

The molluscs found after the nourishment of the littoral of Terracina (Latium, Italy)

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ABSTRACT In the present paper molluscs found after the beach nourishment carried out in 2006 on the coast of Terracina are reported. Altogether were identified 144 taxa, of which 105 Gastropoda, 37 Bivalvia and 2 Scaphopoda.

KEY WORDS Mollusca; beach nourishment; Terracina; Italy; Mediterranean Sea.

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INTRODUCTION

In the years 1950–60 the uncontrolled anthropic alteration carried out on the sandy coasts had as a consequence the modification of currents and tides, thus increasing the beach erosion. The first methods of consolidation of coasts were carried out in the absence of standards and draft rules, thus causing many environmental and aesthetic problems interfering with the dynamics of the coastline. This situation has made it necessary to study and fund several methods based on scientific and technical assessments. The purpose of beach nourishment is to rebuild the eroded beach through the use of suitable sand directly taken from the sea bottom and afterwards released on the eroded beach (Garbin et al., 2012).

At the beginning for the beach nourishment of the littoral of Terracina was utilized a sandy limestone from inland quarries, absolutely unsuitable. This led to continuous washing out and narrowings of the beach that caused with time the silting up of the seabed. Such action, later revealed to be ineffective and disastrous, led to the decision to utilize a sand with morphological and granulometric charac-

teristics as similar as possible to those of the eroded beach (Garbin et al., 2012).

In 2006 it was decided to carry out a kind of "soft" beach nourishment taking directly the sand from the so called "underwater quarry", located on relatively deep seabed off the coast depositing it directly on the eroded beaches (Figs. 1, 2). The most promising underwater cave was discovered about fifty miles north-west from Terracina, specifically off of Torvajonica (Rome) named "Cava sottomarina Torvaianica Sud Zona C2". This is just one of the many quarries of the continental marine shelf of Latium, used in the nourishment of other coasts such as Anzio, Ostia, Montalto di Castro, etc.. This site mainly differs from others in that the storage material was aspirated and drawn at a greater depth, around 110 meters depth.

This operation was divided into two different stages, the first was effected in 2006 for about two kilometers on the first half of the Ponente Beach and the second, to be performed the following year, on the other half up to the port. After the first stage on the shoreline, with the disappointment of the local community, the beach appeared covered with a large amount of pebbles and shells, thus putting

at risk the long tourist season. As a consequence the second stage was canceled (Giannelli et al., 2012).

A total of 1300 meters in length were interested in the beach, were obtained 66,000 square feet of new surface after the intervention with 460,000 cubic meters of sand poured. From the malacological point of view this large amount of material, both fossil and subfossil, is very interesting.

From the several collections made just after the first nourishment and during the immediately following months, altogether 144 taxa have been identified, of which 105 Gastropoda (73%), 37 Bivalvia (26%) and 2 Scaphopoda (1%).

MATERIAL AND METHODS

All species were collected directly along the shore line. Several species (for example *Neptunea contraria* (Linnaeus, 1771) are clearly fossils but for many others it was impossible to detect if it were the state fossil or subfossil. The nomenclature of the species has been updated according to WoRMS Editorial Board (2014).

RESULTS

Taxonomic list

Classis GASTROPODA Cuvier, 1797

Ordo VETIGASTROPODA Salvini-Plawen, 1980

Familia FISSURELLIDAE Fleming, 1822

Genus *Diodora* J.E.Gray, 1821

Diodora gibberula (Lamarck, 1822)

Diodora graeca (Linnaeus, 1758) (Fig. 3)

Diodora cfr *demartiniorum* Buzzurro et Russo 2005 (Fig. 4)

Genus *Emarginula* Lamarck, 1801

Emarginula fissura (Linnaeus, 1758)

Familia TROCHIDAE Rafinesque, 1815

Genus *Clelandella* Winckworth, 1932

Clelandella miliaris (Brocchi, 1814)

Genus *Gibbula* Risso, 1826

Gibbula magus (Linnaeus, 1758)

Familia CALLIOSTOMATIDAE Thiele, 1924 (1847)

Genus *Calliostoma* Swainson, 1840

Calliostoma conulum (Linnaeus, 1758)

Calliostoma granulatum (Born, 1778)

Calliostoma laugieri (Payraudeau, 1826)

Calliostoma zizyphinum (Linnaeus, 1758)

Familia TURBINIDAE Rafinesque, 1815

Genus *Bolma* Risso, 1826

Bolma rugosa (Linnaeus, 1767)

Genus *Homalopoma* Carpenter, 1864

Homalopoma sanguineum (Linnaeus, 1758)

Familia PHASIANELLIDAE Swainson, 1840

Genus *Tricolia* Risso, 1826

Tricolia pullus (Linnaeus, 1758)

Ordo CAENOGASTROPODA Cox, 1960

Familia CERITHIIDAE Fleming, 1822

Genus *Cerithium* Bruguière, 1789

Cerithium alucaster (Brocchi, 1814)

Cerithium protractum (Bivona Ant. in Bivona And., 1838)

Cerithium vulgatum (Bruguière, 1792)

Familia SILIQUARIIDAE Anton, 1838

Genus *Tenagodus* Guettard, 1770

Tenagodus obtusus (Schumacher, 1817)

Familia TURRITELLIDAE Lovén, 1847

Genus *Turritella* Lamarck, 1799

Turritella turbona (Monterosato, 1877)

Familia TRIPHORIDAE Gray, 1847

Genus *Monophorus* Grillo, 1877

Monophorus perversus (Linnaeus, 1758)

Familia EPITONIIDAE Berry, 1910 (1812)

Genus *Epitonium* Röding, 1798

Epitonium clathrus (Linnaeus, 1758)

Epitonium turtonis (Turton, 1819)

Familia EULIMIDAE Philippi, 1853

Genus *Eulima* Risso, 1826

Eulima glabra (da Costa, 1778)

Familia RISSOIDAE Gray, 1847

Genus *Alvania* Risso, 1826

Alvania punctura (Montagu, 1803)

Familia VERMETIDAE Rafinesque, 1815

Genus *Thylacodes* Guettard, 1770

Thylacodes arenarius (Linnaeus, 1758)

Familia APORRHAIIDAE Gray, 1850

Genus *Aporrhais* da Costa, 1778

Aporrhais pespelecani (Linnaeus, 1758)

Familia CALYPTRAEIDAE Lamarck, 1809

Genus *Calyptrea* Lamarck, 1799

Calyptrea chinensis (Linnaeus, 1758)



1



2

Figure 1. Study area: littoral of Terracina, Latium, Italy (right); underwater quarry (left). Figure 2. Littoral of Terracina (Latium, Italy).

- Familia CAPULIDAE Fleming, 1822
- Genus *Capulus* Montfort, 1810
Capulus ungaricus (Linnaeus, 1758)
- Familia TRIVIIDAE Troschel, 1863
- Genus *Erato* Risso, 1826
Erato voluta (Montagu, 1803)
- Genus *Trivia* Gray, 1837
Trivia multilirata (G.B. Sowerby II, 1870)
(Figs. 5, 6)
- Familia CYPRAEIDAE Rafinesque, 1815
- Genus *Luria* Jousseume, 1884
Luria lurida (Linnaeus, 1758)
- Genus *Naria* Broderip, 1837
Naria spurca (Linnaeus, 1758)
- Genus *Schilderia* Tomlin, 1930
Schilderia achatidea (Gray in G.B. Sowerby I, 1837) (Figs. 7, 8)
- Genus *Zonaria* Jousseume, 1884
Zonaria pyrum (Gmelin, 1791) (Figs. 9, 10)
- Familia OVULIDAE Fleming, 1822
- Genus *Pseudosimnia* Schilder, 1927
Pseudosimnia adriatica (G.B. Sowerby I, 1828)
(Figs. 11, 12)
Pseudosimnia carnea (Poiret, 1789) (Figs. 13, 14)
- Genus *Simnia* Risso, 1826
Simnia spelta (Linnaeus, 1758) (Figs. 15, 16)
- Familia NATICIDAE Guilding, 1834
- Genus *Euspira* Agassiz in J. Sowerby, 1837
Euspira fusca (Blainville, 1825)
Euspira guillemirii (Payraudeau, 1826)
Euspira intricata (Donovan, 1804)
Euspira macilenta (Philippi, 1844)
- Genus *Naticarius* Duméril, 1805
Naticarius hebraeus (Martyn, 1786)
Naticarius stercus muscarum (Gmelin, 1791)
- Genus *Tectonatica* Sacco, 1890
Tectonatica rizzae (Philippi, 1844)
- Familia CASSIDAE Latreille, 1825
- Genus *Galeodea* Link, 1807
Galeodea echinophora (Linnaeus, 1758)
- Genus *Semicassis* Morch, 1852
Semicassis granulata undulata (Gmelin, 1791)
- Familia RANELLIDAE Gray, 1854
- Genus *Cabestana* Röding, 1798
Cabestana cutacea (Linnaeus, 1767) (Fig. 17)
- Genus *Charonia* Gistel, 1847
Charonia lampas (Linnaeus, 1758)
- Genus *Monoplex* Perry, 1810
Monoplex corrugatum (Lamarck, 1816)
Monoplex parthenopeum (Von Salis, 1793)
- Genus *Ranella* Lamarck, 1816
Ranella olearium (Linnaeus, 1758)
- Familia BURSIDAE Thiele, 1925
- Genus *Bursa* Röding, 1798
Bursa scrobilator (Linnaeus, 1758) (Figs. 18, 19)
- Familia MURICIDAE Rafinesque, 1815
- Genus *Babelomurex* Coen, 1922
Babelomurex benoiti (Tiberi, 1855)
- Genus *Bolinus* Pusch, 1837
Bolinus brandaris (Linnaeus, 1758)
- Genus *Dermomurex* Monterosato, 1890
Dermomurex scalaroides (Blainville, 1829)
(Fig. 20)
- Genus *Hadriana* Bucquoy et Dautzemberg, 1882
Hadriana craticula (Bucquoy, Dautzemberg et Dollfus, 1882) (Fig. 21)
- Genus *Hexaplex* Perry, 1810
Hexaplex trunculus (Linnaeus, 1758)

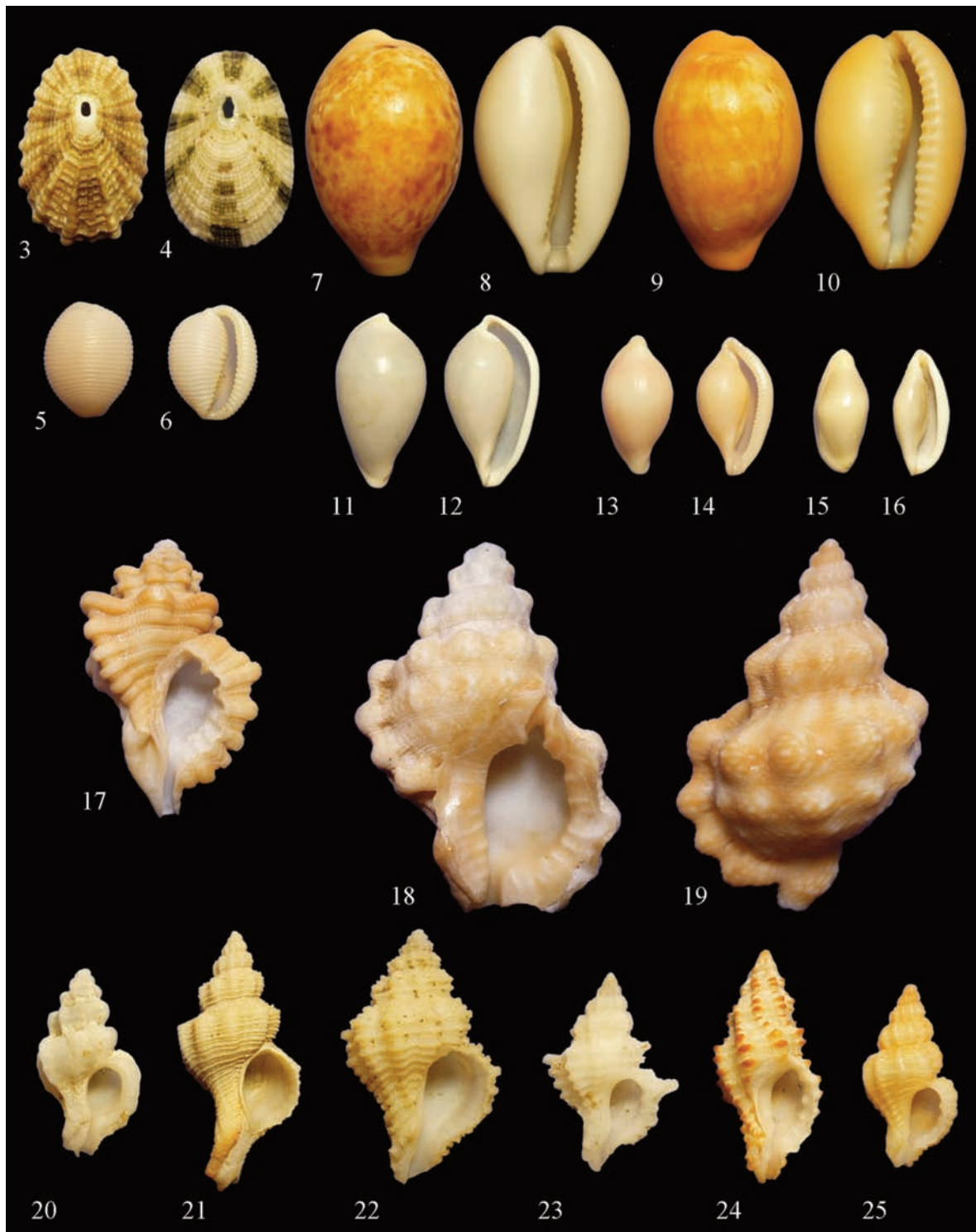


Fig. 3. *Diodora graeca*, h: 25.6 mm. Fig. 4. *Diodora* cfr. *demartiniorum*, h: 25.3 mm. Figs. 5, 6. *Trivia multilirata*, h: 12.2 mm. Figs. 7, 8. *Schilderia achatidea*, h: 38 mm. Figs. 9, 10. *Zonaria pyrum*, h: 34.8 mm. Figs. 11, 12. *Pseudosimnia adriatica*, h: 23.1 mm. Figs. 13, 14. *P. carnea*, h: 16.2 mm. Figs. 15, 16. *Simnia spelta*, h: 13.6 mm. Fig. 17. *Cabestana cutacea*, h: 44.2 mm. Fig. 18, 19. *Bursa scrobilator*, h: 49.2 mm. Fig. 20. *Dermomurex scalaroides*, h: 17.4 mm. Fig. 21. *Hadriania craticula*, h: 31.7 mm. Fig. 22. *Hirtomurex squamosus*, h: 26.5 mm. Fig. 23. *Murexul aradasii*, h: 12 mm. Fig. 24. *Muricopsis cristata*, h: 21 mm. Fig. 25. *Ocinebrina helleri*, h: 16.3 mm.

- Genus *Hirtomurex* Coen, 1922
Hirtomurex squamosus (Bivona Ant. in Bivona And., 1838) (Fig. 22)
- Genus *Murexul* Iredale, 1915
Murexul aradasii (Monterosato in Poirieri, 1883) (Fig. 23)
- Genus *Muricopsis* Bucquoy et Dautzemberg, 1882
Muricopsis cristata (Brocchi, 1814) (Fig. 24)
- Genus *Ocenebra* Gray, 1847
Ocenebra erinaceus (Linnaeus, 1758)
- Genus *Ocinebrina* Jousseaume, 1880
Ocinebrina edwardsi (Payraudeau, 1826)
Ocinebrina helleri (Brusina, 1865) (Fig. 25)
- Genus *Pagodula* Monterosato, 1884
Pagodula echinata (Kiener, 1840) (Fig. 26, 27)
- Genus *Trophonopsis* Bucquoy, Dautzemberg et Dollfuss, 1882
Trophonopsis muricata (Montagu, 1803)
- Genus *Typhinellus* Jousseaume, 1880
Typhinellus labiatus (de Cristofori et Jan, 1832) (Fig. 28, 29)
- Familia MARGINELLIDAE Fleming, 1828
- Genus *Volvarina* Hinds, 1844
Volvarina mitrella (Risso, 1826)
- Familia MITRIDAE Swainson, 1829
- Genus *Mitra* Lamarck, 1798
Mitra cornicula (Linnaeus, 1758)
Mitra zonata (Marryat, 1818)
- Familia COSTELLARIIDAE Mac Donald, 1860
- Genus *Vexillum* Röding, 1798
Vexillum ebenus (Lamarck, 1811)
Vexillum granum (Forbes, 1844)
Vexillum tricolor (Gmelin, 1791)
- Familia BUCCINIDAE Rafinesque, 1815
- Genus *Euthria* Gray, 1850
Euthria cornea (Linnaeus, 1758)
- Genus *Neptunea* Röding, 1798
Neptunea contraria (Linnaeus, 1771)
- Familia NASSARIIDAE Iredale, 1916 (1835)
- Genus *Nassarius* Duméril, 1805
Nassarius corniculum (Olivi, 1792)
Nassarius incrassatus (Strom, 1768)
Nassarius nitidus (Jeffreys, 1867)
Nassarius pygmaeus (Lamarck, 1822)
- Familia COLUMBELLIDAE Swainson, 1840
- Genus *Mitrella* Risso, 1826
Mitrella coccinea (Philippi, 1836)
Mitrella minor (Scacchi, 1836)
Mitrella scripta (Linnaeus, 1758)
- Familia FASCIOLARIIDAE Gray, 1853
- Genus *Fusinus* Rafinesque, 1815
Fusinus rostratus (Olivi, 1792) (Fig. 30)
- Familia CLATHURELLIDAE H. Adams et A. Adams, 1858
- Genus *Comarmondia* Monterosato, 1884
Comarmondia gracilis (Montagu, 1803)
- Familia MITROMORPHIDAE Casey, 1904
- Genus *Mitromorpha* Carpenter, 1865
Mitromorpha karpathoensis (Nordsiek, 1969)
Mitromorpha mediterranea (Mifsud, 2001)
- Familia MANGELIIDAE P. Fisher, 1883
- Genus *Bela* Gray, 1847
Bela nebula (Montagu, 1803)
- Genus *Mangelia* Risso, 1826
Mangelia costata (Pennant, 1777)
Mangelia costulata (Risso, 1826)
Mangelia sp.
- Familia DRILLIIDAE Olsson, 1964
- Genus *Crassopleura* Monterosato, 1884
Crassopleura maravignae (Bivona Ant. in Bivona And., 1838)

- Familia CLAVATULIDAE Gray, 1853
- Genus *Fusiturris* Thiele, 1929
Fusiturris similis (Bivona Ant. in Bivona And., 1838)
- Familia RAPHITOMIDAE Bellardi, 1875
- Genus *Raphitoma* Bellardi, 1847
Raphitoma cfr. *atropurpurea* (Fig. 31)
Raphitoma cfr. *echinata* (Fig. 32)
Raphitoma leufroyi (Michaud, 1828) (Fig. 33)
Raphitoma sp. 1 (Fig. 34)
Raphitoma sp. 2
- Ordo HETEROSTROPHA P. Fischer, 1885
- Familia ARCHITECTONICIDAE J.E. Gray in M.E. Gray, 1850
- Genus *Discotectonica* Marwick, 1931
Discotectonica discus (Philippi, 1844) (Figs. 35, 36)
- Genus *Heliacus* d'Orbigny, 1842
Heliacus fallaciosus (Tiberi, 1872) (Fig. 37)
- Genus *Pseudotorinia* Sacco, 1892
Pseudotorinia architae (O.G. Costa, 1841) (Figs. 38-40)
- Familia MATHILDIDAE Dall, 1889
- Genus *Mathilda* Semper, 1865
Mathilda quadricarinata (Brocchi, 1814)
- Familia PYRAMIDELLIDAE Gray, 1840
- Genus *Euparthenia* Thiele, 1931
Euparthenia bulinea (Lowe, 1841) (Figs. 41, 42)
- Familia ACTEONIDAE d'Orbigny, 1843
- Genus *Acteon* Montfort, 1810
Acteon tornatilis (Linnaeus, 1758)
- Familia RINGICULIDAE Philippi, 1853
- Genus *Ringicula* Deshayes, 1838
Ringicula auriculata (Ménard de la Groye, 1811)
- Ordo CEPHALASPIDEA P. Fischer, 1883
- Familia CYLICHNIDAE H. Adams et A. Adams, 1854
- Genus *Cylichna* Lovén, 1846
Cylichna cylindracea (Pennant, 1777)
- Familia SCAPHANDRIDAE G.O. Sars, 1878
- Genus *Scaphander* Montfort, 1810
Scaphander lignarius (Linnaeus, 1758)
- Ordo UMBRACULIDA Odhner, 1939
- Familia UMBRACULIDAE Dall, 1889 (1827)
- Genus *Umbraculum* Schumacher, 1817
Umbraculum umbraculum (Lightfoot, 1786)
- Classis BIVALVIA
- Ordo SOLEMYOIDA Dall, 1889
- Familia NUCULIDAE Gray, 1824
- Genus *Nucula* Lamarck, 1799
Nucula nucleus (Linnaeus, 1758)
Nucula sulcata (Bronn, 1831)
- Familia NUCULANIDAE H. Adams et A. Adams, 1858 (1854)
- Genus *Nuculana* Link, 1807
Nuculana pella (Linnaeus, 1767)
- Ordo ARCOIDA Stoliczka, 1871
- Familia ARCIDAE Lamarck, 1809
- Genus *Anadara* Gray, 1847
Anadara polii (Mayer, 1868)
- Genus *Arca* Linnaeus, 1758
Arca tetragona (Poli, 1795)
- Familia GLYCYMERIDIDAE Dall, 1908 (1847)

- Genus *Glycymeris* da Costa, 1778
Glycymeris glycymeris Linnaeus (1758)
- Ordo PECTINOIDA Gray, 1854
- Familia PECTINIDAE Rafinesque, 1815
- Genus *Aequipecten* P. Fisher, 1886
Aequipecten commutatus (Monterosato, 1875) (Fig. 43)
Aequipecten opercularis (Linnaeus, 1758) (Fig. 44)
- Genus *Manupecten* Monterosato, 1872
Manupecten pesfelis (Linnaeus, 1758)
- Genus *Mimachlamys* Iredale, 1929
Mimachlamys varia (Linnaeus, 1758) (Fig. 45)
- Genus *Pecten* O.F. Muller, 1776
Pecten jacobaeus (Linnaeus, 1758) (Fig. 46)
Pecten maximus (Linnaeus, 1758) (Fig. 47)
- Genus *Pseudamussium* Morch, 1853
Pseudamussium clavatum (Poli, 1795) (Fig. 48)
- Genus *Similipecten* Winckworth, 1932
Similipecten similis (Laskey, 1811)
- Genus *Talochlamys* Iredale, 1935
Talochlamys multistriata (Poli, 1795) (Fig. 49)
- Familia SPONDYLIDAE Gray, 1826
- Genus *Spondylus* Linnaeus, 1758
Spondylus gaederopus (Linnaeus, 1758)
- Ordo OSTREOIDA Férussac, 1822
- Familia OSTREIDAE Rafinesque, 1815
- Genus *Ostrea* Linnaeus, 1758
Ostrea edulis (Linnaeus, 1758)
- Ordo LUCINOIDA Gray, 1854
- Familia LUCINIDAE Fleming, 1828
- Genus *Lucinella* Monterosato, 1884
Lucinella divaricata (Linnaeus, 1758)
- Genus *Lucinoma* Dall, 1901
Lucinoma borealis (Linnaeus, 1767)
- Genus *Myrtea* Turton, 1822
Myrtea spinifera (Montagu, 1803)
- Ordo VENEROIDA Gray, 1854
- Familia CHAMIDAE Lamarck, 1809
- Genus *Chama* Linnaeus, 1758
Chama gryphoides (Linnaeus, 1758)
- Familia CARDITIDAE Férussac, 1822
- Genus *Centrocardita* Sacco, 1899
Centrocardita aculeata (Poli, 1795)
- Familia ASTARTIDAE d'Orbigny, 1844 (1840)
- Genus *Astarte* J.de C. Sowerby, 1816
Astarte fusca (Poli, 1795)
- Familia CARDIIDAE Lamarck, 1809
- Genus *Laevicardium* Swainson, 1840
Laevicardium oblongum (Gmelin, 1791)
- Genus *Papillicardium* Sacco, 1899
Papillicardium papillosum (Poli, 1795)
- Genus *Parvicardium* Monterosato, 1884
Parvicardium minimum (Philippi, 1836)
- Familia MACTRIDAE Lamarck, 1809
- Genus *Lutraria* Lamarck, 1799
Lutraria lutraria (Linnaeus, 1758)
Lutraria oblonga (Gmelin, 1791)
- Familia TELLINIDAE Blainville, 1814
- Genus *Tellina* Linnaeus, 1758
Tellina serrata (Brocchi, 1814)
- Familia SOLECURTIDAE d'Orbigny, 1846



Figs. 26, 27. *Pagodula echinata*, h: 19.8 mm. Figs. 28, 29. *Typhinellus labiatus*, h: 18.1 mm. Fig. 30. *Fusinus rostratus*, h: 36.2 mm. Fig. 31. *R. cfr. atropurpurea*, h: 15.4 mm. Fig. 32. *R. cfr. echinata*, h: 21.6 mm. Fig. 33. *R. leufroyi*, h: 22 mm. Fig. 34. *Raphitoma* sp., h: 22.7 mm. Figs. 35, 36. *Discotectonica discus*, h: 26.6 mm. Fig. 37. *Heliacus fallaciosus*, h: 16.3 mm. Figs. 38-40. *Pseudotorinia architae*, h: 8.7 mm. Figs. 41, 42. *Euparthenia bulinea*, h: 13.9 mm. Fig. 43. *Aequipecten commutatus*, h: 24.8 mm. Fig. 44. *A. opercularis*, h: 33.9 mm. Fig. 45. *Mimachlamys varia*, h: 26.4 mm. Fig. 46. *Pecten jacobeus*, h: 61 mm. Fig. 47. *Pecten maximus*, h: 74.9 mm. Fig. 48. *Pseudamussium clavatum*, h: 30.4 mm. Fig. 49. *Talochlamys multistriata*, h: 24.7 mm.

Genus *Solecurtus* Blainville, 1824
Solecurtus scopula (Turton, 1822)

Familia VENERIDAE Rafinesque, 1815

Genus *Chamelea* Morch, 1853
Chamelea striatula (da Costa, 1778)

Genus *Clausinella* Gray, 1851
Clausinella fasciata (da Costa, 1778)

Genus *Globivenus* Coen, 1934
Globivenus effossa (Philippi, 1836)

Genus *Pitar* Romer, 1857
Pitar rudis (Poli, 1795)

Genus *Timoclea* Brown, 1827
Timoclea ovata (Pennant, 1777)

Genus *Venus* Linnaeus, 1758
Venus nux (Gmelin, 1791)

Ordo ANOMALODESMATA Dall, 1889

Familia CUSPIDARIIDAE Dall, 1886

Genus *Cuspidaria* Nardo, 1840
Cuspidaria cuspidata (Olivi, 1792)

Classis SCAPHOPODA

Ordo DENTALIIDA Starobogatov, 1974

Familia DENTALIIDAE Children, 1834

Genus *Antalis* H. Adams et A. Adams, 1854
Antalis dentalis (Linnaeus, 1758)
Antalis inaequicostata (Dautzenberg, 1891)

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