Non-Indigenous Species

1.1 Introduction

The Mediterranean basin is a major recipient of marine non-indigenous species (NIS)[1], with estimates of the number of NIS present varying from 573 species (Galil, 2009)[2] to 986 species, 249 of which are associated with the Central Mediterranean region (Zenetos *et al*., 2012)[3]. Marine NIS enter the Mediterranean basin due to deliberate or accidental introduction by man through various vectors or pathways including:

- introduction through corridors namely the Suez Canal;
- maritime transport (shipping especially via hull fouling and ballast waters) and
- aquaculture/fish farming (deliberate or accidental as contaminants and escapes)

Secondary introductions and further spread of such species from the area(s) of their first arrival could proceed by natural and man-mediated means. The general warming trend observed in the Mediterranean basin and ever increasing maritime traffic are also considered to be facilitating the introduction and establishment of thermophilic species - Atlantic and Indo-Pacific species - through the Straits of Gibraltar, and Suez Canal, respectively, and subsequent spread to the central Mediterranean, including the Maltese Islands. As a result, rapid and drastic changes are occurring in the marine biota of the Mediterranean Sea, with threats of disruption of ecosystem stability and of "biotic homogenization".

This report provides a review of 56 NIS recorded from Malta in line with the requirements of the EU Marine Strategy Framework Directive. Four of the species under consideration may in actual fact not classify strictly as non-indigenous either due to their cryptogenic[4] status in the Mediterranean Sea (e.g. *Acanthophora nayadiformis* and *Aplysia parvula*) or due to the fact that they are considered by Zenetos *et al*. (2012) to occur in the Mediterranean as a consequence of natural range expansion through the Straits of Gibraltar (e.g. *Seriola fasciata* and *Sphoeroides pachygaster*)[5].

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1 '*Non-Indigenous species*' for the purpose of this report are being defined in line with the MSFD Task Group report for Descriptor 2: i.e. species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify species as NIS.

2 Galil, B.S. 2009. Taking stock: inventory of alien species in the Mediterranean Sea. *Biological Invasions*; **11**(2): 359-372.

3 Zenetos, A. *et al*. 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways *Mediterranean Marine Science;* **13**(2): 328-352.

4 Cryptogenic species are species of which origin is not known.

5 Zenetos *et al*. (2012) exclude species of tropical Atlantic origin that have expanded their distribution range. Experts indicate that there may be other species of Atlantic origin (in addition to *Seriola fasciata* and *Sphoeroides pachygaster*) for which means of introduction into the Mediterranean from the Atlantic is still unclear at this stage. Given current uncertainties, such species are being retained as part of this review.

This review builds on the work of Sciberras & Schembri (2007a) which constitutes a review of records of alien species from Malta[6]. 43 NIS recorded through such work are included in this review, while some species have been omitted either in view of paucity of actual records being made from Malta (although recorded from nearby islands e.g. Lampedusa) or because records are considered to be doubtful. Species which are being omitted include *Aspidosiphon mexicanus*, *Etrumeus teres*, *Parupeneus* sp.*,* and *Seriola carpenteri*.

Various new records have been made since the work of Sciberras and Schembri (2007a) and are subsequently documented in this Review. Amongst these are new records of *Amphistegina lobifera* (recorded in 2006)[7], *Aplysia dactylomela* (recorded in 2008)[8]*, Atys macandrewi* (recorded in 2006)[9], *Cassiopea andromeda* (recorded in 2009)[10]*, Cephalopholis taeniops* (recorded in 2008)[11]*, Epinephelus malabaricus* (recorded in 2011)[12]*, Fulvia fragilis* (recorded in 2008)[13], *Melibe viridis* (recorded in 2008)[14]*, Microcosmus squamiger* (no date of record; documented in 2009)[15], *Oplegnathus fasciatus* (recorded in 2009)[16], *Paraleucilla magna* (recorded in 2007)[17]*, Rhopilema nomadica* (recorded in 2004)[18] and *Scatophagus argus* (recorded at least since 2007) [19]*.*

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6 Sciberras M. & Schembri P. J. 2007a. A critical review of records of alien marine species from the Maltese Islands and surrounding waters (Central Mediterranean); *Mediterranean Marine Science*; **8**: 41-66.

7 Yokes, M. B. Meric E. & Avsar, N. 2007. On the Presence of Alien Foraminifera *Amphistegina lobifera* Larsen on the coasts of the Maltese Islands. *Aquatic Invasions*, 2(4): 439-441.

8 Schembri, P.J. 2008. Occurrence of the alien sea hare *Aplysia dactylomela* Rang, 1828 (Opisthobranchia, Aplysiidae) in Malta. *Mediterranean Marine Science* **9**(2): 113-116.

9 Cachia, C. & Mifsud, C. 2007. On the presence of *Atys macandrewi* E.A. Smith, 1872 (Gastropoda: Haminoeidae) in the Mediterranean; *Iberus*; **25**: 43-48

10 Schembri, P.J., Deidun, A. & Vella, P.J. 2010. First record of *Cassiopea andromeda* (Scyphozoa: Rhizostomeae: Cassiopeidae) from the central Mediterranean Sea. *Marine Biodiversity Records;* 3: 2pp.

11 Deidun, A. Castriota, L. & Arrigo S. 2011. A tale of two Atlantic fish migrants: records of the lesser amberjack *Seriola fasciata* and the African hind *Cephalopholis taeniops* from the Maltese Islands. *Journal of the Black Sea/ Mediterranean Environment*, **17**(3): 223-233.

12 Schembri, P.J. & Tonna, R. 2001. Occurrence of the Malabar grouper *Epinephelus malabaricus* (Bloch & Schneider, 1801) (Actinopterygii, Perciformes, Serranidae), in the Maltese Islands. *Aquatic Invasions* **6**(1): 129–132.

13 Goud, J. & Mifsud, C. 2009. *Fulvia fragilis* (Forsskål in Niebuhr, 1775) (Bivalvia: Cardiidae), an alien species new to the Maltese malacofauna; *Aquatic Invasions*; **4**(2): 389-391.

14 Borg, J.A., Evans, J. & Schembri, P.J. 2009.Occurrence of the alien nudibranch *Melibe viridis* (Kelaart, 1858) (Opisthobranchia, Tethydidae), in the Maltese Islands; *Mediterranean Marine Science;* **10**(1): 131-136.

15 Izquierdo-Muñoz, A., Díaz-Valdéz, M. & Ramos-Esplá, A.A.. 2009. Recent non-indigenous ascidians in the Mediterranean Sea; *Aquatic Invasions;* **4**(1): 59-64.

16 Schembri, P.J., Bodilis, P., Evans, J. & Francour, P. 2010. Occurrence of *Oplegnathus fasciatus* (Temminck et Schlegel, 1844) (Actinopterygii: Perciformes: Oplegnathidae) in Malta (Central Mediterranean) with a discussion on possible modes of entry. *Acta Ichthyologica et Piscatoria* **40**(2): 101–104.

17 Zammit, P.P., Longo, C. & Schembri, P.J. 2009. Occurrence of *Paraleucilla magna* Klautau *et al.,* 2004 (Porifera: Calcarea) in Malta. *Mediterranean Marine Science;* **10**(2): 135-138.

18 Deidun, A., Arrigo, S. & Piraino, S. 2011. The westernmost record of *Rhopilema nomadica* (Galil, 1990) in the Mediterranean – off the Maltese Islands, *Aquatic Invasions* **6**(1): 99-103.

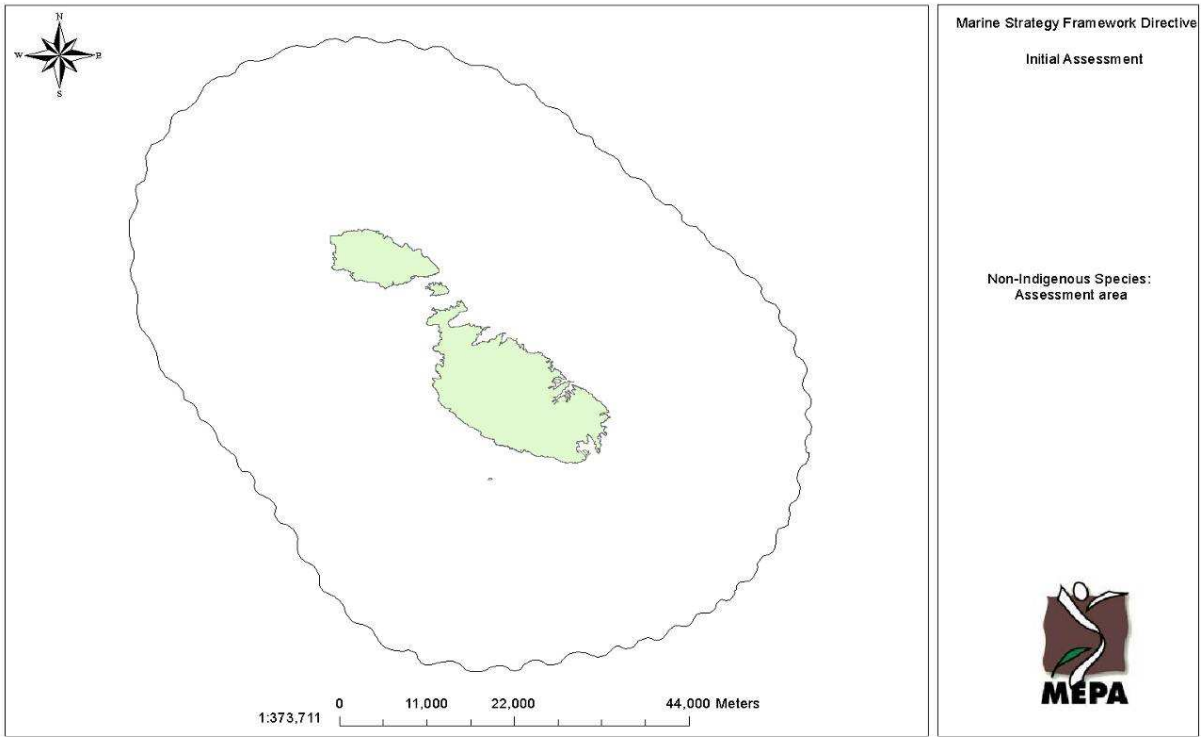
19 Zammit, E. & Schembri, P.J. 2011. An overlooked and unexpected introduction? Occurrence of the spotted scat *Scatophagus argus* (Linnaeus, 1766) (Osteichthyes: Scatophagidae) in the Maltese Islands. *Aquatic Invasions*; **6**(1): 79–83.

This Review hence provides updated information on marine NIS sited from Malta to date, and also includes information obtained via two unpublished commissioned national studies on alien flora and fauna, respectively[20].

The spatial/assessment area considered in this Review is indicated in Figure 1. . This assessment area may be adjusted once new data becomes available. The following sections address the data requirements of the criteria and indicators for evaluating good environmental status in line with the MSFD Descriptor 2:

- Criterion 2.1 Abundance and state characterisation of NIS, in particular invasive species:
  - Trends in abundance, temporal occurrence and spatial distribution in the wild of NIS, particularly invasive NIS (2.1.1)
- Criterion 2.2 Environmental impact of invasive NIS
  - Ratio between invasive NIS and native species in some well studied taxonomic groups (e.g. fish, macroalgae, molluscs) (2.2.1);
  - Impacts of NIS at the level of species, habitats and ecosystems where feasible (2.2.2)

Figure 1: NIS assessment area used for the purposes of the MSFD Initial Assessment



[20] The studies in question are: (1) Lanfranco, E. 2005. Biodiversity Action Plan: Alien Flora Data Sheets reported from the Maltese Islands. Report commissioned by the Environment Protection Department as part of the Biodiversity Action Plan and Habitat Inventorying Programme. (Unpublished) and (2) Mifsud D. 2006. Biodiversity Action Plan: Alien Fauna Data Sheets reported from the Maltese Islands. Report commissioned by the Environment Protection Department as part of the Biodiversity Action Plan and Habitat Inventorying Programme. (Unpublished)

1.2 Description of relevant legislation and management measures

National legislation dealing with NIS is built on the requirements of global and regional conventions, e.g. the Convention on Biological Diversity (CBD), the Convention on the Conservation of Migratory Species of Wild Animals, the Bern Convention, the Barcelona Convention and its SPA and Biodiversity Protocol and the EC Nature Directives.

The requirements of these are transposed mainly via the Flora, Fauna and Natural Habitats Protection Regulations, 2006 (Legal Notice 311 of 2006, as amended). Essentially legal obligations focus on the need to prevent the introduction of, and control or eradicate NIS which threaten ecosystems, habitats and species.

With respect to regulation of potential vectors of NIS, the Malta Environment and Planning Authority (MEPA) has issued general binding rules (GBRs) on underwater cleaning of maritime vessels. These GBRs are aimed at improving the environmental performance of operations involved in water cleaning and maintenance of marine vessel hulls, underwater sea apertures and propellers. Only registered operators are allowed to carry out in-water vessel cleaning and maintenance. Cleaning is only allowed in approved areas, while no cleaning is allowed in bathing areas and protected sites designated under Legal Notice 311 of 2006. One of the conditions is that no marine fouling removed during the underwater cleaning operation shall be released into the sea.

Malta is also required to implement Council Regulation (EC) No 708/2007 concerning use of alien and locally absent species in aquaculture. As yet, Malta has not ratified the Ballast Water Convention.

A currently ongoing activity which is relevant to non-indigenous species is the gathering of data for the identification of selected marine non-indigenous species in Malta's five Marine Protected Areas (MPAs) – that is in the area of Dwejra and Mgarr ix-Xini in Gozo, the area off the North West coast of Malta, between Rdum Majjiesa and Ras ir-Raħeb, a significant stretch of area along the North East of the Islands, and an area between Filfla and Ghar Lapsi. This initiative, which is one of the activities of the EU co-financed MedPAN North project, is being carried out with the voluntary participation of divers. The selection of NIS in this project was based on existent scientific literature and limited to those which are easily identifiable and likely to be present in local Marine Protected Areas. The species in question are *Lophocladia lallemandii, Halophila stipulacea, Caulerpa racemosa* var. *cylindracea, Asparagopsis* spp., *Percnon gibbesi, Bursatella leachi, Sphoeroides pachygaster, Fistularia commersonii, Siganus luridus,* and *Stephanolepis diaspros.* The surveys will be carried out twice – one was held in January 2013 and another will be held in May 2013 – the aim is that they are carried out before and after noticeable temperature changes have occurred at specific layers within the water column. Scientific guidance is being provided by the Department of Biology within the University of Malta. The generation of data via this project will allow further studies to be carried out, with a focus on the control or management of such species and protection of natural marine ecosystems. It is foreseen that via the implementation of this project, various gaps in current knowledge (see Section 6 of this Review) will be addressed.

1.3 Analysis & Characteristics of NIS: Presence, abundance and trends of non-indigenous species

The marine NIS considered in this Review are listed in Table **1**. Species representativity is as follows:

- phytobenthos or macroalgae - 10 species
- zoobenthos (including crustaceans, echinoderms and molluscs) - 33 species
- ray-finned fish - 13 species[21].

The establishment success of the recorded NIS is as follows: 52% as 'established'[22] or possibly so, 34% as 'casual'[23] and 14% as 'questionable'[24]. Out of the 29 species that are established, 8 of these are also invasive[25] in Malta (28%).

Abundance of the NIS, when encountered, ranked as follows: 43% as 'low'[26], 14% as 'moderate'[27], 9% as 'high'[28] and 34% as 'not known'[29]. In the majority of cases NIS have a low abundance or else, their abundance is not known. Species whose abundance is high, also exhibit characteristics of invasiveness. Whereas species such as *Fistularia commersonii*, *Halophila stipulacea*, *Percnon gibbesi* and *Pinctada radiata* are all on the increase, numbers of *Bursatella leachi* fluctuate sporadically.

Figure 2 compares the number of marine NIS recorded from the Malta and from the Central Mediterranean Sea (based on figures given by Zenetos *et al*., 2010[30]; updated by Zenetos *et al*. 2012). Whereas macrophytes, polychaetes and molluscs, followed closely by the crustaceans and fish, are the most commonly introduced or transported taxonomic group at the sub-region level, marine molluscs predominate at a national level (amounting to 18

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[21] This number of non-indigenous fish species recorded in Malta excludes the presence of *Siganus rivulatus*, for which Malta is listed as one locality of occurrence in the FishBase, DAISIE factsheet and IUCN Red List. As stated in Schembri, P.J.; Deidun, A. & Falzon, M.A. 2012. One *Siganus* or two? On the occurrence of *Siganus luridus* and *Siganus rivulatus* in the Maltese Islands. *Marine Biodiversity Records*.**5**: 1-4, evidence suggests that *Siganus rivulatus* has never been recorded from the Maltese Islands and does not occur.

[22] i.e. introduced population of species established in the wild with free-living, self-maintaining and self-perpetuating populations unsupported by and independent of humans

[23] i.e. those species having been recorded only once or twice or record is based on isolated specimens

[24] i.e. introduced species with insufficient information, as well as cryptogenic species, or supposedly NIS which are very similar to native species and which are difficult to identify

[25] i.e. introduced species that have overcome biotic and abiotic barriers, and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact

[26] i.e. the NIS makes up only a small part of the relevant native community; NIS are considered rare or occasional in the assessment area

[27] i.e. the NIS constitutes less than a half of the abundance of the native community; NIS are considered frequent in the assessment area

[28] i.e. the NIS exceeds half, i.e. quantitatively dominates in the invaded community; this does not mean that the NIS is abundant throughout the assessment area

[29] i.e. no qualitative or quantitative data available

[30] Zenetos, A. *et al*. 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I: Spatial distribution. *Mediterranean Marine Science;* **11**(2): 381-493.

documented species), followed by fish (13 species) and then macrophytes (10 species). The number of marine NIS recorded from Malta to date may be due to the fact that only taxa with well-known taxonomy or taxa that are large, conspicuous and hence easily identifiable from native ones, have so far received attention, whereas small, less conspicuous, and understudied species may be overlooked, such as in the case of foraminiferans, polychaetes and ascidians (thereby possibly resulting in an underestimation of NIS in Malta). A list of non-indigenous taxonomic groups for the Mediterranean Sea, including less studied groups such as plankton, is provided by Streftaris, Zenetos & Papathanassiou (2005)[31].

[31] Streftaris, N., Zenetos, A. & Papathanassiou, E. 2005. Globalisation in marine ecosystems: The story of non-indigenous marine species across European Sea. *Oceanography and Marine Biology: An Annual Review;* **43**: 419-453.

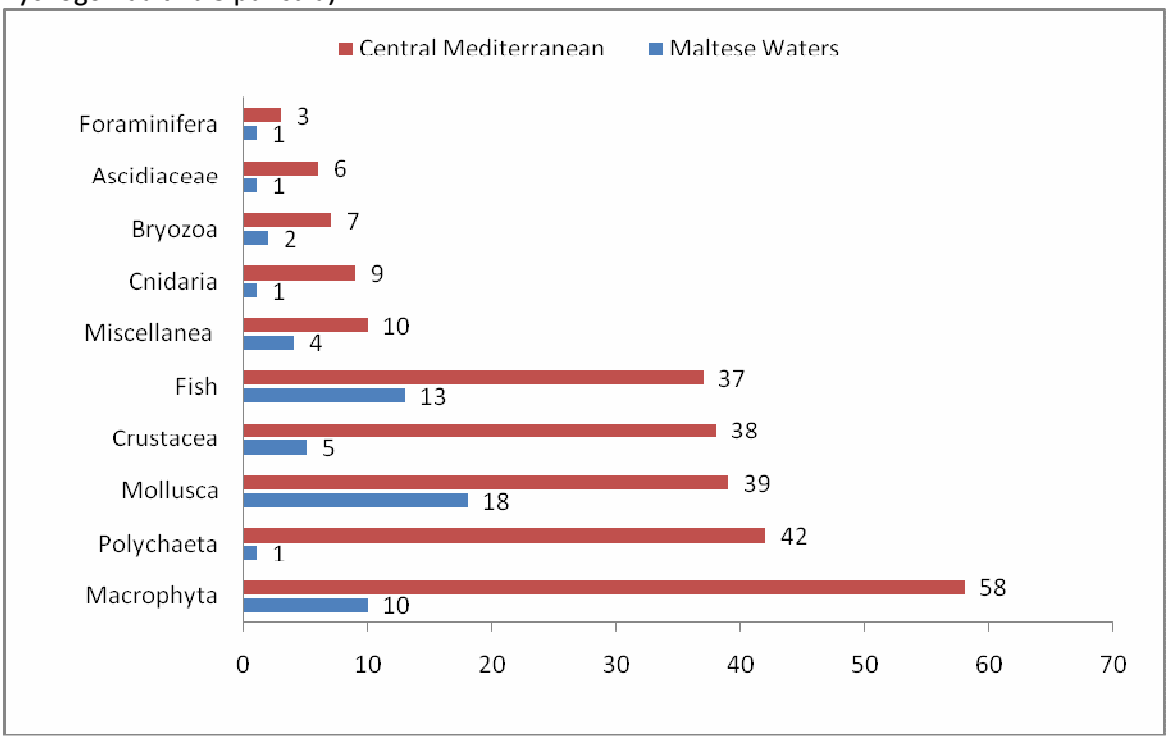
Table 1: List of Non-Indigenous Species considered in this review. The information presented on status, abundance and distribution given in this table is indicative and should be interpreted with caution, as it would need to be substantiated with further research; abundance is not at the level of the whole assessment area, but an indication when species is encountered)

Taxonomic Group		Species	Status	Abundance	Distribution
Macrophyta	Chlorophyta	*Caulerpa racemosa**♣ var. *cylindracea*++	Established, Invasive	High	Many Localities
	Magnoliophyta	*Halophila stipulacea**♣++	Established	Moderate	Several Localities
	Ocrophyta	*Colpomenia peregrina*	Casual	Not Known	Not Known
		Padina boergesenii	Questionable	Not Known	Not Known
	Rhodophyta	*Acanthophora nayadiformis*	Established, Cryptogenic	Moderate	Many Localities
		Asparagopsis sp. ♣+	Established	Moderate	Several Localities
		Botryocladia madagascariensis	Established	Low	Several Localities
		Chondria pygmaea	Established?	Not Known	Several Localities
		Lophocladia lallemandii♣+	Established, Invasive	High	Several Localities
		Womersleyella setacea♣++	Established, Invasive	High	Several Localities
Foraminifera		*Amphistegina lobifera*+	Established	Moderate	Several Localities
Polychaeta		*Branchiomma boholensis*	Questionable	Not Known	Not Known
Bryozoa		*Celleporaria aperta*	Questionable	Not Known	One Locality
		Celleporaria pilaefera	Questionable	Not Known	One Locality
Cnidaria	Scyphozoa	*Cassiopea andromeda*+	Established?	Low	One Locality
		*Rhopilema nomadica**♣+	Casual	Low	Several Localities
Crustacea	Cirripedia	*Megabalanus tintinnabulum*	Questionable	Not Known	Not Known
	Decapoda	*Callinectes sapidus*♣+	Casual	Low	Several Localities
		*Percnon gibbesi**♣++	Established, Invasive	High	Several Localities
	Maxillopoda	*Dosima fascicularis*	Casual	Not Known	One Locality
		Spinocalanus terranovae	Questionable	Not Known	One Locality
Echinodermata		*Eucidaris tribuloides*	Established	Low	Several Localities
		Prionocidaris baculosa	Casual	Not Known	Not Known
Mollusca	Gastropoda	*Anteaeolidiella foulisi* [=*Aeolidiella indica*]	Casual	Low	Not Known
		Aplysia dactylomela+	Casual	Not Known	One Locality
		Aplysia parvula	Questionable, Cryptogenic?	Not Known	One Locality
		Atys macandrewi	Casual	Low	Several Localities
		Bursatella leachii♣++	Established	Low	Several Localities
		Cerithium scabridum♣+	Established	Low	One Locality
		Chelidonura fulvipunctata	Casual	Low	Several Localities
		*Crepidula fornicata**♣+	Casual	Low	Several Localities
		Gibbula cineraria	Casual	Low	Several Localities
		Haminoea cyanomarginata	Established	Low	Several Localities
		Melibe viridis++ [= *Melibe fimbriata*]	Casual	Low	One Locality
		Notocochlis gualteriana [= *Natica gualteriana*]	Casual	Not Known	One Locality
		Polycerella emertoni	Established	Not Known	One Locality?
	Bivalvia	*Atactodea striata*	Casual	Not Known	One Locality
		*Brachidontes pharaonis**♣+	Established, Invasive	High	Many Localities
		*Crassostrea gigas**♣	Established	Low	Several Localities
		Fulvia fragilis++	Established	Low	Several Localities
		*Pinctada radiata**♣++	Established	Moderate	Several Localities
Porifera		*Paraleucilla magna*+	Established	Low	One Locality
Tunicata	Ascidiaceae	*Microcosmus squamiger*+	Casual?	Not known	One Locality?
Fish	Anguilliformes	*Pisodonophis semicinctus*	Questionable	Not Known	Not Known
	Perciformes	*Alepes djedaba*♣	Established	Moderate	Many Localities
		Cephalopholis taeniops	Casual	Low	Several Localities
		Epinephelus malabaricus	Casual	Low	One Locality
		Oplegnathus fasciatus	Casual	Low	Several Localities
		Scatophagus argus	Established	Low	One Locality?
		Selene dorsalis	Casual	Not Known	One Locality
		Seriola fasciata♣+X	Established	Not Known	Several Localities?
		Siganus luridus♣++	Established, Invasive	Low	Several Localities?

Taxonomic Group		Species	Status	Abundance	Distribution
		Sphoeroides pachygaster[*++X]	Established, Invasive	Moderate	Several Localities?
		Sphyraena chysotaenia[*++]	Established	Low	Several Localities?
		Stephanolepis diaspros[++]	Established	Low	Not Known
	Syngnathiformes	*Fistularia commersonii*[*++]	Established, Invasive	Moderate	Several Localities

* Listed as 100 of the Worst Invaders by DAISIE (9 species)
* Listed as 100 Worst Invasive Species in the Mediterranean by Streftaris & Zenetos, 2006 (20 species)
+ Potentially Invasive (13 species) ++ Invasive (13 species) in the Central Mediterranean as documented by Zenetos *et al*., 2010
X Removed from the list by Zenetos *et al* , 2012

Figure 2: Number of marine recorded Non-Indigenous species.
(Miscellanea = Chaetognatha, Ctenophora, Echinodermata, Nematoda, Platyhelminthes, Porifera, Pycnogonida and Sipuncula)



1.4 Activities: Sources/pathways of entry for non-indigenous species in the marine environment

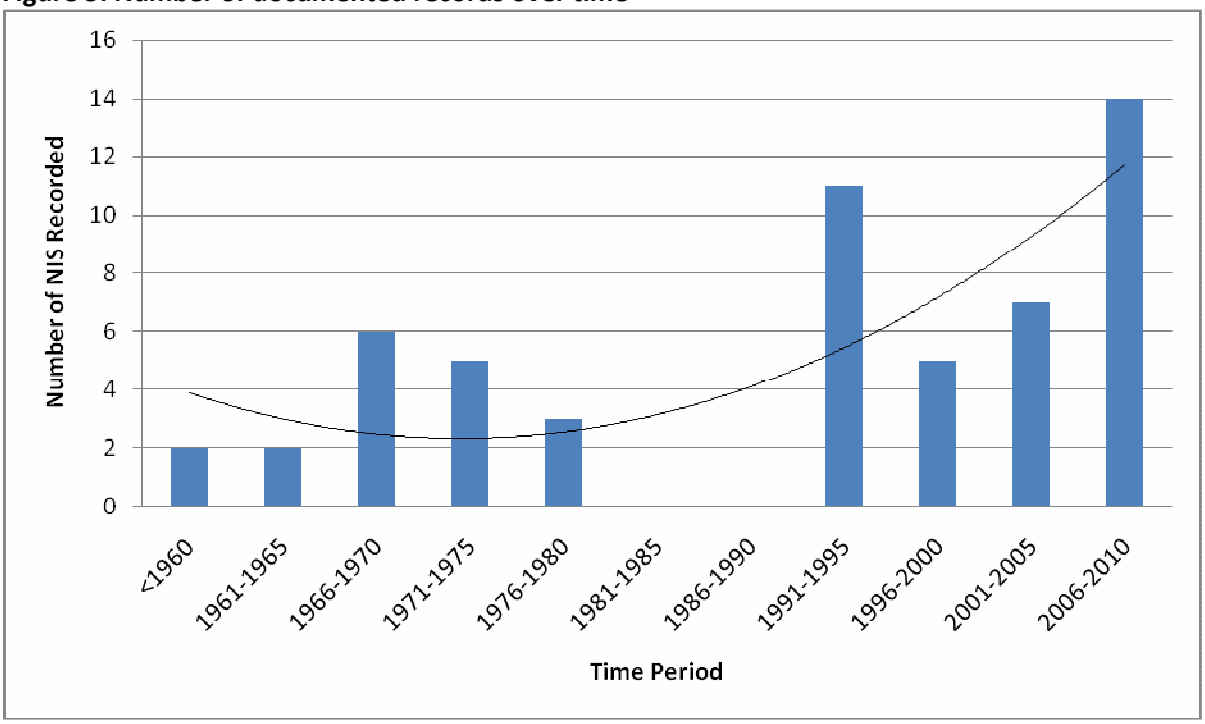
While between 1900 and 1960 only 2 NIS records are available, in contrast, 54 NIS records are documented from 1961 to 2011. This increasing trend in the number of marine NIS recorded from Malta is depicted in

Figure 3. The trend coincides with the increasing scientific interest being given to marine NIS by local experts including by sea users such as divers and fishers who report their unusual findings to experts for identification of the species, as well as the entry of NIS in Malta as a result of range expansion of Atlantic and Lessepsian migrants due to the general warming trend observed in the Mediterranean basin, accidental introduction via maritime traffic or via deliberate introduction. Indeed in the latter case, the number of records for the period 1966 to 1980 is attributed to the attempts to start an aquaculture industry in the mid-1970s,

during which experimental oyster cultures were set up at Marsaxlokk Bay, Mistra Bay and Rinella Bay. Such attempts resulted in both deliberate introductions such as *Crassostrea gigas*[32] (imported from Anglesey, in Wales), as well as accidental introductions, such as *Celleporaria aperta*, *Celleporaria pilaefera* and *Gibbula cineraria*. No records are available for the period 1981 to 1990.

The geographical partitioning of marine NIS in Malta is as follows: 41% of Indo-Pacific including Pacific origin, 23% of Atlantic origin, 20% from the Red Sea and/or Indian Ocean, 14% are Circumtropical and 2% are of Antarctic origin. NIS considered in this Review are in the majority of cases, Lessepsian migrants. These are thermophilic species originating from the Indo-Pacific or Red Sea and Indian Ocean, which have entered the Mediterranean through the Suez Canal, and which subsequently, reached Malta by way of various vectors/pathways as well as westward range expansion. Lessepsian migrants are still considered as NIS because they extend their geographical range following man-made changes in the environment, in this case construction of the Suez Canal. The warming of the Mediterranean Sea is also facilitating the colonisation and spread of Lessepsian Migrants species in the Mediterranean. The phenomenon of "tropicalisation" (associated with the effects of sea warming) has been used to describe the geographical spread and range expansion of such NIS in the Mediterranean. Atlantic migrants to the Mediterranean are also on the increase. Local examples include *Cephalopholis taeniops* and *Seriola fasciata*[33].

Figure 3: Number of documented records over time



[32] Schembri, P.J. & Lanfranco, E., 1996. Introduced species in the Maltese Islands; In: Baldacchino, A.E. & Pizzuto, A. (eds), *Introduction of alien species of flora and fauna*. Proceedings of a seminar held at Qawra, Malta, 5 March.

[33] Deidun, A. Castriota, L. & Arrigo S. 2011. A tale of two Atlantic fish migrants: records of the lesser amberjack *Seriola fasciata* and the African hind *Cephalopholis taeniops* from the Maltese Islands. *J. Black Sea/ Mediterranean Environment*; **17**(3): 223-233.

Overall the NIS pathways responsible for introduction of NIS in Malta are shipping and floating structures, culture activities and aquarium trade. Shipping (either as hull fouling, ballast water or sea chest transportation) is one of the main sources of introduction, followed by aquaculture. NIS recorded from ballast water tanks or, for which ballast water transportation has been given as a possible mode of entry, include for instance *Callinectes sapidus*, *Eucidaris tribuloides*, *Fulvia fragilis* and *Prionocidaris baculosa*, while in the case of *Oplegnathus fasciatus*, transportation in sea chests has been given as the most plausible mode of entry. NIS associated with hull fouling include *Anteaeolidiella foulisi* and *Megabalanus tintinnabulum*[34]. The latter species of barnacle is common on ships entering the Malta drydocks for repairs. The number of accidental introductions of NIS, via aquaculture activities, such as *Celleporaria aperta*, *Celleporaria pilaefera*, *Crepidula fornicata* and *Gibbula cineraria*, outnumbers deliberately introduced NIS such as *Crassostrea gigas.* Species, which occur naturally in the Maltese Islands, but which have also been imported for aquaculture purposes include *Ostrea edulis, Mytilus edulis, Mytilus galloprovincialis, Ruditapes* (=*Tapes*) *decussates, Dicentrarchus labrax, Sparus aurata,* and *Argyrosomus regius.* These 7 species might classify as genetically distinct forms of native species, however in view of insufficient information, they are only mentioned here. On the other hand, escape or release via the aquarium trade is a possible mode of entry for the recent introduction of *Scatophagus argus*. In several cases, however the entry vector/pathway is not known or is assumed, whereas for other species, entry in Malta could have been facilitated by more than one vector/pathway.

[34] This species is listed as questionable in the Mediterranean by Zenetos *et al*., 2010.

1.5 Assessment and Status of NIS – Establishment Success and Spatial Distribution

For a significant part of the NIS recorded from Malta, the spatial distribution is not known. Table 2 provides a list of confirmed locations from where 39 species have been recorded (out of the 56 NIS reviewed). The locations are also mapped in Figure 4.

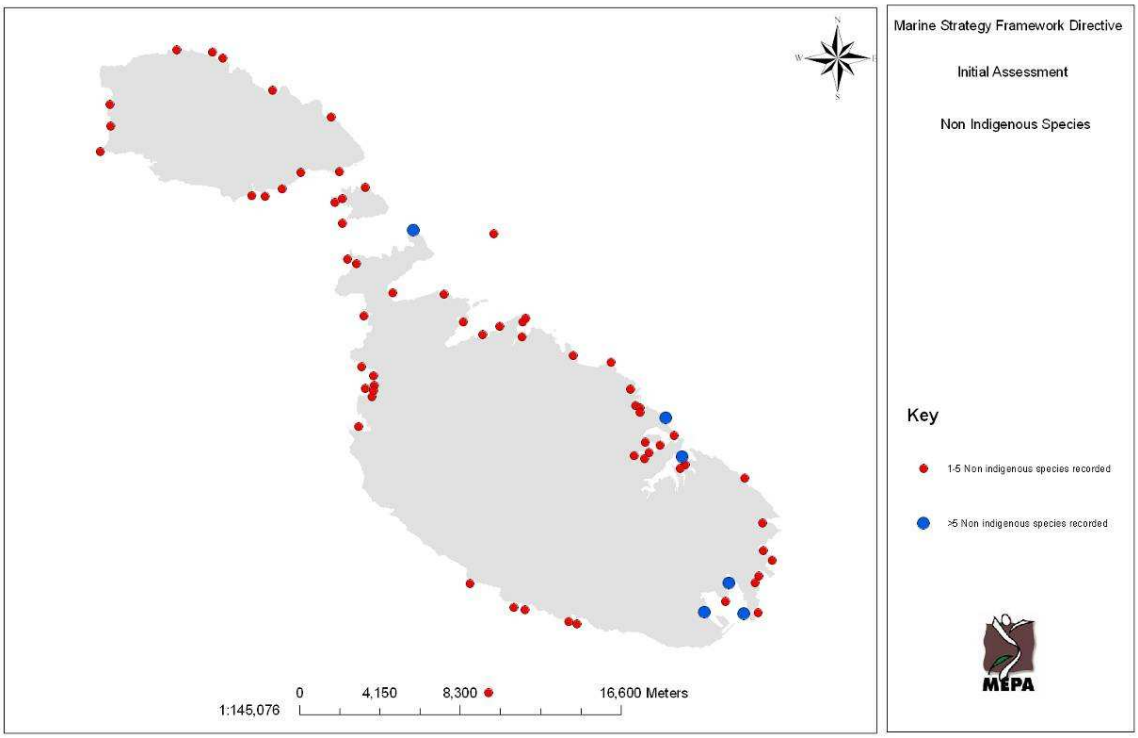
Table 2: Documented locations from where NIS have been recorded. The locations listed here might harbour more NIS; figures may not reflect the actual number of NIS found within that given location.

Location	Site Name	NIS documented from Location	Number of NIS
Malta	Marsaxlokk Bay	*Paraleucilla magna; Fistularia commersonii; Brachidontes pharaonis; Halophila stipulacea; Crassostrea gigas; Atactodea striata; Callinectes sapidus; Fulvia fragilis; Caulerpa racemosa*	9
	Birzebbuga Bay	*Fistularia commersonii; Percnon gibbesi; Halophila stipulacea; Aplysia parvula; Brachidontes pharaonis; Fulvia fragilis; Bursatella leachi; Pinctada radiata; Caulerpa racemosa*	9
	Grand Harbour	*Epinephelus malabaricus; Oplegnathus fasciatus; Bursatella leachi; Callinectes sapidus; Crepidula fornicata; Eucidaris tribuloides; Brachidontes pharaonis; Microcosmus squamiger; Siganus luridus*	9
	Sliema	*Percnon gibbesi; Halophila stipulacea; Brachidontes pharaonis; Bursatella leachi; Pinctada radiata; Caulerpa racemosa; Amphistegina lobifera*	7
	Delimara	*Asparagopsis sp.; Botryocladia madagascariensis; Lophocladia lallemandii; Womersleyella setacea; Brachidontes pharaonis; Caulerpa racemosa; Siganus luridus*	7
	L-Ahrax tal-Mellieha	*Percnon gibbesi; Asparagopsis sp.; Botryocladia madagascariensis; Chondria pygmaea; Lophocladia lallemandii; Womersleyella setacea*	6
	Salina Bay	*Halophila stipulacea; Atys macandrewi; Brachidontes pharaonis; Bursatella leachi; Chelidonura fulvipunctata*	5
	Marsamxett Harbour	*Cassiopea andromeda; Oplegnathus fasciatus; Crepidula fornicata; Eucidaris tribuloides; Brachidontes pharaonis*	5
	Munxar Point, Birzebbuga	*Fistularia commersonii; Percnon gibbesi; Pinctada radiata; Brachidontes pharaonis; Caulerpa racemosa*	5
	Blue Grotto	*Asparagopsis sp.; Botryocladia madagascariensis; Chondria pygmaea; Lophocladia lallemandii; Womersleyella setacea*	5
	Ghar Lapsi	*Percnon gibbesi; Chelidonura fulvipunctata; Brachidontes pharaonis; Caulerpa racemosa; Siganus luridus*	5
	Ras il-Wahx	*Asparagopsis sp.; Botryocladia madagascariensis; Lophocladia lallemandii; Womersleyella setacea*	4
	Xrobb l-Ghagin	*Fistularia commersonii; Scatophagus argus; Percnon gibbesi; Brachidontes pharaonis*	4
	Rinella Bay	*Crassostrea gigas; Celleporaria aperta; Celleporaria pilaefera; Brachidontes pharaonis*	4
	Marsascala	*Fistularia commersonii; Percnon gibbesi; Brachidontes pharaonis; Caulerpa racemosa*	4
	Cirkewwa	*Aplysia dactylomela; Fistularia commersonii; Cephalopholis taeniops; Percnon gibbesi*	4

Location	Site Name	NIS documented from Location	Number of NIS
	St George's Bay, St Julian's	*Halophila stipulacea; Bursatella leachi; Brachidontes pharaonis; Caulerpa racemosa*	4
	Mellieha Bay	*Percnon gibbesi; Natica gualteriana; Brachidontes pharaonis*	3
	Qawra	*Fistularia commersonii; Brachidontes pharaonis; Caulerpa racemosa*	3
	St Thomas Bay, Birzebbuga	*Fistularia commersonii; Brachidontes pharaonis; Caulerpa racemosa*	3
	Zurrieq	*Fistularia commersonii; Caulerpa racemosa, Siganus luridus*	3
	San Lucjan	*Gibbula cineraria; Brachidontes pharaonis*	2
	Bahar ic-Caghaq	*Brachidontes pharaonis; Pinctada radiata*	2
	Spinola Bay	*Brachidontes pharaonis; Caulerpa racemosa*	2
	Pembroke	*Percnon gibbesi; Brachidontes pharaonis*	2
	Mistra Bay	*Crassostrea gigas; Gibbula cineraria;*	2
	Gnejna Bay	*Dosima fascicularis; Pinctada radiata*	2
	Ghajn Tuffieha Bay	*Percnon gibbesi; Brachidontes pharaonis*	2
	Sikka l-Bajda	*Rhopilema nomadica; Lophocladia lallemandii*	2
	Golden Bay	*Percnon gibbesi; Amphistegina lobifera*	2
	Xatt it-Tiben, Sa Maison	*Brachidontes pharaonis*	1
	Ta' Xbiex	*Brachidontes pharaonis*	1
	St Julian's Bay	*Percnon gibbesi*	1
	San Pawl il-Bahar	*Percnon gibbesi*	1
	Ras il-Qawra	*Pinctada radiata*	1
	Pieta Seafront	*Brachidontes pharaonis*	1
	Paradise Bay	*Percnon gibbesi*	1
	Msida Marina	*Brachidontes pharaonis*	1
	Manoel Island	*Fistularia commersonii*	1
	Maghlaq Promontories	*Brachidontes pharaonis*	1
	Kalkara Creek	*Brachidontes pharaonis*	1
	Imgiebah Bay	*Percnon gibbesi*	1
	il-Qarraba, Ghajn Tuffieha	*Brachidontes pharaonis*	1
	il-Mixquqa, Mellieha	*Brachidontes pharaonis*	1
	Fra Ben	*Percnon gibbesi*	1
	Fomm ir-Rih Bay	*Brachidontes pharaonis*	1
	Miger Ilma under Dingli Cliffs	*Brachidontes pharaonis*	1
	Balluta Bay	*Halophila stipulacea*	1
	Anchor Bay	*Brachidontes pharaonis*	1
	Off il-Hofriet	*Caulerpa racemosa*	1
	Blata l-Bajda	*Caulerpa racemosa*	1
	Kalanka t-Tawwalija	*Caulerpa racemosa*	1
Gozo	Dwejra Bay	*Rhopilema nomadica; Brachidontes pharaonis; Caulerpa racemosa; Amphistegina lobifera*	4
	Wardija Point	*Asparagopsis sp.; Lophocladia lallemandii; Womersleyella setacea*	3
	Mgarr ix-Xini	*Percnon gibbesi; Asparagopsis sp.; Womersleyella setacea*	3
	Qbajjar Bay, Marsalforn	*Cerithium scabridum; Brachidontes pharaonis; Siganus luridus*	3
	Mgarr Harbour	*Percnon gibbesi; Halophila stipulacea*	2
	Hondoq ir-Rummien	*Percnon gibbesi; Caulerpa racemosa*	2
	Xwejni Bay	*Fistularia commersonii*	1
	Wied il-Ghasri	*Percnon gibbesi*	1
	Ras il-Hobz	*Fistularia commersonii*	1
	Ramla l-Hamra	*Percnon gibbesi*	1
	Dahlet Qorrot	*Percnon gibbesi*	1
	Ta’ Slima	*Caulerpa racemosa*	1

Location	Site Name	NIS documented from Location	Number of NIS
	Xlendi	*Siganus luridus*	1
	Xatt l-Ahmar	*Caulerpa racemosa*	1
Comino	Ras l-Irqieqa	*Asparagopsis sp.; Botryocladia madagascariensis; Chondria pygmaea; Lophocladia lallemandii; Womersleyella setacea*	5
	Kemmunett	*Asparagopsis sp.; Botryocladia madagascariensis; Womersleyella setacea*	3
	Blue Lagoon	*Brachidontes pharaonis; Melibe viridis; Amphistegina lobifera*	3
	Santa Marija Bay	*Fistularia commersonii*	1
Filfla		*Percnon gibbesi*	1
Hurd's Bank		*Caulerpa racemosa*	1

Figure 4: Map of locations from where records of NIS have been made.



Considering these 72 localities within the assessment area, the distribution of NIS scored as follows: 31% of the species are currently documented from 'one locality'[35]; 48% are documented from 'several localities'[36], 7% are documented from 'many localities' while the distribution of 14% of the species is 'not known'. A species that is known to be widespread has been classified as "many localities"[37]. Such widespread species include: *Acanthophora nayadiformis*, *Alepes djedaba*, and *Caulerpa racemosa* var. *cylindracea*. In the case of other species the spatial distribution or present locations where found, are not known. The number of species recorded at each location is deemed to be a minimum, since other NIS, especially those that are widespread, might also occur in such locations.

When assessing the documented spatial distribution of NIS recorded, it becomes evident that harbours/port areas are main points of entry in view of shipping activities (i.e. Grand Harbour and Marsamxett Harbour) and associated activities such as hull cleaning, as well as bays where aquaculture was or is practised or, where recreational boating and fishing is common, since such activities can spread NIS by way of yacht anchors and fishing gear. The locations with the highest number of documented NIS records in Table 2 are Marsaxlokk Bay and Birzebbuga Bay in the South East of Malta. Both bays are interconnected. Part of Birzebbuga Bay houses the Freeport container transit station and is also the main fuel unloading station for Maltese Islands, while Marsaxlokk Bay harbours the main fishing community in Malta and also aquaculture activity. Multiple NIS are found in such locations and their combined presence, and varying abundances, would cumulatively impact the natural communities found therein. New records are generally made from locations that are well frequented e.g. diving sites and fishing grounds. It is also noteworthy that the Maltese Islands are on the main east to west shipping route and a significant number of commercial, cruise and leisure vessels call at the Maltese Islands (and its main harbours) or pass close to them. The Maltese Islands are also important staging points for drilling platforms, and their occasional duration moored in coastal waters (can be for weeks), giving ample opportunity for movement of biota associated with the platform to inshore waters (Schembri & Tonna, 2011)[38]. It is also noteworthy that man-mediated alterations to the marine environment such as by way of pollution can also assist the establishment of introduced NIS, as documented for polychaetes, which can build dense populations in polluted environments, where competition among species is low and food is abundant, provided (see e.g. Zenetos *et al*., 2010).

A high number of NIS is also recorded at the North Eastern tip of mainland Malta. The high incidence of NIS at this site cannot be explained in terms of the presence of major sources of NIS, such as maritime traffic. Local experts suggest that this could be due to the popularity of the area with divers, translating into a higher effort in identifying NIS at this site (J.A. Borg & P.J. Schembri, personal communication, 2013).

[35] i.e. the NIS is documented from only one locality within the assessment unit
[36] i.e. the species spread beyond one locality but is present in less than half of the considered localities i.e. 2 to 33 localities
[37] i.e. the species' distribution extends to more than half of the considered localities i.e. 34 to 66 localities
[38] Schembri, P.J. & Tonna, R. 2001. Occurrence of the Malabar grouper *Epinephelus malabaricus* (Bloch & Schneider, 1801) (Actinopterygii, Perciformes, Serranidae), in the Maltese Islands; *Aquatic Invasions* **6**(1): 129–132.

1.6 Pressures and impacts of NIS on ecosystems/functional groups

Out of the 56 NIS considered in this review, 26 species are listed as invasive or potentially so in the Central Mediterranean Sea (Zenetos *et al*., 2010) while 20 species are listed amongst the 100 Worst Invasive Species in the Mediterranean (Streftaris & Zenetos, 2006) (*vide* Table 2).

Table 3: Documented Impacts of NIS which are Well Established and/or Invasive in Malta (Information on Impacts extracted from Streftaris & Zenetos, 2006)

Species	Impacts on Biodiversity	Socio-economic Impacts			Impacted Habitats and associated communities
		Fisheries/ Aquaculture	Health & Sanitation	Infrastructure & Building	
Asparagopsis sp.	+	+			Shallow sublittoral rock and biogenic reefs
Brachidontes pharaonis	+			+	Littoral rock and biogenic reefs
Caulerpa racemosa var. *cylindracea*	+	+			Shallow sublittoral sediment; Shallow sublittoral rock and biogenic reefs; Shelf sublittoral sediment; Shelf sublittoral rock and biogenic reefs
Fistularia commersonii	+				Shallow sublittoral rock and biogenic reef
Halophila stipulacea	+				Shallow sublittoral sediment
Lophocladia lallemandii	+				Shallow sublittoral rock and biogenic reef
Percnon gibbesi	+				Shallow sublittoral rock and biogenic reef
Pinctada radiata	+				Shallow sublittoral rock and biogenic reef
Womersleyella setacea	+	+			Shallow sublittoral sediment; Shallow sublittoral rock and biogenic reefs; Shelf sublittoral sediment; Shelf sublittoral rock and biogenic reefs

Certain NIS, while invasive elsewhere in the Mediterranean, are so far reported as casual in Malta (e.g. *Rhopilema nomadica*), or alternatively are established but seem to be low in abundance (e.g. *Bursatella leachi*, *Cerithium scabridum* and *Sphyraena chysotaenia*), albeit further research may prove otherwise. Table 3 provides an indication of documented impacts of well established and/or invasive NIS which are also present in Malta. Impacts by NIS on biodiversity in coastal and marine ecosystems include impacts on native species and communities (e.g. by predation, competition, mixing of exotic genes and introduction of pathogens), impact on habitats (e.g. through habitat modification) and impacts on ecosystem functioning. More detail on the status of pressures and impacts is provided in the following paragraphs, with a focus on species known to be invasive or with an invasive potential, or, although present in low abundance may still have ecological implications. Overall, the extent of local knowledge of marine NIS impacts on native communities, their diversity and structure is currently limited, since studies directly investigating the impact of alien species on the diversity of native biota are lacking.

1.6.1 Macrophytes

Invasive green and red algae pose a high ecological impact on native macrophytic and zoobenthic assemblages through the dense, fast-growing, creeping and permanent meadows they form, combined with the synthesis of secondary metabolites. Among the 10 species of macrophytes (Table 4 reviews those invasive in the Mediterranean), the green alga *Caulerpa racemosa* var. *cylindracea* and the red alga *Womersleyella setacea* are of most concern.

The former species, a notorious marine invader in the Mediterranean, is described as an "ecosystem engineer" due to its alteration of the structure and functioning of native ecosystems, causing a decrease in macrofaunal and macroalgal biodiversity. Camilleri (2005)[39] reports on findings of a study undertaken to assess the impact of *C. racemosa* on phytobenthic/macroalgal communities at Tad-Debbra (Marsaxlokk). One of the observations made during this study was the lower percentage composition of *Posidonia oceanica* where *C. racemosa* was present in comparison to areas where *C. racemosa* was absent. Mifsud & Lanfranco (2007)[40] provide data on the occurrence and abundance of this species gathered from *ad hoc* surveys undertaken between 1997 and 2003. In the locations surveyed, percentage cover ranged from 1 (e.g. Spinola) to 50% (e.g. Blata l-Bajda). Prolific expansion in several habitats is reported with the observation that degraded localities seem to favour the expansion of this green alga. Further studies are required to gather data on shoot densities of *P. oceanica* before and after colonisation of NIS such as *Caulerpa* also in view of its aggressive colonisation and depending on the status of *P. oceanica* before invasion. Nevertheless, at this stage, local experts can indicate with confidence that *C. racemosa* generally colonises areas which are not occupied by *Posidonia oceanica*, particularly in areas where *P. oceanica* meadows are patchy or reticulate. Therefore impacts of *C. racemosa* are almost certainly not related to displacement of the native *P. oceanica* (J.A. Borg & P.J. Schembri, personal communication, 2013).

[39] Camilleri, C. 2005. *Caulerpa racemosa* impact on phytobenthic/macroalgal communities at Tad-Debbra (Marsaxlokk). Abstract of M.Sc. dissertation. In: Dandria, D. (Ed). Biological Abstract 2005. Department of Biology, University of Malta.

[40] Mifsud, C. & Lanfranco, E. 2007. *Caulerpa racemosa* (Chlorophyta, Caulerpales) in the Maltese Islands (Central Mediterranean). *Proceedings of the 3rd Mediterranean Symposium on Marine Vegetation* (Marseilles, 27-29 March 2007). p. 285-287.

Table 4: Life traits of invasive macrophytes (Information extracted from Boudouresque & Verlaque, 2002[41]; Legend: ++ and + = Yes; - = No; ? = not known)

Species	Large Sized	Perennial	Without a resting stage	Sexual Repro-duction	Vegetative multi-plication	Defence metabolites	No or few predators	Functional form group
Asparagopsis sp.	+	-	-	+	+	++	+	Coarsely branched
Caulerpa racemosa	+	+	-	+	+	+	+	Coarsely branched
Halophila stipulacea	-	+	+	+	+	-	-	Coarsely branched
Lophocladia lallemandii	-	?	-	+	-	+	+	Filamentous
Womersleyella setacea	-	-	+	-	+	?	+	Filamentous

W. setacea is also widespread in the Maltese Islands where it inhabits a variety of substrates in the lower infralittoral and circalittoral. This filamentous turf-forming rhodophyte permeates substrates by its fine creeping filaments and changes the physical structure of sediments. It also reduces species numbers and diversity by trapping sediments which prevent the development of other species. In the North East of Malta, *W. setacea* has been observed binding mäerl thalli and restricting the movement of such rhodoliths by currents[42]. As regards other established rhodophytes, *Lophocladia lallemandii* is highly invasive, while *Asparagopsis sp.*, although found in several but few locations, may be of concern if it were to increase further in view of toxic secondary metabolites it produces which repel grazing species, potentially enabling it to form dense stands. *Halophila stipulacea* is a perennial stoloniferous seagrass. Although established, it grows in habitats where few other species grow[43].

1.6.2 Invertebrates

Out of the two scyphomedusan species, *Rhopilema nomadica*, first sited in 2004, is a voracious planktotrophic jellyfish species, which can form very large swarms (as seen in the easternmost parts of the Mediterranean Sea) and can decimate plankton resources. This species is not only a health concern in view of the painful stings it can inflict on bathers, but can also adversely affect tourism, fisheries (e.g. via net clogging) and coastal installations (by blocking intake pipes of cooling systems). Nationally it is thus far a casual introduction.

When looking at introduced crustaceans, the decapod *Percnon gibbesi* is considered to be of concern and is also documented as “one of the most recent and successful invaders in the

[41] Boudouresque, C.F. and Verlaque, M. 2002. Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. *Marine Pollution Bulletin*, 44: 32–38.

[42] Rizzo, M. 2001. An investigation of potential anthropogenic impacts on a mäerl ground off North-Eastern Malta. Unpublished M.Sc. dissertation. Department of Biology, University of Malta, ix + 308pp.

[43] Lanfranco, E. (2002-2005). *Biodiversity Action Plan: Alien Flora Data Sheets reported from the Maltese Islands*. Report commissioned by the Environment Protection Department as part of the Biodiversity Action Plan and Habitat Inventorying Programme. (unpublished)

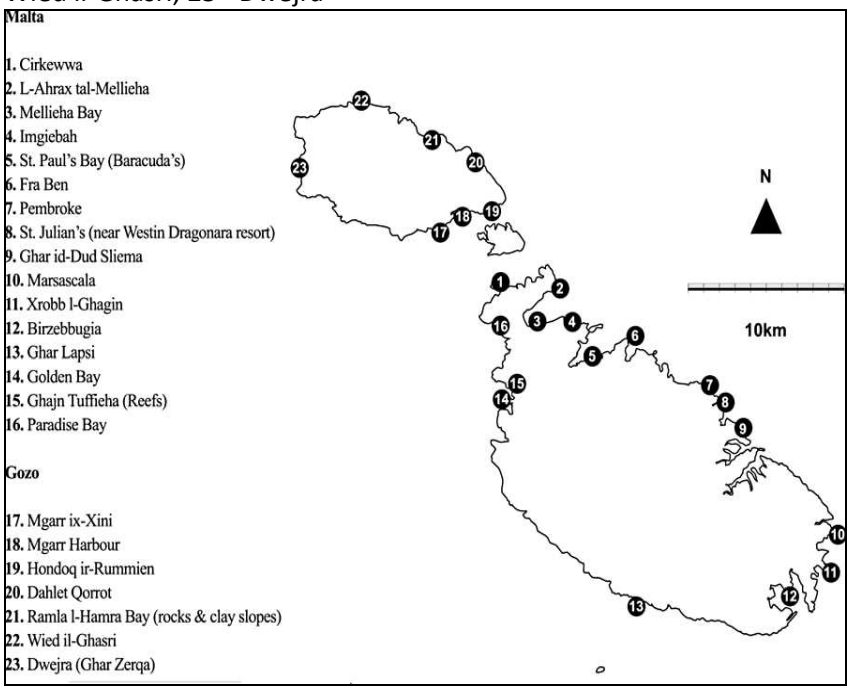
Mediterranean Sea". It was first reported from Malta in 2001[44] and since then has become well established, rapidly increasing both in range and in abundance, reaching 100s in certain areas (e.g. Sliema, Tigne, Munxar Point and Filfla). Information on spatial and bathymetric distribution, population density, habitat preferences, fecundity, breeding season and interspecific interactions of this species is available from 23 localities (Sciberras and Schembri, 2007b; 2008; Figure 5)[45,46]. The species' distribution is controlled by habitat type and availability, with boulder fields being the observed preferred habitat locally (as seen in Għajn Tuffieha, Ramla tal-Mixquqa, Imġiebah, Paradise Bay, Marsascala, Daħlet Qorrot and Ħondoq ir-Rummien). In their initial studies these authors observed *P. gibbesi* to coexist with other crabs *Pachygrapsus marmoratus* and *Eriphia verrucosa*. Both are native species that occur in the same habitats frequented by *P. gibbesi*. *P. gibbesi* was observed to occasionally interact with *P. marmoratus* when the two approached to within circa 15cm. Based on these observations competition by the alien species for resources, mainly space, with the native *P. marmoratus* was suggested. Laboratory studies by the same authors however indicate that *P. marmoratus* shows a competitive advantage over *P. gibbesi* and that it is unlikely to be excluded from its natural habitat by the alien species. Overall, if this species continues to increase in number it could compete with other marine invertebrates having the same habitat and it could also graze on rare algae. Its ecological impact would be deemed high considering its feeding mode of systematically cleaning rocks of vegetation. In contrast to *P. gibbesi*, the blue crab – *Callinectes sapidus* – although document as invasive in certain parts of the Mediterranean (and commercially exploited), it is known from few locations in Malta, although further field studies may reveal otherwise.

[44] Borg J.J. & Attard-Montalto J. 2002. The grapsid crab *Percnon gibbesi* (Milne Edwards, 1853) (Crustacea, Decapoda, Brachyura), a new addition to the marine fauna of Malta; *Cent. Medit. Nat*., **3**: 159-160.

[45] Sciberras, M. & Schembri, P.J. 2007b. Observations on the alien crab *Percnon gibbesi* (Decapoda, Brachyura, Grapsidae) from the Maltese islands; *Rapp. Comm. int. Mer Medit*., **38**: 594.

[46] Sciberras, M. & Schembri, P.J. 2008. Biology and interspecific interactions of the alien crab Percnon gibbesi in the Maltese Islands; *Marine Biology Research*; **4**: 321-332.

Figure 5 - Distribution of *Percnon gibbesi* (Source: Sciberras and Schembri (2007b, 2008) Sites are as follows: 1 – Cirkewwa; 2 – L-Ahrax tal-Mellieha; 3 – Mellieha Bay; 4 – Imgiebah; 5 – St. Paul's Bay; 6 – Fra Ben; 7 – Pembroke; 8 – St Julian's; 9 – Ghar id-Dud Sliema; 10 – Marsascala; 11 – Xrobb l-Ghagin; 12 – Birzebbuga; 13 – Ghar Lapsi; 14 – Golden Bay; 15 – Ghajn Tuffieha; 16 – Paradise Bay; 17 – Mgarr ix-Xini; 18 – Mgarr Harbour; 19 – Hondoq ir-Rummien; 20 – Dahlet Qorrot; 21 – Ramla l-Hamra; 22 – Wied il-Ghasri; 23 - Dwejra



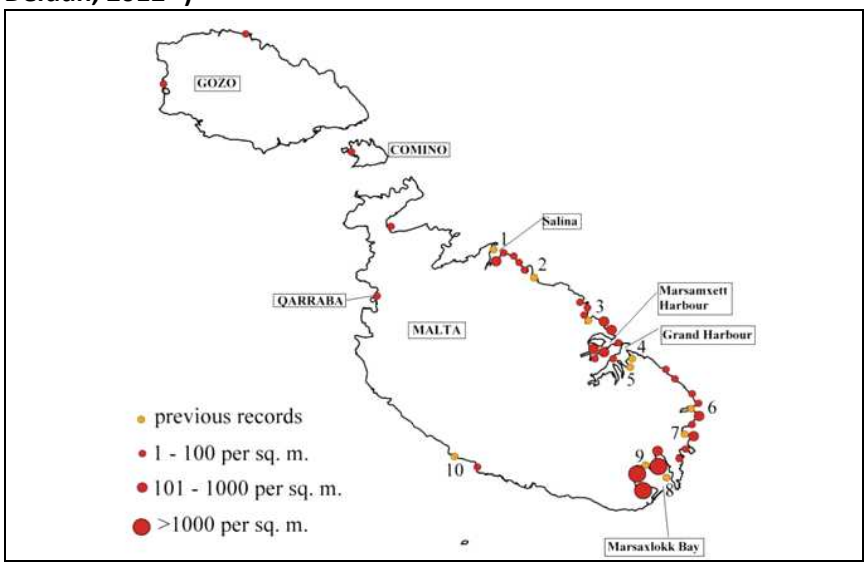
This Review has considered 21 species of molluscs. Out of the gastropoda, *Cerithium scabridum* has remained localised, though it is present in large numbers were found in Qbajjar (Gozo). If the population of this species will increase further, it may compete with other species, especially with congeneric ones. There is currently no impact of this species on public health or economic activity. *Chelidonura fulvipunctata* is occasional where often single specimens are found on infralittoral sandy bottoms. Its current abundance is not known and this may be due to the fact that the species is cryptic in habit. It seems on the increase, and if so, implications would include competition with native species occurring in the same habitat type. *Crepidula fornicata* has thus far been found dead on shores and live on *Ostrea edulis*. When encountered, the species is usually in large numbers, although in Malta it is sporadic. If the population of this species will increase, it could possibly compete with other related and native species of the genus *Crepidula*, which occur in the same habitat type. The species competes with oysters for its food. The impact of this species on economic activity could be due to competition with native bivalve species, especially oysters which are locally often collected as food items. *Bursatella leachi* (although reported as invasive in the Central Mediterranean by Zenetos *et al*., 2010) is frequent when found. Generally, population numbers of this species fluctuate sporadically, although it may be on the increase. It is found on sheltered, littoral sandy bottoms. This species seems to be a

deposit feeder with grazing habits. If the population of this species will increase it could possibly compete with native species, which occur in the same habitat type. *Gibbula cineraria* although initially common when first introduced in the 1970s, is now seemingly on the decline. This species is generally encountered close to fish farming and oyster cultures. If the population of this species will increase it could possibly compete with native species of the genus *Gibbula*, which occur in the same habitat type. The invasive opistobranch *Aplysia dactylomela* although established in the Central Mediterranean is currently considered a casual alien in Malta.

Turning attention to the bivalve molluscs, *Pinctada radiata* is very common and a very well established species, where it is found in all rocky coastal areas. It is considered invasive in the Central Mediterranean (Zenetos *et al*., 2010). Since its original capture, the species is on the increase. This species could possibly compete with other native species which occur in the same habitat type. However this species serves also as a food source for a number of marine organisms such as cephalopods. The most studies non-indigenous bivalve so far by national ecologists is *Brachidontes pharaonis.* Initially recorded in the 1970s, it has since become widespread all over the coastline of Maltese archipelago, in particular the northern and eastern coastal stretches of the island of Malta, as revealed by the work of Cilia and Deidun (2012)[47], which presents comprehensive mapping of this alien bivalve (Figure 6). This Study documents that the species exhibits habitat plasticity, albeit it prefers limestone (particularly globigerina) substrata in inlets with limited wave exposure (mainly within large embayments e.g. Marsaxlokk Bay, Grand Harbour, Marsamxett Harbour and Salina). In areas affected by high marine concentrations of hydrocarbons and other pollutants, the abundance of this species exceeded 1000 individuals per square metre. On the islands of Comino and Gozo, *B. pharaonis* is restricted mainly to concrete jetties, suggesting that vessels are acting as vectors, in proliferating the species, at least in initial stages. One of the impacts of this alien on local biodiversity is the potential displacement of the native Mediterranean mytilid *Mytilaster minimus*, while on the other hand, the native *Ostreola stentina* might competitively exclude *B. pharaonis*.

[47] Cilia, D.P. & Deidun, A. 2012. Branching out: mapping the spatial expansion of the lessepsian invader mytilid *Brachidontes pharaonis* around the Maltese Islands; Marine Biodiversity Records; Vol. 5; e28; Published online

Figure 6: Previous and current records, with the latter including population densities, for *Brachidontes pharaonis* (Source: Cilia & Deidun, 2012[48])



1.6.3 Fish

Among the eleven introduced species of fish covering nine families[49], six species have been classified amongst 100 of the worst invasive species in the Mediterranean (*vide* Table 1 above). *Alepes djedaba*, which can occur in small to large shoals, is a very fast and active predator, preying on small to medium sized demersal fish. It may be competing with other native species, and hence its potential impact is considered to be high. It is known from all around the Maltese shores and is recorded from all local habitats. Although single records were made when species was first introduced, its numbers have increased in following years. Currently there is no impact by this alien species on public health or economic activity.

Sphyraena chysotaenia, although currently rare, is established and is most likely on the increase. It frequents the pelagic and demersal zone of inshore waters, and occurs in bays, creeks and inlets as well as open waters. It preys on small pelagic fish and competition with other demersal predators (e.g. *Sphyraena sphyraena* and *Seriola dumerilli*) may result should it continue to increase. *Sphoeroides pachygaster* is regularly caught by trawlers. *Fistularia commersonii* is the only non-indigenous species of syngnathiformes recorded to date.

[48] Cilia, D.P. & Deidun, A. 2012. Branching out: mapping the spatial expansion of the lessepsian invader mytilid *Brachidontes pharaonis* around the Maltese Islands; Marine Biodiversity Records; Vol. 5; e28; Published online

[49] Carangidae (jacks), Lobotidae (tripletails), Monacanthidae (filefish), Oplegnathidae (knifejaws), Scatophagidae (scats), Serranidae (groupers), Siganidae (rabbitfish), Sphyraenidae (barracudas), and Tetraodontidae (pufferfish)

Certain NIS may have an economic use. Zenetos *et al*. (2010) indicate which non-indigenous fish are marketable and some have even been seen to be offered for sale at the local fish market in Marsaxlokk such as *Fistularia commersonii*[50], *Siganus luridus*[51] and *Scatophagus argus*[52]. On the other hand non-indigenous fish without a direct economic use, may pose an economic burden on fisheries, if in abundance, as they would need to be discarded. The occurrence of *Selene dorsalis* and *Scatophagus argus* in the Central Mediterranean are attributed to aquarium trade (Zenetos *et al*., 2012).

Schembri *et al*. (2012)[53] have confirmed that previous records of *Siganus rivultatus* in Malta are actually *Siganus luridus*. Their conclusions, following an evaluation of all records of siganids collected or photographed in Malta are based on the fact that there do not seem to be any specific records of *S. rivulatus* from these islands. Thirteen records comprising at least 33 specimens supported by photographs or specimens and 25 records of 48 individual rabbitfish identified in the field were all *S. luridus*. *In situ* records have been made from rocky seabed with photophilic algae at depths of 3 to 7m. *S. luridus* is on the increase and is considered to exhibit invasiveness.

1.7 Data gaps

When considering the data provided in this Review, the confidence level is essentially low for all the NIS in question, except for the species *Percnon gibbesi* and *Brachidontes pharaonis* for which the confidence level is considered to be medium. In the latter two cases, the confidence level is not considered high, because the data documented by these field studies cover part of the assessment area of this Review. For a significant part of NIS recorded from Malta, the mode of introduction/entry, abundance, spatial distribution and establishment success, temporal occurrence and proportion of assessment area (%) where NIS are present are not known or could not be assessed in view of data limitations. So far documented records of NIS in Malta present limited data, normally as a result of snapshot studies restricted to point locations, and providing information on year when found, accompanied by a theory/assumption on how it reached these waters. Quantitative data as well as data on impacts of native communities is more often than not lacking, with only recent published literature documenting new records providing quantification of abundance and mapping distributions (e.g. Sciberras & Schembri, 2008; Cilia & Deidun, 2012). Moreover to date, data on marine habitats is generally localised with significant gaps in information on deeper habitat types.

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[50] Deidun, A. & Germanà, A. 2011. On the increasing occurrence of the Bluespotted Cornetfish *Fistularia commersonii* (Rüppel, 1838) in the Central Mediterranean (Osteichthyes, Fistulariidae); *Biodiversity Journal*, **2**(1): 19-26.

[51] Schembri, P.J., Deidun, A. & Falzon, M.A. 2012. One Siganus or two? On the occurrence of *Siganus luridus* and *Siganus rivulatus* in the Maltese Islands; Marine Biodiversity, Vol. 5; e71; page 1 to 4.

[52] Zammit, E. & Schembri, P.J. 2011. An overlooked and unexpected introduction? Occurrence of the spotted scat *Scatophagus argus* (Linnaeus, 1766) (Osteichthyes: Scatophagidae) in the Maltese Islands; *Aquatic Invasions*; **6**(1): 79–83.

[53] Schembri, P.J., Deidun, A. & Falzon, M.A. 2012. One Siganus or two? On the occurrence of *Siganus luridus* and *Siganus rivulatus* in the Maltese Islands; Marine Biodiversity, Vol. 5; e71; page 1 to 4.