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Use of biodiversity hotspots for conservation of Marine Molluscs: a regional approach

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Abstract

A method to define biodiversity hot spots as regards marine molluscs is proposed. Species richness of Italian marine molluscs is analysed by means of data collected by members of the Italian Malacological Society. Data are ordered in the database 'Census of Italian Marine Molluscs' available on the Internet. The Census contains about 20.000 records concerning 901 species sampled in 663 localities around all the Italian coasts. The records are divided into 59 lots; for each lot we formulate an index of species richness not related to the sampling effort. This index shows a positive correlation with the environmental diversity and with the proportion of hard substrates on the sea bottom. In the lots we assess the distribution of species worth of protection (according to literature) and of most rare species. Combining these data with the distribution of lots with higher values of species richness index, we identify hot spots available for conservation.

Keywords: Hot spot, Biodiversity, Mediterranean Sea, Benthos, Molluscs, Conservation.

Introduction

Most of the biosphere is poorly known, thus species richness is often the only available measure of biodiversity in extended areas and for most taxa. Species richness of molluscs can be effective in characterising the marine macrobenthos community and in measuring biodiversity in extended marine areas for the following reasons:

1) Molluscs are distributed worldwide; in marine ecosystems they are among the Phyla

with the highest number of species (e.g. PURVES *et al.*, 1998).

2) It is possible to relate variation in their population composition and structure to environmental changes.

3) They show extreme morphological diversification and may be frequently dominant (n° of individuals and/or biomass) in marine communities.

For these reasons 'Molluscs are a powerful tool to describe biodiversity in marine ecosystems on a wide scale and to indicate community composition and structure'

(CHEMELLO *et al.*, 2000). Moreover the protection of molluscs is in line with the principles of the World Conservation Strategy (UNEP; IUCN & WWF, 1980).

In the Italian Seas 1533 species (80% of the Mediterranean ones) have been identified (BEDULLI *et al.*, 1995a, 1995b, 1995c; BELLO, 1995; BODON *et al.*, 1995). The molluscs of the Mediterranean Sea are relatively well - studied and among the most studied and the best known of the world. In the Italian seas very few species can be considered endemic and, as pointed out by OLIVERIO (2000), none can be defined as 'critically endangered' in accordance with IUCN Red List criteria (SEDDON, 1998). However many species are endangered, threatened and/or members of threatened communities for evolutionary reasons (e.g., deep white corals) or human activities (e.g., *Posidonia oceanica* meadows) (OLIVERIO, 2000; SCOTTI & CHEMELLO, 2000). Causes of molluscs population threat are: habitat destruction, fishing and introduction of alien species. These causes can often work in synergy.

Mollusc biodiversity can be used to locate areas more worthy of protection. To this purpose NORSE (1993) proposed the following criteria: high richness of endemic species, 'source' areas and nursery areas. CHEMELLO *et al.* (2000) propose areas having: high species richness, high biogeographic and ecological value and low level of human impact. Moreover, ecologically representative areas, with international importance and ecological uniqueness should be taken into consideration. These criteria are coherent with a conservation strategy defined 'hot spot' (e.g., MYERS *et al.*, 2000). Our study proposes a different approach to the hot spot strategy: to combine lots with higher values of species richness index with data on distribution of species worth protecting and of rare species.

Materials and Methods

We analyse data collected by the Italian Malacological Society (SIM) for the Census of

Italian Marine Molluscs. Data has been organised in units called records. Each record contains the following information: sample number, sampler code, region code, geographic co-ordinates, date, sampling method, depth, substrate code, habitat code, species code, species name, number of living and dead individuals sampled. Every record has been checked both for taxonomy and ecology by academic malacological specialists designated by the SIM. A total of 19.226 records for 901 species sampled from 1/1/1958 to 31/12/1998 in 663 different localities were collected and analysed.

All data inclusive of sampling methods and ecological features are organised by the authors on a database available free of charge on the Internet at the web site:

<http://estaxp.santateresa.enea.it/www/censim/censimento.htm>.

Since different areas have extreme variability in sampling effort, to analyse our data we divided all records into lots containing a similar number of records. The criterion applied is to link geographical areas to comparable sampling efforts. This operation enabled us to find 59 lots with around 300 records each (mean 326 ± 60.3). This value was chosen in order to have a sample size large enough to represent a particular geographical area and because, frequently, this sample size can easily be related to a district or a region and/or to islands or specific places.

The index of species richness (SRI) is the n° of species in a lot/ n° of records in the same lot. Since we focus particularly on differences between soft and other substrates, we consider hard bottom to be the following substrates: rock, biogenic *i.e.* coralligenous, pebbles, gravel and all kinds of artificial hard substrates. Conversely, mud and sand are considered soft bottom. According to this classification, the Proportional Index of Hard Bottom (PHB) is the n° of records sampled on hard bottom in a lot/ the total n° of records in the same lot. In each lot SRI and PHB have the same denominator (which is always about 300 records).

The Bathymetric Variability Index (BVI) is a measure of the bathymetric variability and is calculated as follows. First in each lot we have considered bathymetric units, defined as the number of depth intervals in which samples have been taken. Depth intervals are 10 m from 0 to 100 m depth and 20 m from 101 to 1000 m. Secondly, we have multiplied all the different sampling depths and the n. of bathymetric units in each lot.

Species with only one individual sampled are considered rare. The species worth protecting are those indicated in BODON *et al.* (1995) and in SCOTTI & CHEMELLO (2000).

The SRI, the number of species worth protecting and the number of rare species are

converted into a 0-10 scale. We have assigned value 10 to the highest values for each variable and we have transformed the lower values proportionally. For each lot, the sum of the values of these three variables is used to assess its hot spot value:

$$\text{hot spot value for lot}_i = (\text{SRI}_i/\text{SRI}_{\text{max}})10 + (\text{n. sp. w. prot}_i/\text{n. sp. w. prot.}_{\text{max}})10 + (\text{n. rare sp.}_i/\text{n. rare sp.}_{\text{max}})10.$$

Results

In each lot the following parameters were assessed: species richness, number of records, number of different habitats, number of

Table 1
List of lots with the following parameters: number species; number of records, number of different habitats, number of localities, PHB, BVI, SRI, species worth of protection and rare species.

| LOT | n° sp. | n° rec. | n° habitat | n° loc. | PHB | BVI | SRI | sp. w. p. | rare sp. |
|----------------------|--------|---------|------------|---------|------|------|-------|-----------|----------|
| MATERA+TARANTO | 277 | 347 | 3 | 12 | 0.91 | 100 | 0.798 | 6 | 0 |
| LIVORNO south | 274 | 344 | 10 | 17 | 0.92 | 350 | 0.797 | 7 | 2 |
| LA SPEZIA | 293 | 373 | 15 | 8 | 0.69 | 143 | 0.786 | 2 | 1 |
| PROCIDA ISLAND | 238 | 311 | 13 | 8 | 0.94 | 90 | 0.765 | 2 | 5 |
| SIRACUSA south | 225 | 296 | 9 | 4 | 0.94 | 132 | 0.760 | 1 | 0 |
| MESSINA + CATANIA | 155 | 204 | 19 | 5 | 0.54 | 117 | 0.760 | 2 | 3 |
| NAPOLI centre north | 249 | 330 | 14 | 13 | 0.92 | 240 | 0.755 | 7 | 5 |
| SALERNO north | 248 | 330 | 14 | 16 | null | 126 | 0.752 | 3 | 0 |
| CAPRAIA ISLAND | 146 | 195 | 8 | 5 | 0.67 | 216 | 0.749 | 2 | 0 |
| GENOVA east | 257 | 352 | 15 | 8 | 0.82 | 160 | 0.730 | 5 | 1 |
| ORISTANO | 210 | 288 | 9 | 3 | 0.92 | 40 | 0.729 | 1 | 2 |
| NAPOLI ISLANDS | 210 | 289 | 12 | 16 | 0.61 | 253 | 0.727 | 1 | 1 |
| PALERMO west | 220 | 310 | 11 | 14 | 0.78 | 130 | 0.710 | 3 | 4 |
| CAGLIARI centre | 167 | 238 | 5 | 3 | 1.00 | 66 | 0.702 | 0 | 1 |
| SIRACUSA north | 210 | 304 | 14 | 25 | 0.67 | 264 | 0.691 | 5 | 0 |
| UDINE+GORIZIA | 134 | 194 | 6 | 5 | 0.00 | 8 | 0.691 | 1 | 0 |
| NAPOLI centre south | 237 | 347 | 6 | 15 | 0.79 | 405 | 0.683 | 3 | 8 |
| RAGUSA+AGRIGENTO | 133 | 197 | 12 | 11 | 0.92 | 64 | 0.675 | 3 | 0 |
| NAPOLI south | 266 | 404 | 14 | 19 | 0.78 | 1419 | 0.658 | 2 | 4 |
| LAZIO | 249 | 385 | 6 | 9 | 1.00 | 300 | 0.647 | 4 | 1 |
| GENOVA west | 242 | 376 | 12 | 9 | 0.95 | 50 | 0.644 | 0 | 1 |
| NAPOLI north | 242 | 376 | 11 | 18 | 0.70 | 294 | 0.644 | 4 | 0 |
| SALERNO south | 236 | 369 | 9 | 11 | 0.90 | 494 | 0.640 | 3 | 0 |
| LIVORNO centre north | 253 | 400 | 5 | 3 | 0.76 | 12 | 0.633 | 3 | 0 |
| LIVORNO centre south | 234 | 371 | 8 | 3 | 0.96 | 56 | 0.631 | 5 | 0 |
| MESSINA IONIAN SEA | 143 | 227 | 12 | 5 | 0.91 | 104 | 0.630 | 3 | 0 |
| SAVONA | 175 | 283 | 8 | 13 | 0.61 | 48 | 0.618 | 0 | 1 |
| CALABRIA | 210 | 348 | 10 | 7 | 0.89 | 18 | 0.603 | 5 | 1 |
| LUCCA + LIVORNO | 167 | 278 | 9 | 8 | 0.99 | 140 | 0.601 | 4 | 0 |

Table 1 (continued)

| LOT | n° sp. | n° rec. | n° habitat | n° loc. | PHB | BVI | SRI | sp. w. p. | rare sp. |
|--------------------------------|--------|---------|------------|---------|------|-----|-------|-----------|----------|
| TRAPANI | 145 | 242 | 11 | 17 | 0.68 | 240 | 0.599 | 5 | 0 |
| TRIESTE | 219 | 366 | 13 | 12 | 0.51 | 28 | 0.598 | 3 | 7 |
| BARI+BRIND.+ ADRIATIC LECCE | 160 | 281 | 4 | 19 | 1.00 | 143 | 0.569 | 2 | 0 |
| GROSSETO | 220 | 389 | 6 | 15 | 1.00 | 81 | 0.566 | 1 | 0 |
| SASSARI west | 151 | 267 | 8 | 6 | 1.00 | 150 | 0.566 | 3 | 1 |
| TARANTO | 164 | 293 | 5 | 11 | 0.94 | 84 | 0.560 | 2 | 0 |
| MARCHE | 199 | 356 | 8 | 32 | 0.39 | 144 | 0.559 | 3 | 2 |
| FAVIGNANA ISLAND | 157 | 291 | 5 | 1 | 1.00 | 16 | 0.540 | 1 | 0 |
| ELBA ISLAND | 219 | 407 | 8 | 25 | 0.96 | 420 | 0.538 | 1 | 1 |
| CAGLIARI west | 198 | 376 | 11 | 7 | 0.91 | 32 | 0.527 | 1 | 0 |
| POTENZA | 168 | 321 | 11 | 6 | 0.88 | 4 | 0.523 | 3 | 2 |
| IMPERIA | 216 | 414 | 9 | 8 | 0.80 | 84 | 0.522 | 6 | 0 |
| LECCE | 161 | 310 | 5 | 12 | 1.00 | 132 | 0.519 | 1 | 0 |
| PALERMO east | 205 | 401 | 11 | 15 | 0.81 | 160 | 0.511 | 1 | 0 |
| CAGLIARI east 1° | 192 | 377 | 4 | 4 | 0.71 | 24 | 0.509 | 1 | 0 |
| CAGLIARI east 3° | 189 | 378 | 5 | 5 | 0.98 | 24 | 0.500 | 1 | 0 |
| SORRENTO | 149 | 300 | 8 | 3 | 0.99 | 8 | 0.497 | 2 | 0 |
| MESSINA TIRRENIAN SEA | 193 | 403 | 15 | 13 | 0.90 | 154 | 0.479 | 4 | 1 |
| NUORO west | 183 | 387 | 3 | 11 | null | 15 | 0.473 | 1 | 0 |
| NUORO east+SASSARI | 183 | 392 | 6 | 5 | 1.00 | 98 | 0.467 | 0 | 2 |
| PESARO+FORLÌ | 130 | 296 | 7 | 16 | 0.04 | 161 | 0.439 | 0 | 1 |
| CAGLIARI east 2° | 152 | 373 | 5 | 9 | 1.00 | 28 | 0.408 | 2 | 0 |
| VENEZIA DEPHT. 18-33 | 142 | 350 | 6 | 13 | 0.32 | 18 | 0.406 | 2 | 1 |
| VENEZIA DEPHT 0-15 | 130 | 335 | 8 | 12 | 0.11 | 9 | 0.388 | 2 | 0 |
| FOGGIA | 148 | 389 | 5 | 33 | null | 84 | 0.380 | 2 | 0 |
| CASERTA | 102 | 274 | 6 | 10 | 0.24 | 130 | 0.372 | 0 | 0 |
| RAVENNA | 116 | 318 | 6 | 15 | 0.00 | 44 | 0.365 | 2 | 0 |
| ABRUZZO | 133 | 367 | 5 | 15 | 0.22 | 143 | 0.362 | 3 | 0 |
| ROVIGO | 67 | 224 | 5 | 11 | 0.00 | 27 | 0.299 | 0 | 0 |
| RAVENNA+FERRARA | 81 | 308 | 4 | 17 | 0.00 | 44 | 0.263 | 0 | 1 |

localities, PHB and BVI (Table 1). The number of species is significantly correlated to the number of records ($R = 0.55$; $n = 59$; $p < 0.001$; Tab. 2) thus this parameter is not reliable to directly measure biodiversity in lots.

On the other hand, SRI is not correlated to the number of records ($R = -0.187$; $n = 59$; $p = n.s.$; Tab. 2) so this index is a reliable measure of biodiversity in different lots. In Table 1 we also list the lots in decreasing order of SRI, moreover we show the number of species worthy of protection and the rare species. Lots having very high values of SRI (> 0.75) are in the Ligurian sea (La Spezia and Livorno south); in the Tyrrhenian Sea

(Procida, Napoli centre-north and Salerno north); in the Northern Ionian Sea (Matera + Taranto) and in the Southern Ionian Sea (Messina + Catania and Siracusa south). Out of 10 lots having lower values of SRI (< 0.45) 8 are distributed in the Adriatic Sea, mostly near the Po River delta.

Correlation tests are portrayed to single out environmental factors affecting species richness. We find positive correlation between the SRI and the number of habitats ($R = 0.51$; $n = 59$; $p < 0.001$; Tab. 2) and between the SRI and the PHB ($R = 0.41$; $n = 56$; $p < 0.01$; Tab. 2). No significant correlation has been found between the SRI and the number of locality

and between the SRI and the BVI (Tab. 2). It is important to point out that the number of habitats and the PHB are not dependant on the number of records (correlation tests: $R = 0.06$; $n = 59$; $p = n.s.$ and $R = 0.233$; $n = 56$; $p = n.s.$ respectively; Tab. 2). In all correlation tests the coefficient R shows no significant variation in relation to angular transformation (LISON, 1982) of the SRI and PHB index.

We identify 60 rare species: 6.6% of all species recorded. Table 3 shows the rare species in alphabetical order. Table 4 shows the 14 species worthy of protection (in alphabetical order) according to BODON *et al.* (1995) and SCOTTI *et al.* (2000).

Table 2
Correlation table with R, n and p values.

| CORRELATION TEST | R | n | p |
|----------------------------|--------|----|---------|
| N. species - N. records | 0.55 | 59 | < 0.001 |
| SRI - N. records | -0.187 | 59 | n. s. |
| SRI - N. habitat | 0.51 | 59 | < 0.001 |
| SRI - PHB | 0.41 | 56 | < 0.01 |
| SRI - N. loc. | -0.177 | 59 | n. s. |
| SRI - BVI | 0.25 | 59 | n. s. |
| N. habitat - N. records | 0.06 | 59 | n. s. |
| PHB - N. records | 0.233 | 56 | n. s. |
| SRI - N. sp. w. Protection | 0.4 | 59 | < 0.01 |
| SRI - N. rare sp. | 0.308 | 59 | < 0.05 |

Table 3
List of rare species in alphabetical order.

| RARE SPECIES | |
|---|--|
| Acanthochitona crinita (Pennant,1777) | Lamellaria latens (Mueller,1776) |
| Aclis ascaris (Turton,1819) | Limacina trochiformis (D'Orbigny,1836) |
| Addisonia excentrica (Tiberi, 1857) | Mangelia brusinae Van Aartsen & Fehr de Wal,1978 |
| Amygdalum agglutinans (Cantraine,1835) | Melanella lubrica (Monterosato,1890) |
| Anisocycla nitidissima (Montagu,1803) | Melanella monterosatoi (Monterosato,1890) |
| Berthella ocellata (Delle Chiaje,1830) | Melanella petitiana (Brusina,1869) |
| Botryphallus epidauricus (Brusina,1866) | Odostomia turriculata (Monterosato,1869) |
| Cerithiopsis barleei (Jeffreys,1867) | Odostomia turrata (Hanley,1844) |
| Cerithiopsis diadema Monterosato,1874 | Panopea glycimeris (Von Born,1778) |
| Cerithium haustellum Monterosato,1903 | Phaseolus pusillus (Jeffreys,1879) |
| Chromodoris krohni (Vérany,1846) | Philine lima (Brown,1827) |
| Cima cylindrica (Jeffreys,1856) | Philine punctata (Adams J.,1800) |
| Cirsonella romettensis (Seguenza G.,1873) | Philine quadrata (Wood S.,1839) |
| Cochlodesma praetenu (Pulteney,1799) | Pholadomya loveni (Jeffreys,1882) |
| Coralliophila sofiae (Aradas & Benoit,1876) | Pleurobranchus membranaceus (Montagu,1815) |
| Coryphella pedata (Montagu,1815) | Pleurobranchus testudinarius (Cantraine,1835) |
| Crenella arenaria (Monterosato,1875) | Pyramidella minuscula (Monterosato,1880) |
| Cuthona caerulea (Montagu,1804) | Pyrunculus ovatus (Jeffreys,1871) |
| Cyclopecten hoskynsi (Forbes,1844) | Rostanga rubra (Risso,1818) |
| Diodora producta (Monterosato,1880) | Sepiola rondeletii (Leach,1817) |
| Eatonina celata (Monterosato,1884) | Solecurtus multistriatus (Scacchi,1835) |
| Elysia viridis (Montagu,1804) | Tethys fimbria (Linné,1767) |
| Epilepton clarkiae (Clark W.,1852) | Trapania fusca (Lafont,1874) |
| Epitonium striatissimum (Monterosato,1878) | Turbonilla attenuata (Jeffreys,1884) |
| Eulimella turris (Forbes,1844) | Turbonilla compressa (Jeffreys,1884) |
| Gibberula turgidula (Locard & Caziot,1900) | Turbonilla hamata Nordsieck F.,1972 |
| Graphis gracilis (Monterosato,1874) | Turbonilla magnifica (Seguenza G.,1879) |
| Heliacus alleryi (Seguenza G.,1876) | Turbonilla multilirata (Monterosato,1875) |
| Hypselodoris coelestis (Deshayes,1865) | Turbonilla obliquata (Philippi,1844) |
| Hypselodoris webbi (D'Orbigny,1839) | Turbonilla paucistriata (Jeffreys,1884) |

Table 4
List of species worth protection
in alphabetical order.

| SPECIES WORTH OF PROTECTION |
|--|
| Alvania clathrella (L. Seguenza, 1903) |
| Alvania subareolata (Monterosato, 1869) |
| Charonia lampas (Linné, 1758) |
| Charonia tritonis (Lamarck, 1816) |
| Erosaria spurca (Linné, 1758) |
| Lithophaga lithophaga (Linné, 1758) |
| Littorina saxatilis (Olivi, 1792) |
| Luria lurida (Lamarck, 1810) |
| Patella ferruginea Gmelin, 1791 |
| Pholas dactylus Linné, 1758 |
| Pinna nobilis Linné, 1758 |
| Pinna rudis Linné, 1758 |
| Schilderia achatidea (J. E. Gray in G. B. Sowerby II, 1837) |
| Tonna galea (Linné, 1758) |
| Zonaria pyrum (Gmelin, 1791) |

In Table 5 we identify the hot spot values of the lots, they are obtained by the sum of converted values of: SRI, number of rare and number of species worthy of protection. The ten lots with a higher hot spot value are marked by asterisks; in Figure 1 the distribution map of the same ten lots is reported. There is a trend towards finding a higher number of species worth protecting and of rare species in lots with higher values of SRI (highly significant positive correlation: $R = 0.40$; $n = 59$; $p < 0.01$; and significant positive correlation $R = 0.308$; $n = 59$; $p < 0.05$ respectively; Tab. 2).

Table 5
List of lots in decreasing order of SRI values. Converted value of SRI,
species worth protecting and rare species are shown.

| LOTS | hotspots value | higher value | SRI | sp.w. of prot | rare sp. |
|----------------------|-----------------------|---------------------|------------|----------------------|-----------------|
| MATERA+TARANTO | 18,6 | * | 10,0 | 8,6 | 0,0 |
| LIVORNO south | 22,5 | * | 10,0 | 10,0 | 2,5 |
| LA SPEZIA | 13,9 | | 9,8 | 2,9 | 1,3 |
| PROCIDA ISLAND | 18,7 | * | 9,6 | 2,9 | 6,3 |
| SIRACUSA south | 11,0 | | 9,5 | 1,4 | 0,0 |
| MESSINA + CATANIA | 16,1 | * | 9,5 | 2,9 | 3,8 |
| NAPOLI centre north | 25,7 | * | 9,5 | 10,0 | 6,3 |
| SALERNO north | 13,7 | | 9,4 | 4,3 | 0,0 |
| CAPRAIA ISLAND | 12,2 | | 9,4 | 2,9 | 0,0 |
| GENOVA east | 17,5 | * | 9,1 | 7,1 | 1,3 |
| ORISTANO | 13,1 | | 9,1 | 1,4 | 2,5 |
| NAPOLI ISLANDS | 11,8 | | 9,1 | 1,4 | 1,3 |
| CAGLIARI centres | 10,0 | | 8,8 | 0,0 | 1,3 |
| UDINE-GORIZIA | 10,1 | | 8,7 | 1,4 | 0,0 |
| NAPOLI centre south | 22,8 | * | 8,6 | 4,3 | 10,0 |
| RAGUSA+AGRIGENTO | 12,7 | | 8,5 | 4,3 | 0,0 |
| NAPOLI south | 16,1 | * | 8,2 | 2,9 | 5,0 |
| LAZIO | 15,1 | | 8,1 | 5,7 | 1,3 |
| NAPOLI north | 13,8 | | 8,1 | 5,7 | 0,0 |
| GENOVA west | 9,3 | | 8,1 | 0,0 | 1,3 |
| SALERNO south | 12,3 | | 8,0 | 4,3 | 0,0 |
| LIVORNO centre north | 12,2 | | 7,9 | 4,3 | 0,0 |
| LIVORNO centre south | 15,0 | | 7,9 | 7,1 | 0,0 |
| MESSINA IONIAN SEA | 12,2 | | 7,9 | 4,3 | 0,0 |
| SAVONA | 9,0 | | 7,7 | 0,0 | 1,3 |
| CALABRIA | 16,0 | | 7,6 | 7,1 | 1,3 |
| LUCCA + LIVORNO | 13,2 | | 7,5 | 5,7 | 0,0 |
| TRAPANI | 14,6 | | 7,5 | 7,1 | 0,0 |
| TRIESTE | 20,5 | * | 7,5 | 4,3 | 8,8 |

Table 5 (continued)

| | | | | | |
|--------------------------------|-----------------------|---------------------|------------|----------------------|-----------------|
| BARI+BRIND.+ ADRIATIC LECCE | 10,0 | | 7,1 | 2,9 | 0,0 |
| GROSSETO | 8,5 | | 7,1 | 1,4 | 0,0 |
| SASSARI west | 12,6 | | 7,1 | 4,3 | 1,3 |
| TARANTO | 9,9 | | 7,0 | 2,9 | 0,0 |
| MARCHE | 13,8 | | 7,0 | 4,3 | 2,5 |
| FAVIGNANA ISLAND | 8,2 | | 6,8 | 1,4 | 0,0 |
| CAGLIARI west | 8,0 | | 6,6 | 1,4 | 0,0 |
| IMPERIA | 15,1 | | 6,5 | 8,6 | 0,0 |
| LECCE | 7,9 | | 6,5 | 1,4 | 0,0 |
| PALERMO east | 7,8 | | 6,4 | 1,4 | 0,0 |
| CAGLIARI east 1° | 7,8 | | 6,4 | 1,4 | 0,0 |
| CAGLIARI east 3° | 7,7 | | 6,3 | 1,4 | 0,0 |
| SORRENTO | 9,1 | | 6,2 | 2,9 | 0,0 |
| MESSINA TIRRENIAN SEA | 13,0 | | 6,0 | 5,7 | 1,3 |
| NUORO west | 7,4 | | 5,9 | 1,4 | 0,0 |
| NUORO east+SASSARI | 8,3 | | 5,8 | 0,0 | 2,5 |
| PESARO+FORLI' | 6,8 | | 5,5 | 0,0 | 1,3 |
| CAGLIARI east 2° | 8,0 | | 5,1 | 2,9 | 0,0 |
| LOTS | hotspots value | higher value | SRI | sp.w. of prot | rare sp. |
| VENEZIA DEPHT. 18-33 m | 7,8 | | 5,1 | 1,4 | 1,3 |
| VENEZIA DEPHT 0-15 m | 6,3 | | 4,9 | 1,4 | 0,0 |
| FOGGIA | 7,6 | | 4,8 | 2,9 | 0,0 |
| CASERTA | 4,7 | | 4,7 | 0,0 | 0,0 |
| RAVENNA | 7,4 | | 4,6 | 2,9 | 0,0 |
| ABRUZZO | 8,8 | | 4,5 | 4,3 | 0,0 |
| ROVIGO | 3,7 | | 3,7 | 0,0 | 0,0 |
| RAVENNA+FERRARA | 4,5 | | 3,3 | 0,0 | 1,3 |

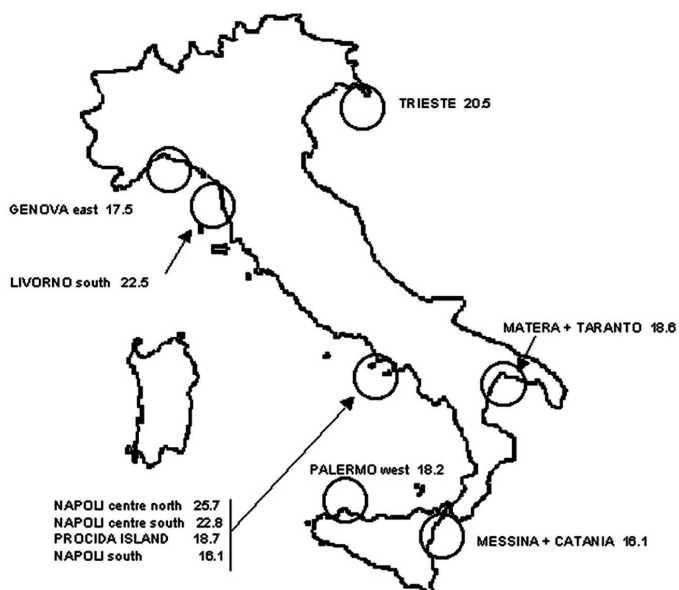


Fig. 1: Map of ten lots with higher hotspot values

Discussion

The aim of our study is to find biodiversity hot spots available for conservation purposes. Hot spot strategies are conceived for the conservation of the maximum of biodiversity with the minimum extension of protected areas. Thus hot spots are a fundamental topic in conservation biology and they are a useful tool to optimise conservation efforts (e.g., KILLEEN *et al.*, 1998; MITTERMEIER *et al.*, 1998; REID, 1998; GINSBERG, 1999; MYERS *et al.*, 2000).

The criteria proposed by NORSE (1993): high diversity, high richness of endemic taxa; 'source' areas and nursery areas are not suitable for marine molluscs conservation in the Mediterranean Sea. In effect, Mediterranean endemic species have a broad distribution inside this basin; moreover we know the biological cycle and ecology of very few species. It is even more difficult to follow the suggestions made by CHEMELLO *et al.* (2000) as they do not give an operational definition of complex concepts such as ecological value, national and international importance and ecological uniqueness.

Our study considers the distribution species worth of protection, of rare species and of species richness and the environmental features of the sampling sites. We consider both data on living molluscs (i.e shells containing the animals) and on tanothocenosis (empty shells), since the wide geographical scale the transportation of empty shells by currents and waves should not significantly affect our results.

The Species Richness Index (SRI) used can be a reliable and useful means to measure biodiversity, because the absence of correlation with the number of records indicate the independence of this parameter from variations in sampling effort (Tab. 2). We individuate lots having higher species richness by ordering their SRI values (Table 1).

Correlation tests indicate that the number of habitats (*i.e.* the measure of habitat

variability) and the proportion of hard substrates (PHB) are positively correlated with the SRI. Since neither the number of habitats nor the PHB are correlated with the number of records, *i.e.* the sampling effort, we consider the number of habitats and the PHB as the most important ecological factors affecting the SRI in lots. We think the ecological significance of PHB is the same as the number of habitats. They both increase environmental heterogeneity (one of the main factors affecting biodiversity) on a large and small scale, respectively.

The results obtained in analysing species richness are combined with data on the distribution of species worthy of protection and of rare species in order to individuate lots that can be considered biodiversity hotspots for Italian marine molluscs. Our results show that hot spots lots are irregularly distributed in different zones of the Italian coasts (Fig. 1), but in the Adriatic Sea we find only one hot spot: Trieste. Our hypothesis is the high hot spot value in this lot is mainly due to the anticlockwise current bringing less eutrophic waters, and possibly containing mollusc larvae from Dalmatian coasts (ALBERTELLI *et al.*, 1998). The mean value of SRI in lots of the Adriatic Sea (0.44) is significantly lower than the corresponding value in lots of the Ligurian Sea (0.67), the Tyrrhenian Sea (0.59) and the Ionian Sea (0.67) (test ANOVA: $F = 21.6$ $p < 0.001$; $F = 12.2$ $p < 0.05$ and $F = 15.5$ $p < 0.01$, respectively). Coherent with these trends, the mean value of PHB (proportion of hard substrates) in the Adriatic coast is significantly lower than the mean value of PHB in the peninsular West coast (0.23 versus 0.82; test ANOVA: $F = 31.36$; $p < 0.001$).

Finally, the significant positive correlation between the number of species worth protection and of rare species and SRI in lots is important. This result means that SRI is both a useful measure of species richness and a reliable indirect indicator of the presence of high number of critical species; *i.e.* SRI is also an indirect indicator of the ecological

importance of the mollusc community in lots. In conclusion, we have to stress that the hot spot method proposed can be considered a useful tool to protect the biodiversity of marine molluscs along the Italian coasts.

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