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National Action Plan on species introductions and invasive species in Cyprus

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Siganus luridus individuals, a high-impact herbivore fish introduced through the Suez Canal – photo credits: Dimitris Poursanidis

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List of acronyms and abbreviations

BWM Convention: International Convention for the Control and Management of Ships' BallastWater and Sediments

CBD: Convention on Biological Diversity

CorGEst: Correspondence Group on GES and Targets

CIESM: The Mediterranean Science Commission (Commission Internationale pour l'Exploration Scientifique de la Méditerranée)

COP: Conference of the Parties

CYIAS: Cyprus Invasive Alien Species database

EASIN: European Alien Species Information Network

EcAp: Ecosystem Approach

EEA: European Environment Agency

ELNAIS: Hellenic Network on Aquatic Invasive species

EU: European Union

GBIF: Global Biodiversity Information Facility

GES: Good Environmental Status

GISIN: Global Invasive Species Information Network

HCMR: Hellenic Centre for Marine Research

IAS: Invasive Alien Species

IMAP: Integrated Monitoring and Assessment Programme

IMO: International Maritime Organisation

MAMIAS: Marine Mediterranean Invasive Alien Species (online database)

MedMIS: Mediterranean Marine Invasive Species information system

MSFD: Marine Strategy Framework Directive

NIS: Non-Indigenous Species

REABIC: Regional Euro-Asian Biological Invasions Centre

UNEP/MAP: United Nations Environment Program / Mediterranean Action Plan

1. Introduction

Biological invasions are major contributors to global change and drivers of native biodiversity loss in marine ecosystems, severely challenging the conservation of biodiversity and natural resources (Katsanevakis et al. 2014a). In marine ecosystems, alien marine species may become invasive and substantially change community structure, cause the loss of native genotypes, modify habitats, affect food web properties and ecosystem processes, impede the provision of ecosystem services, impact human health, and cause substantial economic losses (Perrings 2002; Molnar et al. 2008; Vilà et al. 2010; Katsanevakis et al. 2014a). This is done through a range of mechanisms such as competition, predation, overgrazing, algal blooms, release of toxins, hybridization, disease transmission, habitat modification, and ecosystem engineering (Katsanevakis et al. 2014a).

To mitigate the impacts of invasive alien species 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, monitoring the spread and impact of invasive species, 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, and the pathways of their introduction (Molnar et al. 2008; Katsanevakis et al. 2013, 2014a; Zenetos et al. 2012; Galil et al. 2014). Prevention is generally more cost-effective and environmentally desirable than post-introduction measures, such as eradication or long-term containment, which in the marine environment are extremely difficult.

The last decades, the serious implications of biological invasions have been globally recognized, and efforts have been made for the mitigation of their impacts. Aichi Target 9 of the Convention on Biological Diversity (CBD) states 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 target is also reflected in Target 5 of the EU Biodiversity Strategy (European Commission COM/2011/244) and is one of the objectives of the recent EU Regulation (No 1143/2014) on the prevention and management of the introduction and spread of invasive alien species. Regulation 1143/2014 seeks to address the problem of invasive alien species in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have. The Regulation foresees three types of interventions: prevention, early detection and rapid eradication, and management.

The Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) specifically recognizes the introduction of marine alien species as a major threat to European biodiversity and ecosystem health, requiring EU Member States to include alien species in the definition of Good Environmental Status (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).

In the Mediterranean Sea, the February 2014 Integrated Correspondence Group on GES and Targets (Integrated CorGest) of the EcAp process of the Barcelona Convention selected the

Common Indicator 6 “Trends in the abundance, temporal occurrence and spatial distribution of non-indigenous species, particularly invasive nonindigenous species, notably in risk areas in relation to the main vectors and pathways of spreading of such species” from the integrated list of indicators adopted in the 18th Conference of the Parties (COP 18), as a basis of a common monitoring program for the Mediterranean in relation to non-indigenous species. The Integrated Monitoring and Assessment Programme (IMAP), adopted at the 19th Conference of the Parties to the Barcelona Convention (COP 19) in Athens, included definitions of ecological objectives, operational objectives and related indicators for the implementation of the EcAp, as well as guidelines for monitoring to address Common Indicator 6.

The Protocol concerning specially protected areas and biological diversity in the Mediterranean (SPA Protocol) of the Mediterranean Action Plan invites the Contracting Parties to take “all appropriate measures to regulate the intentional or non-intentional introduction of non-indigenous or genetically modified species into the wild and prohibit those that may have harmful impacts on the ecosystems, habitats or species” (Article 13). Towards this direction the Contracting Parties have agreed on an Action Plan concerning species introductions and invasive species in the Mediterranean Sea.

The main objective of the recently updated Action Plan (UNEP/MAP 2017) is “to promote the development of coordinated efforts and management measures throughout the Mediterranean region in order to prevent as appropriate, minimize and limit, monitor, and control marine biological invasions and their impacts on biodiversity, human health, and ecosystem services, particularly by:

1. strengthening the capacity of the Mediterranean countries to deal with the issue of alien species, within the framework of the EcAp;
2. supporting a regional information network for the efficient exploitation of alien species data and to support the regional policies on biological invasions;
3. further developing MAMIAS, an online platform for the collection, exploitation, and dissemination of information on marine biological invasions in the Mediterranean Sea to support relevant regional and international policies;
4. strengthening the institutional and legislative frameworks at the level of the countries of the region;
5. conducting baseline studies and establishing monitoring programmes, within the framework of the EcAp Integrated Monitoring and Assessment Programme, to collect reliable and pertinent scientific data that can be used for decision-making where necessary;
6. setting up mechanisms for cooperation and the exchange of information among the Mediterranean countries;
7. Elaborating guidelines and any other technical documentation.

The updated Action Plan, invites Mediterranean countries “to establish National Plans to prevent the introduction of new alien marine species by controlling their pathways, and to mitigate their negative impact”. Specifically: “Each National Plan, taking into account the concerned country’s specific features, must suggest appropriate institutional and legislative measures. The National Plan shall be based on the available scientific data and will include programmes for (i) the collection and regular updating of data, especially for the support of EcAp; (ii) the highest possible dissemination of data and relevant information, especially within the framework of MAMIAS; (iii) training and refresher courses for specialists; (iv) awareness-raising and education for the general public, actors and decision-makers; and (v) coordination and collaboration with other states. The national plans must be brought to the attention of all concerned actors and, when possible, coordinated on a regional basis."

The present study develops the National Action Plan of Cyprus concerning species introductions and Invasive species, in accordance to the principles and guidelines of the Mediterranean Action Plan (UNEP/MAP 2017). Some background and state-of-the-art information is initially provided on the status and current knowledge of biological invasions in the Mediterranean and in Cyprus in particular.

2. Biological Invasions in the Mediterranean

A great number of studies in the recent years have substantially increased our level of knowledge on biological invasions in the Mediterranean. In the following sections, a synopsis of the available information is provided, specifically on the number and taxonomic identity of the alien species in the Mediterranean, their main pathways of introduction, their spatial distribution, and impacts.

2.1 Alien species inventories

Basin-wide inventories of the marine alien species of the Mediterranean have been published the last years by two research teams, Zenetos et al. (2010, 2012) and Galil (2012), Galil et al. (2016). The inventory by Zenetos et al. (2010), later updated by Zenetos et al. (2012), reported a total of 986 alien and cryptogenic species in the Mediterranean. It included both multicellular and unicellular species, and also species flagged as questionable or cryptogenic. The Galil (2012) inventory, later updated by Galil et al. (2016), included 726 multicellular alien species in the Mediterranean Sea of which 614 were considered as established; it did not include cryptogenic species. Recently, Zenetos et al. (2017) made a critical evaluation of all previous reviews and reported a total of 821 multicellular alien species in the Mediterranean of which 613 were assessed as established. The studies by the two research teams, despite their differences in taxonomic scope, definitions, and species-specific assessments, provided similar results on the taxonomic identity of the alien species in the Mediterranean.

In addition to the basin-wide inventories, many national lists of alien species have been published, most of them the last decade, including Croatia (Pećarević et al. 2013), Cyprus (Katsanevakis et al. 2009), Greece (Zenetos et al. 2009, 2011), Israel (Galil 2007), Italy (Occhipinti-Ambrogi et al. 2011), Libya (Bazairi et al. 2013), Malta (Sciberras and Schembri 2007; Evans et al. 2015), Slovenia (Lipej et al. 2012), Tunisia (Ounifi-Ben Amor et al. 2016; Sghaier et al. 2016), Turkey (Çinar et al. 2005, 2011), and Lebanon (Bitar et al. 2017). These inventories critically reviewed published and grey literature and involved many taxonomic experts, substantially improving our knowledge on the spatial distribution of alien species in the Mediterranean. National inventories have also been submitted by EU member states for the fulfilment of their obligations for the initial assessment of their territorial waters as provisioned by the Marine Strategy Framework Directive. Furthermore, national lists of alien species can be easily derived from the European Alien Species Information Network (EASIN) through its online multiple-criteria search and mapping tools (Katsanevakis et al. 2015).

All known alien species introductions in the Mediterranean have been compiled in the Marine Mediterranean Invasive Alien Species online database (MAMIAS; www.mamias.org), developed by RAC/SPA in collaboration with the Hellenic Centre for Marine Research (HCMR). According to MAMIAS, 1057 non-indigenous species have been reported in the Mediterranean Sea (excluding vagrant species and species that have expanded their range without human assistance through the Straits of Gibraltar), of which 618 are considered as established. Of those established species, 106 have been flagged as invasive. Among the four Mediterranean sub-regions, the highest number of established alien species has been reported in the eastern Mediterranean, whereas the lowest number in the Adriatic Sea (Table 1).

In terms of alien species richness, the dominant group is Mollusca, followed by Crustacea, Polychaeta, Macrophyta, and Fish (Fig. 1). The taxonomic identity of alien species differs among the four sub-basins, with macrophytes being the dominant group in the western and central Mediterranean and in the Adriatic Sea (Table 1).

Table 1: *Summarized information for each Mediterranean sub-region about the status of alien invasions. Sources: MAMIAS, Zenetos et al. (2012)*

	eastern Mediterranean	central Mediterranean	Adriatic	western Mediterranean
number of established alien species	468	183	135	215
most important pathway of introduction	Suez Canal	shipping	shipping	shipping
2nd most important pathway	shipping	Suez Canal	aquaculture	aquaculture
richest taxons in alien biota	Mollusca, Crustacea	Macrophyta, Polychaeta	Macrophyta, Mollusca	Macrophyta, Crustacea
trend in the rate of new introductions (based on the last 3 decades)	increasing	decreasing	decreasing	decreasing

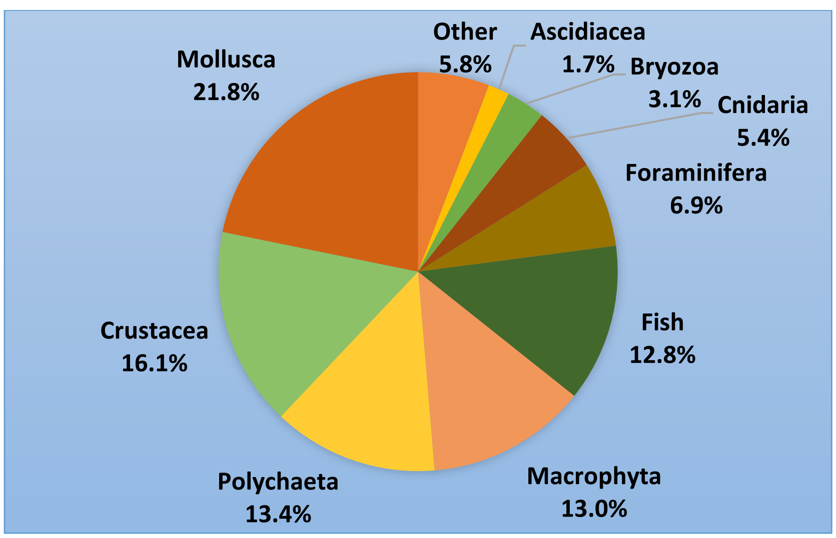

Figure 1: *Contribution of the major taxa in the alien marine biota of the Mediterranean Sea. Modified from Zenetos et al. (2012).*

II.2 Assessment of pathways and gateways of introduction

The main pathways of introduction of alien species in the Mediterranean Sea are the Suez Canal, shipping (ballast waters and hull fouling), aquaculture, and aquarium trade (Zenetos et al. 2012). The latter authors assessed the pathways of introduction of all alien species in the Mediterranean, and concluded that:

- More than half (51.9%) of the marine alien species in the Mediterranean were probably unintentionally introduced through the Suez Canal.
- Shipping is assumed to be the pathway of introduction of >400 species.
- Approximately 20 species have been introduced with certainty via aquaculture, while >50 species (mostly macroalgae), occurring in the vicinity of oyster farms, are assumed to be introduced accidentally as contaminants of imported species.
- A total of 18 species are assumed to have been introduced by the aquarium trade.

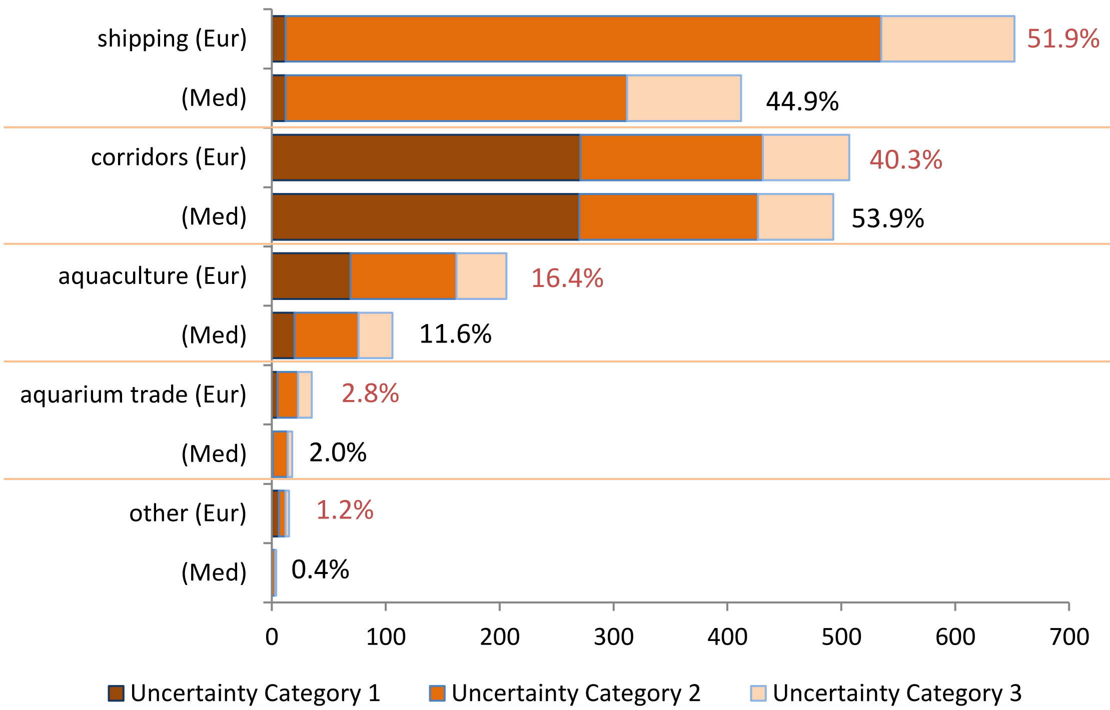

***Figure 2**: Number of marine alien species known or likely to be introduced by each of the main pathways, in Europe (Eur) and the Mediterranean (Med). Percentages add to more than 100% as some species are linked to more than one pathway (red percentages refer to the European total, while black percentages to the Mediterranean total). Uncertainty categories: (1) there is direct evidence of a pathway/vector; (2) a most likely pathway/vector can be inferred; (3) one or more possible pathways/vectors can be inferred; (4) unknown (not shown in the graph). Modified from Katsanevakis et al. (2013), Zenetos et al. (2012), and Katsanevakis and Crocetta (2014).*

The Suez Canal is the most important pathway in the Mediterranean sea, contrary to the case in Europe (Katsanevakis et al. 2013) and globally (Molnar et al. 2008), where canals rank second and third respectively, and shipping is the most important pathway (Fig. 2). New introductions of alien species in the Mediterranean Sea have an increasing trend, reaching almost 200 new species introductions per decade (Fig. 3). Many more species are expected to invade the Mediterranean Sea through the Suez Canal, as it has been continuously enlarged and the barriers for the invasion of Red Sea species have been substantially decreased (Katsanevakis et al. 2013; Galil et al. 2015). The observed increasing trend in new introductions by shipping is expected to halt due to the recent ratification of IMO's (International Maritime Organisation) "International Convention for the Control and Management of Ships' BallastWater and Sediments" (BWM Convention). Nevertheless, introductions by hull-fouling, which was identified as the most common vector for marine alien species so far introduced in European seas (Katsanevakis et al. 2013), will remain or even increase due to the recent adoption of the IMO Anti-fouling Convention in 2004 and the banning of the most effective (i.e. most toxic) of the anti-fouling hull coatings.

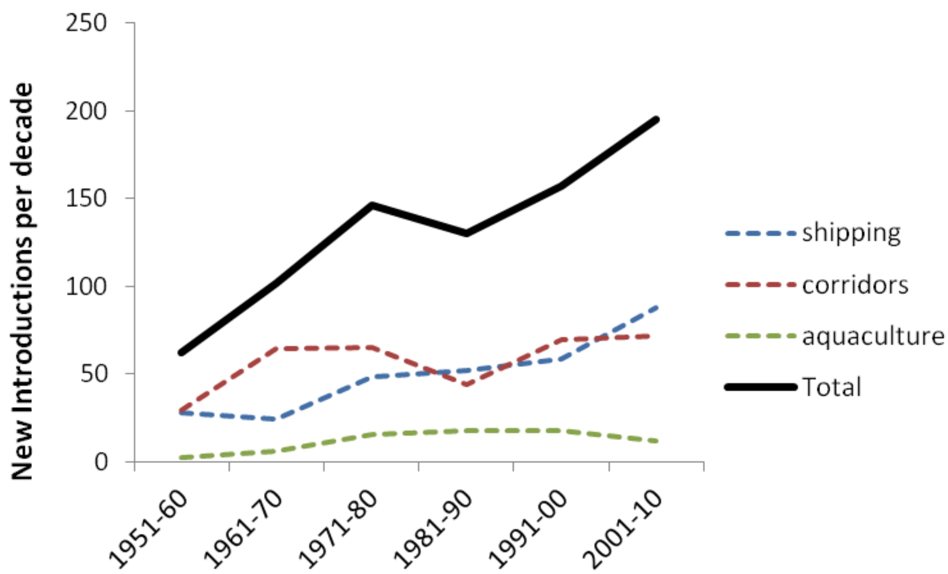

Figure 3*: Trends in new introductions of alien marine species in the Mediterranean per decade (trends in total introductions and by the three most important pathways) (modified from Zenetos et al. 2012)*

An assessment of the 'gateways' (i.e. countries of initial introduction) to alien invasions in the European Seas revealed marked geographic patterns depending on the pathway of introduction (Fig. 4; Nunes et al. 2014). Lessepsian migration is the predominant pathway of first introductions in Egypt, Lebanon, Israel, Syria and the Palestine Authority (all in the eastern Mediterranean), representing more than 70% of each country's first introduction events. For the other Mediterranean countries, shipping was the predominant pathway of initial introduction. Israel is the country with the highest number of recorded first introductions in the Mediterranean and adjacent seas, followed by Turkey (including also the Black Sea), France (including also the Atlantic waters), and Italy (Fig. 4).

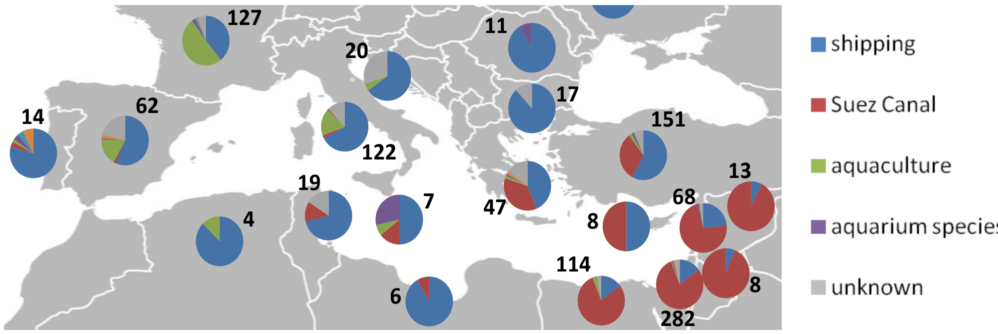

***Figure 4**: Proportion of marine alien species introduced for the first time in the Mediterranean and adjacent Seas through different pathways of introduction, per recipient country (i.e. countries of initial introduction). For clarity, data is shown for countries with more than two recorded first introduction events (numbers shown next to the charts). Modified from Nunes et al. (2014).*

II.3 Spatial distribution

The first comprehensive maps of the spatial distribution of marine alien species in the Mediterranean Sea were published by CIESM, covering Crustacea (Galil et al. 2002), fish (Golani et al. 2002), molluscs (Zenetos et al. 2004), and recently macrophytes (Verlaque et al. 2015). Since 2012, the launching of the European Alien Species Information Network (EASIN) provided new opportunities for assessing the spatial distribution of alien species in all European Seas (Katsanevakis et al. 2015). The EASIN online mapping tools allow the mapping in real time of the distribution of any single species or aggregated combination of species at four levels: by country, marine ecoregions, river basins, and on a standard 10×10 km grid. EASIN harmonizes and integrates information from many different sources. For marine species in the Mediterranean, it includes the CIESM data and also data from the Global Biodiversity Information Facility (GBIF; http://www.gbif.org/), the Global Invasive Species Information Network (GISIN; http://www.gisin.org), the Regional Euro-Asian Biological Invasions Centre (REABIC;http://www.reabic.net/), the Hellenic Network on Aquatic Invasive species (ELNAIS: https://services.ath.hcmr.gr/), the HCMR/EEA database (managed by the Hellenic Centre for Marine Research), the Mediterranean Marine Invasive Species information system (MedMIS, managed by IUCN; http://www.iucn-medmis.org), the Marine Mediterranean Invasive Alien Species online database (www.mamias.org), and EASIN-Lit (http://easin.jrc.ec.europa.eu/About/EASIN-Lit). EASIN-Lit is an EASIN product providing georeferenced records as retrieved from published literature (Trombetti et al. 2013).

Based on the EASIN mapping tools, Katsanevakis et al. (2014b) assessed the spatial distribution of marine alien species in the Mediterranean by pathway of introduction (Fig. 5). An aggregated map of the distribution of species introduced through the Suez Canal (Fig. 5 top) shows a characteristic pattern of high species richness in the south-eastern Levantine Sea, which declines anticlockwise along the coastline of the Levantine Sea and further westwards and northwards along the northern Mediterranean coast, and also westwards along the north-African coastline. A maximum of 129 species per 10 x 10 km cell is reached in the Haifa coastal areas, along the Israeli coastline. The distribution of species introduced by shipping is strikingly different to the one of Lessepsian species, with hotspot areas along the north-western Mediterranean coastline from Martigues and Marseille (France) to Genova (Italy), eastern Sicily (Italy), the Saronikos, Thermaikos and Evvoikos Gulfs (Greece), and the coastlines of the eastern Levantine (SE Turkey, Syria, Israel, and Lebanon) (Fig. 5 middle). Two main hotspots are observed for species introduced by aquaculture, the Tau lagoon (Gulf of Lion, France) and the Venice lagoon (northern Adriatic, Italy) (Fig. 5 bottom).

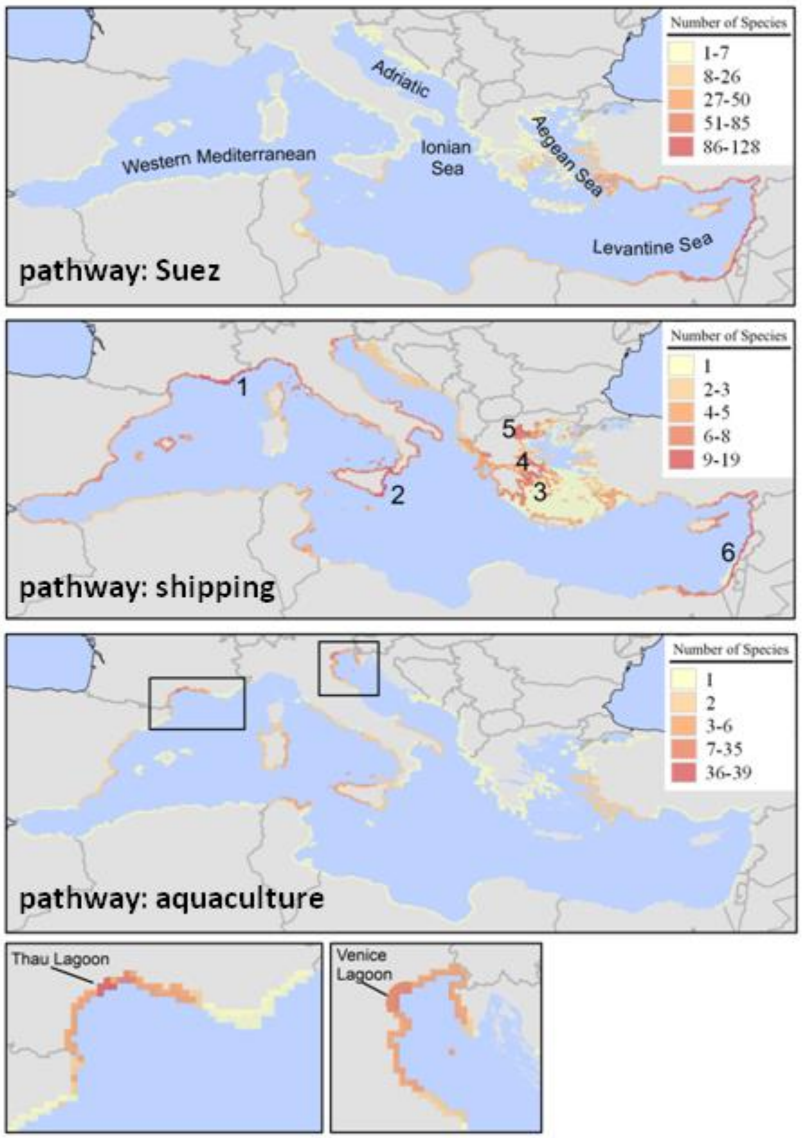

Figure 5*: Richness (number of species in a 10 × 10 km grid) of marine alien species introduced in the Mediterranean Sea through the Suez Canal (top), by shipping (middle), and by aquaculture (bottom). High-richness areas in the middle map: (1) north-western Mediterranean coastline from Martigues and Marseille (France) to Genova (Italy); (2) eastern Sicily; (3) Saronikos Gulf; (4) Evvoikos Gulf; (5) Thermaikos Gulf; (6)* the coastlines of SE Turkey, Syria, Israel, and Lebanon. The maps were produced by EASIN's mapping widget and are modified from Katsanevakis et al. (2014b).

II.4 Impact assessments

A systematic review of the impacts of marine invasive species on biodiversity and ecosystem services in the European Seas has been conducted recently (Katsanevakis et al. 2014a), covering the entire Mediterranean Sea. It was found that food provision was the ecosystem service that was impacted by the highest number of alien species. Of the 87 assessed invasive species (of which 60 occur in the Mediterranean Sea), thirty percent had an impact on entire ecosystem processes or wider ecosystem functioning, more often in a negative fashion. Forty-nine of the assessed species were reported as being ecosystem engineers, which fundamentally modify, create, or define habitats by altering their physical or chemical properties.

There are many mechanisms through which invasive alien species impact biodiversity and ecosystem services (Figs. 6 & 7). Katsanevakis et al. (2014a) reported not only negative impacts but also many positive impacts of alien species and stressed that the "native good, alien bad" view is a misconception, and the role of most of the alien species in marine ecosystems is rather complex. Many alien species often benefit some components of native biodiversity and can enhance or provide new ecosystem services. One of the main outcomes of the study by Katsanevakis et al. (2014a) was that evidence for most of the reported impacts is weak, as it is based on expert judgement or dubious correlations, while only for very few cases the reported impacts were inferred via manipulative or natural experiments. A need for stronger inference is evident, to improve our knowledge base of marine biological invasions and better inform environmental managers.

Based on (1) the review of impacts by Katsanevakis et al. (2014a), (2) the spatial distribution of alien species in the Mediterranean as assessed through EASIN, and (3) the distribution of the main marine habitats in the Mediterranean, a framework for mapping cumulative impacts of invasive alien species has been recently developed by Katsanevakis et al. (2016). Specifically, a conservative additive model was developed to account for the Cumulative IMPacts of invasive ALien species (CIMPAL) on marine ecosystems. According to this model, cumulative impact scores were estimated on the basis of the distributions of invasive species and ecosystems, and both the reported magnitude of ecological impacts and the strength of such evidence. The magnitude of such impacts in the Mediterranean Sea was estimated for every combination of the 60 invasive species highlighted by Katsanevakis et al. (2014a) and 13 habitats, for every 10 x 10 km cell of the basin (Fig. 8). Spatial patterns of cumulative impacts varied depending on the pathway of initial introduction of the invasive species in the Mediterranean Sea. Species introduced by shipping gave the highest impact scores and impacted a much larger area than those introduced by aquaculture and the Suez Canal. Invasive species were ranked based on their contribution to the cumulative impact score across the Mediterranean, and, overall, invasive macroalgae had the highest impact among all taxonomic groups (Fig. 9).

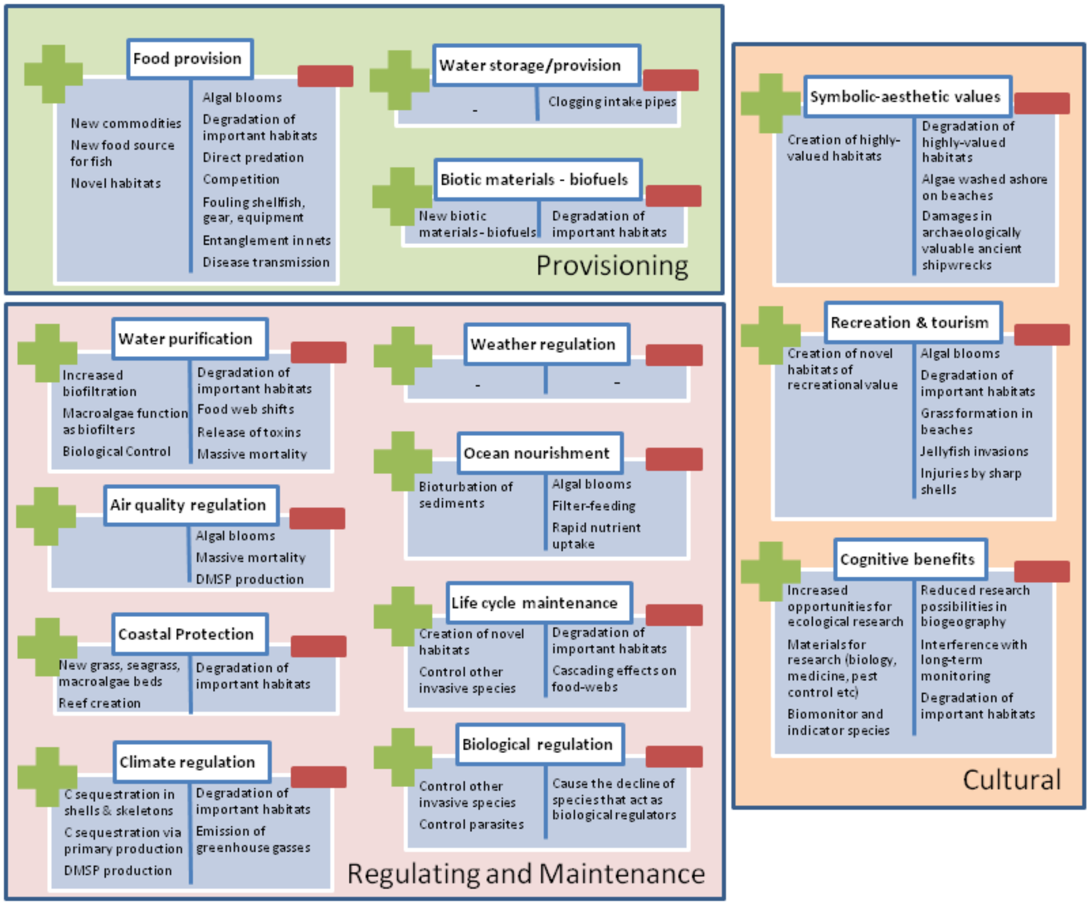

***Figure 6**: Main mechanisms through which alien species impact ecosystem services (sensu Liquete et al. 2013). Green cross: positive impacts, Red minus sign: negative impacts. Source: Katsanevakis et al. (2014a).*

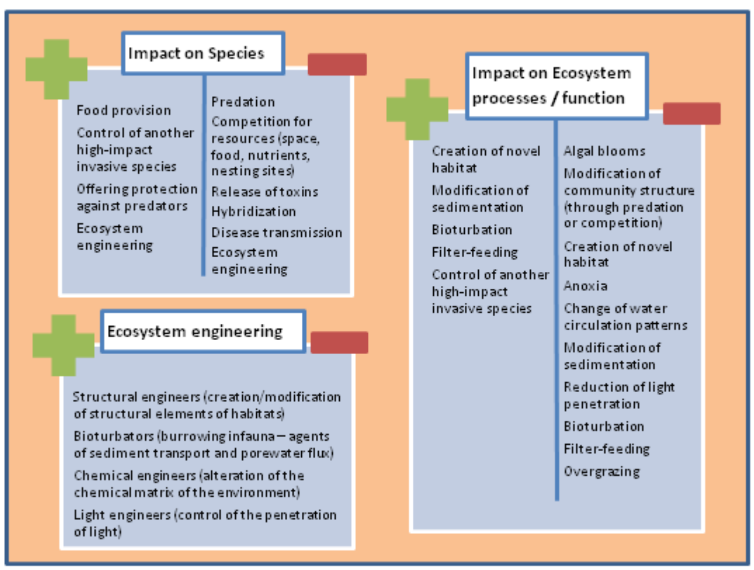

***Figure 7**: Main mechanisms through which alien species impact biodiversity. Green cross: positive impacts, Red minus sign: negative impacts. Source: Katsanevakis et al. (2014a).*

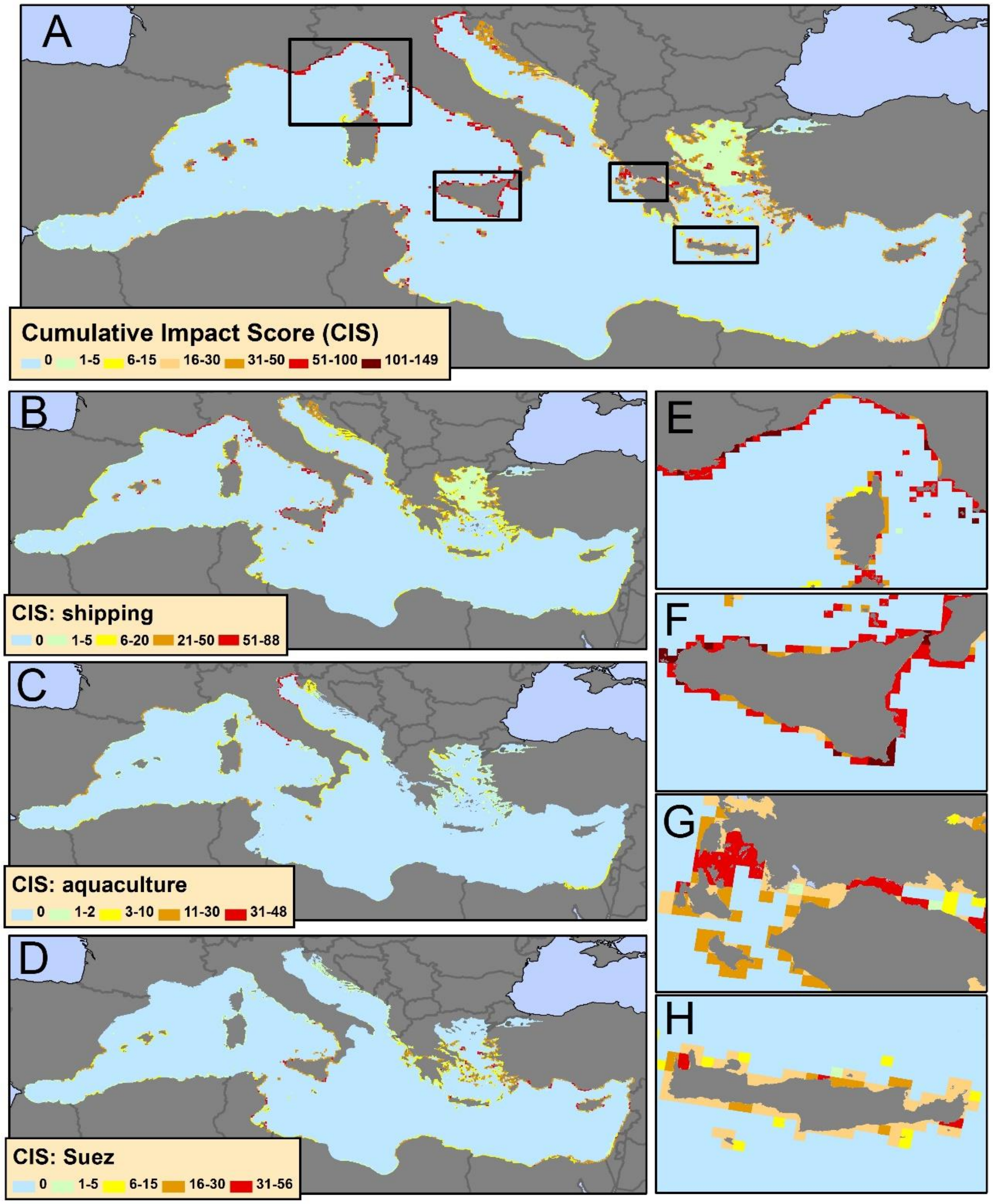

Figure 8*. Mediterranean Sea map (a) of the cumulative impact (CIMPAL) score of 60 invasive alien species to 13 marine habitats. Maps of cumulative impact scores to the same marine habitats by species likely introduced by shipping (b), aquaculture (c), and through the Suez Canal (d). Magnifications of the Ligurian Sea and Corsica (e), Sicily (f), the Greek Ionian Archipelagos and adjacent gulfs (g), and Crete (h). Source: Katsanevakis et al. (2016).*

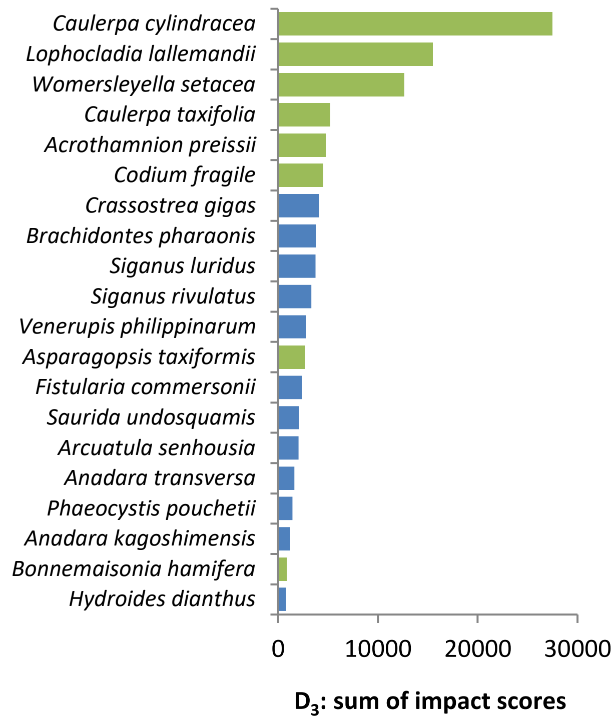

Figure 9. *Relative importance of the 60 high-impact species as assessed by indicator CIMPAL-D3, i.e. the sum of impact scores of the species across the entire Mediterranean basin (only the top 20 species are shown in the chart). Macrophytes are coloured green.*

3. Alien species in Cyprus

The first inventory of the alien marine species of Cyprus was published in 2009 (Katsanevakis et al. 2009). It included 126 alien or cryptogenic marine alien species, of which 42 molluscs, 28 fish, 19 polychaetes, 15 phytobenthic species, 12 crustaceans, and 10 species from other taxa. Most of these species (101) had an Indo-Pacific or Indian Ocean origin and their dominant mode of introduction was the Suez Canal. Among the 126 species, 80 were considered as established, 31 were casual records, 9 were cryptogenic, and 6 were considered as questionable.

Since that first inventory, many more species have been recorded (e.g. Iglésias and Frotté 2015; Crocetta et al. 2015; Lipej et al. 2017). In MAMIAS, 139 species have been included as being reported in Cyprus (Table 2). Very recently, the Cyprus Invasive Alien Species database (CYIAS) was established (but it is not yet online and publicly available), in which 155 marine alien species have been included. There is an increasing trend in the reporting of alien marine species in Cyprus (Fig. 10) and thus their total number is expected to keep increasing.

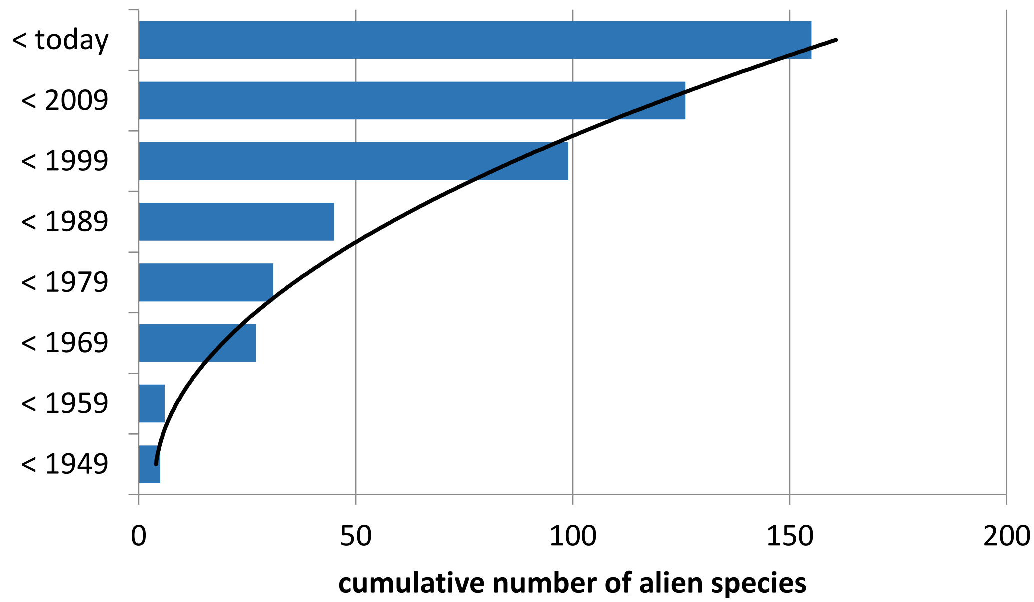

Figure 10*. Cumulative number of alien marine species in Cyprus per decade, based on the reported year of first sighting. Updated from Katsanevakis et al. (2009).*

Cyprus has developed a program of measures for the implementation of Article 13 of the Marine Strategy Framework Directive (MSFD) (DFMR, 2016). Specifically, the definition of Good Environmental Status (GES) in relation to alien marine species accepts that: GES is achieved if (1) invasive alien species (IAS) do not dominate in the abundance/biomass of each taxonomic group in the main habitat types, especially in MPAs; (2) the introduction of IAS that have been introduced directly in the waters of Cyprus through a primary pathway (i.e. secondary dispersal from other countries is excluded) by human activities such as shipping, aquaculture and aquarium trade, is minimized; and (3) the species that have been introduced directly in Cyprus through a primary pathway are not established beyond 'high-risk areas' such as ports, marinas, aquaculture installations etc, while their abundance in these 'high-risk areas' is minimized. Cyprus has excluded from its program of measures species introduced through the Suez Canal, as (according to Article 14 of the MSFD) neither Cyprus nor any other EU member state may take action or inaction to prevent further introductions through this pathway.

The program of measures, in relation to alien species, includes:

- Restrictions in the use of non-indigenous species in aquaculture (existing measure): Control or/and restrictions in the use of non-indigenous species in aquaculture by implementing Regulation 708/2007 of 11 June 2007 concerning the use of alien and locally absent species in aquaculture.
- Program for the reduction of the population of *Lagocephalus* spp (existing measure): Efforts to reduce the populations of *Lagocephalus* spp. by targeted fishing, on the basis of previous efforts of monitoring and sampling.
- Reduction of the populations of non-indigenous species by selective removal methods (new measure): Extension of the fishing period for the program for the reduction of the population of *Lagocephalus* spp. by targeted fishing, and investigation of selective removal methods to reduce invasive alien species that have documented negative impacts on important fisheries resources and the marine environment of Cyprus.
- Monitoring program of alien species (new measure): Implementation of a monitoring program of alien species, especially in coastal waters.

Table 2: *Inventory of alien species in Cyprus, according to MAMIAS (last updated in 2016)*

Species	Ecofunctional Group	Origin	Establishment
Acanthophora nayadiformis	Benthic Plants	Indo-Pacific	cryptogenic/questionable
Acteocina mucronata	Zoobenthos	Red Sea	established
Alepes djedaba	Demersal Fish	Indo-Pacific	established
Alvania dorbignyi	Zoobenthos	Circumtropical	cryptogenic
Amphistegina lobifera	Zoobenthos	Circumtropical	invasive
Apanthura sandalensis	Zoobenthos	Indo-Pacific	established
Aplysia dactylomela	Demersal Mollusca	Circumtropical	invasive
Apogonichthyoides pharaonis	Demersal Fish	Indo-Pacific	invasive
Aquilonastra burtoni	Zoobenthos	Indian W	invasive
Asparagopsis armata	Benthic Plants	Pacific SW	invasive
Atherinomorus forskalii	Pelagic Fish	Indo-Pacific	invasive
Brachidontes pharaonis	Zoobenthos	Indian W	invasive
Branchiomma bairdi	Zoobenthos	Atlantic/Pacific	invasive
Branchiomma luctuosum	Zoobenthos	Indo-Pacific	invasive
Bulla arabica	Zoobenthos	Indo-Pacific	invasive
Callinectes sapidus	Demersal Crustacea	Atlantic W	invasive
Cassiopea andromeda	Zoobenthos	Indo-Pacific	invasive
Caulerpa racemosa var. cylindracea	Benthic Plants	Indo-Pacific	invasive
Caulerpa racemosa var. lamourouxii f. requienii	Benthic Plants	Indo-Pacific	established
Caulerpa racemosa var. turbinata /uvifera	Benthic Plants	Indo-Pacific	cryptogenic/questionable
Ceratonereis mirabilis	Benthic Plants	Indo-Pacific	invasive
Cerithidium perparvulum	Zoobenthos	Pacific	established
Cerithiopsis pulvis	Zoobenthos	Red Sea	established
Cerithiopsis tenthrenois	Zoobenthos	Indian	established
Cerithium nesioticum	Zoobenthos	Indian W	established
Cerithium scabridum	Zoobenthos	Indian W	invasive
Chama aspersa	Zoobenthos	Indo-Pacific	established
Chama pacifica	Zoobenthos	Indo-Pacific	invasive
Charybdis helleri	Demersal Crustacea	Indo West Pacific	invasive
Charybdis longicollis	Demersal Crustacea	Indian W	invasive
Chelidonura fulvipunctata	Demersal Mollusca	Indo-Pacific	established
Chondria coerulescens	Benthic Plants	Atlantic E	established
Chromodoris annulata	Demersal Mollusca	Indian	invasive
Chrysallida maiae	Zoobenthos	Red Sea	established
Cingulina isseli	Zoobenthos	Subtropical	established
Cladophora cf. patentiramea	Benthic Plants	Indo-Pacific	established
Conomurex persicus	Zoobenthos	Indian W	invasive

Cycloscala hyalina	Zoobenthos	Indo-Pacific	established
Cylichnina girardi	Zoobenthos	Indo-Pacific	established
Dendostrea frons	Zoobenthos	Indo-Pacific	invasive
Dussumieria elopsoides	Pelagic Fish	Indo-Pacific	established
Enchelycore anatina	Demersal Fish	Atlantic Tropical	established
Equulites klunzingeri	Demersal Fish	Indian	established
Ergalatax junionae	Zoobenthos	Indian W	invasive
Erugosquilla massavensis	Demersal Crustacea	Indian W	invasive
Etrumeus teres	Pelagic Fish	Subtropical	invasive
Eusyllis kupfferi	Zoobenthos	Atlantic	established
Finella pupoides	Zoobenthos	Indo-Pacific	established
Fistularia commersonii	Demersal Fish	Indo-Pacific	invasive
Flabellina rubrolineata	Zoobenthos	Indo-Pacific	established
Fulvia fragilis	Zoobenthos	Indian	invasive
Gafrarium pectinatum	Zoobenthos	Indo-Pacific	established
Ganonema farinosum	Benthic Plants	Indian	cryptogenic/established
Halophila stipulacea	Benthic Plants	Red Sea	invasive
Hamimaera hamigera	Zoobenthos	Indo-Pacific	established
Hemiramphus far	Demersal Fish	Indo-Pacific	established
Herdmania momus	Zoobenthos	Indo-Pacific	established
Herklotsichthys punctatus	Pelagic Fish	Red Sea	established
Himantura uarnak	Demersal Fish	Indo-Pacific	established
Hydroides dianthus	Zoobenthos	Atlantic NW	invasive
Hydroides elegans	Zoobenthos	Circumtropical	invasive
Hydroides heterocerus	Zoobenthos	Indian W	established
Hypselodoris infucata	Demersal Mollusca	Indo-Pacific	established
Infundibulops erythraeus	Zoobenthos	Indian W	established
Lagocephalus sceleratus	Demersal Fish	Indo-Pacific	invasive
Lagocephalus spadiceus	Demersal Fish	Indo-Pacific	established
Lagocephalus suezensis	Demersal Fish	Red Sea	established
Laodicea fijiana	Zooplankton	Indo-Pacific	questionable
Leucotina natalensis	Zoobenthos	Indo-Pacific	established
Linopherus canariensis	Zoobenthos	Atlantic	established
Lophocladia lallemandii	Benthic Plants	Indo-Pacific	invasive
Lysidice collaris	Zoobenthos	Indo-Pacific	established
Malleus regula	Zoobenthos	Indo-Pacific	established
Marsupenaeus japonicus	Demersal Crustacea	Indo-Pacific	invasive
Melibe viridis	Demersal Mollusca	Indo-Pacific	invasive
Metapenaeopsis aegyptia	Demersal Crustacea	Indo-Pacific	established
Metapenaeus monoceros	Demersal Crustacea	Indo West Pacific	invasive

Metasychis gotoi	Demersal Crustacea	Indo-Pacific	established
Metaxia bacillum	Zoobenthos	Red Sea	established
Neopseudocapitella brasiliensis	Zoobenthos	Atlantic/Pacific	established
Notomastus aberans	Zoobenthos	Indian W	established
Notomastus mossambicus	Zoobenthos	Indian	invasive
Oenone cf. fulgida	Zoobenthos	Indo-Pacific	questionable
Ophiactis macrolepidota	Zoobenthos	Circumtropical	established
Ophiactis savignyi	Zoobenthos	Circumtropical	established
Paphia textile	Zoobenthos	Indo-Pacific	established
Paradella dianae	Zoobenthos	Pacific NE	established
Parexocoetus mento	Pelagic Fish	Indo-Pacific	invasive
Pegidia lacunata	Benthic Protozoa	Indo-Pacific	established
Pempheris vanicolensis	Demersal Fish	Indo-Pacific	invasive
Penaeus semisulcatus	Demersal Crustacea	Indo West Pacific	invasive
Percnon gibbesi	Demersal Crustacea	Atlantic W	invasive
Phascolosoma scolops	Zoobenthos	Indo-Pacific	established
Pilumnopeus vauquelini	Demersal Crustacea	Indian W	established
Pinctada radiata	Zoobenthos	Indo-Pacific	invasive
Pista unibranchia	Zoobenthos	Indo-Pacific	established
Polysiphonia atlantica	Zoobenthos	Circumboreal	cryptogenic/questionable
Polysiphonia fucoides	Benthic Plants	Atlantic N	established
Portunus segnis	Demersal Crustacea	Indian	invasive
Prosphaerosyllis longipapillata	Zoobenthos	Pacific SW	casual
Psammotreta praerupta	Zoobenthos	Indo-Pacific	casual
Pseudochama corbieri	Zoobenthos	Red Sea	established
Pseudolachlanella slitella	Benthic Protozoa	Indo-Pacific	established
Pseudonereis anomala	Zoobenthos	Indo-Pacific	invasive
Pteragogus pelycus	Demersal Fish	Indian	invasive
Purpuradusta gracilis notata	Zoobenthos	Indian W	established
Pyrunculus fourierii	Zoobenthos	Indo-Pacific	established
Rhinoclavis kochi	Zoobenthos	Indo-Pacific	invasive
Rhopilema nomadica	Zooplankton	Red Sea	invasive
Rissoina bertholleti	Zoobenthos	Indian W	established
Sargocentron rubrum	Demersal Fish	Indo-Pacific	invasive
Saurida undosquamis	Demersal Fish	Indo-Pacific	invasive
Scarus ghobban	Demersal Fish	Indo-Pacific	established
Scomberomorus commerson	Pelagic Fish	Indo-Pacific	invasive
Sepioteuthis lessoniana	Demersal Mollusca	Indo-Pacific	invasive
Septifer cumingii	Zoobenthos	Red Sea	invasive
Siganus luridus	Demersal Fish	Indian	invasive
Siganus rivulatus	Demersal Fish	Red Sea	invasive

Sillago sihama	Demersal Fish	Indo-Pacific	invasive
Smaragdia souverbiana	Zoobenthos	Indo-Pacific	established
Sphoeroides pachygaster	Demersal Fish	Atlantic Tropical	range expansion
Sphyraena chrysotaenia	Demersal Fish	Indo-Pacific	invasive
Spirobranchus tetraceros	Zoobenthos	Circumtropical	established
Spirorbis marioni	Zoobenthos	Atlantic/Pacific	established
Spondylus spinosus	Zoobenthos	Indo-Pacific	invasive
Stephanolepis diaspros	Demersal Fish	Red Sea	invasive
Sticteulima cf. lentiginosa	Zoobenthos	Indo-Pacific	casual
Stypopodium schimperi	Benthic Plants	Indo West Pacific	invasive
Synaptula reciprocans	Zoobenthos	Indo-Pacific	invasive
Syrnola fasciata	Zoobenthos	Indo-Pacific	established
Terebella ehrenbergi	Zoobenthos	Indo-Pacific	questionable
Thaisella lacera	Zoobenthos	Indian	established
Thalamita poissonii	Demersal Crustacea	Indo West Pacific	cryptogenic/established
Turbonilla edgarii	Zoobenthos	Indo-Pacific	established
Upeneus moluccensis	Demersal Fish	Indo-Pacific	invasive
Upeneus pori	Demersal Fish	Indian	invasive
Womersleyella setacea	Benthic Plants	Indo-Pacific	invasive
Zafra savignyi	Zoobenthos	Red Sea	established
Zafra selasphora	Zoobenthos	Indian W	established

4. Action plan

According to the updated Action Plan concerning species introductions and invasive species in the Mediterranean Sea (UNEP/MAP 2017), the National Action Plan of Cyprus shall include programmes for (i) the collection and regular updating of data, especially for the support of EcAp; (ii) the highest possible dissemination of data and relevant information, especially within the framework of MAMIAS; (iii) training and refresher courses for specialists; (iv) awareness-raising and education for the general public, actors and decision-makers; and (v) coordination and collaboration with other states. In the following sections each of these five objectives is developed. The monitoring actions of the Plan will be co-financed by the European Maritime and Fisheries Fund (EMFF) in the framework of the Operational Program "THALASSA 2014-2020".

4.1 Plan for the collection and regular updating of data, especially for the support of EcAp

The Action Plan for the collection and regular updating of data is based on the UNEP/MAP guidelines for the implementation of the Integrated Monitoring and Assessment Programme (IMAP), which lays down the principles for an integrated monitoring in the Mediterranean Sea and aims to facilitate the implementation of article 12 of the Barcelona Convention and several monitoring related provisions under different protocols with the main objective to assess GES. Its backbone is the 11 Ecological Objectives and their 27 common indicators as presented in the decision IG.22/7 of the 19th Meeting of the Contracting Parties (COP 19), held in February 2016.

Common Indicator 6 of IMAP is about "*Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species (NIS)*". It is an 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 pathway but also, indirectly, the effectiveness of the different existing policies targeting alien species in the Mediterranean Sea.

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

'Trend in abundance' is defined as the interannual change in the estimated 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 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 a non-indigenous species.

In the guidelines for the implementation of Common Indicator 6 (UNEP(DEPI)/MED WG.430/3) the following recommendations are given:

- 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 program, rapid assessment studies may be undertaken, usually but not exclusively at marinas, jetties, and fish farms (e.g. Pederson et al. 2003).
- 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.
- 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).
- The monitoring of NIS generally should start on a localized 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 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.
- Monitoring at "hot-spots" and "stepping stone 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.

In accordance with the general IMAP guidelines, the following monitoring programs will be implemented in Cyprus:

4.1.1 Monitoring of NIS in Cavo Greco and Nissia MPAs

Monitoring of NIS will be conducted in two marine protected areas (MPAs) of the Natura 2000 network in the coastal waters of Cyprus: Cavo Greco (KAVO GKREKO: CY3000005) and Nissia (THALASSIA PERIOCHI NISIA: CY3000006). These 2 areas are located in the south-easterm part of the island (Fig. 11). The geographical location of the 2 areas justifies them as "hot-spots" for Non-Indigenous Species (NIS) introductions, especially of Indo-Pacific origin due to the proximity with the Suez Canal, which is the most significant pathway for NIS in the Mediterranean and in the Levantine Basin (see Section 2). In addition, the selection of the two areas was based on their special interest, since they are included in the Natura 2000 network due to the significant biodiversity they host.

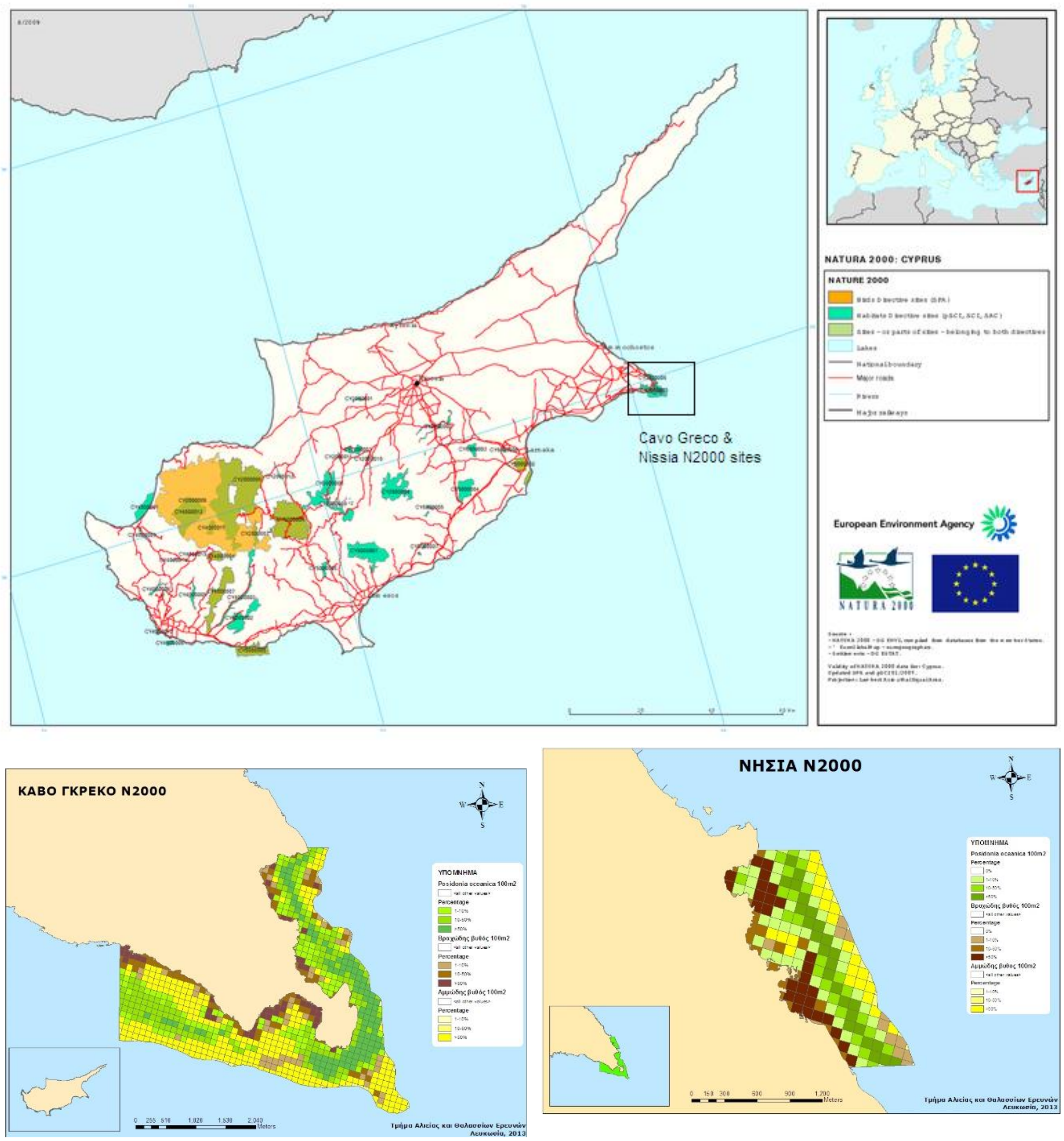

Figure 11: *(top panel) Location of the two MPAs to be monitored for NIS, Cavo Greco and Nissia. (bottom panels) Borders and habitat maps of Cavo Greco (left) and Nissia (right).*

Surveys will be conducted in the three basic habitat types of the study areas, i.e. rocky bottoms, sandy bottoms and Posidonia oceanica beds (Fig. 11) at a sufficient number of stations. These stations will be surveyed on an annual basis. During the first year of the monitoring (baseline survey), four seasonal sampling expeditions (winter, spring, summer, autumn) will be conducted. During the second year, two seasonal samplings, one in winter and one in summer, will be conducted. After evaluating the results of the first two years, the monitoring scheme (number of stations, number of seasonal surveys, etc) for the following years will be decided. The time series of monitoring NIS in the two MPAs will provide the basis for estimating trends in abundance, temporal occurrence and spatial distribution of NIS and the ratio between NIS and native species in the most important taxonomic groups.

Monitoring in the two MPAs will aim at fish communities, macroalgae, angiosperms and epibenthic megafauna (invertebrates). Specifically:

Monitoring fish

Species composition, population density and biomass will be estimated based on underwater visual surveys with SCUBA diving. Strip transect sampling will be conducted, which is widely applied for fish community studies (Katsanevakis et al. 2012). At every sampling station three repetitive transects will be surveyed, each of dimensions 25 x 5 m. The divers/researchers will be moving along a 25-m diving line, defining the centreline of each strip, and will record all fish within 2.5 m from the centreline (La Messa and Vacchi 1999; Giakoumi et al. 2012). For every recorded individual an estimate of its length will be recorded. Total length data will be converted to biomass according to the allometric equation $W=aL^b$, where W is the net mass (in g) and L the total length (in cm). Parameters a and b will be retrieved from the published literature, preferably from studies in the eastern Mediterranean (e.g. Moutopoulos and Stergiou 2002) and from FishBase (Froese and Pauly 2009).

Mean population density and biomass will be estimated for each fish species and each habitat (for both indigenous and non-indigenous species). For every habitat, the ratio of non-indigenous to indigenous population densities and biomasses will be estimated. Standard errors and 95% confidence intervals of all estimates will be calculated based on non-parametric bootstrap (Efron and Tibshirani 1993).

Monitoring epibenthic megafauna

For the monitoring of epibenthic megafauna, the approach of estimating occupancy (probability of presence) by jointly estimating detectability based on repetitive surveys at each station will be followed (according to the protocols developed by Issaris et al. 2012). Occupancy has been proposed as an appropriate state variable when monitoring the spatial and temporal evolution of biological invasions (Hanspach et al. 2008; Katsanevakis et al. 2011; Issaris et al 2012). Accounting for detectability by applying proper methods is crucial to avoid underestimating occupancy due to false absences. The basic requirement of these methods is that sampling stations are surveyed for the presence/absence of the target species more than once during a sampling season (MacKenzie et al. 2002).

According to the general scheme proposed by Issaris et al. (2012), K observers simultaneously but independently search for the target species at each of N sampling sites. Occupancy ψ is jointly modelled with probability of detection p under a model-based approach (MacKenzie et al. 2006). A site might be either occupied (with probability ψ) or unoccupied (with probability $1 - \psi$) by the target species. If the site is unoccupied, the target species will not be detected. If the site is occupied, each observer *j* will either detect the target species (with probability p_j) or not (with probability $q_j = 1 - p_j$). The probability of each detection history can be expressed as a function of ψ and p_j. For example, the probability of the detection history H_i=10 (denoting that the site *i* was surveyed by two observers, with the species being detected by the first but not be the second) would be $\Pr(H_i = 10) = \psi p_1 q_2 = \psi p_1(1-p_2)$. For sites where the species is not detected by any of the observers, there are two possibilities, either the species is present but never detected (a 'false absent') or the species is genuinely absent. Thus, $\Pr(H_i{=}00) = \psi q_1 q_2 + (1-\psi)$. By deriving such expressions for each of the *N* observed detection histories, the likelihood of the data will be $L(\psi, \mathbf{p} \mid H_1, H_2, ..., H_N) = \prod_{i=1}^{N} \Pr(H_i)$, where **p** is the vector of detection probabilities; ψ and p_j can be estimated with standard maximum likelihood techniques (MacKenzie et al. 2006).

For each target species, the potential relationships between the model parameters (occupancy and detection probabilities) and environmental/spatial variables can be investigated. Covariates can be incorporated by using the logistic model $\theta_i = \exp(\mathbf{Y_i}\boldsymbol{\beta}) \cdot (1 + \exp(\mathbf{Y_i}\boldsymbol{\beta}))^{-1}$, where ϑ_i is the probability of interest (occupancy or detection probability), $\mathbf{Y_i}$ are the covariates to be modelled, and $\boldsymbol{\beta}$ denotes the vector of the covariate coefficients to be estimated. Standard maximum likelihood techniques will be applied to obtain estimates of the model parameters (MacKenzie et al. 2006). Model selection will be based on the Akaike's Information Criterion (AIC; Burnham and Anderson 2002).

Surveys for epibenthic megafauna in the study areas will be conducted in the same sampling stations and transects as for fish. Epibenthic megafauna will be recorded (simple presence/absence) at each of the three repetitive transects of each station by two independent experienced observers during 15-min surveys at each transect. Identification will be conducted in situ and in case of doubts photographic samples or limited biological samples will be taken for species identification in the lab. The analysis of the data will be conducted using the open-access software PRESENCE (Hines 2006).

Monitoring macroalgae, angiosperms and encrusting fauna

Photoquadrat sampling will be applied to monitor the diversity and coverage of indigenous and non-indigenous communities of macroalgae, angiosperms and encrusting fauna. A sufficient number of photographic quadrats of dimensions 50 x 50 cm will be taken on both hard and soft substrates. Sampling will be conducted at the same stations and transects as to those of the fish surveys. At each of these sampling stations 20 photographic samples will be taken. To ensure random sampling, a 100-m diving line, marked every 5 m, will be deployed randomly at each station and the quadrats will be placed with one side adjacent to the line and their corner at the exact position of each line mark.

The software photoQuad (Trygonis and Sini 2012) will be used for the analysis of the photographic samples. This software has been developed in the Department of Marine Sciences, University of the Aegean, is free, and has been designed specifically for 2D analysis of photographic quadrats for ecological applications. After the pre-processing of the pictures, all species will be identified, and a basic library of species will be created. The method of stratified random points will be applied to estimate the percent coverage of each species, based on 100 points per quadrat. The mean and 95% confidence intervals of the coverage of each species will be estimated for each of the two surveyed habitat types in the study areas. Restricted sampling might be necessary for the identification of some taxa.

4.1.2 Monitoring of NIS in ports, marinas and other hotspot areas

Initially, a study to identify all hotspot areas of NIS introductions in Cyprus will be conducted. Potential hotspot areas include ports, marinas, aquaculture facilities, areas of increased seawater temperature etc. All potential hotspot areas will be mapped and during the first year it will decided which of these areas will be included in the monitoring scheme.

At each of these areas a rapid assessment survey of sessile indigenous and non-indigenous species will be conducted on an annual basis. Conditional on the availability of funds, occupancy surveys for monitoring of benthic megafauna, will also be conducted, on a less regular basis.

Rapid assessment surveys of sessile indigenous and non-indigenous species

Rapid assessment surveys of sessile communities on docks, permanently installed pontoons, floats, tires, ropes, and any other available hard substratum will be conducted in all hotspot areas (see e.g. Pederson et al. 2003). Fouling communities will be sampled by the team participating in the rapid assessment surveys, which should include taxonomic experts familiar with native and non-native marine organisms. This will be done by using scrapers, nets, various pans for viewing organisms on the dock, dissecting equipment and all necessary equipment for preserving and transferring specimens in the lab. Participants will be able to identify species in the field and verify them in the laboratory. A list of species will be maintained and voucher specimens will be preserved and archived. At each location, sampling time will be limited to one hour, and thus all locations will be sampled within a limited number of days. The final output of the rapid assessment surveys will be inventories of both indigenous and non-indigenous species at each hotspot area.

Occupancy surveys for monitoring benthic megafauna (optional)

At the close vicinity of each of the selected hotspot areas, occupancy surveys with snorkeling and SCUBA diving will be conducted (see also 4.1.1). Specifically, shallow rocky reefs will be surveyed by snorkeling (at least five transects at each hotspot area), and deeper waters will be surveyed by SCUBA (at least three transects at each of the main three habitats: hard bottom, soft bottom, *Posidonia oceanica* beds). Each transect will be surveyed for 15 min by two independent observers, who will record all benthic or benthopelagic NIS detected (including fish, invertebrates, and macrophytes). The methodology by Issaris et al. (2012) will be applied (see 4.1.1 for details).

4.1.3 Monitoring NIS through the MEDITS survey

The aim of the project “**Mediterranean International Bottom Trawl Survey**” (**MEDITS**) in the Cyprus coastal zone is the evaluation of the abundance and distribution of benthic and demersal species around the island as well as elements of their demographic structure. The survey is implemented in the framework of the Cyprus National Data Collection Programme, under the Community Data Collection Framework (Regulations (EC) 199/2008, 665/2008 and Decision 2010/93/EU), and is based on the MEDITS instruction manual (Medits Handbook version 8, 2016).

The sampling stations surveyed cover all the coastal area under the effective control of the Cyprus Republic (from Agia Napa to Chrysochou Bay). In total 26 sampling stations are assigned inside the 10-50, 50-100, 100-200, 200-500 and 500-800 m depth zones parallel to the coastline (Table 3), according to the continental shelf and slope which extends from 10 to 800m depth. The shallower depth zones are sampled more intensively since in many areas no suitable hauls are available in the deepest zones. Spatial distribution of sampling stations is given in Fig. 12.

Table 3. *MEDITS sampling stations distribution by depth stratum*

Stratum	Depth zone (m)	No of Hauls	Hauls by stratum
32101	10-50	5	1, 5, 9, 12, 25
32102	50-100	9	2, 6, 7, 8, 10, 11, 13, 24,27
32103	100-200	5	3, 14, 15, 20, 23
32104	200-500	3	4, 21, 22
32105	500-800	4	16, 17, 19,28
Total hauls		**26**	

The MEDITS dataset can be used to estimate a time series of relative abundance and biomass of native and alien species that thrive on soft bottoms in the territorial waters of Cyprus. A 10-year time series is already available and the MEDITS survey will continue on an annual basis. Hence, trends in relative abundance and biomass of alien species can be easily estimated in accordance to the Common Indicator 6 of the IMAP.

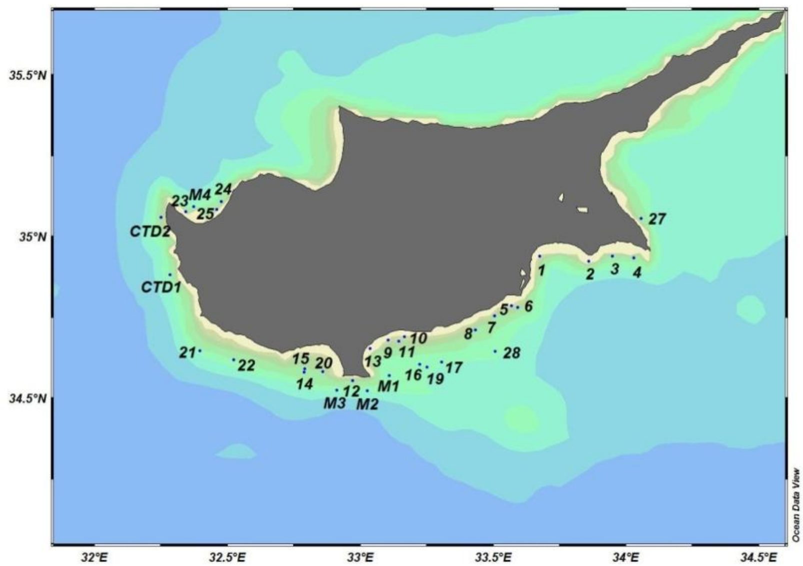

Figure 12. *MEDITS survey sampling stations distribution.*

4.1.4 National inventory of NIS

A national inventory of NIS in Cyprus will be created by updating the current inventories (see section 3). This inventory will be updated on an annual basis and will be made available to MAMIAS.

The inventory will be updated based at least on the following sources:

i. The new data collected by the monitoring surveys of NIS in Cavo Greco and Nissia MPAs.
ii. The new data collected by the monitoring surveys of NIS in ports, marinas and other hotspot areas.
iii. New publications in the scientific and grey literature.
iv. Unpublished records by scientists, fishermen, divers and other citizen scientists.

All records, especially the unpublished records by citizen scientists, should be appropriately validated by taxonomic experts to be included in the national inventory on the basis of physical samples or (if sufficient) on photographic samples.

The inventory will include at least the scientific name of each record, the date of first sighting in Cyprus, the origin of the species, the most probable pathway(s) of introduction, its establishment success in Cyprus, a proper reference of its first record, and georeferenced records of NIS presence with relevant dates. Nomenclature will be based on the World Register of Marine Species (WoRMS Editorial Board, 2016). Typology in relation to the establishment success will follow Zenetos et al. (2010). Classification of the pathways of introduction will follow CBD's recent classification (https://www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf) and its European application as reflected in EASIN.

4.2 Plan for disseminating of data and relevant information, especially within the framework of MAMIAS

The following actions are planned for disseminating data and relevant information.

-A dedicated webpage on the NIS of Cyprus will be created in the website of the Department of Fisheries and Marine Research of the Ministry of Agriculture, Rural Development and Environment. In the pages of this website, information will be provided on the IAS of Cyprus (photos, description, impacts, identification guide, distribution, date of first record etc).

-The outputs and relevant reports of all monitoring activities (Section 4.1) will be made publicly available through the Ministry's dedicated website.

-The annual updates of the national inventory of NIS in Cyprus (Section 4.1.3) and the outputs of the monitoring activities (Sections 4.1.1 & 4.1.2) will be communicated each year to RAC/SPA to be used for updating MAMIAS and for any other use in the framework of IMAP.

4.3 Plan for training and refresher courses for specialists

The possibility to organize the following training courses, through collaboration with RAC/SPA or by other means, will be investigated.

Training school for monitoring methods

Solid monitoring frameworks are the foundation of adaptive management and ecosystem-based approaches, as they provide the necessary information to evaluate the performance and effectiveness of management actions. Beyond management applications, biological monitoring may have purely scientific objectives such as testing ecological hypotheses, assessing the effect of natural and anthropogenic pressures, and understanding the function of ecosystem components and the mechanisms of ecological processes. Monitoring can be defined as the process of regularly gathering information about some system state variables in a systematic way for the purpose of assessing system state and its change over time. Monitoring programmes are typically based on obtaining estimates of a state variable, appropriately replicated in space and time. Such state variables are defined as variables describing some fundamental attribute of the system and characterizing its status. Decisions about which variables to monitor are determined by the objectives of the monitoring program. State variables of interest for the monitoring of marine populations and communities include abundance, population density, biomass, population structure, biodiversity, and occupancy (Katsanevakis et al. 2012).

Many of the monitoring methods applied in practice have been developed in the recent decades; the development and application of monitoring methods remains an active area of biometric and wildlife research. In most BSc and MSc programs in marine sciences, monitoring methods are not systematically taught, and thus most of marine scientists do not have a sufficient background to design and apply monitoring programs in marine ecology, in particular for monitoring biological invasions. To improve the knowledge base and operational capacity of marine scientists in Cyprus to monitor marine populations and communities, especially NIS, a training school will be organised on monitoring methods. The training school will cover the following topics through theoretical lectures, training on specialized software and hands-on practice with real data:

-Ecological monitoring and state variables – definitions and examples

-The issue of imperfect detectability in the marine environment

-Sampling design – random, systematic and stratified sampling

-Plot sampling (with emphasis on strip transects by SCUBA diving)

-Distance sampling – use of the software DISTANCE

-Capture-recapture methods in closed and open populations

-Occupancy estimation with repetitive sampling – the use of the software PRESENCE

-Monitoring marine populations – commonly applied methods for the main taxa

<u>Training school for impact assessment of NIS</u>

A good understanding of the mechanisms and magnitude of the impact of invasive alien species (IAS) on ecosystem services and biodiversity is a prerequisite for the efficient prioritisation of actions to prevent new invasions or for developing mitigation measures. This training school will focus on impact assessment of IAS, and various approaches will be discussed. Such impact assessments are not taught in most of the BSs and MSc programs in marine sciences and thus most of marine scientists do not have a sufficient background to conduct impact assessments of IAS. To improve the knowledge base and operational capacity of marine scientists in Cyprus, a training school will be organised on impact assessments of IAS. The training school will cover the following topics through theoretical lectures and hands-on practice with real data:

-Assessing the impact of NIS through manipulative and field experiments, modelling, and non-experimentally based correlations.

-Protocols for impact assessments (e.g. GISS, MISK, GB Scheme, GABLIS, Harmonia+, etc.)

-Cumulative IMPacts of invasive Alien species (CIMPAL) – mapping the impact of alien species on marine ecosystems

4.4 Plan for awareness-raising and education of the general public, actors and decision-makers

The following actions for awareness-raising and education of the general public, actors and decision-makers will be implemented:

- A fully illustrated identification guide of the NIS of Cyprus will be created. Representative high definition photographs of the species with summary information (name, origin, NIS/IAS, habitat, depth, impacts etc) will be included. The aim of this pocket filed guide is to assist in the future quick identification of the NIS/IAS in the coastal waters of Cyprus by scientists, citizen-scientists, and the general public.
- In the dedicated webpage on the NIS of Cyprus by the Department of Fisheries and Marine Research of the Ministry of Agriculture, Rural Development and Environment, information written in a simple way for the general public will be provided, explaining what are alien species, how they arrived in Cyprus (pathways), what are their impacts, how to act to mitigate NIS impacts, bad practices that assist the secondary spread of already established alien species, best practices to avoid new introductions (targeting fishers, owners of recreational boats, aquarium holders, pet shops etc).
- In addition to the information in the website, and if deemed efficient, brochures, posters and other educational and awareness material will be prepared for the awareness-raising and education of the general public or specific target groups.

4.5 Plan for coordination and collaboration with other states

The National Action plan of Cyprus will be brought to the attention of all concerned actors on a regional basis. Furthermore, in coordination and collaboration with other states, Cyprus will:

- participate at pertinent international initiatives, including joining international agreements and bilateral cooperation for preventing new NIS introductions and mitigating the impacts of established species in the Mediterranean;
- strengthen and where necessary set up systems to control the intentional import and export of NIS;
- promote cooperation with the concerned authorities in neighbouring states regarding the detection of introduced species and risk assessment;
- fulfil its related obligations according to the EU Regulation 1143/2014 in IAS;
- fulfil its related obligations according to the EU Marine Strategy Framework Directive;
- fulfil its related obligations for the implementation of EcAp and IMAP of the Barcelona Convention.

5. Revision of the Action Plan

A mid-term assessment of the implementation of the Action Plan should be performed in **2020**, to assess up-to-date attainment of objectives within the Plan's timeframe and to identify, if needed, moderate adjustments.

A comprehensive review of the implementation of the Action Plan, highlighting the achievements and failures will be conducted in **2022**. The Action Plan will be updated to reflect the national and regional needs, especially those of EU legislation and policies, and of the Barcelona Convention.

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