National Action Plan on species introductions and invasive species in Lebanon

Beirut, March 2018

Study required and financed by:
Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafat
BP 337
1080 Tunis Cedex – Tunisie

Responsible of the study:
Dr. Michel Bariche
Biology Department
American University of Beirut
Riad el Solh
Lebanon

Reference of the study:
Contract No xxx

Table of contents

List of acronyms and abbreviations

BWM Convention: International Convention for the Control and Management of Ships' Ballast Water and Sediments
CBD: Convention on Biological Diversity
COP: Conference of the Parties
EcAp: Ecosystem Approach
EDNIS: Early Detection of NIS
EU: European Union
GEF/UNDP/IMO: Global Environment Facility / United Nations Development Program / International Maritime Organisation
GES: Good Environmental Status
IMAP: Integrated Monitoring and Assessment Programme
IMO: International Maritime Organisation
MAMIAS: Marine Mediterranean Invasive Alien Species (online database)
MoE: Ministry of Environment
MPA: Marine Protected Areas
MSFD: Marine Strategy Framework Directive
NIS: Non-Indigenous Species
RAC/SPA: Regional Activity Centre for Specially Protected Areas
REMPEC: Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
SPA/BD: Specially Protected Areas and Biological Diversity
SPA: Specially Protected Areas
UNCLOS: United Nations Convention on the Law of the Sea
UNEP/MAP: United Nations Environment Program / Mediterranean Action Plan
UNHCR: United Nations High Commissioner for Refugees
WWI: World War I

1. Introduction

Biological invasions are considered among the most important problems affecting global biodiversity (Halpern et al., 2008; Molnar et al., 2008; Golani and Appelbaum-Golani, 2010). In fact, anthropogenic activities, such as transport, agriculture, aquaculture and recreation, have increased importantly over the last 150 years (Simberloff and Rejmánek, 2011). These activities resulted in the intentional or unintentional movement and introduction of living organisms to areas beyond their natural zoogeographical range. As such, these bioinvasions have resulted in a negative impact on native biodiversity and ecosystem functioning worldwide (Pyšek and Richardson, 2010; Simberloff et al., 2013; Katsanevakis et al., 2014). Non-indigenous species (NIS) are nowadays commonly found in terrestrial, freshwater and marine environments, threatening habitats, food webs, communities and ecosystems (e.g. Molnar et al. 2008; Pyšek and Richardson, 2010; Simberloff and Rejmánek, 2011; Lowry et al., 2013; Katsanevakis et al., 2014).

A non-indigenous species is considered invasive when it spreads rapidly, colonizing the new environment and causing damage (Molnar et al., 2008). This damage can be great and may vary from habitat modification to competition over similar resources, predation, hybridization and even disease transmittal (Simberloff and Rejmánek, 2011; Albins, 2013; Giakoumi, 2014; Vergés et al., 2016). Some invasive species have had negative socio-economic impacts altering fisheries and social activities (Bax et al., 2003; Simberloff and Rejmánek, 2011). They are sometimes referred to as ecosystem engineers because of their potential impact on ecosystem structure and function (Darrigran and Damborenea, 2011; Moyle and Garcia-Berthou, 2011). The cost of biological invasions on the United States economy alone was estimated at over $100 billion annually and a myriad of ecologists, economists, geneticists, agronomists, evolutionists, fisheries and forestry scientists are intensively studying biological invasions worldwide from different perspectives and interests (Simberloff and Rejmánek, 2011).

Bioinvasions in the Mediterranean Sea

Biological invasions are also affecting the Mediterranean Sea biodiversity and ecosystem, and NIS are being recorded throughout the Mediterranean (e.g. Streftaris and Zenetos, 2006; Galil, 2007; Katsanevakis et al., 2014). In fact, several hundreds of species are considered to be NIS in the Mediterranean Sea, despite the fact that data are absent for many species, particularly invertebrates (Coll et al., 2010). It is generally accepted that the majority of NIS in the Mediterranean originate from the Indo-West Pacific biogeographical realm, and have entered through the Suez Canal (Coll et al., 2010; Galil, 2012; Galil et al., 2018; Zenetos et al., 2010; 2012; 2017). Other means of introductions are shipping, aquaculture, ornamental pet trade, oil rigs or also range expansion from the tropical Atlantic through the Strait of Gibraltar (e.g. Galil, 2012; Zenetos et al., 2012; Pajuelo et al., 2016). Furthermore, introduction rates seem to have increased in the Mediterranean at an alarming rate (Golani, 2010; Edelist et al., 2013; Samaha et al., 2016).

The opening of the Suez Canal was a major event as it facilitated the passage and establishment of dozens of NIS to the eastern Mediterranean (Por, 1978; 2010). These organisms of Indo-Pacific origin are commonly named Lessepsian migrants, after Ferdinand de Lesseps who built the canal (Por, 1978). The ecological and economic consequences of Lessepsian invasion are enormous (Sala et al., 2011; Galil et al., 2015) and huge efforts have been made to understand the mechanisms allowing species of Red Sea origin to be successful in their new environment (Belmaker et al., 2013).

The Marine Mediterranean Invasive Alien Species (MAMIAS, http://mamias.org/), which is an online database that lists NIS in the Mediterranean Sea, reports a total of 1299 alien species, out of which 434

are established and 109 are invasive (as of 19 March 2018). Most of these species originate from the Indo-Pacific region and the most important pathways to the Mediterranean being the Suez Canal and introduction via shipping/fouling (Figures 1, 2).

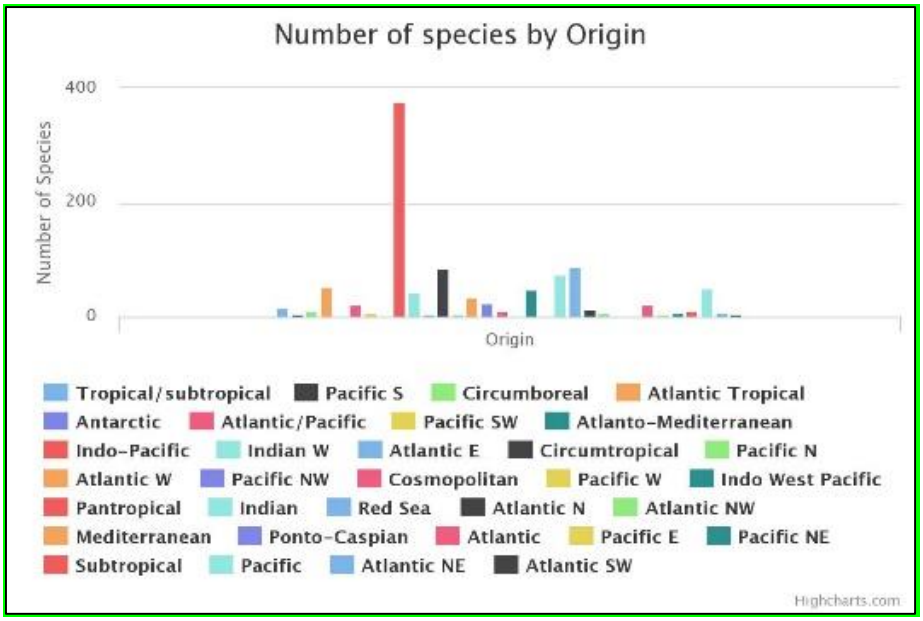

Figure 1. Number of NIS in the Mediterranean Sea according to their native range (MAMIAS, as of 19 March 2018)

Legal framework addressing NIS

The problem with NIS is considered of high importance all over the world. On an international level, Article 8 (h) of the Convention on Biological Diversity (CBD) invites Contracting Parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". Aichi Target 9 of the Strategic Plan for Biodiversity resulting from the tenth meeting of the Conference of the Parties (COP) states, "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."

The CBD also adopted in 1995, the Ecosystem Approach (EcAp) as a main tool of action of important programmes of the Convention. The latter is defined as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". It considers the ecosystem as a whole unit of elements in continuous interaction and promotes control of human activities in a sustainable way for conservation of the marine environment (COP 5 Decision V/6; COP 7 Decision VII/11).

According to Article 6 of the CBD, Contracting Parties, including Lebanon, should develop national biodiversity strategies and action plans to protect the marine environment and the biological diversity. Furthermore, the United Nations Convention on the Law of the Sea (UNCLOS) states that a country has the right to explore and use marine resources in an area ranging from the coast to 200 nautical miles. UNCLOS promotes reducing pollution and introduction of invasive species to protect the marine environment.

On a national level, Lebanon has set in its "National Biodiversity Stratefy and action Plan" (NBSAP) a national target corresponding to Aichi target 9 that "by 2030, effective measures are in place to control the introduction and diffusion of invasive alien species into the environment" (MoE/UNEP/GEF, 2016).

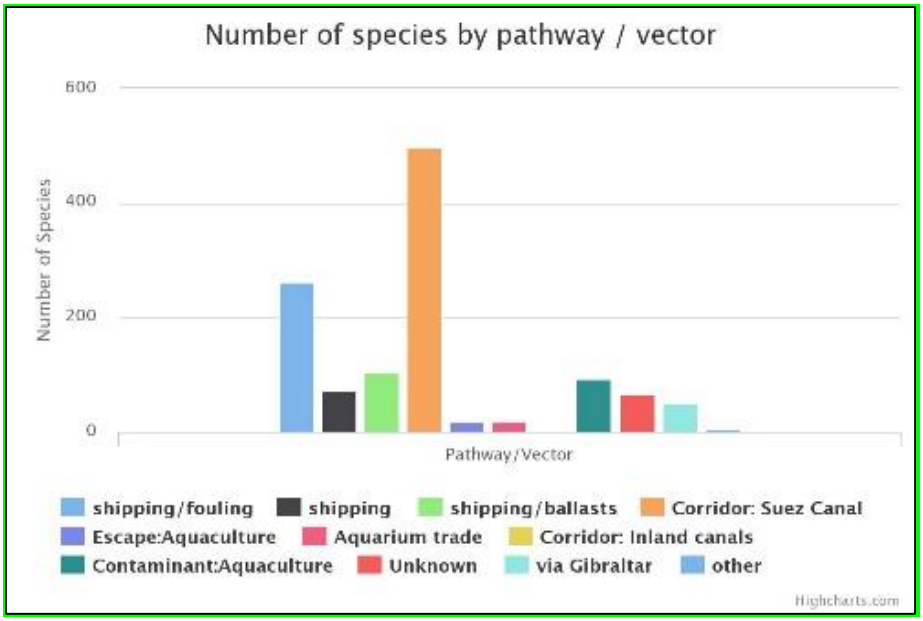

Figure 2. Number of NIS in the Mediterranean Sea according to the mode of Introduction (MAMIAS, as 19 March 2018)

On a Mediterranean level, the Contracting Parties adopted in 1995 an amended version of the Barcelona Convention of 1976, the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean.

- In 1975, the Mediterranean Action Plan (UNEP/MAP or MAP) was approved within the framework of the United Nations Environment Programme. The aim was to join forces of the countries around the Mediterranean to reduce marine pollution and protect this environment. In 1995, following the third Earth Summit of 1992, the Contracting Parties adopted MAP Phase II known as the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean. MAP Phase II is adopted today by the European Community and 21 Mediterranean countries, including Lebanon, that collaborate to prevent pollution in the marine environment and preserve coastal areas ecologically or socially important.
- In 1995, the Protocol concerning "Specially Protected Areas and Biological Diversity" (SPA/BD Protocol) was adopted in Barcelona as one of the seven Protocols of the Barcelona Convention. It supports the establishment and management of Specially Protected Areas (SPAs), and the protection of endangered or threatened species.
- The SPA/BD Protocol requires in its Article 13.1 that Contracting Parties take "all appropriate measures to regulate the intentional or accidental introduction of non-indigenous or genetically modified species to the wild and prohibit those that may have harmful impacts on the ecosystems, habitats or species". In Article 13.2, "the Parties shall endeavour to implement all possible measures to eradicate species that have already been introduced when, after scientific assessment, it appears that such species cause or are likely to cause damage to ecosystems, habitats or species".

- In 2003, an Action Plan concerning species introductions and invasive species in the Mediterranean Sea was adopted within the framework of the UNEP/MAP. The Action Plan gives special importance to the introduction of NIS through shipping. This was further emphasized in the International Convention on the Control and Management of Ship's Ballast Water and Sediments of the International Maritime Organization (IMO). Ballast water management, if properly implemented should be an efficient tool to reduce bioinvasions. On the other hand, the use of antifouling paints was banned by the IMO as of 2003, and this will increase the introduction of organisms with hull fouling.

The Regional Activity Centre for Specially Protected Areas (SPA/RAC), which is helping the Mediterranean countries to apply the SPA/BD Protocol, considers NIS as one of the major problems requiring special attention at the regional level. It also collaborates with the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) to implement the "Building Partnerships to Assist Developing Countries to Reduce the Transfer of Harmful Aquatic Organisms in Ships' Ballast Water" ("GloBallast Partnerships" Project) in the Mediterranean which is considered as a high priority region in this GEF/UNDP/IMO Project.

On a European level, the EU Biodiversity Strategy also requires the prevention of introduction and management of introduced invasive alien species (Target 5). The EU Marine Strategy Framework Directive invites the Member States to take actions on alien species in European Seas in order to "reach Good Environmental Status by 2020" (UNEP/MAP, 2017).

The Contracting Parties of the Barcelona Convention emphasized on the Ecosystem Approach at their 15th meeting. Their aim was to create "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations", and thus a "Good Environmental Status in the Mediterranean Sea and Coast". Moreover, an Ecosystem Approach Roadmap including ecological and operational goals, indicators and monitoring programmes had been defined to reach this aim.

This resulted in the Integrated Monitoring and Assessment Programme (IMAP), which was adopted in 2016. IMAP allows assessing the situation in the marine environment, including non-indigenous species, in a quantitative manner using Good Environmental Status (GES) descriptions and common indicators. The latter communicate the information in an easy, standardized style that can be observed by the Mediterranean Contracting Parties. This is very helpful for decision makers as any change in the marine environment will be detected. Common indicator 6, "Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species in the water column and seabed", deals with NIS. Mediterranean countries refer to Common Indicator 6 to monitor NIS.

Lebanon: General Information

Lebanon is a small mountainous country situated at the easternmost part of the Mediterranean Sea. It is constituted by different regions, out of which a coastal plain and a mountain range stretching parallel to the Mediterranean coast (Emery and George, 1963). The continental shelf is relatively narrow and steep with a seabed generally rugged. Surface waters are relatively well mixed during the cold season and more stratified the rest of the year.

Following the independence of the country (1943), a civil war started in 1975 and seriously affected the country's infrastructure, weakening institutions and resulted in the displacement of a large part of the

populations mainly towards coastal areas. After a short reconstruction period, the country underwent a swift war, known as the 2006 Israeli war. In a few weeks, it had led to the destruction of most Lebanese infrastructure facilities and housing units (e.g. bridges, industrial enterprises, schools, airport). In addition it had led to a massive oil spill along most of its shoreline as a consequence of bombing power plant fuel tanks. This was followed by the Syrian crisis (2011), which resulted in the displacement of around 2.2 million Syrian refugees to Lebanon, according to the UNHCR Syria Regional Refugee Response – Lebanon (estimate of 2015). This crisis has imbalanced the Lebanese financial stability, affecting the quality and quantity of services provided and the environmental status, and it is only expected to worsen as several hundreds of thousands of Lebanese have become unemployed or pushed into poverty (worldbank.org, April 2017).

During the civil war and the post-conflict period, relatively little scientific research was made to assess the value of marine sciences and fisheries in Lebanon, as concern for environmental issues during this period was non-existent or at least ranked very low on the government's list of priorities. This resulted in a tremendous lack of scientific knowledge among scientists and stakeholders as well as a lack of awareness among fishermen and citizens, leading to various environmental abuses. Threats to the Lebanese coastal waters are numerous and a wide range of anthropic activities contribute directly or indirectly to the degradation of the Lebanese marine environment and its resources. These are pollution, illegal or unregulated fishing practices, the use of destructive fishing methods, spearfishing, blast fishing and the use of poisons, uncontrolled and illegal construction on the coast. All of these, contribute to the destruction of habitats and depletion of resources one way or another.

Two Marine Protected Areas (MPAs) exist in the country:
- The *Palm Islands Nature Reserve* (Act No. 121, issued March 9, 1992) is an MPA situated in the north of Lebanon, about 6 km northwest of the city of Tripoli. It consists of a group of three rocky islets and 500 m of their surrounding coastal waters. The largest island is Palm Island (known as *Jazeerat al Nakheel* or *Jazeerat al Araneb*) with an area of 40.000 m^2. It is followed by Sanani (40.000 m^2) and Ramkine islets (*Jazeerat al Fanar*, 16.000 m^2). The total surface area of the reserve is about 4.2 km^2 (Tohme et al., 2004). While Palm Island has a rocky shoreline and a wide sandy beach, Sanani and Ramkine are mainly rocky. It is designated as a Mediterranean Specially Protected Area and SPAMI under the 1995 Barcelona Convention. The islands were also identified as a Ramsar Wetland of Special International Importance in 1980, and as an Important Bird Area by BirdLife International. The islands are known to be a significant site for Green Turtles (*Chelona mydas*) and Loggerhead Turtles (*Caretta caretta*) which are found in their vicinity and some nest on their beaches. The islands are also a suitable habitat for the Mediterranean Monk Seal (*Monachus monachus*), which is very occasionally recorded in the area. They also act as resting and nesting grounds for various migratory birds, some of which are endangered (Tohme et al., 2004; BirdLife International, 2009). The main treats to the islands' fauna and flora are recreational summer visitors, introduced mammals (rats and feral rabbits) and illegal fishing activities that take place.
- The *Tyre Coast Nature Reserve* (Act No. 708, issued November 5, 1998) is another MPA situtated in the south of Lebanon, south of the city of Sour (Tyre). It consists of a number of private lands of a surface area of about 3.9 km^2 and a long sandy beach, divided in two by a Refugee camp. The beach is open to the public, and the other section of the reserve includes a freshwater spring of historic importance, in addition to being used for agricultural practices. This Reserve is of high importance, it is designated as SPAMI under the 1995 Barcelona Convention and a Ramsar site under the Ramsar Convention on Wetlands of International Importance, a nesting site for seaturtles and one of the last sandy beaches in Lebanon.
Numerous marine habitats have experienced high rates of destruction and some are irreversibly damaged. The loss of habitats is mainly due to coastal development (resorts, marina, jetties), diversion of freshwater for domestic and agricultural use, as well as dumping untreated wastewater in rivers and the sea, thereby

reducing significantly water quality and affecting habitats and wildlife. Some habitats are particularly more vulnerable than others such as vermetid terraces, estuaries, and seagrass meadows.
In addition, many non-indigenous marine species thrive in the Lebanese waters are a type of biopollution. Their presence has certainly added to the degradation of the marine environment since they are known to have significant impacts on marine organisms, community and ecosystem, as well as on human economy and health (Katsanevakis et al., 2014). Large schools of the jellyfish *Rhopilema nomadica* thrive in the Lebanese waters several months each year, sometimes stretching along the entire coast and exerting significant impacts on planktonic organisms, the fisheries sector (clogging fishing nets and damaging the catch), as well as tourism and socio-economic activities; such as injury to sunbathers. Pufferfishes, notably *Lagocephalus sceleratus*, displays also serious impact on the environment, fishery and human health. The emerging lionfish invasion in the Mediterranean is another matter of high concern and worry, particularly because of the venomous spines and impacts on the environment (e.g. Green et al., 2012; Albin, 2015; Rocha et al., 2015). The impact of myriads of non-indigenous and invasive species present in the Mediterrananean is little known and need further investigation and assessment, at least for the most invasives (Katsanevakis et al., 2014).

2. Non-indigenous species in Lebanon

The marine environment of Lebanon is highly prone to the arrival of NIS of Indo-Pacific origin. This is due to its relative short distance to the point of entry (Suez Canal), the country's geographical position on the route of Lessepsian migration and the wide diversity of marine habitats (Figure 3). Other factors, such as coastal degradation may also facilitate the establishment of alien newcomers.

Lebanon has always been an understudied area, despite its long history. No detailed inventory on the marine NIS of Lebanon exist but a series of publications and reports with different levels of accuracy. The aim of the chapter is to provide an exhaustive list of NIS species for Lebanon but to highlight the most important work, in which NIS and invasive marine species are recorded. It is also evident that some taxa are studied more than others and that some species are more conspicuous, and thus more detectable than others. The reader should be aware that the high occurrence of non-indigenous organisms in some taxa, such as fishes, decapods or molluscs, may be related to that.

Among the oldest records on marine organisms from Lebanon are from some scientists who studied the marine fauna of the region. As such, Fowler (1923) described native fish species from Beirut and Steinitz (1929), Moazzo (1931) and Pallary (1938) identified marine invertebrates, some of which were non-indigenous such as *Portunus pelagicus*, *Malvufundus regula* or *Cerithium scabridum* and *Murex forskoehli* respectively. Following the French Mandate for Syria and Lebanon founded after WWI, Gruvel (1928, 1931) explored extensively the Lebanese-Syrian region and reported the presence of some non-indigenous fish species such as *Siganus rivulatus*, *Hemiramphus far*, *Equulites klunzingeri*. He also reported non-indigenous invertebrates such as decapods (*Marsupenaeus japonicus*, *Metapenaeus monoceros*, *Penaeus semisulcatus*, *Portunus pelagicus*) and molluscs (*Pinctada radiata* and *Brachidontes pharaonis*)[1].

[1] All species names were updated according to the World Register of Marine Species (Horton et al., 2018) or the Catalogue of fishes (Eschmeyer et al., 2017).

Figure 3. Map of the eastern part of the Mediterranean Sea and the northern Red Sea, showing the geographical location of Lebanon and the Suez Canal.

A score of non-indigenous fishes were recorded afterwards in the 1960s-70s, the most prominent species being *Upeneus moluccensis*, *Upeneus pori*, *Scomberomorus commerson*, *Siganus luridus*, *Stephanolepis diaspros*, *Dussumieria elopsoides*, *Saurida lessepsianus, Hyporhamphus affinis*, *Parexocoetus mento*, *Sargocentron rubrum, Atherinomorus forskali*, *Apogonichthyoides pharaonis*, *Alepes djedaba*, *Callionymus filamentosus*, *Stephanolepis diaspros*, *Lagocephalus guentheri, Sphyraena chrysotaenia* and *Himantura uarnak* (George et al., 1964; George and Athanassiou, 1965; 1966a; b; 1967; George et al., 1971). Then Mouneimné (1977, 1978, 1979) reported additional species: *Herklotsichthys punctatus*, *Pelates quadrilineatus*, *Sillago suezensis*, *Pomadasys stridens*, *Platycephalus indicus*, *Cynoglossus sinusarabici*, *Lagocephalus suezensis*, *Pempheris mangula*, *Terapon puta* and *Lutjanus argentimaculatus*. Within the same period, some non-indigenous invertebrates were also recorded such as the crustacean *Erugosquilla massavensis* (Holthuis, 1961), the echinoderm *Asterina burtoni* (Tortonese, 1966) or annelids (*Pseudeurythoe acarunculata*, *Timarete anchylochaeta*, *Branchiomma cingulatum, Hydroides heterocera* (Laubier, 1966)[1]. A review of the literature on benthic macroinvertebrates from the same period can be found in Fadlallah (1975), who also reported several NIS of marine invertebrates from Lebanon. More recently, "first records" and early invasive events for non-indigenous fish species became more common and many species of various origins were also detected from Lebanon. They are grouped in Table I.

A relatively recent field survey carried in specific sites showed the presence of a dozens of NIS, were alien molluscs and fishes accounted for about 31% and 21% of the species respectively (RAC/SPA – UNEP/MAP,

2014). A representative number of non-indigenous marine invertebrates reported in the literature from Lebanon, including cryptogenic and some questionable species, is summarized in Table II.

Table I: List of non-indigenous fish species recorded from Lebanon since 2005.

Family	Species	Family	Species
Apogonidae	*Cheilodipterus novemstriatus*	Pomacentridae	*Abudefduf vaigiensis*
Carangidae	*Seriola fasciata*	Rachycentridae	*Rachycentron canadum*
Chaetodontidae	*Heniochus intermedius*	Scaridae	*Scarus ghobban*
Champsodontidae	*Champsodon vorax*	Scorpaenidae	*Pterois miles*
Leiognathidae	*Equulites popei*	Serranidae	*Cephalopholis taeniops*
Lutjanidae	*Lutjanus argentimaculatus*		*Epinephelus fasciatus*
Mullidae	*Parupeneus forsskali*		*Paranthias furcifer*
	Pseudupeneus prayensis		*Pseudanthias squamipinnis*
Nemipteridae	*Nemipterus randalli*	Synanceiidae	*Synanceia verrucosa*
Ostraciidae	*Ostracion cubicus*	Syngnathidae	*Hippocampus fuscus*
Platycephalidae	*Platycephalus indicus*	Tetraodontidae	*Sphoeroides pachygaster*
Plotosidae	*Plotosus lineatus*		*Tylerius spinosissimus*
Pomacanthidae	*Pomacanthus maculosus*		

Bariche, 2010a; b; 2011; 2012; Bariche and Saad, 2005; 2008; Bariche and Azzurro, 2012; Bariche and Heemstra, 2012; Bariche et al., 2013b; c; Harmelin-Vivien et al., 2005; Lelli et al., 2007; Bitar, 2013; Crocetta et al., 2015; Dailianis et al., 2016; Gerovasileiou et al., 2017.

Finally, some information on NIS among planktonic organisms, including meroplankton, from Lebanon can be found in the following references (Gruvel, 1931; Abboud-Abi Saab, 1985a; b; 1989; 2003; Lakkis and Novel-Lakkis, 1985; Lakkis and Zeidane, 1988; 1989; Zeidane and Lakkis, 1995; Lakkis, 2012).

Table II. List of marine invertebrates with a non-indigenous status (alien, cryptogenic, questionable) recorded from Lebanon (the list is not exhaustive). Species names were updated according to the World Register of Marine Species (Horton et al., 2018).

Taxon	Family	Species
Cnidaria		
Hydrozoa	Aglaopheniidae	*Macrorhynchia philippina* Kirchenpauer, 1872
	Eudendriidae	*Eudendrium carneum* Clarke, 1882
	Sertulariidae	*Diphasia digitalis* (Busk, 1852)
		Dynamena quadridentata (Ellis & Solander, 1786)
		Sertularia marginata (Kirchenpauer, 1864)
		Sertularia techocarpa ?
Schyphozoa	Mastigiidae	*Phyllorhiza punctata* Lendenfeld, 1884
	Rhizostomatidae	*Rhopilema nomadica*
Anthozoa	Oculinidae	*Oculina patagonica* de Angelis, 1908
Annelida		
Polychaeta	Serpulidae	*Hydroides brachyacantha* Rioja, 1941
		Hydroides dirampha Mörch, 1863
		Hydroides elegans (Haswell, 1883)
		Hydroides heterocera (Grube, 1868)
		Hydroides minax (Grube, 1878)
		Hydroides operculata (Treadwell, 1929)
		Spirobranchus kraussii (Baird, 1865)
		Spirobranchus tetraceros (Schmarda, 1861)
	Spirorbidae	*Spirorbis marioni Caullery & Mesnil, 1897*

Mollusca		
Gastropoda	Acteocinidae	*Acteocina mucronata* (Philippi, 1849)
	Amathinidae	*Amathina tricarinata* (Linnaeus, 1767)
	Aplysiidae	*Aplysia dactylomela* Rang, 1828
		Bursatella leachii Blainville, 1817
		Syphonota geographica (A. Adams & Reeve, 1850)
	Cerithiidae	*Cerithium scabridum* Philippi, 1848
		Rhinoclavis kochi (Philippi, 1848)
	Cerithiopsidae	*Cerithiopsis pulvis* (Issel, 1869)
	Chromodorididae	*Hypselodoris infucata* (Rüppell & Leuckart, 1830)
		Goniobranchus annulatus (Eliot, 1904)
	Columbellidae	*Zafra savignyi* (Moazzo, 1939)
	Cypraeidae	*Purpuradusta gracilis notata* (Gill, 1858)
	Dialidae	*Diala semistriata* (Philippi, 1849)
	Fasciolariidae	*Fusinus verrucosus* (Gmelin, 1791)
	Flabellinidae	*Coryphellina rubrolineata* O'Donoghue, 1929
	Mnestiidae	*Mnestia girardi* (Audouin, 1826)
	Muricidae	*Ergalatax junionae* Houart, 2008
		Indothais sacellum (Gmelin, 1791)
		Murex forskoehlii Röding, 1798
	Plakobranchidae	*Elysia grandifolia* Kelaart, 1858
	Pleurobranchidae	*Pleurobranchus forskalii* Rüppell & Leuckart, 1828
	Polyceridae	*Plocamopherus ocellatus* Rüppell & Leuckart, 1828
	Pyramidellidae	*Cingulina isseli* (Tryon, 1886)
		Pyrgulina pupaeformis (Souverbie, 1865)
		Syrnola fasciata Jickeli, 1882
	Retusidae	*Pyrunculus fourierii* (Audouin, 1826)
	Scaliolidae	*Finella pupoides* A. Adams, 1860
	Strombidae	*Conomurex persicus* (Swainson, 1821)
	Tethydidae	*Melibe viridis* (Kelaart, 1858)
	Trochidae	*Pseudominolia nedyma* (Melvill, 1897)
		Trochus erithreus Brocchi, 1821
Bivalvia	Arcidae	*Anadara natalensis* (Krauss, 1848)
	Cardiidae	*Fulvia fragilis* (Forsskål in Niebuhr, 1775)
		Afrocardium richardi (Audouin, 1826)
	Chamidae	*Chama asperella* Lamarck, 1819
		Chama pacifica Broderip, 1835
	Laternulidae	*Laternula anatina* (Linnaeus, 1758)
	Mactridae	*Mactra lilacea* Lamarck, 1818
		Mactra olorina Philippi, 1846
	Malleidae	*Malleus regula* (Forsskål in Niebuhr, 1775)
	Myidae	*Sphenia rueppellii* A. Adams, 1851
	Mytilidae	*Brachidontes pharaonis* (P. Fischer, 1870)
		Lioberus ligneus (Reeve, 1858)
	Ostreidae	*Dendostrea folium* (Linnaeus, 1758)
	Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)
	Spondylidae	*Spondylus spinosus* Schreibers, 1793
	Veneridae	*Gafrarium savignyi* (Jonas, 1846)
		Petricola fabagella Lamarck, 1818
Cephalopoda	Loliginidae	*Sepioteuthis lessoniana* Férussac [in Lesson], 1831

Crustacea		
Isopoda	Anthuridae	*Apanthura sandalensis* Stebbing, 1900
		Apanthura stanjeki Wägele, 1981
	Cymothoidae	*Anilocra pilchardi* Bariche & Trilles, 2006
		Ceratothoa collaris Schiödte & Meinert, 1883
		Cymothoa indica Schioedte & Meinert, 1884
Decapoda	Hippolytidae	*Saron marmoratus* (Olivier, 1811)
	Leucosiidae	*Coleusia signata* (Paul'son, 1875)
		Myra subgranulata Kossmann, 1877
	Majidae	*Micippa thalia* (Herbst, 1803)
	Matutidae	*Matuta victor* (Fabricius, 1781)
	Penaeidae	*Metapenaeus stebbingi* Nobili, 1904
		Penaeus semisulcatus De Haan, 1844 [in De Haan, 1833-1850]
	Percnidae	*Percnon gibbesi* (H. Milne Edwards, 1853)
	Plagusiidae	*Plagusia squamosa* (Herbst, 1790)
	Portunidae	*Callinectes sapidus* Rathbun, 1896
		Charybdis (Charybdis) hellerii (A. Milne-Edwards, 1867)
		Charybdis (Goniohellenus) longicollis Leene, 1938
		Portunus pelagicus (Linnaeus, 1758)
		Thalamita indistincta Apel & Spiridonov, 1998
		Thalamita poissonii (Audouin, 1826)
	Xanthidae	*Atergatis roseus* (Rüppell, 1830)
		Actaea savignii (H. Milne Edwards, 1834)
Pycnogonida	Phoxichilidiidae	*Anoplodactylus digitatus* (Böhm, 1879)
Echinodermata		
Asteroidea	Asterinidae	*Aquilonastra burtoni* (Gray, 1840)
Echinoidea	Diadematidae	*Diadema setosum* (Leske, 1778)
Ophiuroidea	Ophiactidae	*Ophiactis macrolepidota* Marktanner-Turneretscher, 1887
		Ophiactis savignyi (Müller & Troschel, 1842)
Holothuroidea	Synaptidae	*Synaptula reciprocans* (Forsskål, 1775)
Bryozoa		
Cyclostomata		
	Vesiculariidae	*Amathia verticillata* (delle Chiaje, 1822)
Cheilostomata		
	Anthroporidae	*Akatopora leucocypha* (Marcus, 1937)
	Bugulidae	*Bugula neritina* (Linnaeus, 1758)
	Candidae	*Licornia jolloisii* (Audouin, 1826)
	Celleporidae	*Celleporina bitari* Harmelin, 2014
		Predanophora longiuscula (Harmer, 1957)
	Hippoporidridae	*Scorpiodinipora costulata* (Canu & Bassler, 1929)
	Lepraliellidae	*Celleporaria brunnea* (Hincks, 1884)
		Celleporaria labelligera Harmer, 1957
		Celleporaria sherryae Winston, 2005
		Celleporaria vermiformis (Waters, 1909)
		Drepanophora birbira Powell, 1967
	Microporellidae	*Microporella browni* Harmelin, Ostrovsky, Cáceres-Chamizo & Sanner, 2011
		Microporella coronata (Audouin, 1826)

		Microporella genisii (Audouin, 1826)
		Microporella harmeri Hayward, 1988
	Petraliellidae	*Mucropetraliella thenardii* (Audouin, 1826)
	Phidoloporidae	*Schizoretepora hassi* Harmelin, Bitar & Zibrowius, 2007
	Smittinidae	*Parasmittina egyptiaca* (Waters, 1909)
		Parasmittina protecta (Thornely, 1905)
		Parasmittina serruloides Harmelin, Bitar & Zibrowius, 2009
		Parasmittina spondylicola Harmelin, Bitar & Zibrowius, 2009
		Smittina nitidissima (Hincks, 1880)
	Thalamoporellidae	*Thalamoporella harmelini* Soule, Soule & Chaney, 1999
		Thalamoporella rozieri (Audouin, 1826)
	Watersiporidae	*Watersipora subtorquata* (d'Orbigny, 1852)
Tunicata		
Ascidiacea	Ascidiidae	*Phallusia nigra* Savigny, 1816
	Corellidae	*Rhodosoma turcicum* (Savigny, 1816)
	Pyuridae	*Herdmania momus* (Savigny, 1816)

Cnidaria: **Hydrozoa:** Abboud-Abi Saab et al., 2003; Zibrowius and Bitar, 2003; Morri et al. 2009. **Scyphozoa:** Lakkis 1971; Lakkis and Zeidane 1985, Goy et al., 1990; Abboud-Abi Saab et al., 2003; Dailianis et al., 2016. **Anthozoa:** Bitar & Zibrowius, 1997; Zibrowius and Bitar, 2003. ***Annelida:*** **Polychaetes:** Zibrowius & Bitar, 1981; Abboud-Abi Saab et al., 2003. ***Mollusca:*** **Gastropoda:** Pallary, 1938; Bogi and Khairallah, 1987; Bitar and Kouli-Bitar, 1998; Valdés and Templado, 2002; Abboud-Abi Saab et al., 2003; Zibrowius & Bitar, 2003; Crocetta et al., 2013a; Bitar, 2014; Tsiamis et al., 2015. Bivalvia: Gruvel, 1931; Moazzo, 1931; Christensen, 1972; Abboud-Abi Saab et al., 2003; Zibrowius & Bitar, 2003; Crocetta et al., 2013; Bitar 2014. Cephalopoda: Crocetta et al., 2014. ***Crustaceans:*** **Isopoda:** Abboud-Abi Saab et al., 2003; Bariche and Trilles, 2006; 2008; Trilles and Bariche, 2006. **Decapoda:** Steinitz, 1929; Shiber, 1981; Abboud-Abi Saab et al., 2003; Katsanevakis et al., 2011; Crocetta et al., 2015; Zenetos et al., 2015. **Pycnogonida:** Abboud-Abi Saab et al., 2003. **Echinodermata:** Tortonese, 1966; Abboud-Abi Saab et al., 2003; Zibrowius and Bitar G, 2003; Nader and El Indary, 2011. **Bryozoa:** Abboud-Abi Saab et al., 2003; Harmelin, 2014 ; Harmelin et al., 2007; 2009; 2016. ***Tunicata*****: Ascidiacea:** Abboud-Abi Saab et al., 2003; Zibrowius and Bitar, 2003.

Among the work related to the marine macrophytes of Lebanon the following references are among the most relevant: Basson et al., 1976; Bitar, 1999; Lakkis et al., 1996; Lakkis, 2013; Lakkis and Novel-Lakkis, 2000; 2001; 2007; Abboud-Abi Saab et al., 2003; Bitar 2010; Belous and Kanaan, 2015; Kanaan et al., 2015. A survey of the marine macroflora was recently published following an analysis of historical data and additional observations. It recorded a total of 29 macrophytes with a non-indigenous status (alien, cryptogenic, questionable) (Bitar et al., 2017) (Table III). Finally, the MAMIAS online database, reports a total of 215 marine NIS from Lebanon. The list of species was retrieved in March 2018 and is available in the Annexe.

3. Action Plan for Lebanon

Following the recommendations of the Action Plan concerning species introductions and invasive species in the Mediterranean Sea (UNEP/MAP, 2017), the National Action Plan for each Mediterranean country should be based on the available scientific data and should include programmes for:

- the collection and regular updating of data, especially for the support of Ecosystem Approach
- the highest possible dissemination of data and relevant information, especially within the framework of MAMIAS
- training and refresher courses for specialists
- awareness-raising and education campaigns for the general public, stakeholder and decision-makers
- coordination and collaboration with other countries

3.1 Data collection on NIS and update at the national level

3.1.1 National inventory of marine NIS

The marine fauna and flora of the coastal waters of Lebanon are poorly studied. As mentionned earlier, the geographic location (Figure 1), the diversity of marine habitats and other reasons make Lebanon highly prone to the arrival and establishment of marine NIS, particularly those of indo-pacific origin. This is supported by the fact, that the coastal waters of the Levant, are the ones that harbor a higher number of NIS than the rest of the Mediterranean (Zenetos et al., 2012; MAMIAS, 2018).

A national inventory of marine NIS in the coastal waters of Lebanon should take place. Since a full inventory is time consuming and requires human and financial ressources, most of which are lacking in the country, assessments should be done in selected sites that are considered representative for the country's various marine environments. Such inventories should be done along different seasons (spring, summer, fall, winter) and will incorporate previous knowledge and fill important gaps in less studied organisms. Since this issue is of importance to all countries around the Mediterranean, the collaboration with EU countries, especially in the identification of organisms should be of great help. This will also update the current knowledge on previously reported NIS (Tables I, II, III, Annexe).

A baseline assessment conducted between 1999 and 2002 reported a relatively wide array of new NIS from Lebanon (Abboud-Abi Saab et al., 2003). Data aquired from extensive field surveys resulted in a multitude of first records and publications, all incorporated in Tables II and III. This work can be considered as a reference point for future inventories.

Recommended actions:

i. Inventory of exotic species in hotspot areas known to be suitable for NIS
   - Field surveys of marinas and fishermen ports, where biotic and physical conditions are suitable for NIS.
   - Field surveys of shipping ports and their vicinity, where fouling organisms and ballast water are potential vectors, in additon to the environmental conditions.

ii. Inventory of NIS in key marine biocenoses and habitats
   - Field surveys in the supra and mediolittoral, more precisely on vermetid reefs.
   - Field surveys on hard bottoms in the infralittoral (*sensu* Bellan-Santini et al., 2007).
   - Field surveys on soft bottoms in the infralittoral (*sensu* Bellan-Santini et al., 2007).
   - Field surveys on *Cymodocea nodosa* meadows.
   - Inventory of planktonic NIS in neritic waters.

iii. Inventory of NIS in fisheries
   - Field surveys of small scale fisheries landings (entangling nets and longlines) at ports and fish auctions.
   - Field surveys of small pelagic fish landings (lampara nets and purse seines) at ports and fish auctions.
   - Promote the reporting of unusual organisms by professional fishermen.
   - Promote the reporting of unusual organisms by occasional anglers, divers and spearfishers.

- Design an informational exchange platform for NIS reporting between stakeholders and the scientific community or the concerned Ministry (hotline, website, social media). A monetary incentive may be allocated for the purchase of some organisms.

Table III. List of non-indigenous macrophytes recorded from Lebanon (the list is not exhaustive).

Taxon	Family	Species
Macroflora		
Chlorophyta	Bryopsidaceae	*Bryopsis pennata* J.V.Lamouroux, 1809
	Caulerpaceae	*Caulerpa chemnitzia* (Esper) J.V.Lamououx, 1809
		Caulerpa mexicana Sonder ex Kützing, 1849
		Caulerpa racemosa var. lamourouxii f. requienii (Montagne) Weber-van Bosse, 1898
		Caulerpa scalpelliformis (R.Brown ex Turner) C.Agardh, 1817
		Caulerpa taxifolia var. distichophylla (Sonder) Verlaque, Huisman & Procaccini, 2013
	Cladophoraceae	*Cladophora herpestica* (Montagne) Kützing, 1849
		Cladophora patentiramea (Montagne) Kützing, 1849
	Codiaceae	*Codium arabicum* Kützing, 1856
		Codium parvulum (Bory de Saint Vincent ex Audouin) P.C.Silva, 2003
		Codium taylorii P.C.Silva, 1960
	Ulvaceae	*Ulva lactuca* Linnaeus, 1753
Ochrophyta	Dictyotaceae	*Padina boergesenii* Allender & Kraft, 1983
		Spatoglossum variabile Figari & De Notaris, 1853
		Stypopodium schimperi (Kützing) M.Verlaque & Boudouresque, 1991
Rhodophyta	Bonnemaisoniaceae	*Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, 1845
	Cystocloniaceae	*Hypnea cornuta* (Kützing) J.Agardh, 1851
		Hypnea spinella (C.Agardh) Kützing, 1847
		Hypnea valentiae (Turner) Montagne, 1841
	Galaxauraceae	*Galaxaura rugosa* (J.Ellis & Solander) J.V.Lamouroux, 1816
	Liagoraceae	*Ganonema farinosum* (J.V.Lamouroux) K.C.Fan & Yung C.Wang, 1974
	Rhodomelaceae	*Chondria coerulescens* (J.Agardh) Falkenberg, 1901
		Acanthophora nayadiformis (Delile) Papenfuss, 1968
		Laurencia chondrioides Børgesen, 1918
		Lophocladia lallemandii (Montagne) F.Schmitz, 1893
		Polysiphonia atlantica Kapraun & J.N.Norris, 1982
		Womersleyella setacea (Hollenberg) R.E.Norris, 1992
	Solieriaceae	*Sarconema filiforme* (Sonder) Kylin, 1932
Tracheophyta	Hydrocharitaceae	*Halophila stipulacea* (Forsskål) Ascherson, 1867

Hamel, 1930; 1931; Rayss, 1941; Lipkin, 1975; Basson et al., 1976; Bitar, 1999; 2010b; Abboud-Abi Saab et al., 2003; Bitar et al., 2000; 2007; 2017; Belous & Kanaan, 2015; Kapiris et al., 2014.

3.1.2 Monitoring NIS dynamics

The monitoring of selected NIS, particularly those with invasive potential, should be conducted in some key habitats of ecological importance, ideally in MPAs. A regular monitoring could be done on a year, bi-annual or seasonal basis. The type of monitoring and frequency will be done following standard methods and will depend on the habitat or species of concern (e.g. Katsanevakis et al., 2012; Bitar, 2018). This will result in the acquisition of time series data that will be in line with common indicator 6 and will allow to estimate trends in abundances, temporal occurrences and spatial distributions of the selected NIS. Selection of species should be made on the basis of potential invasiveness or the threat to important habitats. Ratios NIS/native species should be calculated as well.

Recommended actions:

i. Monitoring of selected NIS in key marine habitats
   - Regular monitoring the supra and mediolittoral on selected vermetid reefs.
   - Regular monitoring on selected hard bottoms in the infralittoral.
   - Regular monitoring on selected soft bottoms in the infralittoral.
   - Regular monitoring on selected *Cymodocea nodosa* meadows.

ii. Monitoring of NIS in fisheries
   - Regular monitoring of small scale fisheries landings (entangling nets and longlines) at ports and fish auctions.
   - Regular monitoring of small pelagic fish (lampara nets and purse seines) landings at ports and fish auctions.

3.1.3 Early Detection of NIS (EDNIS)

It is generally recommended to promote actions that aim at preventing the arrival of NIS to the subject environment. However, this is not reasonably feasible in the context of introduction to the Mediterranean Sea via the Suez Canal. This is because, at the time being, it is unlikely to control the flow of organisms through the canal itself.

While no system of detection can ever be one hundred percent effective, an early detection system for newly arriving NIS should be implemented in selected hotspots, fish auctions or some ports. After the detection of a new NIS, a quick species identification or assessment of the situation can be done to generate a rapid response effort. Such effort may lead to control eventual establishment of the species in the country, if not a complete eradication of the early occurrence event. However, this may be of concern at the International level, particularly EU countries bordering the Mediterranean Sea. The swift control of a new arrival in the Mediterranean, detected in the Levant (Lebanon), is important to act upon before a population establishes, grows in size and start to spread westwards. The same could be applied to neighboring countries.

Recommended actions:

i. Detection within the national framework
   Creation of a national early detection system in key hotspot areas, where a set of trained stakeholders (employees in ports, fishermen, custom agents…) report unusual observations from:
   - Fishermen ports and marinas
   - Shipping ports and their vicinity

- Fish auctions

ii. Detection within the community

Procedures to detect a marine NIS in the marine environment are generally weak. This is because the probability for a biologist to to detect the arrival of a new exotic species is very low and chance often plays an important role. The use of smartphones and online social media have become a popular mean of exchange of information, photos and videos and an integral part of daily life. An experiment was conducted in 2012 were a public group on Facebook named "Sea Lebanon" was created. The group presented a forum for people to share pictures, information and curiosities related to marine organisms in Lebanon. Members were allowed to share and discuss anything related to Lebanon's sea, including sharing their own sightings. Posts including NIS species were shared by the public which lead to the detection of various newly arrivals in the Mediterranean and Lebanon (e.g. Dailianis et al., 2016; Gerovasileiou et al., 2017). Based on this successful trial, several other groups started in several countries with similar aims. Creating a community based early detection system would:

- Promote the reporting by social media users (fishermen, divers and sea lovers) of organisms that seem alien to them (e.g. Sea Lebanon).
- Promote the reporting directly to the Ministry of Environment (MoE) by social media users of organisms that seem alien to them (e.g. hotline, website, social media). A monetary incentive may be allocated for the purchase of some organisms.

3.2 Information and data dissemination

Information and data collected on NIS should be properly disseminated to ensure that involved stakeholders have easy and early access to it.

Recommended actions:

- Create a national database, that could be available on the website of the Ministry of Environment or a separate entity. The database provides a checklist of NIS species recorded from Lebanon as well as other information such as description, identification, date of first record, habitat, spatial distribution in the Mediterranean, photos, potential impacts to stakeholders. It will be regularly updated and will compile necessary information on each species recorded. This also allows filling gaps in the documentation available in some taxa and would encourage scientists to study them.
- Publish a national report as an annual update to the Ministry of Environment and decision makers on the status of NIS in Lebanon. This will contain a summary on all monitoring activities and actions done during the year and will publicly available.
- Send an updated list on all NIS recorded in the country to SPA/RAC. This could be done on a yearly basis and would be used to update MAMIAS.

3.3 Expert training on identification and monitoring

Training workshops should be organized on various topics and targeting several audience. They will be helpful for the proper implementation of the National Action Plan in the future. Forming a new batch of scientists that would specialize in various groups of NIS would be recommended for the long term.
Recommended actions:

- Organize training workshops informing stakeholders about bioinvasions and their socio-economic and environmental impacts. In these workshops they learn how to recognize, detect and report different types of NIS. Workshops will be tailored to target different stakeholders such as fishermen, scubadivers, MPAs' staff, custom agents etc. Several documents such as identification keys, preserved samples, videos and animations will be made available and the importance of the exchange of information between participants and the scientists or the Ministry of Environment will be highlighted.
- Organize training workshops addressing marine invasive species monitoring and management. Participants could be members of dive centers, NGOs, MPA staff or volunteers. They will receive expert advice on NIS identification and monitoring and will acquire the good practice techniques for the prevention and control of invasives in the marine environment. They will test several monitoring methods in the field using shore observations and diving activities.
- Promote scientific research by funding scholarships and grants for future scientists to study NIS. These scientists will help decision-makers understand clearly the management of established NIS and will provide scientific background for policies and laws. Furthermore, this will allow gaining government endorsement for future mitigation projects.

3.4 Awareness and outreach

Education and awareness-raising on the risks of NIS on economy, ecosystem and society is fundamental to the National Action Plan. Implementation requires the support of the community, governmental bodies, decision-makers and other stakeholders.

Recommended actions:

- Publish user-friendly documents targeting stakeholders and the general public. These documents could be in the form of reports, brochures, awareness billboards, posters etc. These will explain the impacts and costs of NIS and will be distributed by the Ministry of Environment.
- Prepare a user-friendly mobile application compiling pictures of NIS present and their major features, habitats and impacts. This will be available for public use.
- Prepare seminars on NIS and their impacts that will be presented in schools, universities and dive centers.
- Promote national measures on prevention and control of certain NIS such as increase of fishing of some species (e.g. puffers) or the promotion of the consumption of others (e.g. the lionfish). These could be in the form of media campaigns, public events, etc.

3.5 Coordination at the National, Mediterranean and International levels

A legislative framework governing the control of NIS in Lebanon is necessary. Obstacles hindering the effective implementation of the current legislation should be identified in order for Lebanon to meet its international obligations. Since one pathway of introduction of NIS is aquarium trade, control plans for intentional release may be set up. Moreover, if ballast water is properly managed, within the framework of the IMO Convention on the management of ballast waters, the introduction of some NIS could lessen. On a Mediterranean level, a regional strategy on ships' ballast water management was developed to harmonize actions that aim at decreasing the transfer of NIS in ships' ballast water (Decision IG.19/11 adopted at the 16th Ordinary Meeting of the Contracting Parties to the Barcelona Convention).

Recommended actions at the National level:

- Organize a yearly national workshop to discuss the status of NIS in Lebanese water, new finding and advice to the Ministry of Environment.

Recommended actions at the International/Mediterranean level:

- Continue to participate in International/Mediterranean initiatives on NIS and implement any resulting policy or regulation.
- Collaborate with international organizations, NGOs, private agencies that provide financial resources necessary for the implementation of control measures.
- Work with regional and international organizations that provide management programmes of NIS.

4. Follow up on the implementation of the Action Plan

The recommended actions in the Action Plan should be implemented within five years. After that, the accomplishments and inconsistencies of the Plan will be reviewed, and if necessary, amendments could be proposed.

However, a mid-term evaluation after three years is recommended to assess the progress made in the implementation of the actions. The proposed programmes can be updated based on the cooperation and recommendations of involved stakeholders.

5. Implementation table

Action	Deadline	Responsible
1. Data collection on NIS and update at the National level		
National Inventory of marine NIS		
1. Inventory of exotic species in hotspot areas known to be suitable for NIS	2019	MoE in collaboration with SPA/RAC
2. Inventory of NIS in key marine biocenoses and habitats	2019	MoE in collaboration with SPA/RAC
3. Inventory of NIS in fisheries	2019	MoE in collaboration with SPA/RAC
Monitoring NIS dynamics		
1. Monitoring of selected NIS in key marine habitats	2019-2023	MoE
2. Monitoring of NIS in fisheries	2019-2023	MoE
Early Detection of NIS (EDNIS)		
1. Detection within the national framework	2019-2023	MoE
2. Detection within the community	2019-2023	MoE
2. Information and data dissemination		
1. Create a national database	2020	MoE
2. Publish a national report	2019-2023 annually	MoE
3. Send an updated list on all NIS recorded in the country to SPA/RAC	2019-2023 annually	MoE
3. Expert training on identification and monitoring		
1. Organize training workshops informing stakeholders about bioinvasions and their socio-economic and environmental impacts	2020	MoE in collaboration with SPA/RAC
2. Organize training workshops addressing marine invasive species monitoring and management		MoE in collaboration with SPA/RAC
3. Promote scientific research by funding scholarships and grants for future scientists to study NIS	2019-2023 annually	Lebanese government
4. Awareness and outreach		
1. Publish user-friendly documents targeting stakeholders and the general public	2020-2023	MoE

2. Prepare a user-friendly mobile application compiling pictures of NIS	2020-2023	MoE
3. Prepare seminars on NIS and their impacts that will be presented in schools, universities and dive centres	2019-2023 annually	MoE
4. Promote national measures on prevention and control of certain NIS	2019-2023 annually	MoE
5. Coordination at the National, Mediterranean and International levels		
5.1. Recommended actions at the National level:		
1. Organise a yearly national workshop to discuss the status of NIS in Lebanese water, new finding and advice to the Ministry of Environment	2019-2023 (annually)	MoE
5.2. Recommended actions at the International/Mediterranean level:		
1. Continue to participate in International/Mediterranean initiatives on NIS and implement any resulting policy or regulation	2019-2023	MoE
2. Collaborate with international organizations, NGOs, private agencies that provide financial resources necessary for the implementation of control measures	2019-2023	MoE
3. Work with regional and international organizations that provide management programmes of NIS	2019-2023	MoE

References

Abboud-Abi Saab M (1985a) Contribution à l'étude des populations microplanctoniques des eaux côtières libanaises (méditerranée orientale). PhD Thesis, Université d'Aix-Marseille II, France, 281 pp

Abboud-Abi Saab M (1985b) Etude quantitative et qualitative du phytoplancton des eaux côtières libanaises. *Lebanese Science Bulletin* 1(2): 197–222

Abboud-Abi Saab M (1989) Les Dinoflagellés des eaux côtières libanaises- espèces rares ou nouvelles du phytoplancton marin. *Lebanese Science Bulletin* 5(2): 5–16

Abboud-Abi Saab M, Bitar G, Harmelin JG, Harmelin-Vivien M, Romano JC and Zibrowius H (2003) Environnement côtier et biodiversité marine sur les côtes libanaises; inventaire et mise en place d'un ensemble matériel et humain d'observation et d'analyse de leur évolution, degré d'altération des communautés benthiques littorales, *Rapport final* Franco-Lebanese Cooperation Program CEDRE (1999-2002), 75 pp

Albins MA (2013) Effects of invasive Pacific red lionfish *Pterois volitans* versus a native predator on Bahamian coral-reef fish communities. *Biological Invasions* 15: 29–43

Albins MA (2015) Invasive Pacific lionfish *Pterois volitans* reduce abundance and species richness of native Bahamian coral-reef fishes. *Marine Ecology Progress Series* 522: 231–243

Azzurro E and Bariche M (2017) Local knowledge and awareness on the incipient lionfish invasion in the eastern Mediterranean Sea. *Marine and Freshwater Research* 68(10): 1950-1954

Bariche M (2010a) Champsodon vorax (Teleostei: Champsodontidae), a new alien fish in the Mediterranean. *Aqua: International Journal of Ichthyology* 16(4): 197–200

Bariche M (2010b) First record of the angelfish *Pomacanthus maculosus* (Teleostei: Pomacanthidae) in the Mediterranean. *Aqua: International Journal of Ichthyology* 16(1): 31–33

Bariche M (2011) First record of the cube boxfish *Ostracion cubicus* (Ostraciidae) and additional records of *Champsodon vorax* (Champsodontidae) from the Mediterranean. *Aqua: International Journal of Ichthyology* 17(4): 181–184

Bariche M (2012) Recent evidence on the presence of *Heniochus intermedius* (Teleostei: Chaetodontidae) and *Platycephalus indicus* (Teleostei: Platycephalidae) in the Mediterranean Sea. *BioInvasions Records* 1(1): 53–57

Bariche M, Azzurro E (2012) New records and establishment of the Indian Ocean twospot cardinalfish *Cheilodipterus novemstriatus* (Rüppell, 1838) in the Mediterranean Sea. *BioInvasions Records* 1(4): 299–301

Bariche M, Bilecenoglu M, Azzurro E (2013c) Confirmed presence of the Red Sea goatfish *Parupeneus forsskali* (Fourmanoir & Guézé, 1976) in the Mediterranean Sea. *BioInvasions Records* 2(2): 173–175

Bariche M, Heemstra P (2012) First record of the blacktip grouper *Epinephelus fasciatus* (Teleostei: Serranidae) in the Mediterranean Sea. *Marine Biodiversity Records* 5: e1

Bariche M, Kazanjian G, Azzurro E (2014) A lag of 25 years: evidence from an old capture of *Fistularia commersonii* Ruppell, 1838 from Lebanon (Mediterranean Sea). *Journal of Applied Ichthyology* 30: 535–536

Bariche M, Kleitou P, Kalogirou S, Bernardi G (2017) Genetics reveal the identity and origin of the lionfish invasion in the Mediterranean Sea. *Scientific Reports* 7(1): 67–82

Bariche M, Torres M and Azzurro E (2013b) The presence of the invasive Lionfish *Pterois miles* in the Mediterranean Sea. *Mediterranean Marine Science* 14(2): 292–294

Bariche M, Torres M, Smith C, Sayar N, Azzurro E, Baker R, Bernardi G (2015) Red Sea fishes in the Mediterranean Sea: a preliminary investigation of a biological invasion using DNA barcoding. *Journal of Biogeography* 42(12): 2363–2373

Bariche M, Trilles JP (2005) Preliminary check-list of Cymothoids (Crustacea: Isopoda) parasitic on marine fishes from Lebanon. *Zoology in the Middle East* 34: 53–60

Bariche M, Trilles JP (2006) *Anilocra pilchardi* n. sp., a new parasitic cymothoid isopod from off Lebanon (Eastern Mediterranean). *Systematic Parasitology* 64: 203–214

Bariche M, Trilles JP (2008) *Ceratothoa collaris* (Isopoda: Cymothoidae) new to the eastern Mediterranean, with a redescription and comments on its distribution and host specificity. *Journal of the Marine Biological Association of the United Kingdom* 88(1): 85–93

Basson PW, Hardy JT, Lakkis V (1976) Ecology of marine macroalgae in relation to pollution along the coast of Lebanon. *Acta Adriatica* 18(19): 307–325

Bax N, Williamson A, Aguero M, Gonzalez E, Geeves W (2003) Marine invasive alien species: a threat to global biodiversity. *Marine Policy* 27(4): 313–323

Belmaker J, Parravicini V, Kulbicki M (2013) Ecological traits and environmental affinity explain Red Sea fish introduction into the Mediterranean. *Global Change Biology* 19(5): 1373–1382

Belous O, Kanaan H (2015) Marine algae of the Lebanese coast. Raidy Printing Group, First edition, 215 pp

BirdLife International (2009) Important bird area factsheet: Palm Islands Nature Reserve, Lebanon. Downloaded from the Data Zone at https://www.birdlife.org on 4/1/2010

Bitar G (1999) Sur les Caulerpa de la côte libanaise (Méditerranée orientale*). Actes de l'atelier sur les espèces de Caulerpa invasives en Méditerranée*. Heraklion, Crete, Greece, 18-20 March 1998. PNUE, PAM, MED POL. MAP Technical Reports Series, pp 275–277

Bitar G (2010b) La flore marine benthique introduite de la côte libanaise. Etat actuel de trois espèces envahissantes. *INOC-Tischreen University, International conference on Biodiversity of the Aquatic Environment,* pp 107–114

Bitar G (2013) Sur la presence des poissons exotiques nouveaux de la cote libanaise (Mediterranee orientale). *Rapport Commission international Mer Méditerranée*, 40: 592

Bitar G (2014) Les mollusques exotiques de la cote libanaise. Exotic molluscs from the Lebanese coast. *Bulletin de la Societe Zoologique de France* 139(1–4): 37–45

Bitar G (2018) National monitoring programme for biodiversity in Lebanon (NMPBL) EO2-Non indigenous species (ENI)

Bitar G, Harmelin JG, Verlaque M, Zibrowius H (2000) Sur la flore marine benthique supposée Lessepsienne de la côte libanaise. Cas particulier de *Stypopodium schimperi*. In: RAC/SPA (eds), *Proceedings of the First Mediterranean Symposium on Marine Vegetation*, Ajaccio, 3-4 Oct. 2000, RAC/SPA, PNUE, pp 97–100

Bitar G, Kouli-Bitar S (1998) Check-list of the marine benthic Mollusca of Lebanon and biogeographical comments on some new records (Inventaire des Mollusques marins benthiques du Liban et remarques biogeographiques sur quelques especes nouvellement signalees). *Mesogee.* 56: 37–44

Bitar G, Ramos-Esplá A, Ocaña O, Sghaier YR, Forcada A, Valle C, El Shaer H, Verlaque M (2017) The introduced marine macroflora of Lebanon and its distribution on the Levantine coast. *Mediterranean Marine Science* 18: 138–155

Bitar G, Zibrowius H (1997) Scleractinian corals from Lebanon, Eastern Mediterranean, including a non-lessepsian invading species (Cuidevia: Scleractinia). *Scientia Marine* 61(2): 227–231

Bogi C, Khairallah NH (1987) Nota su alcuni molluschi de provenienza Indo-Pacifica raccolti nella baia di Jounieh (Libano) - Contributo I. *Notiziario del CISMA* 10: 54–60

Coll M, Piroddi C, Steenbeek J, Kaschner K, Ben Rais Lasram F, Aguzzi J, Ballesteros E, Nike Bianchi C, Corbera J, Dailianis T, Danovaro R, Estrada M, Froglia C, Galil BS, Gasol JM, Gertwagen R, Gil J, Guilhaumon F, Kesner-Reyes K, Kitsos M-S, Koukouras A, Lampadariou N, Laxamana E, Loópez-Fé de la Cuadra CM, Lotze HK, Martin D, Mouillot D, Oro D, Raicevich S, Rius-Barile J, Saiz-Salinas JI, San Vicente C, Somot S, Templado J, Turon X, Vafidis D, Villanueva R and Voultdiadou E (2010) The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. PLoS ONE 5(8): e11842, 10.1371/journal.pone.0011842

Crocetta F, Agius D, Balistreri P, Bariche M, Bayhan Y, Çakir M, Ciriaco S, Corsini-Foka M, Deidun A, Zrelli R, Ergüden D, Evans J, Ghelia M, Giavasi M, Kleitou P, Kondylatos G, Lipej L, Mifsud C, Özvarol Y, Pagano A, Portelli P, Poursanidis D, Rabaoui L, Schembri P, Taşkin E, Tiralongo F, Zenetos A (2015) New Mediterranean Biodiversity Records (October 2015). *Mediterranean Marine Science* 16(3): 682–702

Crocetta F, Bitar G, Zibrowius H, Capua D, Dell'Angelo B, Oliverio M (2014) Biogeographical homogeneity in the eastern Mediterranean Sea - III. New records and a state of the art of Polyplacophora, Scaphopoda and Cephalopoda from Lebanon. *Spixiana* 37(2): 183–206

Crocetta F, Bitar G, Zibrowius H, Oliverio M (2013b) Biogeographical homogeneity in the eastern Mediterranean Sea. II. Temporal variation in Lebanese bivalve biota. *Aquatic Biology* 19(1): 75–84

Crocetta F, Zibrowius H, Bitar G, Templado J, Oliverio M (2013a) Biogeographical homogeneity in the eastern Mediterranean Sea - I: the opisthobranchs (Mollusca: Gastropoda) from Lebanon. *Mediterranean Marine Science* 14(2): 403–408

Dailianis T, Akyol O, Babali N, Bariche M, Crocetta F, Gerovasileiou V, Ghanem R, Gökoğlu M, Hasiotis T, Izquierdo-Muñoz A, Julian D, Katsanevakis S, Lipej L, Mancini E, Mytilineou C, Ounifi Ben Amor K, Özgül A, Ragkousis M, Rubio-Portillo E, Servello G, Sini M, Stamouli C, Sterioti A, Teker S, Tiralongo F, Trkov D (2016) New Mediterranean Biodiversity Records (July 2016). *Mediterranean Marine Science* 17(2): 608–626

Darrigran G, Damborenea C (2011) Ecosystem engineering impact of *Limnoperna fortunei* in South America. *Zoological Science* 28(1): 1–7

Edelist D, Rilov G, Golani D, Carlton JT, Spanier E (2013) Restructuring the sea: profound shifts in the world's most invaded marine ecosystem. *Diversity and Distributions* 19(1): 69–77

Emery KO, George CJ (1963) The Shores of Lebanon. *Miscellaneous Paper in the Natural Sciences, The American University of Beirut* 1: 1–13

Eschmeyer WN, Fricke R, van der Laan R (eds) CATALOG OF FISHES: GENERA, SPECIES, REFERENCES. (https://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp). Electronic version accessed 20 March 2018

Fadlallah YH (1975) Systematics and ecology of benthic macroinvertebrates in the eastern Mediterranean, Lebanon. MSc. Thesis, The American University of Beirut, Beirut, Lebanon, 73 pp

Fanelli E, Azzurro E, Battaglia P, Romeo T, Bariche M, Maynou F, Andaloro F (2014) Preliminary data on the isotopic composition of native and lessepsian pelagic species. *Biologia Marina Mediterranea* 21(1): 115–116

Fowler HW (1923) Fishes from Madeira, Syria, Madagascar, and Victoria, Austral. *Proceedings of the Academy of Natural Science of Philadelphia.* 75: 33–45

Galil BS (2007) Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. *Marine Pollution Bulletin* 55: 314–322

Galil BS (2012) Truth and consequences: the bioinvasion of the Mediterranean Sea. *Integrative Zoology* 7(3): 299–311

Galil BS, Boero F, Campbell ML, Carlton JT, Cook E, Fraschetti S, Gollasch S, Hewitt CL, Jelmert A, Macpherson E, Marchini A, McKenzie C, Minchin D, Occhipinti-Ambrogi A, Ojaveer H, Olenin S, Piraino S, Ruiz GM (2015) 'Double trouble': the expansion of the Suez Canal and marine bioinvasions in the Mediterranean Sea. *Biological Invasions* 17(4): 973–976

Galil BS, Marchini A, Occhipinti-Ambrogi A (2018) East is east and West is west? Management of marine bioinvasions in the Mediterranean Sea. *Estuarine, Coastal and Shelf Science* 201: 7–16

Galil BS, Marchini A, Occhipinti-Ambrogi A, Minchin D, Narščius A, Ojaveer H, Olenin S (2014) International arrivals: widespread bioinvasions in European Seas. *Ethology Ecology & Evolution* 26:2–3, 152–171

George CJ, Athanassiou V (1965) On the occurrence of *Scomberomorus commerson* (Lacepède) in St George Bay, Lebanon. *Doriana* 4(157): 1–4

George CJ, Athanassiou V (1966a) Observations of *Upeneus asymmetricus* Lachner, 1954, (Pisces) in St George Bay, Lebanon. *Ann. Mus. Storia Nat. Genova.* 76: 68–74

George CJ, Athanassiou V (1966b) Additions to the check list of the fishes of the coastal waters of Lebanon. *Miscellaneous Papers in the Natural Sciences. The American University of Beirut* 5: 6–8

George CJ, Athanassiou V (1967) A two-year study of the fishes appearing in the seine fishery of St George Bay, Lebanon. *Ann. Mus. Storia Nat. Genova.* 76: 237–294

George CJ, Athanassiou V, Tortonese E (1971) The presence of a third species of the genus Sphyraena (Pisces) in the marine waters of Lebanon. *Ann. Mus. Storia Nat. Genova.* 78: 256–263

George CJ, Athanassiou VA, Boulos I (1964) The fishes of the coastal waters of Lebanon. *Miscellaneous Papers in the Natural Sciences. The American University of Beirut* 4: 1–24

Gerovasileiou V, Akel EHK, Akyol O, Alongi G, Azevedos F, Babali N, Bakiu R, Bariche M, Bennoui A, Castriota L, Chintiroglou CC, Crocetta F, Deidun A, Galinou-Mitsoudi S, Giovos I, Gökoğlu M, Golemaj A, Hadjioannou L, Hartingerova J, Insacco G, Katsanevakis S, Kleitou P, Korun J, Lipej L, Malegue M, Michailidis N, Mouzai Tifoura A, Ovalis P, Petrović S, Piraino S, Rizkalla SI, Rousou M, Savva I, Şen H, Spinelli A, Vougioukalou KG, Xharahi E, Zava B, Zenetos A (2017) New Mediterranean Biodiversity Records (July 2017). *Mediterranean Marine Science* 18(2): 355–384

Giakoumi S (2014) Distribution patterns of the invasive herbivore *Siganus luridus* (Rüppell, 1829) and its relation to native benthic communities in the central Aegean Sea, Northeastern Mediterranean. *Marine Ecology* 35(1): 96–105

Golani D (2010) Colonization of the Mediterranean by Red Sea fishes via the Suez Canal – Lessepsian migration. In: Golani D, Appelbaum-Golani B (eds), Fish invasions of the Mediterranean Sea: Change and renewal. Pensoft Publishers, Sofia, pp 145–188

Golani D, Appelbaum-Golani B (2010) Fish invasions of the Mediterranean Sea: Change and Renewal. Pensoft, Sofia, 332 pp

Goy J, Lakkis S, Zeidane R (1990) Les méduses de la Méditerranée orientale. *Bull. Inst. Océanogr.* No. spéc. 7: 79–88

Green SJ, Akins JL, Maljković A, Côté IM (2012) Invasive lionfish drive Atlantic coral reef fish declines. *PLoS ONE* 7: e32596

Gruvel A (1928) Répartition géographique de quelques crustacés comestibles sur les côtes d'Egypte et de Syrie. *Comptes rendus de la société de biogéographie* 5(39): 45–46

Gruvel A (1931) Les Etats de Syrie. Richesses marines et fluviales. Exploitation actuelle – Avenir. *Société d'Editions Géographiques, Maritimes et Coloniales*, 453 pp

Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, Bruno JF, Casey KS, Ebert C, Fox HE, Fujita R, Heinemann D, Lenihan HS, Madin EMP, Perry MT, Selig ER, Spalding M, Steneck R, Watson R (2008). A global map of human impact on marine ecosystems. *Science* 319: 948–952

Hamel G (1930) Les Caulerpes méditerranéennes. *Revue Algologique, France*, 5, 229–230

Hamel G (1931) Sur le *Cladostephus dubius* Bory. *Travaux cryptogamiques dédiés à Louis Mangin*. Laboratoire Cryptogamique, Museum National d'Histoire Naturelle, Paris, 309–312

Harmelin JG (2014) Alien bryozoans in the eastern Mediterranean Sea – new records from the coast of Lebanon. *Zootaxa* 3893(3): 301–308

Harmelin JG, Bitar G, Zibrowius H (2007) *Schizoretepora hassi* sp. nov. (Bryozoa: Phidoloporidae) from Lebanon (Eastern Mediterranean) and reappraisal of *Schizotheca serratimargo* (Hincks, 1886). *Les Cahiers de Biologie Marine* 48: 179–186

Harmelin JG, Bitar G, Zibrowius H (2009) Smittinidae (Bryozoa, Cheilostomata) from coastal habitats of Lebanon (Mediterranean sea), including new and non-indigenous species. *Zoosystema* 31(1): 163–187

Harmelin JG, Bitar G, Zibrowius H (2016) High xenodiversity versus low native diversity in the south-eastern Mediterranean: bryozoans from the coastal zone of Lebanon. *Mediterranean Marine Science* 17(2):217-439

Harmelin-Vivien ML, Bitar G, Harmelin JG and Monestiez P (2005) The littoral fish community of the Lebanese rocky coast (eastern Mediterranean Sea) with emphasis on Red Sea immigrants. *Biological Invasions* 7(4): 625–637

Hasan H, Noël P (2008) First record of *Thalamita indistincta* Apel & Spiridonov, 1998 (Decapoda,Brachyura, Portunidae) in the Mediterranean. *Crustaceana* 81(2): 247–252

Horton T, Kroh A, Ahyong S, Bailly N, Boury-Esnault N, Brandão SN, Costello MJ, Gofas S, Hernandez F, Mees J,Paulay G, Poore GCB, Rosenberg G, Decock W, Dekeyzer S, Lanssens T, Vandepitte L, Vanhoorne B, Verfaille K, Adlard R, Adriaens P, Agatha S, Ahn KJ, Akkari N, Alvarez B, Anderson G, Angel M, Arango C, Artois T, Atkinson S, Bank R, Barber A, Barbosa JP, Bartsch I, Bellan-Santini D, Bernot J, Berta A, Bieler R, Blanco S, Blasco-Costa I, Blazewicz M, Bock P, Böttger-Schnack R, Bouchet P, Boxshall G, Boyko CB, Bray R, Breure B, Bruce NL, Cairns S, Campinas Bezerra TN, Cárdenas P, Carstens E, Chan BK, Chan TY, Cheng L, Churchill M, Coleman CO, Collins AG, Corbari L, Cordeiro R, Cornils A, Coste M, Crandall KA, Cribb T, Cutmore S, Dahdouh-Guebas F, Daly M, Daneliya M, Dauvin JC, Davie P, De Broyer C, De Grave S, de Mazancourt V, de Voogd N, Decker P, Decraemer W, Defaye D, d'Hondt JL, Dijkstra H, Dohrmann M, Dolan J, Domning D,

Downey R, Drapun I, Ector L, Eisendle-Flöckner U, Eitel M, Encarnação SCd, Enghoff H, Epler J, Ewers-Saucedo C, Faber M, Feist S, Figueroa D, Finn J, Fišer C, Fordyce E, Foster W, Frank JH, Fransen C, Furuya H, Galea H, Garcia-Alvarez O, Garic R, Gasca R, Gaviria-Melo S, Gerken S, Gheerardyn H, Gibson D, Gil J, Gittenberger A, Glasby C, Glover A, Gómez-Noguera SE, González-Solís D, Gordon D, Grabowski M, Gravili C, Guerra-García JM, Guidetti R, Guiry MD, Hadfield KA, Hajdu E, Hallermann J, Hayward B, Hendrycks E, Herbert D, Herrera Bachiller A, Ho JS, Høeg J, Hoeksema B, Holovachov O, Hooper J, Houart R , Hughes L, Hyžný M, Iniesta LFM, Iseto T, Ivanenko S, Iwataki M, Jarms G, Jaume D, Jazdzewski K, Kantor Y, Karanovic I, Karthick B, Kim YH, King R, Kirk PM, Klautau M, Kociolek JP, Köhler F, Kolb J, Kotov A, Krapp-Schickel T, Kremenetskaia A, Kristensen R, Kulikovskiy M, Kullander S, La Perna R, Lambert G, Lazarus D, Le Coze F, LeCroy S, Leduc D, Lefkowitz EJ, Lemaitre R, Liu Y, Lörz AN, Lowry J, Ludwig T, Lundholm N, Macpherson E, Madin L, Mah C, Mamos T, Manconi R, Mapstone G, Marek PE, Marshall B, Marshall DJ, Martin P, McInnes S, Meidla T, Meland K, Merrin K, Mesibov R, Messing C, Miljutin D, Mills C, Moestrup Ø, Mokievsky V, Molodtsova T, Monniot F, Mooi R, Morandini AC, Moreira da Rocha R, Moretzsohn F, Mortelmans J, Mortimer J, Musco L, Neubauer TA, Neubert E, Neuhaus B, Ng P, Nguyen AD, Nielsen C, Nishikawa T, Norenburg J, O'Hara T, Okahashi H, Opresko D, Osawa M, Ota Y, Páll-Gergely B, Patterson D, Paxton H, Peña Santiago R, Perrier V, Perrin W, Petrescu I, Picton B, Pilger JF, Pisera A, Polhemus D, Potapova M, Pugh P, Read G, Reimer JD, Reip H, Reuscher M, Reynolds JW, Richling I, Rimet F, Ríos P, Rius M, Rogers C, Rützler K, Rzhavsky A, Sabbe K, Saiz-Salinas J, Sala S, Santos S, Sar E, Sartori AF, Satoh A, Schatz H, Schierwater B, Schmidt-Rhaesa A, Schneider S, Schönberg C, Schuchert P, Senna AR, Serejo C, Shaik S, Shamsi S, Sharma J, Shear WA, Shenkar N, Shinn A, Short M, Sicinski J, Siegel V, Sierwald P, Simmons E, Sinniger F, Sivell D, Sket B, Smit H, Smit N, Smol N, Souza-Filho JF, Spelda J, Sterrer W, Stienen E, Stoev P, Stöhr S, Strand M, Suárez-Morales E, Summers M, Suttle C, Swalla BJ, Taiti S, Tanaka M, Tandberg AH, Tang D, Tasker M, Taylor J, Taylor J, Tchesunov A, ten Hove H, ter Poorten JJ, Thomas J, Thuesen EV, Thurston M, Thuy B, Timi JT, Timm T, Todaro A, Turon X, Tyler S, Uetz P, Utevsky S, Vacelet J, Vachard D, Vader W, Väinölä R, Van de Vijver B, van der Meij SE, van Haaren T, van Soest R, Van Syoc R, Vanreusel A, Venekey V, Vinarski M, Vonk R, Vos C, Walker-Smith G, Walter TC, Watling L, Wayland M, Wesener T, Wetzel C, Whipps C, White K, Williams D, Williams G, Wilson R, Witkowski A, Witkowski J, Wyatt N, Wylezich C, Xu K, Yasuhara M, Zanol J, Zeidler W (2018) World Register of Marine Species (WoRMS), WoRMS Editorial Board Available from https://www.marinespecies.org at VLIZ. Accessed 2018-03-26

Kanaan H, Belous O, Chokr A (2015) Diversity investigation of the seaweeds growing on the Lebanese coast. *Journal of Marine Science: Research and Development* 5(1): 1–12

Kapiris K, Apostolidis C, Baldacconi R, Basusta N, Bilecenoglu M, Bitar G, Bobori DC, Boyaci YO, Dimitriadis C, Djurovic M, Dulcic J, Durucan F, Gerovasileiou V, Gokoglu M, Koutsoubas D, Lefkaditou E, Lipej L, Markovic O, Mavric B, Ozvarol Y, Pesic V, Petriki O, Siapatis A, Sini M, Tibullo D, Tiralongo F (2014) New Mediterranean Marine biodiversity records (April, 2014). *Mediterranean Marine Science* 15(1): 198–212

Katsanevakis S, Coll M, Piroddi C, Steenbeek J, Ben Rais Lasram F, Zenetos A, Cardoso AC (2014) Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. *Frontiers in Marine Science* 1(32): 1–11

Katsanevakis S, Poursanidis D,Yokes MB, Macic V, Beqiraj S, Kashta L, Sghaier YR, Zakhama-Sraieb R, Benamer I, Bitar G, Bouzaza Z, Magni P, Bianchi CN, Tsiakkiros L, Zenetos A (2011) Twelve years after the first report of the crab *Percnon gibbesi* (H. Milne Edwards, 1853) in the Mediterranean: current distribution and invasion rates. *Journal of Biological Research-Thessaloniki* 16: 224–236

Katsanevakis S, Wallentinus I, Zenetos A, Leppakoski E, Cinar ME, Ozturk B, Grabowski M, Golani D, Cardoso AC (2014) Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* 9(4): 391–423

Katsanevakis S, Weber A, Pipitone C, Leopold M, Cronin M, Scheidat M, Doyle TK, Buhl-Mortensen L, Buhl-Mortensen P, D'Anna G, de Boois I, Dalpadado P, Damalas D, Fiorentino F, Garofalo G, Giacalone VM, Hawley KL, Issaris Y, Jansen J, Knight CM, Knittweis L, Kröncke I, Mirto S, Muxika I, Reiss H, Skjoldal HR and Vöge S (2012) Monitoring marine populations and communities: methods dealing with imperfect detectability. *Aquatic Biology* 16(1): 31–52,

Katsanevakis S, Zenetos A, Belchior C, Cardoso AC (2013) Invading European Seas: Assessing pathways of introduction of marine aliens. *Ocean & Coastal Management* 76: 64–74

Khoury R, Antoun N, Khater C, Abou Habib N (2015) Lebanon's 5th National Report to the Convention on Biological Diversity, Ministry of Environment-Lebanon

Lakkis S (1971) Contribution a l'etude du zooplancton des eaux libanaises. *Marine Biology* 11(2): 138–148

Lakkis S (2013) Flore et faune marines du Liban (Méditerranée Orientale). Biologie, Biodiversité, Biogéographie. Aracne Publ., Rome, 510 pp

Lakkis S, Bitar G, Novel-Lakkis V, Zeidane R (1996) Etude de la diversité biologique au Liban: faune et flore marines et côtières. PNUE, Ministère de l'Agriculture, Beyrouth, Publication 5:1–126

Lakkis S, Novel-Lakkis V (1985) Les Tintinnides (Tintinnina) des eaux côtières libanaises: composition, distribution et cycle annuel. *Lebanese Science Bulletin* 1(1): 43–58

Lakkis S, Novel-Lakkis V (2000) Distribution of phytobenthos along the coast of Lebanon (Levantine Basin, East Mediterranean). *Mediterranean Marine Science* 1/2: 143–164

Lakkis S, Novel-Lakkis V (2001) Importance des Caulerpes dans les peuplements algaux de la côte libanaise (Méditerranée Orientale). In**:** Gravez V, Ruitton S, Boudouresque CF, Le Direac'h L, Meinesz A, Scabbia G, Verlaque M (eds), Fourth international Workshop on *Caulerpa taxifolia*, GIS Posidonie Publ., Marseille, France, pp 315–327

Lakkis S, Novel-Lakkis V (2007) Diversity and distribution of macrophytes along the coast of Lebanon (Levantine Basin, Eastern Mediterranean). *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 38: 526

Lakkis S, Zeidane R (1985) Les hydroméduses des eaux néritiques Libanaises: Composition et distribution. *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 29(9): 179–180

Lakkis S, Zeidane R (1988) Larves de crustacés décapodes des eaux côtières libanaises: composition, diversité et cycle annuel. *Lebanese Science Bulletin* 4(2): 5–26

Lakkis S, Zeidane R (1989) L'Ichtyoplancton des Eaux Côtières Libanaises: Structure et Différentiation Ecologique. *Lebanese Science Bulletin* 5(2): 17–42

Laubier L (1966) Sur quelques annélides polychètes de la région de Beyrouth. *Miscellaneous Papers in the Natural Sciences. The American University of Beirut* 5: 9–22

Lelli S, Colloca F, Carpentieri P, Russell BC (2008) The threadfin bream *Nemipterus randalli* (Perciformes: Nemipteridae) in the eastern Mediterranean Sea. *Journal of Fish Biology* 73(3): 740–745

Lipkin Y (1975) *Halophila stipulacea*, a review of a successful immigration. *Aquatic Botany* 1:203–215

Lowry E, Rollinson EJ, Laybourn AJ, Scott TE, Aiello-Lammens ME, Gray SM, Mickley J, Gurevitch J (2013) Biological invasions: A field synopsis, systematic review, and database of the literature. *Ecology and Evolution* 3(6): 182–196

Moazzo G (1931) Contribution à la faune malacologique marine des côtes libano-syriennes. In: Gruvel A (1931) Les Etats de Syrie; Richesses marines et fluviatiles. Exploitation actuelle – Avenir. *Société d'Editions Géographiques, Maritimes et Coloniales* pp 437–453

Molnar JL, Gamboa RL, Revenga C, Spalding MD (2008) Assessing the global threat of invasive species to marine biodiversity. *Frontiers in Ecology and the Environment* 6(9): 458–492

Morri C, Puce S, Bianchi CN, Bitar G, Zibrowius H, Bavestrello G (2009) Hydroids (Cnidaria: Hydrozoa) from the Levant Sea (mainly Lebanon), with emphasis on alien species. *Journal of the Marine Biological Association of the United Kingdom* 89(1): 49–62

Mouneimné N (1977) Liste des poissons de la côte du Liban (Mediterranée orientale). *Cybium* 1(1): 37–66

Mouneimné N (1978) Poissons des côtes du Liban (Méditerranée Orientale), biologie et pêche. Thèse de Doctorat d'Etat ès-Sciences Naturelles, Universite Pierre et Marie Curie, Paris, France, 490 pp

Mouneimné N (1979) Poissons nouveaux pour les côtes libanaises. *Cybium* (6): 105–110

Moyle PB, Garcia-Berthou E (2011) Fishes. In: Simberloff D, Rejmánek M (2011) Encyclopedia of Biological Invasions (No. 3) University of California Press: Berkely, CA, 229–234

Nader M, El Indary S (2011) First record of *Diadema setosum* (Leske, 1778)(Echinodermata, Echinoidea, Diadematidae) from Lebanon, Eastern Mediterranean. *Aquatic Invasions* 6(1): S23–S25

Pajuelo JG, González JA, Triay-Portella R, Martín JA, Ruiz-Díaz R, Lorenzo JM, Luque Á (2016) Introduction of non-native marine fish species to the Canary Islands waters through oil platforms as vectors. *Journal of Marine Systems* 163: 23–30

Pallary P (1938) Les mollusques marins de la Syrie. *Journal de Conchyliologie* 82(1): 5–58

Por FD (1978) Lessepsian migration: the influx of Red Sea biota into the Mediterranean by way of the Suez Canal (Vol. 23). Springer-Verlag, Berlin, 228 pp

Por FD (2010) The new Tethyan ichthyofauna of the Mediterranean: historical background and prospect. In: Golani D, Appelbaum-Golani B (eds), Fish invasions of the Mediterranean Sea: change and renewal. Pensoft Publishers, Sofia-Moscow, Russia, pp 13–33

Pyšek P, Richardson D (2010) Invasive species, environmental change and management, and health. *Annual Review of Environment and Resources* 35: 25–55

RAC/SPA - UNEP/MAP, 2014. Ecological characterization of sites of interest for conservation in Lebanon: Enfeh Peninsula, Ras Chekaa cliffs, Raoucheh, Saida, Tyre and Nakoura. By Ramos Espla AA, Bitar G, Khalaf G, El Shaer H, Forcada A, Limam A., Ocaña O., Sghaier Y.R. & Valle C. Ed. RAC/SPA - MedMPAnet Project, Tunis. 168 pages + annexes.

Rayss T (1941) Sur les Caulerpes de la côte palestinienne. *Palestinian Journal of Botany, Jerusalem Series* 2: 103–124

Rocha LA, Rocha CR, Baldwin CC, Weigt LA, McField M (2015) Invasive lionfish preying on critically endangered reef fish. *Coral Reefs* 34: 803–806

Sala E, Kizilkaya Z, Yildirim D, Ballesteros E (2011) Alien marine fishes deplete algal biomass in the eastern Mediterranean. *PLoS ONE* 6(2): e17356

Samaha C, zu Dohna H, Bariche M (2016) Analysis of Red Sea fish species' introductions into the Mediterranean reveals shifts in introduction patterns. *Journal of Biogeography* 43(9): 1797–1807

Shiber JG (1976) Penaeid shrimp from the coast of Lebanon. *Cercetari marine, IRCM* 9: 127–139

Shiber JG (1981) Brachyurans from Lebanese Waters. *Bulletin of Marine Science* 31(4): 864–875

Simberloff D, Martin JL, Genovesi P, Maris V, Wardle DA, Aronson J, Courchamp F, Galil B, Garcia-Berthou E, Pascal M, Pyšek P, Sousa R, Tabacchi E, Vilà M (2013) Impacts of biological invasions: what's what and the way forward. *Trends in Ecology and Evolution* 28(1): 58–66

Simberloff D, Rejmánek M (eds) (2011) Encyclopedia of Biological Invasions (No. 3) University of California Press, Berkely, CA, 765 pp

Steinitz W (1929) Die Wanderung indopazifischer Arten ins Mittelmeer seit Beginn der Quartar-periode. (Die Wanderung indopazifischer Arten ins Mittelmeer seit Beginn der Quartar-periode.) *Internationale Revue der gesamten Hydrobiologie und Hydrographie* 22(1): 1–90

Streftaris N, Zenetos A (2006) Alien marine species in the Mediterranean – the 100 ''worst invasives'' and their impact. *Mediterranean Marine Science* 7(1): 87–118

Tohme G, Jaradi GR, Mneimneh A (2004) *Biodiversity assessment and monitoring in protected areas / Lebanon / Leb/95/G31: Palms islands nature reserve* (PDF). Ministry of the Environment (August 2005), Beirut, Lebanon, 115 pp

Tortonese E (1966) Echinoderms from the coast of Lebanon. *Miscellaneous Papers in the Natural Sciences. The American University of Beirut* 5: 2–5

Trilles JP, Bariche M (2006) First record of the Indo-Pacific Cymothoa indica (Crustacea, Isopoda, Cymothoidae), a Lessepsian species in the Mediterranean Sea. *Acta Parasitologica* 51(3): 223–230

Tsiamis K, Aydogan Ö, Bailly N, Balistreri P, Bariche M, Carden-Noad S, Corsini-Foka M, Crocetta F, Davidov B, Dimitriadis C, Dragicevic B, Drakulic M, Dulcic J, Escanez A, Fernandez-Alvarez FA, Gerakaris V, Gerovasileiou V, Hoffman R, Izquierdo-Gomez D, Izquierdo-Munoz A, Kondylatos G, Latsoudis P, Lipej L, Madiraca F, Mavric B, Parasporo M, Sourbes L, Taskin E, Turker A, Yapici S (2015) New Mediterranean Biodiversity Records (July 2015). *Mediterranean Marine Science* 16(2): 472–488

UNHCR Syria Regional Refugee Response – Lebanon. UNHCR Syria Regional Refugee Response. Retrieved 28 July 2017

Valdés A, Templado J (2002) Indo-Pacific dorid nudibranchs collected in Lebanon (Mediterranean Sea). *Iberus* 20(2): 23–30

Vergés A, Doropoulos C, Malcolm HA, Skye M, Garcia-Pizá M, Marzinelli EM, Campbell AH, Ballesteros E, Hoey AS, Vila-Concejo A, Bozec YM, Steinberg PD (2016) Long-term empirical evidence of ocean warming leading to tropicalization of fish communities, increased herbivory, and loss of kelp. *Proceedings of the National Academy of Sciences of the United States of America* 113(48), 13791–13796

Zenetos A, Akel EHK, Apostolidis C, Bilecenoglu M, Bitar G, Buchet V, Chalari N, Corsini-Foka M, Crocetta F, Dogrammatzi A, Drakulic M, Fanelli G, Giglio G, Imsiridou A, Kapiris K, Karachle PK, Kavadas S, Kondylatos G, Lefkaditou E, Lipej L, Mavric B, Minos G, Moussa R, Prato E, Pancucci-Papadopoulou MA, Renda W, Rios N, Rizkalla SI, Russo F, Servonnat M, Siapatis A, Sperone E, Theodorou JA, Tiralongo F, Tzovenis I (2015) New Mediterranean Biodiversity Records (April 2015). *Mediterranean Marine Science* 16(1): 266–284

Zenetos A, Çinar ME, Crocetta F, Golani D, Rosso A, Servello G, Shenkar N, Turon X, Verlaque M (2017) Uncertainties and validation of alien species catalogues: The Mediterranean as an example. *Estuarine, Coastal and Shelf Science* 191: 171–187

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, García Raso JE, Çinar ME, Almogi-Labin A, Ateš AS, Azzurro E, Ballesteros E, Bianchi CN, Bilecenoglu M, Gambi MC, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle PK, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci-Papadopoulou MA, Ramos Esplá A, Salas C, San Martín G, Sfriso A, Streftaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012 A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD) Part 2 Introduction trends and pathways. *Mediterranean Marine Science* 13(2): 328–352

Zenetos A, Gofas S, Verlaque M, Cinar ME, Raso G, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglia C, Siokou I, Violanti D, Sfriso A, San Martín G, Giangrande A, Katağan T, Ballesteros E, Ramos-Esplá A, Mastrototaro F, Ocaña O, Zingone A, Gambi MC, Streftaris N (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science* 11(2): 381–493

Zibrowius H, Bitar G (1981) Serpulidae (Annelida Polychaeta) indo-pacifiques établis dans la région de Beyrouth, Liban *Rapport Commission international Mer Méditerranée* 27(2): 159–160

Zibrowius H, Bitar G (2003) Invertebres marins exotiques sur la cote du Liban. *Lebanese Science Journal* 4(1): 67–74

Annexe

Inventory of alien species recorded from in Lebanon as retrieved from MAMIAS (retrieved in March 2018)

Species name	Ecofunctional Group	Origin	Establishment
Anotrichium okamurae	Benthic Plants	Pacific NW	cryptogenic/questionable
Asparagopsis taxiformis	Benthic Plants	Indo-Pacific	invasive
Caulerpa mexicana	Benthic Plants	Indo-Pacific	established
Caulerpa racemosa var. lamourouxii f. requienii	Benthic Plants	Indo-Pacific	established
Caulerpa racemosa var. turbinata /uvifera	Benthic Plants	Indo-Pacific	cryptogenic/questionable
Caulerpa scalpelliformis	Benthic Plants	Indo-Pacific	established
Chondria coerulescens	Benthic Plants	Atlantic E	established
Cladophora herpestica	Benthic Plants	Indo-Pacific	established
Diadema setosum	Benthic Plants	Indo West Pacific	casual
Galaxaura rugosa	Benthic Plants	Red Sea	established
Ganonema farinosum	Benthic Plants	Indian	cryptogenic/established
Halophila stipulacea	Benthic Plants	Red Sea	invasive
Hypnea spinella	Benthic Plants	Pantropical	established
Hypnea valentiae	Benthic Plants	Red Sea	established
Lophocladia lallemandii	Benthic Plants	Indo-Pacific	invasive
Padina boergesenii	Benthic Plants	Indo-Pacific	established
Stypopodium schimperi	Benthic Plants	Indo West Pacific	invasive
Coscinospira hemprichii	Benthic Protozoa	Indo-Pacific	established
Heterostegina depressa	Benthic Protozoa	Circumtropical	established
Planogypsina squamiformis	Benthic Protozoa	Circumtropical	established
Atergatis roseus	Demersal Crustacea	Indo-Pacific	established
Callinectes sapidus	Demersal Crustacea	Atlantic W	invasive
Charybdis helleri	Demersal Crustacea	Indo West Pacific	invasive
Charybdis longicollis	Demersal Crustacea	Indian W	invasive
Coleusia signata	Demersal Crustacea	Indo West Pacific	established
Erugosquilla massavensis	Demersal Crustacea	Indian W	invasive
Ixa monodi	Demersal Crustacea	Red Sea	established
Marsupenaeus japonicus	Demersal Crustacea	Indo-Pacific	invasive
Metapenaeus monoceros	Demersal Crustacea	Indo West Pacific	invasive
Metapenaeus stebbingi	Demersal Crustacea	Indian	invasive
Micippa thalia	Demersal Crustacea	Indo West Pacific	established
Myra subgranulata	Demersal Crustacea	Indian W	established
Penaeus semisulcatus	Demersal Crustacea	Indo West Pacific	invasive
Percnon gibbesi	Demersal Crustacea	Atlantic W	invasive
Plagusia squamosa	Demersal Crustacea	Indo-Pacific	established
Portunus segnis	Demersal Crustacea	Indian	invasive
Thalamita poissonii	Demersal Crustacea	Indo West Pacific	cryptogenic/established
Trachysalambria palaestinensis	Demersal Crustacea	Red Sea	established

Alepes djedaba	Demersal Fish	Indo-Pacific	established
Apogonichthyoides pharaonis	Demersal Fish	Indo-Pacific	invasive
Callionymus filamentosus	Demersal Fish	Circumtropical	established
Champsodon vorax	Demersal Fish	Indo West Pacific	established
Crenidens crenidens	Demersal Fish	Indian	established
Cynoglossus sinusarabici	Demersal Fish	Red Sea	established
Epinephelus fasciatus	Demersal Fish	Indo-Pacific	casual
Equulites klunzingeri	Demersal Fish	Indian	established
Fistularia commersonii	Demersal Fish	Indo-Pacific	invasive
Hemiramphus far	Demersal Fish	Indo-Pacific	established
Heniochus intermedius	Demersal Fish	Indian	casual
Himantura uarnak	Demersal Fish	Indo-Pacific	established
Hyporhamphus affinis	Demersal Fish	Indo-Pacific	casual
Lagocephalus sceleratus	Demersal Fish	Indo-Pacific	invasive
Lagocephalus spadiceus	Demersal Fish	Indo-Pacific	established
Lagocephalus suezensis	Demersal Fish	Red Sea	established
Lutjanus argentimaculatus	Demersal Fish	Indo-Pacific	casual
Nemipterus randalli	Demersal Fish	Indian	established
Ostracion cubicus	Demersal Fish	Indo-Pacific	casual
Oxyurichthys petersi	Demersal Fish	Red Sea	established
Pelates quadrilineatus	Demersal Fish	Indo-Pacific	established
Pempheris vanicolensis	Demersal Fish	Indo-Pacific	invasive
Petroscirtes ancylodon	Demersal Fish	Indian	established
Platycephalus indicus	Demersal Fish	Indo-Pacific	established
Pomacanthus maculosus	Demersal Fish	Indo-Pacific	casual
Pomadasys stridens	Demersal Fish	Indian	established
Pteragogus pelycus	Demersal Fish	Indian	invasive
Sargocentron rubrum	Demersal Fish	Indo-Pacific	invasive
Saurida undosquamis	Demersal Fish	Indo-Pacific	invasive
Scarus ghobban	Demersal Fish	Indo-Pacific	established
Siganus luridus	Demersal Fish	Indian	invasive
Siganus rivulatus	Demersal Fish	Red Sea	invasive
Silhouettea aegyptia	Demersal Fish	Red Sea	established
Sillago sihama	Demersal Fish	Indo-Pacific	invasive
Sphoeroides pachygaster	Demersal Fish	Atlantic Tropical	range expansion
Sphyraena chrysotaenia	Demersal Fish	Indo-Pacific	invasive
Stephanolepis diaspros	Demersal Fish	Red Sea	invasive
Terapon puta	Demersal Fish	Indo-Pacific	established
Tylosurus crocodilus	Demersal Fish	Indo West Pacific	casual
Upeneus moluccensis	Demersal Fish	Indo-Pacific	invasive
Upeneus pori	Demersal Fish	Indian	invasive
Elysia grandifolia	Demersal Mollusca	Indian	established

Hypselodoris infucata	Demersal Mollusca	Indo-Pacific	established
Plocamopherus ocellatus	Demersal Mollusca	Red Sea	established
Tayuva lilacina	Demersal Mollusca	Indo-Pacific	cryptogenic
Anilocra pilchardi	Parasites	Indo-Pacific	casual
Cymothoa indica	Parasites	Indo-Pacific	casual
Atherinomorus forskalii	Pelagic Fish	Indo-Pacific	invasive
Dussumieria elopsoides	Pelagic Fish	Indo-Pacific	established
Etrumeus teres	Pelagic Fish	Subtropical	invasive
Herklotsichthys punctatus	Pelagic Fish	Red Sea	established
Parexocoetus mento	Pelagic Fish	Indo-Pacific	invasive
Scomberomorus commerson	Pelagic Fish	Indo-Pacific	invasive
Tylosurus choram	Pelagic Fish	Indo-Pacific	casual
Acteocina mucronata	Zoobenthos	Red Sea	established
Afrocardium richardi	Zoobenthos	Red Sea	established
Amathina tricarinata	Zoobenthos	Red Sea	established
Amphisorus hemprichii	Zoobenthos	Circumtropical	established
Amphistegina lobifera	Zoobenthos	Circumtropical	invasive
Anoplodactylus digitatus	Zoobenthos	Tropical/subtropical	established
Apanthura sandalensis	Zoobenthos	Indo-Pacific	established
Aquilonastra burtoni	Zoobenthos	Indian W	invasive
Brachidontes pharaonis	Zoobenthos	Indian W	invasive
Branchiomma boholensis	Zoobenthos	Indo-Pacific	established
Bursatella leachii	Zoobenthos	Circumtropical	invasive
Cassiopea andromeda	Zoobenthos	Indo-Pacific	invasive
Cellana rota	Zoobenthos	Indian W	invasive
Cerithiopsis pulvis	Zoobenthos	Red Sea	established
Cerithium scabridum	Zoobenthos	Indian W	invasive
Chama pacifica	Zoobenthos	Indo-Pacific	invasive
Chrysallida maiae	Zoobenthos	Red Sea	established
Cinachyrella australiensis	Zoobenthos	Indo-Pacific	questionable
Cingulina isseli	Zoobenthos	Subtropical	established
Cirriformia semicincta	Zoobenthos	Red Sea	questionable
Conomurex persicus	Zoobenthos	Indian W	invasive
Cylichnina girardi	Zoobenthos	Indo-Pacific	established
Diala semistriata	Zoobenthos	Indo-Pacific	established
Diphasia digitalis	Zoobenthos	Circumtropical	casual
Dynamena quadridentata	Zoobenthos	Circumtropical	established
Ergalatax junionae	Zoobenthos	Indian W	invasive
Eusyllis kupffferi	Zoobenthos	Atlantic	established
Exogone breviantennata	Zoobenthos	Circumtropical	established
Finella pupoides	Zoobenthos	Indo-Pacific	established
Fulvia fragilis	Zoobenthos	Indian	invasive
Fusinus verrucosus	Zoobenthos	Indian	established

Gafrarium pectinatum	Zoobenthos	Indo-Pacific	established
Haliotis pustulata cruenta	Zoobenthos	Indian W	casual
Herdmania momus	Zoobenthos	Indo-Pacific	established
Hydroides branchyacanthus	Zoobenthos	Indo-Pacific	established
Hydroides diramphus	Zoobenthos	Circumtropical	established
Hydroides elegans	Zoobenthos	Circumtropical	invasive
Hydroides heterocerus	Zoobenthos	Indian W	established
Hydroides minax	Zoobenthos	Indo-Pacific	established
Hydroides operculatus	Zoobenthos	Indian	invasive
Infundibulops erythraeus	Zoobenthos	Indian W	established
Laternula anatina	Zoobenthos	Indo-Pacific	established
Linopherus canariensis	Zoobenthos	Atlantic	established
Lysidice natalensis	Zoobenthos	Indo-Pacific	questionable
Macrorhynchia philippina	Zoobenthos	Circumtropical	invasive
Mactra olorina	Zoobenthos	Red Sea	established
Malleus regula	Zoobenthos	Indo-Pacific	established
Microcosmus exasperatus	Zoobenthos	Indo-Pacific	established
Microporella browni	Zoobenthos	Indian	established
Microporella genisii	Zoobenthos	Circumtropical	established
Microporella harmeri	Zoobenthos	Circumtropical	casual
Murex forskoehlii	Zoobenthos	Indian W	established
Neanthes willeyi	Zoobenthos	Indo-Pacific	casual
Oculina patagonica	Zoobenthos	Atlantic SW	invasive
Ophiactis macrolepidota	Zoobenthos	Circumtropical	established
Ophiactis savignyi	Zoobenthos	Circumtropical	established
Paphia textile	Zoobenthos	Indo-Pacific	established
Parasmittina egyptiaca	Zoobenthos	Indian	established
Parasmittina serruloides	Zoobenthos	Indo-Pacific	established
Parasmittina spondylicola	Zoobenthos	Indo-Pacific	casual
Perinereis nuntia	Zoobenthos	Indian	casual
Phallusia nigra	Zoobenthos	Circumtropical	invasive
Pinctada radiata	Zoobenthos	Indo-Pacific	invasive
Pseudominolia nedyma	Zoobenthos	Indian W	invasive
Pseudonereis anomala	Zoobenthos	Indo-Pacific	invasive
Purpuradusta gracilis notata	Zoobenthos	Indian W	established
Pyrunculus fourierii	Zoobenthos	Indo-Pacific	established
Retiscrupocellaria jolloisii	Zoobenthos	Indo-Pacific	established
Rhinoclavis kochi	Zoobenthos	Indo-Pacific	invasive
Rhodosoma turcicum	Zoobenthos	Circumtropical	established
Rhynchozoon larreyi	Zoobenthos	Indo-Pacific	established
Scorpiodinipora costulata	Zoobenthos	Subtropical	established
Serpula hartmanae	Zoobenthos	Pacific N	questionable
Sertularia marginata	Zoobenthos	Tropical/subtropical	established

Sertularia thecocarpa	Zoobenthos	Indo-Pacific	established
Smittina nitidissima	Zoobenthos	Circumtropical	established
Spirobranchus kraussii	Zoobenthos	Indo-Pacific	invasive
Spirobranchus tetraceros	Zoobenthos	Circumtropical	established
Spirorbis marioni	Zoobenthos	Atlantic/Pacific	established
Spondylus spinosus	Zoobenthos	Indo-Pacific	invasive
Syllis bella	Zoobenthos	Pacific	established
Syllis cf. mayeri	Zoobenthos	Atlantic W	questionable
Symplegma brakenhielmi	Zoobenthos	Indo-Pacific	established
Synaptula reciprocans	Zoobenthos	Indo-Pacific	invasive
Syrnola fasciata	Zoobenthos	Indo-Pacific	established
Tellina valtonis	Zoobenthos	Indian W	established
Thaisella sacellum	Zoobenthos	Indian W	established
Timarete anchylochaeta	Zoobenthos	Pacific	questionable
Zafra savignyi	Zoobenthos	Red Sea	established
Zeuxo (Parazeuxo) coralensis	Zoobenthos	Circumtropical	established
Acartia fossae	Zooplankton	Indo-Pacific	established
Aequorea conica	Zooplankton	Indo-Pacific	casual
Bougainvillia niobe	Zooplankton	Atlantic Tropical	questionable
Calanopia elliptica	Zooplankton	Indo-Pacific	established
Calanopia media	Zooplankton	Indo-Pacific	established
Centropages furcatus	Zooplankton	Atlantic/Pacific	established
Cirrholovenia tetranema	Zooplankton	Circumtropical	established
Clytia mccradyi	Zooplankton	Circumtropical	range expansion
Eucheilota paradoxica	Zooplankton	Circumtropical	established
Eucheilota ventricularis	Zooplankton	Cosmopolitan	casual
Fabienna oligonema	Zooplankton	Atlantic Tropical	casual
Halitiara inflexa	Zooplankton	Indo-Pacific	casual
Kantiella enigmatica	Zooplankton	Indian	casual
Labidocera agilis	Zooplankton	Indo-Pacific	questionable
Labidocera detruncata	Zooplankton	Indo-Pacific	casual
Labidocera madurae	Zooplankton	Indo-Pacific	established
Labidocera orsinii	Zooplankton	Red Sea	casual
Labidocera pavo	Zooplankton	Indo-Pacific	established
Nubiella mitra	Zooplankton	Pacific SW	questionable
Paracartia grani	Zooplankton	Atlantic	established
Paracytaeis octona	Zooplankton	Indian W	casual
Parvocalanus crassirostris	Zooplankton	Atlantic/Pacific	established
Rhopilema nomadica	Zooplankton	Red Sea	invasive
Sphaerocoryne bedoti	Zooplankton	Circumtropical	casual
Tetrorchis erythrogaster	Zooplankton	Circumtropical	established
Triconia rufa	Zooplankton	Indian W	established
Clytia linearis	Zooplankton-Zoobenthos	Tropical/subtropical	invasive

Eudendrium carneum	Zooplankton-Zoobenthos	Circumtropical	established
Eudendrium merulum	Zooplankton-Zoobenthos	Circumtropical	established
Filellum serratum	Zooplankton-Zoobenthos	Tropical/subtropical	established
Haliscera bigelowi	Zooplankton-Zoobenthos	Tropical/subtropical	established
Moerisia carine	Zooplankton-Zoobenthos	Indo-Pacific	established
Trichydra pudica	Zooplankton-Zoobenthos	Circumboreal	casual