UNITED NATIONS

EP

UNEP/MED WG.474/Inf.3

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

24 Avril 2019
Original: English

Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries

Rome, Italy, 21 May 2019

Agenda item 3: Guidance on monitoring concerning the biodiversity and non-indigenous species common indicators

Monitoring protocol of the Ecosystem Approach Common Indicators 6

UNEP/MAP
SPA/RAC - Tunis, 2019

E. Guidelines for monitoring non-indigenous species (NIS)

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1. Background

The Ecosystem Approach (EcAp) process was elucidated in 2008 at the 15th Meeting of the Contracting Parties to the Barcelona Convention, in Decision IG. 17/6, with the vision of "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations", along with an Ecosystem Approach Roadmap, aiming to achieve this vision. Subsequently, the Parties agreed on strategic goals to achieve the Ecosystem Approach vision, on 11 Ecological Objectives (EOs), and on matching Good Environmental Status (GES) descriptions, targets and indicators, including EO 2 (Non-indigenous species).

At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties (CPs) to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) adopted the Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP) which describes the strategy, themes, and products that the Contracting Parties are aiming to deliver, through collaborative efforts in the framework of the Mediterranean Action Plan(MAP) , during the second cycle of the implementation of the Ecosystem Approach Process in 2016-2021.

The overarching principles guiding the development of the IMAP include (i) adequacy; (ii) coordination and coherence; (iii) data architecture and interoperability based on common parameters; (iv) concept of adaptive monitoring; (v) risk-based approach to monitoring and assessment, and (v) the precautionary principle, in addition to the overall aim of integration.

Data and information are gathered through integrated monitoring activities on the national level and shared in a manner that creates a compatible, shared regional pool of data, usable by each Contracting Party. The IMAP information system will ensure the establishment of the regional pool of data and will allow the production of common indicator assessment reports in an integrated manner, following the monitoring specifics and data provided, which ensures comparability across the Mediterranean region. Integration is achieved through IMAP both at monitoring level, through an integrated monitoring system, following common principles and undertaken in a coordinated manner, and at assessment level, with the overall aim to assess the overall status of the marine and coastal environment.

The common indicators are the backbone of IMAP which covers 11 ecological objectives including the non-indigenous species (EO2), Citing UNEP/MAP (2017):

'In the context of the IMAP, a common indicator is an indicator that summarizes data into a simple, standardized, and communicable figure and is ideally applicable in the whole Mediterranean basin, or at least on the level of sub-regions, and is monitored by all Contracting Parties. A common indicator is able to give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers.'

1.1 Definitions

The following definitions have been extracted from the Decision IG.22/7 (Barcelona Convention, COP19, 2016) entitled ''Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria'' and from the Joint Research Centre (JRC) guidance document on the MSFD Descriptor 2 (Non-indigenous species), citable as Olenin et al. (2010).

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 adverse effect on biological diversity,

ecosystem functioning, socio-economic 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.

The key term "…levels that do not adversely alter the ecosystems" is described as the absence or minimal level of "biological pollution". The latter is defined as the impact of IAS at a level that disturbs environmental quality by effects on: an individual (internal biological pollution by parasites or pathogens), a population (by genetic change, i.e. hybridization), a community (by structural shift), a habitat (by modification of physical-chemical conditions) or an ecosystem (by alteration of energy flow and organic material cycling). The biological and ecological effects of bio-pollution may also cause adverse economic consequences.

1.2 Legislative framework outside EcAp

The CBD's (Convention on Biological Diversity) Strategic Plan for Biodiversity 2011-2020 includes twenty measurable Aichi Biodiversity Targets, which need to be met by 2020, including Target 9 which refers to NIS: '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.'

COP Decision VI/23 includes guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species9. Guiding principle 5 on Research and monitoring recognizes that these are required not only to develop an adequate knowledge base to address the problem but are also key to early detection of new invasive alien species.

Monitoring should include both targeted and general surveys, and benefit from the involvement of other sectors, including local communities. Research on an invasive alien species should include a thorough identification of the invasive species and should document: (a) the history and ecology of invasion (origin, pathways and time-period); (b) the biological characteristics of the invasive alien species; and (c) the associated impacts at the ecosystem, species and genetic level and also social and economic impacts, and how they change over time.

The European Union's Marine Strategy Framework Directive (MSFD) is a wide-ranging framework directive (2008/56/EC) with the overall objective of achieving or maintaining Good Environmental Status (GES) in Europe's seas by 2020 (MSFD, 2008). Eleven high level qualitative Descriptors of GES have been defined in Annex I of the MSFD, including Descriptor 2, for which GES has been defined as 'Non-Indigenous Species introduced by human activities are at levels that do not adversely alter the ecosystem.' Currently, the first six-year cycle of the MSFD is nearing completion, with EU Member States having submitted to the EU Commission their respective Programme of Measures (PoM) prior to their eventual implementation, following the collection of monitoring data for different Descriptors.
EU Regulation 1143/2014 lists the Invasive Alien Species (IAS) of Union Concern which should be the target or management measures and in which no commercial trade is allowed. Currently, this Regulation lists only terrestrial and freshwater species, and not marine ones.
Parties to the Bern Convention are required to Parties "to strictly control the introduction of non-native species" (Article 11.2.b). The European Strategy on Invasive Alien Species adopted under the framework of the Convention similarly addresses research and monitoring10. Monitoring that is systematic helps build an understanding of the ecological, distribution, patterns of spread and responses of IAS to management.

1.3 Scope and introduction to EcAp Common Indicator 6

The scope of this document is to elucidate the monitoring guidelines to address the EcAp Common Indicator 6: "Trends in abundance, temporal occurrence and spatial distribution of non- indigenous species, particularly invasive non-indigenous species, notably in risk areas in relation to the main vectors and pathways of spreading of such species".
This Common Indicator was selected by the February 2014 Integrated Correspondence Group on GES and Targets (Integrated CorGest) of the EcAp process of the Barcelona Convention from the integrated list of indicators adopted in the 18th Conference of the Parties (COP18), as a basis of a common

monitoring programme for the Mediterranean in relation to non-indigenous species, being preferred over other Common Indicators for Ecological Objective (EO) 2 (Non-indigenous species), such as the 'Ratio between non-indigenous invasive species and native species in some well-studied taxonomic groups.'

Common Indicator 6 is a trend indicator, whose main objective is to establish reliable, long-term data-sets as a first step of monitoring. In order for this trend indicator to become operational, at least two years of relevant data are necessary, in order to allow a minimal comparison of two annual datasets. In the absence of relevant pre-application (of the trend indicator) data, it is advised to deploy a two-year dataset collected after the optimisation of the indicator.

Although the GES for EO2 has not yet been fully elucidated by Contracting Parties, with respect to Non-Indigenous species, UNEP/MAP (2014) establishes the following aspirations:

(i) that no new non-indigenous species are introduced, and
(ii) that the number and composition of non-indigenous species have decreased to such a level where only non-indigenous species which had previously settled at a location are present, i.e. a reference level indicating that the number of non-indigenous species has remained the same in the period of three successive years, assuming that the eradication of established marine NIS is virtually impossible.

1.4. Aims and objectives

The main aim of this document is to provide guidance to environmental management practitioners (e.g. environmental authority representatives, researchers, students, Marine Protected Area [MPA] representatives) on field methodologies for monitoring Non-Indigenous Species (NIS) in MPAs and in identified hotspots. This provision of guidance is pursuant to enabling the same practitioners to achieving the goals of EcAp Common Indicator 6, by reviewing recognised good practices in the field of NIS monitoring protocols.

2. Monitoring protocol

2.1 Rationale and strategy

Two potential metrics/attributes of the Common Indicator 6 identified within UNEP/MAP (2014) are the following:

(i) Abundance of non-indigenous species
(ii) Temporal occurrence and spatial distribution of non-indigenous species

(i) It is widely recognised that the collection of abundance monitoring data is an expensive process. It is thus recommended to focus monitoring efforts on the recording of all NIS in a particular area – i.e. on the compilation of site-specific NIS inventories. The collection of abundance monitoring data might only be justified in cases of a species exhibiting abrupt spreading beyond a pre-defined threshold. Given the broad geographical range of monitored areas within different Contracting Parties, it is recommended that these thresholds are calculated as a fraction or percentage of the total monitored coastline, rather than as an absolute length of coastline. A relevant threshold example could be the spread of a NIS within a coastal stretch exceeding 5% of the total national coastal extent, or the doubling of the number of coastal monitoring stations at which a NIS has been reported.

(ii) To monitor the trend indicator of non-indigenous species two parameters [A] and [B] should be calculated on a 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, computed as follows:

[A]: The number of non-indigenous species at T_n (year of reporting) that was not present at T_{n-1} (previous year). To calculate this parameter, the non-indigenous species lists of both years are compared to check which species were recorded in T_n but were not recorded in T_{n-1} regardless of whether or not this species

was present in years antecedent to T_{n-1}. To calculate this parameter, the total number of non-indigenous species is used in the comparison (although species names should also be listed).

[B]: The number of non-indigenous species at T_n minus the number of non-indigenous species at T_{n-1}.

Trends in both [A] and [B] should be monitored to develop the best management plan for non-indigenous species in an area.

2.2 Spatial and temporal considerations (the 'Where' and the 'When')

It is recommended that NIS surveys are conducted within both 'hotspots' areas (e.g. ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore structures) and within marine areas subject to some form of environmental management, most notably Marine Protected Areas (MPAs).

'Hotspots' 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 considerable number of vessels) or

(ii) an elevated number of NIS already established within the confines of the same hotspot.

Typically, hotspots 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' hotspots could also be considered within this same category, including locations subject to intense anchoring pressure during the tourist season.

In terms of NIS 'hotspots', UNEP/MAP (2014) recommends that NIS monitoring is conducted for at least two hotspot 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 locations do not directly influence each other;
- Vulnerable areas with prospects for 'inoculation' or 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 representativity. 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.

The exact geographical location of each selected sampling station in both hotspots and MPAs should be recorded through GPS coordinates, so as to enable consistent sampling on successive occasions.

In terms of sampling frequency, it is recommended that hotspots are monitored on a bi-annual/six-monthly frequency, so as to cover both spring and autumn seasons, with the same monitoring survey being conducted after three years.

MPAs should be monitored on an annual basis (preferably in spring), given that the rate of introduction of new NIS within MPAs is expected to be lower than that observed within hotspots, such that the latter sites should be sampled with a higher intensity. The rationale behind the preference for the spring season for monitoring purposes is that recruitment in most marine species takes places during this season, and thus conducting monitoring surveys in spring allows for the collection of different NIS life stages which only occur during this time of the year.

The following table summarises the recommended spatial and temporal recommended dimensions of the NIS monitoring:

Sampling location typology	**Recommended number of sampling stations**	**Recommended sampling frequency**
'Hotspots'	Two per NIS introduction pathway	Bi-annual/six-monthly
Marine Protected Areas (MPAs)	At least two per MPA	Annual

2.3 Procedures (the 'Which' and 'How')

Which NIS to focus upon within the trend analyses is one of the most important considerations to make. The trend indicator (2.1ii), in fact, hinges on the compilation of a preliminary inventory of NIS present within a monitored marine area, which will then also feed into attribute/metric 2.1i. The compilation of this baseline NIS list will also, in turn, allow the identification of reference conditions and thus facilitate a better definition of GES for EO2. This first NIS inventory can be compiled through the exclusive or mixed deployment of any of the following tools:

(a) **Rapid Assessment Survey**. According to Lehtiniemi et al. (2015), rapid assessment is 'a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest time frame possible to produce reliable and applicable results for its defined purpose. Protocols for rapid assessment of marine and coastal biological diversity are available (e.g. UNEP/CBD/SBSTTA/8/INF/13 – Pedersen et al., 2005). Rapid assessment monitoring for targeted species enables direct reporting to management when a notable species is encountered, and the 'field' work can be undertaken by a small group of experts. The method is cost-effective and relevant when prompt management response is sought, but unsuitable for detection of newly arrived introductions;

(b) **Literature review**, specifically of recently-published (preferably not earlier than 2010) national censuses or inventories of recorded NIS. For EU Member States, the MSFD IA (Initial Assessment) reports for Descriptor 2 could hold useful relevant information, as well as a number of international and regional (European or Mediterranean basin-scale) databases and lists. These include the European Alien Species Information Network (EASIN) developed by the Joint Research Centre of the European Commission, which facilitates the exploration of non-indigenous species information in Europe (and the entire Mediterranean), from distributed resources through a network of interoperable web services, following internationally recognized standards and protocols. Additional global relevant databases include the CABI Invasive Species Compendium, the GISD (IUCN Invasive Species Specialist Group and IUCN Global Invasive Species Database) and FISHBASE, whilst additional databases of regional interest include DAISIE (Delivering Alien Invasive Species Inventories for Europe), the CIESM Exotic Species Atlas linked with NIS base, the MAMIAS Database from the Specially Protected Areas Regional Activity Centre (SPA/RAC) of the UNEP/MAP Barcelona Convention and the ESENIAS East and South European Network for Invasive Alien Species. Regional data portal on invasive alien species (IAS) in East and South Europe.

(c) **Citizen science**. 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' events organised 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. An example of a national citizen science campaign is Spot the Alien Fish (www.aliensmalta.eu) one, targeting fish NIS in the Maltese Islands, whilst a number of additional citizen science campaigns operate on.

Within hotspots, a two-pronged monitoring approach is recommended, namely:

(i) Rapid Assessment Survey, as optimised for NIS monitoring within hotspots in Minchin (2007) and in UNEP/MAP (2014). These surveys are conducted by a team of marine species experts spending a specified time period (ideally, this is standardised to ensure uniformity, with a duration of 30 minutes considered to be a feasible one for each individual survey) at the survey site (preferably through SCUBA diving, but possibly even through snorkelling in very shallow areas) and identifying species by observation of artificial substrates such as jetties and wharves, pontoons, long-standing buoys and other artificial structures such as fish-farm cages. A site master records the scientists, findings and abundance of species at each site. Samples of specimens may also be taken back to the lab, where species identification is confirmed, through ex situ analyses involving dissection, microscopic examination and liaison with reputable taxonomists of a pan-Mediterranean profile. This is especially feasible for taxonomically-challenging groups such as sponges, hydroids, serpulids, bryozoans and ascidians. In order to further assist in taxonomic identification efforts within the targeted taxa, samples of recorded species should be preserved in absolute, non-denatured ethanol for subsequent molecular analyses. The basic equipment necessary to conduct this monitoring survey includes underwater photographic and/or video cameras, preferably supplemented by the provisions of high levels of artificial light (e.g. through the provision of strobes or basic flash) and underwater data recording facilities, which might include an underwater slate and pencil, or a laminated notebook, per SCUBA diver.

(ii) Scraping technique. This is to be deployed along vertical transects running from the surface of the monitored artificial structure hosting the fouling assemblage down to the foot of the same structure, with sampling stations being placed at a minimum of three different depths along the same transect. The scraping protocol was developed within CIESM's PORTAL programme (Galil, 2008), which in turn was based on the CRIMP methods first described by Hewitt & Martin (1996) and later by Hewitt & Martin (2001). It involves the collection of the fouling community enclosed within a quadrat of standard dimensions (commonly, 50cm x 50cm) through scraping by means of appropriate utensils (e.g. hammer and chisel), within a fine-mesh bag, followed by ex situ, laboratory analyses and identification. Once on land, the collected samples should be preserved by placing the fine-mesh bag directly in a five-litre bucket where its contents are left to soak in non-denatured ethanol (at least 70%) prior to laboratory examination. Different preservatives other than ethanol might need to be deployed for taxa such as ascidians, for which a formaldehyde: seawater mixture is preferred. Caution should be applied when handling formaldehyde given its highly corrosive and carcinogenic nature.

Figure 1 illustrates the standard 50cmx50cm quadrat normally deployed during scraping exercises within fouling communities.

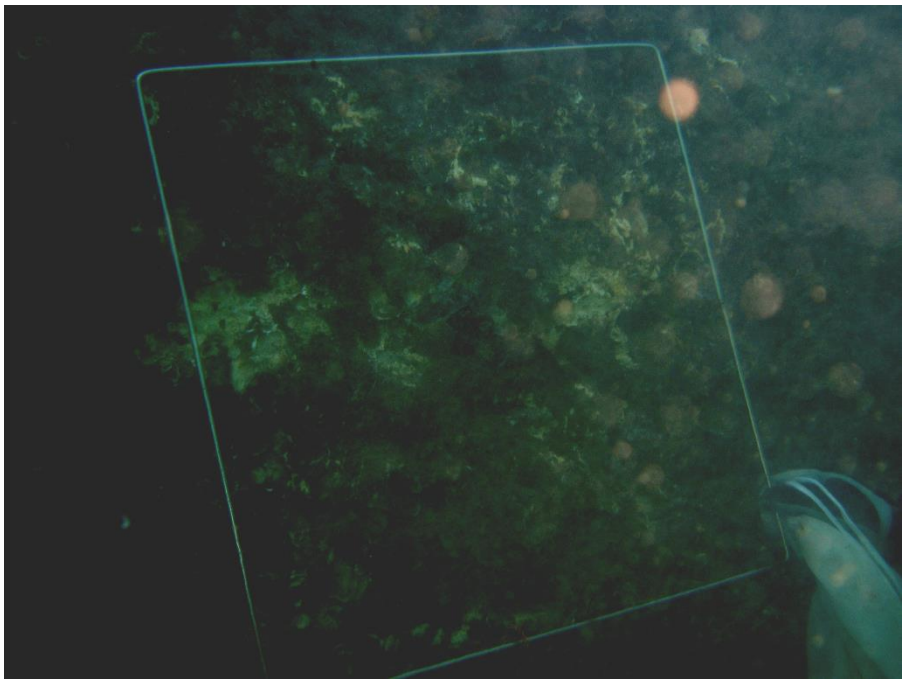

Figure 1 – 50cmx50cm quadrat deployed during scraping exercises within fouling communities (credits for photo: A. Deidun).

Within MPAs, the monitoring protocol for NIS have been developed by the IUCN and is elucidated in Otero (2013). Linear transects having an individual length of 100m, perpendicular to the shoreline and representative of the habitats, depth ranges and substrates within the MPAs are identified. Three replicate and comparable transects at each MPA sampling station are deployed, with a minimum distance of 10m between each transect. Ideally, the linear transect is laid out in the field through the use of a measuring tape of adequate length, which is secured on the seabed at both ends through the use of extra weights.

The location of each transect is identified by GPS coordinates for latitude and longitude to ensure faithful reproduceability in future occasions of the conducted monitoring. Non-indigenous species encountered up to five meters on either side of transect are recorded, counted and geo-referenced. Figure 2 illustrates the field conduction of the prescribed monitoring protocol within MPAs.

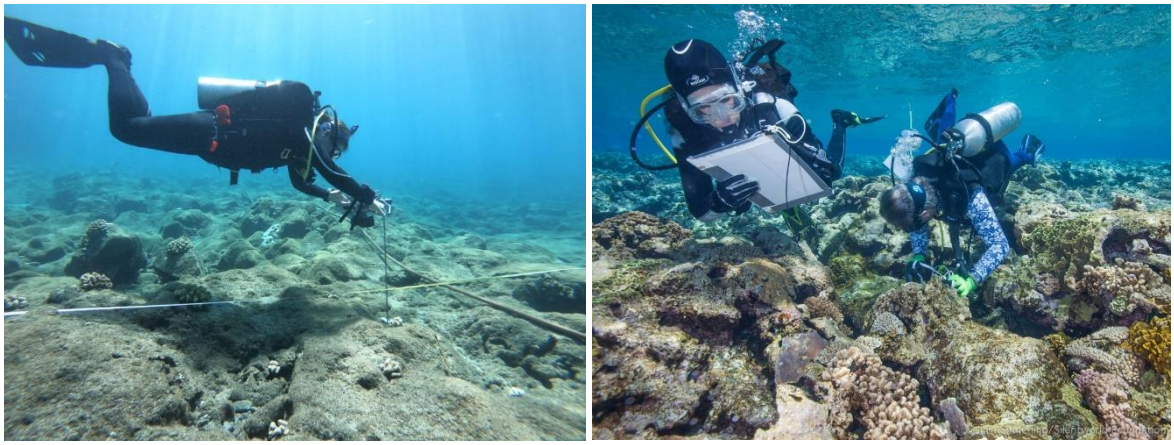

Figure 2 – Field conduction of the proposed monitoring protocol within MPAs (credits for photos: http://blog.owuscholarship.org/).

The water depth at which different NIS species are recorded during RAS or at which scraping samples are collected should be recorded. SCUBA divers must thus be equipped with water depth gauges to be

able to achieve this requisite. Voucher specimens of first records should be retained within catalogued collections for reference purposes.

Additional, complementary data which should be collected for **both hotspots and MPA**s on a non-mandatory basis include:

(a) Semi-quantitative estimates of abundance of both (i.e. native and non-native) community components, through the deployment of different techniques for different taxonomic groups. For instance,

(i) for fish, direct counting for a fixed (e.g. 10-15 minutes at each site) span of time within a visual census could be deployed;

(ii) for benthic macroalgae, direct counting of clusters of the same species, followed by an estimation of the Braun-Blanquet cover index for a standard number of clusters (e.g. 3) of the same macroalgal species could be performed. A similar approach would be useful for quantifying sessile, encrusting invertebrates present in the area. Alternatively, the CARLIT index, adopted within the Water Framework Directive (WFD) and the MSFD, could be quantified;

(iii) individuals sessile and slow-moving non-encrusting invertebrates (e.g. gastropods) can be counted directly over a pre-determined time span (e.g. 10-15 minutes) or within a pre-determined spatial area (e.g. 5mx5m benthic area).

(b) Values for salient water biogeochemical parameters, including water column temperature, salinity and dissolved oxygen content, should be recorded, where possible.

Collection of ancillary socio-economic metrics, through:

(c) Preliminary observations of tangible impacts of the recorded NIS on native species, also through semi-quantitative (and probably arbitrary) indices of impact intensity on native species, potentially including broad impact categories ranging from 'High' to 'Low';

(d) Assessment and identification of potential introduction pathways for each recorded NIS.

Assessment of potential introduction pathways should take into consideration ongoing developments from the pathway assessment exercise by the IUCN-Species Survival Commission-Invasive Species Specialist Group on pathway terminology, classification and analysis of pathway data (http://www.cbd.int/doc/meetings/cop/cop-12/information/cop-12-inf-10-en.pdf).

The salient features of every proposed NIS monitoring protocol for both invasion hotspots and MPAs are summarised in Table 1.

Table 1 - Summary table of salient features of the proposed NIS monitoring protocols for invasions hotspots and MPAs.

Monitored marine area typology	Monitoring parameter	Recommended monitoring methodology	Recommended equipment to be deployed during monitoring	Advantages of monitoring protocol	Limitations of monitoring protocol
NIS hotspots	Number/diversity of broader NIS community	Rapid Assessment Survey (RAS)	• Underwater photographic and/or video camera • Underwater slates or notebooks	Rapid and easy to apply	Requires taxonomic experts in the field; might overlook some cryptic NIS through non-observation; provides only semi-quantitative measures of abundance

	Number, abundance and density of native and non-native fouling community	Scraping technique	• Quadrat (e.g. 50cmx50cm) • Chisel and hammer • Fine-mesh bag • Five-litre buckets • Preservative (e.g. non-denatured ethanol)	Exhaustively records all species (both NIS and non-NIS) occurring in an area; provides abundance and density (quantitative data)	Destructive technique
MPAs	Number and abundance of NIS	Linear transect and visual census technique	• Underwater photographic and/or video camera • Measuring tape • Extra weight for securing both ends of measuring tape Underwater slates or notebooks	Rapid and easy to apply; allows analyses of trends in NIS abundance if conducted regularly in the same area	Requires taxonomic experts in the field; might overlook some cryptic NIS through non-observation; provides only semi-quantitative measures of abundance

2.4 Data analyses and interpretation

A positive or negative trend in [B] illustrates respectively an increase and a decrease in the total number of non-indigenous species in an area, which is a good trend indicator of non-indigenous species. One also needs to calculate [A] however as it is possible to have both a negative trend in [B], indicating a decrease in the total number of non-indigenous species, and a positive trend in [A] at the same time, indicating that management in the area is not sufficient yet. A positive trend in [A] ([A]>0) indicates that ―new species are introduced into the area and one should therefore investigate how and with which pathway they are introduced. If this concerns a pathway introduced by anthropogenic activities, one may focus management on that pathway. If the new non-indigenous species arrive by their natural distribution capacities, one may focus on back tracking the location of origin and focus management on that location.
Consequently, for all monitored stations, [A] at T_n = [A] at T_{n-1} = [A] at T_{n-2} = 0 and [B] at T_n = [B] at T_{n-1} = [B] at T_{n-2}, should indicate that no new non-indigenous species were introduced in the last three years, and that the number of non-indigenous species is decreased to a level where only settled (for at least three years) non-indigenous species are present.

3. Data handling policies

NIS and ancillary data collected on a national basis should be validated by an expert panel prior to it being submitted to a pan-Mediterranean, geo-referenced repository which can referenced by different user typologies (e.g. MPA managers, government environmental agencies, NGOs, research institutes). The MAMIAS database is a good candidate for such a repository, given its pan-Mediterranean nature, but unless this database is re-activated and its public access reinstated, alternative, relevant repositories should be availed of, including the EASIN, CIESM and GBIF ones. Protocols detailing how the NIS databases held within the selected final repository can be supplemented by citizen science reports being submitted by the public should be elucidated at a subsequent stage.

Field workers engaged in the deployment of the monitoring protocols must be confident they are recording most of the NIS species occurring in a particular area, in order to ensure a good quality of the data being recorded. UNEP/MAP (2014) states that the minimum threshold of the total NIS in an area which need to be recorded is that of 90% and that different statistical techniques exist for assessing progress towards achieving this. Further guidance to NIS monitoring practitioners should be provided in future on how to quantify statistically the fraction of total NIS occurring in an area which have been sampled.

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