UNITED NATIONS

EP

UNEP(DEPI)/MED WG.431/Inf.14

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

7 April 2017
Original: English

Thirteenth Meeting of Focal Points for Specially Protected Areas
Alexandria, Egypt, 9-12 May 2017

Agenda item 9: Assistance in the implementation of the first phase of the Integrated Monitoring and Assessment Programme (IMAP) on biodiversity and non-indigenous species in the framework of the EcAp roadmap

Guidance on developing invasive alien species national and sub-regional lists

UN Environment/MAP
SPA/RAC - Tunis, 2017

Note:

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Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafat
B.P. 337 - 1080 Tunis Cedex - Tunisia
E-mail: car-asp@rac-spa.org

The original version of this document was prepared for the Regional Activity Centre for Specially Protected Areas (RAC/SPA) by Argyro Zenetos, SPA/RAC Consultant

Introduction

According to CBD, Aichi Target 9, "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."

Aichi Target 9 is reflected in Target 5 of the EU Biodiversity Strategy (European Commission COM/2011/244)[By 2020, invasive alien species are identified, priority species controlled or eradicated, and pathways managed to prevent new invasive species from disrupting European biodiversity]. Moreover, under the new EU Regulation (No 1143/2014) European countries, and their relevant authorities will have obligations and commitments in respect to invasive alien species (**IAS**). These include prioritising pathways for prevention**, identifying the most harmful species for responses** (list of species of EU concern), enforcing effective early warning and rapid response mechanisms for the IAS of EU concern, eradicating such species at an early stage of invasion, and taking management measures for IAS that are widely spread.

At Mediterranean level, The Protocol concerning specially protected areas and biological diversity in the Mediterranean (SPA Protocol) of the Mediterranean Action Plan, an "Action plan concerning species introductions and invasive species" called 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" (UNEP-MAP-RAC/SPA 2005). SPA/RAC made substantial efforts to support the Action Plan on species introductions and invasive species, especially by initiating the development of the **MAMIAS** database, providing technical tools and educational documents, raising awareness on the risks associated with alien species, and funding research projects (i.e. ALBAMONTE, MedMPAnet).

According to an assessment of the Status of the implementation of the Action plan concerning species introductions and invasive species (Katsanevakis, 2015) many Contracting Parties made important steps in adopting legislation to control the introduction of alien species, assessing the status regarding biological invasions in their territorial waters, and improving the monitoring and control of ballast waters. However, progress in these issues was not made by all Parties. Yet, most of the Parties have not established national action plans to control the introduction of alien species and mitigate the negative impacts of such introductions, and they have not yet developed training and awareness raising programmes on risks, legal aspects, ballast water management and fouling, as provisioned by the Action Plan. Despite the progress made, much still needs to be done to reach all the objectives set out in the Action Plan.

One of the key issues of the Action plan, a tool also necessary as an Early Warning System in MAMIAS, is to compile a **list of invasive species** of Mediterranean concern (at national and sub-regional level).

Terminology

In studies of alien species, they alternatively have been called 'Non Indigenous', 'exotic', 'introduced', 'non native' 'invasive' and 'naturalised'. The definition of **alien species** used herein follows the European Commission (2008): a species, subspecies or lower taxon,

introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce".

Invasive Alien species (IAS) are here defined as those established aliens that have overcome biotic and abiotic barriers and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact, such as threat to the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems, and human health

The European Commission defines IAS as Invasive Alien Species causing « *a significant negative impact on biodiversity as well as serious economic and social consequences* » (European commission, 2013).

Criteria for Potential IAS as Early warning system

1. *Check if the species is present in one of the following lists (Tables 1, 3, 4)*
2. *Carry out a risk assessment study following one of the developed protocols*
3. *Testing, ranking by employing CIMPAL*
4. *Prioritize based on ecological traits.*

Criterion 1: ***How many invasive marine aliens in the Mediterranean***

It is very difficult to identify invasive species from around the world that really are "worse" than any others. Species and their interactions with ecosystems are very complex. Some species may have invaded only a restricted region, but have a high probability of expanding and causing further great damage (e.g. the lionfish *Pterois miles*). Other species may already be globally widespread, and causing cumulative but less visible damage. Many biological families or genera contain large numbers of invasive species, often with similar impacts.

On compiling a list of the 100 of the world's worst invasive alien species: from the global invasive species database (Lowe et *al*., 2000) selected by using two criteria: their serious impact on biological diversity and/or human activities and their illustration of important issues surrounding biological invasion**.** To ensure the inclusion of a wide variety of examples, only one species from each genus was selected. Absence from the list does not imply that a species poses a lesser threat. The first list was updated in 2013[1]

Streftaris et *al* (2006) compiled their invasive species of the 100 most invasive marine species in the Mediterranean by selecting among the established, rapidly expanding alien species, those which were abundant locally or regionally and were reported to have some impact (negative or positive). The Zenetos et *al*, (2010) list of 'invasive and potentially invasive alien species in the Mediterranean, which includes 134 species, was compiled by taxonomic experts through a literature search. Since no objective criteria were available, the choice of 'invasive species is subjective. Depending on personal interest some species were favoured over others.

[1] http://www.issg.org/database/species/search.asp?st=100ss

Katsanevakis et *al,* (2014) who reviewed critically the Impacts of invasive alien marine species on ecosystem services and biodiversity at a pan-European level, compiled a list of 87 species, 64 of which occur in the Mediterranean. Their selection of candidate species was based on the '100 of The Worst'list of DAISIE (Delivering Alien Invasive Species Inventories for Europe; http://www.europe-aliens. org/speciesTheWorst.do), the NOBANIS fact sheets on Invasive Alien Species (European Network on Invasive Alien Species; http://www.nobanis.org/Fact sheets.asp), the SEBI 'List of worst invasive alien species threatening biodiversity in Europe' (Streamlining European 2010 Biodiversity Indicators; http://biodiversity.europa.eu/topics/sebi-indicators), and the datasheets of CABI's Invasive Species Compendium (CABI-ISC; http://www.cabi. org/isc/).Furthermore, based on the authors' data and expertise, and the review of the scientific and grey literature, an updated European list of high-impact marine species was proposed.

At regional level the Zenetos et *al* (2010) proposed list of invasive species , updated to March 2016 and enriched some of the recent findings is listed in Table 1 is presented. The list includes 115 species, and their potential to become invasive. However, only 41 of the 88 species, which are listed in Katsanevakis et al, 2014 as high impacting ones, have exhibited today invasive behaviour. The remaining 21 are present, some of them established but there is no documentation on invasiveness.

Table 1: Distribution of invasive alien species in the Mediterranean MSFD areas. * denores high impacting species according to Katsanevakis et al., 2014. Species in bold are records of recent IAS. Red shadowed species is for invasive ones in any MSFD area, blue denotes establishment and yellow presence but no establishment.

Taxon		**WMED**	**CMED**	**ADRIA**	**EMED**
Bryozoa	**Tricellaria inopinata*				
Bryozoa	***Amathia verticillatum***				
Chlorophyta	**Caulerpa cylindracea*				
Chlorophyta	**Caulerpa taxifolia*				
Chlorophyta	**Codium fragile subsp. fragile*				
Chlorophyta	*Ulva australis*				
Chlorophyta	*Codium parvulum*				
Chordata/Ascidiacea	**Microcosmus squamiger*				
Chordata/Ascidiacea	*Parexocoetus mento*				
Chordata/Ascidiacea	*Pempheris rhomboidea*				
Chordata/Ascidiacea	*Phallusia nigra*				
Chordata/fish	**Fistularia commersonii*				
Chordata/fish	**Lagocephalus sceleratus*				
Chordata/fish	**Plotosus lineatus*				
Chordata/fish	**Saurida undosquamis*				
Chordata/fish	**Siganus luridus*				
Chordata/fish	**Siganus rivulatus*				
Chordata/fish	*Atherinomorus forskalii*				

Chordata/fish	*Cassiopea andromeda*				
Chordata/fish	*Cheilodipterus novemstriatus*				
Chordata/fish	*Etrumeus golani*				
Chordata/fish	*Liza carinata*				
Chordata/fish	*Pteragogus trispilus*				
Chordata/fish	*Sargocentron rubrum*				
Chordata/fish	*Scomberomorus commerson*				
Chordata/fish	*Sillago suezensis*				
Chordata/fish	*Sphyraena chrysotaenia*				
Chordata/fish	*Sphyraena flavicauda*				
Chordata/fish	*Stephanolepis diaspros*				
Chordata/fish	*Upeneus moluccensis*				
Chordata/fish	*Upeneus pori*				
Cnidaria	**Oculina patagonica*				
Cnidaria	**Rhopilema nomadica*				
Cnidaria	*Clytia hummelincki*				
Cnidaria	*Clytia linearis*				
Cnidaria	*Garveia franciscana*				
Cnidaria	*Macrorhynchia philippina*				
Crustacea	**Callinectes sapidus*				
Crustacea	*Charybdis helleri*				
Crustacea	*Percnon gibbesi*				
Crustacea	**Portunus segnis*				
Crustacea	**Rhithropanopeus harrisii*				
Crustacea	*Charybdis longicollis*				
Crustacea	*Dyspanopeus sayi*				
Crustacea	*Erugosquilla massavensis*				
Crustacea	***Farfantepenaeus aztecus***				
Crustacea	*Heterosaccus dollfusi*				
Crustacea	*Melicertus hathor*				
Crustacea	*Metapenaeus monoceros*				
Crustacea	*Metapenaeus stebbingi*				
Crustacea	***Penaeus aztecus***				
Crustacea	*Penaeus semisulcatus*				
Ctenophora	**Mnemiopsis leidyi*				
Echinodermata	*Aquilonastra burtoni*				
Echinodermata	***Diadema setosum***				
Echinodermata	*Synaptula reciprocans*				

Foraminifera	*Amphistegina lobifera*				
Mollusca	**Anadara kagoshimensis*				
Mollusca	**Anadara transversa*				
Mollusca	**Arcuatula senhousia*				
Mollusca	**Brachidontes pharaonis*				
Mollusca	**Chama pacifica*				
Mollusca	**Pinctada imbricata radiata*				
Mollusca	**Rapana venosa*				
Mollusca	**Ruditapes philippinarum*				
Mollusca	**Spondylus spinosus*				
Mollusca	*Aplysia dactylomela*				
Mollusca	*Bulla arabica*				
Mollusca	*Bursatella leachii*				
Mollusca	*Cellana rota*				
Mollusca	*Cerithium scabridum*				
Mollusca	**Crassostrea gigas*				
Mollusca	*Conomurex persicus*				
Mollusca	*Dendostrea frons*				
Mollusca	*Ergalatax junionae*				
Mollusca	*Erosaria turdus*				
Mollusca	*Fulvia fragilis*				
Mollusca	*Goniobranchus annulatus*				
Mollusca	*Limnoperna securis*				
Mollusca	*Melibe viridis*				
Mollusca	*Pseudominolia nedyma*				
Mollusca	*Rhinoclavis kochi*				
Mollusca	*Sepioteuthis lessoniana*				
Mollusca	*Septifer cumingii*				
Ochrophyta	**Sargassum muticum*				
Ochrophyta	**Stypopodium schimperi*				
Ochrophyta	**Undaria pinnatifida*				
Plants	**Halophila stipulacea*				
Polychaeta	**Ficopomatus enigmaticus*				
Polychaeta	**Hydroides dianthus*				
Polychaeta	**Hydroides elegans*				
Polychaeta	*Hydroides operculatus*				
Polychaeta	*Branchiomma bairdi*				
Polychaeta	*Branchiomma luctuosum*				
Polychaeta	*Ceratonereis mirabilis*				

Polychaeta	*Desdemona ornata*				
Polychaeta	*Dorvillea similis*				
Polychaeta	*Laonome triangularis*				
Polychaeta	*Leodice antennata*				
Polychaeta	*Leonnates indicus*				
Polychaeta	*Leonnates persicus*				
Polychaeta	*Notomastus mossambicus*				
Polychaeta	*Polydora cornuta*				
Polychaeta	*Prionospio krusadensis*				
Polychaeta	*Prionospio saccifera*				
Polychaeta	*Pseudonereis anomala*				
Polychaeta	*Pseudopolydora paucibranchiata*				
Polychaeta	*Spirobranchus kraussii*				
Polychaeta	*Streblospio gynobranchiata*				
Rhodophyta	**Acrothamnion preissii*				
Rhodophyta	**Asparagopsis armata*				
Rhodophyta	**Asparagopsis taxiformis*				
Rhodophyta	**Bonnemaisonia hamifera*				
Rhodophyta	**Gracilaria vermiculophylla*				
Rhodophyta	**Lophocladia lallemandii*				
Rhodophyta	**Womersleyella setacea*				

At national level

At national level, different authors have listed as invasive in their country species that are invasive elsewhere, potentially invasive in their country. Table 2 summarizes some of the recent results (after the first version of MAMIAS) at country level.

Table 2. State of art on invasive alien species (selected countries)

	No of aliens	No of IAS	Source
Greece	236+	36+3	Zenetos et al., 2015 ESENIAS Crocetta et al., 2015 : ***Diadema setosum, Pterois miles*** Nikolopoulou et al., 2013 : ***Penaeus aztecus***
Malta	66+3	7+1?	Evans et al., 2015 Deidun et al., 2015 (*L.* ***sceleratus***) Portelli, et al., 2015 Deidun et al, 2016
Libya	63	8?	Bazairi et al., 2013
Tunisia	136 zoo 27 phyto	15 zoo+5? 11 phyto	Ounifi-Amor et al., 2016 Sghaier et al., 2016
Croatia	61+8	9+3?	Pećarević et al., 2013 Dulčić et al., 2014 (***Fistularia***)

			Dulčić et al., 2015 (***Percnon***) Šprem, et al., 2014 (***Lagocephalus***)
Slovenia	15+5	3	Lipej et al., 2012 (15) Ciriaco & Lipej, 2015 (*Opleognathus*) Lučić et al., 2015(***Pseudodiaptomus marinus***)
Italy	>230	??	ESENIAS tools Balistreri & Ghelia, 2015 (***Rhopilema nomadica***) Lagocephalus sceleratus

The following species have been recently included among invasive/potentially invasive at country level.

Malta*: Caulerpa cylindracea, Lophocladia lallemandi, Womersleyella setacea, Brachidontes pharaonis, Percnon gibbesi, Fistularia commersonii, Siganus luridus; Lagocephalus sceleratus*

Croatia : *Acrothamnion preissii , Asparagopsis armata, Caulerpa taxifolia, Caulerpa cylindracea, Lophocladia lallemandii, Womersleyella setacea, Bursatella leachii, Aplysia dactylomela, Ficopomatus enigmaticus, Percnon gibbesi, Fistularia commersonii, Lagocephalus sceleratus,*

Slovenia *: Codium fragile subsp. Fragile, Anadara kagoshimensis*, *Arcuatula senhousia, Rapana venosa, Bursatella leachii, Crassostrea gigas, Ficopomatus enigmaticus*

Libya : *Asparagopsis taxiformis, Percnon gibbesi, Fistularia commersonii, Pempheris vanicolensis, Siganus luridus, Siganus rivulatus, Sphyraena flavicauda, Lagocephalus sceleratus*

Tunisia : *Acrothamnion preissii, Asparagopsis armata, A. taxiformis* Indo-Pacific lineage*, Hypnea cornuta, Lophocladia lallemandii, Womersleyella setacea, Caulerpa chemnitzia, C. cylindracea, C. taxifolia, Codium fragile* subsp. *fragile* and *Halophila stipulacea, Pinctada radiata imbricata, Fulvia fragilis, Ruditapes philippinarum, Bursatella leachii , Cerithium scabridum, Ficopomatus enigmaticus, Hydroïdes dianthus, Hydroides dirampha, Hydroïdes elegans, Percnon gibbesi, Libinia dubia, Metapenaeus monoceros, Trachysalambria curvirostris Portunus (Portunus) segnis*, *Amathia verticilla*

The following five IAS species are recently reported but are not yet invasive in Tunisia: *Oculina patagonica, Plotosus lineatus, Lagocepahlus sceleratus, Rhopilema nomadica, Brachidontes pharaonis,*

What is coming next : species present in the region

Twenty one species, among the proposed impacting ones in Katsanevakis et *al* (2014), are recorded in the Mediterranean but not as invasive. Some of them such as *Paralithodes camchaticus* are accidental findings with very low probability to be established. Some are locally established but not invasive (*Acartia tonsa*, *Mercenaria mercenaria, Mya arenaria, Petricolaria pholadiformis, Crepidula fornicata, Cordylophora caspia)*. A few were until recently considered *as native (Teredo navalis, Amphibalanus imrovisus, Austrominius modestus, Botryloides violaceus, Styela clava*). *Liza haematocheila and Eriocheir sinensis* are

invasive in freshwaters mostly, marginally present in estuarine environments. The remaining 7 species have a high probability of spreading (see Table 3 for their distribution in the Mediterranean).

The exact distribution of *Penaeus japonicus* is unknown as it has been confused/misidentified with the lessepsian immigrant *Penaeus pulchricaudatus* Stebbing, 1914. To these we should add the latest record is that *of Mytilus edulis* following the Costa Concordia cruise-ship disaster which occurred just off the coast of Italy on January 13th, 2012 (Casoli et *al*., in press)

Table 3: Potential IAS already present in the Mediterranean (source: MAMIAS).

Species	**Distribution in the Mediterranean**
Grateloupia turuturu Yamada, 1941 Rhodophyta	France (1982), Italy (1987), Spain (1988), **Israel (2013)**
Polysiphonia morrowii Harvey, 1857 Rhodophyta	Italy (1992), France (1997)
Spirorbis marioni Caullery & Mesnil, 1897 Polychaeta	Lebanon, Greece, Syria, Cyprus, Turkey, Spain, France, Italy
Hemigrapsus sanguineus (De Haan, 1835) Crustacea, Decapoda	Croatia (2001), Tunisia (2003)
Penaeus japonicus Spence Bate, 1888 Crustacea, Decapoda	Spain & Algeria (1970), France (1972), Italy (1985) ?? ???
~~*Palaemon macrodactylus* Rathbun, 1902~~ Crustacea, Decapoda	~~Spain (2005),~~ **Italy (2011)**
Beroe ovara sensu Mayer Ctenophora	Greece (2004), Italy & Slovenia (2005), Israel (2011)
Polysiphonia morrowii Harvey, 1857	

What is coming next : species absent in the Mediterranean -HORIZON Scanning

Horizon scanning, the systematic examination of future potential threats and opportunities, leading to prioritization of IAS threats is seen as an essential component of IAS management.

A workshop was held in Brussels in 2015 with the overarching aim of reviewing and validating an approach to horizon scanning to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on biodiversity or related ecosystem services in the EU over the next decade (Roy et *al*., 2015)

From a review of the horizon scanning methods and data sources identified, a horizon scanning method was developed, broadly based on the one employed by Roy et *al*. (2014) for Britain. It was apparent that the method had to be adapted to be applicable at the scale of the EU, given that in principle the species under consideration could invade from anywhere in the world.
The method developed focused on four main criteria:
i) the likelihood of arrival,
ii) the likelihood of establishment,
iii) the likelihood of spread post invasion and,
iv) the potential impact on biodiversity.

Roy et al., (2015) have examined 72 marine species as potential invaders in European Seas. The 24 proposed species, ranking from very high possibility of introduction to medium are presented in Table 4. In bold species already present in the Mediterranean, but not necessarily in European countries.

Table 4 : Proposed species (source : Roy et al, 2015)

Rank	Species	English Name	Invaded range	Bioregions threatened	Already present in EU?
VERY HIGH	***Pterois miles* (Bennett, 1828)**	devil firefish, lion fish	MED, WTA	MED, MAC, ATL	Yes
VERY HIGH	***Penaeus aztecus* Ives, 1891**	northern brown shrimp	MED, CIP	MED, MAC	Yes
VERY HIGH	***Plotosus lineatus* (Thunberg, 1787)**	striped eel catfish	MED, TNWP, CIP, TA	MED, MAC	No
VERY HIGH	*Homarus americanus* H. Milne Edwards, 1837	American Lobster	TNEA, ATL	ATL, MED, MAC	Yes
VERY HIGH	***Codium parvulum* (Bory ex Audouin) P.C.Silva, 2003**	a green alga	MED	MED, MAC	No
VERY HIGH	***Botrylloides giganteum* (Pérès, 1949)**	tunicate	MED	MED, MAC	Yes
VERY HIGH	*Crepidula onyx* G. B. Sowerby I, 1824	Onyx slippersnail	CIP, TNWP	ATL, MED, MAC	No
VERY HIGH	***Mytilopsis sallei* (Récluz, 1849)**	black striped mussel	MED, CIP, WIP, TNWP	MED, MAC, ATL, BAL, BLK	No
HIGH	***Pseudonereis anomala* Gravier, 1900**	a polychaete	MED	MED, MAC	Yes
HIGH	*Acanthophora spicifera M.Vahl)* Børgesen, 1910	a red alga	EIP, CIP	MED, MAC	No
HIGH	***Charybdis japonica* (A. Milne-Edwards, 1861)**	Asian paddle crab	TA	MED, MAC, ATL	Yes
HIGH	*Perna viridis* (Linneaus, 1758)	Asian Green mussel	TA, CIP, EIP, TNEP, TNW	MED, MAC, ATL	No
HIGH	*Symplegma reptans* (Oka, 1927)	tunicate	ETP, EIP	MED, MAC, ATL, BLK	No
HIGH	*Potamocorbula amurensis* (Schrenck, 1861)	Asian basket clam	TNEP, TA	MED, MAC, ATL, BLK, BAL	No
HIGH	***Macrorhynchia philippina* Kirchenpauer, 1872**	White stinger	MED, MAC, ATL	MED, MAC, ATL	Yes
MEDIUM	*Polyopes lancifolius* (Harvey) Kawaguchi & Wang, 200	a red alga	TNEA, ATL	ATL, MED, MAC	Yes
MEDIUM	***Rhodosoma turcicum* (Savigny, 1816)**	tunicate	WTA, MED	MED, MAC, ATL	yes
MEDIUM	***Dorvillea similis* (Crossland, 1924)**	a polychaete	MED	MED, MAC	No
MEDIUM	*Ciona savignyi* Herdman, 1882	tunicate	TNEP, TSWA, TA	ATL, BLK, BAL, MED, MAC	No
MEDIUM	*Didemnum perlucidum* F. Monniot, 1983	tunicate	WTA, EIP, CIP, ETP, TA	MED, MAC	No
MEDIUM	*Ascidia sydneiensis* Stimpson, 1855	green tube tunicate	ETA, WTA, CIP, EIP, TSA	MED, MAC, ATL	No
MEDIUM	*Balanus glandula* (Darwin 1854)	acorn Barnacle	TSWA, TNWA, TSA	ATL, BAL	No
MEDIUM	*Dictyosphaeria cavernosa* (Forsskål) Børgesen, 1932	green bubble weed	EIP	MED, MAC	No
MEDIUM	*Zostera japonica* Ascherson & Graebner, 1907	dwarf eelgrass	TNEP	MED, MAC, ATL, BLK, BAL	No

To these we should add, the invasive impacting marine species, which are reported in Katsanevakis et al (2014), but are yet absent in the Mediterranean . These are : *Marenzelleria spp., Cercopagis pengoi, Caprella mutica, Ensis directus, Urosalpinx cinerea, Hydroides ezoensis, Crassostrea virginica, Victorella pavida, Telmatogeton japonicas, Alexandrium monilatum, Gymnodinium catenatum, Coscinodiscus wailesii , Fibrocapsa japonica, Pseudochattonella verruculosa*.

Once again euryhaline species such *Potamopyrgus antipodarum, Platorchestia platensis, Spartina alterniflora , Spartina anglica, Gammarus tigrinus, Neogobius melanostomus ,* which are better adopted to fresh-brackish environments, should be excluded. To the low probability invaders in the Mediterranean Sea the snow crab (*Chionoecetes opilio)* should be added. Furthermore species native in the Mediterranean such as *Palaemon elegans, Alexandrium minutum* are not to be considered as candidates.

Criterion 2 : Risk assessment protocols

Risk assessment is a scoring system that assess the impact of alien species and can be used to identify the most harmful alien species. In the last decades, risk assessment has gained much interest as an instrument to support policy makers in their decisions regarding the need for managing non-native species (Verbrugge et *al*., 2012).

This approach is based on the concept of 'propagule pressure' and has the additional benefit of been more objectively understood as biogeographical, rather than taxonomic, phenomena. Risk assessment protocols for IAS generally contain the main stages of invasion: (1) entry,

(2) establishment, (3) spread, and (4) impacts. Because of the large number of non-native species that spread worldwide, there is a particular need for quick screening tools which can help to identify which new coming species have the potential to become invasive. Therefore, risk identification is one of the most important applications in risk assessment of non-native species (Verbrugge et *al*., 2012).

Australia & New Zealand, United States, Canada and Mexico plus a few European countries have developed national risk assessment protocols to identify low, moderate and high risk species. These were reviewed by Verbrugge et *al*., (2010). It was concluded that the available risk assessment protocols remarkably differ regarding

- their scope and completeness. The majority of the protocols are generic and they can be applied to all taxonomic groups and types of ecosystems
- Data requirements
- Scoring methods
- Uncertainty : Uncertainties can occur at three levels: method, reviewer and data.
- Policy compliance
- User friendliness : The risk assessment protocols range from a simple questionnaire to Microsoft Access applications

A more recent review by Roy et *al*. (2014b) with the scope to inform the EU on development of minimum standards necessary to ensure effective risk assessment methods for the EU screened the risk assessment methodologies the most used ones bein the following:

Belgium : **Harmonia**[+2] is a recently developed scheme for the first-line risk assessment of potentially invasive alien species. It stems from a review of the former ISEIA protocol that now incorporates all stages of invasion and different types of impacts.

Great Britain : Non-native Species Risk Assessment (GB NNRA) : The GB NNRA can be used to assess non-native species from any taxonomic group or environment, either established in the territory or not. It comprises a series of detailed questions, based on those developed by EPPO, divided into four sections: entry, establishment, spread and impact. Economic, environmental and social impacts are assessed, with a particular focus on potential biodiversity and ecosystem impacts

Norwegian alien species impact assessment: the development of the Norwegian set of criteria has been used to produce Norwegian lists of alien species in 2012. It is not legally binding, but constitutes the basis of management decisions by the Norwegian Environment Agency. The set of criteria assesses the negative ecological impact of alien species along two separate axes, viz. invasiveness and effect.

Generic Impact Scoring System GISS. : The Generic Impact Scoring System (GISS) is a semi-quantitative scoring system which measures the impact of alien and invasive species as environmental and economic impact in 12 impact categories. As a generic system, it allows a direct comparison of species and it can be used for all taxonomic groups of animals and plants. GISS primarily allows ranking and prioritization of species according to their impact, but can also be used to establish black lists or warning lists at country level

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[2] http://ias.biodiversity.be/harmoniaplus

The Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts ("IUCN Black List") The classification scheme is a Black List approach, but one that identifies different levels of impact within the Black List. It is based on the mechanisms of impact used to code species in the IUCN Global Invasive Species Database, and the semi-quantitative scenarios describing impacts developed by Nentwig et *al*. (2010) (Blackburn et *al*., 2014)

Fourteen criteria were agreed, through consensus methods, to represent the minimu standards.

According to Roy et al 2014b, the minimum standards are:

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)
2. Includes the likelihood of entry, establishment, spread and magnitude of impact
3. Includes description of the actual and potential distribution, spread and magnitude of impact
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes
6. Can broadly assess environmental impact with respect to ecosystem services
7. Broadly assesses adverse socio-economic impact
8. Includes status (threatened or protected) of species or habitat under threat
9. Includes possible effects of climate change in the foreseeable future
10. Can be completed even when there is a lack of data or associated information
11. Documents information sources
12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary
13. Includes uncertainty
14. Includes quality assurance

Moreover, Roy et *al* (2014b) prepared a draft list of "IAS of EU concern". Such a list should include species that are already established within the EU but also be extended to a scoping study to consider species that are not yet established but that may present a significant threat to Europe in the near future. In total, the draft list of proposed "IAS of EU concern" includes 25 plant species, 12 vertebrate species, and 13 invertebrate species. There are similar numbers of terrestrial and freshwater species (24 and 20 respectively) but only six marine species [*Crassostrea gigas, Caprella mutica, Crepidula fornicata, Didemnum vexillum, Rapana venosa, Sargassum muticum*].

Criterion 3 : Testing, ranking by employing CIMPAL

As a step forward, quantification and mapping of impacts as well as a better understanding of how anthropogenic changes and human pressures facilitate many invasions will greatly assist managers and policy makers.

A conservative additive model 'CIMPAL' has been developed by Katsanevakis et *al* (2016) to account for the Cumulative IMPacts of invasive ALien species on marine ecosystems. According to this model, cumulative impact scores are 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. In the Mediterranean Sea case study, the magnitude of impact was estimated for every combination of 60 invasive species and 13 habitats, for every 10 x 10 km cell of the basin. Invasive species were ranked based on their contribution to the cumulative impact score across the Mediterranean. Such analysis allows the identification of hotspots of highly impacted areas, and prioritization of sites, pathways and species for management actions.

Criterion 4. Prioritize for monitoring based on ecological traits.

Temperature preference is one of the most important ecological traits and without doubt, one of the factors determining the distribution of species.(Ben Rais Lasram et *al*. 2008; Raitsos et *al*. 2010).

Arndt & Schembri (2015) analysed the relationship between dispersal and establishment success and a pool of different traits for 101 Lessepsian fish species using generalized linear models. Their models did not reveal a significant relationship between the sea surface temperature in the native range of immigrant fishes and their dispersal or establishment success in the Mediterranean Sea.

The minimum depth in which a species was observed was the only significant trait influencing dispersal success. This trait is likely related to the architecture of the Suez Canal since until the 1970s only species with a very low minimum depth were recorded to have entered the Mediterranean, but species occurring in deeper water started to immigrate after 1980 when the canal was deepened to 19.5 m. The establishment success of Lessepsian fishes was significantly linked to size and spawning type. Benthic spawners and species with adhesive eggs represent successful colonizers.

Moreover, successful colonizers are species with a tendency to form schools, whereas solitary species are less successful. The results show that dispersal and establishment success of Lessepsian fish immigrants are influenced by different ecological traits.

A new scheme for selecting highly possible invader is currently under development in ECOMERS lab, in collaboration with IUCN (Francour et *al*, in preparation). The scheme scores the possiblility to include/consider a species as a target species for monitoring by citizen scientists, fishermen, managers.

Discussion

The initial list of IAS of EU concern will be based on available risk assessments compliant with agreed minimum standards but horizon scanning is seen as critical to inform future updating of the list, in order to prioritise the most threatening new and emerging IAS. In the Mediterranean region no country has developed or applied a risk assessment protocol for any marine species.

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