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Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix D: Revised Guidance Fact Sheets for the IMAP Common Indicator 6 related to Non-Indigenous Species

UNEP/MAP
SPA/RAC-Tunis 2021

I. Introduction and objectives

1. The IMAP Common Indicator Guidance Factsheets share a common template, which is illustrated in Table 1 below. The information gathered in the frame of the "Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean", and the additional documents consulted, enabled to update the different sections of the factsheets that were discussed with the members of the informal Online Working Group (19 April 2021).

Table 1. Template of IMAP Common Indicator Guidance Factsheets

Indicator Title			
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**	**IMAP Reference No and definition**
Rationale			**Scientific rationale and marine policy context (including relevant references)**
Justification for indicator selection			
Scientific References			
Policy Context and targets			
Policy context description			
Targets			
Policy documents			
Indicator analysis methods			**Agreed scientific methodologies in use, including detailed monitoring requirements**
Indicator Definition			
Methodology for indicator calculation			
Indicator units			
List of Guidance documents and protocols available			
Data Confidence and uncertainties			
Methodology for monitoring, temporal and spatial scope			
Available Methodologies for Monitoring and Monitoring Protocols			
Available data sources			
Spatial scope guidance and selection of monitoring stations			
Temporal Scope guidance			
Data analysis and assessment outputs			**Data reporting, analysis and aggregation (outpout)**
Statistical analysis and basis for aggregation			
Expected assessments outputs			
Known gaps and uncertainties in the Mediterranean			
Contacts and version Date			**Document Registration**
Key contacts within UNEP for further information			
Version No	**Date**	**Author**	

2. The revised Guidance Factsheet of CI6 is reproduced in the Sections II in highlights and strikethrough.

II. Revision of the Guidance Factsheet of CI6

Indicator title	Common Indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species (NIS) particularly invasive, non-indigenous species notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Decreasing abundance of introduced NIS in risk areas	Invasive NIS introductions are minimized	Abundance of NIS introduced by human activities reduced to levels giving no detectable impact.

Rational

Justification for indicator selection

Marine invasive alien species[1] are regarded as one of the main causes of biodiversity loss in the Mediterranean, potentially modifying all aspects of marine and other aquatic ecosystems. They represent a growing problem due to the unprecedented rate of their introduction and the unexpected and harmful impacts that they have on the environment, economy and human health. According to the latest regional reviews, more than 6% of the marine species in the Mediterranean are now considered non-native species as around 1000 alien marine species have been identified. ~~while their number is increasing at a rate of one new record every 2 week (Zenetos et al. 2012) NIS introductions still occur, the rate of NIS introductions decreases in the time period 2006-2017. The decreasing trend can be assigned to polices effectiveness as well as to other reasons, such as decreasing pool of potential NIS species, variations in sampling effort or available expertise (Galil et al., 2018). However only~~ Around 12% of all of NIS in the Mediterranean are today considered as invasive, or potentially invasive (Rotter et al., 2020)[2]. Macrophytes (macroalgae and seagrasses) are the dominant NIS group in the western Mediterranean and Adriatic Sea. Polychaetes, crustaceans, molluscs and fishes are the dominant NIS group in the eastern as well algae for the central Mediterranean (Zenetos et al., 2010, 2012). Although the highest alien species richness occurs in the eastern Mediterranean, ecological impact shows strong spatial heterogeneity with risk areas in all Mediterranean sub-basins (Katsanevakis et al. 2016). Besides, these numbers should be modulated acknowledging that there is no exhaustive knowledge (neither standard monitoring) of all introduced species in most areas of the Mediterranean Sea.

To mitigate the impacts of NIS on biodiversity, human health, ecosystem services and human activities there is an increasing need to take action to control biological invasions. With limited funding, it is necessary to prioritise actions for the prevention of new invasions and for the development of mitigation measures. This requires a good knowledge of the impact of invasive species on ecosystem services and biodiversity, their current distributions, the pathways of their introduction, and the contribution of each pathway to new introductions.

Common indicator 6 is a trend indicator that summarizes data related to biological invasions in the Mediterranean into simple, standardized and communicable figures and is able to give an indication of the degree of threat or change in the marine and coastal ecosystem. Furthermore, it can be a useful indicator to assess on the long-run the effectiveness of management measures implemented for each

[1] Invasive alien species (IAS) are a subset of established NIS which have spread, are spreading, or have demonstrated their potential to spread elsewhere, and which have an effect on biological diversity and ecosystem functioning (by competing with and on some occasions replacing native species), socio-economic values, and/or human health in invaded regions. (Decision IG.22/7)

pathway but also, indirectly, the effectiveness of the different existing policies targeting alien species in the Mediterranean Sea.

However, the overall ecological impact of NIS on the Mediterranean Sea remains relatively difficult to quantify, and it evaluation is mainly qualitative; nevertheless, there have been some good attempts at quantification (Katsanevakis et al., 2014, 2016; Gallardo et al., 2016). In particular, the analyses of Katsanevakis et al. (2014) have led to the conclusion that the majority of the recognized invasive species in the European seas (72%) have both positive and negative effects ~~impacts~~ on the native ~~biota~~ ecosystem . ~~Few have only positive effects (8%), while more (~20%) have only negative effects on the host environment.~~

To take effective actions against biological invasion, knowledge about the-vectors and associated pathways of introduction of NIS is crucial. Corridors and shipping represent the main ~~vector~~ pathway of introduction for NIS in the Mediterranean, ~~followed by vessels~~, though the relative importance of pathways vary among individual countries and current knowledge on vectors and pathways.

Scientific References

Galil BS, Marchini A, Occhipinti-Ambrogi A, Minchin D, Narščius A, Ojaveer H, Olenin S. (2014). International arrivals: widespread bioinvasions in European Seas. Ethol Ecol Evol. 26(2–3):152–171. doi:10.1080/03949370.2014.897651.

Galil BS., Agnese Marchini and Anna Occhipinti-Ambrogi (2018). Mare Nostrum, Mare Quod Invaditur—The History of Bioinvasions in the Mediterranean Sea. In: Queiroz Ana Isabel & Simon Pooley Eds. Editors. Histories of Bioinvasions in the Mediterranean. Springer.

Gallardo, B., Clavero, M., Sánchez, M. I., and Vilà, M. (2016). Global ecological impacts of invasive species in aquatic ecosystems. Glob. Chang. Biol. 22, 151–163. doi: 10.1111/gcb.13004

Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M. E., Oztürk, B., et al. (2014). Impacts of marine invasive alien species on ecosystem services and biodiversity: a pan-European review. Aquat. Invas. 9, 391–423. doi: 10.3391/ai.2014.9.4.01

Katsanevakis, S., Tempera, F., Teixeira, H., 2016. Mapping the impact of alien species on marine ecosystems: the Mediterranean Sea case study. Diversity and Distributions 22, 694–707.

REMPEC (2020). Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean".

Rotter Ana, Klun Katja, Francé Janja, Mozetič Patricija, Orlando-Bonaca Martina (2020). Non-indigenous Species in the Mediterranean Sea: Turning from Pest to Source by Developing the 8Rs Model, a New Paradigm in Pollution Mitigation. Frontiers in Marine Science 7: 178. 10.3389/fmars.2020.00178

Zenetos A., Gofas, S., Verlaque, M., Cinar, M. E., García Raso, E., et al., 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11, 2, 381-493.

Zenetos A., Gofas, S., Morri, C., Rosso, A., Violanti, D., et al., 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterranean Marine Science, 13/2, 328-352.

Policy Context and targets (other than IMAP)

Policy context description

The Convention on Biological Diversity (CBD) recognised the need for the "compilation and dissemination of information on alien species that threaten ecosystems, habitats, or species to be used in the context of any prevention, introduction and mitigation activities", and calls for "further research on

the impact of alien invasive species on biological diversity" (CBD, 2000). The objective set by Aichi Biodiversity Target 9 is that "by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment". This is also reflected in Target 5 of the EU Biodiversity Strategy (EU 2011). The EU Regulation 1143/2014 on the management of invasive alien species seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the impacts that these species can have on the human health or economy. The Regulation foresees three types of interventions; prevention, early detection and rapid eradication, and management and includes a list of 66 (as per second update) Invasive Alien Species (IAS) of European concern for which direct management measures are solicited.

The Marine Strategy Framework Directive (MSFD), which is the environmental pillar of EU Integrated Maritime Policy, sets as an overall objective to reach or maintain "Good Environmental Status" (GES) in European marine waters by 2020. It specifically recognizes the introduction of marine alien species as a major threat to European biodiversity and ecosystem health, requiring Member States to include alien species in the definition of GES and to set environmental targets to reach it. Hence, one of the 11 qualitative descriptors of GES defined in the MSFD is that "non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem" (Descriptor 2).

The updated EU Decision 2017/848, defined a set of Criteria, including criteria elements, and methodological standards are defined, for each descriptor. Under descriptor 2, the following criteria are defined 1) Newly introduced non-indigenous species, 2) Established non-indigenous species, particularly invasive non-indigenous species, which include relevant species on the list of invasive alien species of Union concern adopted in accordance with Article 4(1) of Regulation (EU) No 1143/2014 and species which are relevant for use under criterion D2C3.

Member States shall establish that list through regional or subregional cooperation and 3) Species groups and broad habitat types that are at risk from non-indigenous species, selected from those used for Descriptors 1 and 6. Although Ecological Objective 2 and the Common Indicator 6 were in line with the MSFD descriptor 2 objectives and targets, defined in the EU Decision 2010/477/EU, there is significant difference with the update directive 2017/848. Assessment of CI6 is complementary to first two criteria under D2, however, no assessment of adverse impacts on species and habitats is yet elaborated under IMAP.[3]

Indicator/Targets

Aichi Biodiversity Target 9

EU Biodiversity Strategy Target 5

EU Regulation 1143/2014 targets

MSFD Descriptor 2 and related criteria, indicators and environmental targets

Policy documents

Aichi Biodiversity Targets - https://www.cbd.int/sp/targets/

Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea. UN Environment/MAP Athens, Greece 2017.- https://www.racspa.org/sites/default/files/action_plans/pa_alien_en.pdf

EU Biodiversity Strategy - https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en#ecl-inpage-324

~~EU Regulation 1143/2014 -~~

[3] Text amended to reflect the latest EU Decisions

Marine Strategy Framework Directive - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN

Commission Decision EU 2017/848 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU - https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0848&from=EN

~~Decision on criteria and methodological standards on good environmental status of marine waters - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010D0477(01)&from=EN~~

EU Regulation 1143/2014 - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1143&from=EN

Indicator analysis methods

General definitions (according to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria)

'Non-indigenous species' (NIS; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS. However, secondary introductions of NIS from the area(s) of their first arrival could occur without human involvement due to spread by natural means.

'Invasive alien species' (IAS) are a subset of established NIS which have spread, are spreading or have demonstrated their potential to spread elsewhere and have an effect on biological diversity and ecosystem functioning (by competing with and on some occasions replacing native species), socioeconomic values and/or human health in invaded regions. Species of unknown origin which cannot be ascribed as being native or alien are termed cryptogenic species. They also may demonstrate invasive characteristics and should be included in IAS assessments.

In order to provide basis for development of relevant policies to address NIS, assessment of pathways of introduction is needed.

Indicator Definition

For the needs of Common Indicator 6, the following definitions apply:

- 'Trend in abundance' is defined as ~~the interannual~~ change between assessment periods in the estimated population density/ranks ~~total number~~ of ~~individuals of~~ a non-indigenous species ~~population~~ in a specific marine area.
- 'Trend in temporal occurrence' is defined as the ~~interannual~~ change between assessment periods in the estimated number of new introductions and the total number of non-indigenous species in a specific country or preferably the national part of each subdivision, preferably disaggregated by pathway of introduction.
- 'Trend in spatial distribution' is defined as ~~the interannual~~ change of the total marine 'area' occupied by non-indigenous species. This area should be defined according to the scale of assessment.

In order for this trend indicator to become operational, at least two assessment periods of relevant data are necessary, in order to allow a minimal comparison of two annual datasets.

Methodology for indicator calculation

To estimate Common Indicator 6, a trend analysis (time series analysis) of the available monitoring data needs to be performed, aiming to extract the underlying pattern of NIS number variability over time, which may be hidden by noise. A formal regression analysis is the recommended approach to estimate such trends. This can be achieved through a simple linear regression analysis or through more sophisticated modelling tools (when extensive datasets are available), such as the generalized linear or additive models (GLM/GAM). See details in document "S*cales of monitoring & assessment, assessment criteria and thresholds values of the IMAP EO2/CI6: non-indigenous species"*

~~To monitor trends in temporal occurrence, two parameters [A] and [B] should be calculated on a predefined time period yearly basis. Parameter [A] provides an indication of the introductions of "new" species (in comparison with the prior year), and parameter [B] gives an indication of the increase or decrease of the total number of non-indigenous species:~~

~~[A]: The number of non-indigenous species at Tn that was were not present at Tn-1. To calculate this parameter the non-indigenous species lists of both years are compared to check which species were recorded in year n, but were not recorded in year n-1 regardless of whether or not these species was present in earlier years. To calculate this parameter the total number of non-indigenous species is used in the comparison.~~

~~[B]: The total number of known non-indigenous species at Tn minus the corresponding total number of non-indigenous species at by Tn-1. Hereby Tn stands for the year of reporting.~~

Indicator units

'Trends in abundance': absolute value and % change per assessment period ~~year~~

'Trends in temporal occurrence': number and % change in new introductions or number and % change in the total number of alien species per assessment period ~~year (or per decade if there are gaps in the availability of annual data)~~

'Trends in spatial distribution': absolute value and % change in the total marine surface area occupied or absolute value and % change in the length of the occupied coastline (in the case of shallow-water species that are present only in the coastal zone).

List of guidance documents and protocols available

As provided for in the Decision IG.23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017), Monitoring Protocols for IMAP Common Indicator related to Non-Indigenous species were approved by the 7th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 9 September 2019)[4].

~~There are no established standard protocols for the monitoring of NIS. However,~~ Consistent NIS monitoring protocols are already implemented in many Mediterranean countries, in relation to several monitoring obligations linked with the Ballast Water Convention, the EU Water Framework Directive, and the EU Marine Strategy Framework Directive, and as provided by specialised agencies or institutions (e.g. IUCN for MPAs, CIESM). These methods may be useful to complement the estimation of Common Indicator 6.

Several guidelines for NIS monitoring and assessment are available at: European and Regional Sea conventions https://mcc.jrc.ec.europa.eu/main/dev.py?N=20&O=407&titre_chap=D2%20Non-indigenous%20species&titre_page=Monitoring%20&%20assessment (accessed 13/04/2021). Some guidance on the monitoring of biodiversity (including for monitoring non-indigenous species) within the context of the MSFD is provided in:

[4] UNEP/MED WG.467/16, Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species.

- Zampoukas et al. (2014) Technical guidance on monitoring for the Marine Stategy Framework Directive;
- JRC Scientific and Policy Reports (EUR collection), Publications Office of the European Union, EUR 25009 EN – Joint Research Centre, doi: 10.2788/70344, ISBN: 978-92-79-35426-7, 166p;
- Olenin, S., Alemany, F., Cardoso, A.C., Gollasch, S., Goulletquer, P., Lehtiniemi, M., McCollin, T., Minchin, D., Miossec, L., Ambrogi, A.O. and Ojaveer, H., 2010. Marine Strategy Framework Directive–Task Group 2 Report–Non-indigenous Species, vol. 10.

HELCOM (Helsinki Commission, the RSC for the Baltic Sea) has published online guidance notes for the application of eRAS (extended Rapid Assessment Survey) in the monitoring of NIS (https://helcom.fi/media/publications/Guidelines-for-monitoring-of-non-indigenous-species-by-eRAS.pdf)

The EU Project BALMAS has provided guidelines for the monitoring of NIS in ballast water:

- David M. and Gollasch S. 2015. BALMAS Ballast Water Sampling Protocol for Compliance Monitoring and Enforcement of the BWM Convention and Scientific Purposes. BALMAS project, Korte, Slovenia, Hamburg, Germany. 55 pp

Data confidence and uncertainties

The trend analysis should be accompanied by an evaluation of confidence and uncertainties. Standard regression methods (simple linear regression, generalized linear or additive models, etc.) provide estimates of uncertainty (standard errors and confidence intervals of estimated trends). Such uncertainty estimates should accompany all reported trends. Only long-term follow-ups of all the relevant parameters (states and pressures), will ultimately make it possible to precisely quantify the GES and gradually reduce the amount of uncertainty between the changes due to natural variations and those resulting from anthropogenic pressures.

Furthermore, the issue of imperfect detectability should be properly addressed, as it may cause an underestimation of the relevant state variables (abundance, occupancy, geographical range, species richness). Many available methods properly tackle the issue of imperfect detection when monitoring biodiversity, by jointly estimating detectability (see Katsanevakis et al. 2012 for a review).

Methodology for monitoring, temporal and spatial scope

Available methodologies for monitoring and monitoring protocols

It is recommended to use standard monitoring methods traditionally being used for marine biological surveys, including, but not limited to plankton, benthic and fouling studies described in relevant guidelines and manuals. However, specific approaches may be required to ensure that alien species are likely to be found, e.g. in rocky shores, port areas and marinas, offshore areas and aquaculture areas.

As a complimentary measure and in the absence of an overall NIS targeted monitoring programme, rapid assessment studies may be undertaken, usually but not exclusively at marinas, jetties, and fish farms (e.g. Pederson et al. 2003). Besides, a review (as exhaustive as possible) of all scientific publications on (more or less) recent new introductions of species, besides the taxonomic status of these NIS, is pre-required to have the minimum basis of knowledge. This is also very often the main and only data sources for assessment when monitoring is not in place.

[With rigorous quality control in place, national and regional citizen science campaigns are ideal for NIS monitoring purposes. Members of local communities, due to their broad geographic distribution and familiarity with their natural environment, can in fact, be of great help to track invasive species in both terrestrial and aquatic systems (Delaney et al., 2008). A renewed drive to identify components of the

natural world, through 'bioblitz'[5] events organized round the globe, is bolstering the interaction between formal scientists and informal/citizen ones, also through the availability of low-budget underwater photography and video-capture hardware on the market.] ~~The compilation of citizen scientists' input, validated by taxonomic experts, can be useful to assess the geographical ranges of established species or to early record new species.~~

For the estimation of Common Indicator 6, it is important that the same sites are surveyed each monitoring period, otherwise the estimation of the trend might be biased by differences among sites. The exact geographical location of each selected sampling station in both risk areas and MPAs should be recorded through GPS coordinates, so as to enable consistent sampling on successive occasions.

Standard methods for monitoring marine populations include plot sampling, distance sampling, mark-recapture, removal methods, and repetitive surveys for occupancy estimation (see Katsanevakis et al. 2012 for a review specifically for the marine environment).

To provide guidance to the Contracting Parties to the Barcelona on field methodologies for monitoring NIS CI6 in identified risk areas and MPAs, guidelines for monitoring NIS in the Mediterranean (UNEP/MED WG.467/16, 2019) was developed by reviewing recognised good practices in the field of NIS monitoring protocols :

1. UNEP/MED WG.467/16, 2019, Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species, 7th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece, 9 September 2019. p.118-130
2. Katsanevakis S, et al., 2012. Monitoring marine populations and communities: review of methods and tools dealing with imperfect detectability. Aquatic Biology 16: 31–52.
3. Pederson J, et al., 2003 Marine invaders in the northeast: Rapid assessment survey of non-native and native marine species of floating dock communities, August 2003 (available in https://dspace.mit.edu/bitstream/handle/1721.1/97032/MITSG_05-3.pdf?sequence=1)

Available data sources

Marine Mediterranean Invasive Alien Species database (MAMIAS) - http://dev.mamias.org/ [Version Beta]

European Alien Species Information Network (EASIN) - http://easin.jrc.ec.europa.eu/

CIESM Atlas of Exotic Species in the Mediterranean - http://www.ciesm.org/online/atlas/

World Register of Introduced Marine Species (WRiMS) - http://www.marinespecies.org/introduced

Global Invasive Species Database - http://www.iucngisd.org/gisd/

CABI Invasive Species Compendium - https://www.cabi.org/isc

AquaNIS - http://www.corpi.ku.lt/databases/index.php/aquanis

For taxonomic status: World Register of Marine Species (WoRMS) - http://www.marinespecies.org/

NEMESIS - Smithsonian Environmental Research Center's National Estuarine and Marine Exotic Species Information System - https://nemesis.nisbase.org/nemesis/

Spatial scope guidance and selection of monitoring stations

~~The monitoring of NIS generally should start on a localised scale, such as "hot-spots" and "stepping stone areas" for alien species introductions. Such areas include ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore structures. Areas of~~

[5] A BioBlitz is a celebration of biodiversity. It's an event that focuses on finding and identifying as many species as possible in a specific area over a short period of time. Students, scientists, naturalists, and community members join together in these events to explore the natural world. Typically led by educators, scientists, or Park/MPA rangers, BioBlitzes are an opportunity to take a snapshot of the biodiversity of a place. Participants of all ages can learn techniques for observing and collecting data within a designated area and time frame.

~~special interest such as marine protected areas, lagoons etc. may be selected on a case by case basis, depending on the proximity to alien species introduction "hot spots". The selection of the monitoring sites should therefore be based on a previous analysis of the most likely "entry" points of introductions and "hot spots" expected to contain elevated numbers of alien species.~~

[It is recommended that NIS surveys are conducted within both risk areas (harbours, ports, marinas, marine culture, etc.) and within vulnerable marine areas (where the environmental conditions promote the establishment of NIS) and Marine Protected Areas (MPAs).

Risk areas are defined as the most feasible entry/introduction points for NIS by virtue of:

(i) a preliminary desk study which identifies particular site-specific features (e.g. a harbour frequented by a number of vessels at risk of introduction of NIS, or marine culture) or

(ii) a high number and/or abundance of NIS already established within the confines of risk and vulnerable areas

Typically, Risk areas would include site typologies such as harbours, ports, yacht marinas, mariculture cages, offshore structures and thermal effluent discharge locations. Sites not necessarily in close proximity to these 'conventional' risk areas could also be considered within this same category, including locations subject to intense anchoring pressure during the tourist season.

In terms of NIS risk areas, UNEP/MAP (2019)[6] recommends that NIS monitoring is conducted following the provided guidance at least in two risk areas locations per potential introduction pathway, most notably commercial shipping, recreational boating and aquaculture. The same report provides guidance in the form of criteria, which should be applied when selecting candidate hotspot locations, as follows:

- Past research has shown them to be hotspots for non-indigenous species that can be transported with the transport vector concerned;
- The species communities at the two risk areas have minimal direct influence each other;
- Vulnerable areas with prospects for invasion by new introductions.

In terms of MPAs, a minimum of two sampling stations per MPA are recommended, with the two stations being located within different management zones within the same MPA. In terms of the specific positioning of the two NIS monitoring stations within each MPA, it is recommended to ensure a high degree of geographical and ecological representability. This can be ensured in a variety of ways, including:

a) opting for a minimum threshold of physical distance between the two sampling stations, expressed as a percentage of the total lateral extent of the MPA in question (e.g. the distance between the two sampling stations should not be inferior to 25% of the total lateral extent of the MPA);
b) opting for sampling stations dominated by different marine biocoenoses (e.g. algal-dominated rocky reef versus seagrass meadow);
c) opting for sampling stations incorporated within anthropogenic or ecological features of interest, with potential candidates including wrecks (which are considered as promoting the establishment of NIS – e.g. Bariche [2012]), a benthic area heavily impacted by anchoring or a sea urchin barren.]

It is important to establish a network of monitoring sites at regional level in which common protocols are applied so that Common Indicator 6 can be assessed at national, sub-regional and regional levels.

The use of Habitat Suitability Models and Ecological Niche Modelling (ENM) may be considered at a later stage of IMAP to identify priority monitoring sites and to predict the spread of NIS.

[6] UNEP/MED WG.467/16 Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species, 7th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece.

A revision and agreement on the nested areas (bottom-up approach) is needed that includes integration of monitoring scales based on nested approach, proposing the list of monitoring and reporting units in the Mediterranean Sea. The geographical distribution of NIS, showing a higher presence in the Aegean and Levantine basin, should be taken into consideration when defining monitoring stations. The nested approach has to consider the differences in NIS occurrence in the different sub-basins.

Temporal Scope guidance

~~Monitoring at "hot-spots" and "steppingstone areas" for alien species introductions would typically involve more intense monitoring effort, e.g. sampling at least once a year at ports and their wider area and once every two years in smaller harbours, marinas, and aquaculture sites.~~

Sampling should be done on an annual / seasonal basis depending on the species group or target habitat's types. See details in document "Scales of monitoring & assessment, assessment criteria and thresholds values of the IMAP EO2/CI6: non-indigenous species".

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Standard statistics for regression analysis should be applied to estimate trends and their related uncertainties.

Expected assessments outputs

- Graphs of the time series of the calculated metrics (abundance, occurrence, spatial extent), including confidence intervals;
- Distribution maps of the selected NIS, highlighting temporal changes in their spatial distribution;
- National ~~annual~~ inventories (and also by the national part of each marine subdivision, if relevant) of non-indigenous species and respective year of introduction if known;
- National inventories clustering NIS according to main pathways of introduction (e.g. seaways, shipping, mariculture, etc.) if known;

Known gaps and uncertainties in the Mediterranean

The lack of regular dedicated and coordinated monitoring at national and regional scale implies a low confidence in the assessment of NIS, even if the continuous and regular occurring of new introductions are demonstrated~~.~~

NIS identification is of crucial importance, and the lack of taxonomical expertise has already resulted in several NIS underestimated for certain time periods. The use of molecular approaches including bar-coding are sometimes needed to confirm the results of conventional taxonomic species identification.

Sampling effort currently greatly varies among Mediterranean countries and thus on a regional basis current assessments and comparisons may be biased.

Evidence for most of the reported impacts of alien species is weak, mostly based on expert judgement; a need for stronger inference is needed based on experiments or ecological modelling. The assessment of trends in abundance and spatial distribution is largely lacking.

Contacts and version Date

Key contacts within UNEP for further information

car-asp@spa-rac.org

Version No	Date	Author

V.1	20/07/2016	SPA/RAC
V.2	14/04/2017	SPA/RAC
V.3	30/09/2020	SPA/RAC-REMPEC