Mollusca	Gastropoda	***Hexaplex trunculus* (Linnaeus, 1758)**	U	E					A, B, F
Mollusca	Gastropoda	*Polycera hedgpethi* Er. Marcus, 1964		U					A, B
Mollusca	Gastropoda	*Polycerella emertoni* A. E. Verrill, 1880		U	U				A, B
Mollusca	Gastropoda	*Tonicia atrata* (G.B. Sowerby II, 1840)		U			E		A, B, F
Mollusca	Gastropoda	*Tritia neritea* (Linnaeus, 1758)	E	U					A, F
Mollusca	Gastropoda	***Urosalpinx cinerea* (Say, 1822)**	U	U					A
Mollusca	Polyplacophora	*Chaetopleura angulata* (Spengler, 1797)		U	U	E	E	E	A, B, F
Mollusca	Vetigastropoda	*Steromphala adansonii* (Payraudeau, 1826)		E					A, F
Nematoda	Chromadorea	***Anguillicoloides crassus* (Kuwahara, Niimi & Itagaki, 1974) Moravec & Taraschewski, 1988**	E	U	U	E	E		U
Ochrophyta	Phaeophyceae	***Colpomenia peregrina* Sauvageau, 1927**		E	E	E	E	E	A, B, F
Ochrophyta	Phaeophyceae	*Pylaiella littoralis* (Linnaeus) Kjellman, 1872	E						U
Ochrophyta	Phaeophyceae	***Sargassum muticum* (Yendo) Fensholt, 1955**	E	U	U	E	E	E	A, F
Ochrophyta	Phaeophyceae	*Scytosiphon dotyi* M.J.Wynne, 1969		E	U		U		A, F
Ochrophyta	Phaeophyceae	***Undaria pinnatifida* (Harvey) Suringar, 1873**	E	E		E	E		A, F
Platyhelminthes	Monogenea	***Pseudodactylogyrus anguillae* (Yin & Sproston, 1948) Gusev, 1965**	E	U					U
Platyhelminthes	Monogenea	***Pseudodactylogyrus bini* (Kikuchi, 1929)**		U					U
Porifera	Demospongiae	***Celtodoryx ciocalyptoides* (Burton, 1935)**	E						U
Rhodophyta	Bangiophyceae	*Pyropia suborbiculata* (Kjellman) J.E.Sutherland, H.G.Choi, M.S. Hwang & W.A.Nelson, 2011		U		E	E		A, B
Rhodophyta	Florideophyceae	*Agardhiella subulata* Kraft & M.J.Wynne, 1979		U					A, F
Rhodophyta	Florideophyceae	***Agarophyton vermiculophyllum* (Ohmi) Gurgel, J.N.Norris & Fredericq, 2018**	E	U	U	E	E	E	A, F
Rhodophyta	Florideophyceae	*Aglaothamnion feldmanniae* Halos, 1965		E					B, F
Rhodophyta	Florideophyceae	***Anotrichium furcellatum* (J.Agardh) Baldock, 1976**	E	U	U	E	E	E	B, F
Rhodophyta	Florideophyceae	*Antithamnion amphigeneum* A.J.K.Millar, 1990		U			E	E	B, F
Rhodophyta	Florideophyceae	*Antithamnion densum* (Suhr) M.A.Howe, 1914	E	U	U	E			B, F
Rhodophyta	Florideophyceae	*Antithamnion hubbsii* E.Y.Dawson, 1962	E	U			E	E	A, B

Rhodophyta	Florideophyceae	*Antithamnionella elegans* (Berthold) J.H.Price & D.M.John, 1986		E					B, F
Rhodophyta	Florideophyceae	***Antithamnionella spirographidis* (Schiffner) E.M.Wollaston, 1968**	E	E	U	E	E	E	A, B, F
Rhodophyta	Florideophyceae	***Antithamnionella ternifolia* (J.D.Hooker & Harvey) Lyle, 1922**	E	E		E	E	E	B, F
Rhodophyta	Florideophyceae	***Asparagopsis armata* Harvey, 1855**	E	E	E	E	E	E	B, F
Rhodophyta	Florideophyceae	***Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, 1845**		E	U		E	E	B, F
Rhodophyta	Florideophyceae	***Bonnemaisonia hamifera* Hariot, 1891**	E	E	E			E	B, F
Rhodophyta	Florideophyceae	*Botryocladia wrightii* (Harvey) W.E.Schmidt, D.L.Ballantine & Fredericq, 2017		U					U
Rhodophyta	Florideophyceae	*Caulacanthus ustulatus* (Mertens ex Turner) Kützing, 1843	E						U
Rhodophyta	Florideophyceae	*Colaconema codicola* (Børgesen) Stegenga, J.J.Bolton & R.J.Anderson, 1997	E						U
Rhodophyta	Florideophyceae	*Dasya sessilis* Yamada, 1928	E	E		E	E	E	A, B, F
Rhodophyta	Florideophyceae	***Dasysiphonia japonica* (Yendo) H.-S.Kim, 2012**	E	E					A, B, F
Rhodophyta	Florideophyceae	*Dipterosiphonia dendritica* (C.Agardh) F.Schmitz, 1897			U				U
Rhodophyta	Florideophyceae	*Gracilaria chorda* Holmes, 1896	U						U
Rhodophyta	Florideophyceae	*Grateloupia filicina* (J.V.Lamouroux) C. Agardh, 1822					U		U
Rhodophyta	Florideophyceae	*Grateloupia subpectinata* Holmes, 1912	E	E					A, F
Rhodophyta	Florideophyceae	***Grateloupia turuturu* Yamada, 1941**	E	E		E			A, F
Rhodophyta	Florideophyceae	*Herposiphonia parca* Setchell, 1926	E						U
Rhodophyta	Florideophyceae	*Hypnea valentiae* (Turner) Montagne, 1841	E						U
Rhodophyta	Florideophyceae	*Laurencia brongniartii* J.Agardh, 1841	E						U
Rhodophyta	Florideophyceae	*Lomentaria hakodatensis* Yendo, 1920	E	E	U		E	E	A, F
Rhodophyta	Florideophyceae	***Melanothamnus harveyi* (Bailey) Díaz-Tapia & Maggs, 2017**	E	E	U	E	E	E	A, F
Rhodophyta	Florideophyceae	*Pachymeniopsis lanceolata* (K.Okamura) Y.Yamada ex S.Kawabata, 1954		U					A, F
Rhodophyta	Florideophyceae	*Polyopes lancifolius* (Harvey) Kawaguchi & Wang, 2002	E						U
Rhodophyta	Florideophyceae	***Polysiphonia morrowii* Harvey, 1857**	U	U					A
Rhodophyta	Florideophyceae	*Scageliopsis patens* Wollaston, 1981		E		E	E		F
Rhodophyta	Florideophyceae	*Solieria chordalis* (C.Agardh) J.Agardh, 1842		E	E				F

Rhodophyta	Florideophyceae	*Spongoclonium caribaeum* (Børgesen) M.J.Wynne, 2005	E	E					F
Rhodophyta	Florideophyceae	*Symphyocladia marchantioides* (Harvey) Falkenberg, 1897				E	E		U
Rhodophyta	Florideophyceae	*Symphyocladiella dendroidea* (Montagne) D.Bustamante, B.Y.Won, S.C.Lindstrom & T.O.Cho, 2019	E						U
Tracheophyta	Magnoliopsida	***Spartina alterniflora* Loisel.**	E						U
Tracheophyta	Magnoliopsida	***Spartina townsendii var. anglica* C.E. Hubbard**	E						U
Tracheophyta	Magnoliopsida	***Spartina townsendii var. townsendii* H. & J. Groves**	E						U

List of NIS that were not included in the Horizon-Scanning exercise for the sub-region Macaronesia (AMA) and their distribution and population status by Member State (MS) and Marine Reporting Unit (MRU). Probable introduction pathways are also shown. NIS with known adverse effects are shown in bold black and those with high impacts reported in EASIN are in bold red. Population status: E - Established; NE - Not Established; U - Undetermined. Introduction pathways: A - Aquaculture; B - Ballast water; D - Marine Debris; F - Fouling; L - Live Bait; T - Aquarium Trade; U - Unknown.

Phylum	Class	Species	Population Status			Probable introduction pathways
			ES	PT		
			Canary Islands	Azores	Madeira	
Bryozoa	Gymnolaemata	*Aetea anguina* (Linnaeus, 1758)	U	U		A, B
Bryozoa	Gymnolaemata	*Aetea ligulata* Busk, 1852	U			U
Bryozoa	Gymnolaemata	*Aetea longicollis* (Jullien, 1903)	U			U
Bryozoa	Gymnolaemata	*Aetea sica* (Couch, 1844)	U	U		D
Bryozoa	Gymnolaemata	*Aetea truncata* (Landsborough, 1852)	U			U
Bryozoa	Gymnolaemata	*Amathia citrina* (Hincks, 1877)		U		U
Bryozoa	Gymnolaemata	***Amathia gracilis* (Leidy, 1855)**		U		B, F
Bryozoa	Gymnolaemata	*Amathia lendigera* (Linnaeus, 1758)		U		U
Bryozoa	Gymnolaemata	***Amathia verticillata* (delle Chiaje, 1822)**		E	E	A, B, D, F
Bryozoa	Gymnolaemata	***Beania maxilladentata* Ramalho, Muricy & Taylor, 2010**			U	B, F
Bryozoa	Gymnolaemata	*Beania mirabilis* Johnston, 1840	U	U		U
Bryozoa	Gymnolaemata	*Bicellariella ciliata* (Linnaeus, 1758)		U		U
Bryozoa	Gymnolaemata	***Bugula neritina* (Linnaeus, 1758)**	E	E	E	A, B, D, F
Bryozoa	Gymnolaemata	*Bugulina avicularia* (Linnaeus, 1758)	U		U	U
Bryozoa	Gymnolaemata	*Bugulina flabellata* (Thompson in Gray, 1848)		U		U
Bryozoa	Gymnolaemata	***Bugulina fulva* (Ryland, 1960)**	U	U	E	B, D, F
Bryozoa	Gymnolaemata	***Bugulina simplex* (Hincks, 1886)**	E	E	E	B, F
Bryozoa	Gymnolaemata	***Bugulina stolonifera* (Ryland, 1960)**	E	E	E	B, F

Bryozoa	Gymnolaemata	*Callopora dumerilii* (Audouin, 1826)		U		U
Bryozoa	Gymnolaemata	***Celleporaria inaudita* Tilbrook, Hayward & Gordon, 2001**			E	B, F
Bryozoa	Gymnolaemata	*Celleporina fragilis* Aristegui, 1989		U		U
Bryozoa	Gymnolaemata	*Chorizopora brongniartii* (Audouin, 1826)	U			U
Bryozoa	Gymnolaemata	*Collarina balzaci* (Audouin, 1826)		U		U
Bryozoa	Gymnolaemata	***Copidozoum tenuirostre* (Hincks, 1880)**		U		U
Bryozoa	Gymnolaemata	***Cradoscrupocellaria bertholletii* (Audouin, 1826)**			U	B, F
Bryozoa	Gymnolaemata	*Cradoscrupocellaria hirsuta* (Jullien, 1903)		U		U
Bryozoa	Gymnolaemata	*Cradoscrupocellaria insularis* Vieira, Spencer Jones & Winston, 2013		U		U
Bryozoa	Gymnolaemata	*Cradoscrupocellaria reptans* (Linnaeus, 1758)		U		B, F
Bryozoa	Gymnolaemata	*Cribrilaria innominata* (Couch, 1844)	U	U		U
Bryozoa	Gymnolaemata	*Crisularia gracilis* (Busk, 1858)		U	U	F
Bryozoa	Gymnolaemata	***Cryptosula pallasiana* (Moll, 1803)**			E	A, F
Bryozoa	Gymnolaemata	*Electra pilosa* (Linnaeus, 1767)	U			U
Bryozoa	Gymnolaemata	*Escharina vulgaris* (Moll, 1803)	U			U
Bryozoa	Gymnolaemata	*Fenestrulina malusii* (Audouin, 1826)	U			U
Bryozoa	Gymnolaemata	*Halysisis diaphana* (Busk, 1860)		U		U
Bryozoa	Gymnolaemata	*Haplopoma impressum* (Audouin, 1826)		U		U
Bryozoa	Gymnolaemata	*Jellyella tuberculata* (Bosc, 1802)	U			U
Bryozoa	Gymnolaemata	*Microporella ciliata* (Pallas, 1766)	U			U
Bryozoa	Gymnolaemata	*Nolella gigantea (Busk, 1856)*			E	U
Bryozoa	Gymnolaemata	*Nolella stipata* Gosse, 1855		U		U
Bryozoa	Gymnolaemata	***Parasmittina alba* Ramalho, Muricy & Taylor, 2011**			E	B, F
Bryozoa	Gymnolaemata	***Parasmittina multiaviculata* Souto, Ramalhosa & Canning-Clode, 2016**			E	B, F
Bryozoa	Gymnolaemata	***Parasmittina protecta* (Thornely, 1905)**			E	B, F

Bryozoa	Gymnolaemata	*Porella concinna* (Busk, 1854)		U		U
Bryozoa	Gymnolaemata	***Reptadeonella violacea* (Johnston, 1847)**	E	U	E	B, F
Bryozoa	Gymnolaemata	*Reteporella mediterranea* (Smitt, 1867)		U		U
Bryozoa	Gymnolaemata	*Savignyella lafontii* (Audouin, 1826)			U	U
Bryozoa	Gymnolaemata	*Schizobrachiella sanguinea* (Norman, 1868)		U		U
Bryozoa	Gymnolaemata	*Schizoporella dunkeri* (Reuss, 1848)		U		A
Bryozoa	Gymnolaemata	***Schizoporella errata* (Waters, 1878)**	U	E	E	A, B, F
Bryozoa	Gymnolaemata	*Schizoporella unicornis* (Johnston in Wood, 1844)	U	E		F
Bryozoa	Gymnolaemata	***Schizoporella pungens* Canu & Bassler, 1928**			E	B, F
Bryozoa	Gymnolaemata	*Scruparia ambigua* (d'Orbigny, 1841)	U			U
Bryozoa	Gymnolaemata	*Scrupocaberea maderensis* (Busk, 1860)		U		U
Bryozoa	Gymnolaemata	*Smittina cervicornis* (Pallas, 1766)		U		A
Bryozoa	Gymnolaemata	*Stephanollona contracta* (Waters, 1899)		U		U
Bryozoa	Gymnolaemata	***Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985**		E	E	A, B, D, F
Bryozoa	Gymnolaemata	***Virididentula dentata* (Lamouroux, 1816)**		E	E	B, F
Bryozoa	Gymnolaemata	*Watersipora souleorum* Vieira, Spencer Jones & Taylor, 2014		U		A
Bryozoa	Gymnolaemata	***Watersipora subtorquata* (d'Orbigny, 1852)**		E	E	A, B, D, F
Bryozoa	Gymnolaemata	*Umbonula ovicellata* Hastings, 1944		U		A
Bryozoa	Stenolaemata	***Crisia denticulata* (Lamarck, 1816)**		U		U
Bryozoa	Stenolaemata	*Crisia ramosa* Harmer, 1891		U		U
Bryozoa	Stenolaemata	*Disporella hispida* (Fleming, 1828)		U		U
Bryozoa	Stenolaemata	*Entalophoroecia robusta* Harmelin, 1976		U		U
Bryozoa	Stenolaemata	*Idmidronea contorta* (Busk, 1875)		U		U
Bryozoa	Stenolaemata	*Stomatopora gingrina* Jullien, 1882		U		U
Bryozoa	Stenolaemata	*Tubulipora liliacea* (Pallas, 1766)		U		U

Bryozoa	Stenolaemata	*Tubulipora serpens* Canu & Bassler, 1928		U		U
Chlorophyta	Ulvophyceae	*Anadyomene stellata* (Wulfen) C.Agardh, 1823		U		U
Chlorophyta	Ulvophyceae	*Avrainvillea canariensis* A. Gepp & E.S. Gepp, 1911			U	U
Chlorophyta	Ulvophyceae	***Caulerpa cylindracea* Sonder, 1845**	E			B, F
Chlorophyta	Ulvophyceae	***Caulerpa prolifera* (Forsskål) J.V.Lamouroux, 1809**		E		U
Chlorophyta	Ulvophyceae	***Caulerpa webbiana* Montagne, 1837**		E	E	B, F
Chlorophyta	Ulvophyceae	*Cladophora dalmatica* Kützing, 1843		U		U
Chlorophyta	Ulvophyceae	*Cladophora laetevirens* (Dillwyn) Kützing, 1843		U		U
Chlorophyta	Ulvophyceae	*Cladophoropsis membranacea* (Hofman Bang ex C.Agardh) Børgesen, 1905		E		U
Chlorophyta	Ulvophyceae	*Codium effusum* (Rafinesque) Delle Chiaje, 1829		U		U
Chlorophyta	Ulvophyceae	***Codium fragile subsp. fragile* (Suringar) Hariot, 1889**		E		B, F
Chlorophyta	Ulvophyceae	***Codium fragile* (Suringar) Hariot, 1889**	U			U
Chlorophyta	Ulvophyceae	*Derbesia tenuissima* (Moris & De Notaris) P.Crouan & H.Crouan, 1867		U		U
Chlorophyta	Ulvophyceae	***Halimeda incrassata* (J.Ellis) J.V.Lamouroux, 1816**		E		U
Chlorophyta	Ulvophyceae	*Ulva lactuca* Linnaeus, 1753		U		U
Cnidaria	Myxozoa	***Sphaerospora testicularis***	U			A
Ctenophora	Tentaculata	***Vallicula multiformis* Rankin, 1956**			U	F, D, T
Echinodermata	Echinoidea	***Ova canalifera* (Lamarck, 1816)**			U	U
Entoprocta	NA	*Barentsia discreta* (Busk, 1886)			E	U
Mollusca	Bivalvia	*Hiatella arctica* (Linnaeus, 1767)		U		U
Mollusca	Bivalvia	***Lyrodus pedicellatus* (Quatrefages, 1849)**		U	U	U
Mollusca	Bivalvia	***Mytilus edulis* Linnaeus, 1758**		E		A, F
Mollusca	Bivalvia	***Ostrea edulis* Linnaeus, 1758**		E		A
Mollusca	Bivalvia	*Papillicardium papillosum* (Poli, 1791)			E	B
Mollusca	Bivalvia	***Pinctada imbricata radiata* (Leach, 1814)**		E		B, F

Mollusca	Bivalvia	***Psiloteredo megotara*** **(Hanley in Forbes & Hanley, 1848)**		U	U	B
Mollusca	Bivalvia	***Ruditapes decussatus*** **(Linnaeus, 1758)**		E		A
Mollusca	Gastropoda	***Aplus dorbignyi*** **(Payraudeau, 1826)**		E		B
Mollusca	Gastropoda	***Aplysia dactylomela*** **Rang, 1828**			E	U
Mollusca	Gastropoda	***Bedeva paivae*** **(Crosse, 1864)**			E	A, B
Mollusca	Gastropoda	*Doto fluctifraga* Ortea & Perez, 1982			U	A, B
Mollusca	Gastropoda	***Hexaplex trunculus*** **(Linnaeus, 1758)**		E	E	A, B, D, F
Mollusca	Gastropoda	***Phorcus sauciatus*** **(Koch, 1845)**		E		U
Mollusca	Gastropoda	*Terebra corrugata* Lamarck, 1822	U			U
Mollusca	Gastropoda	*Tonna pennata* (Mörch, 1853)			U	B
Mollusca	Gastropoda	***Truncatella subcylindrica*** **(Linnaeus, 1767)**		E	U	B, D
Mollusca	Gastropoda	*Williamia gussoni* (Costa O. G., 1829)			E	B, D
Myzozoa	Dinophyceae	***Alexandrium minutum*** **Alexandria Harbour (EG) (Horton et al., 2019)**		E		B, D
Ochrophyta	Phaeophyceae	*Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier, 1851	U			U
Ochrophyta	Phaeophyceae	*Corynophlaea cystophorae* J.Agardh, 1882	U			U
Ochrophyta	Phaeophyceae	*Cutleria multifida* (Turner) Greville, 1830		U		U
Ochrophyta	Phaeophyceae	*Ectocarpus siliculosus* (Dillwyn) Lyngbye, 1819		U		U
Ochrophyta	Phaeophyceae	*Leathesia marina* (Lyngbye) Decaisne, 1842		U		U
Ochrophyta	Phaeophyceae	*Papenfussiella kuromo* (Yendo) Inagaki 1958		E		U
Ochrophyta	Phaeophyceae	***Petalonia binghamiae*** **(J. Agardh) K.L.Vinogradova, 1973**		E		B, F
Ochrophyta	Phaeophyceae	*Sphacelaria fusca* (Hudson) S.F.Gray, 1821		U		U
Ochrophyta	Phaeophyceae	*Sphacelaria tribuloides* Meneghini, 1840		U		U
Ochrophyta	Phaeophyceae	*Sphaerotrichia divaricata* (C.Agardh) Kylin, 1940		U		U
Ochrophyta	Phaeophyceae	***Stypopodium schimperi*** **(Kützing) Verlaque & Boudouresque, 1991**	U			U
Ochrophyta	Phaeophyceae	***Undaria pinnatifida*** **(Harvey) Suringar, 1873**	U			U

Phoronida	NA	Phoronopsis harmeri Pixell, 1912		U		U
Phoronida	NA	Phoronis hippocrepia Wright, 1856		U		U
Phoronida	NA	Phoronis psammophila Cori, 1889		U		U
Porifera	Calcarea	***Paraleucilla magna* (Klautau, Monteiro & Borojevic, 2004)**	U	E	U	A, B, D, F
Porifera	Demospongiae	*Cinachyrella alloclada* (Uliczka, 1929)		U		U
Porifera	Demospongiae	***Crambe crambe* (Schmidt, 1862)**	E		E	B, F
Porifera	Demospongiae	***Desmacella meliorata* Wiedenmayer, 1977**		U		B, F
Porifera	Demospongiae	***Haliclona (Rhizoniera) indistincta* (Bowerbank, 1866)**			U	B, F
Porifera	Demospongiae	***Mycale (Carmia) senegalensis* Lévi, 1952**			U	B, F
Porifera	Demospongiae	***Prosuberites longispinus* Topsent, 1893**			E	F
Rhodophyta	Bangiophycyeae	*Pyropia leucosticta* (Thuret) Neefus & J.Brodie, 2011		U		U
Rhodophyta	Compsopogonophyceae	*Erythrotrichia carnea* (Dillwyn) J.Agardh, 1883		U		U
Rhodophyta	Florideophyceae	***Acrothamnion preissii* (Sonder) E.M.Wollaston, 1968**		E		B, F
Rhodophyta	Florideophyceae	*Aglaothamnion cordatum* (Børgesen) Feldmann-Mazoyer 1941		E		B, F
Rhodophyta	Florideophyceae	*Aglaothamnion tenuissimum* (Bonnemaison) Feldmann-Mazoyer, 1941		U		B, L
Rhodophyta	Florideophyceae	***Anotrichium furcellatum* (J.Agardh) Baldock, 1976**		U	E	A, B, F
Rhodophyta	Florideophyceae	***Antithamnion densum* (Suhr) M.A.Howe, 1914**		U		B
Rhodophyta	Florideophyceae	***Antithamnion diminuatum* Wollaston, 1968**	U	E		B, F
Rhodophyta	Florideophyceae	***Antithamnion hubbsii* E.Y.Dawson, 1962**		E		B, F
Rhodophyta	Florideophyceae	*Antithamnionella boergesenii* (Cormaci & G.Furnari) Athanasiadis, 1996		U	U	B, F
Rhodophyta	Florideophyceae	***Antithamnionella spirographidis* (Schiffner) E.M.Wollaston, 1968**		U	U	A, B, D, F
Rhodophyta	Florideophyceae	***Antithamnionella ternifolia* (J.D.Hooker & Harvey) Lyle, 1922**		E		B, F
Rhodophyta	Florideophyceae	***Asparagopsis armata* Harvey, 1855**	E	E	E	A, B, F
Rhodophyta	Florideophyceae	***Asparagopsis taxiformis* Alexandria, EG (Guiry & Guiry, 2019)**	E	E	E	A, B, F
Rhodophyta	Florideophyceae	***Bonnemaisonia hamifera* Hariot, 1891**	E	E		B, F

Rhodophyta	Florideophyceae	*Carradoriella denudata* (Dillwyn) A.M.Savoie & G.W.Saunders, 2019		U		U
Rhodophyta	Florideophyceae	*Caulacanthus ustulatus* (Mertens ex Turner) Kützing, 1843		U		U
Rhodophyta	Florideophyceae	*Ceramium atrorubescens* Kylin, 1938	U			U
Rhodophyta	Florideophyceae	***Ceramium cingulatum* Weber-van Bosse, 1923**	U	E		U
Rhodophyta	Florideophyceae	*Ceramium codii (H.Richards) Mazoyer, 1938*		U		U
Rhodophyta	Florideophyceae	*Ceramium gaditanum* (Clemente) Cremades, 1990		U		U
Rhodophyta	Florideophyceae	*Chondria coerulescens* (J.Agardh) Sauvageau, 1897		U		A
Rhodophyta	Florideophyceae	*Chondria dasyphylla* (Woodward) C.Agardh, 1817		U		U
Rhodophyta	Florideophyceae	*Chondrus crispus* Stackhouse, 1797		U		U
Rhodophyta	Florideophyceae	***Corynomorpha prismatica* (J.Agardh) J.Agardh, 1876**		NE		U
Rhodophyta	Florideophyceae	*Cryptonemia seminervis* (C.Agardh) J.Agardh, 1846		U		U
Rhodophyta	Florideophyceae	*Dasya baillouviana* (S.G.Gmelin) Montagne, 1841		U		A, B, F
Rhodophyta	Florideophyceae	*Dipterosiphonia dendritica* (C.Agardh) F.Schmitz, 1897	E			U
Rhodophyta	Florideophyceae	*Erythrodermis traillii* (Holmes ex Batters) Guiry & Garbary, 1990		U		U
Rhodophyta	Florideophyceae	***Grallatoria reptans* M.A.Howe, 1920**		U		B, F
Rhodophyta	Florideophyceae	***Grateloupia doryphora* (Montagne) M.Howe, 1914**	U			U
Rhodophyta	Florideophyceae	*Grateloupia filicina* (J.V.Lamouroux) C. Agardh, 1822		E		A
Rhodophyta	Florideophyceae	*Grateloupia imbricata* Holmes, 1896	U		U	U
Rhodophyta	Florideophyceae	***Grateloupia lanceola* (J.Agardh) J.Agardh, 1851**	U			U
Rhodophyta	Florideophyceae	***Grateloupia turuturu* Yamada, 1941**		E	U	B, F
Rhodophyta	Florideophyceae	*Griffithsia corallinoides* (Linnaeus) Trevisan, 1845		U		U
Rhodophyta	Florideophyceae	***Gymnophycus hapsiphorus* Huisman & Kraft 1983**		E		F
Rhodophyta	Florideophyceae	***Hypnea flagelliformis* Greville ex J. Agardh, 1851**		E		B, F
Rhodophyta	Florideophyceae	*Hypnea musciformis* (Wulfen) J.V.Lamouroux, 1813		U		U
Rhodophyta	Florideophyceae	*Hypnea spinella* (C.Agardh) Kützing, 1847		U		U

Rhodophyta	Florideophyceae	*Jania longifurca* Zanardini, 1844		U		U
Rhodophyta	Florideophyceae	*Jania virgata (Zanardini)* Montagne, 1846		U		U
Rhodophyta	Florideophyceae	***Laurencia brongniartii* J.Agardh, 1841**		E		U
Rhodophyta	Florideophyceae	*Laurencia caduciramulosa* Masuda & Kawaguchi, 1997	U			U
Rhodophyta	Florideophyceae	***Laurencia chondrioides* Børgesen, 1918**		E		U
Rhodophyta	Florideophyceae	*Laurencia dendroidea* J.Agardh 1852		E	U	U
Rhodophyta	Florideophyceae	*Leptosiphonia brodiei* (Dillwyn) A.M.Savoie & G.W.Saunders, 2019		U		U
Rhodophyta	Florideophyceae	*Lomentaria clavellosa* (Lightfoot ex Turner) Gaillon, 1828		U		U
Rhodophyta	Florideophyceae	*Lomentaria orcadensis* (Harvey) Collins, 1937		U		U
Rhodophyta	Florideophyceae	***Lophocladia trichoclados* (C.Agardh) F.Schmitz, 1893**		E		B, F
Rhodophyta	Florideophyceae	*Mastocarpus stellatus* (Stackhouse) Guiry, 1984		U		U
Rhodophyta	Florideophyceae	***Melanothamnus harveyi* (Bailey) Díaz-Tapia & Maggs, 2017**	E	E		B, F
Rhodophyta	Florideophyceae	***Melanothamnus sphaerocarpus* (Børgesen) Díaz-Tapia & Maggs, 2017**		E	U	B, F
Rhodophyta	Florideophyceae	*Pachymeniopsis lanceolata* (K.Okamura) Y.Yamada ex S.Kawabata, 1954			U	A, F
Rhodophyta	Florideophyceae	*Predaea huismanii* Kraft, 1984	U			U
Rhodophyta	Florideophyceae	*Ptilothamnion pluma* (Dillwyn) Thuret, 1863		U		U
Rhodophyta	Florideophyceae	***Scageliopsis patens* Wollaston, 1981**		U		B, F
Rhodophyta	Florideophyceae	*Schottera nicaeensis* (J.V.Lamouroux ex Duby) Guiry & Hollenberg, 1975		U		U
Rhodophyta	Florideophyceae	*Scinaia acuta* M.J.Wynne, 2005	U			U
Rhodophyta	Florideophyceae	***Spongoclonium caribaeum* (Børgesen) M.J.Wynne, 2005**		E		B, F
Rhodophyta	Florideophyceae	***Symphyocladia marchantioides* (Harvey) Falkenberg, 1897**		E		B, F
Rhodophyta	Florideophyceae	*Vertebrata fucoides* (Hudson) Kuntze, 1891		U		U
Rhodophyta	Florideophyceae	*Vertebrata hypnoides* (Welwitsch) Kuntze, 1891		U		U
Rhodophyta	Florideophyceae	*Vertebrata reptabunda* (Suhr) Díaz-Tapia & Maggs, 2017		U		U
Rhodophyta	Florideophyceae	***Womersleyella setacea* (Hollenberg) R.E.Norris, 1992**	E			U

Rhodophyta	Florideophyceae	***Xiphosiphonia pinnulata* (Kützing) Savoie & G.W.Saunders, 2016**		E		B, F