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CONTRIBUTION TO KNOWLEDGE OF ECHINODERMATA OF BOKA KOTORSKA BAY

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ABSTRACT

Paper present results of personal investigation and compilation with literature data about echinoderms in the Boka Kotorska Bay. This area has specific feature regarding to physical-chemical factors. Semi closed basin is under strong impact of anthropogenic activities and rainfall. Echinoderms are sessile or slow motion animals and under high impact of this parameters.

Research shows presence of 32 species of echinoderms on the area. Regarding the species mentioned by previous authors this research finds out nine species, for the first time recorded in the Bay. On the other side, the present survey shows absence of 16 species, noted in historic data.

Key words: echinoderms, Boka Kotorska Bay, Adriatic Sea, biodiversity

INTRODUCTION

The territory of Boka Kotorska Bay, for its specific features is attractive for many categories of researches. The Bay is located on southeast side of Adriatic Sea, and consists of four smaller, linked bays (Kotor, Risan, Tivat and Herceg Novi). Layers of fine mud cover the bottom of the Bay. According to Lepetić (1965) in the Kotor bay and the Risan bay, as well as, in the area of Verige straits is covered by clay, while just the area in front of Risan consists of sandy clay. The Tivat bay is dominantly composed of clay while the bottom of the Herceg Novi bay consists of clay, loam-clay, sandy clay and sand.

Due to combination of abiotic factors, we consider the Boka Kotorska Bay as specific biotope. Petersen (1915) said that physical condition of the sea bottom has a big impact on benthos animal distribution. Echinoderms as sessile and slow motion organisms are under direct impact of environment. Using sediments and sea water, they bring into body all dissolved noxious substance. Some of them are tolerant to the polluted and stressed environment (Tortonese, 1965), while others give negative response (Buznikov, 1984) and retreat the area.

Investigation of Echinoderms inside Boka Kotorska Bay was initiated by Kolosvary (1938), who first made a list of this group of marine organisms. Having studied the benthos communities of Boka bay, Karaman & Gamulin-Brida (1970) have provided a lot of data on diversity and distribution of echinoderms in biocoenosis, in the studied area. The researches of the Kotor-Risan Bay, carried out by Bruno (1972) resulted in preliminary list of echinoderms while Stjepčević & Parezan (1980) described echinoderms of the studied territory, as part of the study on general description and components of benthos biocoenosis. Studied ecology of mussels and oysters Stjepčević (1974)

registered some species of echinoderms as predators. Significant contribution to knowledge about echinofauna of this zone gave Milojević (1979).

Investigation conducted in the Bay of Boka Kotorska, after almost 30 years, aimed to show the present state of echinoderm fauna on this area. Data from the fieldwork and from the literature, presented in this document, form a checklist of echinoderms in the mentioned area.

MATERIAL AND METHODS

Material collection, on the previous define 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 profundity, which depended on the field configuration, as well as bottom type. By autonomy diving was investigated 11 sites and two positions by otter trawling (Tab.1) (it was experimental study because the trawling is prohibited in the Boka Kotorska Bay). Material was 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, 1969 and corrected by ERMS (Hansson, 2001).

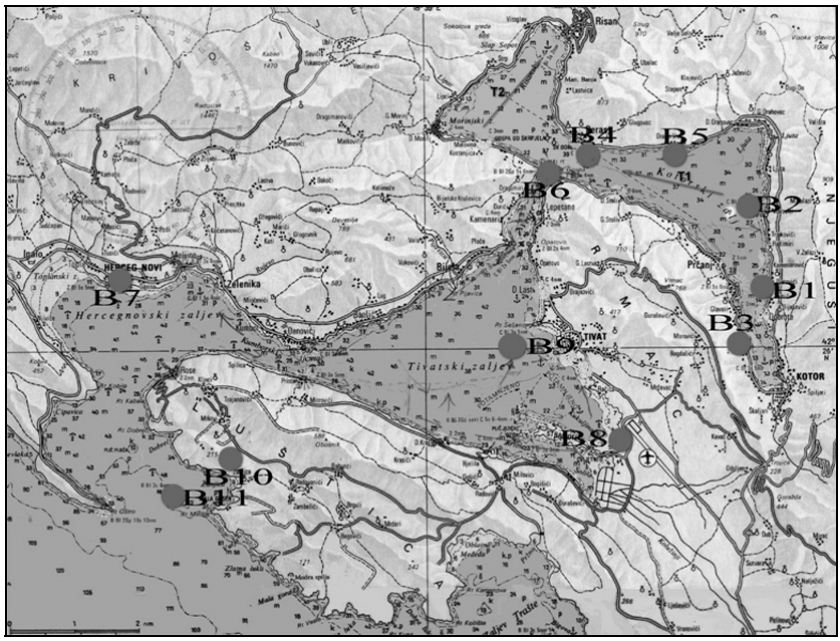

Figure 1. Map of investigated area

Table 1. Sites investigated by SCUBA diving (B1-B11) and by otter trawl (T1-T2)

Station No.	Locality	Depth (m)	Bottom type
B1	Kotor-Plagenti	0-15	Mud
B2	Kotor-Sv. Stasije	0-15	Mud-sand
B3	Kotor-Glavati	0-18	Sand, mud, gravels
B4	Perast-ostrvo Sv.Đorđe	0-20	Mud
B5	Dražin vrt	0-28	Mud-sand
B6	Verige	0-20	Sand-stones
B7	Herceg Novi	0-18	Sand-stones
B8	Tivat-uvala Kukoljina	0-8	Mud, stones
B9	Tivat-Arsenal	0-15	Mud, sand
B10	Žanjice	0-20	Stones, gravels
B11	Rt Arza	0-30	Sand, rocks
T1	Sv. Stasije-Perast	29-39	Sand, mud
T2	Kostanjica-Risan	32-23	Sand, mud

RESULTS AND DISCUSSION

Personal investigation shows presence of 32 species of the Echinoderms on investigated area (Table 2). Number of recorded species is less than earlier researches show (Karaman & Gamulin-Brida, 1970; Bruno, 1972; Milojević, 1979; Stjepčević & Parenzan, 1980). Regarding the species mentioned by previous authors this research finds out nine species, for the first time recorded in the Bay. On the other side, the present survey shows absence of 16 species, noted in historic data. If we take into consideration high anthropogenic impact inside the Boka Kotorska Bay, absence of some species is expected. Also, previous investigations were done by grab, dredge or beam trawl while this one is based mainly on SCUBA diving and just two samples done by otter trawl, so it can be a reason for the high differences between sampled species.

Table 2. List of echinoderms of Boka Kotorska Bay (L – literature data; P – present study; AM – Atlantic-Mediterranean; C – Cosmpolitan; ME – Mediterranean endemics; MSE–Mediterranean subendemics.)

Taxa	L	P	Distribution	Depth range (m) L	Depth range (m) P
Classis: CRINOIDEA					
Fam: Antedonidae					
Antedon mediterranea (Lamarck, 1816)	x	x	ME	1-420	3-120
Classis: ASTEROIDEA					
Fam: Asteriidae					
Coscinasterias tenuispina (Lamarck, 1816)	x	x	AM	0-165	1-25
Marthasterias glacialis (Linnaeus, 1758)	x	x	AM	0-180	0-80
Fam: Asterinidae					
Anseropoda placenta (Pennant, 1777)	x		AM	40-100	80-120
Fam: Astropectinidae					
Astropecten aranciacus (Linnaeus, 1758)	x		AM	1-132	29-100

Astropecten irregularis pentacanthus (Delle Chiaje, 1827)	x	x	ME	3-1829	10-120
Astropecten jonstoni (Delle Chiaje, 1827)	x		ME	2-12	8-11
Astropecten platyacanthus (Philippi, 1837)	x		ME	2-64	15-25
Astropecten spinulosus (Philippi, 1837)	x	x	ME	2-55	10-13
Fam: Echinasteridae					
Echinaster (Echinaster) sepositus (Retzius, 1783)	x	x	AM	0-250	0-120
Fam: Luidiidae					
Luidia ciliaris (Philippi, 1837)	x		AM	4-400	80-120
Fam: Ophidiasteridae					
Hacelia attenuata Gray, 1840		x	AM	1-150	5-35
Ophidiaster ophidianus (Lamarck, 1816)	x	x	AM	0-105	1-35
Classis: OPHIUROIDEA					
Fam: Amphiuridae					
Amphipholis squamata (Delle Chiaje, 1828)	x		C	0-740	–
Amphiura chiajei Forbes, 1843	x		AM	5-1200	–
Amphiura filiformis (O.F. Müller, 1776)	x		AM	5-1200	–
Amphiura mediterranea Lyman, 1882	x		ME	3-90	–
Fam: Ophiodermatidae					
Ophioderma longicauda (Bruzelius, 1805)	x	x	AM	0-70	2-120
Fam: Ophiomyxidae					
Ophiomyxa pentagona (Lamarck, 1816)	x		AM	0-250	6-25
Fam: Ophiotrichidae					
Ophiothrix fragilis (Abildgaard, 1789)	x	x	AM	0-1244	1-80
Fam: Ophiuridae					
Ophiura albida Forbes, 1839	x	x	AM	2-850	20-30
Ophiura ophiura (Linnaeus, 1758)	x		AM	0-685	25-120
Classis: ECHINOIDEA					
Fam: Arbaciidae					
Arbacia lixula (Linnaeus, 1758)		x	AM	0-40	0-15
Fam: Brissidae					

Brissopsis lyrifera (Forbes, 1841)	x	x	AM	5-1500	15-25
Brissus unicolor (Leske, 1778)		x	AM	0-250	5-30
Fam: Cidaridae					
Cidaris cidaris (Linnaeus, 1758)		x	AM	47-2000	7-120
Fam: Echinidae					
Paracentrotus lividus (Lamarck, 1816)	x	x	AM	0-80	0-15
Psammechinus microtuberculatus (Blainville, 1825)	x		AM	4-685	80-120
Fam: Fibulariidae					
Echinocyamus pusillus (O.F. Müller, 1776)	x		AM	0-1250	5-35
Fam: Loveniidae					
Echinocardium cordatum (Pennant, 1777)	x	x	C	0-230	3-25
Echinocardium fenauxi Péquignat, 1963		x	MSE	3-128	15-20
Fam: Schizasteridae					
Schizaster canaliferus (Lamarck, 1816)		x	MSE	1-100	5-35
Fam: Spatangidae					
Spatangus purpureus (O.F. Müller, 1776)	x	x	AM	15-969	3-30
Fam: Toxopneustidae					
Sphaerechinus granularis (Lamarck, 1816)	x	x	AM	2-100	1-20
Classis: HOLOTHUROIDEA					
Fam: Cucumariidae					
Leptopentacta elongata (Düben & Koren, 1846)	x	x	AM	0-150	27-37
Leptopentacta tergestina (M. Sars, 1857)	x	x	ME	8-170	27-37
Ocnus planci (Brandt, 1835)	x	x	AM	2-350	5-30
Ocnus syracusanus (Grube, 1840)	x	x	ME	7-100	5-30
Thyone fusus mediterranea Madsen, 1941	x		ME	20-150	–
Fam: Holothuriidae					
Holothuria (Panningothuria) forskali Delle Chiaje, 1823	x	x	AM	1-100	10-40
Holothuria (Thymiosycia) impatiens (Forskål, 1775)	x		C	0-30	5-25
Holothuria (Holothuria) mammata Grube, 1840		x	ME	1-77	5-30

Holothuria (Roweothuria) poli Delle Chiaje, 1823	x	x	AM, Red Sea	0-250	3-35
Holothuria (Platyperona) sanctori Delle Chiaje, 1823		x	AM	1-30	4-35
Holothuria (Holothuria) tubulosa Gmelin, 1790	x	x	AM	0-100	1-37
Fam: Stichopodidae					
Parastichopus regalis (Cuvier, 1817)	x	x	AM	5-1200	20-120
Fam: Synallactidae					
Mesothuria intestinalis (Ascanius, 1805)		x	AM	18-4255	8-10
Fam: Synaptidae					
Labidoplax digitata (Montagu, 1815)	x		AM	2-600	–

Class: CRINOIDEA

Antedon mediterranea (Lamarck, 1816)

Locality: B11

Depth: about 30 m

Ecology: sessile species, wide ecological distribution in Mediterranean and Adriatic Sea. Common in meadows of Posidonia and Caulerpa, on the cliff, corals and algal assemblages. The depth varies from 15 to 80m (Tortonese, 1965).

Class:ASTEROIDEA

Coscinasterias tenuispina (Lamarck, 1816)

Locality: B9, B10

Depth: 0-20 m

Ecology: species characteristic for cliffs, stones and gravels. Prefer the biocoenosis of photophilic algae. Distributed in Mediterranean and Atlantic.

Marthasterias glacialis (Linnaeus, 1758)

Locality: B1, B2, B3, B6, B7, B9, B10, B11

Depth: 0-30 m

Ecology: species with wide ecological distribution. Abundant on sandy and gravel detrital bottom. Known as predator species, recorded in mussels' cages (Stjepčević, 1974).

Astropecten irregularis pentacanthus (Delle Chiaje, 1825)

Locality: B2,

Depth:0-15m

Ecology: it is considered as one of the most abundant species of *Asteroidea* in the Mediterranean. Can be found in the shallow water up to the depth of over 900 (Tortonese, 1965). On locality B2 we founded the species in coastal terrigenous biocoenosis.

Astropecten spinulosus (Philippi, 1837)

Locality: B3

Depth: 0-15 m

Ecology: species inhabits sandy and mud substrate as well as meadows of *Posidonia oceanica* and *Caulerpa sp.* Wide spread in Mediterranean.

Echinaster sepositus (Retzius, 1783)

Locality: B5, B6, B7, B9, B10, B11

Depth: 5-30 m

Ecology: species distributed in Mediterranean and Atlantic. It is typically found on cliffs, in Posidonia meadows and on coralligenous, detrital, muddy and sandy bottom.

Hacelia attenuata Gray, 1840

Locality: B11

Depth: 0-30 m

Ecology: wide distributed in Mediterranean, while in Adriatic Sea it isn't recorded in the northern part (Zavodnik, 1981, 1999). Typical representative of coralligenous community. Common on bedrock and cliffs.

Ophidiaster ophidianus (Lamark, 1816)

Locality: B11

Depth: 0-30 m

Ecology: bedrock, cliffs and compos coralligenous community. Distributed in Mediterranean, while in Adriatic only in south and central part (Zavodnik, 2003).

Class: OPHIUROIDEA

Ophioderma longicauda (Retzius, 1805)

Locality: B10

Depth: 0.5-20 m

Ecology: widely distributed in Mediterranean and Adriatic Sea. Common on cliffs, on gravel and algae in shallow water, in *Posidonia* and *Caulerpa* meadows, on corals and muddy bottom.

Ophiotrix fragilis (Abildgaard, 1789)

Locality: B3, B6, B7, B10,

Depth: 2-20 m

Ecology: distinctly littoral species with wide ecological distribution. Bedrock and outcrops, bare substrates and covered with algal turf. Abundant in coral colonies (*Cladocora caespitosa*).

Ophiura albida Forbes, 1839

Locality: T1, T2

Depth: 20-30 m

Ecology: species very tolerant to the salinity variation. Specimens recorded only in the inner part of the Koka Kotorska Bay. Populate sandy and mud bottom.

Class: ECHINOIDEA

Arbacia lixula (Linnaeus, 1758)

Locality: B10, B11

Depth: 1-20m

Ecology: belong to biocoenosis of photophilic algae. Abundant on rocks, cliffs, gravels in shallow water. Prefer high sunlight.

Brissopsis lyrifera (Forbes, 1841)

Locality: T1, T2

Depth: 15-25 m

Ecology: Very numerous species on sandy-mud bottoms inside the Bay of Kotor. Species populate depth range from 5 to 1500 m (Tortonese, 1965) on sandy, sandy-mud and mud substrates.

Brissus unicolor (Leske, 1778)

Locality: B3, B5, B7

Depth: 5-30 m

Ecology: inhabit sandy and sandy-mud sea bad. Wide distributed all around Atlantic and Mediterranean.

During the study dead tests predominantly collected.

Cidaris cidaris (Linnaeus, 1758)

Locality: B7

Depth: 0-18 m

Ecology: species inhabit depth range from 50 to 2000 m (Tortonese, 1965) and different substrates such as rock cliffs and mud.

Paracentrotus lividus (Lamarck,1816)

Locality: B8, B9

Depth:5-30m

Ecology: widely distributed in Mediterranean and Atlantic. Typical infralittoral species, recorded on the cliff, gravels and algae in shallow water, *Posidonia* meadows.

Echinocardium cordatum (Pennant, 1777)

Locality: B7

Depth: 3-15 m

Ecology: species has cosmopolitan distribution. Lives buried in sandy substrate.

Echinocardium fenauxi Péquignat, 1963

Locality: B7

Depth: 15-20 m

Ecology: species populate well sorted sand.

Schizaster canaliferus (Lamarck, 1816)

Locality: B7

Depth: 5-15 m; substrates: sandy-mud.

Ecology: species prefer sandy, sandy-mud and mud substrate. Wide spread in Atlantic and Mediterranean. Within collected material dominated dead test.

Spatangus purpureus (O.F. Müller, 1776)

Locality: B7

Depth: 3-15 m

Ecology: species lives buried in substrate. Prefer sandy, sandy-mud and mud substrates.

Sphaerechinus granularis (Lamarck, 1816)

Locality: B1, B3, B5, B6, B8, B9

Depth: 2-30m

Ecology: wide ecology distribution. Common in meadows of *Posidonia*, on sandy and gravel bottom, between cliffs. Can be noted also in corals environment.

Class:HOLOTHURIOIDEA

Leptopentacta elongata (Düben & Koren, 1846)

Locality: T1, T2

Depth: 27-37 m

Ecology: species inhabit sandy-mud and silt substrates. During research collected only by trawl nets inside the Bay of Kotor.

Leptopentacta tergestina (M. Sars, 1857)

Locality: T1, T2

Depth: 27-37 m

Ecology: species inhabit sandy-mud and silt substrates. During research collected only by trawl nets inside the Bay of Kotor.

Ocnus planci (Brandt, 1835)

Locality: B1

Depth: 2-15m

Ecology: in profundity from 5 to 250 m. Different kind of bottom (sandy, muddy, detrital, corals beds and meadows of Posidonia).

Ocnus syracusanus (Grube, 1840)

Locality: T2

Depth: 5-30 m

Ecology: species prefers sandy-mud and organic detritus substrates. Wide spread all around Mediterranean. During research collected only by trawl nets.

Holothuria (Panningothuria) forskali Delle Chiaje, 1823

Locality: B3

Depth: 3-15 m

Ecology: species inhabit sandy-mud substrates mix with gravels and fissures in rocks with deposited sand, meadows of *Posidonia oceanica*. Species with wide Atlantic–Mediterranean distribution.

Holothuria mammata Grube, 1840

Locality: B6

Depth: 20-28m

Ecology: rare species, noted in Mediterranean and Atlantic. Material collected on sandy-muddy bottom.

Holothuria polii Delle Chiaje, 1823

Locality: B1, B2, B5, B6, B8, B9, B10

Depth: 1-28m

Ecology: different kinds of beds, sandy, muddy, meadows of Posidonia and Caulerpa. Very often in community with H. *tubulosa*.

Holothuria tubulosa Gmelin, 1788

Locality: B2, B3, B4, B7, B8, B11

Depth: 1-25m

Ecology: species with wide ecological distribution (Pikard, 1965). All kinds of sandy bottom, muddy beds and Posidonia meadows, from few meters in depth up to 100m (Tortonese, 1965).

Parastichopus regalis (Cuvier, 1817)

Locality: T1, T2,

Depth: 20-39 m

Ecology: species mostly inhabit mud and sandy substrates together with *Echinus melo, Ophiura texturata*.

Mesothuria intestinalis (Ascanius, 1805)

Locality: B8

Depth: 0.5-8m

Ecology: distributed in Mediterranean and Atlantic on depth from 20 to 200m (Tortonese, 1965). This species is part of deep mud biocoenosis.

Regarding the species number in the classes, the richest class is *Holothuroidea* (11), than the class of *Echinoidea* with ten species, while the class of *Asteroidea* is represented by seven species. To the class of *Ophiuroidea* belong 3 species and to the class of *Crinoidea* one species. Number of recognized taxa is about 60% of total echinoderms registered up to today on the Montenegrin shelf (Kašćelan, 2010), and about 30 % of the number of echinoderms populate Adriatic Sea (Radović, 1999).

Thermophilic species *Ophidiaster ophidianus*, registered on locality B11, is second record of species for the Boka Kotorska Bay after Babić (1913). Along Montenegrin coast this species is recognized by Kolosvary (1937) and Gamulin-Brida (1983). Outer part of the Bay, locality Rt Arza is new finding place of *Hacelia attenuate* which is common species in littoral zone of Adriatic. Sea stars with wide distribution, *Marthasterias glacialis* and *Echinaster sepositus,* are recorded on almost all explored localities.

In collected material are identified tree representatives of *Ophiuroidea* (*Ophiotrix fragilis, Ophioderma longicauda* and *Ophiura albida*). *Ophiotrix fragilis* is mostly collected from coral community (*Cladocora caespitosa*). It's interesting that species *Ampiura chaiajei,* widely distributed and numerous in the Bay (Milojević, 1979), during the period of research, was not collected. We consider this as a result of the method applied (SCUBA diving). *Ophiura albida* was very numerous on the mud bottom in the inner part of the Bay.

The species *Paracentrotus lividus* and *Arbacia lixula,* founded on stations B10 and B11, were numerous. These species covered rocks and stones on the depth from 5 to 10 m. This was first record for *Arbacia lixula* for the investigated area and second record for *Paracentrotus lividus,* after Kolosvary (1937). Widely distributed species *Sphaerechinus granularis* is collected in almost all studied area. Findings of *Brissus unicolor, Cidaris cidaris, Echinocardium fenauxi* and *Schizaster canaliferus* are new records for the studied area.

Taxonomic identification of material shows presence of tree new species of *Holothuroidea* for marine fauna of Boka Kotorska Bay (*Holothuria mammata, Holothuria sanctori* and *Mesothuria intestinalis)*. *Holothuria mammata* and *Mesothuria intestinalis* are first record for fauna of Montenegro.

H. mammata was found on the locality B5, characterized by sandy-muddy bed. This species is considered as rare, and its ecology is unknown up today. In the Adriatic Sea, it is registered near Trieste (Tortonese, 1965), in the region of Puglia (Ungaro, 1995) and in zone of national park Mljet (Zavodnik, 2003). *Mesothuria intestinalis* was collected in the Tivat Bay (B8). This founding represents a curiosity from bathymetric aspect. The species is characteristic for deep mud bottom, from 20 m up to few hundred meters (Tortonese, 1965), while Zavodnik (1961) recorded it at about 850 m of profundity in Adriatic Sea. These exemplars are collected from muddy bottom

on the depth of 8m. These phenomena can be solely explained by the fact that the conditions prevailing in the Bay on the stated location similar to those characterizing enormous depths which are usually occupied by this species.

The substrate features and depths seem to affect the distribution of echinoderms, confirming previous observations in the same and other marine areas (Milojevic, 1979). Some species, such as *Paracentrotus lividus*, considered as an indicator of environmental quality (Cunha et al. 2005), was found to be abundant on rocky substrate and *Posidonia oceanica* meadows, within first 10 m of depth. This species inhabit only outer part of the Boka Kotorska Bay, where impact of open sea is strong. On the contrary *Ophiura albida* was very numerous on muddy substrate within stratum of 21-30 m and was present mostly inside biocenoses of terrigenous mud.

Six species are Mediterranean endemics (Antedon mediterranea, Holothuria (Holothuria) mammata, Astropecten spinulosus, Leptopentacta tergestina, Ocnus syracusanus, Astropecten irregularis pentacanthus) and two species are Mediterranean subendemics (Schizaster canaliferus, Echinocardium fenauxi).

Personal and literature data show presence of 48 species in the Boka bay which is about 90 % of the species registered on the Montenegrin part of the Adriatic Sea (Kašćelan, 2010). This fact indicates that the studied area is rich in biodiversity and not enough explore.

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