

DISTRIBUTION OF THE ECHINODERMS (ECHINODERMATA) ON THE CONTINENTAL SHELF IN OPEN WATERS OF THE MONTENEGRIN COAST

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ABSTRACT

This paper presents results of the first intensive investigation of echinoderms on the continental shelf in open waters of the Montenegrin coast. Analyses of collected material indicate that the researched area is populated by 43 echinoderm species grouped into 24 families: one crinoid (Crinoidea), 17 asteroids (Asteroidea), 4 ophiuroids (Ophiuroidea), 12 echinoids (Echinoidea), and 9 holothurians (Holothuroidea). Ten species are recorded for the first time in this area and three of them are new records for fauna of Montenegro.

Key words: echinoderms, continental shelf, Montenegrin coast, Adriatic Sea

INTRODUCTION

Montenegrin coast is a small part of the Adriatic coast situated on its south-eastern side. This position makes Montenegrin coast a link between Mediterranean and Adriatic Sea. It is an area with strong influence of warm and nutrient-rich Mediterranean waters, unlike the central and northern part of the Adriatic Sea. Specific combination of abiotic factors was a basis for intensive study of echinoderms, sessile and slow moving animals on the continental shelf zone of the Montenegrin coast.

The first information on echinoderms in the Mediterranean dates from the 18th century. The first checklist consisted of 95 species (Ludwig,

1879). Tortonese (1980) lists 144 species in the Mediterranean, as result of a long-time research, and Riedl (1991) noted 132 representatives of the phylum Echinodermata in the same area. First information about echinoderm diversity in the Adriatic Sea was for the northern part of the area of Venice (Olivi, 1792). Echinoderm diversity of central and southern Adriatic (up to the level of Dubrovnik) was reached for the first time by Heller (1863, 1868). In his review of the Adriatic echinoderms a total of 53 species are listed. At the beginning of the twentieth century, Babić (1913) provides important notes on some species of Asteroidea in the Adriatic Sea, where, among other things, he provides some very valuable information for the southern Adriatic. Kolosváry (1936, 1936/37, 1939,) mentioned 73 echinoderms for the east coast. Recent studies show that the number of species in the Adriatic Sea echinoderms is 101 (Radović, 1999).

Shelf of Montenegrin coast is relatively poorly understood in terms of diversity of echinoderms, especially the coastal strip in the area where the coast is rocky. For the open sea of Montenegro coast, Milojević (1979, 1982, 1984, 1986) lists 11 species of Asteroidea and 9 species of Ophiuroidea. Recently research shows presence of 50 species of echinoderms along Montenegrin coast including the Boka Kotorska bay (Kaščelan et al., 2009). But the exact number of species is unknown regarding the invasive species (Yokes and Galil, 2006).

MATERIAL AND METHODS

Study area

The study area was divided into zones because of the large differences in morphological and ecological characteristics, in order to make processing of the collected material easier.

Zone I includes the area from the Cape Mirište to the Cape Platamuni; it's zone of deep shelf. This zone is characterized by the isobaths of 50 m located a short distance from the coast. The coast is steep and rocky, with the sandy area starting at depths of 20-30 m.

Zone II extend from the Cape Platamuni to the Cape Volujica. It is a zone of shallower depths, which is a limiting factor for the presence of certain species and their abundance. Within this zone, the depth gradually increases moving away from the coastline, so it does not have significant depth "steps" as the previous zone. The sea bottom is generally presented by solid substrates, which from the coast to a depth exceeding to the fine sand and silt sand.

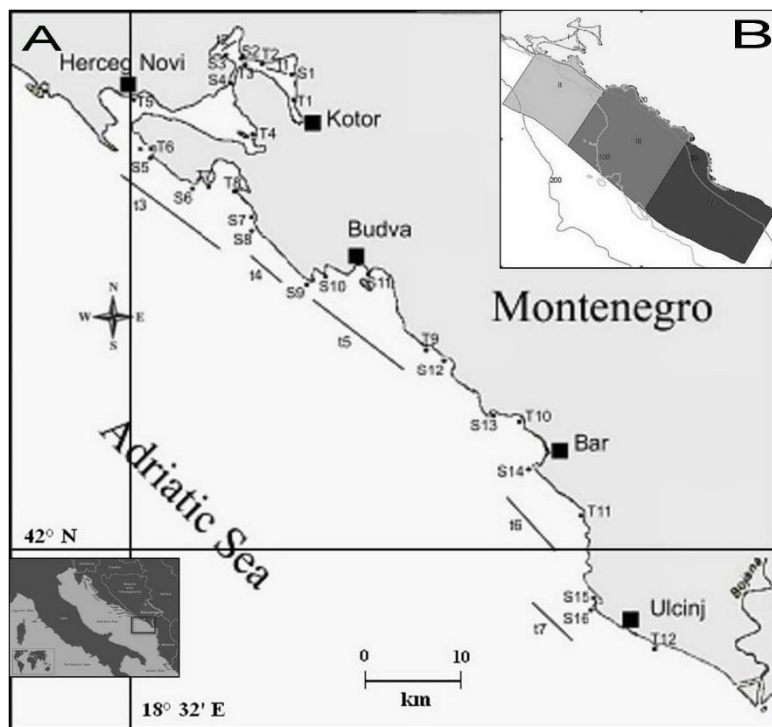


Figure 1.A) Study area (T – transect; S – randomly chosen locations; t – trawl net position); B) Distinct sections within the study area.

Zone III includes the area from the Cape Volujica to the mouth of Bojana. This area is highly impacted by the Bojana River, which is manifested through the species that inhabit this area. The area is characterized by shallow waters at a great distance from the coast. The substrate is mostly moving, presented with fine sand and silt.

Material collection, on the previously defined positions, was done mainly by SCUBA diving (up to 30 m in depth) and by otter trawling (Fig. 1). Field work was conducted from 2008 to 2010. These localities varied according to depth, which depended on the field configuration, as well as bottom type. A total of 17 sites were investigated by autonomy diving and 5 positions by otter trawling (Tab.1). Collected specimens were immediately anaesthetized with a saturated solution of menthol in sea water and later preserved in 70% alcohol. Determination was done according to Tortonese, 1965 and Koehler, 1924 and corrected by ERMS (Hansson, 2001).

Table 1. Positions where material is collected with geographic coordinates, bottom type and maximum depth

Station	Zone	Locality	N	E	Bottom type	Max. depth
T7	II	Rt Kočište	42°21.769'	18°38.981	Rock	20 m
T8		Rt Trašte	42°21.496'	18°41.312	Rock	5 m
T9	III	Uvala Lučice	42°12.069'	18°56.994	Rock-sand	15 m
T10		Rt Ratac	42°07.328'	19°04.022	Rock-sand	15 m
T11	IV	U. Veliki Pijesak	42°02.019'	19°08.590	Rock-sand	15 m
T12		Rt Đeran	41°54.366'	19°14.157	Rock-sand	8 m
S6		Rt Mačka	42°21.443'	18°38.009'	Rock	40 m
S7	II	Rt Žabica	42°20.464'	18°42.124'	Rock-sand	33 m
S8		Uvala Sipavica	42°20.093'	18°42.447'	Rock-sand	23 m
S9		Rt Platamuni	42°16.002'	18°47.008'	Rock-stone	22 m
S10		Rt Jaz	42°16.211'	18°48.373'	Rock-sand	29 m
S11	III	Budva	42°16.566'	18°51.411'	Rock-sand	13 m
S12		Uvala Buljarica	42°11.422'	18°57.548'	Sand	10 m
S13		Uvala Majevik	42°08.108'	19°01.482'	Rock-stone	8 m
S14		Rt Bigovica	42°04.301'	19°05.153'	Rock-sand	29 m
S15		Uvala Valdanos	41°57.026'	19°10.081'	Sand	11 m
S16	IV	Rt Mendra	41°57.097'	19°09.101'	Rock-mud	15 m
t3		Zlatna luka - Rt Krakavica	N 42°22.10' E 18°34.20'	N42°17.80 E18°43.20'	Mud	100-72 m
t4		Platamuni - Kalafat	N 41°14.08' E 18°45.04'	N42°15.56 E18°40.04'	Mud	80-120 m
t5		Drobni pijesak - Rt Platamuni	N 42°13.13' E 18°48.29'	N42°10.35 E18°38.27'	Mud	80-120 m
t6		Rt Bigovica - Rt Mendra	N 42°03.387' E 19°04.037'	N41°56.40 E19°06.99'	Mud	53-50 m
t7		Stari Ulcinj - Ulcinj	N 41°58.56' E 19°08.04'	N41°57.67' E19°08.46'	Sand-mud	25-30 m

RESULTS AND DISCUSSION

The list of the echinoderm fauna of Montenegrin open sea continental shelf (the south Adriatic Sea) includes 43 different echinoderm species, grouped into 24 families, of which one crinoid (Crinoidea), 17 asteroids (Asteroidea), 4 ophiuroids (Ophiuroidea), 12 echinoids (Echinoidea), and 9 holothurians (Holothuroidea). New data shows ten new records for this area, of which five holothurians (*Ocnus planci*, *Holothuria forskali*, *Holothuria impatiens*, *Holothuria mammata*, *Holothuria sanctori*), two echinoids (*Brissus unicolor*, *Arbacia lixula*), two ophiuroids (*Ophioderma longicauda*, *Ophiomyxa pentagona*) and one asteroid (*Coscinasterias tenuispina*). Three species are new for the echinoderm fauna of Montenegro, namely one species of irregular echinoids (*Brissus unicolor*) and two holothurians (*Holothuria mammata*, *Holothuria sanctori*). Until nowadays, 101 species of echinoderms were recorded in the Adriatic Sea (Radović 1999) and about 154 species in the Mediterranean Sea (Koukouras *et al.* 2007). This value is variable, since a few alien species of echinoderms already occur in the Mediterranean, and it is expected that the chances for successful transport of other Lessepsian migrants are improving due to the enlargement of the depth and width of the Suez Canal since the late 1970s (Yokes & Galil 2006). In regard to these numbers, the number of echinoderms present on the Montenegrin open sea continental shelf of the south Adriatic Sea (43 species) represents 42.57% of the species recorded so far in the Adriatic Sea, and 27.92% of the current total number of Mediterranean echinoderms. Of approximately 43 echinoderm species endemic to the Mediterranean (Tortonese 1979; Hansson 2001; Tanti & Schembri 2006), 10 (23.25%) occur on the continental shelf of the Montenegrin open part of the south Adriatic Sea.

The studied area represents a part of the south Adriatic continental shelf which is generally different from the central and north parts of the Adriatic Sea. The inflow of warm Mediterranean waters, through the Strait of Otranto, is very important, because these waters bring a lot of nutritive materials (Buljan & Zore-Armanda 1971, Zavodnik 1972a). This biogeographic link between the south Adriatic and the Mediterranean Sea enables thermophilic species, such as asteroids *Hacelia attenuata* and *Ophidiaster ophidianus*, and echinoid *Centrostephanus longispinus*, to populate this area. These three species are rare in the central Adriatic, and they have not been found in the north Adriatic so far (Zavodnik 1972a, 1997, 2003; Bakran-Petricioli *et al.* 1995).

List of taxa of Echinodermata from Montenegro open sea continental shelf (the south Adriatic Sea)

Classis: CRINOIDEA

Fam: Antedonidae

Antedon mediterranea (Lamarck, 1816)

Material: 220 specimens; stations: S8, S14, t3, t5, t6, t7; depth: 3-120 m; substrates: rocks, stones, assemblages of encrusting organisms.

Distribution: Mediterranean.

Remarks: Numerous in trawl nets.

Classis: ASTEROIDEA

Fam: Asteriidae

Coscinasterias tenuispina (Lamarck, 1816)

Material: 15 specimens; stations: T7, T9, T12, S6, S8; depth: 1-25 m; substrates: rocks, stones.

Distribution: Atlantic–Mediterranean.

Marthasterias glacialis (Linnaeus, 1758)

Material: 70 specimens; stations: T7, T8, T11, T12, S6, S7, S8, S11, S14, S15, S16, t3, t4, t5, t6, t7; depth: 0-80 m; substrates: rocks, stones, sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Very numerous on various substrates within studied stations.

Fam: Asterinidae

Anseropoda placenta (Pennant, 1777)

Material: 4 specimens; stations: t3, t6; depth: 80-120 m; substrates: sand, sandy-mud, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by trawl nets.

Fam: Astropectinidae

Astropecten aranciacus (Linnaeus, 1758)

Material: 2 specimens; stations: S14, t5; depth: 29-100 m; substrates: sand, mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Astropecten bispinosus (Otto, 1823)

Material: 12 specimens; stations: S8, t6; depth: 25-53 m; substrates: sand, mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Astropecten irregularis pentacanthus (Delle Chiaje, 1827)

Material: 204 specimens; stations: t3, t4, t5, t6, t7; depth: 10-120 m; substrates: sand, mud, organic detritus.

Distribution: Mediterranean.

Remarks: Considered as the most frequent and most abundant Mediterranean sea star (Vidović-Matvejev, 1978; Milojević, 1986; Ungaro 1995).

Astropecten jonstoni (Delle Chiaje, 1827)

Material: 10 specimens; stations: T12, S15; depth: 8-11 m; substrates: sand, mud, organic detritus, meadows of *Posidonia oceanica*.

Distribution: Mediterranean.

Astropecten platyacanthus (Philippi, 1837)

Material: 8 specimens; stations: T11, S9; depth: 15-25 m; substrates: sand, mud, organic detritus.

Distribution: Mediterranean.

Astropecten spinulosus (Philippi, 1837)

Material: 2 specimens; stations: S11; depth: 10-13 m; substrates: sand, mud.

Distribution: Mediterranean.

Remarks: Collected from leaves of *Posidonia oceanica*.

Tethyaster subinermis (Philippi, 1837)

Material: 1 specimen; stations: t7; depth: 25-30 m; substrates: sand, mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by a trawl net.

Fam: Chaetasteridae

Chaetaster longipes (Retzius, 1805)

Material: 7 specimens; stations: S6, S8; depth: 20-35 m; substrates: rocky cliffs within coralligenous communities.

Distribution: Atlantic–Mediterranean.

Remarks: According to literature data, it prefers circalittoral and upper bathyal soft bottoms (Zibrowius, 1991), but during this study it was collected only from rocky cliffs.

Fam: Echinasteridae

Echinaster (Echinaster) sepositus (Retzius, 1783)

Material: 124 specimens; stations: T7, T8, T9, T10 T11, S6, S7, S8, S9, S10, S11, S13, S14, S15, S16, t3, t4, t5, t6, t7; depth: 0-120 m; substrates: rocks, gravels, sand, meadows of sea grasses.

Distribution: Atlantic–Mediterranean.

Remarks: Collected from almost all sampling stations.

Fam: Goniasteridae

Peltaster placenta (Müller & Troschel, 1842)

Material: 9 specimens; stations: S6, S8, t3; depth: 25-120 m; substrates: rocky cliffs within coralligenous communities, sand, mud.

Distribution: Atlantic–Mediterranean

Fam: Luidiidae

Luidia ciliaris (Philippi, 1837)

Material: 3 specimens; stations: t4; depth: 80-120 m; substrates: sand, mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by trawl nets.

Luidia sarsi Düben & Koren, 1845

Material: 1 specimen; stations: t5; depth: 80-120 m; substrates: sand, mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by a trawl net.

Fam: Ophidiasteridae

Hacelia attenuata Gray, 1840

Material: 34 specimens; stations: T7, T9, S6, S7, S8; depth: 5-35 m; substrates: rocks, rocky cliffs within coralligenous communities, stones.

Distribution: Atlantic–Mediterranean

Ophidiaster ophidianus (Lamarck, 1816)

Material: 38 specimens; stations: T7, T9, S7, S8, S12; depth: 1-35 m; substrates: rocks, stones.

Distribution: Atlantic–Mediterranean.

Remarks: Recorded for the second time after the first finding by Kolosváry (1937).

Classis: OPHIUROIDEA

Fam: Ophi dermatidae

Ophioderma longicauda (Bruzelius, 1805)

Material: 21 specimens; stations: T8, T12, S8, S11, S12, S15, t3, t7; depth: 2-120 m; substrates: under stones and gravels, sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Recorded for the second time after the first finding by Kolosváry (1938, 1940).

Fam: Ophiomyxidae

Ophiomyxa pentagona (Lamarck, 1816)

Material: 13 specimens; stations: S11, S14; depth: 6-25 m; substrates: gravels, mud, sand.

Distribution: Atlantic–Mediterranean.

Fam: Ophiotrichidae

Ophiotrix fragilis (Abildgaard, 1789)

Material: 376 specimens; stations: T8, T9, T11, S8, S14, S15, t6; depth: 1-80 m; substrates: under stones and gravels, colonies of the stony coral *Cladocora caespitosa*.

Distribution: Atlantic–Mediterranean.

Fam: Ophiuridae

Ophiura ophiura (Linnaeus, 1758)

Material: 27 specimens; stations: t3, t6, t7; depth: 25-120 m; substrates: sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by trawl nets.

Classis: ECHINOIDEA

Fam: Arbaciidae

Arbacia lixula (Linnaeus, 1758)

Material: 607 specimens; stations: T7, T8, T9, T10, T12, S6, S7, S8, S9, S10, S11, S15; depth: 0-15 m; substrates: large rocks, coarse stones.

Distribution: Atlantic–Mediterranean.

Fam: Brissidae

Brissopsis lyrifera (Forbes, 1841)

Material: 15 specimens; stations: T9, T11; depth: 15-25 m; substrates: sand, sandy-mud, mud.

Distribution: Atlantic–Mediterranean.

Brissus unicolor (Leske, 1778)

Material: 12 specimens; stations: T7, S7; depth: 5-30 m; substrates: sandy-mud, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Dead tests predominantly collected during the study.

Fam: Cidaridae

Cidaris cidaris (Linnaeus, 1758)

Material: 9 specimens; stations: S6, S8, t5; depth: 7-120 m; substrates: rock cliffs, mud.

Distribution: Atlantic–Mediterranean.

Remarks: A single specimen collected from the mud bottom and all others from rock cliffs.

Fam: Echinidae

Echinus acutus Lamarck, 1816

Material: 2 specimens; stations: t5; depth: 80-120 m; substrates: sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by a trawl net.

Echinus melo Lamarck, 1816

Material: 10 specimens; stations: t6; depth: 80-120 m; substrates: sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by a trawl net.

Paracentrotus lividus (Lamarck, 1816)

Material: 686 specimens; stations: T7, T8, T9, T10, T11, T12, S6, S7, S8, S9, S11, S13, S15, S16; depth: 0-15 m; substrates: large rocks, boulders, stones, meadows of *Posidonia oceanica*.

Distribution: Atlantic–Mediterranean.

Remarks: Recorded for the second time after the first finding by Kolosváry (1938, 1940).

Psammechinus microtuberculatus (Blainville, 1825)

Material: 3 specimens; stations: t6; depth: 80-120 m; substrates: sand, mud.

Distribution: Atlantic–Mediterranean.

Remarks: Collected only by a trawl net.

Fam: Diadematidae

Centrostephanus longispinus (Philippi, 1845)

Material: 19 specimens; stations: T7, S6, S7, S8, t3; depth: 25-120 m;
substrates: rock cliffs, mud.

Distribution: Atlantic–Mediterranean.

Fam: Fibulariidae

Echinocyamus pusillus (O.F. Müller, 1776)

Material: 904 specimens; stations: T7, T8, T9, T10, T11; depth: 5-35 m;
substrates: well-sorted sand.

Distribution: Atlantic–Mediterranean.

Remarks: Almost all collected specimens were dead tests.

Fam: Loveniidae

Echinocardium cordatum (Pennant, 1777)

Material: 9 specimens; stations: T7, T9, T12; depth: 3-25 m; substrates:
sand.

Distribution: Cosmopolitan.

Fam: Spatangidae

Spatangus purpureus (O.F. Müller, 1776)

Material: 38 specimens; stations: T7, T8, T9, T10, T11, T12, S7, S8, S15;
depth: 3-30 m; substrates: sand.

Distribution: Atlantic–Mediterranean.

Fam: Toxopneustidae

Sphaerechinus granularis (Lamarck, 1816)

Material: 255 specimens; stations: T7, T8, T9, T10, S7, S8, S9, S11, S13, S14, S15; depth: 1-20 m; substrates: stones, sand, mud, meadows of *Posidonia oceanica*.

Distribution: Atlantic–Mediterranean.

Classis: HOLOTHUROIDEA

Fam: Cucumariidae

Ocnus planci (Brandt, 1835)

Material: 7 specimens; stations: S14, t6; depth: 5-30 m; substrates: sandy-mud, organic detritus.

Distribution: Atlantic–Mediterranean.

Ocnus syracusanus (Grube, 1840)

Material: 2 specimens; stations: t6; depth: 5-30 m; substrates: sandy-mud, organic detritus.

Distribution: Mediterranean.

Remarks: Collected only by trawl nets.

Fam: Holothuriidae

Holothuria (Panningothuria) forskali Delle Chiaje, 1823

Material: 12 specimens; stations: T8, S6, S8; depth: 10-40 m; substrates: fissures in rocks with deposited sand, meadows of *Posidonia oceanica*.

Distribution: Atlantic–Mediterranean.

Holothuria (Thymiosycia) impatiens (Forskål, 1775)

Material: 9 specimens; stations: T8; depth: 5-25 m; substrates: sand, mud, organic detritus, meadows of sea grasses.

Distribution: Cosmopolitan.

Holothuria (Holothuria) mammata Grube, 1840

Material: 80 specimens; stations: T7, T9, T10, S11, S15; depth: 5-30 m; substrates: sand, mud, organic detritus, meadows of sea grasses.

Distribution: Mediterranean.

Holothuria (Roweothuria) poli Delle Chiaje, 1823

Material: 150 specimens; stations: T8, T9, T10, T11, S8, S11; depth: 3-35 m; substrates: sand, mud, organic detritus, meadows of sea grasses.

Distribution: Atlantic–Mediterranean, Red Sea.

Holothuria (Platyperona) sanctori Delle Chiaje, 1823

Material: 18 specimens; stations: T7, T8, S8; depth: 4-35 m; substrates: large rocks, fissures in rocks, sand.

Distribution: Atlantic–Mediterranean.

Holothuria (Holothuria) tubulosa Gmelin, 1790

Material: 122 specimens; stations: T7, S7, S8, S9, S10, S11, S13, S14, S15, S16; depth: 1-37 m; substrates: sand, mud, organic detritus, meadows of sea grasses.

Distribution: Atlantic–Mediterranean.

Fam: Stichopodidae

Parastichopus regalis (Cuvier, 1817)

Material: 65 specimens; stations: S14, t3, t4, t6; depth: 20-120 m;
substrates: sand, mud, silt.

Distribution: Atlantic–Mediterranean.

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