Research Article

The Macrobenthic Species of the Infralittoral to Circalittoral Transition Zone off the Northeastern Coast of Malta (Central Mediterranean)

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Summary. *The macrobenthic assemblages of the sedimentary bottoms off the northeastern coast of Malta were studied during the summer of 1993. Grab and dredge samples were collected from depths of 21-75m from an area of approximately 48 km² off Comino, Mellieha Bay and St. Paul's Bay. Below ca. 40m the bottom was predominantly sandy with meadows of* Posidonia oceanica, *giving way to bare sand in the lower infralittoral. Between 45m and 75m, the bottom consisted of organogenic gravel with abundant free-living calcareous rhodophytes, predominantly the corallines* Phymatolithon calcareum *and* Lithothamnion corallioides. *Such bottoms, known as maerl, have not been reported previously from the Maltese Islands. 19 species of macroalgae, 1 phanerogam, and 108 species of macrofauna were recorded, the bulk of these from the maerl bottom. An additional 122 species of molluscs occurred as empty shells. Maerl bottoms support a high species richness, even if abundance is low. There is evidence to suggest that maerl is the predominant bottom type all along the northeastern coast of the Maltese Islands in the transition between the lower infralittoral and the circalittoral, which occurs at depths of 45-75m.*

Keywords: Benthos, Infralittoral, Circalittoral, Macrobenthic assemblages, Maerl, Transition zone, Maltese Islands.

The sublittoral marine benthic assemblages of the Maltese Islands have only recently started being investigated (Borg 1991, 1995; Valentino, 1991; Busuttil, 1992; Buttigieg, 1993; Borg & Schembri, 1995a,b,c; Jones, 1996; Micallef, 1996; Pirotta, 1996; Borg et al., 1997). However, most studies were carried out by diving using SCUBA. Therefore, practically all work has focused on the infralittoral, mainly at depths not exceeding 40m, as this is considered to be the limit for safe diving using normal SCUBA techniques. The available scanty data on the biotic assemblages of the lower infralittoral and upper circalittoral is mainly descriptive and based on studies made more than a century ago (McAndrew, 1850; Piccone, 1883-84) and on the more or less casual observations of sports divers and fishermen (Rolié, 1991; Anderson et al., 1992).

In 1993, UNESCO funded an oceanographic survey of the coastal waters off the northeastern coast of Malta. Although primarily concerned with physical oceanography, we were afforded the opportunity of carrying out some remote sampling of the macrobenthos. We chose to focus on the transition zone between the lower infralittoral and the upper circalittoral, in order to extend our knowledge of the benthic assemblages of the Maltese Islands to those of deeper water. Being transitional between infralittoral assemblages dominated by photophilic algae and phanerogams, and circalittoral ones dominated by sciaphilic algae and sessile invertebrates, this zone is of considerable biological interest (Pérès, 1967; 1982; 1985). Such studies may be of more than local interest since these transitional biocoenoses have been extensively investigated only in the Western Mediterranean and there are very few data from the central and eastern parts of this sea (Albertelli et al., 1995).

The study area was centred on a point located at 36°00.80'N/14°25.80'E and covered approximately 48 km² of the seabed off Comino, Mellieha Bay and St. Paul's Bay (Figure 1). Data on the water column in this area have been published recently by Drago (1997); some of Drago's stations lie very close to our own benthic sampling stations. During summer, the upper 50m layer of water shows considerable stratification in temperature and salinity. A sharp halocline occurring at a depth of ca. 16m separates a surface layer of warm water and high salinity from the underlying layers (Drago, 1997).

Material and Methods

Benthic samples were collected in August 1993 using a 0.1m² Van Veen grab and a 48cm wide naturalist dredge fitted with a 5mm mesh net bag. Both types of equipment were deployed from a 14m long Maltese fishing vessel (*luzzu*) equipped with derrick and capstan winch. Two replicate grab samples were collected from each of four pre-determined stations along a N-S transect off Ras il-Griebeg (Mellieha Bay); two replicate dredge samples were collected from each of four transects located off Comino, Mellieha Bay and St. Paul's Islands (Figure 1). Station details are given in Tables 1 and 2. All station positions were determined using a boat-mounted Global Positioning System (GPS).

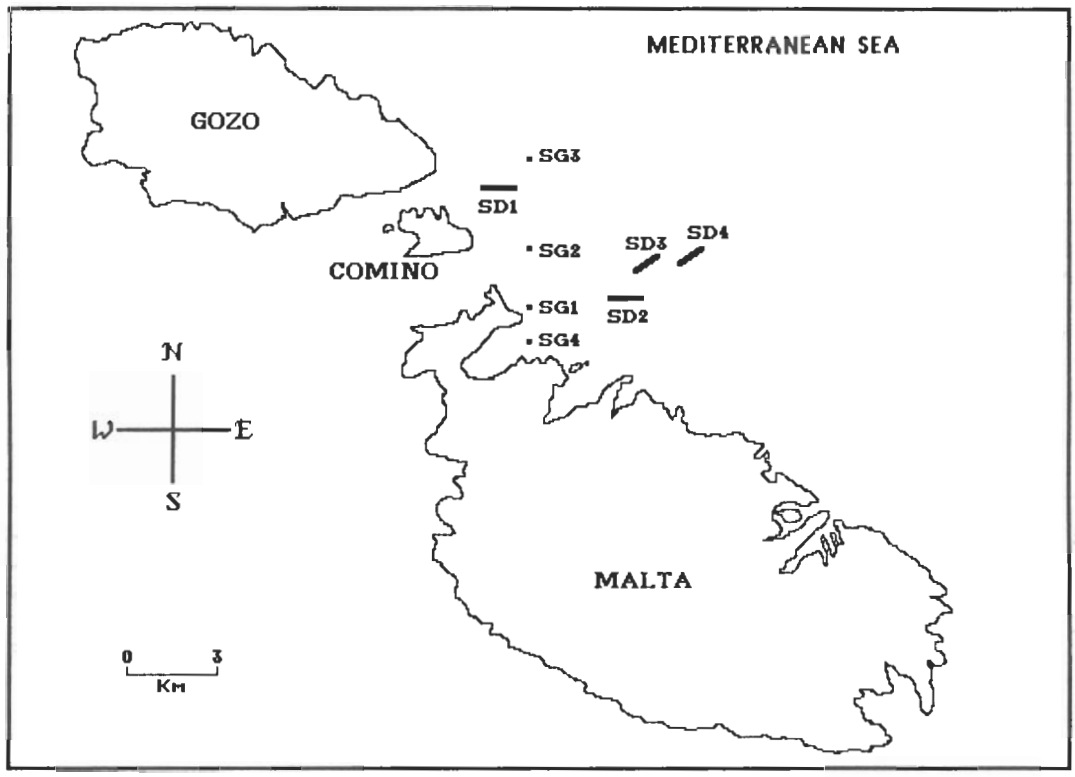

Figure 1. Map of the Maltese Islands showing the location of the sampling stations: SG - grab stations; **SD** - dredge stations (lines show the vessel's navigational route).

Station code	Station position	Depth (m)
SG1	35° 59.60'N/14° 23.00'E	38
SG2	36° 00.80'N/14° 23.00'E	21
SG3	36° 01.60'N/14° 23.00'E	75
SG4	35° 58.90'N/14° 23.00'E	30

Table 1 Details of the grab sample stations.
All stations were sampled on 24th August 1993.

Station code	Date (1997)	Station positions	Depth (m)
SD1	25/8	36° 01.60'N/14° 22.00'E	50
		to 36° 01.60'N/14° 22.35'E	60
SD2	25/8	35° 58.90'N/14° 25.19'E	65
		to 35° 58.90'N/14° 25.45'E	65
SD3	25/8	35° 59.55'N/14° 26.01'E	45
		to 35o 59.75'N/14° 26.25'E	46
SD4	26/8	35° 59.62'N/14° 27.52'E	51
		to 35° 59.85'N/14° 27.75'E	55

Table 2. Details of the dredge sample stations.

Samples were transported to the laboratory for subsequent sorting and identification of biota. In the laboratory, samples were sieved through a 2mm mesh and only specimens retained by the sieve were considered. Free living coralline algae were identified on entirely morphological grounds using the keys given in Hamel & Lemoine (1952). Other algae, phanerogams, and all fauna were identified using standard identification manuals. Difficult species were confirmed by specialists in the group (see Acknowledgements).

Results

All grab and dredge samples collected between depths of 45m to 75m (Tables 1 and 2) consisted of shell gravel with free living calcareous algae and little fine sediment and detritus. The dominant free-living algae were the corallines *Phymatolithon calcareum* and *Lithothamnion corallioides*, while the dominant erect forms were *Stilophora rhizodes*, *Cystoseira spinosa*, *Dictyota fasciola*, *Womersleyella setacea*, and *Flabellia petiolata*.

Grab samples collected from stations SG1, SG2 and SG4 consisted of fine sand. These samples had very few macrofauna and, with one exception, no macroflora. Live attached shoots of *Posidonia oceanica* were present in station SG4, the most inshore station. Water depth increases with increasing distance from the shore, except for station SG2 where the water is only 21m due to the presence of a rocky shoal, Is-Sikka l-Bajda.

A total of 19 macroalgae, 1 phanerogam, and 108 macrofaunal species were recorded as live individuals from the samples collected (Tables 3 and 4). An additional 122 species of molluscs were present as

unbroken dead shells (Table 5). No attempt at identifying fragments of shells, tests or other organic remains was made. Most of the specimens were identified to species level, except some polychaetes, which were only identified to family or genus.

In terms of taxocenic abundance, the molluscs were dominant, followed by crustaceans and polychaetes. In terms of species abundance, the gastropod *Bittium latreillii* was the most numerous, with a total of 398 individuals collected from the dredge and grab samples. All other macrofaunal species were present at much lower abundances (less than 20 individuals collected from the dredge and grab samples).

Species	Station
HETEROKONTOPHYTA	
Asperococcus bullosus Lamouroux	SD3
Cystoseira spinosa Sauvageau v. spinosa	SD3, SD4
Dictyota fasciola Lamouroux	SD3, SD4
Sporochnus pedunculatus C. Agardh	SD4
Stilophora rhizodes (Turner) J. Agardh	SD3, SD4
RHODOPHYTA	
Chondria sp.	SD3, SD4
Cryptonemia tunaeformis (Bertolini) Zandarini	SD3
Lithophyllum racemus (Lamarck) Foslie	SD3
Lithothamnion corallioides P. L. & H. M. Crouan	SD1, SD3, SD4
Osmundaria volubilis (L.) R. E. Norris	SD3
Peyssonnelia rosa-marina Boudouresque & Denizot	SD1, SD3, SD4
Phymatolithon calcareum (Pallas) Adey & McKibbin	SD1, SD3, SD4
Polysiphonia sp.	SD3
Rytiphloea tinctoria (Clemente) C. Agardh	SD3
? Sporolithon sp.	SD4
Syridia filamentosa (Wulfen) Harvey	SD4
Womersleyella setacea (Hollenberg) R. E. Norris	SD3, SD4
CHLOROPHYTA	
Flabellia petiolata (Turra) Nizamuddin	SD3, SD4
Halimeda tuna (Ellis & Solander) Lamouroux	SD4
SPERMATOPHYTA	
Posidonia oceanica (L.) Delile	SG4

Table 3. List of macroalgae and phanerogams recorded during the present study.

Table 4. List of macrofaunal species recorded during the present study.

Species	Station
FORAMINIFERA	
Miniacina miniacea (L.)	SD3
ANNELIDA	
POLYCHAETA	
? Autosyllis sp.	SD4
Dendronereis sp.	SD1
Eunice sp. A	SD3
Eunice sp. B	SD3
Eunice torquata Quatrefages	SD4
Glycera sp.	SG3
Hemipodus sp.	SD1, SD3
Hermonia sp.	SD1
Hydroides uncinata (Philippi)	SD3
Laeonereis sp.	SD3
Lumbrineris sp.	SD3
Lumbrineridae sp.	SG1
Lysidice ninetta Audoiun & Milne Edwards	SG2, SD4
Lysidice sp.	SD3
Nematonereis unicornis (Grube)	SD4
Nereis sp.	SD1
Nicon sp.	SD1
Psammolyce sp.	SD3
Sabellidae sp.	SD1
Sigolonidae sp.	SD4
Spionidae sp.	SG2
SIPUNCULA	
Aspidosiphon muelleri Diesing	SG1, SG3, SD1, SD3
CRUSTACEA	
DECAPODA CARIDEA	
Alpheus macrocheles (Hailstone)	SD3
Athanas nitescens var. *laevirhincus* (Risso)	SD3
Hippolyte sp.	SD4
Hippolytidae sp.	SD4
Processa cf. *robusta* Nouvel & Hothuis	SD1
Thoralus cranchii (Leach)	SD3
DECAPODA ANOMURA	
Anapagurus cf. *breviaculeatus* Fenizia	SD4
Calcinus tubularis (L.)	SD3
Cestopagurus timidus (Roux)	SD3, SD4
Galathea intermedia Lilljeborg	SD3
Paguridae sp.	SD4
Pagurus chevreuxi (Bouvier)	SD3
Pagurus cuanensis Bell	SD2, SD3
Pagurus excavatus (Herbst)	SD4
Pagurus forbesii Bell	SD4

Table 4 continued. List of macrofaunal species recorded during the present study.

Species	Station
DECAPODA BRACHYURA	
Atelecyclus rotundatus (Olivi)	SG3
Ebalia edwardsi Costa	SD3, SD4
Eurynome aspera (Pennant)	SG3
Liocarcinus corrugatus (Pennant)	SD3, SD4
Macropodia longirostris (Fabricius)	SD3
Parthenope massena (Roux)	SD4
TANAIDACEA	
Apseudes ? talpa (Milne Edwards)	SG3
ISOPODA	
Anthura gracilis (Montagu)	SG2
AMPHIPODA	
Amphithoe ramondi Audouin	SD3, SD4
Ceradocus orchestiipes A. Costa	SG3, SD1
Ceradocus semiserratus (Bate)	SG2, SG3, SD1
Cheirocratus sundevallii (Rathke)	SG3
Dexamine spinosa (Montagu)	SG2, SD3
Lepidepecreum longicorne (Bate & Westwood)	SD3
Leucothoe cf. *spinicarpa* (Abildgaard)	SD3
Lysianassa costae Milne Edwards	SG2
Lysianassa longicornis Lucas	SG2, SD1
Maera grossimana (Montagu)	SD1
Socarnes filicornis (Heller)	SD3, SD4
MOLLUSCA	
POLYPLACOPHORA	
Acanthochitona fascicularis (L.)	SD4
Leptochiton cancellatus (G. B. Sowerby II)	SD1
GASTROPODA	
Bittium latreillii (Payraudeau)	SG3, SD1, SD3, SD4
Caecum subannulatum (De Folin)	SD1
Caecum trachea (Montagu)	SD1, SD3
Calyptrea chinensis (L.)	SD4
Gibbula ardens (Von Salis)	SG1
Gibbula magus (L.)	SD3
Haminoea hydatis (L.)	SD3, SD4
Melanella polita (L.)	SD3
Natica hebreus (Martyn)	SD1
Rissoella inflata (Locard)	SD3
Vermetus semisurrectus Ant.Bivona	SG3, SD4
Vitreolina philippi (Rayneval, Ponzi & Van Den Heck)	SD3
Volvarina mitrella (Risso)	SD4

Table 4 continued. List of macrofaunal species recorded during the present study.

Species	Station
BIVALVIA	
Aequipecten opercularis (L.)	SD4
Anomia ephippium L.	SD4
Arca noae L.	SD1
Astarte fusca (Poli)	SD1
Chlamys flexuosa (Poli)	SD4
Chlamys varia (L.)	SD4
Diplodonta apicalis Philippi	SD2, SD3
Glans aculeata (Poli)	SG3
Glans trapezia (L.)	SG2
Gonilia caliglypta (Dall)	SD1, SD4
Goodalia macandrewi Smith	SD2, SD3
Gouldia minima (Montagu)	SD4
Hiatella arctica (L.)	SD1
Lissopecten hyalinus (Poli)	SD4
Modiolarca subpicta (Cantraine)	SD1, SD2, SD3
Neolepton sulcatulum (Jeffreys)	SD3
Palliolum incomparabile (Risso)	SD4
Pecten jacobeus (L.)	SD4
Plagiocardium papillosum (Poli)	SG1, SD3
Pteromeris minuta (Scacchi	SD1, SD3, SD4
Timoclea ovata (Pennant)	SD3
Venus verrucosa L.	SG3
SCAPHOPODA	
Pulsellum lofotense (M. Sars)	SD1
BRYOZOA	
Celleporina pumicosa (Pallas)	SD3
Hippopodinella lata Busk	SD1, SD3
Lichenopora radiata (Audouine & Savigny)	SD3
Margaretta cereiodes (Ellis & Solander)	SD3
ECHINODERMATA	
CRINOIDEA	
Antedon mediterranea (Lamarck)	SD1, SD3
ASTEROIDEA	
Asterina gibbosa (Pennant)	SG2
Astropecten aranciacus (L.)	SD1
Echinaster sepositus (Retzius)	SD1
ECHINOIDEA	
Brissus unicolor (Leske)	SG1
Genocidaris maculata A..Agassiz	SG2, SD3
Echinocyamus pusillus (O. F. Muller)	SG2, SD1, SD3
Neolampas rostellata A..Agassiz	SD1
Spatangus purpureus O. F. Muller	SD2

Table 5. List of empty gastropod shells and dead bivalves recorded during the present study.

Species	Station
GASTROPODA	
Acmea virginia (O. F. Mueller)	SD1
Alvania beani (Hanley in Thorpe)	SD1
Alvania lineata Risso	SD2, SD3
Alvania mamillata Risso	SG2
Alvania wienkauffi Jacobusi-Oliviero, Amati & Nofroni	SD2, SD3
Anisocycla pontieli (Folin)	SD1
Atlanta fusca Souleyet	SD1
Atlanta peroni Lesueur	SD1
Barleeia cf. *unifasciata* (Montagu, 1803)	SD1, SD2
**Bittium latreillii* (Payraudeau, 1826)	SG2, SG3, SD1, SD2, SD3, SD4
Buccinulum corneum (L.)	SG3
Caecum clakii Carpenter	SD1
**Caecum subannulatum* De Folin	SD1, SD3, SD3
**Caecum trachea* Monatgu	SD1, SD3
Calliostoma zizyphinium (L.)	SD4
**Calyptrea chinensis* (L.)	SD4
Careliopsis modesta (De Folin)	SD3
Cerithidium submamillatum (De Rayneval, Ponzi & Van Den Heck)	SD1, SD2, SD3
Cerithiopsis tubercularis (Montagu)	SD1, SD2, SD3
Cerithium vulgatum Bruguiere	SG3, SD4
Chrysallida clathrata (Jeffreys)	SD1, SD3
Chrysallida doliolum (Philippi)	SD1
Chrysallida emaciata (Brusina)	SD1
Chrysallida excavata (Philippi)	SD1, SD3
Chrysallida obtusa (T. Brown)	SD1, SD3
Clathromangelia quadrillum (Dujardin)	SD3
Conus mediterraneus Hwass in Bruguiere	SD3, SD2, SD4
Coralliophilia meyendorffi (Calcara)	SD3
Crassopleura incrassata (Dujardin)	SD1
Cresis acicula Rang	SD1
Curveulima sp.	SD1
Cylichnina umbilicata (Montagu)	SD1
Dermomurex scalaroides (Blainville)	SD4
Dikoleps cutleriana (Clark)	SD1
Dikoleps nitens (Philippi)	SD3
Dikoleps pusilla (Jeffreys)	SD1, SD3
Eatonina ochroleuca (Brusina)	SD1, SD3
Emarginula rosea Bell T.	SD1
Epitonium aculeatum (Allan)	SD1
Eulimella aciculata (Philippi)	SD1
Eulimella ventricosa (Forbes)	SD1
Euspira nitida (Donovan, 1804)	SD1
Fusinus rostratus (Olivi)	SD4
Fusinus rudis (Philippi)	SD1

* Also recorded live from the same or other stations (see Table 4).

Table 5 continued. List of empty gastropod shells and dead bivalves recorded during the present study.

Species	Station
Gibberula miliaria (L.)	SG2, SD2, SD3
Gibberulina philippi (Monterosato)	SD1, SD2
**Gibbula ardens* (Von Salis)	SG1
Gibbula guttadauri (Philippi)	SD1, SD2, SD3
Gibbula turbinoides (Deshayes)	SG1
Granulina marginata (Bivona)	SD2, SD3
Granulina occulta (Monterosato)	SD1
Haedropleura secalina (Philippi)	SD1
Haedropleura septangularis (Montagu)	SG3
**Haminoea hydatis* (L.)	SG1, SG2, SG3, SD1, SD2, SD3
Jujubinus exasperatus (Pennant)	SG2, SG3, SD1, SD4
Jujubinus montagui (W. Wood)	SD4
Jujubinus striatus (L.)	SD4
Lamellaria perspicua (L.)	SD3
Limacina inflata (D'Orbigny)	SD1, SD3
Mangelia smithi (Forbes)	SD1
Mangeliella fieldeni Van Aartsen & Fehr de Wal	SD3
**Melanella polita* (L.)	SD1
Mitrella scripta (L.)	SG3, SD4
Mitrolumna olivoidea (Cantraine)	SD2, SD4
Nanobalcis nana (Monterosato)	SD1
Obtusella intersecta (S. W. Wood)	SD1, SD3
Odostomia acuta Jeffreys	SD1
Odostomia carrozzai Van Aartsen	SD1
Odostomia clavulus (Loven)	SD1
Odostomia conoidea (Brocchi)	SD1
Odostomia conspicua Alder	SD1, SD3
Odostomia eulimoides Hanley	SD1
Odostomia fusulus Monterosato	SD1
Ondina vitrea (Brusina)	SD3
Opalia hellenica (Forbes)	SD1
Philbertia cf. *philberti* (Michaud)	SD1
Philbertia pseudohystrix (Sykes)	SD1
Philene catena (Montagu)	SD3
Philene intricata Monterosato	SD1
Philene scabra (Mueller)	SD1
Protatlanta souleyeti (E. A. Smith)	SD3
Pyrunculus hoernesii (Weinkauff)	SD1
Raphitoma echinata (Brocchi)	SD1, SD3
Raphitoma laviae (Philippi)	SD1
Retusa mammilata (Philippi)	SD2, SD3
Rissoa incospicua (Alder)	SD1, SD3
Rissoa philippi (Aradas & Maggiore)	SD1, SD3
Rissoa radiata (Philippi)	SD1
Rissoa violacea Desmarest	SD3
**Rissoella inflata* Locard	SD2, SD3
Rissoina bruguiere (Payraudeau)	SG2, SD1

* Also recorded live from the same or other stations (see Table 4).

Table 5 continued. List of empty gastropod shells and dead bivalves recorded during the present study.

Species	Station
Roxania utriculus (Brocchi)	SD1
Sabinella bonifaciae F. Nordsieck	SD1
Scissurella costata D'Orbignyi	SD1, SD3
Skenia serpuloides (Montagu)	SD1, SD3
Skeniodes exilissima (Philippi)	SD3
Stricteulima jeffreysiana (Brusina)	SD1, SD3
**Timoclea ovata* (Pennant)	SD1
Tricolia speciosa (Van Muehlfeldt)	SG2
Triphoridae sp.	SD1, SD2, SD3
Turbonilla pumila Seguenza	SD3
Turbonilla pusilla (Philippi)	SD1
Turbonilla rufa (Philippi)	SD1
Turitella turbona Monterosato	SD1, SD4
**Vermetus semisurrectus* Ant. Bivona	SD2
Vexillum ebenus (Lamarck)	SG3, SD4
Vexillum savignyi (Payraudeau)	SD1, SD2, SD4
**Vitreolina philippi* (De Rayneval, Ponzi & Van den Heck)	SD2
**Volvarina mitrella* (Risso)	SG3, SD4
Volvulella acuminata (Bruguiere)	SD1
Weinkauffia turgida (Forbes)	SD1
Williamia gussoni (O. G. Costa)	SD1
SCAPHOPODA	
Dentalium dentalis (L.)	SD1
Dentalium vulgare Da Costa	SD1
**Pulsellum lofotense* (M. Sars)	SD1
POLYPLACOPHORA	
Acanthochitona fascicularis (L.)	SD1, SD2
BIVALVIA	
Abra prismatica (Monatagu)	SD3
**Aequipecten opercularis* (L.)	SG3, SD1, SD4
Arca noea (L.)	SD4
**Astarte fusca* (Poli)	SG3, SD1, SD4
**Goodalia macandrewi* (Smith)	SD2, SD3
**Chlamys flexuosa* (Poli)	SD4
**Chlamys varia* (L.)	SD4
Clausinella brogniarti (Payraudeau)	SD1
Digitaria digitaria (L.)	SD2, SD3, SD4
**Diplodonta apicalis* Philippi	SD3, SD4
**Glans aculeata* (Poli)	SG3
**Glans trapezia* (L.)	SD4
Glycymeris sp.	SD4
**Gonilia calyglypta* (Dall)	SD1
Gouldia minima (Montagu)	SD2, SD3, SD4
Hyalopecten similis (Laskey)	SD1
Kellia suborbicolaris (Montagu)	SD1

* Also recorded live from the same or other stations (see Table 4).

Table 5 continued. List of empty gastropod shells and dead bivalves recorded during the present study.

Species	Station
Limatula subauriculata (Montagu)	SG3, SD1, SD3, SD4
**Lissopecten hyalinus* (Poli)	SG1, SD1, SD4
Modiolula phaseolina (Philippi)	SD1
**Neolepton sulcatulum* (Jeffreys)	SD1
Nucula nitidosa Winkworth	SD4
Nuculana pella (L.)	SD1
**Palliolum incomparabile* (Risso)	SD1, SD4
Parvicardium scriptum (B.D.D.)	SD1, SD3
**Pecten jacobeus* (L.)	SD4
**Plagiocardium papillosum* (Poli)	SG3, SD1, SD4
Psammobia costulata Turton	SD2
**Pteromeris minuta* (Scacchi)	SD2, SD4
Scacchia oblonga (Philippi)	SD1
Tellina donacina (L.)	SD2

* Also recorded live from the same or other stations (see Table 4).

Discussion

The lower limit of the Mediterranean infralittoral is defined as the maximum depth at which marine phanerogams and photophilic algae can live (Pérès and Picard, 1964; Pérès, 1967, 1982; 1995; Bellan-Santini et al., 1994) and the seagrass *Posidonia oceanica* is often used as an indicator species. In the Maltese Islands, the maximum depth at which stands of this species have been recorded is 44m (Borg and Schembri, 1995c). Grab samples from depths less than 40m taken during the present study consisted of fine sand devoid of epiflora and with an impoverished epifauna. The nature of the substratum and the biota present suggest that this assemblage is closest to the SFBC *'sables fin bien calibrès'* [fine well-sorted sand] biocoenosis of Pérès and Picard (1964) (see also Pérès, 1967; 1982; Picard, 1983; Bellan-Santini et al., 1994). On the basis of the distribution of *Posidonia oceanica*, it appears that with the exception of stations SG2 and SG4, our samples were taken from the lower limit of the infralittoral zone (SG1, SD3) and from the upper circalittoral (SG3, SD1, SD2, SD4).

Below depths of 45m and down to 75m (the maximum depth sampled in this study) the substratum consisted of shell and algal gravel. This corresponds to the coastal detritic bottoms of Pérès and Picard (1964), consisting of organogenic gravels derived from present-day organisms (Pérès, 1985; Bellan-Santini et al., 1994). The biota present, particularly the abundant free-living corallines *Phymatolithon calcareum* and *Lithothamnion corallioides* characterise these assemblages as belonging to the 'nullipore facies' of the coastal detritic biocoenosis of Pérès and Picard (1964). Such bottoms and the assemblages they support are better known as 'maerl'. Maerl is characterized by accumulations of unattached,

calcareous rhodophytes which take the form of either twig-like thalli, or ones encrusting some solid but mobile granule, usually a stone or shell. Maerl beds form on level sea-bottoms within the photic zone where currents are strong enough to turn the free-living thalli over, preventing them from getting buried and exposing all their surfaces to light (Bosellini & Ginsburg, 1971; Steneck, 1986). Although maerl assemblages occur worldwide (Bosence, 1983), they have been little studied, including in the Mediterranean. In the Western Mediterranean, maerl beds occur down to depths of 65m (Pérès, 1985) while in the Eastern Mediterranean, where the water is more clear, some maerl beds extend below 100m (Jacquotte, 1962). Maerl therefore appears to be associated with the infralittoral to circalittoral transition zone.

Due to its complex structure, maerl generally provides a heterogeneous bottom with a range of microhabitats, and consequently it has a high biotic diversity (Cabioch, 1969; Keegan, 1974; Bosence, 1979) . Furthermore, it appears that maerl beds support a number of rare and unusual species, some of which are exclusive to this habitat type. For example, in the Mediterranean, the alga *Crpytonemia tunaeformis*, which was also found in our study, seems to occur only in this habitat type (UNEP/ IUCN/GIS Posidonie, 1990). For these reasons and because they are isolated and inextensive biotopes, maerl beds are of considerable conservation value (Bellan-Santini et al., 1994). However, maerl beds are under threat in many places from direct exploitation and anthropogenic impacts. In the Mediterranean the main threats are dredging and trawling, which disrupt and erode the maerl beds, and modification of the hydrodynamic regime due to coastal developments such as construction of harbours and artificial beaches (UNEP/IUCN/GIS Posidonie, 1990). Elsewhere, maerl beds are also threatened by direct exploitation for agricultural fertiliser, and due to eutrophication (Guiry & Blunden, 1991).

This is the first time that living maerl beds have been reported from the Maltese Islands. Previously, the only maerl known was a very small patch (ca. 3400m^2) at a depth of 42m discovered off the coast of the island of Comino in 1994 (Borg & Schembri, unpublished). This bed did not contain any live maerl thalli, indicating that it is probably a relict ground.

The maerl grounds discovered in this study support a high species richness but overall a low abundance. The most abundant macrofaunal species was the gastropod *Bittium latreillii*. Locally, this species occurs also in abundance in other (infralittoral) biotopes, including *P. oceanica* meadows and the assemblages of photophilic algae on hard substrata (Borg, 1991). A number of species listed by Pérès (1967) as characteristic of the maerl facies, such as the echinoderms *Echinocyamus pusillus* and *Spatangus purpureus*, and the crabs *Parthenope massena* and *Ebalia edwardsi*, were also recorded by us. A particularly interesting record is that of the circumtropical alga *Womersleyella setacea*, which was first recorded from the Mediterranean only recently, initially on the French coast (Verlaque, 1989) and subsequently on the Tuscan coast (Airoldi et al., 1994) and Lampedusa (Cormaci et al., 1994).

Surprisingly, Pérès (1967) describes the benthic assemblages of maerl as "rather poor". In the present study, over a hundred different macrobenthic species have been recorded live from the maerl grounds off the northeastern coast of Malta, and over a hundred additional species as dead shells. This species richness is comparable to that of meadows of the seagrass *P. oceanica*, which normally have 100-200 different macrobenthic species in each single locality (Templado, 1984) and which are considered to be one of the most species-rich of Mediterranean biotopes. It is likely that in making his statement, Pérès (1967) was probably referring to species abundance rather than to richness. For our study area, Admiralty charts give the bottom type as 'coral'. As no organisms, apart from calcareous algae, which could be interpreted as 'coral' were recovered during our study, we are of the opinion that in the context of the northeastern coast of the Maltese Islands at least, 'coral' on Admiralty charts refers to maerl bottoms. If this is so, then maerl may cover extensive areas of sea bed off the northeastern coast of Malta, since Admiralty charts show 'coral' bottoms to be present all along this coast at depths greater than ca. 40m.

In summary, this work, although limited, shows that in our study area, and possibly all along the north-eastern coast of the Maltese Islands, the lower infralittoral consists of sandy bottoms with sea-grass meadows giving way to bare sand at depths greater than ca. 40m, although seagrass may occur down to 44m or even deeper. The infralittoral grades into the fine sediments of the circalittoral at depths of more than 80m via a strip of maerl where conditions permit the formation of this type of bottom. This transitional maerl bottom provides a complex habitat with a high diversity of associated macrobenthos, which contrasts with the lower diversity of the generally bare sediments of the lower infralittoral and the circalittoral. Little is known about this biotope and a more detailed study of local maerl would be of great interest.

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