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Agenda item 5: Baseline for the IMAP Common Indicator 6 related to Non-Indigenous Species

Baseline for the IMAP Common Indicator 6 related to Non-Indigenous Species

Note by the Secretariat

At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and its Protocols adopted the Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP).

The IMAP foresees in its initial phase of implementation (2016-2019) the development of a baseline assessment of the extant non-indigenous species (NIS) (EO2) that will provide a reference point against which the success of future actions could be measured. After this baseline data has been gathered during the initial phase of IMAP, it will be possible to set reference levels, following the assessment criteria set out in the Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7). In addition, the Contracting Parties requested the Secretariat to develop citizen survey guidance for NIS, to enable them to use this additional cost-efficient methodology, which also strengthens public awareness and participation.

At their 20th Ordinary Meeting (COP 20, Tirana, Albania, 17-20 December 2017), the Contracting Parties endorsed, in Decision IG.23/6, the key findings of the 2017 Mediterranean Quality Status Report (the MED QSR Decision), that captured the sporadic inventories of NIS and the importance of assessing their pathways and impacts and highlighted the increasing trend of new introductions of alien species into the Mediterranean.

In this context, the Contracting Parties to the Barcelona Convention were asked to designate national experts that will establish the inventory/baseline of NIS at national level. This baseline will be used as a reference point for new introductions of NIS during the forthcoming assessments (2023) that will be made within the Ecosystem Approach process and the IMAP.

The baseline is being developed in synergy with the EU Marine Strategy Framework Directive (MSFD), where each European Member State has already established its own baseline since 2012 (Tsiamis et al., 2021). A common template was agreed to be used in close collaboration with the Joint Research Centre (JRC) of the European Commission to avoid duplication of work. Completed templates filled by the designated national experts, discussed by the informal Online Working Group on NIS and endorsed by the Focal Points through the CORMON and, as appropriate, will be uploaded to the Marine Mediterranean Invasive Alien Species Database (MAMIAS)¹.

This document presents the elaboration process of refined NIS baseline inventories at national, sub-regional and regional levels based on a collaborative approach including the national experts designated by the CPs and with the participation of regional and international NIS experts.

The present document is submitted to this CORMON Meeting on Biodiversity and Fisheries for endorsement and agreement on the way forward for its use to the purpose of the 2023 Med QSR.

¹ It is an online platform created by SPA/RAC, in the framework of the Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea, and dedicated for the collection, exploitation, and dissemination of information on marine biological invasions in the Mediterranean Sea available as beta version at <http://dev.mamias.org>

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List of Acronyms

MEDQSR	Mediterranean Quality Status Report
ADRIA	Adriatic
AL	Albania
CBD	Convention on Biological Diversity
CI6	Common Indicator 6
CMED	Central Mediterranean
CPs	Contracting Parties
CY	Cyprus
DZ	Algeria
EcAp	Ecosystem Approach
EG	Egypt
EL	Greece
EMED	Eastern Mediterranean
EO2	Ecological Objective 2
ES	Spain
EU	European Union
FR	France
GEF	Global Environment Facility
GES	Good Environmental Status
HCMR	Hellenic Centre for Marine Research
HR	Croatia
IL	Israel
IMAP	Integrated Monitoring and Assessment Programme
IT	Italy
JRC	Joint Research Centre
LB	Lebanon
LY	Libya
MA	Morocco
MAMIAS	Marine Mediterranean Invasive Alien Species
ME	Montenegro
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MT	Malta
NIS	Non-indigenous species
SI	Slovenia
SPA/RAC	Specially Protected Areas Regional Activity Centre
TN	Tunisia
TR	Turkey
WMED	Western Mediterranean
UNEP/MAP	United Nation Environment Programme / Mediterranean Action Plan

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1. Introduction

Non-indigenous, invasive species are globally acknowledged as one of the major threats to biodiversity, ecosystems and the services they provide (CBD, 2010; EU, 2011). As a consequence, they constitute one of the elements that are taken into consideration when assessing the health of the environment and formulating management strategies in order to achieve and sustain good ecological status (EU, 2008; UNEP/MAP, 2016). In the framework of the Integrated Monitoring and Assessment Programme for the Mediterranean Sea (IMAP), NIS are addressed with Common Indicator 6 (CI6), which assesses “Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species”. The national implementation and harmonization of IMAP across all Mediterranean countries requires the elaboration of a number of parameters, among which the establishment of a refined baseline of the NIS present at the national and regional level, is fundamental as a starting point for any further evaluations.

The present work aimed to collect the available material on the presence of marine NIS in the Mediterranean countries in the form of existing national inventories, combine it with new and up-to-date information on new species records, the taxonomy and biogeography of the registered species and agreed methodological standards, in order to arrive at refined NIS baselines at the national and regional level. The final outcome is the result of a collaborative process between national and regional experts, involving detailed exchange of information and the building of consensus on the final lists, as these will constitute a tool for the determination of thresholds for CI6 and will have management implications for the Contracting Parties.

2. Methodology for the elaboration of the NIS Baseline in the Mediterranean

The workflow of the elaboration process included 3 major steps, A) the critical revision and update of the existing national inventories by SPA/RAC regional experts; B) the subsequent validation of the revised lists with the contribution of national experts, invited/consulted taxonomic experts and the NIS Online Working Group, leading to the refined and finalised inventories and C) the compilation of the regional and subregional baseline, where national data were aggregated at two levels, the EcAp subregion level and the pan-Mediterranean level. These 3 steps are presented in detail below.

2.1. National inventories and first revision by regional experts

2.1.2. Data and definitions

The national inventories of EU Mediterranean countries submitted to JRC (Joint Research Centre of the European Commission) in January 2021 for the purposes of the 2012-2017 assessment cycle, were made available and formed the starting point for the revision process of these 8 countries. These included data up until 2017. For the rest of the Mediterranean countries, national NIS inventories were provided by national experts designated by the CPs to the Barcelona Convention, for Albania, Algeria, Israel, Lebanon, Libya, Morocco and Tunisia. For a small number of countries that had not submitted national inventories (see Table 1), initial national baselines were created with data retrieved from the Hellenic Centre for Marine Research (HCMR) offline database.

Table 1. Initial NIS inventories that formed the starting point for each national baseline, along with the source that provided the data

Country	Data Source
Albania (AL)	National expert
Algeria (DZ)	National expert
Bosnia-Herzegovina	HCMR database – 1 record only
Croatia (HR)	JRC/Tsiamis et al. 2021/National experts
Cyprus (CY)	JRC/Tsiamis et al. 2021
Egypt (EG)	National expert
France (FR)	JRC/Tsiamis et al. 2021/national expert
Greece (GR)	National expert
Italy (IT)	JRC/Tsiamis et al. 2021/National experts
Israel (IL)	National expert
Lebanon (LB)	National expert
Libya (LY)	National expert
Malta (MT)	National expert/ JRC/Tsiamis et al. 2021
Monaco	NA
Montenegro (ME)	HCMR database
Morocco (MA)	National expert
Slovenia (SI)	National expert
Spain (ES)	National expert
Syria (SY)	HCMR database
Tunisia (TN)	HCMR database/ National expert
Turkey (TR)	HCMR database/National experts

a. Taxonomic groups

Unicellular plankton species were not included in the inventories, as most of the recent checklist on Mediterranean NIS have excluded them (Zenetos et al., 2017; Galil et al., 2018) because their origin is in doubt and subject to revisions. In exceptional cases they will be listed (case by case).

Parasites on the other hand were included in accordance with the latest recommendations (UNEP/MED, 2021) and recent literature (at the basin level see Zenetos et al., 2008 and at country level e.g., Libya: Shakman et al., 2019; Tunisia: Ounifi-Ben Amor et al., 2016; Israel: Galil et al., 2020).

Foraminifera were treated inconsistently, with most but not all countries including them in their inventories, and a strong divergence of opinion among national experts on the status of many species. As a result, particular attention was paid to this group, with the invited contribution of a large number of taxonomic experts, and the results are presented in a separate section of this report. Moreover, foraminifera species are presented in a separate worksheet of the Baselines Excel spreadsheets.

b. Establishment success

The establishment success of each NIS is reported as:

Established: Species with >2 records distributed in space and time, indicating self-sustaining populations, according to recent literature. Includes locally established species.

Casual: Species with 1 or 2 records of live specimens.

Invasive: Species with evidence of large populations, rapid spread and potentially documented impacts on biodiversity and ecosystem services in the Mediterranean. The strength of evidence for the documentation of impacts can vary from field experiments and direct observations to non-experimental based correlations and expert judgement.

Unknown: Species with 1 or 2 records of live specimens after 2010, where reporting lags may conceal their true establishment status as well as old records whose recent population status is not reported/published.

Questionable: the term was applied to species whose establishment success is unknown (even though the record itself is valid) because the species were not found again in repeated surveys since the first finding.

Clarification: species records with insufficient information (e.g., no voucher or description provided) or with uncertain identification, whose presence in the country needs to be confirmed (by re-examination of material if available). These records are annotated as QR (questionable record) and are not retained in the final NIS lists but are presented together with the data deficient species.

Excluded: Records of species based on non-living animals (applies mostly to Mollusca) and records of species not reported in the wild (e.g., polychaeta, bryozoa found only on ship hulls) are explicitly annotated and were excluded from the validated regional/subregional checklists but are still reported for future reference.

Where establishment success information was not provided by the countries, it was extracted from the offline HCMR database. Two cases are noteworthy: i) for Italy, the establishment success followed Servello et al. 2019 but the information was not revised and validated by national experts and for Israel, the establishment success was interpreted by the regional experts, based on the population status (i.e. abundant, common, local, rare, single record) which was provided by Israel's national experts, complemented by the literature and the HCMR database.

c. Alien / ambiguous status

The alien status is reported as:

Alien: species with clear evidence of their non-native origin and strong indication of an anthropogenic mode of introduction.

Partly native: i.e., species that are native in a Mediterranean country while they are non-indigenous in other Mediterranean countries.

Range-expanding: i.e., species that have most likely entered the Mediterranean through natural range expansion.

Cryptogenic i.e., species that cannot be demonstrably classified as native or non-indigenous in a particular region.

Crypto-expanding: species with some evidence on their non-indigenous status but with uncertainty due to unclear mode of introduction from the native range (natural spread vs human mediated).

Debatable/Status unresolved: species with unresolved taxonomic status, e.g., species complexes, suspected undescribed native species, or species where taxonomic experts' opinions differ. These species were the subject of extensive discussion during the elaboration process and are explicitly annotated/presented separately in the final regional baseline.

Native and range-expanding species were excluded from the inventories during the revision and validation process.

d. Pathway of introduction

The most plausible pathway(s) of introduction at national level was inserted by most countries. Only two countries (Albania and Syria), did not include pathway/vector. In case it was reported in the old way, it was interpreted according to the CBD (2014) classification scheme e.g., canals/Suez Canal as Corridor, Vessels/shipping as Transport –Contaminant, Culture as Escape from Confinement or Release in Nature. The pathway field was not filled in the same way by all countries. In European countries, it followed the JRC template, while in the non-EU countries it was reported in one column, either abbreviated or in full. However, this was amended at the regional scale. In case the pathway was missing, it was extracted either from the EASIN database or the relevant publications when possible. Despite the efforts, the pathway remained unknown in some cases.

e. Reference year

The reference year for the baseline was selected on the basis of two parameters. The first is related to the trends of new introduction of non-indigenous species in the Mediterranean, as revealed by preliminary analysis of the relevant data in recent publications [e.g., Algeria (Grimes et al., 2018; Bensari et al., 2020; Bakalem et al., 2020, Libya (Shakman et al., 2019); Montenegro (Petović et al., 2019; Pešić et al., 2020); Israel (Galil et al., 2020)] and the HCMR database (UNEP/MED WG. 500/7 – Zenetos & Galanidi, 2021). The second is motivated by the need to harmonise with the timeframe of similar work carried out for the purposes of the MSFD, which includes 8 of the 21 Contracting Parties to the Barcelona Convention and the Mediterranean region as a whole. Trends in new marine NIS introductions between 1970 and 2020 are consistently increasing throughout the Mediterranean and, in many countries, this is the result of increased scientific effort, thus the reference year should be the most recent year practical. Following the assessment and reporting 6-year periods already established for EU countries under the MSFD, where the next assessment will cover the 2018-2023 period, it was recommended that the reference year to set national NIS baselines for the Mediterranean should be 2017.

Nevertheless, national inventories, as well as the regional and subregional database are prepared and submitted with data until 2020, i.e., species detected until December 2020 and published until February 2022. This facilitates the updating of MAMIAS and EASIN with the most up-to-date information and enables the publication of a truly authoritative work on the current state of marine NIS in the Mediterranean. Furthermore, it contributes to the continuous work necessary to carry out the forthcoming status assessment (2023 MED QSR) in the framework of IMAP, as well as reporting for the MSFD for the subset of EU Mediterranean countries.

2.1.3. First round of revisions by the regional experts

Initial inventories were updated with new data up to 2020, according to recently published literature and major national/regional reviews (Zenetos et al., 2017 and Zenetos & Galanidi, 2020 for the whole Mediterranean, Katsanevakis et al., 2020 for previously unpublished records, Servello et al., 2019 for Italy, Zenetos et al., 2020 for Greece, Algeria : Grimes et al., 2018 ; Libya : Shakman et al., 2019 ; Israel : Galil et al. 2020; Tunisia : Ounifi-Ben Amor et al., 2016; Lebanon : Bitar et al., 2017 marine plants, Bariche et al., 2020 fishes; Turkey : series of publications on Turkish marine fauna and flora in 2014, Turan et al., 2018 for fishes, Çınar et al., 2021 for the most recent comprehensive update ; Montenegro : Petović et al., 2019 and Pešić et al., 2020; Egypt : reviews by taxonomic group, e.g. Zakaria et al., 2016 for zooplankton, Akel & Karachle, 2017 for fishes; Halim & Abdel Messeih, 2016 for ascidians; Syria : Ammar, 2019 for zoobenthos, Ali, 2018 for fishes).

Additional records were sought in global biodiversity databases, i.e., Global Biodiversity Information Facility (GBIF) and Ocean Biodiversity Information System (OBIS) as appropriate and validated through personal communications with local and taxonomic experts where necessary.

Moreover, major taxonomic reviews and Atlases were consulted for updates on the alien status of species; specifically, Isopoda were revised following Castelló et al., 2020, Polychaeta according to Zenetos et al., 2017 and Langeneck et al., 2020 (but see further discussion about polychaeta in section C), macroalgae based on Verlaque et al., 2015 and Mollusca based on Crocetta et al., 2017 and Albano et al., 2021. Foraminifera were treated at this stage according to Stulpinaite et al., 2020 (for more details see dedicated section).

Finally, nomenclature was revised where necessary following WoRMS (2021), and the year/reference of first record in each country was double-checked and corrected in a large number of cases.

At this end of this phase, 19 updated NIS inventories were elaborated and shared with the national experts for a validation process.

2.2. Validation process

During the validation phase, the revised inventories were sent back to the national experts who were asked to assess the validity of species additions and removals, the corrections in first record citations, comment on potential misreporting and misidentifications and add any further records based on national data. Particular attention was paid to the alien status of species, where a number of uncertainties and discrepancies was observed in the assignment of species to the different categories, most notably the cryptogenic and debatable species. Expert advice for certain taxonomic groups, such as macroalgae, polychaetes, ascidians (see Annex I for selected communications) was sought from recognised taxonomic experts who offered valuable insights and help clarify the status of many debatable species.

After several rounds of communication with countries' experts whereby many of these discrepancies were resolved, a workshop was organised in July 2021 with the wider participation of appointed national experts for the NIS Baselines as well as experts from the NIS Online Working Group. Besides general considerations about how the debatable species should be approached at the regional level, a number of species were also discussed individually and were agreed upon.

Taking into consideration the outcomes of this workshop, additional rounds of revisions at the bilateral and group level ensued, including status changes and additions of new species records as new literature emerged. A chronicle of the major revision/validation steps until the national inventories were finalised is presented in Table 2.

Table 2. Chronicle of revisions

Country	1 st validation	2 nd validation	final
Albania (AL)	29.04.2021		29.04.2021
Algeria (DZ)	21.04.2021		21.04.2021
Croatia (HR)	07.06.2021		07.06.2021/28.01.2022
Cyprus (CY)	24.04.2021		26.10.2021
Egypt (EG)	07.06.2021	24.09.2021	21.10.2021/24.10.2021
France (FR)	11.05.2021	18.05.2021	19.10.2021/2.12.2021
Greece (GR)			21.10.2021/29.01.2022
Italy (IT)	17.05.2021	11.06.2021	14.09.2021/24.12.2021

Israel (IL)	04.06.2021	08.07.2021	07.09.2021
Lebanon (LB)	30.04.2021		30.04.2021
Libya (LY)	28.04.2021		28.04.2021
Malta (MT)	30.04.2021		30.04.2021
Montenegro (ME)	20.04.2021		20.04.2021
Morocco (MA)	22.04.2021		22.04.2021
Slovenia (SI)	04.05.2021		06.05.2021
Spain (ES)	04.06.2021	31.08.2021	15.10.2021/20.12.2021
Syria (SY)	16.07.2021		21.07.2021
Tunisia (TN)	NA	NA	Revised HCMR data
Turkey (TR)	12.05.2021	27.05.2021	27.05.2021

2.3. Collation of the Regional & Subregional Baselines

Once all national inventories were completed, data was aggregated at two levels, the EcAp subregion level and the pan-Mediterranean level. Year of first detection and establishment success of each species were adjusted accordingly. Regarding pathway of introduction, at the regional and subregional level, pathways were assigned according to the most likely means of primary introduction of the first record in the region/each subregion respectively. The regional and subregional spreadsheets contain the following information: Species name and authority, taxonomic classification (Kingdom, Phylum, Class, Order, Family), year of first detection, country of first detection, citation for the first record, alien status, overall establishment success in the Mediterranean, primary pathway of introduction. Due to the different strength of evidence for the documentation of invasiveness, this information is presented at the subregional level in addition to establishment success, accompanied by country annotations. Any unresolved differences with regards to alien status of species or the validity of specific records were explicitly presented.

Draft versions were sent to all national experts for a final check and a second workshop was organised on the 1st of December 2021 to discuss any pending issues with regards to differences in alien status classification among countries and how to handle these at the regional level. Two were the main outcomes of this workshop: a) crypto-expanding species may be assigned a different status in different subregions, depending on their origin and the strength of evidence about a potential introduction or natural expansion, and b) Prof. M.E. Çınar pointed out that it is unadvised to exclude any species from the NIS lists without providing any concrete evidence and data, e.g., making comparisons of the Mediterranean individuals identified as the species with their type specimens. With particular reference to polychaete species, it was highlighted that for many of the debatable species, their morphology and pattern of distribution/spread provide strong indications for an alien origin and it was proposed that, instead of regarding these species as debatable or questionable, we consider them “likely alien species”.

Therefore, in order to avoid the introduction of too many different terms, all species that were previously referred to as debatable, species for which experts’ opinions differ, as well as likely alien polychaete species are placed in a Data Deficient category for the attention of scientists, as a reference for future changes and updates and until further evidence unequivocally resolves their status. These species are reported separately in the regional baselines, but the consensus was not to consider them for GES assessments until there is more conclusive evidence for their status.

A third important outcome was the almost unanimous support for the inclusion of Foraminifera species in the baseline, after rigorous validation by a group of taxonomic experts (see dedicated section for details).

In order to achieve the highest possible completeness and accuracy of the final baseline a few amendments were made to the validated national inventories in the light of new published evidence, and after consultation with the national experts involved.

3. Results

Non-Indigenous species

After the revision and validation process, the number of non-indigenous species present in each subregion and the whole basin can be seen in Table 3. In total, 1011 non-indigenous species have been found in Mediterranean marine waters, of which 748 are currently considered established, which makes the overall establishment rate almost 74%. This value varies in the different subregions, with the lowest establishment rate in CMED and the highest in EMED. When it comes to actual numbers, as expected, the eastern Mediterranean has the highest number of NIS with 786 species, followed by WMED, CMED and ADRIA.

Table 3. Number of NIS at the regional and subregional level and their establishment success.

(Sub)region	NIS	Established	Casual	Unknown	Questionable
EMED	786	570	175	38	3
CMED	286	180	73	32	1
ADRIA	207	140	43	21	3
WMED	322	221	74	23	4
MED	1011	748	224	35	4

Taxonomic groups

The 1011 Mediterranean NIS include 144 Macrophytes, 224 Mollusca, 188 Arthropoda, 203 Chordata, 83 Annelida, 33 Bryozoa, 42 Cnidaria, 47 Foraminifera and 47 taxa belonging to other taxonomic groups. The different taxonomic groups are variably represented in the 4 subregions (Figure 1). Macrophytes are the most dominant group in ADRIA and WMED, primarily as contaminants in shellfish consignments towards the major shellfish culture areas of the northern Adriatic and the French coast (see also next section on pathways of introduction). Mollusca, Arthropoda and Chordata (predominantly Osteichthyes) are the main taxa in EMED with more than 140 species each. Many of these are species of Indo-Pacific origin and warm affinities. Annelida almost invariably constitute 9-10% of the NIS found, regardless of subregion, while Osteichthyes is the most common taxon reported in the CMED. Foraminifera are represented by 43 species in the EMED (or 6%) but much lower species numbers (between 7 and 9 or 2-4%) in the other subregions.

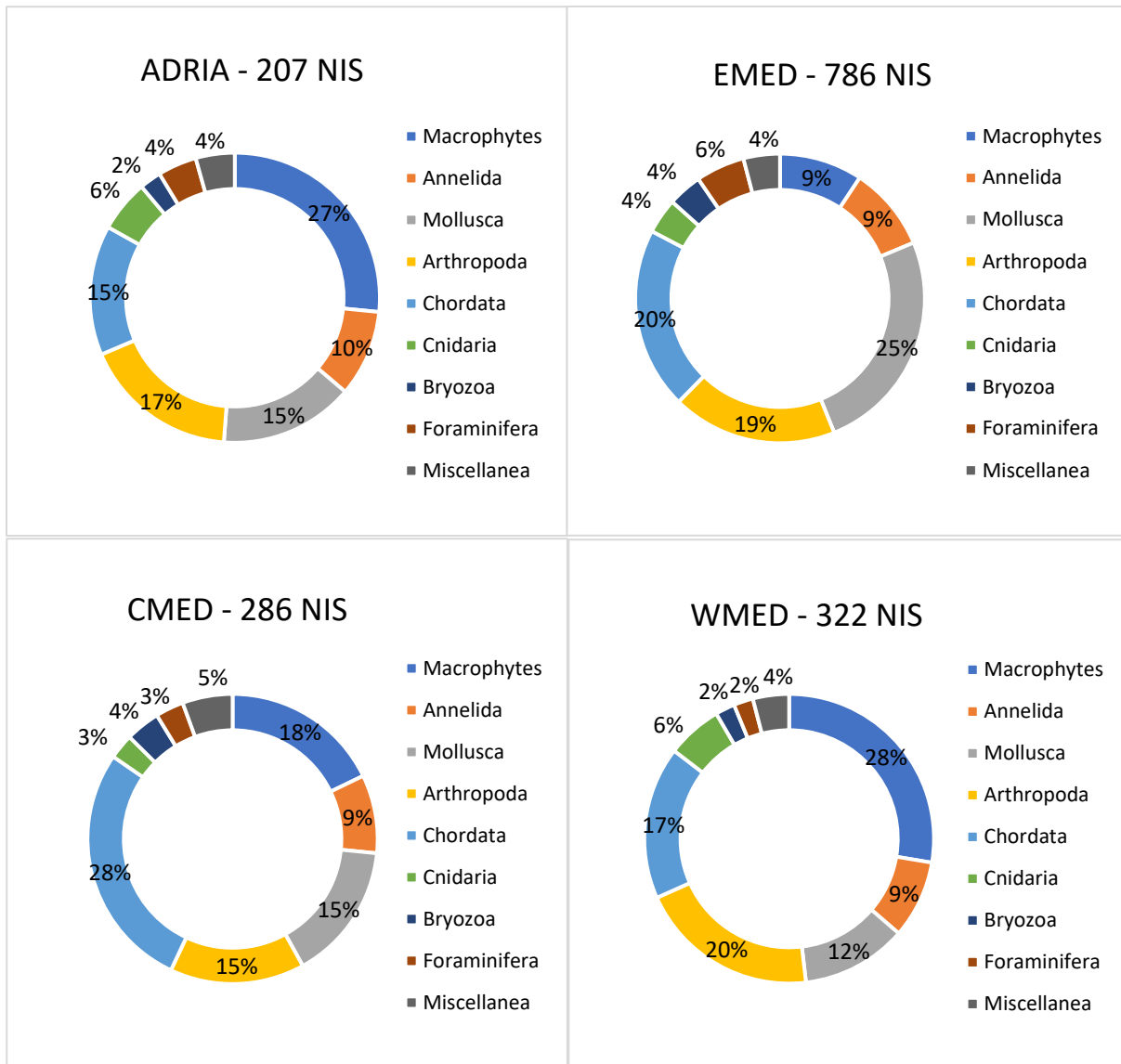


Figure 1. Representation of the major taxonomic groups among the NIS present in the different Mediterranean subregions.

Pathways of Introduction

Roughly half the non-indigenous species present in the Mediterranean have Corridor as their primary pathway of introduction, i.e., have most likely entered through the Suez Canal. This number reaches 60% in the Eastern Mediterranean, but this pathway is not applicable as we move westwards and northwards to the other subregions, where Lessepsian species migrate to a large extent by natural dispersal (pathway Unaided). CMED has the largest proportion of Unaided species, as it accepts naturally dispersing NIS propagules from all other subregions. Noteworthy also is the higher percentage of Contaminant species in ADRIA (19%) and the WMED (19.4%), which are linked to aquaculture activities, while escapees have their largest representation in ADRIA with 6% of the species linked to ornamental trade or escape from non-domestic aquaria. The two main shipping vectors together (i.e. Ballast water and Hull fouling) constitute the primary pathway for almost one third of the NIS entering the Mediterranean but as high as 45% of the NIS present in ADRIA.

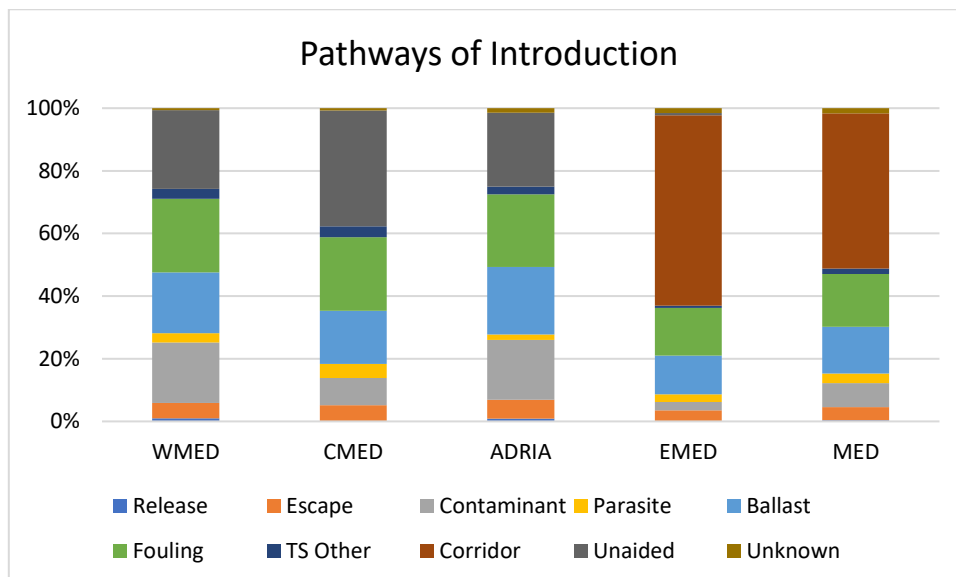


Figure 2. Primary pathways of introduction of marine NIS per Mediterranean subregion and regionally.

Species that were linked to more than one pathway were given a value of 1/k for each of the k associated pathways so that the overall contribution of each species to the total number of new aliens was always 1. Pathway names in the legend correspond to the CBD pathways as follows:

Release	RELEASE IN NATURE: Fishery in the wild (including game fishing)
	RELEASE IN NATURE: Other intentional release
Escape	ESCAPE FROM CONFINEMENT: Aquaculture / mariculture
	ESCAPE FROM CONFINEMENT: Botanical garden/zoo/aquaria (excluding domestic aquaria)
	ESCAPE FROM CONFINEMENT: Pet/aquarium/terrarium species (including live food for such species)
	ESCAPE FROM CONFINEMENT: Live food and live bait
Contaminant	TRANSPORT- CONTAMINANT: Contaminant on animals (except parasites, species transported by host/vector)
	TRANSPORT- CONTAMINANT: Contaminant on plants (except parasites, species transported by host/vector)
Parasite	TRANSPORT- CONTAMINANT: Parasites on animals (including species transported by host and vector)
Ballast	TRANSPORT- STOWAWAY: Ship/boat ballast water
Fouling	TRANSPORT- STOWAWAY: Ship/boat hull fouling
TS-Other	TRANSPORT- STOWAWAY: Angling/fishing equipment
	TRANSPORT- STOWAWAY: Hitchhikers on ship/boat (excluding ballast water and hull fouling)
	TRANSPORT- STOWAWAY: Organic packing material, in particular wood packaging
	TRANSPORT- STOWAWAY: Other means of transport
Corridor	CORRIDOR: Interconnected waterways/basins/seas
Unaided	UNAIDED: Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5

Temporal trends

The rate of new NIS introductions displays a generally upwards trend with a noticeable increase in the slope after the 1990’s in most Mediterranean subregions with the exception of WMED. In the last decade this trend appears to be levelling off, although values for 2010-2020 may still change slightly, given the lag between introduction, observation as well as reporting of new NIS sightings. The CMED is the only subregion where new NIS continue to appear at an increasing rate.

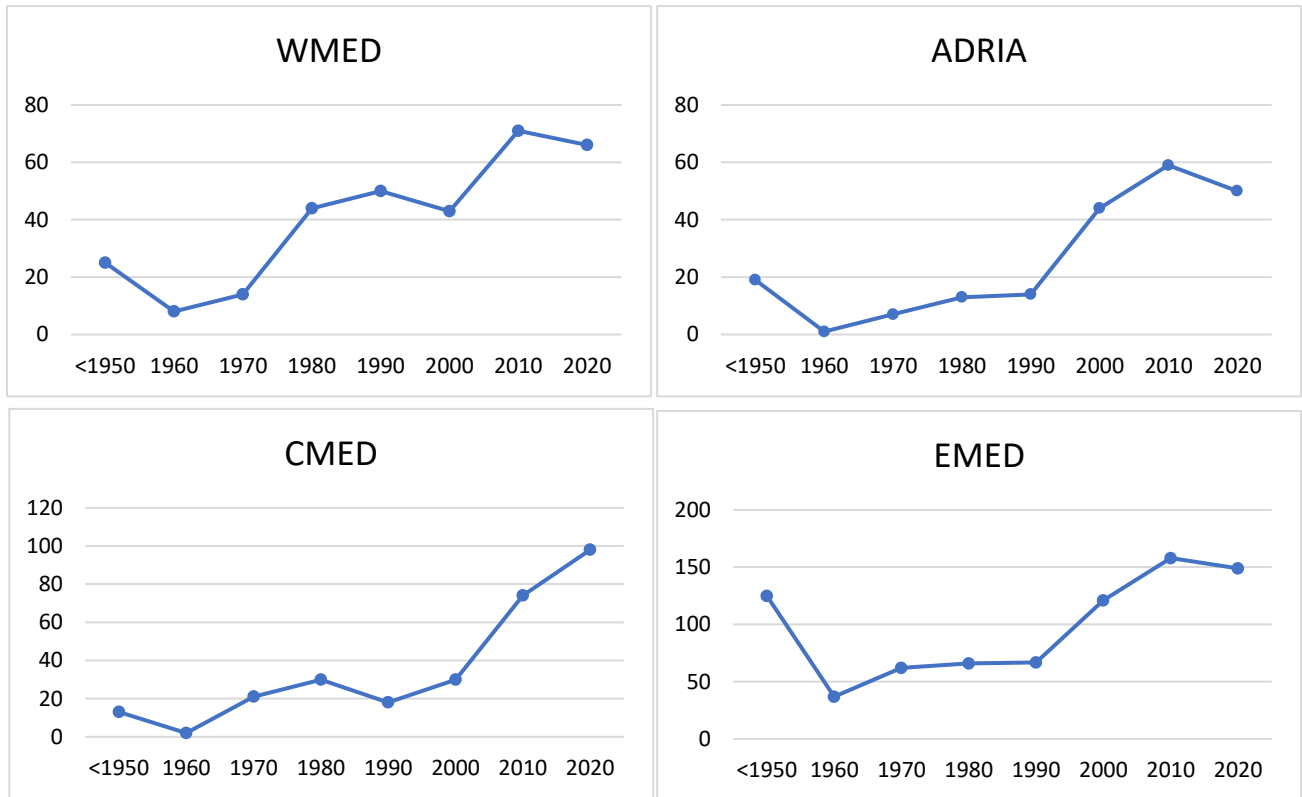


Figure 3. Trends in new introduction of validated NIS per decade in the Mediterranean subregions.

National level

The total number of NIS together with the cryptogenic and data-deficient species per Mediterranean country is depicted in Fig. 4. The highest number of species is observed in Israel and Turkey, followed by Italy, Lebanon and Egypt, with values generally decreasing as we move towards the Adriatic and west Mediterranean countries. It is worth noting that the relatively high numbers of cryptogenic and data deficient species in Italy and Spain is related to the more comprehensive reporting by these countries.

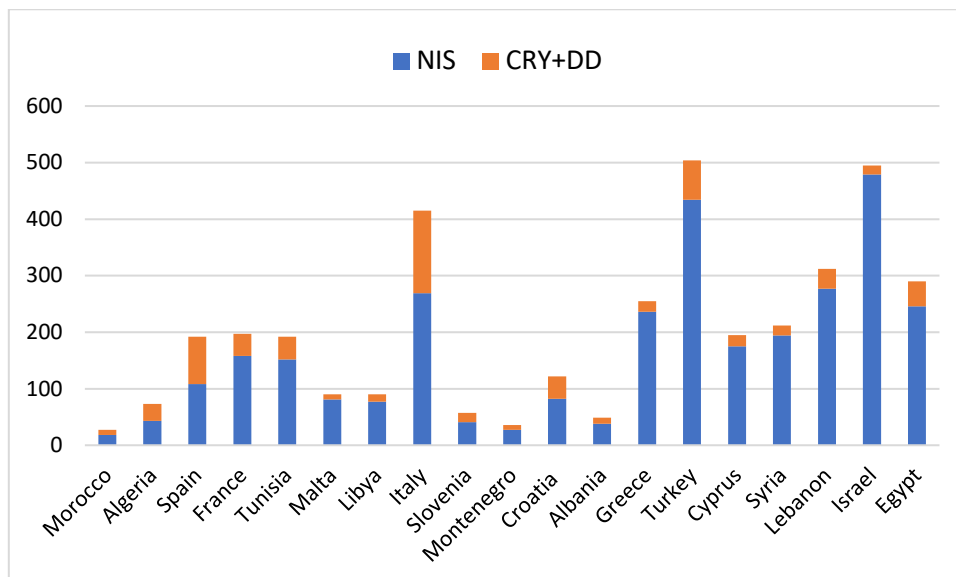


Figure 4. Total number of validated NIS per Mediterranean country (blue) with cryptogenic (CRY) and data deficient (DD) species displayed in orange.

Data deficient species

During the validation process, every effort was made to document all the changes made, differences of opinion among experts and the emergence of new information. Data deficient species not included in the final regional and subregional baselines, as described in the methodology section, are explicitly presented, both in the data spreadsheets and in the following Tables (Tables 4-7) as they can often be a source of confusion and ambiguity.

Table 4. Species with debatable alien status, where expert opinions differ. These are placed in the Data deficient category and it was agreed that they should not be used for GES assessments.

Species	Divergent opinions
<i>Abudefduf</i> spp.	WMED, ADRIA, EMED - Specimens of the genus <i>Abudefduf</i> visually classified may belong to different cryptic species of genus <i>Abudefduf</i> (Dragicevic et al. 2021) and require further investigation. Only molecularly identified specimens of the introduced species are retained as valid records.
<i>Acanthophora nayadiformis</i> (Delile) Papenfuss, 1968	NIS in TR, IL - CRY elsewhere in the MED
<i>Alexandrium taylori</i> Balech	NIS in ES, cryptogenic elsewhere
<i>Amathia verticillata</i> (delle Chiaje 1822)	NIS in TR, IL - CRY elsewhere in the MED
<i>Amphibalanus improvisus</i> (Darwin, 1854)	NIS in TR - CRY elsewhere
<i>Amphisorus hemprichii</i> Ehrenberg, 1840	NIS in TR - cryptogenic elsewhere
<i>Anotrichium okamurae</i> Baldock, 1976	NIS in IL - <i>A. furcellatum</i> elsewhere, Cryptogenic
<i>Atys angustatus</i> E. A. Smith, 1872	CRY in TR - NIS elsewhere in the MED
<i>Bursatella leachii</i> Blainville, 1817	CRY in IT, IL - NIS elsewhere in the MED - inv in DZ, MA, ES

<i>Diplosoma listerianum</i> (Milne Edwards, 1841)	NIS in FR, GR, SI, TR - CRY in IT, ES
<i>Ectocarpus siliculosus</i> var. <i>hiemalis</i> (P.L.Crouan & H.M.Crouan) Gallardo	NIS in IT - CRY in TR
<i>Filellum serratum</i> (Clarke, 1879)	NIS in TR - CRY elsewhere in the MED
<i>Ganonema farinosum</i> (Lamouroux) Fan & Wang, 1974	NIS in TR, IL - CRY elsewhere in the MED
<i>Hydroides dirampha</i> Mörch, 1863	CRY in ES - NIS elsewhere in the MED
<i>Hydroides elegans</i> (Haswell, 1883)	CRY in ES - NIS elsewhere in the MED
<i>Latigammaropsis togoensis</i> (Schellenberg, 1925)	NIS in TR - CRY in IL, TN
<i>Laurencia minuta</i> Vandermeulen, Garbary & Guiry 1990	NIS in IL - Cryptogenic/species complex?
<i>Microporella harmeri</i> Hayward, 1988	NIS in IL - Cryptogenic/species complex? (Zenetos et al., 2017)
<i>Niphates toxifera</i> Vacelet, Bitar, Carteron, Zibrowius & Pérez, 2007	NIS in TR - possibly native in IL, debatable alien status in the MED
<i>Ophioblennius atlanticus</i> (Valenciennes, 1836)	NIS in IT - REX in MT
<i>Percnon gibbesi</i> (H. Milne Edwards, 1853)	NIS in TR - CRY-EX elsewhere in the Med
<i>Pylaiella littoralis</i> (Linnaeus) Kjellman	CRY in ES, NIS elsewhere
<i>Pyropia koreana</i> (M.S.Hwang & I.K.Lee) M.S.Hwang, H.G.Choi Y.S.Oh & I.K.Lee, 2011	NIS in IL - CRY elsewhere in the MED
<i>Thecacera pennigera</i> (Montagu, 1813)	NIS in IT - CRY elsewhere in the MED
<i>Vertebrata fucoides</i> (Hudson) Kuntze 1891	NIS in TR - CRY elsewhere in the MED

Two foraminifera species, namely *Amphistegina lobifera* Larsen, 1976 and *Amphistegina lessoni* d'Orbingy in Guérin-Méneville, 1932, were discussed during the workshops and in bilateral communications with some experts who consider them cryptogenic. Finally, it was agreed to retain them as non-indigenous throughout the Mediterranean as per the opinion of the consulted foraminifera experts.

Table 5. Polychaete species previously classified as questionable alien species in the Mediterranean following Langeneck et al. (2020) and now characterised as likely alien as per the recommendation of M.E. Çinar

Likely alien polychaeta	
<i>Eurythoe complanata</i> (Pallas, 1766)	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar
<i>Eurythoe laevisaetis</i> Fauvel, 1914	NIS in MT - excluded by ES as range expanding (1992, Arias et al., 2013)
<i>Lumbrinerides neogesae</i> Miura, 1981	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar
<i>Metasychis gotoi</i> (Izuka, 1902)	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar
<i>Neopseudocapitella brasiliensis</i> Rullier & Amoureux, 1979	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar

<i>Novafabricia infratorquata</i> (Fitzhugh, 1973)	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar
<i>Pista unibranchia</i> Day, 1963	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar
<i>Polydora colonia</i> Moore, 1907	NIS in ES - QUE in IT (following Langeneck et al., 2020)
<i>Sigambra parva</i> (Day, 1963)	Questionable species in the MED according to Langeneck et al. (2020) - accepted as Likely alien following the recommendation by M.E. Çinar

Five more polychaeta species were concluded by Langeneck et al. (2020) as having questionable records in Italy specifically but are considered as valid NIS for the rest of the Mediterranean. These are:

Axionice medusa (Savigny, 1822)

Leodice antennata Savigny in Lamarck, 1818

Nereis persica Fauvel, 1911

Prionospio pulchra Imajima, 1990

Prionospio sexoculata Augener, 1918

Finally, regarding polychaetes, it is noted that a number of species are present at the national or subregional level only, which were previously listed as NIS but currently considered as questionable following Langeneck *et al.* (2020) and it is recommended that a re-examination of the available material, in comparison with type specimens and possibly in conjunction with molecular methods in order to reach a more conclusive decision about their status.

Table 6. Likely alien polychaete species with a restricted national or subregional distribution which require further investigation to fully clarify their status.

Species	Country
<i>Diopatra hupferiana hupferiana</i> (Augener, 1918)	IT
<i>Dispio uncinata</i> Hartman, 1951	IT, MT, ES, HR
<i>Erinaceusyllis serratosetosa</i> (Hartmann-Schröder, 1982)	IT, ES
<i>Hesionura serrata</i> (Hartmann-Schröder, 1960)	IT, ES
<i>Leiochrides australis</i> Augener, 1914	IT, ME, ES
<i>Lumbrinerides acutiformis</i> Gallardo, 1968	IT
<i>Mediomastus capensis</i> Day, 1961	IT, GR, HR
<i>Neanthes agulhana</i> (Day, 1963)	GR, IT, HR, ES
<i>Notopygos megalops</i> McIntosh, 1885	IT
<i>Oenone cf. fulgida</i> (Lamarck, 1818)	IT
<i>Podarkeopsis capensis</i> (Day, 1963)	IT, HR
<i>Prionospio pygmaeus</i> Hartman, 1961	IT, EG
<i>Protodorvillea egena</i> (Ehlers, 1913)	IT
<i>Rubifabriciola ghardaqa</i> (Banse, 1959)	IT

Species records currently excluded from the regional/subregional baselines because they were either not found in the wild or their records are based solely on casual findings of empty shells are presented for future reference.

Table 7. Species excluded from the regional and subregional baselines because they were either not found in the wild or their records are based solely on casual findings of empty shells.

Species	Year	Country	Reference	Reason for exclusion
<i>Boccardia proboscidea</i> Hartman, 1940	2014	France	Radashevsky et al., 2019	in oyster shell in a restaurant
<i>Celleporaria pilaefera</i> (Canu & Bassler, 1929)	1975	Malta	Agius et al., 1977	on aquaculture cages
<i>Saccostrea glomerata</i> (Gould, 1850)	2015	France	Ulman et al., 2017	on boat hull
<i>Canarium mutabile</i> (Swainson, 1821)	1991	Israel	Mienis, 2001b	shell only
<i>Ergalatax contracta</i> Reeve, 1846	2001	Israel	Mienis, 2004a	shells only
<i>Haliotis pustulata</i> Reeve, 1846	1961	Israel	Talmadge, 1971	shells only
<i>Nassa situla</i> (Reeve, 1846)	2004	Israel	Mienis, 2008	shell only
<i>Nassarius concinnus</i> (Powys, 1835)	1968	Israel	Mienis, 2008	Shell only
<i>Notocochlis gualtieriana</i> (Récluz, 1844)	1961	Israel	Mienis, 1986/Mienis, 2000	shells only
<i>Rhinoclavis sinensis</i> (Gmelin, 1791)	2003	Israel	Mienis, 2004	shell only
<i>Rissoina spirata</i> Sowerby, 1825	2997	Israel	Gianuzzi-Savelli, 1997	shell only

Foraminifera

Following the recommendations of the OWG, taxonomic experts were invited to review and agree on a final list of Foraminifera to be considered for the actual analysis.

Following the correspondence, the list of the assigned new and controversial species is as follows:

Added in the Med list as NIS

<i>Ammodiscus gullmarensis</i> Höglund, 1948
<i>Cornuspiroides striolata</i> (Brady, 1882)
<i>Nodobaculariella cristobalensis</i> McCulloch, 1977
<i>Nodobaculariella galapagosensis</i> McCulloch, 1977
+ the ones present only in Israel detailed in the following list

species	detection year	pathway	establishment success	source	Remarks	
<i>Agglutinella compressa</i> El-Nakhal, 1983	NIS	1998	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Ammodiscus gullmarensis</i> Höglund, 1948	NIS					Alien for the moment as it has been described first from the Gullmar Fjord in 1947, but appears also in the Mediterranean under the name <i>Involuntina</i> cf. <i>I. planorbis</i> (Parker 1958, Pl. 1 figs. 1-2) and <i>Ammodiscus planus</i> since at least 1976 (see Cimerman and Langer 1991 pl. 2). Highly likely that it was here before, but not reported
		2013	COR, TS	est	Hyams-Kaphzan et al., 2018 as <i>Ammodiscus planorbis</i>	
<i>Amphistegina lessonii</i> d'Orbigny, 1826	NIS	1996	COR, TS	est	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Amphistegina lobifera</i> Larsen, 1976	NIS	1950	COR, TS	inv	Emery & Neev, 1960	
<i>Borelis schlumbergeri</i> (Reichel, 1937)	NIS	1999	COR, TS	est	Hyams, 2000; Lazar 2007	Elongate <i>Borelis schlumbergeri</i>
<i>Cibicides mabahethi</i> Said, 1949	NIS	1998	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Clavulina</i> cf. <i>C. multicamerata</i> Chapman, 1907	NIS	1999	COR, TS	cas	Hyams, 2000 as <i>Clavulina angularis</i> d'Orbigny	
<i>Cycloforina</i> sp.	NIS	2002	COR, TS	cas	Langer, 2008	
<i>Elphidium striatopunctatum</i> (Fichtel & Moll, 1798)	NIS	1998	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Epistomaroides punctulata</i> (Said, 1949)	NIS	2005	COR, TS	est	Almogi-Labin & Hyams-Kaphzan, 2012	
<i>Haddonina</i> sp.	NIS	1996	COR, TS	cas	Hyams-Kaphzan, unpublished	
<i>Pseudohauerina diversa</i> ex <i>Hauerina diversa</i> Cushman, 1946	NIS	1993	COR, TS	est	Yanko et al., 1998	
<i>Heterostegina depressa</i> d'Orbigny, 1826	NIS	1993	COR, TS	est	Yanko et al., 1998 (not illustrated)	
<i>Loxostomina</i> cf. <i>L. africana</i> (Smutter, 1955)	NIS	1996	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Neoconorbina clara</i> (Cushman, 1934)	NIS	1997	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Operculina ammonoides</i> (Gronovius, 1781)	NIS	<1995	COR, TS	est	Yanko, 1995/Merkado, 2016	I don't have Yanko 1995
<i>Pararotalia</i> cf. <i>P. socorroensis</i> (McCulloch, 1977)	NIS	1997	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Paratrochammina madeirae</i> Brönnimann, 1979	NIS	1997	COR, TS	cas	Hyams, 2000/Hyams Kaphzan et al., 2008	
<i>Pegidia lacunata</i>	NIS	1994	COR, TS	cas	Langer, 2008	
<i>Planispirinella exigua</i> (Brady, 1879)	NIS	1997	COR, TS	cas	Hyams-Kaphzan, unpublished/Stulpinaite et al. 2020	
<i>Planogypsina acervalis</i> (Brady, 1884)	NIS	1998	COR, TS	cas	Hyams-Kaphzan, unpublished/Stulpinaite et al. 2020	
<i>Praceroelagena oceanica</i> (Albani, 1974)	NIS	2003	COR, TS	cas	Hyams, 2006/Hyams-Kaphzan, 2016	
<i>Pseudohauerinella dissidens</i> (McCulloch, 1977)	NIS	1998	COR, TS	est	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Pseudomassilina australis</i>	NIS					This species was not found along the Israeli coasts (only <i>P. cf. P. austarilis</i>)
<i>Pseudomassilina reticulata</i> (Heron-Allen & Earland, 1915)	NIS	1993/1998	COR, TS	cas	Yanko et al., 1993/ 1998 by Hyams, 2000	I don't have Yanko 1993 so I can't check
<i>Pyrgo denticulata</i> (Brady, 1884)	NIS	1993/ 1996	COR, TS	est	Yanko et al., 1993/1996 by Hyams (2000)	I don't have Yanko 1993
<i>Quinqueloculina</i> cf. <i>Q. mosharrafai</i> Said, 1949	NIS	2013	COR, TS	cas	Hyams-Kaphzan et al., 2014	
<i>Quinqueloculina</i> cf. <i>Q. multimarginata</i> Said, 1949	NIS	1996	COR, TS	cas	Hyams, 2000/Hyams Kaphzan et al., 2008	
<i>Sigmamiliolinella australis</i> (Parr, 1932)	NIS	2005	COR, TS	est	Avnaim-Katav, 2010 core-top; Hyams-Kaphzan et al., 2014	
<i>Siphonaperta distorta</i> (Cushman, 1954)	NIS	1996	COR, TS	est	Hyams, 2000/Hyams-Kaphzan et al., 2008	
<i>Sorites variabilis</i> Lacroix, 1941	NIS	1993	COR, TS	est	Yanko et al., 1998	Not illustrated
<i>Naxotia attenuata</i> ex <i>Spiraloculina attenuata</i> Cushman & Todd,	NIS	1997	COR, TS	cas	Hyams, 2000/Hyams Kaphzan et al., 2008	
<i>Spiroloculina</i> aff. <i>S. communis</i> Cushman & Todd, 1944	NIS	1996	COR, TS	cas	Hyams, 2000 /Hyams Kaphzan et al., 2008	
<i>Spiroloculina angulata</i>	NIS	1993	COR, TS	est	Yanko et al., 1993	I don't have Yanko 1993
<i>Spiroloculina nummiformis</i> Said, 1949	NIS	1997	COR, TS	cas	Hyams, 2000/Hyams Kaphzan et al., 2008	
<i>Varidentella</i> cf. <i>V. neostriatula</i> (Thalman, 1950)	NIS	1996	COR, TS	cas	Hyams, 2000; Hyams Kaphzan et al., 2008	
<i>Nodophthalmidium antillarum</i>	NIS	1991	COR, TS	est	Yanko et al. 1994/Hyams, 2000	Not illustrated in Yanko
<i>Cymbaloporetta</i> sp. 1	CRY	1998	COR?, TS	est	Hyams, 2000 /Hyams Kaphzan et al., 2008	

Excluded as native agreed by all

<i>Recurvoidella bradyi</i> (Robertson, 1891)
<i>Veloroninoides scitulus</i> (Brady, 1881)

Excluded as native and/or having fossil records in the Mediterranean-- no consensus

<i>Bolivina arta</i> MacFadyen, 1931
<i>Bolivina striatula</i> Cushman, 1922
<i>Iridia diaphana</i> Heron-Allen and Earland, 1914
<i>Globobulimina auriculata</i> (Bailey, 1894)
<i>Monalysidium acicularis</i> (Batsch, 1791)
<i>Miliolinella</i> cf. <i>hybrida</i> (Terquem, 1878)
<i>Pulleniatina obliquiloculata</i> (Parker & Jones, 1862)
<i>Pyramidulina catesbyi</i> (d'Orbigny, 1839)
<i>Sorites orbiculus</i> Ehrenberg, 1839
<i>Peneroplis arietinus</i> (Batsch, 1791)
<i>Peneroplis planatus</i> (Fichtel & Moll, 1798)
<i>Planogypsina squamiformis</i> (Chapman, 1901)

Debatable (diverging expert opinions)

<i>Amphisorus hemprichii</i> Ehrenberg, 1840	NIS in TR - cryptogenic elsewhere
<i>Cymbaloporetta plana</i> (Cushman, 1915)	NIS in TR - cryptogenic elsewhere
<i>Cymbaloporetta squamosa</i> (d'Orbigny, 1839)	NIS in TR - cryptogenic elsewhere
<i>Euthymonacha polita</i> (Chapman, 1904)	NIS in TR - cryptogenic elsewhere
<i>Polymorphina fistulosa</i> Williamson, 1858	NIS in TR - DD elsewhere
<i>Peneroplis pertusus</i> (Forsskål in Niebuhr, 1775)	NIS in TR -cryptogenic elsewhere

Likely aliens: id needs to be confirmed –no consensus

<i>Articulina alticostata</i> Cushman, 1944
<i>Articulina mayori</i> Cushman, 1922
<i>Astacolus insolitus</i> (Schwager, 1866)
<i>Bulimina biserialis</i> Millett, 1900
<i>Dentalina albatrossi</i> (Cushman, 1923)
<i>Heterocyclina tuberculata</i> (Möbius, 1880)
<i>Sigmoihauerina bradyi</i> (Cushman, 1917)
<i>Pseudonodosaria brevis</i> (d'Orbigny, 1846)
<i>Pyramidulina perversa</i> (Schwager, 1866)
<i>Quinqueloculina</i> sp. C
<i>Triloculina</i> sp. A
<i>Triloculinella asymmetrica</i> (Said, 1949)
<i>Vaginulinopsis sublegumen</i> Parr, 1950

4. Final considerations

The current reflexion served to deliver refined baselines for NIS in the Mediterranean and its four subregions separately. The baselines include only validated species records observed until the end of 2020 and are the result of much deliberation and collaboration among a large number of national and taxonomic experts. This is an important milestone for the implementation of IMAP and sets the foundation for further steps, i.e., the refinement of threshold values and work towards defining and assessing GES.

Besides the elaboration of the baseline data and the update of existing refined national lists (JRC Baselines for EU Mediterranean countries) with data up to 2020, this work has made some other significant contributions to NIS knowledge at the regional level. The most important of these was a significant progress in the harmonisation of the regional/subregional inventories; this was achieved in two ways: a) the mobilisation and generous contribution of the taxonomic experts and b) the organization of the NIS OWG meetings, which promoted collaboration and the exchange of knowledge, insights and views on species where experts' opinions differed.

As a result, both the alien status but also the validity of records of a large number of species have been clarified and agreed upon. Furthermore, where knowledge was incomplete or consensus could not be reached, all the available information has been reported on data deficient species and questionable records and synthesized it at the regional and subregional level.

The second important contribution was the advancement of the NIS list of foraminifera species, made with the participation of the contacted forams' experts. While the status of some foraminifera species

remains unresolved, consensus or partial consensus was reached for many of them and there was strong support by the taxonomic experts to include this group in the Baseline.

The results of this national, sub-regional and regional analysis will be used as a baseline for the purpose of the 2023 Med QSR.

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