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LIFE BaĦAR for N2K (LIFE12 NAT/MT/000845)

ACTION A2: Data Analysis and Interpretation

Report on the third analysis following the second surveying phase carried out through Action A3

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Corrigendum (August 2022): References to Inshore Areas B and D (2016 surveys) have been corrected in Figure 4.3.1.2 and Figure 4.3.1.3.

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Executive Summary

The Life+ Benthic Habitat Research for marine Natura 2000 site designation (LIFE BaĦAR for N2K) project is an EU LIFE+ research programme that aims to conduct research on benthic habitats in Maltese waters to support designation of marine Natura 2000 sites. The project comprises the collation of existing information on marine benthic habitats in Maltese waters, the carrying out of scientific surveys in areas where knowledge gaps are identified, and the analysis of the data collected during these surveys in order to map the distribution of three habitat types listed in Annex I of the Habitats Directive: sandbanks, reefs and marine caves. Action A2 is led by the Department of Biology (DoB) of the University of Malta (UoM), and concerns analysing and interpreting data generated during the LIFE BaĦAR for N2K project. The present report presents the analysis of findings following the second marine habitat surveys carried out through Action A3 in the summer of 2016, and as such constitutes the deliverable of the third Action A2 analysis: "Report containing analysis of second phase of A3 surveys and final recommendation of prioritised habitats for protection."

In summary, analysis of the data collected during the Action A3 surveys resulted in the following main findings with regards to the three habitats of interest for the LIFE BaĦAR for N2K project:

Reefs

- Identification of new areas with extensive and diverse cold water coral assemblages at depths of 300 m to 1000 m extending some 70 km along the Malta Graben, including antipatharian coral (*Leiopathes glaberrima*) forests at 200 m to 400 m, and predominantly white corals (*Madrepora oculata,* and to a lesser extent *Lophelia pertusa*) in waters deeper than 500 m. In some areas at depths of 800 m to 1000 m the seabed is dominated by the alcyonacean *Callogorgia verticillata*, together with other less abundant habitat-forming and associated species (especially sponges, cnidarians, echinoderms, molluscs, crustaceans and fish).
- Discovery of a dead (possibly fossil) lithistid sponge reef located north of Gozo at a depth of ca. 300 m, and extending over a 7 km long area, serving as a substratum for several living species including sponges, cnidarians and bryozoans.
- Identification of areas with dead coral frameworks, one site with a boulder field at 100 m depth, and sporadic sites with rocky outcrops covered by coralline concretions at depths of 60 m to 120 m, supporting benthic faunal assemblages that comprise a range of sponges, cnidarians, echinoderms, molluscs and crustaceans which, however, were less species rich than the assemblages recorded from areas with either living cold water corals or the lithistid reef.
- Characterisation of infralittoral algal assemblages and associated fauna found on the submarine part of emergent vertical rock faces at depths between 2 m to 35 m.
- The main threats and pressures on typical species found in the reef habitats surveyed during the Action A3 surveys were due to marine litter, in particular lost/discarded fishing gear. The overall conservation status of reef habitats is, however, considered to be favourable.

Sandbanks

- The results indicate that sandbanks in the Maltese Islands tend to be present in very shallow waters, at depths ranging from ca. 0.02 m to 2.00 m. The surveyed sandbanks had variable dimensions, with lengths ranging from ca. 11 m to 180 m, and widths ranging from ca. 1.5 m to 17 m, were permanently submerged, and surrounded by deeper water. They were thus consistent with the description of Habitat 1110 given in the Interpretation Manual of European Union habitats in the physical sense.
- No macroflora, and thus no *Cymodocea nodosa*, were recorded on any of the surveyed sandbanks. Instead, associations with *C. nodosa* were found throughout the infralittoral, down to ca. 45 m. *C. nodosa* is thus clearly not limited to the environmental conditions created by sandbanks in the Maltese Islands, is not generally present where such conditions occur, and is therefore not a useful indicator species for this habitat type.

Caves

- A total 37 emergent and 52 fully submerged caves were recorded in inshore areas during the LIFE BaĦAR surveys, which varied in both size and structure from small caves measuring only a few metres, to large fissures and extensive tunnel systems penetrating deeply into the rock. Large caves showed a marked zonation from the cave entrance to the inner end of the cave, and generally three distinct zones could be distinguished: (i) an outer section where some light penetrates and allows the growth of photophilic algae at the mouth and progressively more sciaphilic species are present further inwards from the mouth; (ii) a tenebrous middle section dominated by sessile invertebrates such as a few sponges, hydroids, brachiopods, corals, tubicolous polychaetes, bryozoans, and foraminifera together with a few highly sciaphilic algae (mostly encrusting corallines); and (iii) a completely dark inner section, or dark side chambers, largely devoid of sessile organisms.
- New records of a total of 17 deep-water caves, mostly located west and north of Gozo at depths between 205 m to 450 m, but that also include a cave recorded at the edge of the Malta Graben at 795 m, were made. Typical species found at the entrance of such deep-water caves were recorded, although the ROV was not able to penetrate into the caves to record footage of biotic assemblages found within.
- The main threats and pressures on typical species found in the cave habitats surveyed during the Action A3 surveys were due to marine litter, in particular plastics accumulating inside caves. The overall conservation status of cave habitats is however considered to be favourable.

Three inshore sites were identified as hosting areas that have the potential to be proposed as Sites of Community Importance (SCI) based on the analysis of information collected under Actions A1 and A3. In order of priority these are:

(i) a site bordering the northwestern coast of Gozo;
(ii) a site bordering the southwestern coast of Malta;
(iii) a site bordering the southern coast of Gozo.

The sites were selected to protect the large number of emergent as well as submerged caves (Habitat 8330), and reefs (Habitat 1170) that are present. The species assemblages present in these habitats are typical of cave and reef habitats found in the Maltese Islands, and *Centrostephanus longispinus* (listed in Annex IV of the Habitats Directive) was recorded from these sites.

Five offshore sites were identified as hosting areas that have the potential to be proposed as Sites of Community Importance (SCI). In order of priority these are:

(i) a site bordering the southwestern limit of the 25 nautical mile FMZ surrounding the Maltese Islands;
(ii) a site bordering the eastern edge of the Malta Graben;
(iii) a site bordering the western edge of the Malta Graben;
(iv) a site located to the north of Gozo;
(v) a site bordering the northwestern limit of the FMZ, which also lies along the eastern edge of the Malta Graben.

The sites were selected to protect deep-sea caves (Habitat 8330) and offshore reef habitats (Habitat 1170) also taking into consideration habitats which are not included in the Habitats Directive but which are listed in the UNEP/MAP/RAC-SPA "*Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest*", since Malta and the EU collectively are party to the Barcelona Convention and its protocols. The species assemblages associated with these habitats are typical of offshore habitats found in the deep sea around the Maltese Islands. *Corallium rubrum* and *Centrostephanus longispinus* (listed in Annex V and Annex IV of the Habitats Directive respectively) were recorded from these sites.

1. Introduction

1.1. LIFE BaĦAR for N2K project

The Life+ Benthic Habitat Research for marine Natura 2000 site designation (LIFE BaĦAR for N2K) project is an EU LIFE+ research programme that aims to study selected benthic habitats in Maltese waters to support designation of marine Natura 2000 sites. Only limited information is available on the location and conservation status of many marine habitats in Malta, hindering the designation of representative areas to be proposed for inclusion in the Natura 2000 network.

Against this background, the project aims and objectives stated in the project description of the LIFE BaĦAR for N2K project are as follows:
Marine habitats are becoming more vulnerable due to human influences. These are protected by various regional and international mechanisms. The Habitats Directive (HD) protects certain marine habitats through legal obligations to designate Sites of Community Importance (SCIs) for areas hosting representative habitats. Following the 2010 Natura 2000 marine biogeographic seminar and various communications with the Commission, Malta is required to address insufficiency to protect certain marine habitats hence the objectives of this project are:

- *Inventory and designation*
- *Increased participation and coordination of stakeholders*
- *Conservation objectives for marine Natura 2000 sites*
- *Increase awareness*

The focus of the LIFE BaĦAR for N2K project is on habitats listed in Annex I of the Habitats Directive: 'Reefs' (Habitat 1170), 'Submerged and partially submerged caves' (Habitat 8330), and 'Sandbanks which are slightly covered by sea water all the time' (Habitat 1110). The project aims to collect and synthesise existing information on these habitats in Maltese waters, to carry out scientific surveys in areas where knowledge gaps are identified, and to analyse the data collected during the scientific surveys. The scientific surveys will be carried out from the Maltese coastline to the 25 nautical mile boundary of the Maltese Fisheries Management Zone (FMZ), and down to depths of 1000 m below sea level.

1.2. Action A2

Action A2 is led by the Department of Biology (DoB) of the University of Malta (UoM), and is concerned with analysing and interpreting scientific data generated during the LIFE BaĦAR for N2K project. The tasks of the UoM-DoB are:

- Reviewing and critically assessing existing data on local benthic habitats, including the quality of available data, in order to identify gaps in knowledge;
- Identifying sites where the three habitats under investigation (i.e. sandbanks, reefs and marine caves) are likely to occur, in order to focus surveys on under-explored locations;
- Analysing biological data collected during field surveys in order to characterise the habitat types and subtypes;

- Contributing to the final assessment of the habitats being studied, including aspects such as habitat classification, relative coverage, species assemblages present, characterising species, conservation status, and threats and pressures.

Ultimately this will enable the compilation of a prioritised list of marine areas to be considered for designation as proposed Sites of Community Importance (pSCI).

The LIFE BaĦAR for N2K project description divides Action A2 into three parts:

1. *1st analysis - Initial data analysis of existing data including recommendation of sites for 1st phase of A3 and A4 surveys;*
2. *2nd analysis - Analysis of 1st phase of remote and ground truthing surveys;*
3. *3rd analysis - Analysis of 2nd phase of remote and ground truthing surveys and final recommendation of priority habitats for protection.*

The first analysis was based on the interpretation of existing data collated through Action A1. It was initially based on data collected by the end of February 2015, and resulted in an assessment of existing data, a gap analysis and a prioritised set of areas recommended for study during the 2015 A3 surveys, which were presented in UoM-DoB's deliverable titled "*Report on the first analysis following the first data collection exercise carried out through Action A1*" (Borg *et al*., 2015a). However, additional data were subsequently incorporated into the Action A1 dataset after the A2 initial analysis report had been concluded, with the final consolidated dataset submitted to UoM-DoB in June 2016. These additional data were subsequently also analysed by UoM-DoB, and the outcome of the analyses was presented through an additional deliverable, titled *"Report on the final analysis of existing data (following the data collection exercise carried out through Action A1)"* (Borg *et al*., 2016a).

The second analysis was also undertaken in two phases. A preliminary analysis to present the general outcomes of the first Action A3 survey and revise the list of offshore areas to be included in the forthcoming bathymetric survey was first undertaken and presented in a report titled "*Report on the initial analysis of findings following the 2015 marine habitat surveys carried out through Action A3*" (Borg *et al*., 2015b). A more thorough analysis, which also took into consideration the material generated by Oceana's processing of raw data collected during the surveys, was subsequently presented in UoM-DoB's deliverable titled "*Report on the second analysis following the first surveying phase carried out through Action A3*" (Borg *et al*., 2016b). This included a detailed analysis and interpretation of the information collected through the first Action A3 survey, as well as recommendations for sites to be surveyed as part of the second Action A3 survey. These recommendations covered inshore survey areas, and offshore areas to be surveyed via a remotely operated vehicle (ROV) and via a multibeam echosounder (MBES) as part of the bathymetric surveys.

The first part of the third analysis entailed preliminary analysis of the multibeam survey results, and included information on the location of offshore ROV dives completed in 2015 and 2016 in relation to the location of bathymetric features of potential interest identified through the multibeam survey. The outcome of this analysis was presented in the additional deliverable titled "*Report containing a preliminary analysis of the multibeam survey*" (Borg *et al*., 2016c).

1.3 Objectives of the third analysis

The present report is concerned with the analysis of findings following the second marine habitat surveys carried out through Action A3 in the summer of 2016, and as such constitutes the deliverable of the second Action A2 analysis: *"Report containing analysis of 2nd phase of A3 surveys and final recommendation of prioritized habitats for protection"*.

According to the LIFE BaĦAR for N2K project description: "*Following the 2nd survey effort the 3rd data analysis will contribute towards the final assessment of the habitats under study by establishing the following as much as practically possible:*

- *habitat type as per standard classifications (Annex I codes and RAC/SPA classification)*
- *location*
- *representativity (excellent, good, significant, non-significant)*
- *relative coverage (%, where applicable)*
- *degree of conservation (structure, function and restoration possibilities)*
- *type of species assemblages present and any species of particular note (no detailed species inventory will be made, species of interest will be those species which are protected or serve as indicators of a particular habitat type*
- *threats and pressures*

This will be necessary so that the final assessment will include a prioritised list of the most appropriate sites for designation. The information from this analysis will also facilitate the compilation of the Standard Data Forms of the potential Sites of Community Importance that will be carried out as part of Action A5."

While the original aim of the present report was to present an analysis of the findings of the second phase of the A3 surveys, a consolidated assessment comprising analysis of all the data collected during the LIFE BaĦAR for N2K project (including through Action A1, and through the first and second sets of marine surveys undertaken as part of Action A3) is considered more appropriate for this third and final analysis, since recommendations on prioritized sites and habitats for protection must be based on all the available data. Therefore, the present report aims to synthesise and present a consolidated analysis of all the data collected through the LIFE BaĦAR for N2K project. More specifically the objectives of the present report are to:

- Map the spatial distribution of the LIFE BaĦAR for N2K priority habitats (i.e. sandbanks, marine caves and reefs) in Maltese waters;
- Identify characteristic species of the LIFE BaĦAR for N2K priority habitats by analysing patterns in species composition and richness;
- Assess the conservation status of the LIFE BaĦAR for N2K priority habitats, and the extent of threats and pressures;
- Present information on any other habitats of conservation interest encountered during the Action A3 surveys;
- Recommend prioritised sites and habitats for protection.

To put this final analysis into context, a brief summary of the findings from the first and second Action A2 analyses, as well as an overview of the data available for the present consolidated assessment are presented below.

2. Prior analysis undertaken through Action A2

2.1. Overview of the first Action A2 analysis, based on data collected through Action A1

2.1.1. Initial analysis of Action A1 data (March 2015)

The initial Action A2 analysis was based on the interpretation of existing data collated through Action A1 by end of February 2015. It resulted in an assessment of existing data, a gap analysis, and a prioritised list of areas recommended for study during the 2015 A3 surveys. Full details of this assessment were presented through the first deliverable of Action A2 (see Borg *et al.*, 2015a); the main outcomes are summarised below.

<u>Reefs</u>

Two broad categories of reefs are distinguished, depending on the nature of the substratum: geogenic and biogenic reefs. Geogenic reefs are rocky marine habitats where animal and plant communities grow on raised or protruding rock or collections of boulders, whereas biogenic reefs consist of biological concretions where the structure is created by the biota themselves, providing a habitat for epibiotic and other species. Reefs are very variable both in form (drop-offs, vertical rock walls, rock or boulder fields etc.) and in terms of the communities they support (attached algae, invertebrates, fish etc.); the Habitats Directive Annex I category 'reefs' is thus composed of a complex of different biotopes.

The GIS dataset produced via Action A1 contained a mixture of items, including bathymetric data obtained from different sources, information on benthic assemblages derived from different surveys, as well as a series of shapefiles showing putative reef habitats, labelled as "Shelf sublittoral rock and biogenic reef", "Shallow sublittoral rock without *Posidonia*", and "Littoral rock Biogenic reef", which incorporated data from multiple sources. Based on this information, as well as on practical knowledge and field experience of the UoM team, the following observations were made with regards to the occurrence and distribution of different types of reefs in the Maltese Islands:

- *The submarine parts of emergent vertical rock faces*: This type of reef is found along extensive parts of the shoreline of the Maltese Islands, including the northwestern, western, and southwestern coast of Gozo and the southwestern coast of Malta.
- *Underwater escarpments:* The data available at present are not of a sufficiently high resolution to identify such underwater escarpments, except in very few places where the vertical drop is of the order of 50 m.
- *Rocky shoals*: Data is only available for rocky shoals which constitute a navigational hazard to mariners; examples include: is-Sikka l-Bajda, is-Sikka ta' San Pawl, Marku shoal, Madalena shoals, St. George's shoals, Merkanti reef, Dragut shoal, Della Larga Forca reef, Żonqor reef, Munxar reef, Bengħisa reef.
- *Boulder fields*: Although data on the occurrence of boulder fields are limited, some boulder shores are shown on topographic maps of the Maltese Islands and it can be assumed that

boulder shores continue underwater as boulder fields. Such boulder shores/fields include those found off Rdum Majjiesa, Rdum il-Qawwi, and l-Aħrax tal-Mellieħa.

- *Littoral crusts, rims and knobs formed by coralline algae*: These are relatively rare, occurring mainly on the sheer vertical cliffs on the southwestern coast of Malta and western coast of Gozo.
- *Vermetid platforms*: These platforms occur mainly at or just below sea level, on the gently sloping shores found along the northeastern coasts of the Maltese Islands.
- *Deep-water coral frameworks*: Live associations of the framework-building corals are known from depths of ca. 390 m to 620 m along an escarpment south of the Maltese Islands, extending from Malta to Linosa.

The lack of detailed bathymetric data and poor data coverage especially for offshore and deep areas were identified to be the major data gaps for reef habitats. A further gap in the available data for reef habitats was the lack of consistency in the names and categories used for the different habitats. This was due to the fact that the data were derived from separate surveys which, in turn, used different classification schemes. The fact that habitat categories in the A1 dataset were not encoded into a single classification scheme hampered interpretation and spatial analysis given that the same habitat-type may appear under different names, or at a different level of detail.

Sandbanks which are slightly covered by sea water all the time

In line with the definition of sandbanks given in the EU Habitat Interpretation Manual (European Commission, 2013), the LIFE BaĦAR for N2K project proposal describes sandbanks as follows: "*permanently submerged banks and surrounded by deeper water, which are composed mainly of sandy sediment, but may also include boulders, cobbles, and mud and other varying grain sizes. Sandbanks form elevated, elongated, rounded or irregular topographic features. Water depth above sandbank is seldom more than 20m below chart datum.* Cymodocea nodosa *and* Zosterum marinae *are the vegetation associated with sandbanks.*"

Sandbanks may potentially occur in large shallow bays, smaller embayments, creeks and harbours of the Maltese Islands, but no comprehensive survey of the distribution of this habitat in Maltese waters had been undertaken by March 2015. A preliminary marine ecological survey of two such 'sandy bedforms with a raised topography' located close to the shore within the large, shallow bays of Għajn Tuffieħa and Mellieħa Bay was carried out in 2013. Sandbanks running more or less parallel to the shore in shallow waters appeared to be present in both bays, but more detailed seasonal studies of physical characteristics needed to be carried out in order to confirm with certainty that these habitats are indeed sandbanks. The actual ecological importance of this habitat in Maltese waters had also not yet been demonstrated.

Borg *et al*. (2015a) pointed out that there was so little information that even the exact definition to be used for this habitat was the subject of ongoing discussions. Disagreements over precisely what constitutes 'sandbanks' as a habitat in the Maltese Islands were creating confusion and hampering determining the precise distribution of this unit: the habitats labelled as 'sandbanks' in the LIFE BaĦAR for N2K Action A1 GIS dataset referred to areas where *Cymodocea nodosa* is found, in line with the discussions between Member States during the Mediterranean marine biogeographic seminars, rather than true sandbanks with the relevant geomorphological features. Information on benthic assemblages alone is not sufficient to map the presence of sandbanks, because the definition of a 'sandbank' refers specifically to a raised structure, a feature that can only be ascertained through more detailed bathymetric data. The low resolution of bathymetric data available for the Maltese Islands was thus identified as a major data gap.

Submerged or partially submerged sea caves

The Maltese Islands, being almost entirely composed of limestones, have an abundance of partially submerged (or 'emergent') and submerged marine caves with different geomorphological characteristics. No comprehensive survey of the distribution of submerged and emergent caves around the Maltese Islands had been carried out by March 2015, and the best-known submerged marine caves were ones which are accessible to divers. These include ones around Gozo, at Dwejra, Wied il-Għasri, Reqqa Point, Ħondoq ir-Rummien and Mġarr ix-Xini; around the Santa Marija (Comino) area, and on the western coast of Comino; and around Malta, at Anchor Bay, Qawra and along the south-western coast of Malta. The LIFE BaĦAR for N2K GIS dataset compiled through Activity A1 contained preliminary information on localities where the presence of emergent marine caves had been recorded during a single visual survey of the Maltese coastline undertaken in 2008.

Data deficiency was a major gap with respect to cave habitats; the limited amount of existing data remained scattered and largely anecdotal. In particular, there was very little information on the potential distribution of marine caves deeper than 40 m or in areas of the coast that are not easily accessible. The only data on cave biota from the Maltese Islands originated from a limited number of preliminary surveys, and detailed surveys of these complex habitats had yet to be carried out.

Threats and pressures

Only a limited amount of data on the location of the following threats and pressures were included in the Action A1 GIS dataset: fuel supply points, marine discharges, desalinisation plants, landfills, spoil grounds / dumping sites. This information was deemed to be of limited use when assessing the conservation status of the habitats being considered, since no data were made available on several important pressures likely to be affecting reefs, marine caves and sandbank habitats in the Maltese Islands, such as coastal developments, anchoring, high densities of SCUBA divers, and commercial / recreational fishing.

Recommendations for Action A3 surveys

Overall, the compilation of data done under Action A1 revealed that data coverage differed between habitats, but important data gaps were identified for all three habitat categories considered. A general pattern identified during the first analysis of Action A2 was that data coverage is higher for inshore areas than for offshore sites. Moreover, even for inshore sites, data coverage on habitats was found to be patchy, with some areas having been subjected to dedicated surveys, and virtually no information being available for other areas. The dataset available by March 2015 was thus only of limited suitability for identifying sites hosting areas having the potential to be designated as pSCIs.

The dataset was however found to be suitable to narrow down potential areas hosting reef, sandbank and cave habitats, and prioritised lists of both inshore and offshore areas recommended for surveying as part of the first Action A3 survey were drawn up (see Figures 2.1.1, 2.1.2 and 2.1.3). Survey site selection took into account the likelihood of occurrence of at least one of the three relevant habitat-types, and priority was given to (i) areas for which minimal data exist, and (ii) areas which fell outside the boundaries of existing marine protected areas. Further details on the criteria used to identify suitable inshore / offshore survey areas are available in Borg *et al*. (2015a).

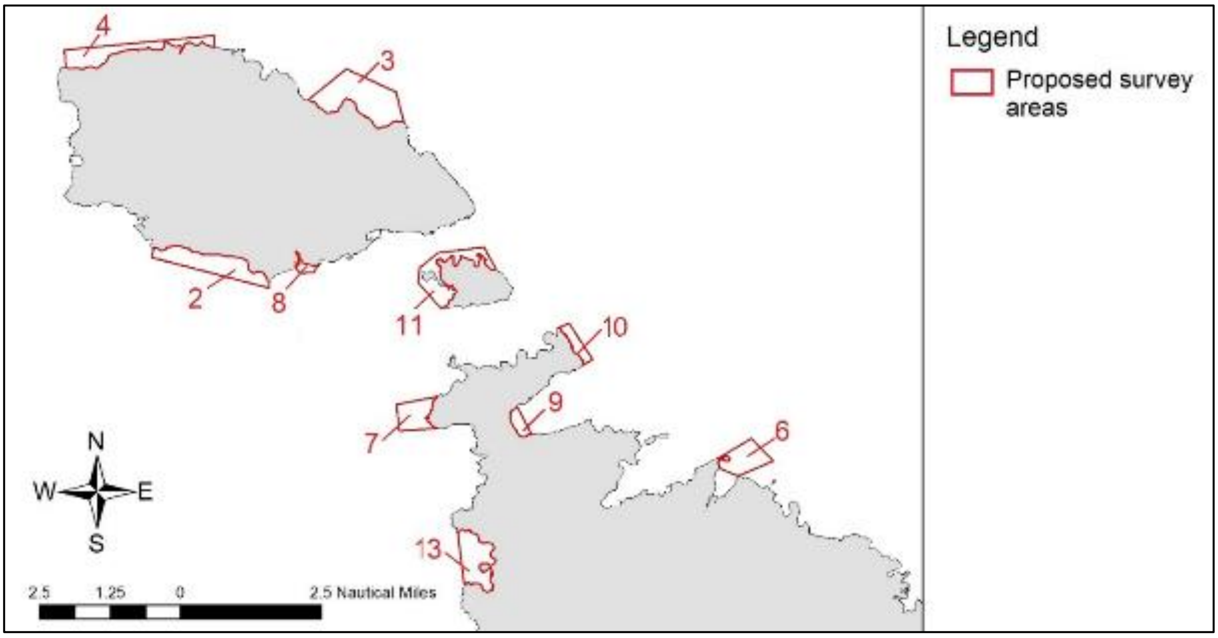

Figure 2.1.1. Map of Gozo and the north of the Maltese Islands showing the locations of inshore areas recommended for surveying during the first Action A3 surveying phase of the LIFE BaĦAR for N2K project. Numbers refer to order of priority.

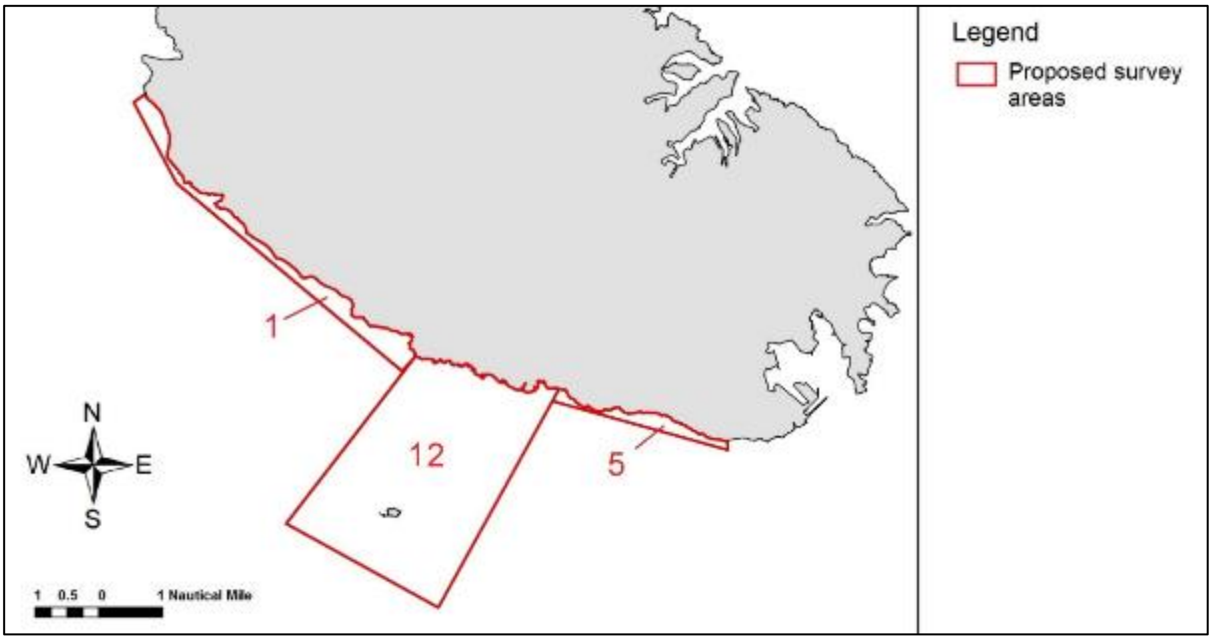

Figure 2.1.2. Map of the south of the Maltese Islands showing the locations of inshore areas recommended for surveying during the first Action A3 surveying phase of the LIFE BaĦAR for N2K project. Numbers refer to order of priority.

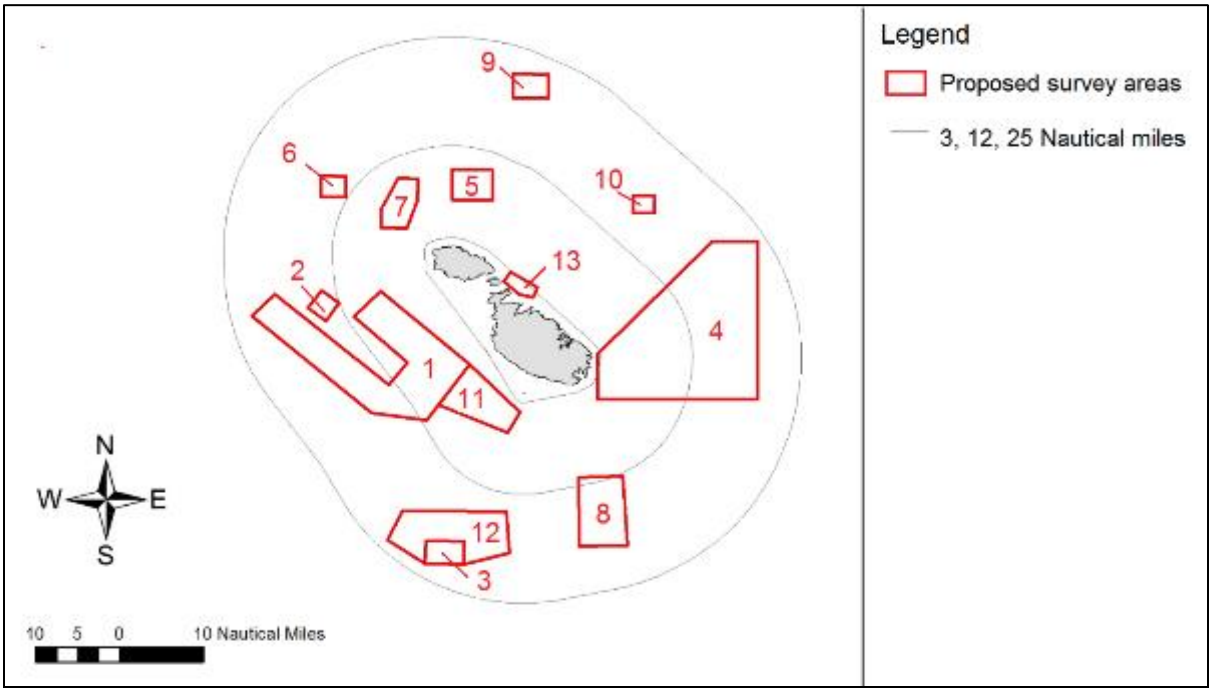

Figure 2.1.3. Map of the Maltese Islands showing the locations of offshore areas (within the 25 NM fisheries management zone) recommended for surveying during the first Action A3 surveying phase of the LIFE BaĦAR for N2K project. Numbers refer to order of priority.

2.1.2. Final analysis of Action A1 data (July 2016)

Additional data were subsequently incorporated into the Action A1 dataset by the MSDEC-DFA after the A2 initial analysis report was concluded, with the final consolidated dataset submitted to UoM-DoB in June 2016. These additional data were analysed by UoM-DoB, with the findings presented through an additional Action A2 deliverable (see Borg *et al.*, 2016a); the main outcomes are summarised below.

Some of the issues with the initial dataset that were highlighted in UoM-DoB's initial analysis report (Borg *et al.*, 2015a) were addressed in the final dataset submitted by MSDEC-DFA in June 2016. In particular, high resolution bathymetric data for shallow waters down to a depth of 50 m obtained through the 'ERDF 156' project (Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys) had been included in the dataset, although high resolution bathymetric data for deeper waters were still not available. In addition, in the case of reef and sandbank habitats, some of the data were encoded using the EUNIS typology, thus allowing comparison of information collected from different sources and originally classified according to different habitat classification schemes. No new location data for these habitats were added to the final dataset; so gaps related to data deficiency, notably the poor data coverage for offshore or deep-water reefs, remained. Information on sandbanks was also still scarce, mostly due to the ambiguity regarding the interpretation of this habitat in the Mediterranean. However, the European Commission had indicated sufficiency for Malta in relation to sandbanks (Environment and Resources Authority, communication to LIFE BaĦAR for N2K Scientific Committee, 21/04/2016).

In the case of caves, UoM-DoB's initial analysis had indicated that the datasets available by February 2015 did not contain all the existent data on caves. MSDEC-DFA addressed this by including additional data for this habitat in the final Action A1 dataset, including new information collected specifically for this project from diving school operators. However, the data coverage was still poor since very little was known about the potential distribution of marine caves deeper than 40 m or in areas of the coast that are not easily accessible. Moreover, some of the caves that were mapped had not been categorised according to whether they are emergent or submerged, which precluded classifying them according to the EUNIS typology.

The final dataset compiled through Action A1 by June 2016 contained additional data on several threats and pressures, including ones related to aviation, shipping, aquaculture, commercial fishing, and particular recreational activities. While these data were deemed useful for assessment of habitat conservation status, as is required when proposing SCIs to the EU, data on other important pressures such as extent of coastal development, recreational boating and anchoring, swimming outside of swimmers zones, or recreational fishing, were still missing.

Overall, some issues with the Action A1 datasets submitted to UoM-DoB by February 2015, including the lack of high resolution bathymetry (for inshore waters), the lack of consistency in habitat classification schemes used (for some, but not all, shapefiles), and the lack of data on several threats and pressures, were addressed and no longer applied in the case of the final dataset submitted in June 2016. However, the general pattern identified during the initial analysis (Borg *et al*., 2015a) that data coverage was patchy for inshore areas and generally poor for offshore sites, was still true. This was subsequently addressed through the Action A3 surveys.

2.2. Overview of the second Action A2 analysis, based on data collected during the first Action A3 survey

The second Action A2 analysis was based on the interpretation of data collected during the first marine habitat survey carried out through Action A3 in the summer of 2015. It resulted in an assessment of the survey findings and a prioritised list of areas recommended for study during the 2016 A3 surveys. Full details of this assessment were presented through another deliverable of Action A2 (see Borg *et al*., 2016b); the main outcomes are summarised below.

The first Action A3 surveys were undertaken between 1 June 2015 and 23 July 2015. The surveys targeted the priority inshore and offshore areas identified through the first Action A2 analysis. A total of 94 dives were carried out with a ROV, mostly at offshore locations, while 12 SCUBA dives were made in inshore areas. Surveys undertaken in offshore areas were primarily aimed at identifying the location of reefs, while inshore surveys also focused on sandbanks and caves. In summary, analysis of the data collected during the first Action A3 surveys resulted in the following main findings with regards to the three habitats of interest for the LIFE BaĦAR for N2K project:

Reefs

- Identification of new areas with extensive and diverse cold water coral assemblages at depths of 300 m to 1000 m extending some 20 km along the Malta Graben. Black coral forests were dominant at 200 m to 400 m, white corals were dominant in waters deeper than 500 m, and some areas at depths of 800 m to 1000 m were dominated by alcyonaceans. Other less abundant habitat-forming and associated species such as sponges, cnidarians, echinoderms, molluscs, crustaceans and fish were also recorded.
- Discovery of a dead (possibly fossil) lithistid sponge reef located northwest of Gozo at a depth of ca. 300 m, and extending over a 7 km wide area, serving as a substratum for several living species including sponges, cnidarians and bryozoans.
- Identification of areas with dead coral frameworks and one site with a boulder field at 100 m depth supporting benthic faunal assemblages comprising a range of sponges, cnidarians, echinoderms, molluscs and crustaceans. However, areas with dead coral frameworks were less species rich than the assemblages recorded from areas with either living cold water corals or the lithistid reef.
- Characterisation of the infralittoral algae assemblages and associated fauna found on the submarine part of emergent vertical rock faces.

Sandbanks

- Absence of sandbanks at the surveyed locations, although several of the areas that could potentially host such habitats were not surveyed due to time limitations.

Caves

- Localisation of 15 emergent and 21 fully submerged caves in inshore areas, which varied in both size and physiognomy from small caves measuring only a few metres, to large fissures and extensive tunnel systems penetrating deeply into the rock. Large caves were characterised by a marked zonation in the associated biotic assemblages from the cave entrance to the inward parts of the cave.
- New records of deep-water caves, mostly located west and north of Gozo at depths of 205 m to 450 m, but also including a cave recorded at the edge of the Malta Graben at 795 m.

In the case of reefs, the main threats and pressures appeared to be due to the presence of marine litter. In particular, discarded fishing gear (limestone slabs and ropes) resulting from dolphinfish (*Coryphaena hippurus*) fishing activities using fish aggregating devices was often observed in offshore sites (see Figure 4.1.3.2), while litter mainly derived from land-based sources was observed closer to the coast. The extent of impacts of litter on the reef organisms could not be assessed, although the reefs generally appeared to be in good status. The main source of threats and pressures on typical species found in emergent and submerged caves in the Maltese Islands is from SCUBA diving, but no impacts due to SCUBA diving were recorded in the surveyed caves, probably because the majority were small, inaccessible or unknown, and thus not frequented by divers. No assessment of sandbank habitats could be undertaken due to the absence of information on the distribution of sandbanks (defined geomorphologically) around the Maltese Islands, and since no such habitats were identified during the first Action A3 surveys.

The 2015 Action A3 survey thus provided information to fill some of the data gaps that were originally identified through the first Action A2 analysis, but the second Action A2 analysis showed that some gaps in knowledge remained to be addressed during the 2016 Action A3 surveys, in particular:

- The lack of detailed bathymetric data, especially for offshore and deep areas, remained a major data gap for reef habitats. In addition, it was not possible to survey all recommended priority areas during the first Action A3 surveys. More information on the distribution of reef habitats in Maltese waters was thus considered necessary to obtain a more complete picture of the distribution of reefs, and on spatial variation in the faunal assemblages they support.
- Data deficiency remained a major gap with respect to sandbank habitats, since there was still no geomorphological information on the presence and distribution of sandbanks around the Maltese Islands. It was recommended that the second Action A3 survey should focus on acquiring and mapping detailed bathymetric data in shallow water areas using the *'Oceana Ranger'* vessel sonar where this was not yet available, coupled with broad-brush surveys of benthic assemblages in areas identified as potentially having sandbanks.
- In the case of caves, since it was not possible to survey all recommended priority inshore areas during the first Action A3 surveys, it was suggested that more information on the distribution of submerged and/or emergent marine caves around the Maltese Islands be collected in 2016. It was also recommended that the second Action A3 surveys will include a detailed biological characterisation of representative examples of emergent and submerged marine caves in different areas.

Based on the analysis and interpretation of the data collected during the first Action A3 survey carried out in 2015, recommendations for areas to be surveyed during the second Action A3 survey were drawn up. Three sets of recommendations were presented by Borg *et al*. (2016b):

(i) Recommendations for inshore surveys;
(ii) Recommendations for offshore bathymetric surveys;
(iii) Recommendations for offshore ROV surveys (see Figures 2.2.1, 2.2.2 and 2.2.3).

Survey site selection took into account the likelihood of occurrence of at least one of the three habitat types of interest and priority was given to:

(i) Areas for which minimal data exist;
(ii) Areas which fell outside the boundaries of existing marine protected areas (MPA).

Further details on the criteria used to identify suitable inshore / offshore survey areas are available in Borg *et al*. (2016b).

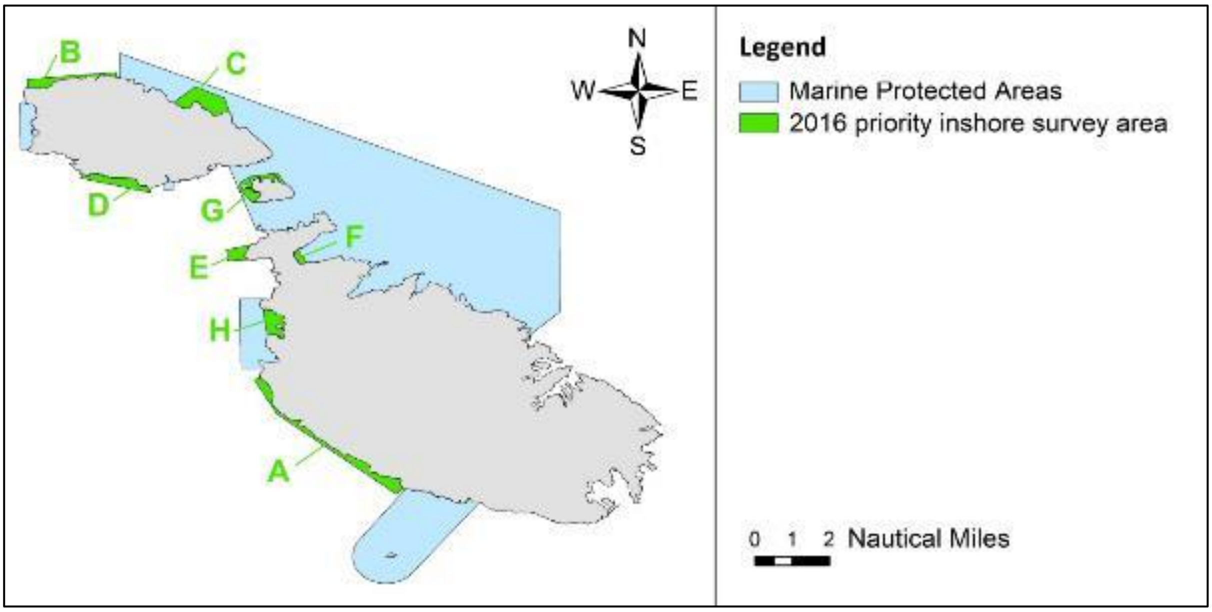

Figure 2.2.1. Map of the Maltese Islands showing the locations of inshore areas recommended for surveying second Action A3 surveying phase of the LIFE BaĦAR for N2K project. Area codes refer to order of priority.

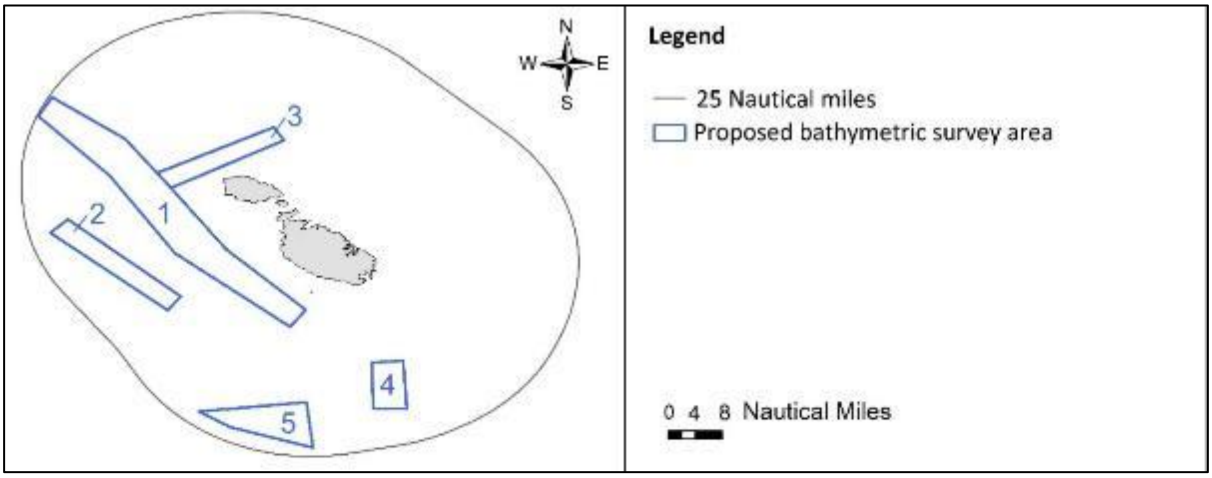

Figure 2.2.2. Map of the Maltese Islands showing the locations of offshore areas (within the 25 NM Fisheries Management Zone) recommended for surveying as part of the bathymetric survey. Numbers refer to order of priority.

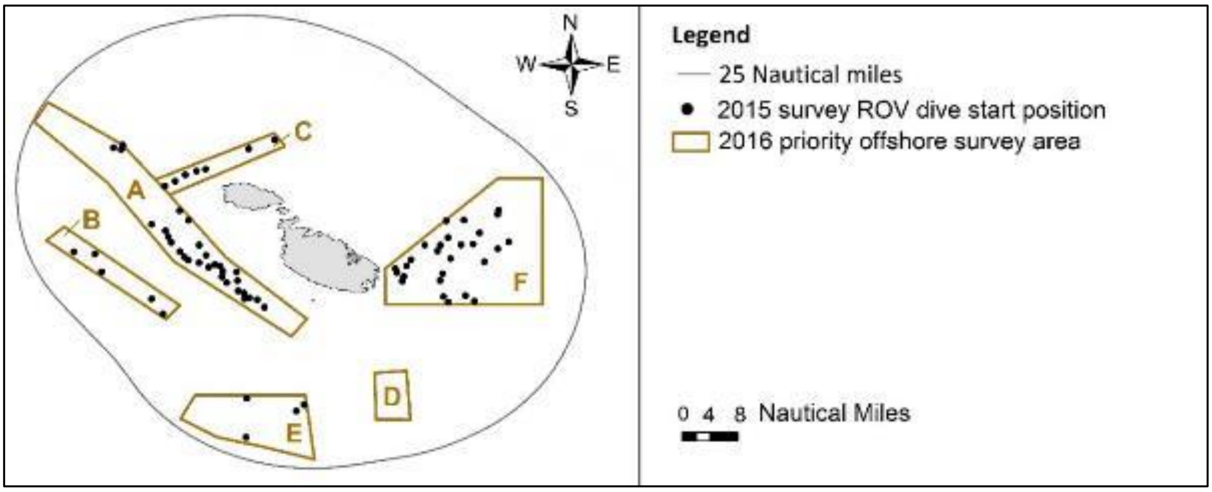

Figure 2.2.3. Map of the Maltese Islands showing the locations of offshore areas (within the 25 NM Fisheries Management Zone) recommended for surveying by ROV during the second Action A3 surveying phase of the LIFE BaĦAR for N2K project. Area codes refer to order of priority.

2.3. Overview of the preliminary analysis of the multibeam survey

As noted above, the second Action A2 analysis (Borg *et al*., 2016b) confirmed that the lack of detailed bathymetric data, especially for offshore and deep areas, remained a major data gap for reef habitats, and more detailed bathymetric information in conjunction with biotic data was considered critical in order to inform and guide the selection of sites to form part of the Natura 2000 Network. This was addressed through issuing a 'Service Tender for High Resolution Seafloor Mapping and Bottom Characterization in Maltese Waters' (hereinafter 'multibeam survey') in order to (i) obtain bathymetric data for five priority areas within the 25 nautical mile FMZ surrounding the Maltese Islands, and to (ii) carry out sediment sampling and seabed classification of the five priority areas.

A preliminary analysis of the findings from the multibeam survey was undertaken by UoM-DoB and presented through an additional Action A2 deliverable (Borg *et al*., 2016c). The original intention was that the multibeam survey would be completed in time for the findings to be used to guide the 2016 ROV surveys undertaken by Oceana; however, various delays resulted in the multibeam surveys commencing after Oceana's surveys were already concluded. Consequently, the preliminary analysis of the multibeam survey results did not advise on their applicability to the ROV surveys, but instead included information on the location of offshore ROV dives completed in 2015 and 2016 in relation to the location of bathymetric features of potential interest identified through the multibeam survey.

The preliminary analysis indicated that the multibeam campaign located several offshore reefs in the form of rocky outcrops, ridges, escarpments, and plateaus in Areas 1, 2, 3 and 5 (see Figure 2.2.2), whereas Area 4 was characterised by a gently sloping sedimentary bottom. Comparison of the locations of offshore ROV dives to the locations of interesting bathymetric features identified by the multibeam survey revealed that the great majority of features of interest were surveyed in the 2015 and 2016 ROV surveys. Some minor features of interest were, however, missed during the ROV surveys, including what appear to be circular elevated features in Areas 1 and 3.

3. Data available for the third Action A2 analysis

3.1. Data available through Action A1

For the purposes of the final Action A2 analysis, all the data made available through Action A1 and included in the final consolidated version of the A1 dataset compiled by June 2016, will be taken into consideration where relevant. Although the Action A1 data have been previously analysed in the first phase of Action A2 (Borg *et al*., 2015, 2016; see Section 2.1), the objective of the first analysis was to identify data gaps and thus make recommendations for the Action A3 surveys, whereas in the present analysis the dataset generated through Action A1 will be used in conjunction with the findings made through Action A3 to undertake a consolidated assessment of all the data collected during the LIFE BaĦAR for N2K project and make recommendations on prioritized sites and habitats for protection.

Details of the individual GIS shapefiles included in the dataset were given in the Action A1 Activity reports (MSDEC-DFA, 2015, 2016) and will not be repeated here. In summary, the dataset includes the following types of data:

- Physical data (e.g. the coastline of the Maltese Islands and bathymetric data)
- Zoning data (e.g. the boundaries of existing MPAs, trawling areas, and swimmers' zones)
- Habitats data
- Threats and pressures data

While Action A1 was intended to be a desktop data collection exercise compiling existing data, the dataset also includes some data collected or generated by the MSDEC-DFA specifically for this project (e.g. data on marine caves collected through interviews with diving school operators and fishing activity maps generated through analysis of fishery data). In addition, following recommendations made in the Action A2 initial analysis report (Borg *et al*., 2015a), most of the habitats data were encoded using the EUNIS typology, thus allowing comparison of information collected from different sources and originally classified according to different habitat classification schemes.

3.2. Data available through Action A3

3.2.1. Data available through the multibeam survey

The multibeam survey was undertaken from 28 July to 28 August 2016 by the Irish company Geomara, which won the 'Service Tender for High Resolution Seafloor Mapping and Bottom Characterization in Maltese Waters'. The dedicated research vessel 'RV Hercules', which was fitted with a hull-mounted Kongsberg 710 multibeam echo-sounder (MBES) and was equipped with a Van Veen grab for sediment sampling, was used to complete the survey. The main survey objectives were to obtain bathymetric data and carry out sediment sampling and seabed classification within the five priority areas recommended for surveying by Borg *et al*. (2016b; see Figure 2.2.2). The MBES was used to survey the entire area of the five priority zones; thus high resolution bathymetric data and seafloor characterisation (through backscatter data) is available for all areas shown in Figure 2.2.2 (total area =

ca. 1,300 km^2). Sediment sampling was undertaken at 50 stations within these areas (Figure 3.2.1), and used for ground-truthing the results of the multibeam backscatter analysis in order to attribute the different backscatter signals to different sediment type classes, and hence produce seabed classification maps.

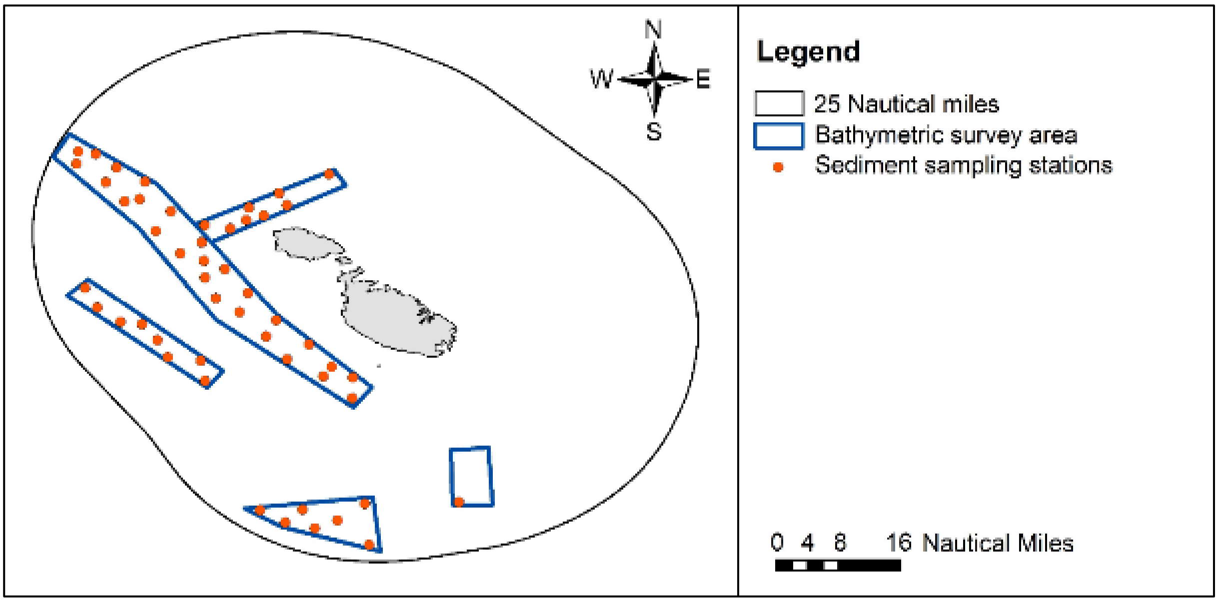

Figure 3.2.1. Map of the Maltese Islands showing the locations of sediment sampling stations within the five offshore areas surveyed through the multibeam survey.

3.2.2. Data available through the 2015 and 2016 surveys undertaken by Oceana

The Action A3 surveys undertaken by Oceana in 2015 and 2016 were carried out using the research catamaran '*Oceana Ranger*'. The first survey was held between 1 June 2015 and 23 July 2015, while the second survey was made between 26 May 2016 and 31 July 2016. Offshore surveys were made using a Saab Seaeye Falcon DR ROV, equipped with a High Definition Video (HDV) camera and able to simultaneously track the position and depth of each transect. Based on estimates of average vessel speed (0.2 knots), and the camera angle of view (app. 1.75 m), ca. 650 m^2 of seabed could be studied during one hour of ROV surveying. Low resolution video footage was recorded for the entire duration of each of the ROV dives; high definition video clips were recorded in addition when features of interest were observed. The ROV was also used occasionally to survey inshore areas, but most of the coastal surveys were undertaken by professional SCUBA divers equipped with underwater photo and video cameras.

A total of 94 ROV dives were carried out in 2015, of which 85 targeted offshore survey sites and 9 targeted coastal sites. A further 112 ROV dives in offshore areas were made in 2016. In the case of SCUBA diving, a total of 12 dives were made in 2015 while 30 dives were undertaken in 2016. The locations of ROV dives carried out during the 2015 and 2016 surveys are shown in Figure 3.2.2.1, and the locations of SCUBA dives carried out in 2015 and 2016 are shown in Figure 3.2.2.2. Overall, an area of 428,672 m^2 was surveyed via SCUBA diving (101,640 m^2 in 2015 and 327,032 m^2 in 2016), while the ROV surveys covered 15,177 m^2 in inshore areas during 2015 and a total of 621,744 m^2 in offshore areas between the two sets of surveys (178,973 m^2 in 2015 and 442,771 m^2 in 2016). Therefore, the total area sampled during the Action A3 surveys by Oceana was 1,065,593 m^2.

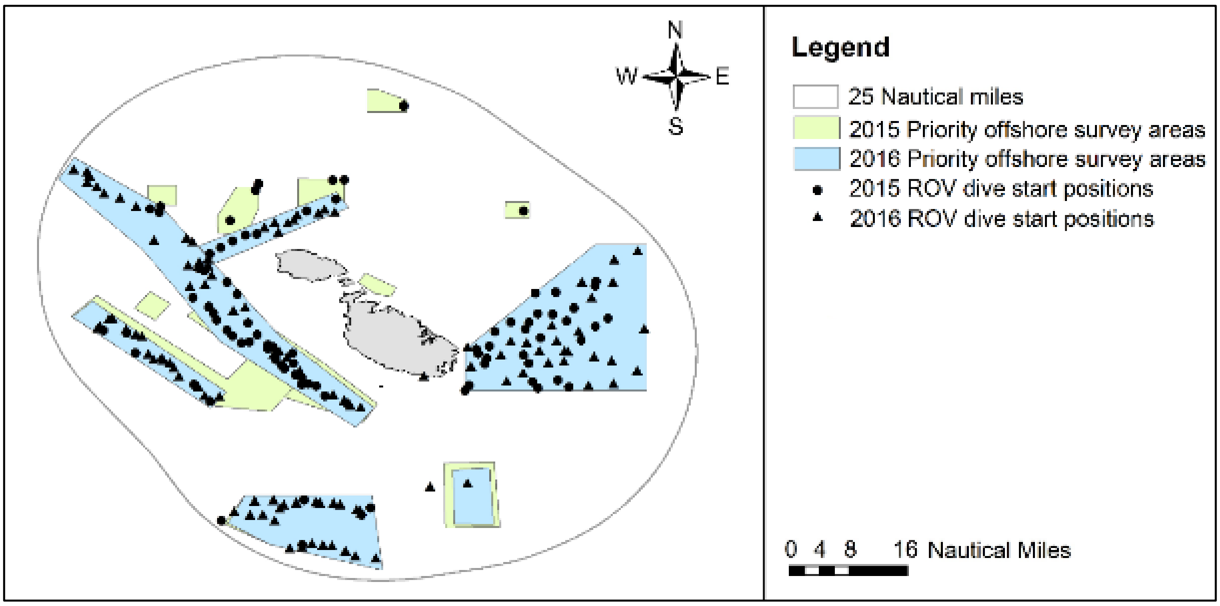

Figure 3.2.2.1. Map of the Maltese Islands showing the locations of offshore areas (within the 25 NM Fisheries Management Zone) recommended for surveying during the 2015 and 2016 Action A3 surveys, as well as the locations where ROV dives were carried out (dive starting positions are shown).

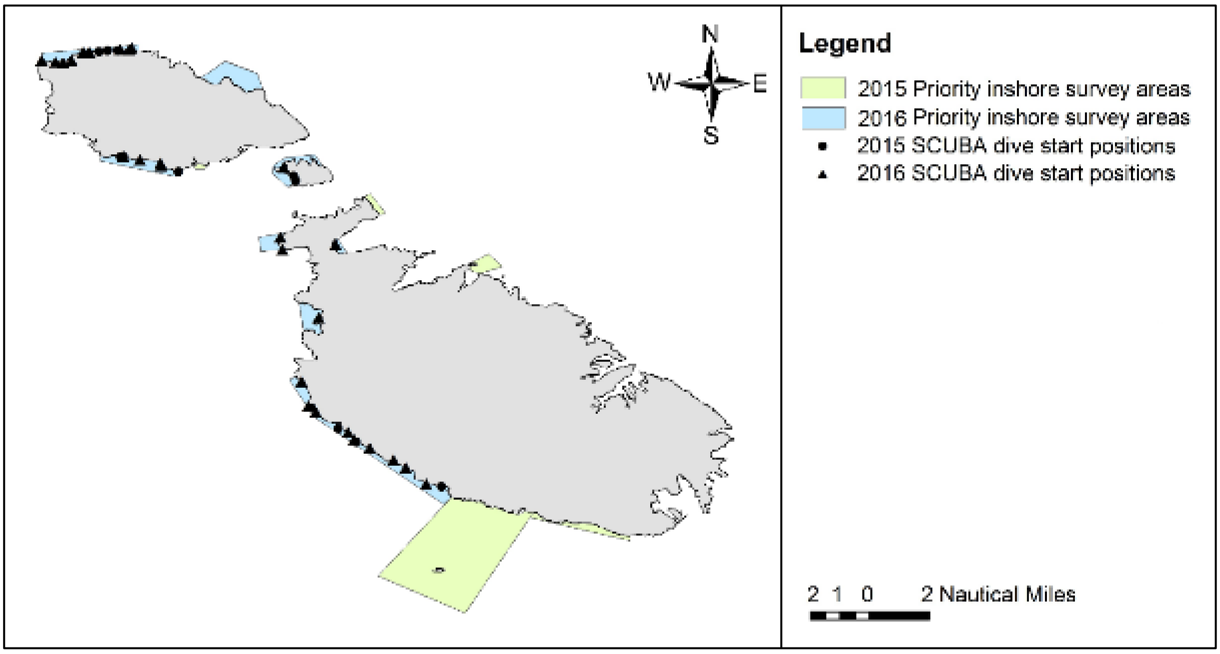

Figure 3.2.2.2. Map of the Maltese Islands showing the locations of inshore areas recommended for surveying during the 2015 and 2016 Action A3 surveys, as well as the locations where SCUBA dives were carried out (dive starting positions are shown).

In addition to video and camera recordings, several samples of biota were collected using the ROV arm, or directly by SCUBA divers. In 2015, 98 samples were collected using the ROV at depths ranging from 95 m to 1007 m, while 22 samples were collected via SCUBA diving. In 2016, 48 samples were collected from offshore areas with the ROV at depths ranging from 70 m to 950 m, while 36 samples were collected by SCUBA divers. The ROV specimen samples were mostly cnidarians and poriferans, but also included algae, crustaceans, annelids, brachiopods, bryozoans, echinoderms and molluscs. SCUBA divers focussed on collecting samples in caves, and the majority of samples were poriferans.

4. Consolidated Analysis and Interpretation of data collected through Action A1 and Action A3

4.1. Habitat 1170: Reefs

4.1.1. Reefs identified through Action A1 or encountered during the Action A3 surveys

A summary of the outcome of the Action A2 analysis of data on reefs that were collated through Action A1 is given in Section 2.1, with the knowledge gaps identified being addressed through collection of new data as part of the Action A3 surveys (see Section 3). Action A3 obtained high-resolution bathymetric data for specific offshore areas through the MBES survey, and high-definition video footage of the seafloor, which was used to characterise the benthic assemblages, through the ROV surveys. Indeed, the surveys undertaken in offshore areas (see Figures 3.2.1 and 3.2.2.1) were primarily aimed at identifying the locations of reefs and characterising the type of species assemblages present. The main findings from the Action A1 and the Action A3 surveys are summarised in Figures 4.1.1.1, 4.1.1.2 and 4.1.1.3.

No reefs were present in some of the surveyed offshore sites, which were characterised by muddy bottoms with only occasional small rocky outcrops; these included areas towards the northwestern parts of the Maltese FMZ (e.g. Areas 5, 9 and 10 in Figure 2.1.3) and also to the south of Malta (e.g. Area D in Figure 2.2.3, which was shown through the analysis of multibeam backscatter data to consist of a gently sloping seabed characterised by a soft sedimentary bottom). On the other hand, steep escarpments were found on both sides of the Malta Graben and some 20 km southwest of the island of Malta (see Figures 4.1.1.1 and 4.1.1.2). These escarpments occurred from depths of 300–500 m down to depths of 700 m to 1000 m, although the exact depth range varied depending on location. The multibeam backscatter analysis and ROV surveys indicated that these escarpments were composed of hard substrata with overhangs and crevices in places, although relatively flat areas where the rocky bed was covered by a muddy/silty layer were present between successive tiers of escarpments.

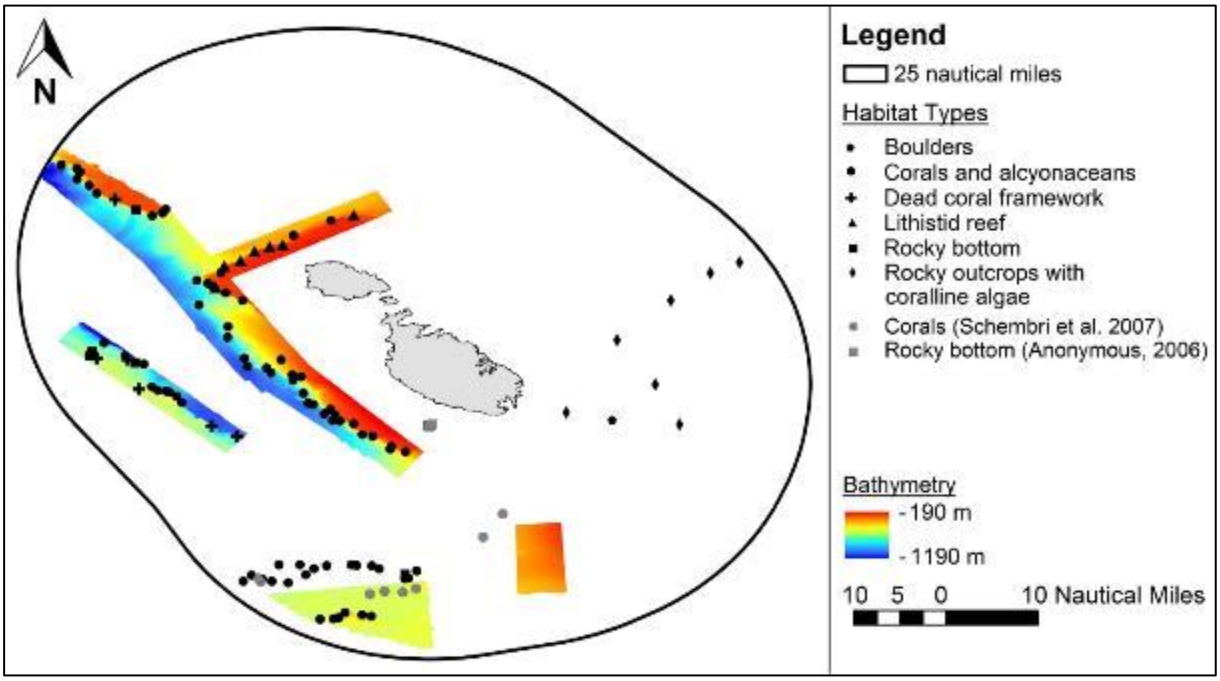

Figure 4.1.1.1. Map of the Maltese Islands showing the locations of offshore reef habitats documented through Action A1 or encountered during the Action A3 surveys held in 2015 and 2016.

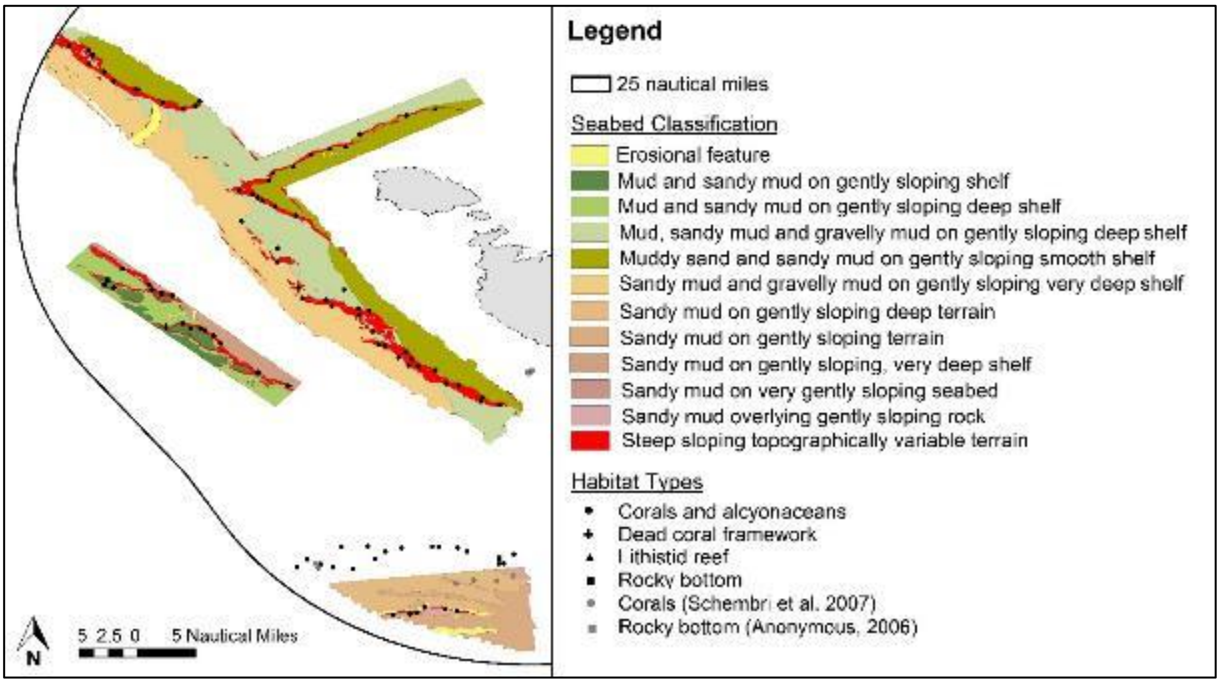

Figure 4.1.1.2. Map of the Maltese Islands showing the locations of offshore reef habitats found in waters deeper than 200m documented through Action A1 or encountered during the Action A3 surveys held in 2015 and 2016, together with information on the seabed bottom-type derived from analysis of multibeam backscatter data obtained through Action A3; reefs were mostly found associated with steeply sloping terrain constituting submarine escarpments (red shading), including the escarpment foot and adjacent plain.

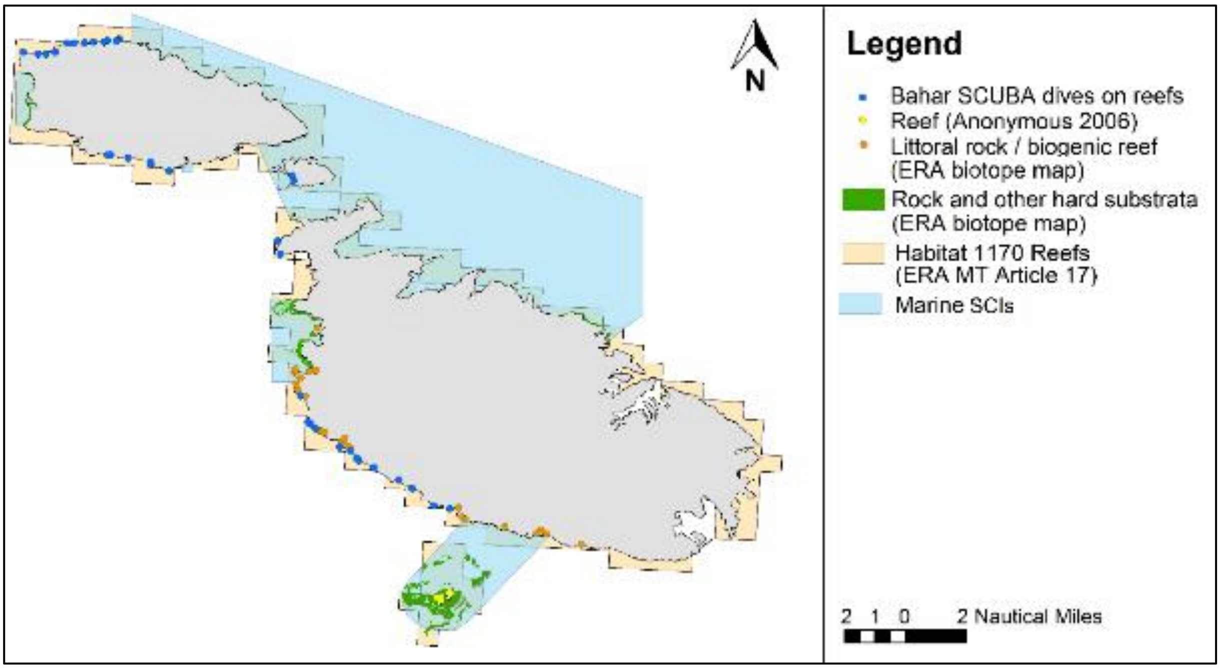

Figure 4.1.1.3. Map of the Maltese Islands showing the locations of inshore reef habitats documented through Action A1 or encountered during the Action A3 surveys held in 2015 and 2016; the boundaries of marine Sites of Community Importance (SCIs) designated to protect benthic habitats are also shown.

Rocky escarpments constitute geogenic reefs, but in several places the hard substrata were colonised by reef-forming deep-water corals, thus resulting in biogenic frameworks on top of the geogenic reefs. The presence of such reefs in the southwest region of the Maltese FMZ was already documented and included in the Action A1 dataset. Nonetheless, the Action A3 surveys have shown that in this region the escarpment with corals extends further east of previously studied locations, while a second ridge was also discovered further south. In addition, the finding of coral frameworks and alcyonacean forests along the two sides of the Malta Graben is a new discovery made through this project. On the west side of the graben, parts of the escarpment were characterised by dead (probably fossil) coral frameworks, while some rocky areas devoid of corals and supporting only live sponges were also observed. Other parts, particularly towards the centre of the surveyed area, thriving living coral and alcyonacean assemblages were observed. Extensive areas with living coral and alcyonacean assemblages were also recorded from all along the escarpment on the east side of the Malta Graben. Such assemblages represent typical cnidarian-dominated megabenthic communities on deep-water hard substrata.

Another two reef types were also recorded during the Action A3 surveys. A dead (probably fossil) lithistid (stony sponge) reef was discovered northwest of Gozo. This reef occurred at a depth of around 300 m and extended over a 7 km long area. Since the lithistid sponges which originally formed the biogenic reef are dead no further accretion of the reef structure is occurring, but this still provides a hard substratum for colonization by epibiota including habitat forming species such as alcyonaceans. The multibeam survey also showed that these lithistid reefs lie very close to another steep escarpment, which itself constitutes a geogenic reef. A boulder field was also discovered in shallower waters (ca. 100 m) to the east of Malta. However, this reef only occupied a small area within the surveyed location. In addition, several areas that were generally characterised by soft sedimentary bottoms included patches with rocky outcrops. Of particular interest were some of the outcrops found in the shallower waters (60 m to 120 m) to the east of Malta, since there the outcrops were covered with coralline algae forming calcareous bioconcretions that can be considered to fall under the definition of reefs given in the EU Habitat Interpretation Manual (European Commission, 2013), even though these do not constitute a true multi-layered coralligenous assemblage and are best described as pre-coralligenous concretions.

In the case of inshore areas, the data available prior to the start of the project and collated through Action A1 indicated the presence of several different kind of reefs along the Maltese coasts, including the submarine parts of emergent vertical rock faces, rocky shoals, boulder fields, littoral biogenic crusts and vermetid platforms. However, information on the assemblages associated with these habitats was only available for a few selected areas, most of which lie within the boundaries of existing MPAs. In particular, little information was available on those parts of the shores that are not accessible from land, such as areas where the coast is dominated by cliffs. The SCUBA and coastal ROV dives undertaken during the Action A3 surveys were primarily focused on locating caves (see Section 3.2.2) along such coastal cliffs, including in the infralittoral zone. This allowed collection of data on the submarine part of emergent vertical rock faces (see Figure 4.1.1.3), which as noted above is one of the reef types that occur in inshore areas in the Maltese Islands. Such data are useful since the biotic assemblages present on these reefs have not been extensively studied.

4.1.2. Reef assemblages

Offshore reefs

The most diverse faunal assemblages in deeper waters (see Figure 4.1.2.1) were the cnidarian-dominated megabenthic communities on escarpments surveyed on either side of the Malta Graben and further southwest along the escarpments previously identified as forming part of the 'South Malta Coral Province' (mean ± SD species richness of 36.0 ± 13.4 per dive) and those found associated with the escarpment and lithistid reef north of Gozo (mean ± SD species richness of 38.4 ± 14.9 per dive). Less diverse assemblages were recorded on hard substrata that lacked living corals (i.e. dead coral frameworks or rocky bottoms without corals; mean ± SD richness of 21.1 ± 8.9 species per dive), with the diversity here being similar to that found in areas characterised by soft bottoms (mean ± SD richness of 22.6 ± 8.9 species per dive). The faunal assemblage found associated with the boulder area located to the east of Malta included 34 species, while the diversity associated with the coralline concretions located in the same general area was slightly lower (mean ± SD richness of 27.3 ± 12.7 species per dive). Thus, the highest richness overall was recorded along the escarpment on the east flank of the Malta Graben and along the stony sponge reef located northwest of Gozo.

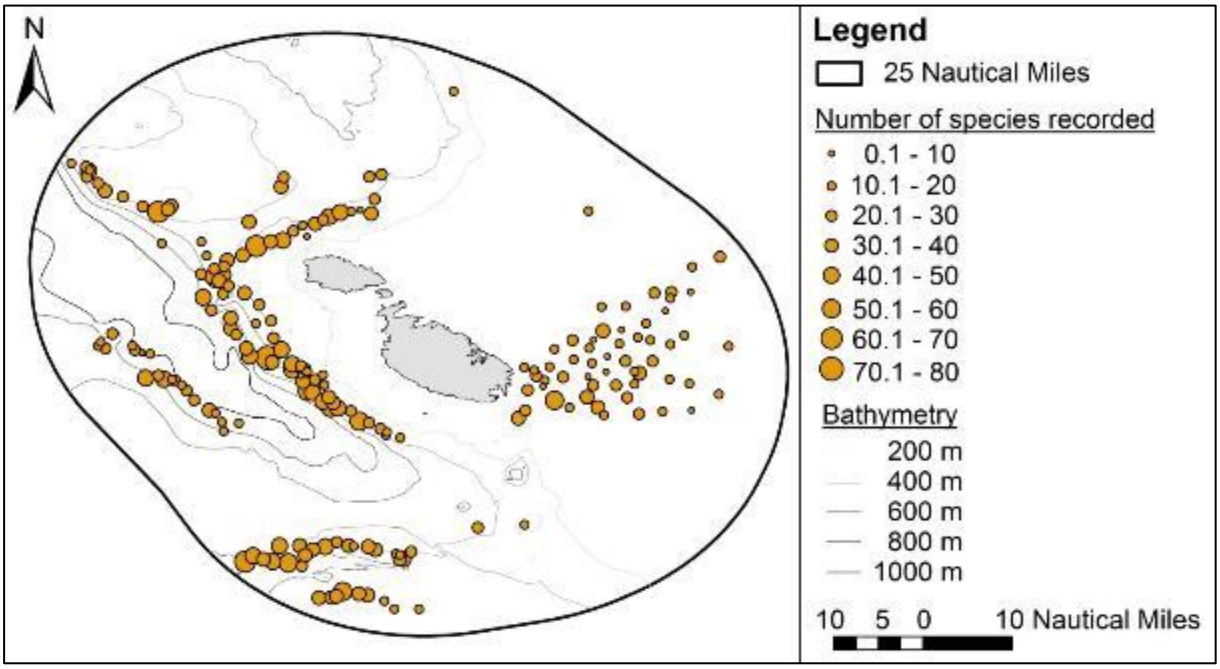

Figure 4.1.2.1. Map of the Maltese Islands showing the number of species recorded per dive from the offshore ROV dives carried out during the Action A3 surveys of the LIFE BaĦAR for N2K project.

The most abundant habitat-forming species on escarpments included the scleractinian (stony coral) *Madrepora oculata* (Figure 4.1.2.2), the antipatharian (black coral) *Leiopathes glaberrima* (Figure 4.1.2.3) and the alcyonacean (soft coral) *Callogorgia verticillata* (Figure 4.1.2.4). Several other less abundant habitat-forming species were also encountered, including species of conservation interest, such as antipatharians (Figure 4.1.2.5), the stony coral *Lophelia pertusa* (Figure 4.1.2.6) and the precious red coral *Corallium rubrum* (see Section 4.5.2). Other relevant habitat-forming species included the cnidarians *Acanthogorgia* sp., *Bebryce mollis, Dendrobrachia bonsai, Muriceides lepida*, *Placgorgia massiliensis* and *Swiftia pallida* and the poriferans *Hexadella dedritifera* and cf. *Pachastrella monilifera*. A high diversity of associated fauna (especially sponges, echinoderms, molluscs, crustaceans and fish) was also present.

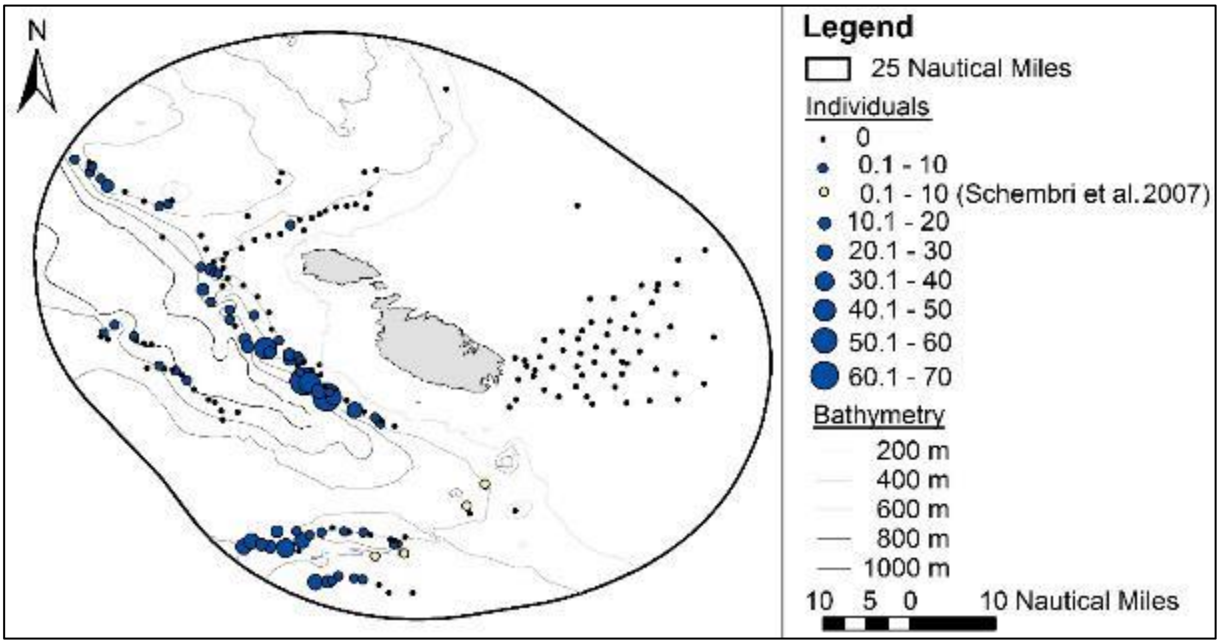

Figure 4.1.2.2. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Madrepora oculata* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project. Locations where *Madrepora oculata* was known to be present based on the data compiled during the Action A1 are also shown.

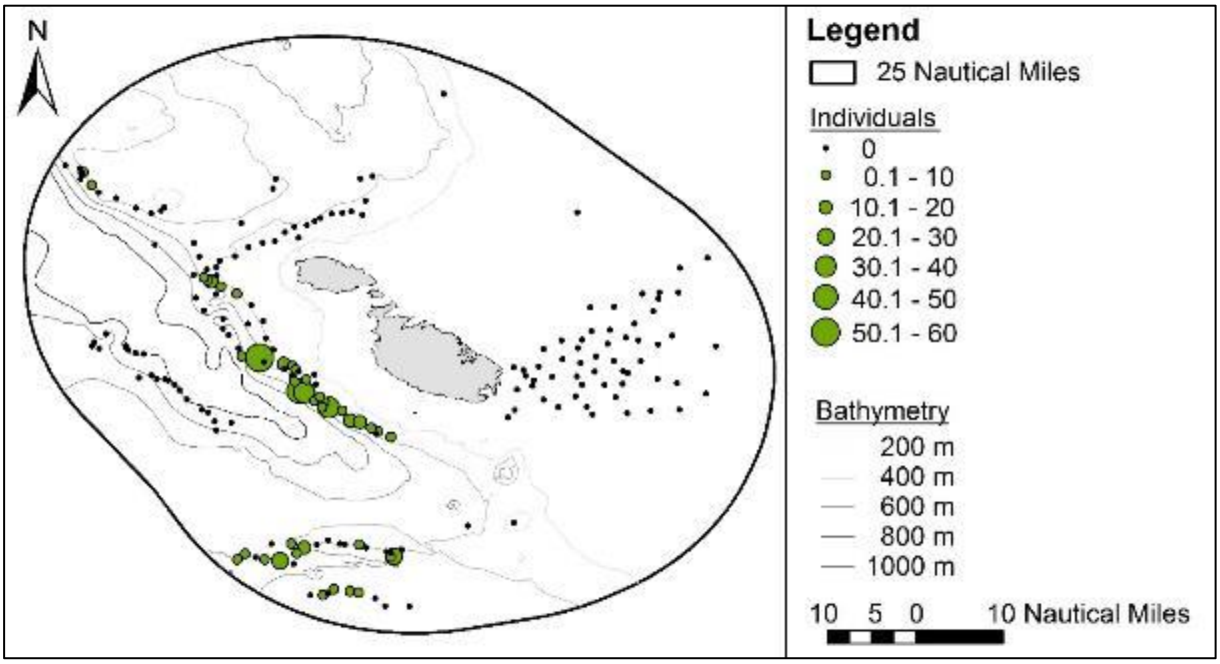

Figure 4.1.2.3. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Leiopathes glaberrima* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project.

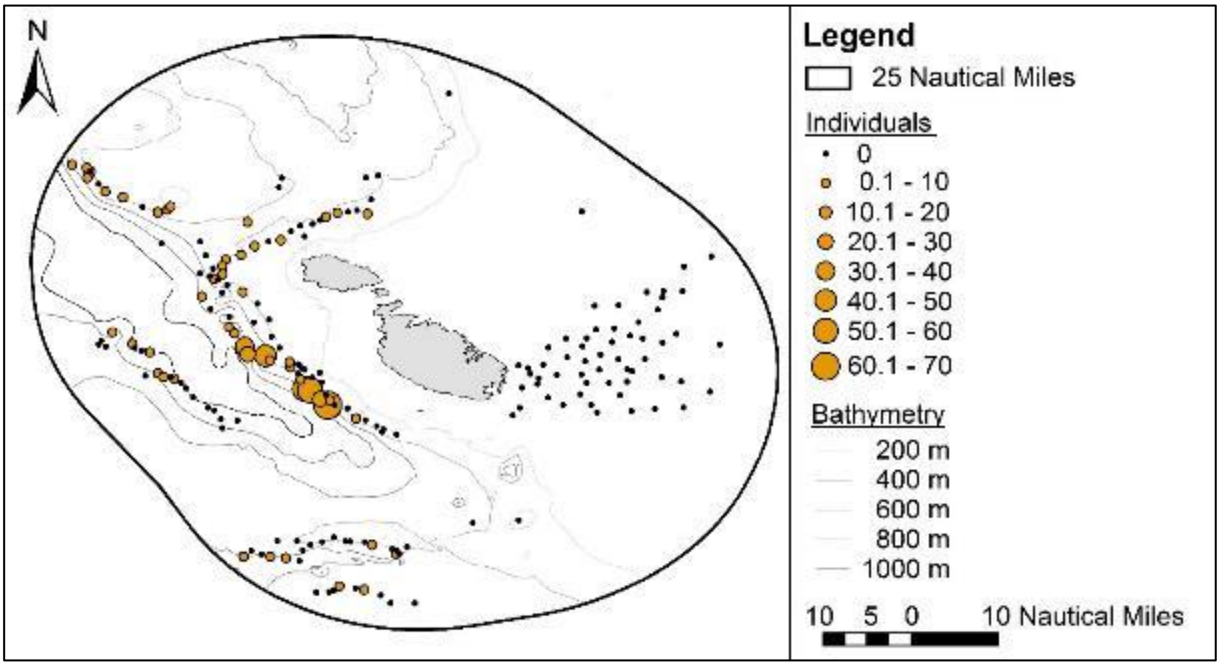

Figure 4.1.2.4. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Callogorgia verticillata* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project.

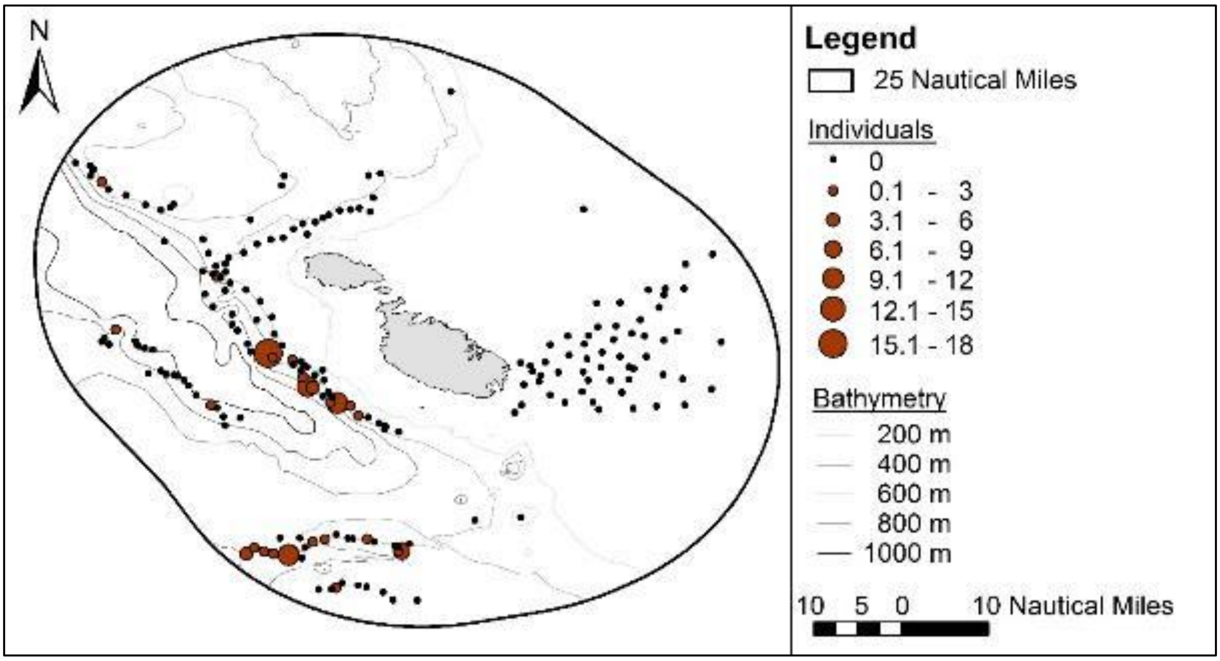

Figure 4.1.2.5. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of anthipatharian sightings (excluding *Leiopathes glaberrima*) recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project.

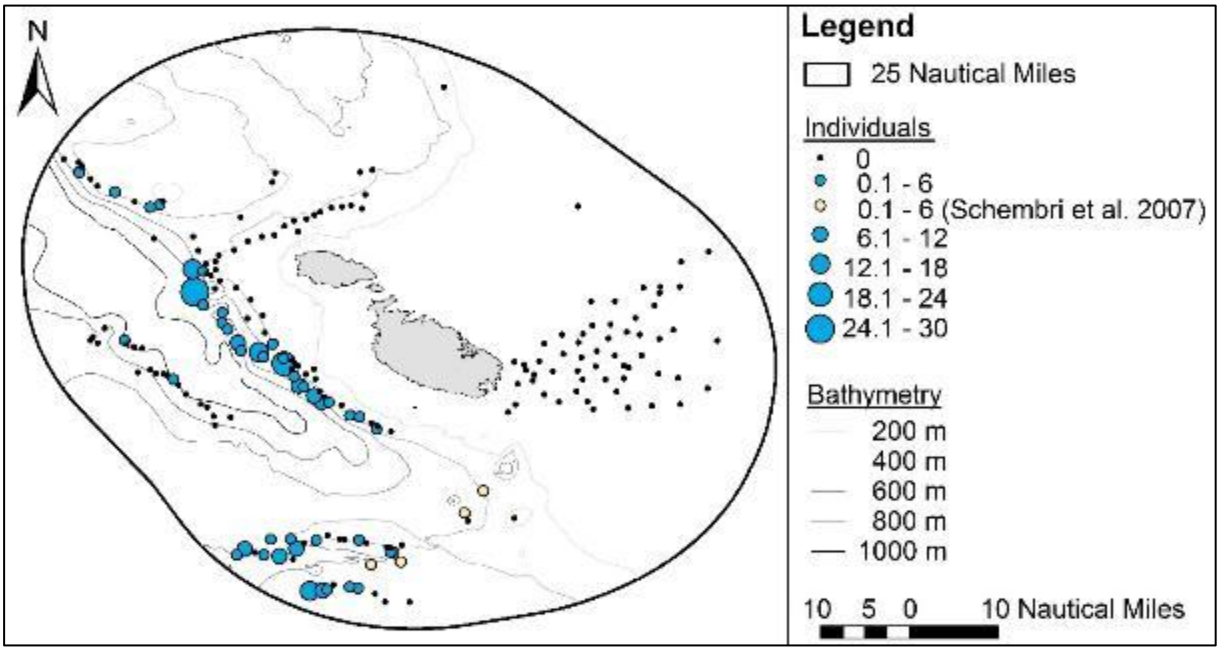

Figure 4.1.2.6. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Lophelia pertusa* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project. Locations where *Lophelia pertusa* was known to be present based on the data compiled during the Action A1 are also shown.

The bamboo coral *Isidella elongata* (Figure 4.1.2.7) was found in association with reef habitats in several areas within the Malta FMZ, particularly on flat plains at the foot or plateaux of escarpments. The EU Habitat Interpretation Manual (European Commission, 2013) lists "Facies of *Isidella elongata* and *Callogorgia verticillata*" as a characteristic assemblage associated with reef habitats. This habitat is in addition included in the UNEP/MAP/RAC-SPA "*Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest*" (UNEP/MAP/RAC-SPA, 2006) because it is characterised by species associated only with such habitats, "among which are numerous endemics, some of which can be considered as pre-Messinian relicts" (Bellan-Santini *et al*., 2002). The facies with *I. elongata* are also included in the UNEP/MAP/RAC-SPA reference list because they can contain abundant populations of marketable crustaceans and cephalopods, although it is not known whether this is due to the presence of benthic cnidarians (Bellan-Santini *et al*., 2002). Dense aggregations of *I. elongata* are presently very scarce in the Mediterranean, and the species itself has recently been listed as 'critically endangered' on the IUCN[1] Red List of Threatened Species (Otero *et al*., 2017).

[1] International Union for Conservation of Nature; https://www.iucn.org/regions/mediterranean

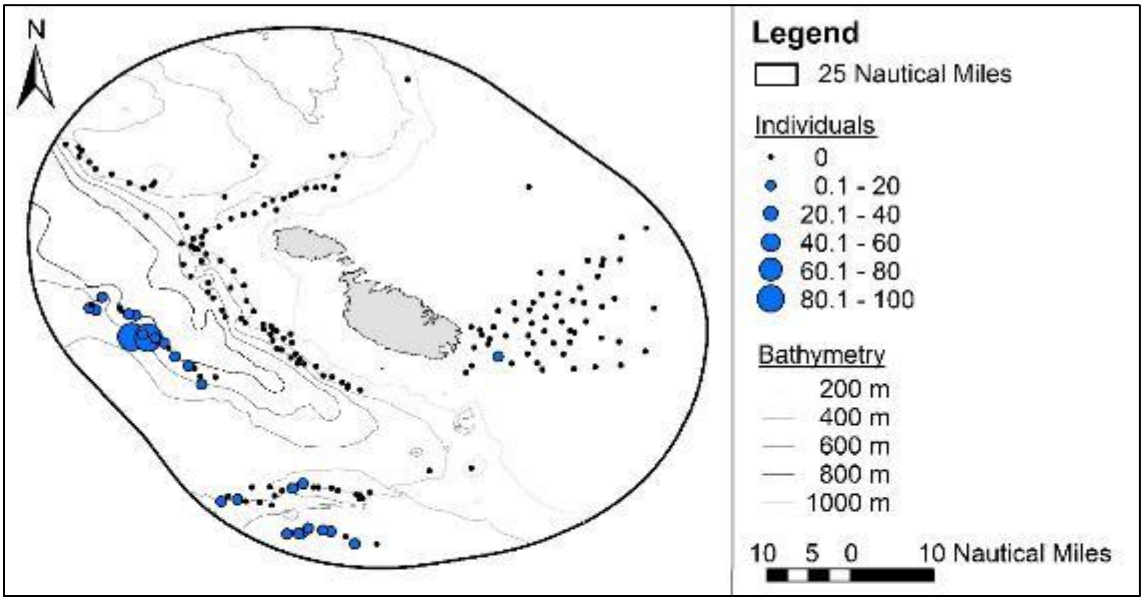

Figure 4.1.2.7 Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Isidella elongata* sightings recorded associated with reef habitats during the Action A3 surveys of the LIFE BaĦAR for N2K project.

The depth distribution of the three main habitat-forming taxa indicated a vertical stratification of the coral and alcyonacean dominated areas (Figure 4.1.2.8). *Leiopathes glaberrima* was the dominant species at depths of 200–400 m, where it formed antipatharian forests, while the stony reef-forming coral *M. oculata* dominated in deeper waters, with peak abundances recorded at depths of 500–700 m. Alcyonaceans had a more patchy distribution but *C. verticillata* was dominant in places, particularly at depths of 800–1000 m.

In the case of the lithistid reef, no single species was dominant; the more abundant habitat formers included *B. mollis*, cf. *Chironephthya mediterranea*, *Paramuricea macrospina* and *S. pallida*, while *C. verticillata*, *L. glaberrima, H. dedritifera*, *Reteporella* sp. and *Stenocyathus vermiformis* were also noted on several occasions, together with other bryozoans, sponges and cnidarians. The dead coral frameworks and areas classified as rocky bottoms (see Figure 4.1.1.1), most of which were located west of the Malta Graben, lacked an appreciable cover of epibenthic fauna. The two most common species were the alcyonacean *D. bonsai* and the sponge *H. dedritifera*, however, these were generally quite sparse.

In the case of the reef assemblages found in the shallower (<150 m depth) waters located east of Malta, although the small boulder field had the highest species richness, there was no species that was sighted in high abundance in this region, although some habitat formers such as *Alcyonium* spp., *Paralcyonium spinulosum* and *Paramuricea macrospina* were present. The situation was similar on the coralline concretions, where once again no species occurred in high abundance. In general, the benthic faunal assemblage associated with these habitats comprised a range of sponges, cnidarians, echinoderms, molluscs and crustaceans.

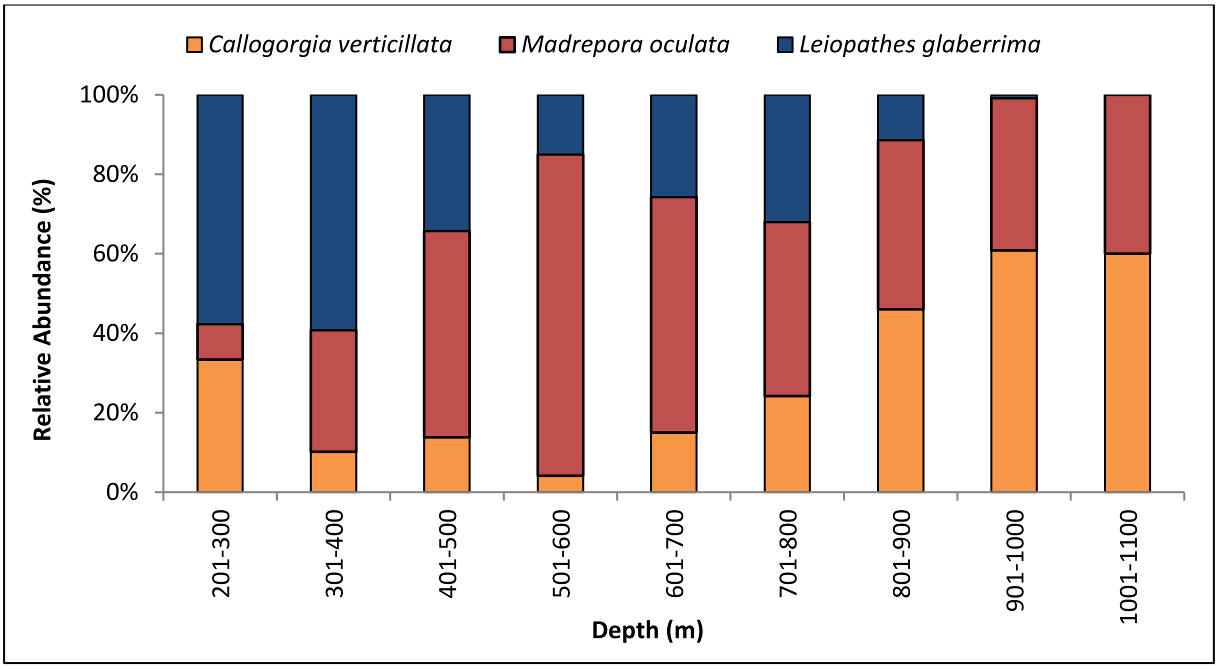

Figure 3.1.2.8. Relative abundance (as percent of total sightings) of the three main habitat-forming species, *Callogorgia verticiallata*, *Madrepora oculata* and *Leiopathes glaberrima*, recorded from different depths during the Action A3 surveys of the LIFE BaĦAR for N2K project.

Inshore reefs

An assemblage of infralittoral algae was present on the submerged portions of cliff faces, with photophilic algae dominating in shallower depths and progressively more sciaphilic ones in the darker regions at greater depths. In the upper well-lit region, the dominant species of the photophilic assemblages were phaeophytes such as *Cystoseira* spp., *Dictyopteris polypodiodes*, *Dictyota* spp. and *Sargassum vulgare*. Along the west coast of Malta in the region between Dingli and Mtaħleb, this assemblage also included areas dominated by the alien alga *Asparagopsis taxiformis*. The deeper, darker regions were characterised by sciaphilic assemblages dominated by encrusting corallines, by *Fabellia petiolata, Peyssonellia squamaria* and *Halimeda tuna*, and by *Halopteris* spp. and *Zonaria tournefortii*. Sciaphilic assemblages also occurred at shallow depths in situations receiving diminished light such as below overhangs. Several faunal species, including sponges, cnidarians, polychaetes, molluscs, crustaceans and echinoderms were observed associated with the infralittoral algal assemblages, including species of conservation interest such as star coral (*Astroides calycularis*), stony coral (*Cladocora caespitosa*), spiny lobster (*Palinurus elephas*), slipper lobster (*Scyllarides latus*), triton snail (*Charonia* sp.), and the grainseed seastar (*Ophidiaster ophidianus*).

4.1.3. Conservation status of reefs

According to Article 1 of the Habitats Directive, the conservation status of a natural habitat will be taken as 'favourable' when:

- Its natural range and areas it covers within that range are stable or increasing;

- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future;
- The conservation status of its typical species is favourable.

In the case of geogenic reefs, the concept of 'range' does not apply. A one-off exercise to locate the different reefs and assess their areas, followed by long-term monitoring to check for any diminishment of the area of the reefs (area is only likely to decrease due to natural or anthropogenic catastrophes, and not increase, since all geogenic reef types are large-scale geomorphological structures) is needed in order to assess the status of these habitats in terms of area. Through the data collection exercise undertaken in Action A1, and the 2015 and 2016 Action A3 surveys, the location and areas of several reefs in Maltese waters have been established, which serve as useful baseline references for future surveys.

In the case of biogenic reefs, 'range' may be taken as a decrease or increase in the length of shoreline (for littoral reefs), or extent of area of the seabed covered by the reef (for sublittoral reefs), while the 'area' status refers to the precise, actual area occupied by the reef within the range (since a habitat may have a patchy distribution within its natural range). Unlike geogenic reefs, the range of biogenic reefs must be monitored on an ongoing basis in order to detect changes as a result of adverse impacts, that is, long-term monitoring is needed in order to assess the status of these habitats in terms of both range and area. In this regard, the Action A3 surveys have contributed information on the distribution (i.e. range and area) of living coral frameworks within the 25 NM FMZ, providing a baseline against which any future surveys of the area may be compared.

In assessing structure and function of reefs, two main types of anthropogenic pressures need to be taken into account in the case of geogenic reefs:

1. pressures which affect the physical structure of the reef (which are likely to be catastrophic events such as for instance a large tanker running aground on a shoal, or the collapse of part of a submarine rock face);
2. those that will affect the species living on a reef (due to pressures such as fishing, anchoring, pollution etc.).

Changes in structure, function and presence of typical species need to be monitored by using permanent transects established along the depth gradient of the reefs (that is, from deep to shallow water). Once a time series of data is available the current condition of the habitat could then be assessed using indicators such as:

(i) number of algal species;
(ii) number of fauna species associated with the habitat;
(iii) presence / absence of rare species of algae or fauna;
(iv) total coverage of macroalgae;
(v) coverage of specific species of algae;
(vi) coverage of key faunal species (where applicable).

Reefs which are the result of biogenic concretions deposited by reef-building organisms will be primarily affected by pressures that have an impact on these species, which may cause a gradual worsening of reef condition (for instance due to pollution), or a more direct impact in the case of adverse changes due to particular activities or disturbances (such as for instance from bottom fishing or anchoring). As for geogenic reefs, changes in the structure and function of biogenic reefs need to be periodically monitored through transect surveys in order to assess the population structure and condition of the reef-forming species and of selected associated species, using indicators such as estimates of population size (density / cover indices) and population structure (size / age frequency distributions) of those species which form an important structural element of the biocenosis, and which are thus indicative of the structural integrity of the biogenic reef habitat being monitored.

The main threats and pressures on typical species found in the offshore reef habitats surveyed during the Action A3 surveys are due to marine litter. A significant portion of this litter was derived from fishing activities (Figure 4.1.3.1). In particular, discarded fishing gear resulting from dolphinfish (*Coryphaena hippurus*) fishing activities using fish aggregating devices (FADs) was often observed. These FADs are anchored to the sea floor with limestone slabs, and the synthetic mooring ropes are not retrieved at the end of the traditional dolphinfish fishing season. Limestone slabs (Figure 4.1.3.2) and discarded fishing gear (Figure 4.1.3.3) were noted associated with rocky bottoms during most of the ROV dives where hard substrata were observed. The limestone slabs may cause direct damage to reef species when they are deposited on the bottom, while discarded ropes can have adverse effects on the biota as they become entangled with benthic organisms (Bo *et al*., 2014). In addition, several other types of litter, including plastic material, glass bottles, and metallic objects such as rods, cables and drums were also frequently observed (Figure 4.1.3.4). Plastic was by far the most widespread and abundant type of litter (Figure 4.1.3.5). Litter items such as plastics, glass bottles, tin cans, ropes, and car parts and tyres were also encountered in association with reef habitats during the inshore surveys; fishing gear such as lines, traps and nets were also observed, including a trammel net lying parallel to one of the surveyed reefs (Figure 4.1.3.6). The extent of impacts of litter on the reef organisms could not be directly assessed but the reefs generally appeared to be in good status.

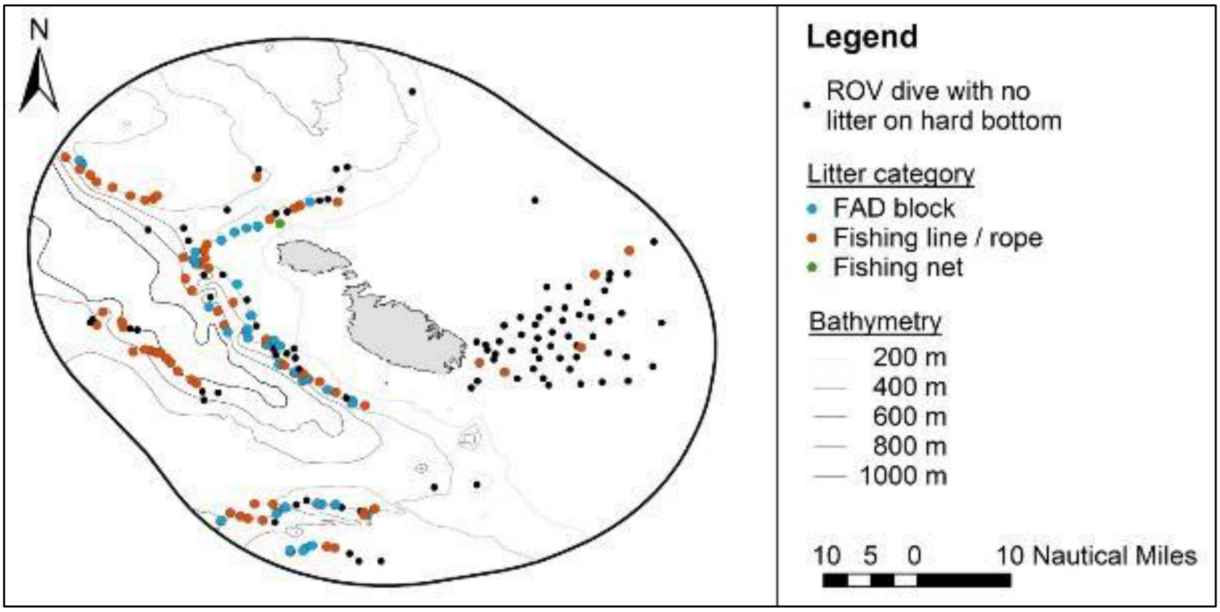

Figure 4.1.3.1. Map of the Maltese Islands showing the locations of different types of fishing-derived litter on hard substrata encountered in offshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

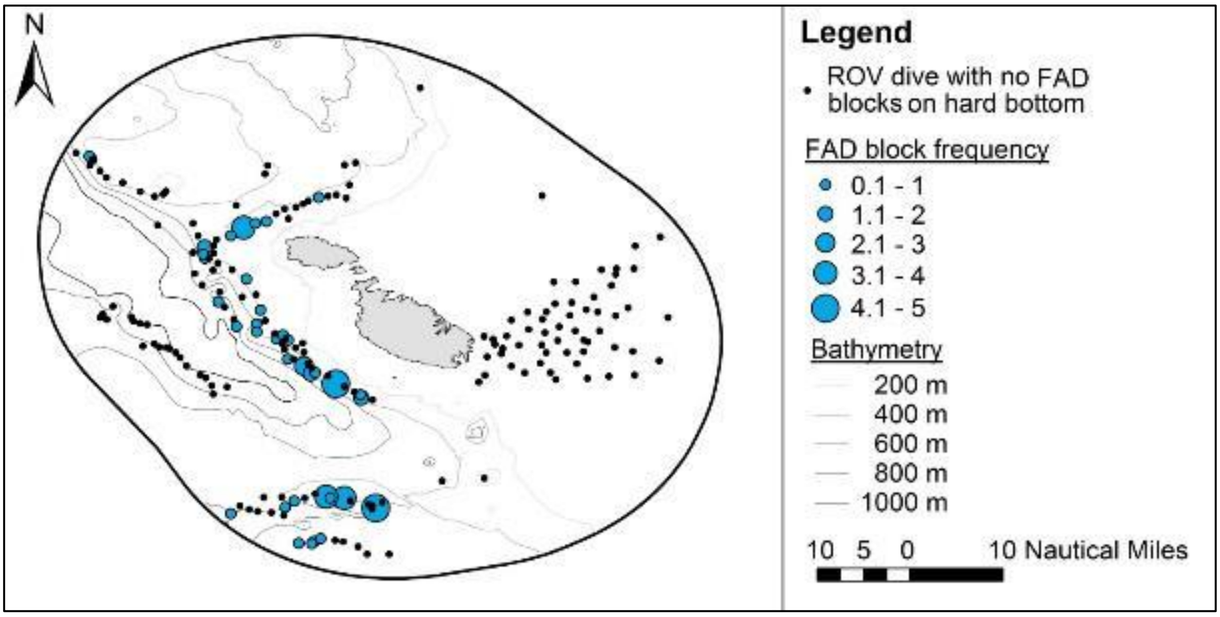

Figure 4.1.3.2. Map of the Maltese Islands showing the locations and frequency of discarded limestone slabs on hard substrata encountered in offshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

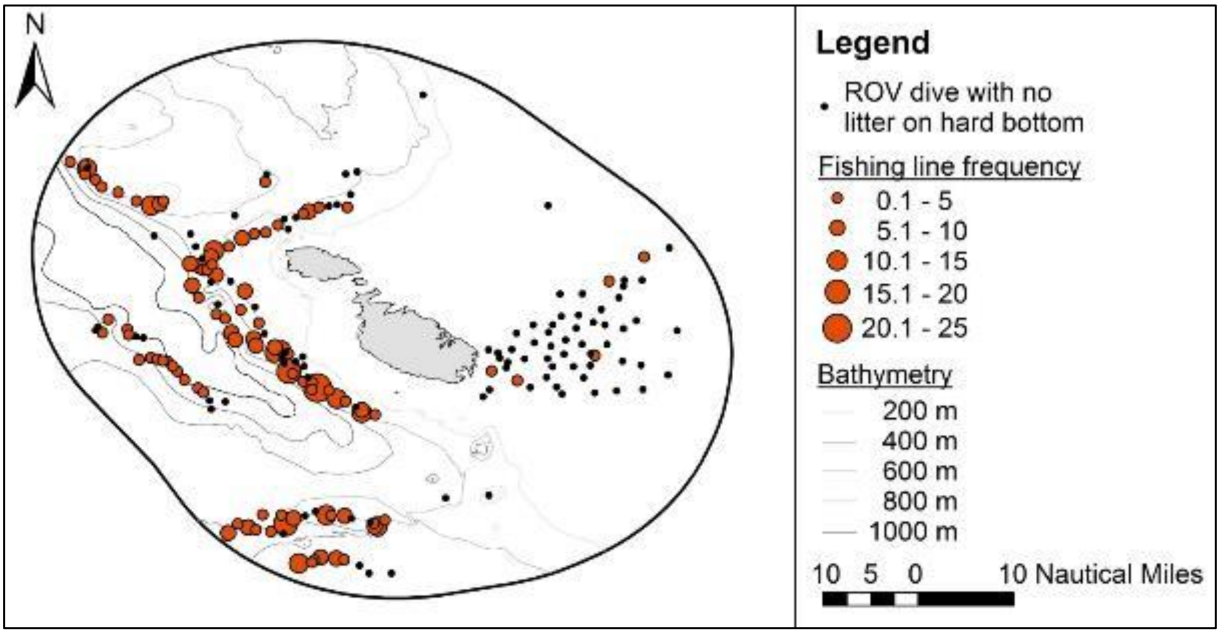

Figure 4.1.3.3. Map of the Maltese Islands showing the locations and frequency of lost or discarded fishing lines/ropes on hard substrata encountered in offshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

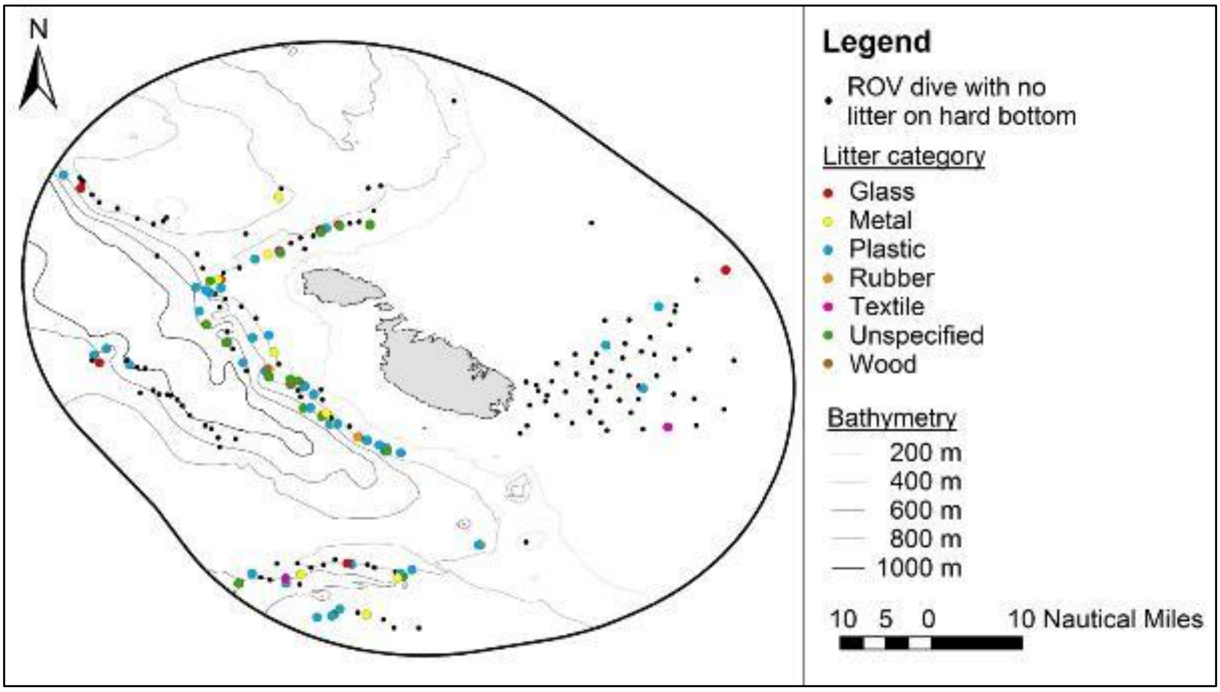

Figure 4.1.3.4. Map of the Maltese Islands showing the locations of different types of marine litter on hard substrata encountered in offshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

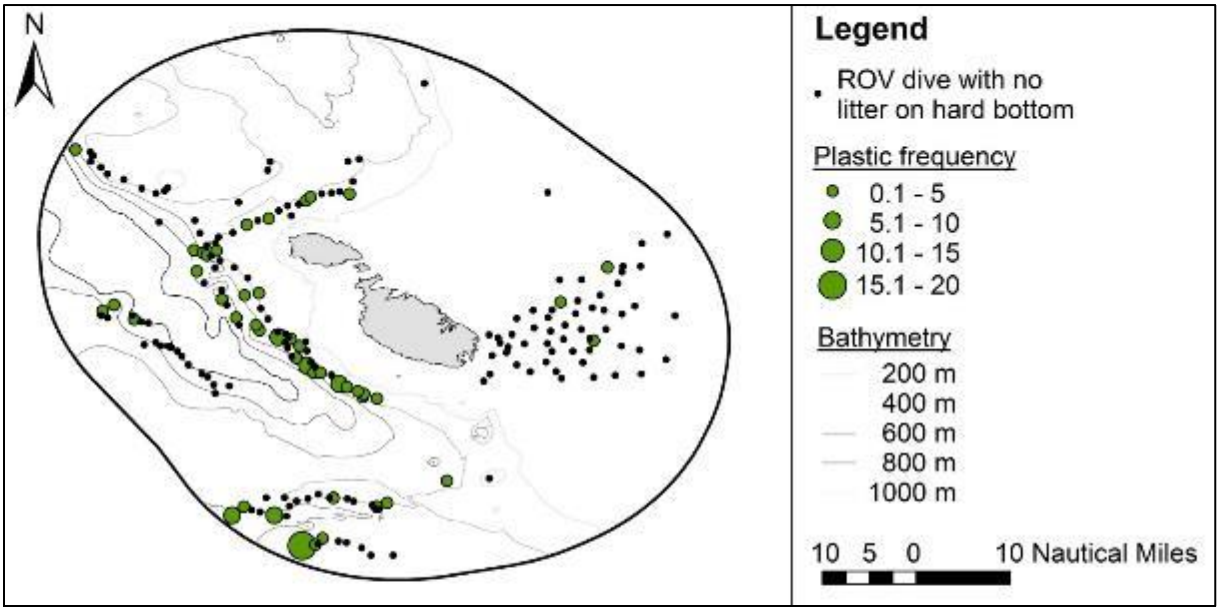

Figure 4.1.3.5. Map of the Maltese Islands showing the locations and frequency of plastic litter on hard substrata encountered in offshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

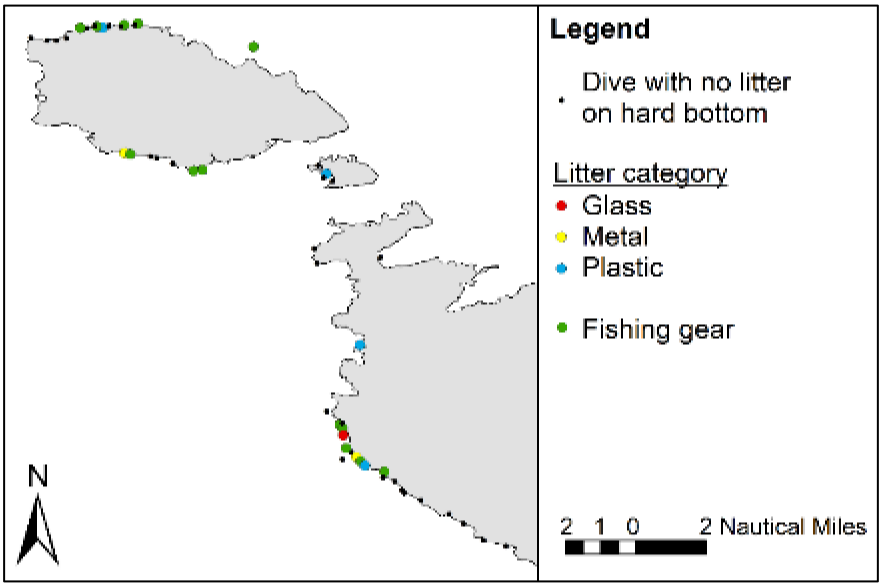

Figure 4.1.3.6. Map of the Maltese Islands showing the locations of different types of marine litter and fishing gear on hard substrata encountered in inshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

An overall assessment of the threats and pressures applicable to reef habitats, partly based on the data collected through Action A1 and on the Action A3 results, is given in Table 4.1.3.1. As noted in the analysis of Action A1 data (Borg *et al*., 2016a), the A1 dataset contained information on fuel supply points, marine discharges and sewage outflow/overflow sites, desalinisation plants, landfills, spoil grounds / dumping sites, aviation (fuel jettison areas), shipping (bunkering areas), aquaculture (aquaculture boundaries), commercial fishing (location of transects where fishers may deploy fish aggregating devices, boundaries of trawling areas, trawling intensity from vessel monitoring system data, fishing activity maps for swordfish, dolphinfish and tuna), and recreational activities (swimmers' zones, dive sites). However, data on other relevant threats and pressures, such as the extent of coastal development, recreational boating and anchoring, swimming outside of swimmers zones, or recreational fishing, were not available. The Action A3 surveys, on the other hand, focused only on threats and pressures that could be visually documented during the habitat surveys, which mostly concerned the presence of marine litter. In order to make a comprehensive assessment of threats and pressures, Table 4.1.3.1 also considers potential threats in addition to ones identified through Actions A1 and A3; activities that are unlikely to pose a threat to reef assemblages (e.g. snorkelling) have been excluded.

Table 4.1.3.1. List of threats and pressures applicable to reef habitats (based on the EU 'Reference list Threats, Pressures and Activities' used for reporting under Article 17 of the Habitats Directive), with explanatory notes.

Code	Description	Notes
D D03.01 D03.03	Transportation and service corridors Port areas Marine constructions	New marine constructions (including slipways and piers that are classified under D03.01 even though they may occur outside port areas) can cause direct mechanical damage to coastal or inshore reefs; no such constructions were noted in most of the areas surveyed through Action A3
E E03	Urbanisation, residential and commercial development Discharges	Discharges will not affect the physical structure of reefs but can have an impact on the biotic assemblages of inshore reefs located within the discharge plume; Action A1 did not document any discharges in the areas selected for surveying.
F F0.1 F02.01 F02.02 F02.03 F05	Biological resource use other than agriculture & forestry Professional passive fishing Professional active fishing Leisure fishing Illegal taking/removal of marine fauna	Passive fishing via trammel nets and traps and leisure fishing (pole fishing or spearfishing) can target fish associated with reef habitats in inshore waters. Passive fishing via demersal longlines has a similar effect if undertaken along offshore reefs. Lost or discarded fishing gear may have additional impacts (see 'H' below). Active fishing through benthic trawling could have detrimental effects on offshore reef species, including those forming biogenic frameworks, although no evidence of such trawling was observed in Action A3, and the reef habitats generally lie outside area designated for trawling. Similar impacts can arise due to illegal fisheries such as those targeting the precious red coral (see Cattaneo-Vietti *et al*., 2017), although thus far there is no evidence that this is occurring in Maltese waters.
G G05.02 G05.03	Human intrusions and disturbances Shallow surface abrasion/mechanical damage to seabed surface Penetration/disturbance below surface of the seabed	Surface abrasion on inshore reefs may occur through light anchoring by small recreational vessels, while more extensive mechanical damage can result from anchoring on reefs by larger vessels such as cargo ships. While such anchoring is unlikely in offshore (deep-water) reefs, the use of limestone blocks to anchor fish aggregation devices (see Figure 4.1.3.2) may cause direct damage to reef species in offshore waters, including those forming biogenic frameworks.
H H01 H03.01 H03.03	Pollution Pollution to surface waters Oil spills in the sea Marine macro-pollution	Pollution will not impact the physical structure of reefs but may affect reef species that are sensitive to the pollutants; oil spills may have a more extensive effect for inshore reefs and are considered a potential threat given the various bunkering zones in Maltese waters as documented through Action A1, even though no major oil spills are known to have occurred. Marine littering was the most extensive anthropogenic impact seen in the Action A3 surveys (see Figures 4.1.3.4 and 4.1.3.6),

		with plastic litter dominating in offshore waters (see Figure 4.1.3.5). Discarded fishing ropes/lines were also very common (see Figure 4.1.3.3), and these can cause damage as they become entangled with reef organisms (Bo *et al*., 2014), including those forming biogenic frameworks.
I I01	Invasive, other problematic species or genes Invasive non-native species	Non-native species may threaten reef assemblages by outcompeting indigenous species; alien species such as *Caulerpa* spp. and *Asparagopsis taxiformis* were documented during the Action A3 surveys in inshore waters, although these were not dominant at the surveyed areas.
K K01.02	Natural biotic and abiotic processes Silting up	Silting up can be a threat to offshore reefs and reef organisms that are not occurring on near-vertical surfaces; several areas with rocky bottoms covered by sediment were recorded during the Action A3 surveys.
L L05	Geological events, natural catastrophes Collapse of terrain, landslide	Natural catastrophes such as collapse of submarine rock faces would result in a reduction of the area occupied by geogenic reefs.
M M01.01 M01.04 M01.05	Climate change Temperature changes pH changes Water flow changes	Climatic changes can have a direct impact on reef species, for example if the temperature and/or pH of an area shifts so conditions are no longer optimal for a given species, or due to extreme events such as temperature anomalies that can cause mass mortalities. Acidification is particularly relevant for biogenic reefs as it can impair the ability of calcium carbonate secretion (and hence reef formation). Water flow changes can be detrimental by causing silting (see 'K' above) or by altering the availability of food supply, which is particularly relevant for sessile suspension feeders.

As indicated above, assessment of the conservation status of reef habitats should ideally be based on long-term monitoring, since this is necessary to indicate whether the range/area of the habitat is stable, to assess if the structure and functions needed for long-term maintenance exist and whether they are being influenced by anthropogenic pressures, and to determine whether the conservation status of typical species is favourable. While such long-term monitoring goes beyond the scope of the LIFE BaĦAR for N2K project, the surveys carried out as part of the project have provided useful data that can support assessment of the conservation status, as well as serve as a baseline against which to compare the outcomes of any future surveys as part of a long-term monitoring plan. Based on the available data, the following conclusions can be made regarding the conservation status of reef habitats:

- As noted above, the concept of range does not apply for geogenic reefs, and there is no evidence of any decrease in area of such habitats. For biogenic reefs, no decline in range or area can be inferred from the results of the LIFE BaĦAR for N2K project; the dead coral frameworks and dead lithistid sponge reef recorded from some areas are probably fossil (or sub-fossil) structures.

- No impacts affecting the physical structure of reefs were documented through the LIFE BaĦAR for N2K project. On the other hand, some pressures that could affect reef assemblages, such as marine litter, and in particular lost or discarded fishing gear, were documented; while the snapshot data generated through the project is not sufficient to determine if these impacts are resulting in changes in population size/structure of key species or a decrease in species richness or coverage, all surveyed reefs appeared to be in good status, indicating good prospects for long-term maintenance of these assemblages.
- The same considerations regarding assessment of structure and functions also apply to assessment of conservation status of key species, which requires long-term population dynamics data in order to assess population viability and changes in natural range of the species. Nonetheless, the available data on the general status of the surveyed reef assemblages suggests that key reef species have self-sustaining populations and no reduction in their natural range can be inferred; there is also a sufficiently large area of habitat to maintain populations on a long-term basis.
- Based on these considerations, the overall conservation status of reef habitats is considered to be favourable.

4.1.4. Reefs of particular interest

The southwest coastline of Malta and the northwest and southwest parts of Gozo are dominated by cliffs whose submerged portions extend down to depths of around 50 m. The reef habitat type 'submarine part of emergent vertical rock face' is therefore common in Maltese inshore waters, but most of these areas lie outside existing MPAs (see Figure 4.1.1.3), in contrast to other types of inshore reefs, such as rocky shoals and vermetid platforms, that are already protected through existing MPAs. From a conservation perspective, what is relevant is to ensure that representative reef habitats are included in Natura 2000 sites. In practice, this means that site selection for inshore reefs should focus on areas where such vertical rock faces are present, since this would ensure adequate representativity of different biotic assemblages across the MPA network. Since caves occur in association with vertical rock faces, the most practical approach is to also consider the distribution of caves and establish protected sites in areas where both reefs and high densities of caves are present. In addition to representativity, site selection will need to be based on area, degree of conservation and global assessment as per Annex III of the Habitats Directive.

In offshore areas, no extensive parts with reef habitats were discovered at depths of between 50 m to 150 m. During the first Action A3 surveys held in 2015, only a single reef which constituted a small boulder field found in a general area that was mostly characterised by mobile substrata was recorded from these depths. Despite the fact that this site was unique, the small area of the boulder field cannot support a high abundance of reef-associated species, making this of limited conservation interest on its own. Further surveys in the general area revealed a few other locations where rocky outcrops with coralline concretions were present, but these concretions were generally small and supported few reef-associated species.

In the case of deeper waters, three main reef types were discovered: a dead lithistid reef, escarpments with dead coral frameworks, and escarpments with living coral reefs or alcyonacean forests. Lithistid sponges were important reef builders in the Late Jurassic and Early Cretaceous (163 mya to 100 mya), particularly on the "European" coasts of the Tethys Sea, but many reef building sponge species subsequently became extinct (Maldonado *et al*., 2015). The reef discovered in Maltese waters is probably a fossil or sub-fossil structure. Although the lithistid sponges that originally formed the reef are dead, the reef itself provides a hard substratum for colonisation by several epifaunal species, and also occurs in association with an escarpment constituting a geogenic reef. The lithistid reef surveyed through the Action A3 surveys is the only one known from the area, and supported a diverse epifaunal assemblage. Although several of the species were also recorded from the cold water coral reefs, the community structure of the lithistid reef assemblage was different.

By definition, steep sublittoral escarpments are all geogenic reefs but extensive areas of the surveyed escarpments were covered with coral frameworks forming a superimposed biogenic reef. Compared to areas with living coral colonies, the sites characterised by only dead frameworks had a lower diversity of species, and are thus of lower conservation interest. Sites with living cold water corals, on the other hand, have a high conservation value. Only six areas with extensive frameworks of living cold water corals (CWC) are known from the Mediterranean (Taviani *et al*., in press): 1. Bari Canyon CWC Province; 2. Santa Maria di Leuca CWC Province; 3. South Malta CWC Province; 4. Melilla CWC Province; 5. Gulf of Lion CWC Province; 6. South Sardinia CWC Province. Such coral provinces are considered to be biodiversity hotspots. The South Malta Coral Province was previously studied through several research cruises (*R/V Meteor* cruise M70-1; MARCOS 2007; MEDCOR 2009; DECORS 2011; see: Freiwald *et al*., 2009; Costantini *et al*., 2010; Tsounis *et al*., 2009), which led to it being described as holding "*a remarkably high diversity, probably representing the richest hotspot of its kind in the Mediterranean basin*" (Angeletti *et al*., 2011). The Action A3 surveys have shown that that area of the coral province in Maltese waters has a much larger extent, since living cold water corals were discovered on the escarpment forming the east side of the Malta Graben, stretching over a length of some 70 km, and to a lesser extent on the escarpment forming the west side of the Malta Graben.

4.2. Habitat 1110: Sandbanks which are slightly covered by sea water

4.2.1. Habitat definition and classification

According to the EU Habitat Interpretation Manual (version EUR28; European Commission, 2013), the EU Habitat's Directive (HD) Annex I Habitat 1110 'Sandbanks which are slightly covered by sea water all the time' can be defined as:

Sandbanks are elevated, elongated, rounded or irregular topographic features, permanently submerged and predominantly surrounded by deeper water. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed *as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata.*

'Slightly covered by sea water all the time' means that above a sandbank the water depth is seldom more than 20 m below chart datum. Sandbanks can, however, extend beneath 20 m below chart datum. It can, therefore, be appropriate to include in designations such areas where they are part of the feature and host its biological assemblages.

In a separate section on 'Plants' associated with this habitat the EU Habitat Interpretation Manual goes on to specify that in the Mediterranean "*the marine angiosperm* Cymodocea nodosa*, together with photophilic species of epiphytes (more than 15 species, mainly small red algae of the Ceramiaceae family), associated with* Posidonia *beds*" may be found on sandbanks. It does however add that: "*On many sandbanks macrophytes do not occur*".

The presence of *Cymodocea nodosa* on a sandy bottom does thus not necessarily mean that a 'sandbank' is present, whereas, conversely, its absence from a sandy bottom does not mean that that bottom cannot be considered to be a 'sandbank'. A 'sandbank' is essentially a geomorphological feature and not a biological one, and although the nature of the sandbank environment will determine which biota are able to live on the sandbank, to use such biota to 'characterise' a sandbank, these biota must be nearly exclusively limited to the environmental conditions created by the sandbank and must nearly always occur where such conditions are found. Clearly, *Cymodocea nodosa* is not such an organism.

4.2.2 Sandbanks identified through Action A1

Despite the lack of information on the distribution of sandbanks in the Maltese Islands, the LIFE BaĦAR for N2K GIS dataset compiled through Activity A1 contains information on several localities where the presence of 'sandbanks' has been recorded (see Figures 4.2.2.1 to 4.2.2.5 below). However, these locations are in fact referring to areas where *Cymodocea nodosa* is found rather than true sandbanks with the relevant geomorphological features.

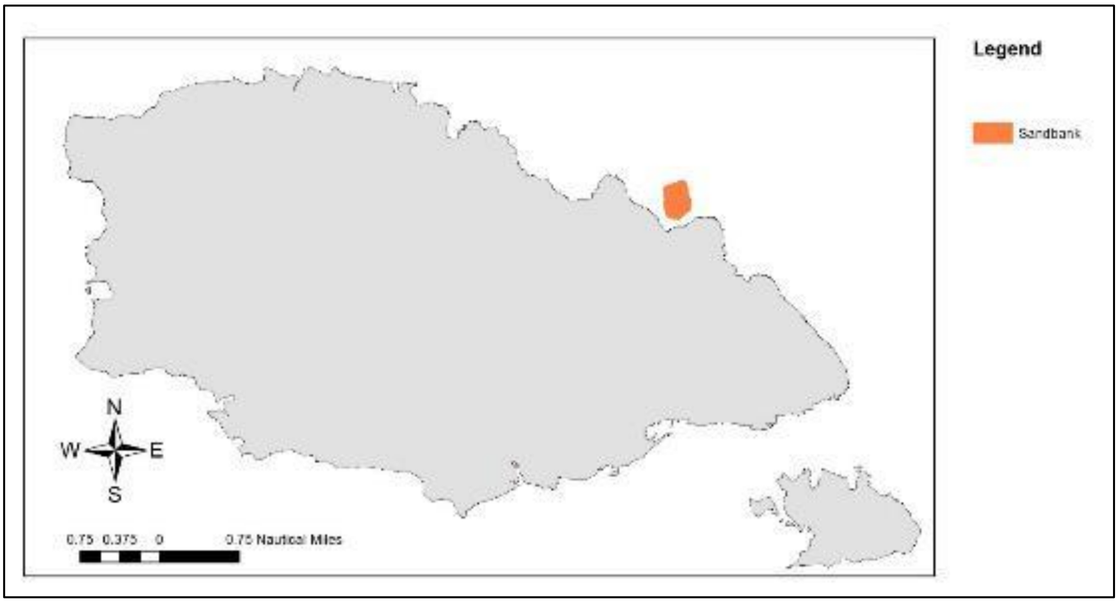

Figure 4.2.2.1. Location of sandbank habitats in Gozo and Comino as included in the LIFE BaĦAR for N2K project Action A1 GIS dataset.

Figure 4.2.2.2. Location of sandbank habitat in Mġarr Ix-Xini as included in the LIFE BaĦAR for N2K project Action A1 GIS dataset.

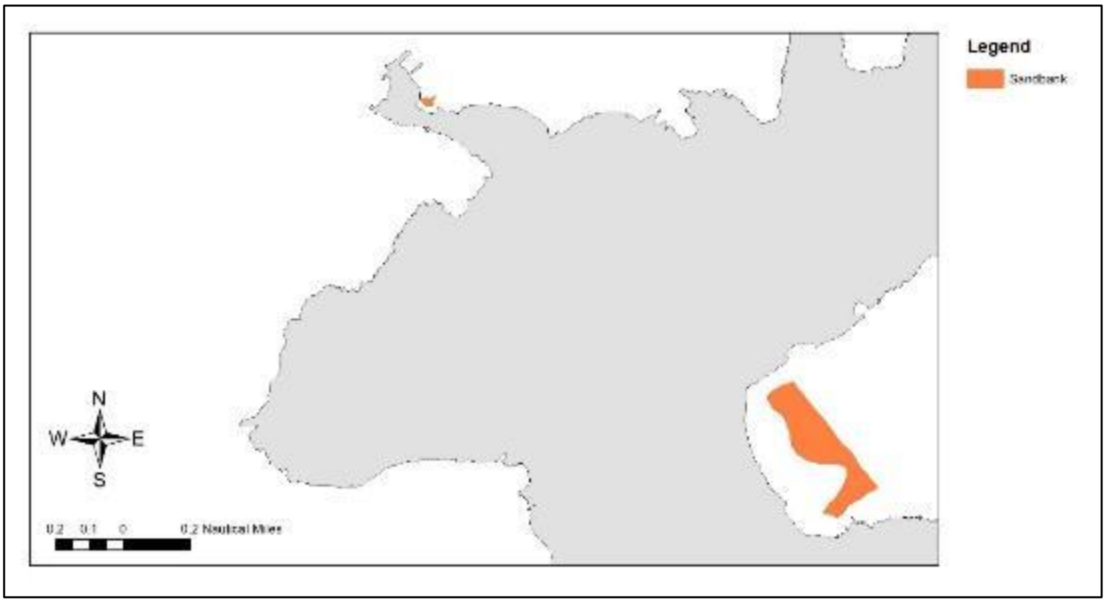

Figure 4.2.2.3. Location of sandbank habitat in the North of Malta as included in the LIFE BaĦAR for N2K project Action A1 GIS dataset.

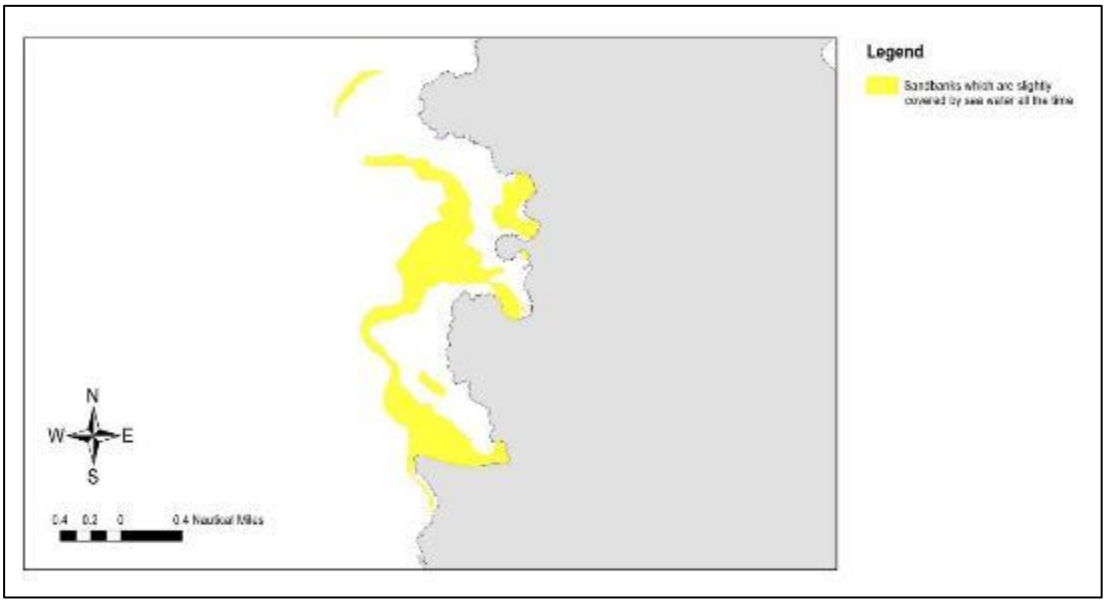

Figure 4.2.2.4. Location of sandbank habitat in the Rdum Majjiesa to Ras ir-Raħeb area as included in the LIFE BaĦAR for N2K project Action A1 GIS dataset.

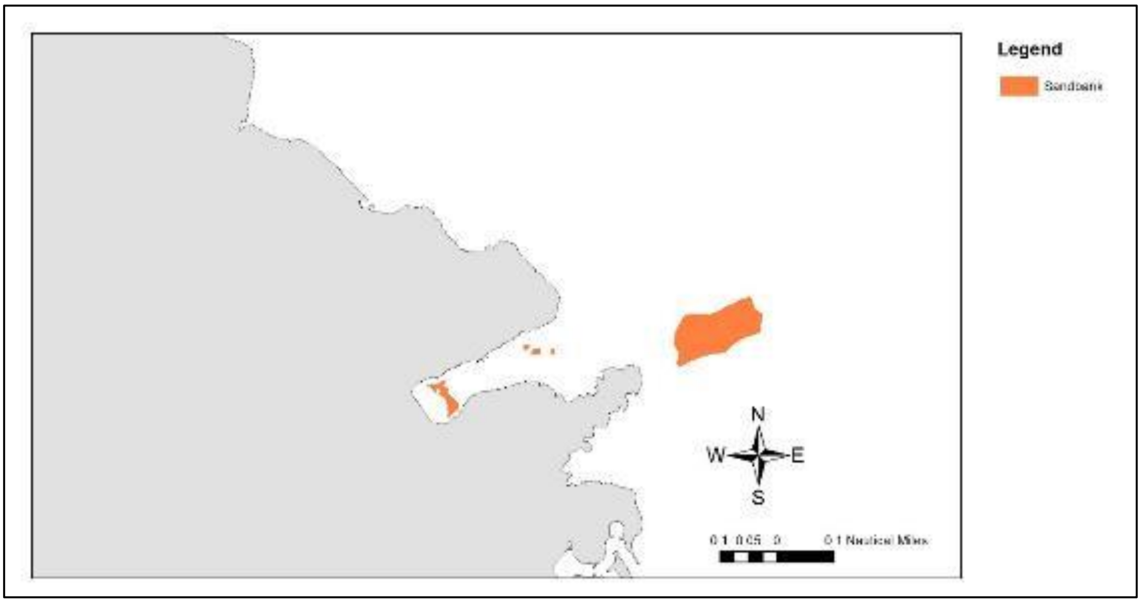

Figure 4.2.2.5. Location of sandbank habitat in the St George Bay and Dragonara Point area as included in the LIFE BaĦAR for N2K project Action A1 GIS dataset.

In addition to the information on localities where the presence of 'sandbanks' has been recorded and included in the Activity A1 GIS dataset, Borg *et al*. (2015a) discuss a preliminary marine ecological survey of two sandy elevations commissioned by the MEPA in 2013. These 'sandy bedforms with a raised topography' were located close to the shore within the large, shallow bays of Għajn Tuffieħa and Mellieħa Bay. Borg *et al*. (2013) found that the water depth at the highest part (the 'crest') of the sandbanks was ca 2 m at Għajn Tuffieħa Bay and ca 0.5 m at Mellieħa Bay. The physical extent of the sandbanks was not studied in detail, however in both bays the sandbanks took the form of a ridge of sand raised above the adjacent sandy bottom and running more or less parallel to the beach shoreline, possibly stretching across most of the width of the bays. In terms of physical structure, both banks were more or less consistent with the description of Habitat 1110 given in the Interpretation Manual of European Union habitats, in that both banks consisted of sandy sediments, and were elevated and elongate, permanently submerged, and surrounded by deeper water.

During the preliminary ecological survey of sandbanks carried out by Borg *et al.* (2013b), samples of infauna were collected using core samplers. The subsequent analysis did not find significant differences in the total number of species or the total abundance of organisms between the sandbanks and nearby non-sandbank 'reference' sites on non-elevated sandy bottoms at each locality. Moreover, no submerged vegetation was present on the sandbanks surveyed in Għajn Tuffieħa Bay and Mellieħa Bay. This confirms that "*on many sandbanks macrophytes do not occur*" as stated in the Interpretation Manual of European Union habitats.

4.2.3. Sandbanks encountered during surveys

The second A2 analysis highlighted that there was still no geomorphological information on the presence and distribution of sandbanks around the Maltese Islands. In order to locate sandy elevations, in 2016 five out of a total of thirty scuba dives were carried out over sandy bottoms at inshore areas C, F, G and H to search for sandbanks in the geomorphological sense. All dives were carried out by a professional team of four scuba divers, two of which were equipped with underwater photo and video cameras. In addition, snorkelers surveyed shallow areas. Sandy elevations were documented and measured at areas F, G and H; no elevations were documented during two surveys carried out at inshore area C.

Inshore Area F - Mellieħa Bay

Two surveys were carried out across Mellieħa Bay, one by SCUBA divers at depths of 2 m to 4 m, and one by snorkelers at depths of up to 1.5 m. Two sandy elevations were located by the snorkelling team at depths of 0.3–0.4 m and 0.02 m. The sandbanks were surrounded by waters which were ca. 0.7 and 0.2 m deep respectively. The approximate physical dimensions of the sandbanks as well as their precise locations were recorded using measuring tapes and a handheld GPS.

The shallowest part of the larger sandy elevation (blue shading in Figure 4.2.2.1) was ca. 3 m wide, and ca. 180 m long, whilst the smaller sandy elevation (green shading in Figure 4.2.2.1) was ca. 11 m long and had a width of ca. 1.5 m. Both sandbanks were located in the northernmost part of Mellieħa Bay. No submerged vegetation was present on the surveyed sandbanks.

Figure 4.2.3.1. Aerial view of the approximate location of two sandbanks in Mellieħa Bay. The shallowest parts of the sandbanks are marked with blue (large sandbank) and green (small sandbank) shading. Points 1 and 2 mark the width of the shallowest area of the larger sandbank. Points 7 and 8 mark the width of the shallowest area of the smaller sandbank. Point 3 represents the deepest point out of the shallow bank in the direction of the coast (0.7 m), while Point 4 is its correspondence at the same depth towards the sea. Points 9 and 10 mark the position of deeper water (0.2 m) next to the smaller sandbank.

Inshore Area H - Għajn Tuffieħa Bay

Three surveys were carried out across Għajn Tuffieħa Bay: (1) SCUBA divers crossed the bay from the south-west to the north-east at depths of 2–3 m, (ii) SCUBA divers crossed the bay from west to east at depths of 1.5 m to 2 m, and (iii) snorkelers crossed the bay surveying at depths of 0.9 m to 1.5 m. A single sandy elevation was located by the snorkelling team at a depth of 0.9 m. The sandbank was surrounded by waters which were ca. 1.4 m deep. The approximate physical dimensions of the sandy elevation, as well as its precise location, were recorded using measuring tapes and a handheld GPS.

At its widest point, the shallowest part of the sandy elevation (blue shading in Figure 4.2.2.2) measured ca. 7.5 m, and the sandy elevation was ca. 90 m long. No submerged vegetation was present on the surveyed sandbank.

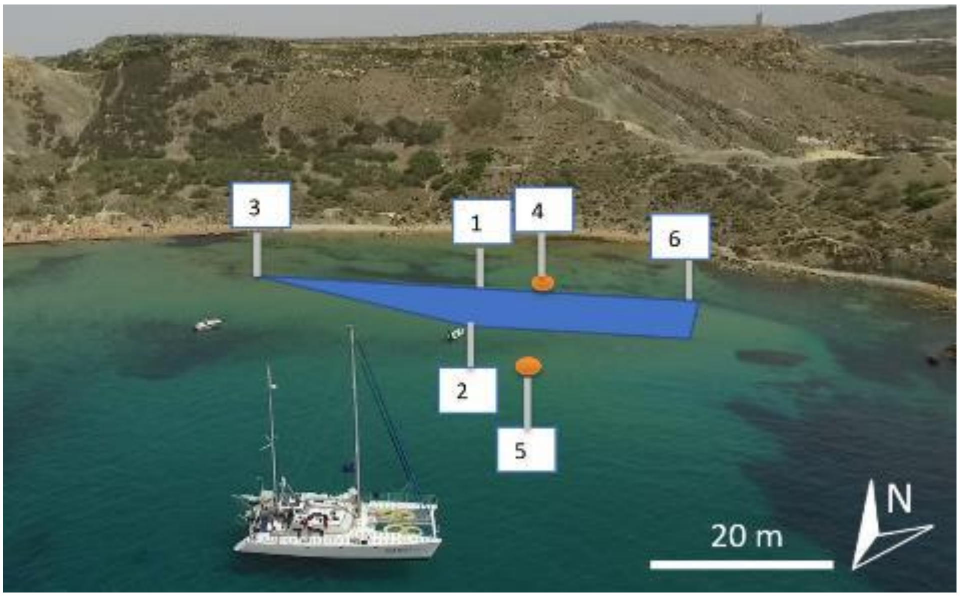

Figure 4.2.3.2. Aerial view of the approximate location of the sandbank in Għajn Tuffieħa Bay. The shallowest part of the sandbank is marked with blue shading. Points 1 and 2 mark the width of the shallowest area of the sandbank, and points 3 and 6 mark the longest part of the sandbank. Point 4 represents the deepest point out of the shallow bank in the direction of the coast (1.4 m), while Point 5 is its correspondence at the same depth towards the sea.

Inshore Area G - Blue Lagoon, Comino

Two surveys were carried out by SCUBA divers at the Comino Blue Lagoon, one crossing the lagoon from west to north at depths of 3 m to 5 m, and the other crossing the lagoon from north to south at depths of 0.9m to 3 m. One minor sandy elevation was located at a depth of 0.9 m. The sandbank was surrounded by waters which were ca. 1 m deep. The approximate physical dimensions of the small sandy elevation, as well as their precise locations, were recorded using measuring tapes and a handheld GPS.

At its widest point, the shallowest part of the sandy elevation (blue shading in Figure 4.2.2.3) measured ca. 17 m, and the longest point of the sandy elevation, stretched over ca. 44 m. No submerged vegetation was present on the surveyed sandbank.

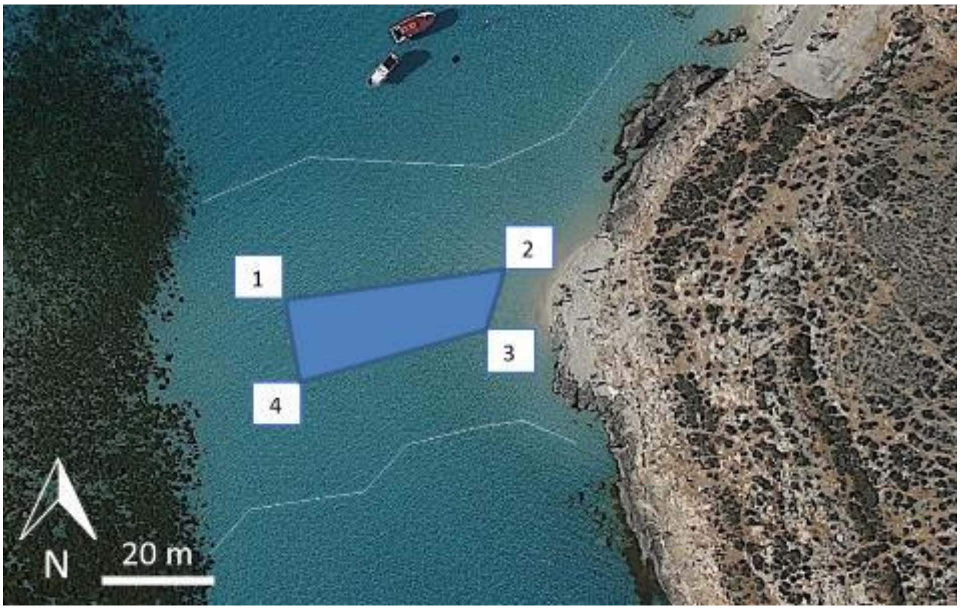

Figure 4.2.3.3. Aerial view of the approximate location of the sandbank in Comino Blue Lagoon. The shallowest part of the sandbank is marked with blue shading. Points 1 and 4 mark the widest part of the sandbank, and points 1 and 2 mark the longest part of the sandbank. The approximate location of the 1 m contour lines is marked by white lines.

4.2.4. Information synthesis and remaining data gaps

The information collected during the second A3 expedition in 2016 indicates that raised sandy elevations tend to be present in very shallow waters in the Maltese Islands, at depths ranging from 0.02 m to 0.9 m. Similarly the sandy elevations surveyed by Borg *et al*. (2013) were located at depths of 0.5 m to 2 m depth. The physical dimensions of the sandbanks surveyed in 2016 were variable, with the lengths of sandy elevations ranging from 11 m to 180 m, and widths ranging from 1.5 m to 17 m. In all cases the surveyed sandbanks were more or less consistent with the description of Habitat 1110 given in the Interpretation Manual of European Union habitats in the physical sense, in that the banks consisted of sandy sediments, were elevated and elongated, were permanently submerged, and were surrounded by deeper water. Detailed geomorphological (and ideally hydrological) studies which span different seasons over several years would however be required in order to understand the processes which maintain sandbanks, and to confirm whether the surveyed sandy elevation indeed persistently have structures in line with the descriptions of sandbanks in the geomorphological literature. Such surveys go beyond the remit of the LIFE BaĦAR for N2K project.

Samples of infauna were not collected during the Action A3 surveys, however Borg *et al*. (2013) did not find any characteristic infauna species to be present on sandy elevations surveyed in Mellieħa and Għajn Tuffieħa Bay. Moreoever, no macroflora, and thus no *Cymodocea nodosa*, were recorded on any of the sandbanks surveyed in 2013 (Borg *et al*., 2013) and during the 2016 A3 surveys. Indeed Borg *et al*. (2015a) point out that in the Maltese Islands, associations with the seagrass *Cymodocea nodosa* are in fact found throughout the infralittoral, from very shallow depths down to about 45 m. *Cymodocea nodosa* may occur as a dense meadow or very sparsely, and the plant may occur as almost monospecific stands or in association with other seagrasses (*Posidonia oceanica* and *Halophila stipulacea*) and/or macroalgae (for example, *Caulerpa cylindracea* or *Caulerpa prolifera*). Long term monitoring of benthic assemblages would be required to ascertain whether there are any biotic assemblages or species which could serve as biological indicators for this habitat type, but such long-term monitoring surveys also go beyond the remit of the LIFE BaĦAR for N2K project.

The sandy elevations which were located and surveyed in the 2016 A3 expedition were all located within existing Marine Protected Areas, and as such the available data indicates that there is no need to designate additional sites for this habitat (Figure 4.2.4.1). However, in the absence of long-term monitoring data it is not possible to draw firm conclusions on whether the sandy elevations which were surveyed during the LIFE BaĦAR for N2K project indeed constitute true sandbanks in line with the definition of HD Annex I Habitat 1110 'Sandbanks which are slightly covered by sea water all the time' included in the EU Habitat Interpretation Manual (version EUR28; European Commission, 2013). Moreover the actual ecological importance of this habitat, and thus the relevance of protecting such habitats in the Maltese Islands has yet to be ascertained.

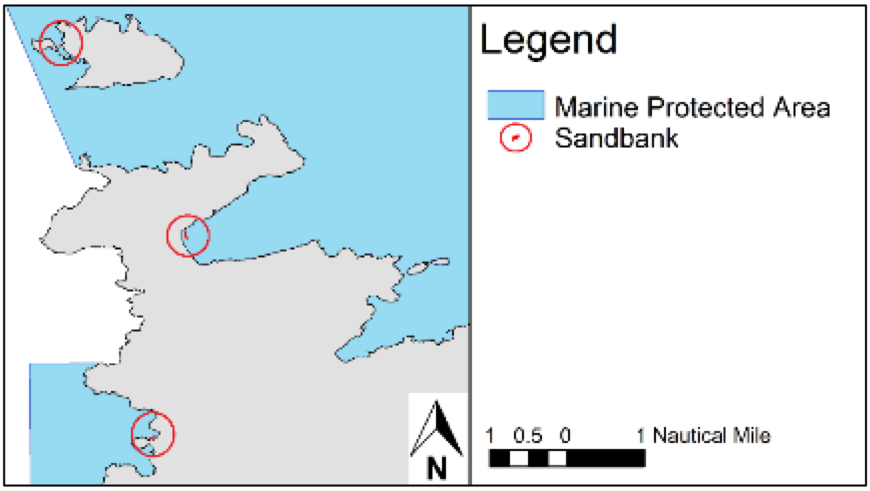

Figure 4.2.4.1. Sandbanks surveyed in Comino and Northern Malta during the 2016 Action A3 expedition. Blue shading indicates the location of existing Marine Protected Areas.

4.3. Habitat 8330: Submerged or partially submerged sea caves

4.3.1. Caves identified through Action A1 or encountered during the A3 surveys

A summary of the outcome of the Action A2 analysis of data on caves that were collated through Action A1 is given in Section 2.1. In order to address knowledge gaps remaining after finalising Action A1 and carrying out the 2015 Action A3 surveys (see Section 3), SCUBA divers used underwater scooters to survey large stretches of coastline and record caves as part of the 2016 Action A3 expedition. A total of 15 partially submerged (hereafter referred to as 'emergent') and 21 fully submerged caves had been located at inshore priority Areas 1, 2, 4 and 11 in the 2015 Action A3 surveys. In 2016, an additional 22 emergent and 31 fully submerged caves were located at inshore priority Areas A, B, D and E. The highest number of caves was found off the northwestern coast of Gozo (Area 4/B; 31 caves), followed by the southwestern coast of Malta (Area 1/A; 26 caves), the southern coast of Gozo (Area 2/D, 22 caves), Comino (Area 11/G; 7 caves), and off Rdum il-Qammieh (Area 7/E; 3 caves). An overview of the caves identified through Action A1 and the Action A3 surveys is presented in Figure 4.3.1.1.

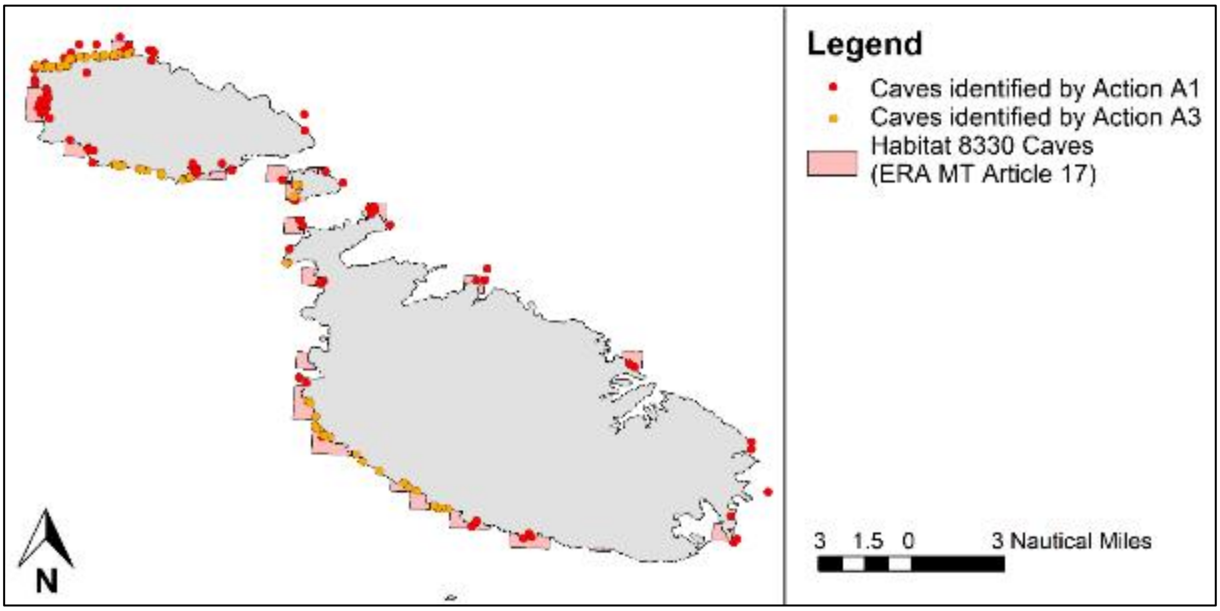

Figure 4.3.1.1. Map of the Maltese Islands showing the locations of caves recorded during the 2015 and 2016 Action A3 surveys of the LIFE BaĦAR for N2K project, and additional caves recorded through Action A1.

The surveyed caves varied in both size and physiognomy from small caves measuring only a few metres, to large fissures and extensive tunnel systems penetrating deeply into the rock. For example, one of the smallest caves recorded in Area 1/A had an entrance ca. 1.5 m high by 1 m wide and extended a mere 2 m into the rock, whilst the largest cave recorded in Area 4/B extended ca. 150 m into the rock and had an entrance ca. 12 m high and 6 m wide. Several caves had chimney-shaped vertical faults rising from the seafloor to the surface, and turns in the main cave passages, as well as overhangs, ledges, and smaller chambers were encountered in numerous caves. The majority of caves surveyed had rocky bottoms, but caves with a sandy entrance and/or sandy floor were also surveyed in Areas 1/A, 2/D, 4/B, 7/E and 11/G, and caves located in Areas 1/A, 2/D, 4/B had bottoms strewn with boulders, possibly indicating past roof-falls. Freshwater seepage was recorded at the rear of an emergent cave extending ca. 15 m into the rock at Area 1/A, in a cave extending 15 m into the rock at a depth of 17 m to 22 m at Area 1/A, in an emergent cave extending 40 m into the rock at area 4/B, and at the rear of a large emergent cave with two entrances extending 70 m into the rock in area 4/B.

Several of the caves were new discoveries and previously unknown; in particular, smaller caves which are less accessible to SCUBA divers had not been previously recorded.

In addition to the caves located during SCUBA dives, seventeen deep-water caves were located during the offshore ROV surveys (Figure 4.3.1.4). Eleven caves were located in priority survey Area A in 2016, five in 2016 Area C, and one was located in 2015 Area 7. Whilst the majority of caves were found at depths of 205–450 m; the deepest cave was recorded at the edge of the Malta Graben at 795 m. Like the inshore caves, these deep water caves also varied in size and physiognomy. However, detailed information on their physical characteristics could not be recorded since it was not possible for the ROV to enter into the caves.

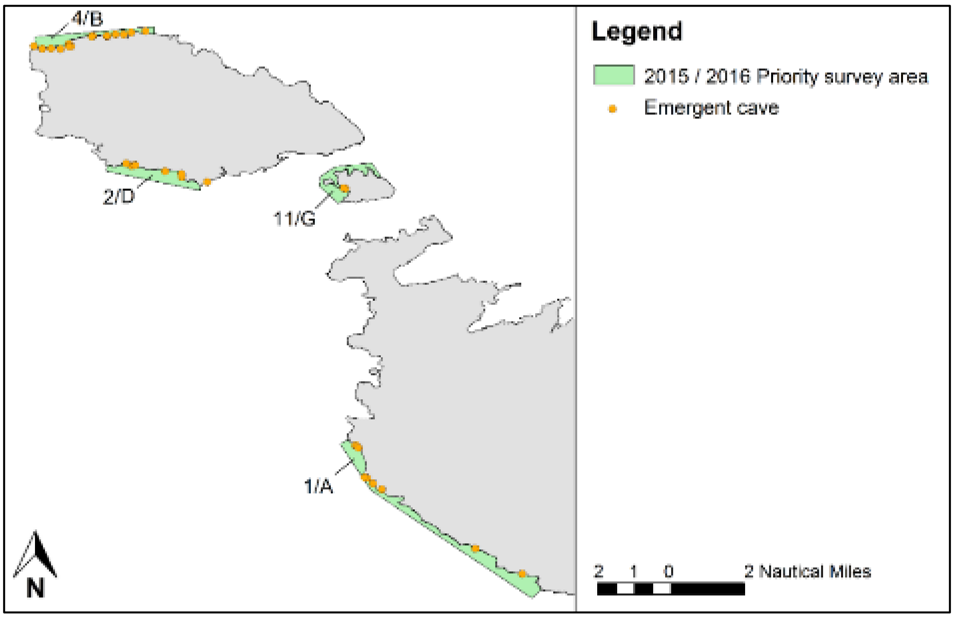

Figure 4.3.1.2. Map of the Maltese Islands showing the locations of emergent caves recorded during the 2015 and 2016 Action A3 surveys of the LIFE BaĦAR for N2K project. Numbers/letters indicate priority of inshore survey areas where caves were located.

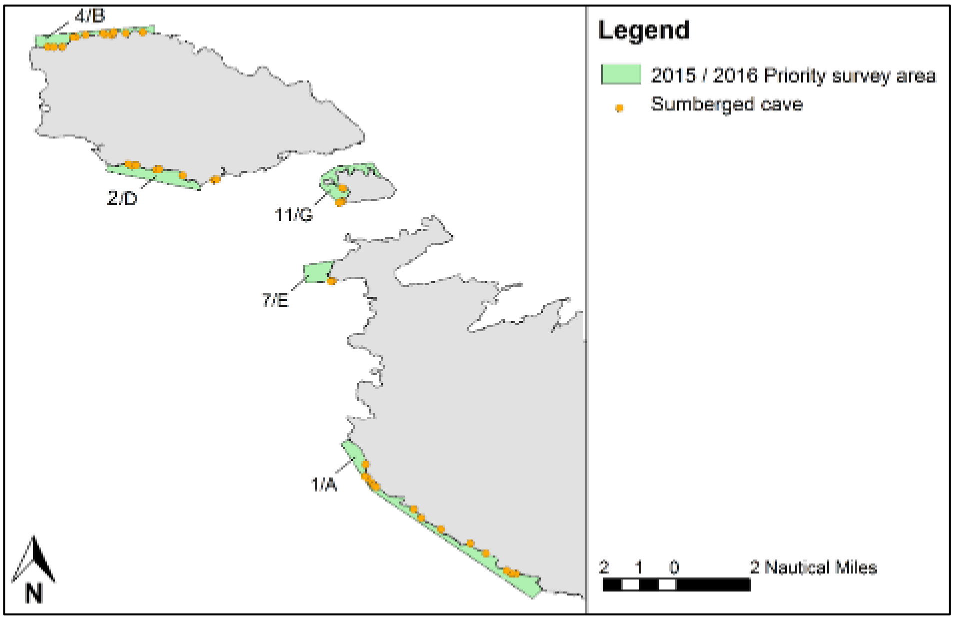

Figure 4.3.1.3. Map of the Maltese Islands showing the locations of submerged caves recorded during the 2015 and 2016 Action A3 surveys of the LIFE BaĦAR for N2K project. Numbers/letters indicate priority rank of inshore survey areas where caves were located.

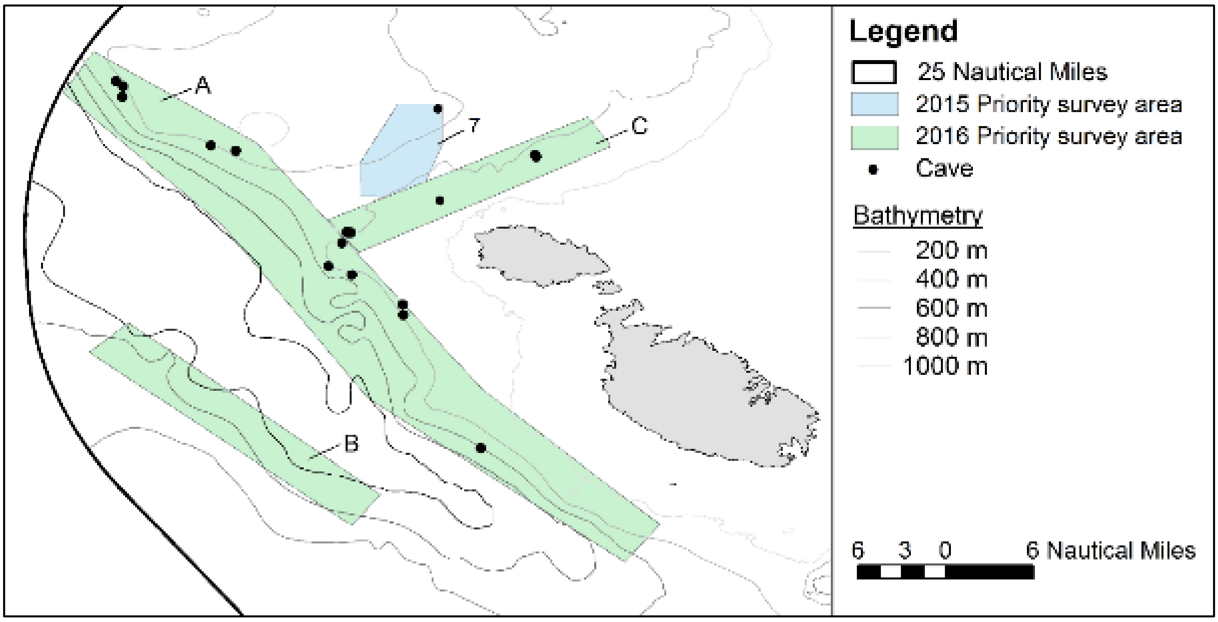

Figure 4.3.1.4. Map of the Maltese Islands showing the locations of offshore caves recorded during the 2015 and 2016 Action A3 surveys of the LIFE BaĦAR for N2K project. Letter/number indicates priority rank of offshore survey areas where caves were located; only priority Area 7 is shown for 2015.

Inshore caves in the Maltese Islands may been formed as a result of both marine and terrestrial processes: direct action of waves on limestone rock at sea-level may turn rock fissures into clefts and eventually caves, or dissolution by ground water may form caves on land. Caves which originate on land may eventually become submerged due to changes in sea-level or due to tectonic movements.

The maximum sea level lowstand during the Pleistocene glaciations was ca. 120 m compared to present day sea level; therefore, caves formed during this period should not be found deeper than this depth. Since a number of caves recorded during the Action A3 surveys were found in deeper waters offshore, there is a possibility that they date back to the Messinian age 5–7 million years ago. During this period, sea levels fell drastically to the point that the Mediterranean was dry in many places.

4.3.2. Cave assemblages

Species assemblages recorded by SCUBA divers show a marked zonation from the cave entrance to the inward end of the cave, and could generally be attributed to three distinct zones:

(i) An outer section where some light penetrates and allows the growth of photophilic algae at the mouth and progressively more sciaphilic species further inwards from the mouth;

(ii) A middle section dominated by sessile invertebrates such as a few sponges, hydroids, brachiopods, corals, tubicolous polychaetes, bryozoans, and foraminifera together with a few highly sciaphilic algae (mostly encrusting corallines);

(iii) A completely dark inner section or dark side chambers largely devoid of sessile organisms.

This is in line with patterns previously recorded in other parts of the Mediterranean, where it has been shown that species richness, biological cover and biomass tend to decrease towards the inner reaches of marine caves (e.g. Bianchi *et al*., 1996; Laborel and Vacelet, 1958; Riedl, 1966). Besides lower levels of light penetration this pattern has been also been attributed to a decrease in water circulation and renewal in the innermost parts of caves, leading to oligotrophic conditions (Buss and Jackson, 1981; Fichez, 1990; Garabou and Flos, 1995).

The main aim of the Action A3 surveys conducted during the LIFE BaĦAR for N2K project was to locate previously unknown caves, and as such no systematic attempt was made at characterising biotic assemblages in detail. A number of samples were collected in order to confirm the preliminary identifications of several rare species encountered during cave surveys. In particular samples of sponges (Porifera) were collected, which will be analysed by specialized taxonomists. It was nevertheless possible to confirm the biocoenotic and ecological characteristics of inshore marine cave habitats in the Maltese Islands recorded in previous studies (Knittweis *et al*., 2015).

Assemblages of sciaphilic algae present on hard substrata at the mouth and entrance of caves were characterised by species such as the chlorophytes *Palmophyllum crassum*, *Cladophora prolifera* and *Flabellia petiolata*, and sciaphilic brown algae such as *Halopteris filicina* and *Zonaria tourneforti*. The most common type of flora found were red algae (Rhodophyta), such as *Lithophyllum incrustans* and *Peysonnelia squamarina*.

The most abundant macroinvertebrates found at the entrance of caves include sciaphilic species of sponges such as *Agelas oroides*, *Crambe crambe*, *Petrosia ficiformis*, *Chondrosia reniformis*, and *Ircinia* sp.; the sipunculan *Phascolosoma granulatum*; species of the polychaete families Amphinomidae, Nereididae, Sabellidae, Serpulidae, and Syllidae; the echinoderms *Ophidiaster ophidianus* and *Hacelia attenuata*; the cnidarian *Astroides calycularis*; and the ascidian *Halocynthia papillosa*. Crustacean species generally recorded from the mouth of caves included several species of hermit crabs (e.g.

Calcinus tubularis); the slipper lobster *Scyllarides latus* and the crawfish *Palinurus elephas*; species belonging to the marine isopod families Janiroidea and Sphaeromatidae; as well as tanaids.

Biotic assemblages found on hard substrata in the semi-dark parts of caves just beyond the cave mouth where dim light is still present included sparse patches of coralline red algae such as *Lithophyllum incrustans* and *Cruoria cruoriaeformis*. The macrofauna present in this zone was more abundant and diverse than the macroflora, and consisted of species such as the anemone *Cerianthus membranacea* in sediment pockets, the scleractinian *Madracis* sp.; the long-spined sea urchin *Centrostephanus longispinus* and the Mediterranean featherstar *Antedon mediterranea*; the sclearctinian *Leptospammia pruvoti*; and a large diversity of sponges. Several species of bryozoans were common in the semi-dark parts of caves of the Maltese Islands, including *Myriapora truncata* and *Sertella* sp. The most common species of crustaceans included the shrimps *Stenopus spinosus*, *Plesionika narval*, the majid crab *Herbstia condyliata*, numerous red cave copepods *Ridgewayia* sp., as well as the mysid *Hemimysis margalefi*. The shrimp *P. narval* may form large swarms.

Species found in totally dark inner parts of caves or in side pockets and chambers include macrofauna such as occasional individuals of the sponge *Fasciospongia* sp., sabellarid and serpulid polychaetes and crustaceans such as *Palaemon serratus*, decapods of the genus *Lysmata*, as well as mysids and ostracods. Moreover, several of the more mobile species found in the semi-dark zones of caves were frequently also encountered in the totally dark inner parts of caves.

Large mobile fauna were frequently observed associated with marine caves in the Maltese Islands during the A3 surveys; examples of such fauna are species of grouper such as *Epinephelus marginatus*, the conger eel *Conger conger*, the cardinalfish *Apogon imberbis*, the forkbeard *Phycis phycis* and the brown meagre *Sciaena umbra*. Interestingly, the alien bluespotted cornetfish *Fistularia commersonii* was on several occasions recorded inside caves during the 2016 A3 expedition.

It was not possible for the ROV to enter into the offshore caves found in deeper waters; however, several species were observed at the entrance of such caves. This included fish such as the dogtooth grouper *Epinephelus caninus*, the greater forkbeard *Phycis phycis*, the parrot seaperch *Callanthias ruber*, the blackbelly rosefish *Helicolenus dactylopterus*, the robust cusk-eel *Benthonectes robustus*; swarms of the shrimps *Plesionika narval* and *Plesionika edwarsii*, the deep-sea swimming crab *Bathynectes maravigna*, the crab *Homola barbata*; the giant deep-sea oyster *Neopycnodonte zibrowii*, and cnidarians such as the red coral *Corallium rubrum*, the white coral *Madrepora oculata,* the gold coral *Savalia savaglia*, the black coral *Antipathes dichotoma*, the alcyonacean (soft coral) *Callogorgia verticillata*, and the alcyonacean *Placogorgia massiliensis*. A number of unidentified species of sponges were also observed.

4.3.3. Conservation status of caves

According to Article 1 of the Habitats Directive, the conservation status of a natural habitat will be taken as 'favourable' when:

- Its natural range and areas it covers within that range are stable or increasing;

- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future;
- The conservation status of its typical species is favourable.

In the case of caves, the concept of 'range' does not apply since these are geological features. A one-off exercise to locate the different caves and assess their areas, followed by long-term monitoring to check for any diminishment of the area of the caves should instead be carried out. Cave area is likely to increase as a result of erosion, and decrease as a result of collapse; both phenomena are important in the Maltese Islands due to the abundance of soft rocks. Dimensions such as depth (relative to sea-level), floor width, wall height and wall bearings measured across the floor will be useful measurements. Moreover, measures of cross-section at pre-determined points will serve as useful baseline reference measurements for future surveys. The total number of existing marine caves is unlikely to change significantly over time, but anthropogenic activity (e.g. coastal development) and natural events (e.g. cliff erosion, storms) may lead to the creation / loss of marine caves, so periodic monitoring will be necessary to assess the status of this habitat in terms of area. Through the data collection exercise undertaken in Action A1, and the 2015 and 2016 Action A3 surveys, the location and areas of numerous caves in Maltese waters have been established, which will serve as useful baseline references for future surveys.

One of the key factors when assessing the status of habitats listed under Annex I is that the specific structure and functions that are necessary for the habitat's long-term maintenance exist, and which are likely to continue to exist in the foreseeable future. This attribute thus refers to characteristic habitat structure as well as to associated characteristic species. In assessing structure and function of caves, two main types of anthropogenic pressures need to be taken into account:

1. pressures which affect the physical structure of the cave (which are likely to be catastrophic events, such as the collapse of part of a cave roof or a submarine rock face);
2. those that will affect the species living in a marine cave (due to pressures such as SCUBA diving, pollution, sedimentation, fishing (e.g. illegal red coral harvesting) etc.).

The presence or absence, relative abundance, and zonation of characterising species will also allow inferences to be made about the current condition of the habitat. The current condition of the habitat can thus be monitored using indicators such as (i) the ratio of selected groups of flora to selected groups of fauna present in the different cave zones, (ii) the ratio of total abundance of species of fleshy and coralline algae present, (iii) presence / absence and or coverage of selected indicator species.

An important source of threats and pressures on typical species found in emergent and submerged caves in the Maltese Islands is from SCUBA diving. The movement of divers inside caves frequently causes mechanical damage to erect benthic species, and trapped air bubbles generated by divers may damage species growing on cave ceilings (Schembri, 1995). A well-known example of such damage is the destruction of fragile bryozoan colonies in caves located at Dwejra, which was first reported by Borg *et al*. in 1997, but continues to the present day.

The main threats and pressures on typical species found in cave habitats surveyed during the Action A3 surveys are due to marine litter. Plastic debris as well as fishing gear were recorded in several of the caves surveyed (Figure 4.3.3.1). No impacts due to SCUBA diving were recorded, mainly because many of the caves were small, inaccessible or unknown, and thus not frequented by divers. Overall the pressures recorded in the surveyed caves appear to be minimal and the caves generally appeared to be in good status.

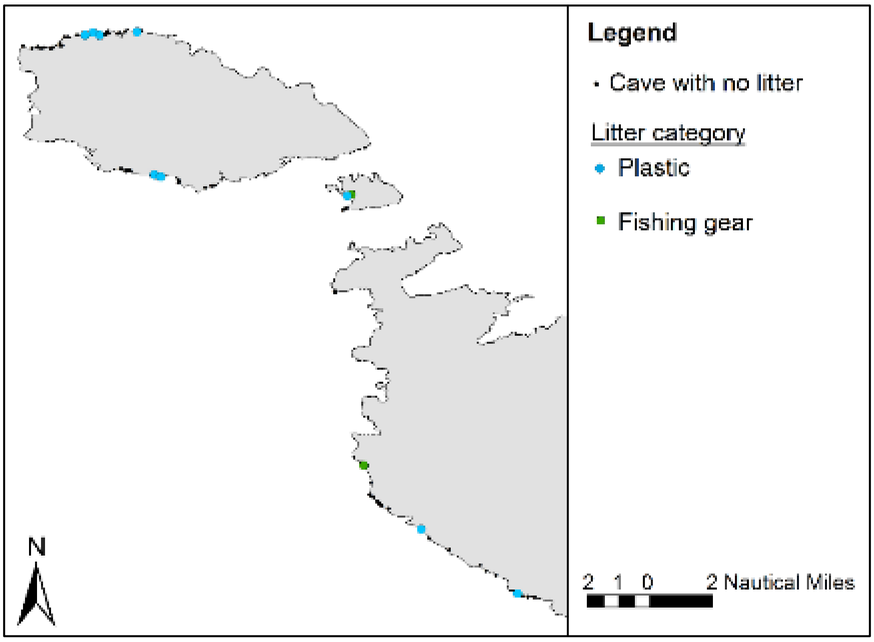

Figure 4.3.3.1. Map of the Maltese Islands showing the locations of different types of marine litter and fishing gear in caves encountered in inshore locations during the Action A3 surveys of the LIFE BaĦAR for N2K project.

An overall assessment of the threats and pressures applicable to cave habitats, partly based on the data collected through Action A1 and on the Action A3 results, is given in Table 4.3.3.1. As noted in the analysis of Action A1 data (Borg *et al*., 2016a), the A1 dataset contained information on fuel supply points, marine discharges and sewage outflow/overflow sites, desalinisation plants, landfills, spoil grounds / dumping sites, aviation (fuel jettison areas), shipping (bunkering areas), aquaculture (aquaculture boundaries), commercial fishing (location of transects where fishers may deploy fish aggregating devices, boundaries of trawling areas, trawling intensity from vessel monitoring system data, fishing activity maps for swordfish, dolphinfish and tuna), and recreational activities (swimmers' zones, dive sites). However, data on other relevant threats and pressures, such as the extent of coastal development, recreational boating and anchoring, swimming outside of swimmers zones, or recreational fishing were not available. The Action A3 surveys, on the other hand, focused only on threats and pressures that could be visually documented during the habitat surveys, which mostly concerned the presence of marine litter. In order to make a comprehensive assessment of threats and pressures, Table 4.3.3.1 also considers potential threats in addition to ones identified through Actions A1 and A3; activities that are unlikely to pose a threat to cave assemblages (e.g. anchoring) have been excluded.

Table 4.3.3.1. List of threats and pressures applicable to cave habitats (based on the EU 'Reference list Threats, Pressures and Activities' used for reporting under Article 17 of the Habitats Directive), with explanatory notes.

Code	Description	Notes
D D03.01 D03.03	Transportation and service corridors Port areas Marine constructions	New marine constructions (including slipways and piers that are classified under D03.01 even though they may occur outside port areas) can cause direct mechanical damage to coastal or inshore caves; no such constructions were noted in most of the areas surveyed through Action A3
E E03	Urbanisation, residential and commercial development Discharges	Discharges will not affect the physical structure of caves but can have an impact on the biotic assemblages of inshore caves located within the discharge plume; Action A1 did not document any discharges in the areas selected for surveying.
F F02.01 F02.03 F05	Biological resource use other than agriculture & forestry Professional passive fishing Leisure fishing Illegal taking/removal of marine fauna	Passive fishing via trammel nets and traps and leisure fishing (pole fishing or spearfishing) can target fish associated with cave habitats in inshore waters. Passive fishing via demersal longlines has a similar effect if undertaken along offshore reefs near caves. Lost or discarded fishing gear may have additional impacts (see 'H' below). Similar impacts can arise due to illegal fisheries such as those targeting precious red coral which can be found in caves (see Cattaneo-Vietti *et al.*, 2017), although thus far there is no evidence that this is occurring in Maltese waters.
G G01.07	Human intrusions and disturbances Scuba diving	The movement of divers inside caves is known to cause mechanical damage to erect benthic species, and trapped air bubbles generated by divers may damage species growing on cave ceilings (Borg *et al.*, 1997; Schembri, 1995).
H H01 H03.01 H03.03	Pollution Pollution to surface waters Oil spills in the sea Marine macro-pollution	Pollution will not impact the physical structure of caves but may affect reef species that are sensitive to the pollutants; oil spills may have a more extensive effect for inshore caves and are considered a potential threat given the various bunkering zones in Maltese waters as documented through Action A1, even though no major oil spills are known to have occurred. Marine littering was the most extensive anthropogenic impact seen in the Action A3 surveys (see Figure 4.3.3.1). Discarded fishing ropes/lines were also recorded in some caves (see Figure 4.3.3.1).
I I01	Invasive, other problematic species or genes Invasive non-native species	Non-native species may threaten cave assemblages by outcompeting indigenous species; a number of alien species have been recorded in Mediterranean marine caves (Gerovasileiou *et al.*, 2016). No alien species were documented during the Action A3 surveys, but this may be due to the fact that no systematic characterisation

		of the biotic assemblages found in caves was undertaken.
K K01.01 K01.02	Natural biotic and abiotic processes Erosion Silting up	Erosion is a phenomenon in Malta due to the abundance of soft rocks. Silting up can be a threat to cave organisms; several caves with soft bottoms were recorded during the Action A3 surveys.
L L05	Geological events, natural catastrophes Collapse of terrain, landslide	Natural catastrophes such as collapse of submarine rock faces would result in a reduction of the area occupied by geogenic structures such as caves. The occasional collapse of a cave roof is likely to be a relatively common phenomenon in Malta due to the abundance of soft rocks; several caves with large boulders on the cave floor likely to have originated from such a cave roof collapse were recorded during the Action A3 surveys.
M M01.01 M01.04 M01.05	Climate change Temperature changes pH changes Water flow changes	Climatic changes can have a direct impact on cave species, for example if the temperature and/or pH of an area shifts so conditions are no longer optimal for a given species, or due to extreme events such as temperature anomalies that can cause mass mortalities. Water flow changes can be detrimental by altering the availability of food supply, which is particularly relevant for sessile suspension feeders.

As indicated above, assessment of the conservation status of cave habitats should ideally be based on long-term monitoring, since this is necessary to indicate whether the range/area of the habitat is stable, to assess if the structure and functions needed for long-term maintenance exist and whether they are being influenced by anthropogenic pressures, and to determine whether the conservation status of typical species is favourable. While such long-term monitoring goes beyond the scope of the LIFE BaĦAR for N2K project, the surveys carried out during this project have provided useful data that can support the assessment of conservation status, as well as serve as a baseline against which to compare the outcomes of any future surveys as part of a long-term monitoring plan. Based on the available data, the following conclusions can be made regarding the conservation status of reef habitats:

- As noted above the concept of range does not apply for caves since they are geogenic structures, and there is no evidence of any decrease in area of such habitats.
- No impacts affecting the physical structure of caves were documented through the LIFE BaĦAR for N2K project. On the other hand some pressures that could affect cave assemblages, such as marine litter and fishing gear were documented; while the snapshot data generated through the project is not sufficient to determine if these impacts are resulting in changes in population size/structure of key species or a decrease in species richness or coverage, all surveyed caves appeared to be in good status indicating good prospects for long-term maintenance of these assemblages.
- The same considerations regarding the assessment of structure and functions also apply to assessment of conservation status of key species, which requires long-term population

dynamics data on which to assess population viability and changes in natural range of the species. Nonetheless, the available data on the general status of the surveyed cave assemblages suggests that key cave species have self-sustaining populations and no reduction in their natural range could be inferred; there is also a sufficiently large area of habitat to maintain populations on a long-term basis.

- Based on these considerations, the overall conservation status of cave habitats is considered to be favourable.

4.3.4. Caves of particular interest

The Maltese Islands are composed almost entirely of limestones which date back to the Oligo-Miocene period. Numerous emergent and submerged marine caves have been formed by a combination of both terrestrial and marine processes (Borg *et al.*, 2013). Biotic communities found in marine caves vary depending on the size and structure of the caves, the degree to which they are submerged, the geology of the cave, the degree of exposure to waves and/or currents and sediment scour. Strong environmental gradients exist, especially in light intensity and turbulence, as one proceeds inwards from the cave mouth. The spatial extent of the different micro-habitats which exist inside caves depends on a number of physiographic features, including the depth of the cave, aspect/size/configuration of the cave mouth, and how deep the cave penetrates into the rock. Other important factors include temperature, the presence of haloclines, the presence of side-branches, chambers, ledges and other geomorphological features in the cave itself, and the nature of the cave floor, which may be rock, strewn with pebbles/cobbles/small boulders, or may be covered with sediment that in turn may be coarse to very fine. Clearly, caves are thus complex habitats with a variety of biotopes. The Action A3 surveys revealed a particularly high density of previously unknown caves off the northwestern coast of Gozo, the southwestern coast of Malta and the southern coast of Gozo, most of which were located outside existing MPAs (Figure 4.3.4.1).

It may not be practical to include the entire range of structural and ecological variation of marine caves that exist in the Maltese Islands in future cave monitoring programmes. Instead, a practical approach for monitoring of coastal caves (i.e. those accessible by SCUBA diving) is to monitor a few representative emergent and fully submerged caves with well developed, undisturbed gradations in community composition from the entrance to the inner parts of the cave. Long-lived species present in undisturbed cave systems are more suitable targets for long term monitoring than short-lived species found in marine caves subject to stronger wave action and scouring. Caves with such less well developed assemblages may contain ephemeral species undergoing succession; one species may be superseded by another in the time period between monitoring events due to natural ecological processes. The following types of marine caves are thus of particular interest:

1. Submerged marine caves with a well-developed marine cave system;
2. Partially submerged marine caves with a well-developed marine cave system.

Although no detailed characterisation of cave assemblages was carried out during the Action A3 surveys, the larger caves surveyed appeared to have such characteristic gradations in community composition.

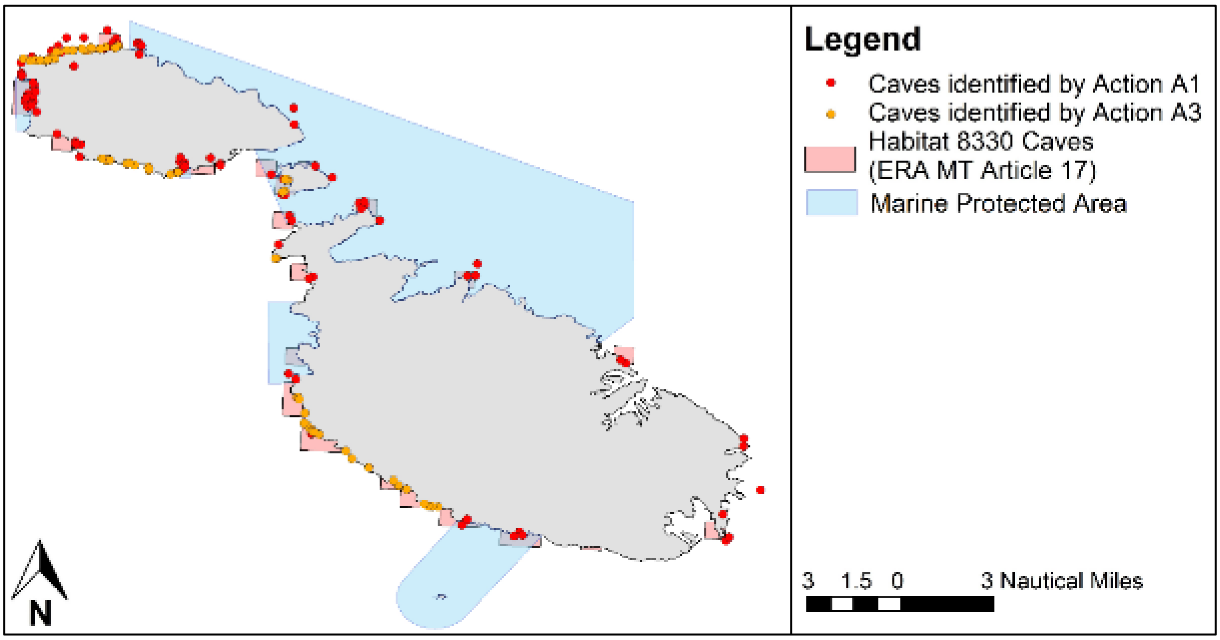

Figure 4.3.4.1. Map of the Maltese Islands showing the locations of inshore caves recorded during the LIFE BaĦAR for N2K project, in relation to previously known caves and exiting Marine Protected Areas.

4.4. Other habitats of conservation interest

4.4.1. Rhodolith accumulations

Rhodoliths are unattached nodules formed by calcareous red algae which may take a number of different forms, ranging from compact spherical nodules to ones with branched, twig-like thalli. Accumulations of rhodoliths, ranging from sparse rhodoliths occurring individually to dense rhodolith beds, were recorded in several sites off southeastern Malta at depths of 50 m to 100 m during the Action A3 surveys, while other sites in this area and also off the northeastern coast that support rhodolith/maerl beds were documented through Action A1 (Figure 4.4.1.1).

Rhodolith and maerl beds are of high conservation value (e.g. Basso *et al*., 2016) which has led to several initiatives aimed at their conservation. Thus, under the Barcelona Convention, maerl beds are included in the UNEP/MAP/RAC-SPA "*Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest*" (UNEP/MAP/RAC-SPA, 2006) while an action plan for their conservation has also been formulated (UNEP/MAP/RAC-SPA, 2008). Within European legislation, Council Regulation 1967/2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, bans the use of specific fishing gear (trawl nets, dredges, shore seines or similar nets) on coralligenous or maerl beds, while the Habitats Directive includes the rhodolith-forming species *Phymatolithon calcareum* and *Lithothamnion corallioides* in Annex V (animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures). It should be noted that in these legislative documents the term "maerl" is defined broadly and used as a collective term for several kinds of assemblages of unattached calcareous red algae on sedimentary bottoms, hence being treated as a synonym for “rhodolith bed”. However, according to Basso *et al*. (2016), “rhodolith beds” should be identified and delimited as those areas of the sea floor with >10% cover of live rhodoliths over a minimum surface of 500 m^2, while the term “maerl” refers to a specific type of rhodolith bed that is composed of non-nucleated, unattached growths of branching, twig-like coralline algae.

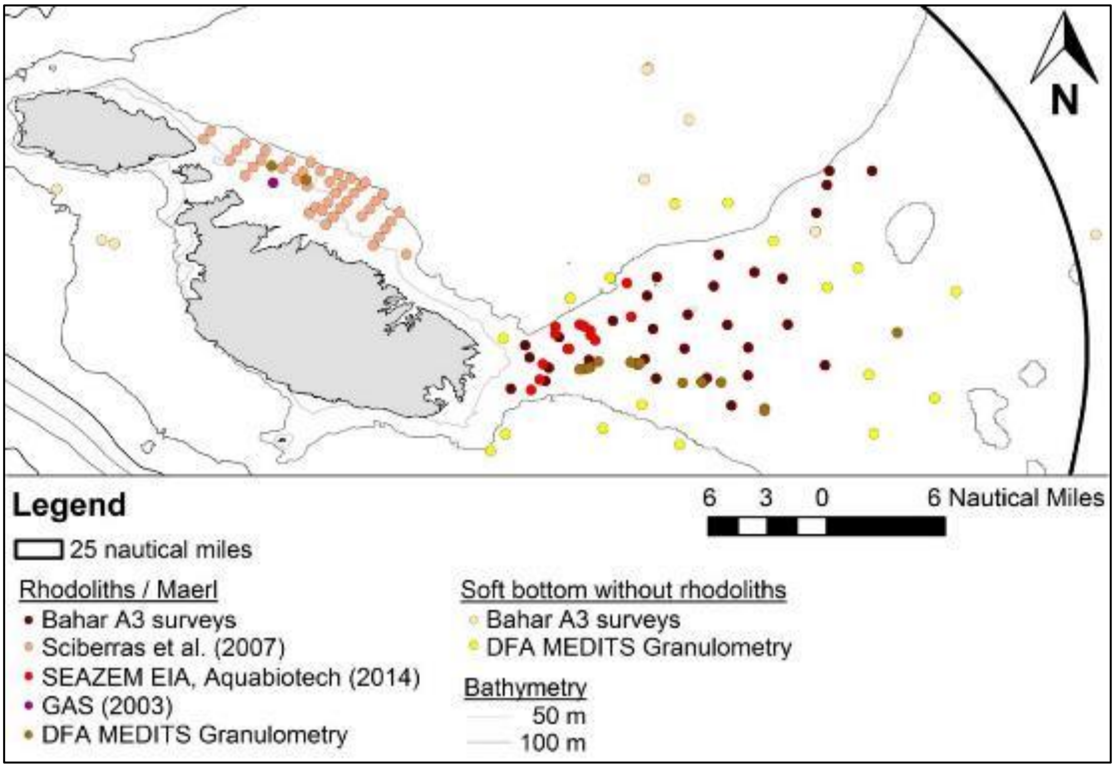

Figure 4.4.1.1. Map of the Maltese Islands showing the locations of rhodolith accumulations documented through Action A1 or encountered during the Action A3 surveys of the LIFE BaĦAR for N2K project.

4.4.2. Bathyal muds with facies of *Funiculina quadrangularis*

Bathyal muds with the sea pen *Funiculina quadrangularis* (Figure 4.4.2.1) were recorded in several areas within the Malta FMZ, particularly on flat plains at the foot or plateaux of escarpments. Other species such as *Pennatula* spp., and in some areas *Kophobelemnon stelliferum* and *Thenea muricata*, as well as motile echinoderms and crustaceans (including *Nephrops norvegicus*) were also recorded in bathyal mud habitats. Bathyal muds with facies of the sea pen *Funiculina quadrangularis* are not protected under EU legislation but are included in the UNEP/MAP/RAC-SPA “*Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest*” (UNEP/MAP/RAC-SPA, 2006) because they are characterised by species associated only with such habitats, “among which are numerous endemics, some of which can be considered as pre-Messinian relicts” (Bellan-Santini *et al*., 2002). The facies with *F. quadrangularis* are also included in the UNEP/MAP/RAC-SPA reference list because they can contain abundant populations of marketable crustaceans and cephalopods, although it is not known whether this is due to the presence of benthic cnidarians (Bellan-Santini *et al*., 2002). Parties to the Barcelona Convention, which include Malta and the EU collectively, are therefore obliged to protect this habitat; for EU Member States this obligation is further reinforced by the Marine Strategy Framework Directive (MSFD). The MSFD translates a number of EU and international commitments related to environmental protection in the marine environment, including the Regional Sea Conventions (RSCs; i.e. the Barcelona Convention in the case of the Mediterranean), to the legal order of the Union. In fact the MSFD includes numerous provisions which aim at ensuring that its implementation not only contributes, but also builds upon the activities of these conventions. In addition, the MSFD considers the establishment of MPAs as an important contribution to the achievement of good environmental status; Article 13(4) of the MSFD requires that the networks of MPAs are coherent and representative, adequately covering the diversity of the constituent ecosystems, and expressly goes beyond Natura 2000 by extending such networks to those MPAs established under the RSCs (European Commission, 2012).

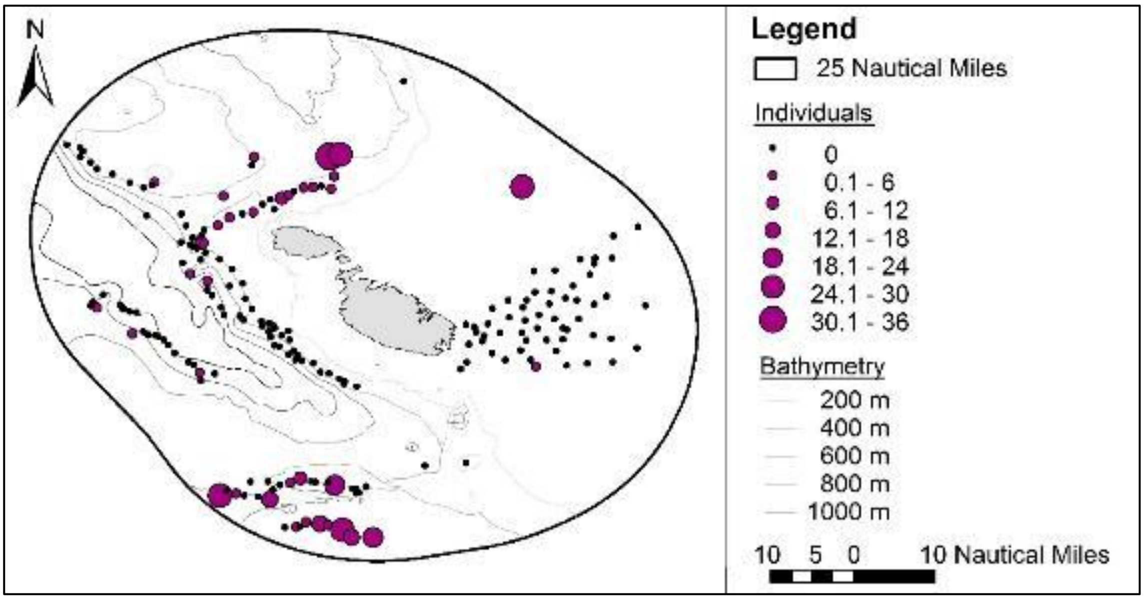

Figure 4.4.2.1. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Funiculina quadrangularis* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project.

4.5. Species protected by the Habitats Directive

None of the species recorded during the surveys were listed in Annex II - Animal and Plant Species of Community Interest whose Conservation Requires the Designation of Special Areas of Conservation - of the Habitats Directive. However, two other 'Species of Community Interest' (as defined in Article 1 (g) of the Habitats Directive) were recorded: the long-spined sea urchin *Centrostephanus longispinus*, and precious red coral *Corallium rubrum*.

4.5.1. Long-spined sea urchin

The long-spined sea urchin *Centrostephanus longispinus*, which is listed in Annex IV – 'Animal and Plant Species of Community Interest in Need of Strict Protection', was recorded during inshore ROV, offshore ROV, and SCUBA surveys (Figure 4.5.1.1). The species was most abundant on soft bottoms off the western coast of Malta at depths of 100 m to 120 m, and off southeastern Malta at depths of 60 m to 120 m.

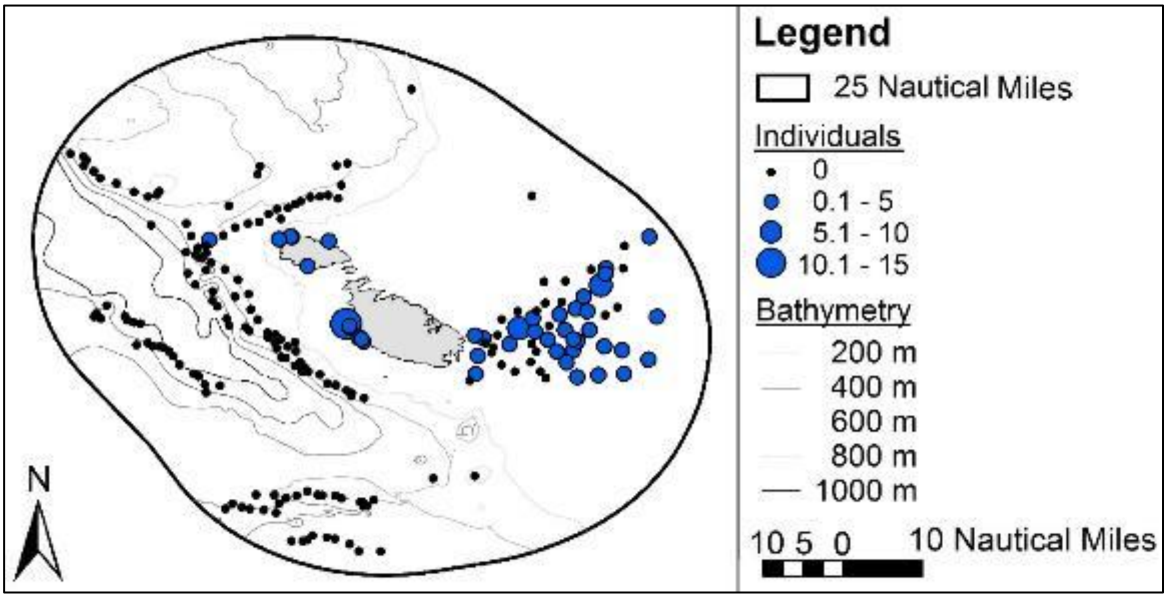

Figure 4.5.1.1. Map of the Maltese Islands showing the locations and frequency (an index of relative abundance) of *Centrostephanus longispinus* sightings recorded during the Action A3 surveys of the LIFE BaĦAR for N2K project.

4.5.2. Precious red coral

The precious red coral *Corallium rubrum*, which is listed in Annex V – 'Animal and Plant Species of Community Interest Whose Taking in the Wild and Exploitation May be Subject to Management Measures', was recorded during the offshore ROV surveys. Colonies of the precious red coral *C. rubrum* were observed at depths of down to 1016 m, which represents the first time that this species has been recorded at depths exceeding 800 m (Knittweis *et al*., 2016).

5. Conclusion

5.1. Synthesis of main findings

In summary, analysis of the data collected during the Action A3 surveys resulted in the following main findings with regards to the three habitats of interest for the LIFE BaĦAR for N2K project:

Reefs

- Identification of new areas with extensive and diverse cold water coral assemblages at depths of 300–1000 m extending some 70 km along the Malta Graben, including antipatharian coral (*L. glaberrima*) forests at 200–400 m and predominantly white corals (*M. oculata* and to a lesser extent *L. pertusa*) in waters deeper than 500 m, with some areas at depths of 800–1000 m dominated by the alcyonacean *C. verticillata*, together with other less abundant habitat-forming and associated species (especially sponges, cnidarians, echinoderms, molluscs, crustaceans and fish).
- Discovery of a dead (possibly fossil) lithistid sponge reef located north of Gozo at a depth of ca. 300 m, and extending over a 7 km long area, serving as a substratum for several species including sponges, cnidarians and bryozoans.
- Identification of areas with dead coral frameworks, one site with a boulder field at 100 m depth, and sporadic sites with rocky outcrops supporting coralline concretions at depths of 60–120 m, supporting benthic faunal assemblages comprising a range of sponges, cnidarians, echinoderms, molluscs and crustaceans which, however, were less species rich than the assemblages recorded from areas with either living cold water corals or the lithistid reef.
- Characterisation of the infralittoral algal assemblages and associated fauna found on the submarine part of emergent vertical rock faces at depths of 2–35 m.
- The main threats and pressures on typical species found in the reef habitats surveyed during the Action A3 surveys were due to marine litter, in particular lost/discarded fishing gear. The overall conservation status of reef habitats is however considered to be favourable.

Sandbanks

- The results indicate that sandbanks in the Maltese Islands tend to be present in very shallow waters, at depths ranging from ca. 0.02 m to 2.00 m. The surveyed sandbanks had variable dimensions, with lengths ranging from ca. 11 m to 180 m, and widths ranging from ca. 1.5 m to 17 m, were permanently submerged, and surrounded by deeper water. They were thus consistent with the description of Habitat 1110 given in the Interpretation Manual of European Union habitats in the physical sense.
- No macroflora, and thus no *Cymodocea nodosa*, were recorded on any of the surveyed sandbanks. Instead associations with *C. nodosa* were found throughout the infralittoral, down to ca. 45 m. *C. nodosa* is thus clearly not limited to the environmental conditions created by sandbanks in the Maltese Islands, is not generally present where such conditions occur, and is therefore not a useful indicator species for this habitat type.
- From the scientific aspect, detailed seasonal studies of physical characteristics are required to confirm which habitats in Malta may be classed as sandbanks in the geomorphological sense, noting the problematic definition in the EU Interpretation Manual. Monitoring of benthic assemblages is also required to ascertain whether there are any biotic assemblages which could serve as biological indicators for this habitat type, and to demonstrate the ecological importance of this habitat.

Caves

- Location of a total 37 emergent and 52 fully submerged caves in inshore areas during the LIFE BaĦAR surveys, which varied in both size and structure from small caves measuring only a few metres, to large fissures and extensive tunnel systems penetrating deeply into the rock. Large caves showed a marked zonation from the cave entrance to the inner end of the cave, and generally three distinct zones could be distinguished: (i) an outer section where some light penetrates and allows the growth of photophilic algae at the mouth and progressively more sciaphilic species further inwards from the mouth; (ii) a tenebrous middle section dominated by sessile invertebrates such as a few sponges, hydroids, brachiopods, corals, tubicolous polychaetes, bryozoans, and foraminifera together with a few highly sciaphilic algae (mostly encrusting corallines); and (iii) a completely dark inner section or dark side chambers largely devoid of sessile organisms.
- New records of a total of 17 deep-water caves, mostly located west and north of Gozo at depths of 205–450 m, but also including a cave recorded at the edge of the Malta Graben at 795 m. Typical species found at the entrance of such deep-water caves were recorded although the ROV was not able to penetrate into the caves to record footage of biotic assemblages found within.
- The main threats and pressures on typical species found in the cave habitats surveyed during the Action A3 surveys were due to marine litter, in particular plastics accumulating inside caves. The overall conservation status of reef habitats is however considered to be favourable.

5.2. Recommendations on sites hosting areas with a conservation potential

Three inshore sites hosting areas with conservation potential (i.e. that have the potential to be proposed as SCIs) were identified. In order of priority these are: (i) a site bordering the northwestern coast of Gozo, (ii) a site bordering the southwestern coast of Malta, and (iii) a site bordering the southern coast of Gozo. The sites were selected to protect the large number of emergent as well as submerged caves (Habitat 8330; Figure 5.2.1), and reefs (Habitat 1170; Figure 5.2.2) present. The species assemblages present in these habitats are typical of cave and reef habitats found in the Maltese Islands (see sections 4.1.2 and 4.3.2 of the present report), and *Centrostephanus longispinus* (listed in Annex IV of the Habitats Directive) is known to occur at the sites.

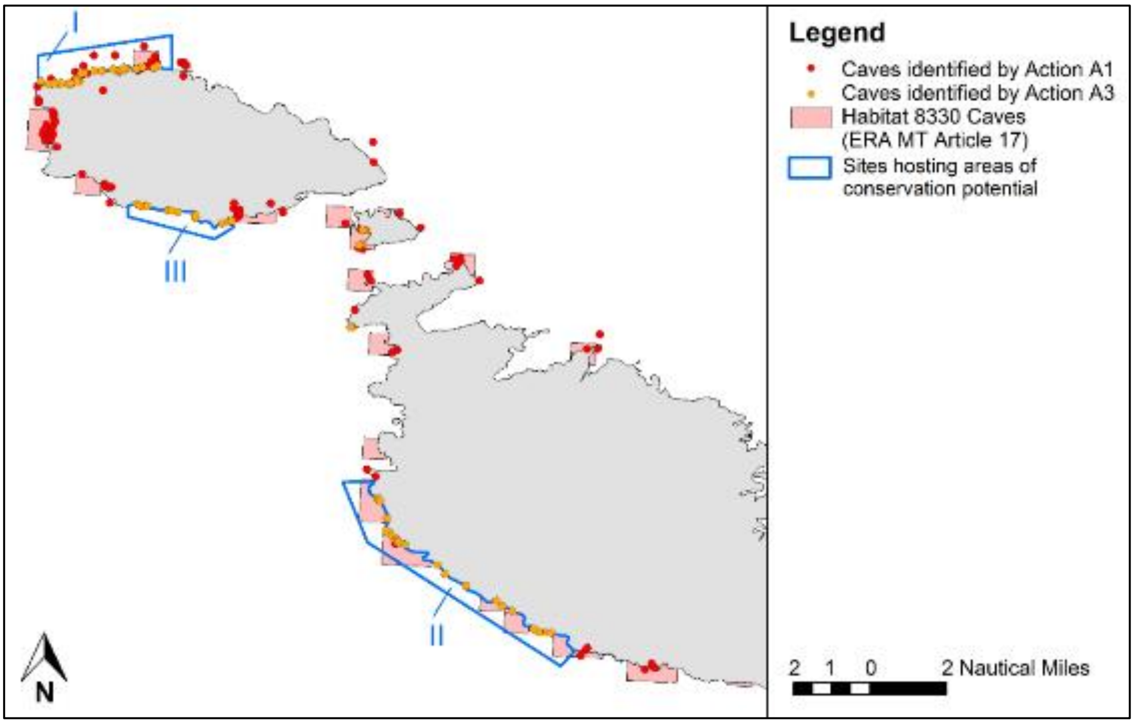

Figure 5.2.1. Map showing recommended locations of inshore sites hosting areas with a conservation potential in relation to cave and reef habitats; the location of recorded caves is also indicated. Roman numbers refer to overall order of priority.

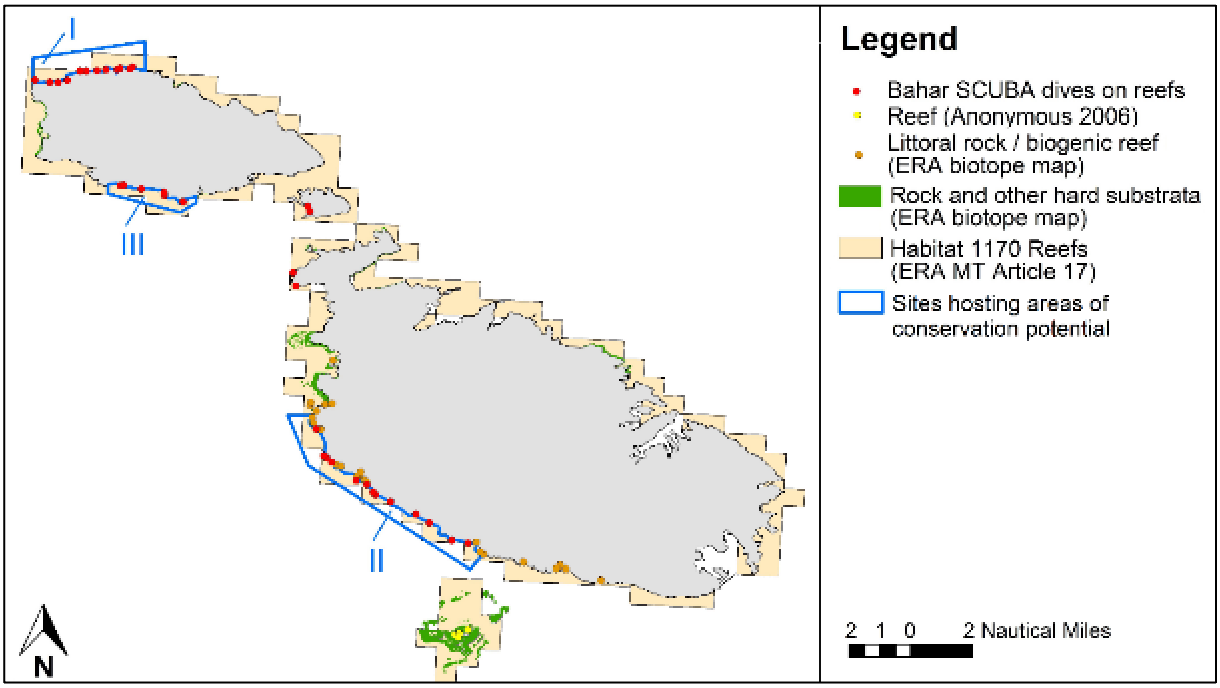

Figure 5.2.2. Map showing recommended locations of inshore sites hosting areas with a conservation potential in relation to cave and reef habitats; the location of recorded reef habitats is also indicated. Roman numbers refer to overall order of priority.

Five offshore sites which may host appropriate areas for designation as proposed Sites of Community Importance (pSCI) are identified. In order of priority these are: (i) a site bordering the southwestern limit of the 25 nautical mile FMZ surrounding the Maltese Islands, (ii) a site bordering the eastern edge of the Malta Graben, (iii) a site bordering the western edge of the Malta Graben, (iv) a site located to the north of Gozo, and (v) a site bordering the northwestern limit of the FMZ, which also lies along the eastern edge of the Malta Graben. The sites were selected to protect deep-sea caves (Habitat 8330; Figure 5.2.3) and offshore reef habitats, including facies of *Isidella elongata* associated with reef habitats in line with the reef habitat definition given in the EU Habitat Interpretation Manual (European Commission, 2013) (Habitat 1170; Figure 5.2.4), also taking into consideration bathyal muds with facies of *Funiculina quadrangularis* when these occurred close to reefs. Both facies with *Isidella elongata* and *Funiculina quadrangularis* are listed in the UNEP/MAP/RAC-SPA "*Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest*" (Figure 5.2.4; see section 4.4.2).

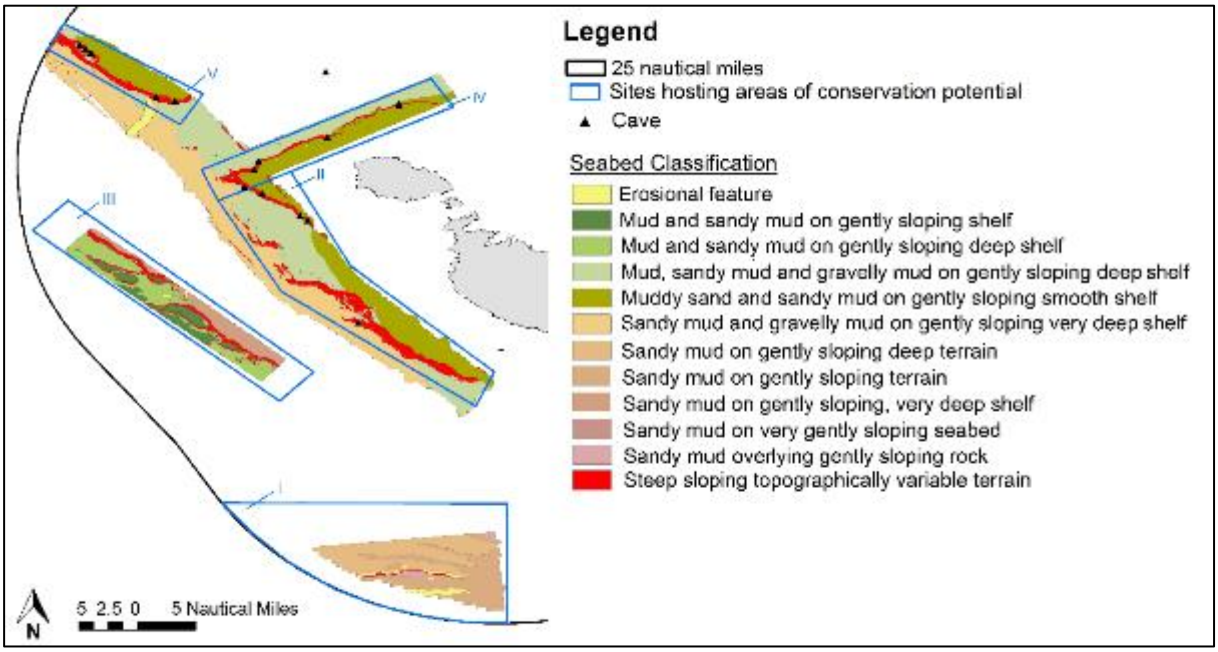

Figure 5.2.3. Map showing recommended locations of offshore sites hosting areas with a conservation potential in relation to reef and cave habitats; the location of recorded caves is also indicated. Roman numbers refer to the overall order of priority.

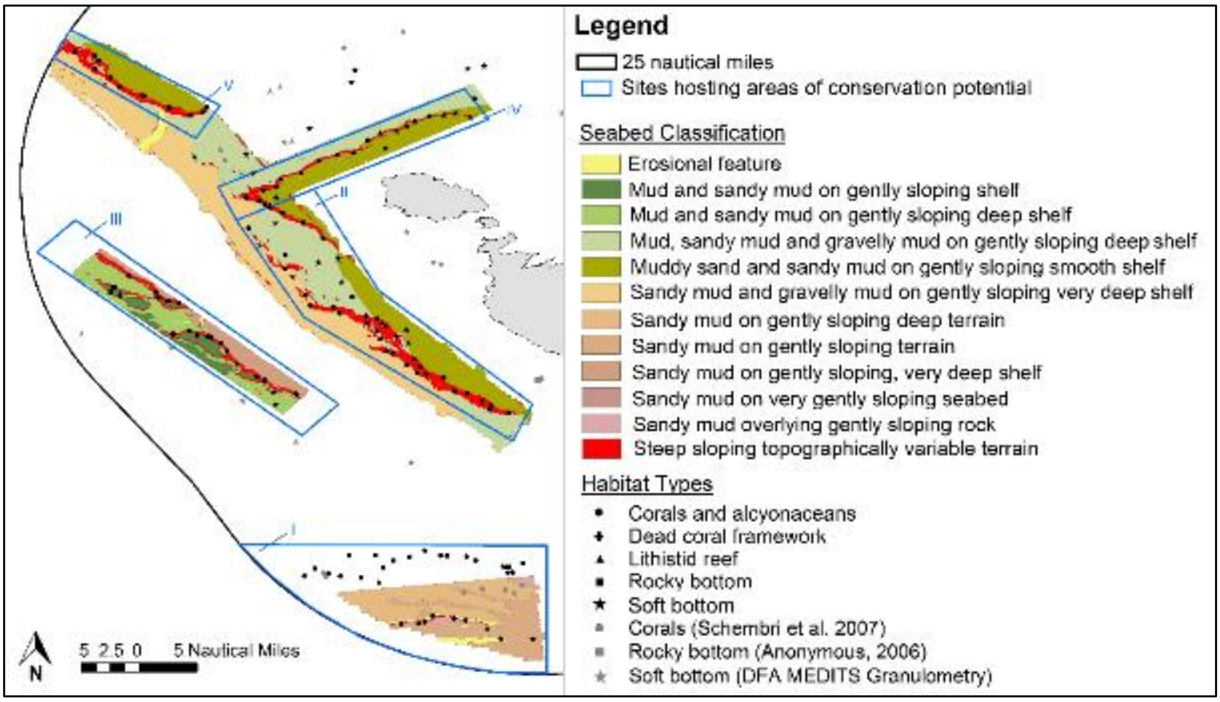

Figure 5.2.4. Map showing recommended locations of offshore sites hosting areas with a conservation potential in relation to reef and cave habitats; the location of different reef habitat types is also indicated. Roman numbers refer to the overall order of priority.

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