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Baseline Marine Benthic Surveys in the Maltese Islands (Central Mediterranean)

J. A. Borg[1], S. A. Micallef[2], K. Pirotta[3], P. J. Schembri[4]

[1]*Department of Biology, Faculty of Science, University of Malta, Msida, Malta. Tel: 356 342488, Fax: 356 312110, E-mail: jabor@cis.um.edu.mt.*

[2]*Malta University Services Ltd., University Campus, Msida, Malta. Tel: 356 343572, Fax: 356 340979.*

[3]*Department of Biology, Faculty of Science, University of Malta, Msida, Malta. Tel: 356 342488, Fax: 356 312110, E-mail: kpir@cis.um.edu.mt.*

[4]*Department of Biology, Faculty of Science, University of Malta, Msida,Malta. Tel: 356 32902789, Fax: 356 312110, E-mail: psch@cis.um.edu.mt.*

Abstract

During the period 1991 to 1997, extensive baseline studies of the submarine geomorphology, infralittoral habitats, macrobenthic assemblages, and demersal fish fauna, were carried out in 14 different sites around the Maltese Islands, using conventional SCUBA diving techniques. These were made as part of assessments of the environmental impact of existing or proposed projects, or in order to produce an inventory of coastal resources. In total, these surveys covered a sea-bed area of *ca.* 7.55km^2 and a coastline length of *ca.* 24 km, and represent the most extensive biological surveys of the marine environment carried out to date in the Maltese Islands. The results of these surveys have been presented as maps showing the type, location, and spatial extent of these physical and biological features. The Pérès & Picard (1964) scheme, as adapted by Pérès (1967; 1982) was used to classify and characterize the benthic assemblages recorded during the surveys.

Our results show that, in terms of spatial extent, the most important macrobenthic assemblages are the communities of photophilic algae on hard substrata, meadows of the sea-grass *Posidonia oceanica* and communities of bare well-sorted sand. For all these, many subtypes and facies exist, depending on the light intensity, hydrodynamic conditions, microtopography, sediment granulometry and other edaphic factors, and anthropic influences, including pollution.

Other assemblages with a limited spatial distribution include meadows of the sea-grass *Cymodocea nodosa* and of the Lessepsian immigrant *Halophila stipulacea* on sandy bottoms, the assemblages of boulder fields which are complexes of photophilic and sciaphilic communities, and those of marine caves. Our maps are supplemented by descriptions of the different habitats and macrobenthic assemblages, species lists, and semi-quantitative data on percentage cover for the dominant macroalgae, shoot density counts for sea-grass meadows, and population density counts for the main macrofaunal species.

These maps and data-sets are intended to be used (i) for assessing the status of habitats, species assemblages, and individual species, around the Maltese Islands in order to recommend appropriate measures for their conservation, including inclusion in red data lists; (ii) for designation of marine protected areas; and (iii) as baselines against which future monitoring studies and surveys can be compared.

Introduction

Up to 1991, basic ecological data on the type and distribution of marine benthic assemblages of the Maltese Islands were lacking and what little information was available was mainly the result of a small number of autecological studies carried out by the Department of Biology of the University of Malta. Small-scale maps of the Maltese Islands showing the distribution of some of the main types of infralittoral habitats and benthic assemblages were published in the Malta Structure Plan (1990) and by Anderson *et al.* (1992). However, these maps were drawn using information obtained from interviews with local SCUBA divers, rather than being constructed using directly obtained field data, and therefore serve as a general indication of the type and distribution of benthic habitats and biota present in the Maltese infralittoral. With the exception of Rolè (1991), no large scale maps of individual areas existed.

Until recently, most coastal development projects in the Maltese Islands have been undertaken without a prior assessment of the marine benthic resources present in the proposed development site, or of the potential impact of the project on these resources. As a result, it has not been possible to assess the effect of any development project on the marine environment. Malta's resulting haphazard coastal development, and the lack of coastal management and planning, have been pointed out by Anderson *et al.* (1992). With the publication of the Malta Structure Plan (1990), it became increasingly evident that there was an urgent need for accurate marine benthic ecological data for environmental impact assessments in connection with coastal development activities, and for assessing the suitability of a number of specific coastal sites as marine protected areas.

During the period 1991 to 1997, a number of marine benthic surveys were commissioned to the present authors by private companies and by Governmental and parastatal agencies. The terms of reference of most of these surveys required: (i) a description of the main geomorphological features, man-made structures, benthic habitat types, and pelagic and benthic macrobiota present; and (ii) a map of the spatial distribution of these physical and biotic features.

Materials and Methods

The surveying technique employed consisted of direct visual recording of features present along line-transects by SCUBA divers. The advantage of this technique is its ease of application; at the same time it is still one of the best techniques available for obtaining qualitative and semi-quantitative data on a range of biological parameters from shallow (0-45m) coastal areas (see for example Gili & Ros, 1985). Hiscock (1987) gives a detailed account on the methodology and uses of such surveys. The main disadvantages of this technique are that it is very labour intensive and slow. Remote sensing techniques would be quicker, however, the use of aerial photography and satellite imagery are limited to a practical depth of *ca.* 12m in the Mediterranean and their application is more suitable for large areas (Belsher *et al.*, 1988), whereas most of the areas surveyed by us were either deep (up to 45m) or very small. In any case, the use of remotely sensed data, and of other techniques such as those using a side-scan sonar, still require a considerable amount of ground-truthing and calibration (Meinesz *et al.*, 1988). This is particularly true when techniques are applied to a previously unexplored area, such as is the case with the Maltese Islands.

For the surveys, SCUBA divers laid transect lines along the bottom at compass bearings perpendicular to the shore. These 'shore' transects varied in length between 100 and 400m and were sited close to prominent land-marks for ease of location. An example of this for Marsalforn Bay (locality 1 in Figure 1), is shown in Figure 2. 'Offshore' transects were similarly laid on the bottom but their starting points were identified using electronic position-finding and navigation equipment. SCUBA divers then swam along the transects and recorded the occurrence, type, and area of bottom covered by the different habitats and benthic assemblages present. Random spot-dives between transects were also made. Photographs of geomorphological features of special interest, and of the main benthic habitats and assemblages present were taken using a Nikonos V underwater camera.

Physical Features

The location and extent of underwater habitats, and of geomorphological features of special interest, were recorded during each survey. The spatial extent covered by different types of bottom was recorded, classification of mobile substrata being based on the Wentworth scale. Depths were recorded using electronic divers' depth gauges and a boat-mounted echo-sounder.

Biological Features

Characterization of the benthic communities was based on indicator species and the nomenclature used follows the scheme of Pérès & Picard as revised by Pérès (1967; 1982). Although the benthic assemblages and most of the species were identified *in situ*, samples were also collected for later identification in the laboratory. Semi-quantitative data on species abundance, in the form of percentage cover of bottom for macroalgae and of density per square meter for macrofauna, were also recorded for the most abundant and characteristic species. In the case of *Posidonia oceanica* meadows, shoot density, mean leaf length and mean no of leaves per shoot, were recorded from random quadrats. A record was also kept of all demersal and pelagic fauna encountered during the surveys.

Results

The surveys made (table 1) covered a total area of 7.55 km^2 and a coastline length of *ca.* 24 km. Figure 1 gives the location of the sites surveyed. The results of these surveys have been presented in the form of detailed reports accompanied by maps and charts describing the type, location, and spatial extent of the various physical and biological features assessed during the surveys. Only few of these reports have been published, however (e.g. Borg & Schembri, 1993; Borg & Schembri, 1995b; 1995c). As an example of the output of these surveys, a bathymetric map, a physical map, and a benthic assemblages map for Marsalforn Bay, Gozo, surveyed in 1995 (Borg & Schembri, 1995a) are presented in Figures 3-5).

Locality	Approximate area surveyed (km^2)	Position on locality map (Figure 1)
Pretty Bay	0.36	13
Hondoq ir-Rummien	0.04	2
Mellieha Bay	0.15	7
Il-Kalanka tal-Gidien	0.07	12
Xrobb l-Ghagin	0.02	11
Wied Ternu	0.04	5
Mistra Bay	0.29	8
Marsalforn Bay	0.12	1
Mellieha Bay	0.03	7
St Paul's Islands	0.98	9
St Julian's Bay, St George's Bay & Pembroke areas	4.72	10
Cirkewwa	0.18	6
Mgarr ix-Xini	0.07	3
Qawra/Dwejra	0.48	4

Table 1. List of localities surveyed and the area of bottom covered at each site.

The more important marine geomorphological features recorded included drop-offs, boulder fields, caves, tunnels, arches and associated formations. The infralittoral zones at Qawra/Dwejra in Gozo and at Cirkewwa in Malta were particularly rich in these features.

Six main benthic assemblages were recorded from the areas surveyed:

(i) The community of photophilic algae on hard substrata (PA)
(ii) The community of semi-obscure caves (SOC)
(iii) The community of *Posidonia oceanica* meadows (POM)
(iv) The community of well sorted sand (WSS)
(v) The community of superficially muddy sands in sheltered areas (SMSSA)
(vi) The community of highly polluted sediments (HPS)

Three others: a community of accumulations of small boulders and cobbles (ASBC), a community of accumulations of small cobbles and pebbles (ASCP), and a community of accumulations of pebbles and gravel (APG), were also recorded, however, each of these was only encountered once and the bottom on which they occurred is suspected to have been modified through anthropogenic activities.

In terms of cover, the most important assemblages, in shallow inshore waters (0-30m), were the community of photophilic algae on hard substrata and the community of *Posidonia oceanica* meadows. In deeper offshore waters (30-45m), the most extensive assemblage was the community of well sorted sand. Overall, the spatial distribution and occurrence of the main assemblage types appeared to be primarily determined by substratum type (see also Borg & Schembri, 1995b; 1995c).

Along most of the open north-eastern coast of the Maltese Islands, the gently sloping shore continued underwater as an equally gently sloping rocky bottom, mainly supporting the community of photophilic algae. This assemblage also covered the surface of large boulders, wherever these occurred on the bedrock. In some places, particularly along the Pembroke coast, large areas of the bedrock were covered by *P. oceanica* meadows. Further offshore, a change in bottom type from rock to sand occurred. The bottom here supported a complex of different assemblages as a result of substratum heterogeneity. These areas, which were characterized by patches of bare sand intermixed with cobbles/pebbles/shingle, small boulders and small patches of bedrock covered with a thin layer of sand, supported a patchwork of assemblages of photophilic algae on hard substrata, those of well sorted sand, and small stands of *P. oceanica*. Further away from the shore this heterogeneous bottom was replaced by extensive *P. oceanica* meadows and by the assemblage of well sorted sand, the former extending to depths of *ca.* 40m and the latter to depths of 45m and deeper. This same distribution pattern also occurred inside bays and inlets, with the difference that at the head of the bay or inlet, large stretches of sand or other mobile sediments, with an impoverished epibiota, usually extended from the mediolittoral to the infralittoral (see, for example, Marsalforn Bay; Figures 4 & 5).

In contrast, most of south-western coast of the Maltese islands is characterized by cliffs and boulder screes. Only two sites (the Qawra/Dwejra area and Mgarr ix-Xini,

both on Gozo) which are quite representative of this coastal area, were surveyed (Figure 1). In these two sites, the infralittoral bottom consisted of bedrock forming vertical drop-offs with boulder fields occurring at their base; both bottom types supported extensive communities of photophilic algae on hard substrata. Since relatively great depths (25-80m) were frequently reached within small horizontal distances (5-200m) from the shoreline, these communities of photophilic algae consisted mainly of sciaphilic facies. Communities of semi-obscure caves were sometimes recorded from caves and cave-like biotopes present in these areas. Seagrass meadows were rarely encountered in these sites.

A number of facies were also recorded, the principal ones being:

(i) Facies of the seagrass *Cymodocea nodosa*, which were mainly recorded from the sandy bottom at the head of bays and inlets.
(ii) Facies of the seagrass *Halophila stipulacea*, which were mainly recorded from inside St. Julian's Bay from the community of highly polluted sediments, and from Cirkewwa.
(iii) Facies of free-living calcareous algae, dominated by *Lithothamnion coralloides* and *Phymatolithon calcareum*, which were mainly recorded from offshore sandy bottoms in deeper (35-45m) waters.

The most diverse macrobenthic assemblages and demersal and pelagic fauna were recorded off St. Julian's Bay, off St George's Bay, off Pembroke, from the Qawra/Dwejra area, from Mgarr ix-Xini and from Cirkewwa.

Anthropogenic Impact

The majority of the localities surveyed appeared to be under considerable pressure from anthropogenic activities including: fishing; bathing, boating and other coastal recreational activities; from coastal touristic resorts, and from fish-farming. In the *Qawra/Dwejra area*, frequent visits in caves by SCUBA divers have resulted in mass destruction of fragile bryozoan colonies growing on the roof of the caves. *P. oceanica* meadows lying directly below offshore fishfarm cages have been completely decimated, while seagrass beds situated in the vicinity of the cages have undergone gross alterations in meadow morphology.

Discussion

The marine benthic surveys carried out by the present authors represent the largest biological surveys of the marine environment carried out to date in the Maltese Islands. These surveys have shown that very large areas of the infralittoral are occupied by two very important community types: the community of photophilic algae on hard substrata and the community of *P. oceanica* meadows. The maps drawn using data acquired from these surveys are the first of their type for the Maltese Islands. The detailed reports which accompany these maps also include species lists for the most abundant mega and macrobenthos, demersal fish fauna and pelagic macrofauna, and semi-quantitative phenological data for *P. oceanica*, percentage cover of bottom by macroalgae and density of macrofauna. These maps and data-sets can be used for (i)

assessing the status of habitats, species assemblages, and individual species, around the Maltese Islands in order to recommend appropriate measures for their conservation and possible inclusion in red data lists; (ii) the designation of marine protected areas; and (iii) as baselines against which future monitoring studies and surveys can be compared.

Of the sites surveyed to date, the most important from the point of view of the presence of (i) interesting geomorphological features; (ii) diversity of habitats and the species they support; (iii) assemblages of high ecological importance; (iv) rich demersal and pelagic fauna; and (v) species of international conservation value, are the Qawra/Dwejra area, Mgarr ix-Xini and Cirkewwa. These areas have already been listed as sites having potential as marine conservation areas (Malta Structure Plan, 1991) and our surveys have confirmed their immense ecological value.

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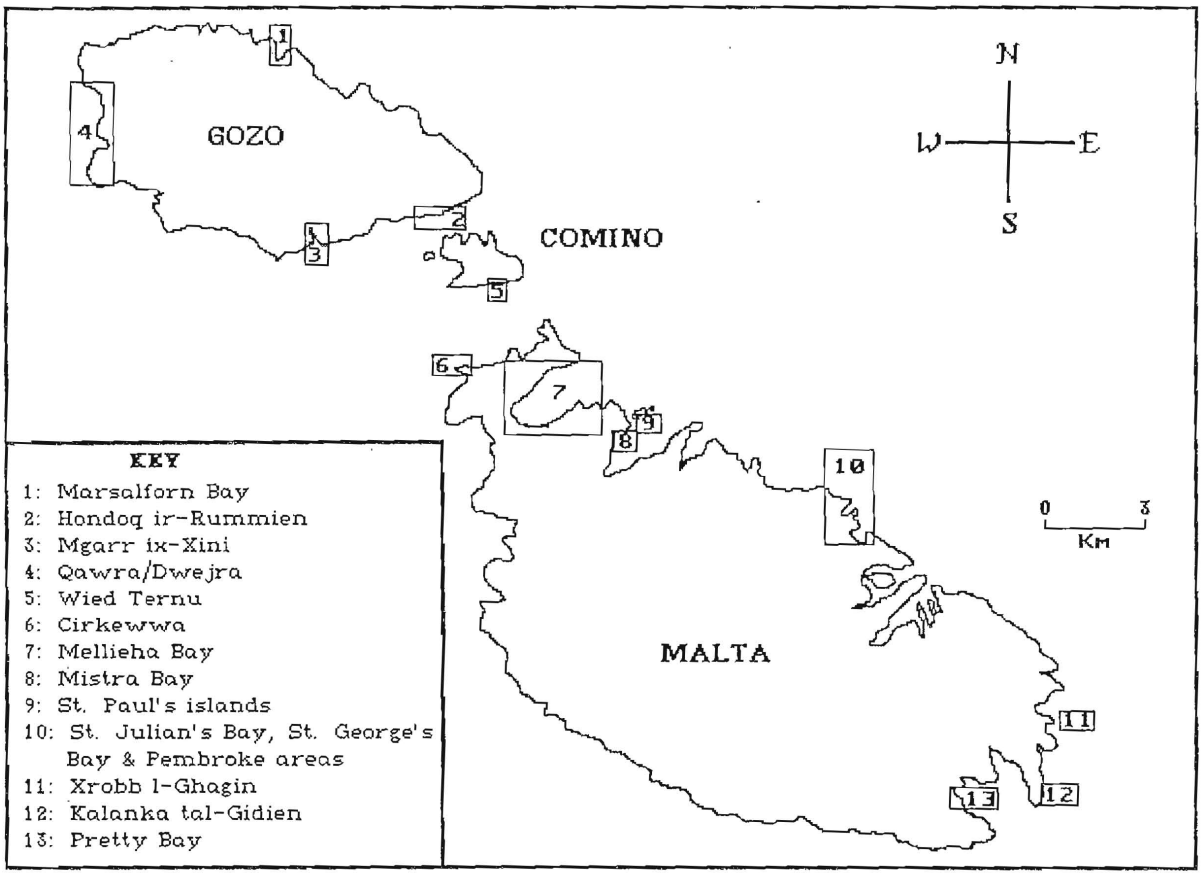

Figure 1: Map of the Maltese Archipelago showing the localities surveyed (numbered boxes).

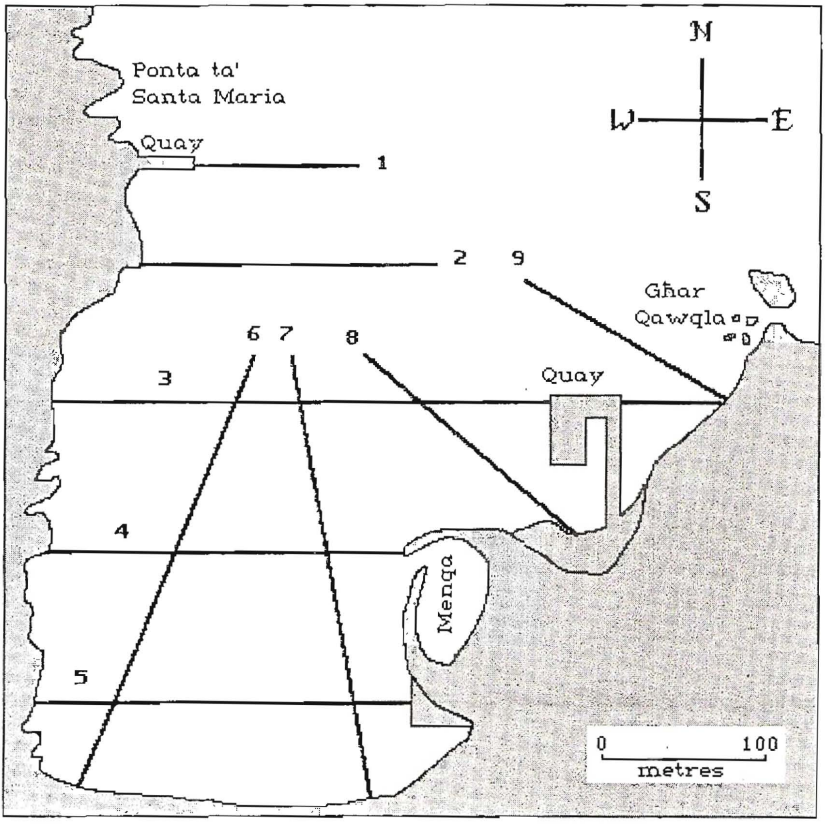

Figure 2: Map of Marsalforn Bay (locality 1 in Figure 1) showing the position of nine underwater transects used to map submarine features in the study area.

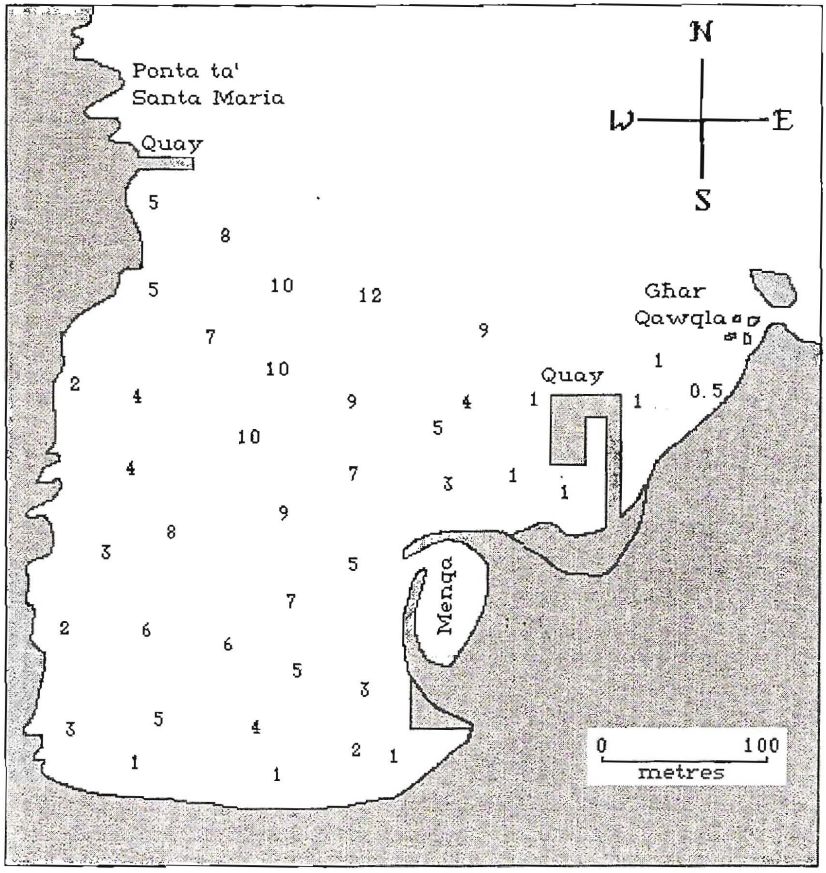

Figure 3: Bathymetric map of Marsalforn Bay (locality 1 in Figure 1). The numbers represent the depth in metres.

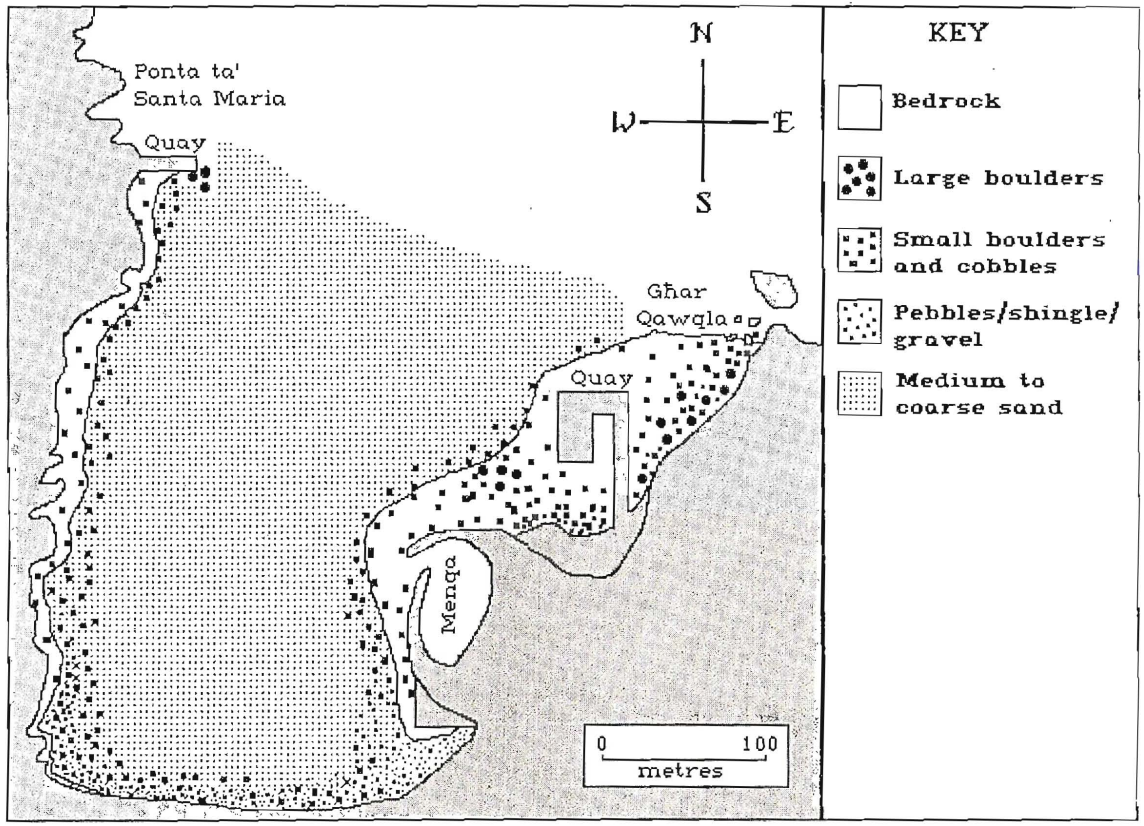

Figure 4: Physical map of Marsalforn Bay (locality 1 in Figure 1) showing the different bottom types present.