Ital. J. Zool., *67*: 287-295 (2000)

Molluscan assemblages associated with photophilic algae in the Marine Reserve of Ustica Island (Lower Tyrrhenian Sea, Italy)

MARCO MILAZZO
RENATO CHEMELLO
Dipartimento di Biologia animale, Università di Palermo, via Archirafi 18, I-90123 Palermo (Italy)

FABIO BADALAMENTI
Laboratorio di Biologia marina, IRMA-CNR, via G. da Verrazzano 17, I-91014 Castellammare del Golfo (TP) (Italy)

SILVANO RIGGIO
Dipartimento di Biologia animale, Università di Palermo via Archirafi 18, I-90123 Palermo (Italy)

ABSTRACT

Very few studies have addressed the effect of protection on macrozoobenthos in marine protected areas, and particularly for sites in the Mediterranean Sea. In the present study, the molluscan assemblages associated with photophilic algal communities of the Marine Reserve of Ustica Island, were investigated. A survey was carried out along transects from 1 to 15 m in depth, during the spring of 1996 at three different sites, subjected to different levels of reserve protection. Species richness and number of individuals reflected the level of protection, and both variables were significantly higher in the integral (most heavily protected) part of the reserve compared with the less well protected buffer areas. Species diversity values showed no correlation with the level of protection. The results reported here do not agree with previous findings on the 'reserve effect' involving large-sized macrozoobenthic species. However, the data reported, together with a study on polychaetes from the same study sites, and visual census observations concerning the fish assemblage of the island may support the hypothesis that protection of piscivore and macrocarnivore species within the integral reserve suppresses populations of small-sized microcarnivorous fish species, allowing 'prey-release' of small benthic invertebrates.

KEY WORDS: Mollusc - Marine protected area - Ustica Island - Mediterranean Sea - Photophilic algae - *Cystoseira.*

ACKNOWLEDGEMENTS

The Authors would like to thank Giovanni D'Anna (IRMA-CNR, Castellammare del Golfo, TP) for statistical support; Giovanni Fulvio Russo (University of Catania), Gianluca Sarà (University of Palermo) and John Pinnegar (University of Newcastle) for critical review of the manuscript; Gianfranco Scotti and Elena Nasta (University of Palermo) for their indispensable help during field work; Bruno Dell'Angelo and Amalia Pandolfo for the identification of Polyplacophora and the specimens of the genus *Rissoa*. This study was funded by MURST 60%-97 (Prof. S. Riggio).

(Received 22 March 2000 - Accepted 18 April 2000)

INTRODUCTION

A major concern of many conservation biologists is the monitoring of biological and socio-economic outcomes as a result of protection measures (Goñi *et al.*, 1998). Due to the complexity of coastal ecosystems, a single change may lead to imbalances in ecosystem function, which will have ramifications for community structure overall (Hurlbert *et al.*, 1972; Jennings & Lock, 1996; Jennings & Kaiser, 1998; Hall, 1999).

The implementation of marine protected areas is usually aimed at reducing the effects of human activities on natural communities (Agardy, 1994), and activities such as spearfishing, diving, and professional and recreational fisheries are often prohibited. Generally, this corresponds with marked changes in the abundance of target fish species (Bell, 1983; Garcia-Rubies & Zabala, 1990; Francour, 1994; Harmelin *et al.*, 1995; Roberts, 1995; Russ & Alcala, 1996) and often of their prey as a result (McClanahan, 1994, 1995; Sala & Zabala, 1996; Sala, 1997; Sala *et al.*, 1998). Top predators may exert a great influence over the abundance of organisms at lower trophic levels and hence over the structure of ecosystems as a whole (Pinnegar *et al.*, 2000). Fish predation may be very substantial within Mediterranean marine protected areas and controls, via a cascade of trophic interactions, the abundance of many benthic species (McClanahan, 1994, 1995; Sala & Zabala, 1996; Sala *et al.*, 1998). On the other hand, however, the abundance of prey species may also be strongly affected by other ecological processes such as those enhancing recruitment (Jennings & Kaiser 1998).

Few studies have addressed the effect of protection on macrozoobenthic invertebrate species. McClanahan (1989) demonstrated on Kenyan coral reefs that densities of large gastropods were not significantly higher within a reserve when compared to sites outside; however, in a large-scale study on six Kenyan lagoons, the same Author (McClanahan, 1990) revealed that the removal of predators (triggerfish) through fishing resulted in an increase in gastropod densities. Similar results were observed in the Marine Reserve of Scandola (NW Mediterranean, France). The large macrozoobenthos of Scandola was poorer in both abundance and species richness within the integral part of the reserve (Boudouresque *et al.*, 1992), where predatory fish were more abundant than outside, where the abundance, biomass and diversity of fishes was much lower (Francour, 1994). The research carried out in the Scandola Marine Reserve (Boudouresque *et al.*, 1992) presently represents the only study available from Mediterranean marine reserves that deals with macrozoobenthic species as descriptors of the 'reserve effect'.

Before the establishment of the Marine Reserve of Ustica Island, only two studies had been carried out on the benthic assemblages at this site, namely those of Chemello (1986), who studied the distribution of gastropod fauna around the island in relation to the different benthic communities present, and that of Giaccone *et al.* (1985) who characterised the algal assemblages from a phytosociological point of view.

The present study aims: (i) to provide further information on the molluscan assemblages associated with photophilic algae in the Marine Reserve of Ustica Island; (ii) to investigate the differences of the molluscan assemblage structure and composition in three sites which are subjected to different levels of protection; (iii) to determine whether diversity indices are good descriptors of protection efficiency.

MATERIALS AND METHODS

Study area

Ustica is a small volcanic island situated 36 miles off the NW Sicilian coast (Lower Tyrrhenian Sea, Italy). Ancient basaltic lavae and more recent effusive rocks make up the majority of the coastal sea substratum (Martelli, 1912; Stella-Starrabba, 1925) and assemblages of photophilic algae, *Posidonia oceanica* beds and coralligenous concretions are the prevailing biotic communities. Some areas of soft bottom exist but these are restricted to small lenses of coarse sand and pebbles (Andaloro F. *et al.*, 1998, *Abstract* in XXIX Congr. SIBM, 78). The Marine Reserve of Ustica Island was established in 1986 but has been running effectively since 1991. It is divided into three areas with different levels of protection (Fig. 1): zone A (integral reserve or no-take area) where all human activities are forbidden except for research; zone B (general reserve or buffer area), where diving, artisanal (limited to local boats) and recreational (limited to anglers) fisheries are allowed; zone C (partial reserve) where all activities, including spearfishing, are permitted but with the exclusion of trawling and purse seine.

Sampling procedures

In June 1996, infralittoral benthic assemblages on hard substrata were sampled at sites within the Ustica Marine Reserve (Fig. 1): Punta di Megna (zone A), Parrino (zone B), Punta dell'Arpa (zone C). In general, rocky substrata were covered by a carpet of photophilic brown algae (Giaccone *et al.*, 1985) and particularly by species belonging to the genus *Cystoseira*.

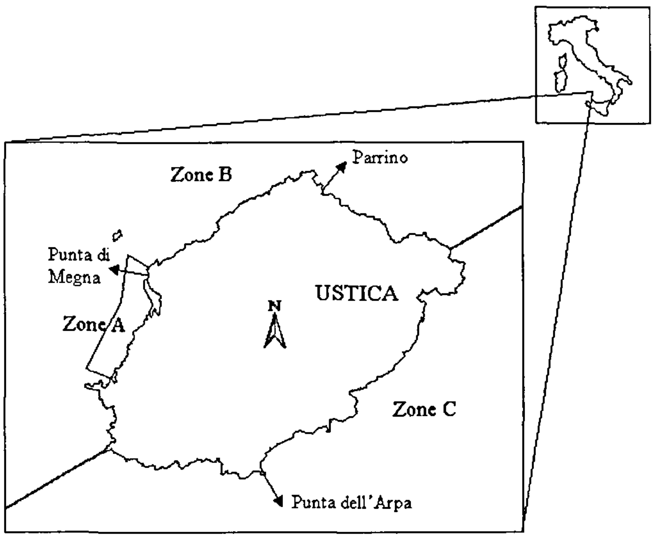

Fig. 1 - Study site and sampling stations.

Samples were collected by scuba divers along line transects at five different depths: -1, -3, -5, -10, and -15 m. Surfaces were cleaned of vagile fauna, by the use of an airlift sampler (Benson, 1989), and macroalgae then scraped from the substratum using hammer and chisel. It was established using the rarefaction curve of the area/species ratio (Chemello R., 1991, PhD thesis) that, at each depth, some 400 cm^2 of algal-covered substratum should be sampled. Two replicated samples for each station were collected.

In laboratory, samples were sorted, sieved through a 0.5 mm mesh and preserved in a 4% formalin solution in sea water. After fixation, adult living molluscs were identified to species level and counted (Van Aartsen *et al.*, 1984; Gofas, 1990; Giannuzzi-Savelli *et al.*, 1994, 1996).

Data analysis

The molluscan assemblage was analysed according to total abundance of individuals (N), total number of species (S), Shannon-Weaver diversity (H'), Pielou's Evenness (J), and Margalef's index (d). The density of molluscs, expressed as mean number of individuals per m^2, in the three zones of the reserve was also calculated. Kruskal-Wallis and Mann-Whitney U tests were employed to determine whether molluscan assemblages within each zone and at each sampling depth were significantly ($P < 0.05$) different from one another (Sokal & Rolf, 1981).

The statistical package PRIMER (Clarke & Warwick, 1994) was used to perform all multivariate analysis, and samples were compared, after a double square root transformation. Ordination of the data was conducted using non-metric multidimensional scaling (MDS; Kruskall & Wish, 1978), based on a Bray-Curtis similarity index of species composition among samples. Unitopic species were not included in the analysis (Chemello R., 1991, PhD thesis).

RESULTS

Table I lists the macroalgal species sampled during the study, and shows that *Cystoseira brachicarpa* v. *balearica*, *C. sauvageauana* v. *polyoedematis*, and *C. compressa* were the dominant macroalgal species in the study site.

A total of 5721 mollusc specimens belonging to 161 different species were collected in the various zones of Ustica Island and these were numerically dominated by Gastropoda (83.2% of the total number of species; 89% of the total number of individuals) while Bivalvia (11.2% of all species; 9.9% of all specimens), and Polyplacophora (5.6% of all species; 1.1% of all specimens) were less frequent (see Appendix I). Overall, in terms of species richness, the Rissoidae (26 species; 16.1% of the total number of species) were the dominant family followed by Muricidae (14 species; 8.7%) and Trochidae (13 species; 8.1%). Rissoidae were also the family with the highest numerical abundance, with 1836 specimens representing 32.1% of the total number of individual molluscs collected. The Tricoliidae represented 9.1% of all individuals collected (523 animals), whilst the Cerithiidae represented 8.8% (505 animals).

The average molluscan density value and the total number of species was higher in zone A in comparison with the other two areas (Table II). Community and diversity variables measured for each of the three zones

TABLE I - *List of macroalgae collected and percentage cover of each species at different depths (m) in the three zones of the reserve.*

Algal species	Zone A					Zone B					Zone C				
	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15
Cystoseira brachicarpa		**	**	**				**	**		*				
Cystoseira brachicarpa v. *balearica*	***										*	**	***	***	**
Cystoseira sauvageauana				*	**										
Cystoseira sauvageauana v. *polyoedematis*					***		***	***	***	***					
Cystoseira schiffneri f. *tenuiramosa*					*										
Cystoseira spinosa				**											
Cystoseira elegans		*	*												
Cystoseira compressa		**				***					**	***	**	**	*

Percentage cover expressed in ranks: * ≤ 25%, ** = 26-50%, *** ≥ 50%.

and at the different sampling depths, are reported in Table III. The number of molluscan species ranged on average from 52 (± 1.4 SD) in the integral reserve (3 m depth) to 22.5 (± 3.5 SD) within the B zone (-1 m). Number of individuals ranged from 362 (± 86.3 SD) within the A zone (15 m depth) to 53.5 (± 23.3 SD) in the partial reserve (-3 m).

There were significant differences in both variables between different zones of the reserve (Kruskal-Wallis test, n = 30, $P < 0.05$ and $P < 0.001$ respectively). Samples of the integral reserve were on average higher in number of individuals and species than samples from reference areas B and C. Paired comparisons (Mann-Whitney U test) among stations revealed that the abundance and number of species varied significantly among the three zones of the reserve. Zone A is significantly different from zone C for both N ($P < 0.001$) and S ($P < 0.01$). Species richness was also significantly higher ($P < 0.01$) in zone B when compared with zone C, but no significant differences were detected between the integral reserve and the general reserve (zone B). There were no significant differences in diversity values among the three zones; however, the mean values of H' and J indices were lower in zone C than in the other two zones. Margalef's index showed similar trends among the three sites considered.

Multidimensional scaling ordination (stress = 0.1) was able to discern three main groupings of samples, separated (along the horizontal axis) according to their level of protection. All depth samples of each zone generally grouped close together, with only slight drift along the vertical axis (Fig. 2). The three main groupings were: (1) the molluscan assemblage of the integral reserve (Punta di Megna, zone A); (2) an intermediate group of the general reserve (Parrino, zone B); (3) the malacofauna of the partial reserve (Punta dell'Arpa, zone C), which was well separated from the other stations.

DISCUSSION

This study of the molluscan assemblages in the infralittoral rocky bottom of the Ustica Island Marine Reserve has highlighted high values of abundance and species richness, especially when compared with similar studies from elsewhere in the Mediterranean Sea (Poulicek, 1985; Chemello & Russo, 1997). Data concerning the molluscan assemblages (collected with the same sampling techniques) on the Sicilian mainland, opposite Ustica Island, revealed much lower values of total species richness (118 species) compared with the results presented here (Chemello *et al.*, 1997).

A qualitative comparison of our set of data on the gastropod fauna of Ustica Island with data from the previous study of Chemello (1986) revealed 17 species (10.6% of the total number) which were reported for the first time at this study site, possibly indicating a natural replacement of species throughout the years (Milazzo *et al.*, 2000). This result is very interesting since the previous study of Chemello (1986) was conducted prior to the establishment of the marine reserve on Ustica Island. As part of the earlier study (Chemello, 1986), several biocoenoses, not only the photophilic algae, were sampled along the island coasts.

Analysis of the total molluscan assemblage revealed that the dominant group of species in the Ustica samples belonged to the family Rissoidae. Similar results have been obtained elsewhere in the Mediterranean Sea (Poulicek, 1985; Ros, 1985; Chemello & Russo, 1997; Chemello *et al.*, 1997).

Our results clearly indicated that the number of individuals and number of species of molluscs are influenced by different degrees of protection. Complete protection (in the integral reserve) enhances N and S, whilst intermediate levels of protection in zone B has an intermediate effect. The molluscan assemblage in zone C was shown to be very different to those in zones A and B, presenting the lowest number of

TABLE II - *Average density and total species richness in the three zones of the reserve.*

Sampling area	Average density (specimens/m²)	Species richness
Integral reserve (zone A)	6300	121
General reserve (zone B)	5500	106
Partial reserve (zone C)	2400	101

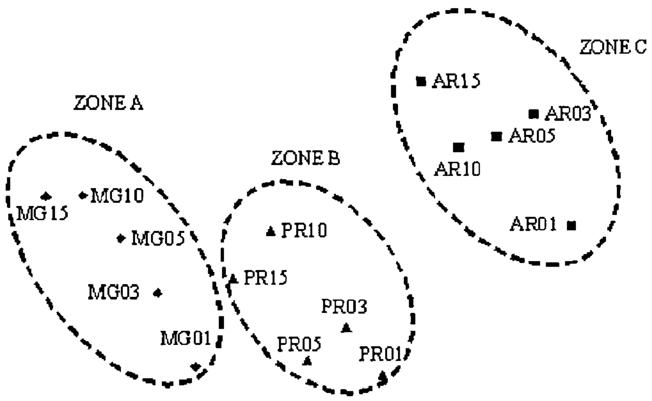

Fig. 2 - Multidimensional scaling ordination model of the different sampling stations with Bray-Curtis clusters superimposed (stress = 0.1). AR, Punta dell'Arpa; MG, Punta di Megna; PR, Parrino.

species and fewer individuals. According to MDS ordination (Fig. 2) it is apparent that the effect of protection is more important in determining species distribution than the hydrodynamic gradient (Riedl, 1971), which has previously been proposed for infralittoral molluscan assemblages of the Mediterranean Sea (Idato *et al.*, 1981; Chemello & Russo, 1997).

In the last decade, several attempts have been made to find a correlation between biological diversity and the degree of protection (Roberts & Polunin, 1992; Bayle & Ramos, 1993; Harmelin *et al.*, 1995), but very few Authors have found a positive correlation both for fish species and benthic invertebrates (Boudouresque *et al.*, 1992; Francour, 1992). In our study, the diversity indices of the molluscan assemblage were not correlated significantly with protection level among the three sites of the reserve.

The results of the present research do not seem to agree with previous observations for the 'reserve effect', associated with large benthic invertebrate species (McClanahan, 1989; Boudouresque *et al.*, 1992). In those earlier studies, numbers of invertebrates were significantly higher outside the reserves in comparison with sites inside. This apparent disparity could be mainly related to the size of the molluscs collected in the present study, notably smaller (between 0.5 mm and 20 mm) than those considered previously. Clearly, small animals will assume different trophic roles in littoral assemblages in comparison with larger invertebrates, and they may possess a very different suite of potential predators. In the Marine Reserve of Ustica Island, there is evidence that, as a consequence of protection, piscivore species (like groupers) are significantly more abundant within the integral reserve than in the other two zones (Vacchi *et al.*, 1998), and for this reason, small sized meso- and microcarnivore species (their prey), such as labrids, gobids, and blennids that are not target species

TABLE III - *Number of individuals, number of species, and diversity indices measured for the three zones of the reserve (mean ± SD).*

Zone	Depth (m)	N	S	H'	J	d
	15	362.0 ± 86.27	45.5 ± 2.12	2.75 ± 0.16	0.72 ± 0.03	7.57 ± 0.05
	10	207.0 ± 33.94	44.5 ± 6.36	3.20 ± 0.30	0.76 ± 0.02	7.51 ± 0.94
A	5	197.0 ± 1.41	39.0 ± 1.41	3.13 ± 0.08	0.85 ± 0.01	7.19 ± 0.26
	3	282.0 ± 8.49	52.0 ± 1.41	3.27 ± 0.01	0.83 ± 0.00	9.04 ± 0.30
	1	218.0 ± 60.81	23.5 ± 0.71	2.53 ± 0.02	0.80 ± 0.01	4.20 ± 0.35
	15	165.0 ± 7.07	39.5 ± 0.71	3.07 ± 0.08	0.84 ± 0.03	7.54 ± 0.08
	10	232.0 ± 57.98	41.0 ± 8.49	2.99 ± 0.15	0.81 ± 0.00	7.34 ± 1.22
B	5	281.5 ± 16.26	38.5 ± 0.71	2.95 ± 0.07	0.81 ± 0.02	6.65 ± 0.19
	3	317.0 ± 15.56	44.0 ± 1.41	3.05 ± 0.11	0.80 ± 0.02	7.47 ± 0.31
	1	112.5 ± 9.19	22.5 ± 3.54	2.48 ± 0.08	0.80 ± 0.01	4.55 ± 0.67
	15	84.5 ± 24.75	36.0 ± 2.83	3.03 ± 0.15	0.85 ± 0.06	7.92 ± 0.11
	10	105.0 ± 41.01	31.5 ± 3.54	2.66 ± 0.02	0.77 ± 0.02	6.60 ± 0.19
C	5	173.0 ± 35.36	39.0 ± 0.00	2.60 ± 0.20	0.71 ± 0.06	7.39 ± 0.30
	3	53.5 ± 23.33	23.5 ± 4.95	2.60 ± 0.16	0.83 ± 0.00	5.69 ± 0.61
	1	70.5 ± 19.09	24.0 ± 1.41	2.70 ± 0.03	0.85 ± 0.03	5.43 ± 0.02

(Arculeo *et al.*, 1996) and which feed directly on small sized invertebrates (Tortonese, 1975; Khoury C., 1987, PhD thesis, Univ. Aix-Marseille II), may be less abundant. Consequently, it is presumable that the molluscan assemblage of the Ustica Island Marine Reserve may be numerically more abundant in A zone, due to a lower predation rate, in comparison with areas outside. Similar research on polychaetes (Badalamenti *et al.*, 1999) at sites around Ustica, has revealed similar observations and may support the 'prey-release' hypothesis. Future research should be addressed to better understanding trophic relationships among fish assemblage and small-sized macrobenthos in marine protected areas.

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APPENDIX I - *Presence/absence matrix of the molluscan species collected at different depths (m) in the three zones of the reserve.*

	Zone A					Zone B					Zone C				
	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15
POLYPLACOPHORA															
Lepidopleurus scabridus (Jeffreys, 1880)		•	•						•						•
Ischnochiton rissoi (Payraudeau, 1826)		•													
Callochiton septemvalvis (Montagu, 1803)	•			•			•		•	•		•		•	•
Lepidochitona monterosatoi Kaas & Van Belle, 1981											•	•	•	•	
Chiton corallinus (Risso, 1826)			•						•			•			
Chiton olivaceus Spengler, 1797		•		•							•	•			
Chiton phaseolinus Monterosato, 1879		•									•		•		
Acanthochitona crinita (Pennant, 1777)			•												
Acanthochitona fascicularis (Linnè, 1767)		•	•		•			•	•			•			•
GASTROPODA															
Acmea virginea (Mueller O.F., 1776)				•					•				•		
Fissurella nubecula (Linnè, 1758)	•					•					•	•			
Diodora gibberula (Lamarck, 1822)	•		•	•											
Diodora graeca (Linnè, 1758)		•													
Emarginula tenera Locard, 1892				•											
Scissurella costata D'Orbigny, 1824	•	•	•	•	•		•	•	•	•		•	•		
Sinezona cingulata (Costa O.G., 1861)	•	•	•	•		•	•				•	•	•	•	•
Clanculus cruciatus (Linnè, 1758)	•	•	•	•	•				•		•		•	•	•
Clanculus jussieui (Payraudeau, 1826)			•	•			•			•					
Calliostoma conulus (Linnè, 1758)			•										•		
Calliostoma l. laugieri (Payraudeau, 1826)		•		•	•	•	•	•	•			•	•		
Calliostoma gualterianum (Philippi, 1848)					•										
Calliostoma zyzyphinum (Linnè, 1758)				•											•
Gibbula ardens (Von Salis, 1793)		•													
Gibbula racketti (Payraudeau, 1826)		•													
Gibbula turbinoides (Deshayes, 1835)		•	•									•	•		
Gibbula a. adansonii (Payraudeau, 1826)						•		•							
Gibbula varia (Linnè, 1758)									•						
Jujubinus exasperatus (Pennant, 1777)										•					
Jujubinus gravinae (Dautzenberg, 1881)	•	•	•	•	•	•	•	•		•	•				•
Jujubinus s. striatus (Linnè, 1758)		•					•	•		•			•	•	
Skenea serpuloides (Montangu, 1808)					•										
Tricolia p. pullus (Linnè, 1758)							•	•							
Tricolia tenuis (Michaud, 1829)		•	•	•	•	•	•	•	•	•		•		•	•
Bolma rugosa (Linnè, 1767)					•										
Cerithium lividulum Risso, 1826												•			
Cerithium rupestre Risso, 1826	•	•	•	•		•	•		•		•	•	•	•	•
Cerithium vulgatum Bruguière, 1792	•					•			•						•
Bittium jadertinum (Brusina, 1865)		•		•	•			•		•					
Bittium l. lacteum Philippi, 1836		•			•				•	•					•
Bittium latreillii (Payradeau, 1826)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bittium reticulatum (Da Costa, 1778)		•					•								
Bittium scabrum (Olivi, 1792)					•										
Eatonina cossurae (Calcara, 1841)	•	•		•		•	•				•		•	•	
Tubbreva micrometrica (Aradas e Benoit, 1876)					•										•
Rissoa auriscalpium (Linnè, 1758)										•					
Rissoa guerini Rècluz, 1843					•		•	•		•	•	•	•		•
Rissoa lia (Monterosato, 1884 ex Benoit ms.)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Rissoa similis Scacchi, 1836		•						•	•						
Rissoa variabilis (Von Muehlfeldt, 1824)		•	•	•	•	•	•	•	•	•	•		•	•	•
Alvania cancellata (Da Costa, 1778)		•	•	•	•	•			•	•	•	•	•	•	•
Alvania consociella Monterosato, 1884						•	•	•	•	•					

(continued)

(continued)

	Zone A					Zone B					Zone C				
	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15
Alvania discors (Allan, 1818)					•		•		•	•			•	•	
Alvania geryonia (Nardo, 1847 ex Chiereghini ms.)										•					
Alvania lineata (Risso, 1826)				•	•		•	•	•	•			•	•	
Alvania mamillata Risso, 1826		•	•	•	•				•	•		•	•	•	•
Alvania scabra (Philippi, 1844)		•	•	•	•	•	•	•	•	•		•	•	•	•
Alvania tessellata Weinkauff, 1868 ex Schwarts ms.				•						•					
Alvania simulans Locard, 1886		•											•		
Alvania sp1															•
Alvania sp2								•	•	•					
Pusillina marginata (Michaud, 1832)					•								•	•	
Pusillina philippii (Aradas e Maggiore, 1844)				•	•					•			•		
Pusillina radiata (Philippi, 1836)					•			•	•	•					•
Setia alleryana (Brugnone, 1873)	•	•	•			•	•	•							
Setia amabilis (Locard, 1886)	•	•	•		•	•	•			•	•				
Setia antipolitana (Van der Linden & Wagner, 1987)						•									
Setia maculata (Monterosato, 1869)	•	•	•								•				
Setia turriculata Monterosato, 1884		•					•	•			•				
Setia sp														•	•
Rissoina bruguieri (Payraudeau, 1826)		•			•				•	•					
Nodulus contortus (Jeffreys, 1856)		•					•	•		•					
Pisinna glabrata (Von Muehlfeldt, 1824)	•	•												•	
Barleeia unifasciata (Montagu, 1803)	•	•	•				•	•	•		•	•		•	
Megalomphalus azonus (Brusina, 1865)		•			•					•					
Vermetus triquetrus (Bivona Ant., 1832)								•							
Dendropoma petraeum (Monterosato, 1844)		•									•				
Trivia pulex (Solander in Gray, 1828)		•	•										•		
Marshallora adversa (Montagu, 1803)		•													
Monophorus perversus (Linnè, 1758)	•														
Monophorus thiriotae Bouchet, 1984				•	•			•						•	•
Cerithiopsis contigua Monterosato, 1878													•		
Cerithiopsis minima (Brusina, 1865)				•									•		
Cerithiopsis tubercularis (Montagu, 1803)		•	•	•	•				•				•	•	•
Dizoniopsis bilineata (Hoernes, 1848)		•													
Melanella polita (Linnè, 1758)		•			•		•	•	•						
Vitreolina incurva (Bucquoy, Dautzenberg & Dollfus, 1883)				•			•	•			•				•
Hexaplex trunculus (Linnè, 1758)		•	•						•						•
Muricopsis cristata (Brocchi, 1814)			•	•	•	•	•					•	•		•
Ocinebrina aciculata (Lamarck, 1822)	•	•	•		•				•	•					
Ocinebrina edwardsii (Payraudeau, 1826)		•	•												
Buccinulum corneum (Linnè, 1758)										•					
Chauvetia mamillata (Risso, 1826)			•	•				•	•	•			•		
Chauvetia brunnea (Donovan, 1804)		•	•	•	•		•		•	•			•		
Chauvetia recondita (Brugnone, 1873)	•	•	•	•	•							•			
Colubraria reticulata (Blainville, 1826)															•
Pisania striata (Gmelin, 1791)	•														
Pollia dorbignyi (Payraudeau, 1826)		•	•	•	•		•		•		•	•	•		•
Pollia scabra Locard, 1866								•	•			•		•	•
Coralliophila meyendorphii (Calcara, 1845)		•		•			•		•		•		•	•	•
Fusinus pulchellus (Philippi, 1844)													•		
Nassarius costulatus cuvierii (Payraudeau, 1826)		•					•	•		•			•		
Columbella rustica (Linnè, 1758)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Mitrella scripta (Linnè, 1758)				•	•		•		•	•			•	•	•
Vexillum ebenus (Lamarck, 1811)	•		•	•		•							•	•	•
Vexillum savignyi (Payraudeau, 1826)		•			•				•	•				•	
Vexillum tricolor (Gmelin, 1790)		•	•	•	•	•	•	•	•	•			•	•	•
Gibberula miliaria (Linnè, 1758)			•	•	•		•	•		•			•		

(continued)

(continued)

	Zone A					Zone B					Zone C				
	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15	-1	-3	-5	-10	-15
Gibberula philippii (Monterosato, 1878)		•			•		•	•	•	•			•		
Granulina boucheti Gofàs, 1992								•		•					
Granulina marginata (Bivona, 1832)	•	•	•	•	•	•	•	•	•	•			•	•	•
Mitra cornicula (Linnè, 1758)	•	•	•		•	•	•	•	•		•	•	•	•	•
Conus mediterraneus Hwass in Bruguière, 1792	•	•	•	•	•	•	•	•	•	•				•	
Clathromangelia quadrillum (Dujardin, 1837)										•					
Mangiliella taeniata (Deshayes, 1835)				•	•			•	•	•			•		
Haedropleura septangularis (Montagu, 1803)										•					
Rissoella diaphana (Alder, 1848)			•	•	•		•		•				•	•	•
Rissoella inflata Locard, 1892				•	•		•	•		•					
Omalogyra atomus (Philippi, 1841)			•			•	•	•	•						
Ammonicera fischeriana (Monterosato, 1869)	•	•		•	•	•	•		•		•	•	•	•	•
Ammonicera rota (Forbes & Hanley, 1850)				•	•	•					•				
Chrysallida doliolum (Philippi, 1844)		•													
Chrysallida obtusa (Brown, 1827)				•	•								•	•	•
Euparthenia humboldti (Risso, 1826)			•												•
Anisocycla pointeli (Folin, 1867)								•							
Odostomia kromi Van Aartsen, Menkh. & Gittenb., 1984								•	•						
Odostomia sp									•	•	•				
Ondina vitrea (Brusina, 1866)										•					
Retusa semisulcata (Philippi, 1836)							•								
Haminoea hydatis (Linnè, 1758)							•	•					•		
Atys jeffreysi (Weinkauff, 1868)															•
Philine catena (Montagu, 1803)								•							
Runcina sp1	•	•	•	•	•		•	•			•	•	•	•	•
Runcina sp2				•											
Elysia viridis (Montagu, 1803)											•				
Aplysia punctata (Cuvier, 1803)			•		•						•	•	•	•	•
Aplysia fasciata Poiret, 1789				•											
Phyllaplysia lafonti (Fischer P., 1870)													•		
Discodoris maculosa Bergh, 1884							•								
Polycera dubia Sars M., 1829				•											
Doriopsilla areolata Bergh, 1880				•											
Tritonia lineata Alder & Hancock, 1848			•	•	•				•				•	•	•
Goniodoris castanea Alder & Hancock, 1845										•					
Cuthona caerule (Montagu, 1804)		•						•			•	•			
BIVALVIA															
Arca noae Linnè, 1758	•	•	•	•	•		•	•	•	•	•		•	•	•
Barbatia barbata (Linnè, 1758)			•	•		•			•	•				•	
Striarca lactea (Linnè, 1758)		•	•	•	•	•	•		•			•		•	
Mytilaster lineatus (Gmelin, 1791)	•														
Musculus costulatus (Risso, 1826)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Lissopecten hyalinus (Poli, 1795)					•										
Chlamys varia (Linnè, 1758)															•
Lima exilis S.V. Wood, 1839															•
Lima lima (Linnè, 1758)										•			•		•
Lima hians (Gmelin, 1791)													•		
Ctena decussata (Costa O.G., 1829)			•						•						
Chama gryphoides Linnè, 1758	•		•					•	•					•	
Pdeudochama gryphina (Lamarck, 1819)	•							•							
Neolepton sulcatulum (Jeffreys, 1859)		•													
Cardita calyculata (Linnè, 1758)	•	•	•			•		•		•	•	•		•	•
Parvicardium exiguum (Gmelin, 1791)															•
Parvicardium ovale (Sowerby G. B. II, 1840)							•	•			•				
Hiatella arctica (Linnè, 1767)				•	•						•				•

Checklist arranged in accordance with Bedulli *et al.* (1995a, b, c) and Bodon *et al.* (1995).