ISSN: 0001-5113 AADRAY	ACTA ADRIAT., 51(1): 35 - 44, 2010	UDC: 593.93(262.3)

Distribution and abundance of the sand star *Astropecten irregularis* (Pennant, 1777) (Echinodermata, Asteroidea) on the continental shelf in the northern and middle Adriatic Sea

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The sand star Astropecten irregularis *(Pennant, 1777) is a very common species in the Adriatic Sea. This study establishes the distribution, biomass and abundance of that species on the continental shelf of the open waters in the northern and middle Adriatic Sea based on experimental sampling by bottom trawl during 11 cruises of the "Pipeta" Expedition (1985-1994). Five hundred and eighteen bottom trawl hauls were performed at 56 predetermined permanent stations along ten transects, over different sediment types at depths of 10 to 430 m.* Astropecten irregularis *was recorded in 82.2% of the hauls, with the highest biomass and abundance indices at depths from 10 to 50 m. The deepest record was in a haul from 313.5 to 412.5 m depth. Even though it was recorded all over the investigated area, it was most abundant in some areas of the northernmost part of the Adriatic, and very abundant in the areas along the western coast. The highest average biomass and abundance indices were recorded on sand-silt-clay sediment, on silty sand and sandy silt and on the clayey silt and silty clay.*

Key words: *Astropecten irregularis*, Adriatic Sea, distribution, abundance

INTRODUCTION

The sea star *Astropecten irregularis* (Pennant, 1777) is one of 23 species of sea stars in the fauna of the Adriatic Sea (RADOVIĆ, 1999) where it was recorded for the first time by SARS (1857). Since then, it was recorded frequently in numerous faunistic and biocoenological papers (GRUBE, 1861, 1864; HELLER, 1863, 1868; LORENZ, 1863; LUDWIG, 1879; GRAEFFE, 1881; STOSSICH, 1883; MARENZELLER, 1895; BRUSINA, 1907; VATOVA, 1928, 1935, 1949, 1950; KOLOSVÁRY, 1936/1937, 1938; KARLOVAC, 1959; ZAVODNIK, 1960, 1977, 1979, 1980, 1997a,b, 1998, 1999, 2003; GAMULIN-BRIDA, 1962, 1965; KARAMAN & GAMULIN-BRIDA, 1970; BRUNO, 1972; VIDOVIĆ-MATVEJEV, 1978; STJEPČEVIĆ & PARENZAN, 1980; ZAVODNIK *et al.*, 1981; GJIKNURI, 1985; MILOJEVIĆ, 1986; ŠPAN *et al.*, 1989; ŽUPANOVIĆ & JARDAS, 1989; GRUBELIĆ, 1992; ŠIMUNOVIĆ, 1992, 1997; UNGARO, 1995). Apart from the species name *Astropecten irregularis* (Pennant, 1777), three other synonyms were used in the literature for the Adriatic Sea: *Asterias pentacantha* Delle Chiaje, 1825; *Astropecten pentacanthus* Müller & Troschel, 1842; *Astropecten irregularis pentacanthus* Döderlein, 1917.

The species is of wide ecological range and is widely distributed in all parts of the Adriatic Sea, both in the coastal area and in the open waters (GAMULIN-BRIDA, 1962; ZAVODNIK & ŠIMUNOVIĆ, 1997). In the Adriatic Sea, *A. irregularis* inhabits different sandy, detritic and muddy bottoms (ZAVODNIK, 1972, 1979, 1980, 1997a, 2003) from 2 to 932 m deep (MARENZELLER, 1895; ZAVODNIK, 1961). It is one of the most common and perhaps the most abundant species in the Mediterranean Sea, where it is present in great numbers on muddy bottoms at depths from 50 to 400 m (TORTONESE, 1965, 1985). Apart from the Mediterranean Sea, the species is distributed in the Atlantic Ocean, from Guinea to Norway.

During the fishery-biological expedition ("Pipeta" Expedition) in the areas of commercial bottom trawling on the continental shelf of the northern and middle Adriatic Sea, by-catches were collected for scientific analysis and evaluation. The sand star *A. irregularis* was a common species in those experimental bottom trawl catches, and this study provides new information on its distribution, biomass and abundance.

MATERIAL AND METHODS

Sampling was performed during 11 cruises of the "Pipeta" Expedition (7th - 17th cruises) of the northern and middle Adriatic Sea, in Italian territorial waters, international waters and in the outer part of Croatian territorial waters up to the line of the outer islands (only one cruise) over a total surface area of 58,509 km^2.

The investigations were carried out from 1985 to 1994: the 7th cruise of the "Pipeta" Expedition was in November - December 1985, 8th in June - July 1986, 9th in May - June 1987, 10th in December 1987 - February 1988, 11th in October - November 1988, 12th in December 1990 - February 1991, 13th in February - March 1992, 14th in July 1992, 15th in September - October 1992, 16th in May - June 1993 and 17th in November 1993 - January 1994.

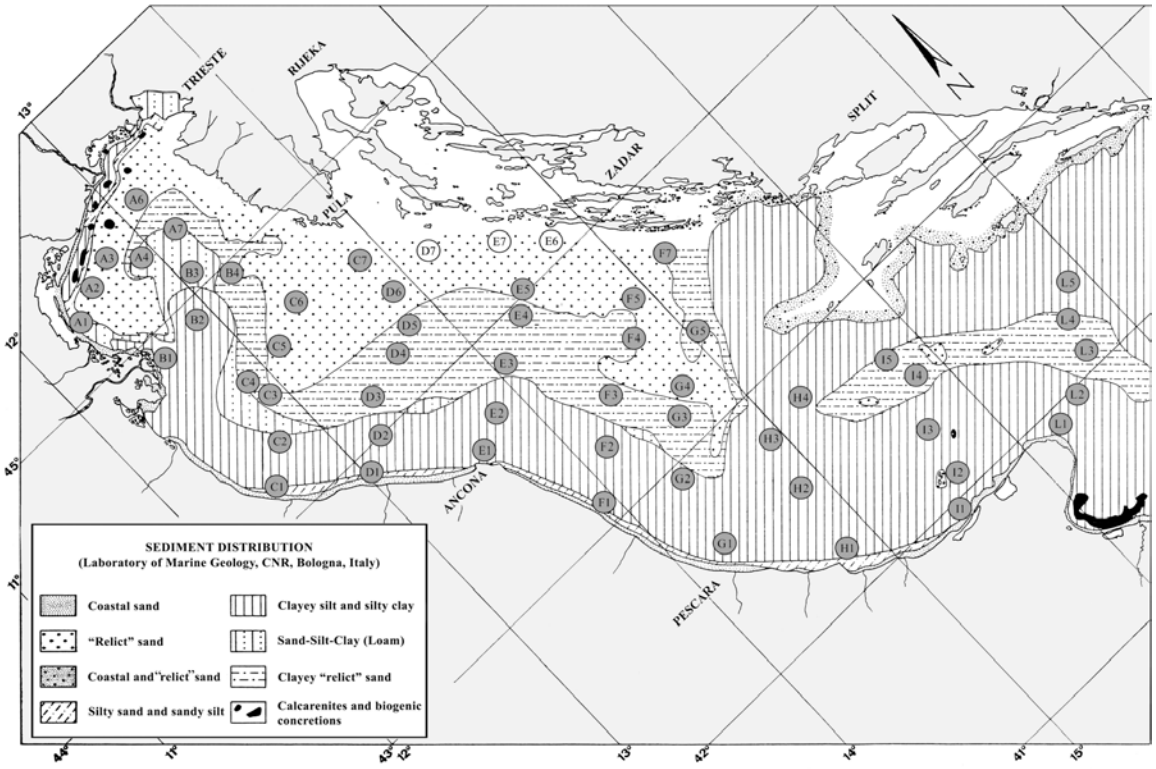

Fig. 1. Distribution of the sand star Astropecten irregularis, *in the area of the Adriatic Sea investigated during the "Pipeta" Expedition (1985 - 1994), superimposed on the distribution of sediments in the Adriatic Sea. Based on: CNR, Istituto di Geologia Marina, Bologna (1981). open circles – negative sites, shaded circles – positive sites*

*Table 1. Coordinates of investigated stations during the 7th cruise of the "Pipeta" Expedition in the Adriatic Sea, depth ranges and sediment types. RS–"relict" sand, CRS–clayey "relict" sand, SSC–sand-silt-clay, CSSC–clayey silt and silty clay, SSSS–silty sand and sandy silt; *16th cruise*

Station	Beginning latitude N	Beginning longitude E	Ending latitude N	Ending longitude E	Depth (m)	Sediment
A1	45° 16.11'	12° 21.85'	45° 13.02'	12° 20.92'	19 – 21	SSSS
A2	45° 18.02'	12° 33.11'	45° 19.31'	12° 37.96'	23 – 30	RS
A3	45° 22.10'	12° 43.06'	45° 23.20'	12° 46.60'	22 – 41	RS
A4	45° 18.89'	12° 53.33'	45° 17.98'	12° 53.77'	30 – 36	CRS / SSC
A6	45° 29.81'	13° 06.44'	45° 29.54'	13° 02.90'	23 – 26	RS
A7	45° 18.20'	13° 10.79'	45° 14.75'	13° 10.19'	32 – 38	SSC
B1	44° 54.92'	12° 35.84'	44° 50.43'	12° 32.13'	21 – 27	CSSC
B2	44° 56.16'	12° 54.01'	44° 52.18'	12° 51.70'	35 – 38	CSSC
B3	45° 06.57'	13° 03.34'	45° 02.84'	13° 04.53'	35 – 41	SSC
B4	44° 59.18'	13° 14.58'	44° 55.16'	13° 15.12'	40 – 44	CRS
C1	44° 11.45'	12° 30.97'	44° 07.85'	12° 35.09'	10 – 14	CSSC / SSSS
C2	44° 15.50'	12° 47.60'	44° 19.71'	12° 44.00'	37 – 49	CSSC
C3	44° 30.50'	12° 51.00'	44° 26.00'	12° 54.50'	40 – 50	RS / CRS / SSC
C4	44° 33.19'	12° 54.54'	44° 37.59'	12° 50.33'	39 – 46	CRS
C5	44° 35.48'	13° 12.58'	44° 33.70'	13° 05.70'	44 – 61	RS
C6	44° 39.00'	13° 28.00'	44° 40.50'	13° 22.50'	45 – 51	RS
C7*	44° 39.64'	13° 48.39'	44° 36.30'	13° 52.07'	48 – 52	RS
D1	43° 56.00'	12° 59.00'	43° 52.50'	13° 04.00'	14 – 19	CSSC / SSSS
D2	44° 02.00'	13° 12.00'	43° 58.50'	13° 17.50'	50 – 58	CSSC
D3	44° 06.50'	13° 23.50'	44° 11.00'	13° 20.00'	63 – 70	CRS
D4	44° 10.50'	13° 41.00'	44° 13.50'	13° 36.00'	64 – 71	CRS
D5	44° 14.30'	13° 51.00'	44° 17.30'	13° 45.30'	65 – 69	CRS
D6	44° 24.44'	13° 55.39'	44° 26.09'	13° 50.00'	55 – 68	RS
D7*	44° 25.85'	14° 16.38'	44° 29.14'	14° 10.53'	54 – 59	RS
E1	43° 35.50'	13° 39.00'	43° 38.50'	13° 35.00'	19 – 24	CSSC
E2	43° 41.00'	13° 53.00'	43° 44.50'	13° 47.00'	72 – 76	CSSC
E3	43° 48.50'	14° 07.50'	43° 51.50'	14° 00.50'	74 – 79	CRS
E4	43° 54.00'	14° 20.50'	43° 58.50'	14° 19.00'	74 – 76	CRS
E5	43° 59.00'	14° 29.50'	44° 03.00'	14° 25.00'	59 – 75	RS
E6*	44° 07.35'	14° 43.62'	44° 04.12'	14° 48.96'	67 – 68	RS
E7*	44° 17.25'	14° 30.94'	44° 13.83'	14° 35.44'	66 – 67	RS
F1	43° 08.00'	13° 54.00'	43° 02.50'	13° 55.00'	17 – 20	CSSC
F2	43° 19.00'	14° 10.00'	43° 14.00'	14° 10.00'	73 – 76	CSSC
F3	43° 28.00'	14° 24.00'	43° 23.00'	14° 25.50'	89 – 99	CRS
F4	43° 32.50'	14° 42.00'	43° 29.50'	14° 45.50'	89 – 109	RS / CRS
F5	43° 41.00'	14° 53.50'	43° 37.00'	14° 55.50'	90 – 99	RS
F7*	43° 45.96'	15° 10.92'	43° 41.47'	15° 16.14'	99 – 112	RS
G1	42° 37.50'	14° 15.00'	42° 33.00'	14° 19.50'	54 – 70	CSSC
G2	42° 53.00'	14° 24.50'	42° 48.50'	14° 26.00'	102 – 124	CSSC
G3	43° 06.50'	14° 35.50'	43° 10.00'	14° 39.00'	109 – 125	CRS
G4	43° 14.00'	14° 48.00'	43° 14.00'	14° 42.00'	101 – 121	RS
G5	43° 22.50'	15° 05.00'	43° 20.00'	15° 00.50'	106 – 132	RS / CRS
H1	42° 12.00'	14° 45.50'	42° 08.00'	14° 47.00'	20 – 35	CSSC
H2	42° 30.78'	14° 53.47'	42° 35.35'	14° 48.16'	158 – 182	CSSC
H3	42° 30.50'	14° 53.50'	42° 34.00'	14° 50.00'	203 – 231	CSSC
H4	42° 45.50'	14° 59.00'	42° 47.50'	14° 53.50'	177 – 195	CSSC
I1	41° 56.50'	15° 25.50'	41° 57.50'	15° 32.00'	21 – 27	CSSC
I2	42° 06.00'	15° 35.00'	42° 06.50'	15° 40.00'	84 – 127	CSSC
I3	42° 19.00'	15° 42.50'	42° 20.50'	15° 36.50'	124 – 145	CSSC
I4	42° 30.50'	15° 51.50'	42° 35.00'	15° 48.50'	130 – 145	CRS
I5	42°40.50'	15° 49.00'	42° 41.50'	15° 43.00'	140 – 165	CSSC / CRS
L1	41° 56.50'	16° 13.50'	41° 52.00'	16° 15.00'	21 – 121	CSSC
L2	42° 00.50'	16° 25.00'	41° 56.00'	16° 29.50'	107 – 116	CSSC
L3	42° 07.00'	16° 39.50'	42° 03.50'	16° 42.50'	165 – 215	CRS
L4	42° 16.00'	16° 45.00'	42° 12.00'	16° 45.50'	210 – 264	CSSC / CRS
L5	42° 24.00'	16° 54.50'	42° 21.00'	16° 53.00'	264 – 479	CSSC

Five hundred and eighteen bottom trawl hauls were performed over the areas of 56 predetermined permanent stations along ten transects (A, B, C, D, E, F, G, H, I, L; Table 1, Fig. 1) over different sediment types: "relict" sand (sediment that settled during the last glacial and that was resedimented during the Holocene transgression), clayey "relict" sand, sand-silt-clay, clayey silt and silty clay, silty sand and sandy silt, at depths from 10 to 430 m. Samples were continuously collected by a commercial trawler using typical commercial trawl bottom net (otter trawl net) with 40 mm square mesh size on cod-end (PICCINETTI, 1972) during day and night. Technical and construction characteristics of the bottom trawl (mesh size, door opening, vessel speed etc.) were constant at all stations during all cruises. Haul duration was mainly one hour, depending on sea conditions, and swept area was calculated using the formula according to SPARRE & VENEMA (1992). The catch of this species at each station was expressed as the number of specimens per km^2 (N km^{-2}; abundance index) and as wet weight per km^2 (kg km^{-2}; biomass index), using catchability coefficient q=1. The sampling scheme was systematic sampling by transects.

Samples of sea star *Astropecten irregularis* were identified according to TORTONESE (1965). Taxonomic nomenclature based on ERMS (COSTELLO *et al.*, 2001) was used.

RESULTS

In the investigated area, the sand star *Astropecten irregularis* was recorded in 82.2% of the hauls. It was caught on all 11 cruises and at almost all stations (Fig. 1). The highest biomass and abundance indices of the species were recorded at depths from 10 to 50 m (Table 2). The deepest record was in a haul from 313.5 to 412.5 m at station L5.

The highest average biomass and abundance were recorded on sand-silt-clay sediment (15.68±33.04 kg km^{-2}; 3686.11±9293.56 N km^{-2}), where the species was recorded in all 30 hauls at depths from 25 to 50 m, and silty sand and sandy silt where the species was recorded in almost all hauls at depths from 10 to 25 m (7.46±6.81 kg km^{-2}; 2624.58±3712.97 N km^{-2}; Table 3). On clayey silt and silty clay, average values were lower yet the sea star inhabited depths from 10 to 25 m in large quantities (9.38±22.24 kg km^{-2}; 2089.25±4009.44 N km^{-2}). The lowest average biomass and abundance indices were recorded on "relict" sand and clayey "relict" sand sediments, even though the species was present in larger quantities at depths from 50 to 150 m on "relict" sand and from 25 to 50 m on clayey "relict" sand (Table 3).

Data of catches were statistically elaborated for all stations where the species was recorded at least once on 11 cruises (Table 4). The highest average values of biomass and abundance

Table 2. Biomass index (kg km^{-2}) and abundance index (N km^{-2}) of Astropecten irregularis *in relation to the depth in the "Pipeta" Expedition study area. n - number of trawl hauls, n+ - number of positive trawl hauls, min - the lowest, max - the highest, and* $\bar{x}$ *- average calculated value, SD - standard deviation*

DEPTH (m)	BIOMASS INDEX kg km^{-2}						ABUNDANCE INDEX N km^{-2}			
	n	n+	min	max	$\bar{x}$	SD	min	max	$\bar{x}$	SD
10 – 25	84	70	0.00	161.99	7.46	18.64	0.00	23141.01	1769.90	3610.00
25 – 50	140	116	0.00	146.17	6.69	16.84	0.00	43846.16	1405.56	4545.92
50 – 100	147	113	0.00	17.74	1.03	2.44	0.00	16334.85	577.11	2026.12
100 – 150	83	72	0.00	10.93	0.77	1.54	0.00	6373.93	430.68	888.87
150 – 200	34	32	0.00	4.37	0.64	0.77	0.00	1573.59	335.42	341.46
>200	27	23	0.00	1.29	0.26	0.39	0.00	1107.17	149.77	214.44

Table 3. Biomass index (kg km^{-2}) and abundance index (N km^{-2}) of Astropecten irregularis *in relation to the sediment type and depth in the "Pipeta" Expedition study area. n - number of trawl hauls, n+ - number of positive trawl hauls, min - the lowest, max - the highest, and $\bar{x}$ - average calculated value, SD - standard deviation*

SEDIMENT	DEPTH (m)	BIOMASS INDEX						ABUNDANCE INDEX			
				kg km^{-2}				N km^{-2}			
		n	n+	min	max	$\bar{x}$	SD	min	max	$\bar{x}$	SD
"RELICT" SAND	TOTAL	107	61	0.00	17.74	1.41	2.96	0.00	16334.85	720.07	2239.02
	10 – 25	17	5	0.00	12.34	1.29	3.09	0.00	1388.46	164.82	362.41
	25 – 50	36	18	0.00	11.44	1.41	2.44	0.00	4556.98	329.37	773.81
	50 – 100	41	29	0.00	17.74	1.29	3.21	0.00	16334.85	1224.29	3316.23
	100 – 150	13	9	0.00	10.93	1.41	3.21	0.00	6373.93	937.98	1972.51
CLAYEY "RELICT" SAND	TOTAL	147	115	0.00	21.34	1.29	2.83	0.00	11385.37	411.78	1084.41
	25 – 50	32	29	0.00	21.34	3.86	4.89	0.00	4207.42	800.29	993.52
	50 – 100	63	43	0.00	13.24	0.51	1.67	0.00	11385.37	340.04	1432.56
	100 – 150	30	24	0.00	4.76	0.51	0.90	0.00	1633.50	228.45	402.01
	150 – 200	13	11	0.00	2.31	0.64	0.64	0.00	1573.59	422.19	423.61
	> 200	9	8	0.00	1.16	0.26	0.39	0.00	324.75	128.82	120.59
SAND – SILT – CLAY	TOTAL	30	30	0.51	146.17	15.68	33.04	107.09	43846.16	3686.11	9293.56
	25 – 50	30	30	0.51	146.17	15.68	33.04	107.09	43846.16	3686.11	9293.56
CLAYEY SILT AND SILTY CLAY	TOTAL	220	210	0.00	161.99	4.24	12.47	0.00	23141.01	929.24	2273.86
	10 – 25	56	55	0.00	161.99	9.38	22.24	0.00	23141.01	2089.25	4009.44
	25 – 50	42	39	0.00	45.25	6.69	9.00	0.00	8227.91	1160.26	1594.29
	50 – 100	43	41	0.00	10.54	1.67	2.31	0.00	1964.93	307.13	445.85
	100 – 150	41	40	0.00	3.99	0.90	0.90	0.00	1969.43	411.14	471.82
	150 – 200	21	21	0.00	4.37	0.64	0.90	18.51	771.37	281.81	277.18
	> 200	17	14	0.00	1.29	0.26	0.26	0.00	1107.17	160.70	258.92
SILTY SAND AND SANDY SILT	TOTAL	11	10	0.00	17.10	7.46	6.81	0.00	9626.66	2624.58	3712.97
	10 – 25	11	10	0.00	17.10	7.46	6.81	0.00	9626.66	2624.58	3712.97

indices were recorded at station B3 (sediment: sand-silt-clay, depth: 39 m) where the species was sampled during all hauls (26.10±50.01 kg km^{-2}; 7151.47±14897.15 N km^{-2}; Table 4). High average values (24.81±46.15 kg km^{-2}; 4212.43±6494.01 N km^{-2}) were also recorded at station B1 (sediment: clayey silt and silty clay, depth: 24 m) where the species was present in all samples. Average values >5 kg km^{-2} were recorded at stations A4, A7, B2, C1, C2, C7, E1 and I1; at most other stations these values were <2 kg km^{-2} (Table 4).

DISCUSSION

This investigation confirmed that *Astropecten irregularis* is a very common sea star on the mobile bottoms in the open part of the northern and middle Adriatic Sea. Even though it was recorded over the entire investigated area, it was most abundant in some areas of the northernmost part of the Adriatic. Also, the sand star was very abundant in the areas along the western coast. The species was not recorded only at three stations in the eastern part of the Adriatic, but

Table 4. Biomass index (kg km^{-2}) and abundance index (N km^{-2}) of Astropecten irregularis *at the stations where the species was recorded during the "Pipeta" Expedition. n - number of trawl hauls, n+ - number of positive trawl hauls, min - the lowest, max - the highest, and* $\bar{x}$ *- average calculated value, SD - standard deviation*

STATION	BIOMASS INDEX kg km^{-2}						ABUNDANCE INDEX N km^{-2}			
	n	n+	min	max	$\bar{x}$	SD	min	max	$\bar{x}$	SD
A1	3	3	1.03	4.24	3.21	1.93	144.63	571.33	343.90	214.83
A2	10	4	0.00	5.27	1.03	1.80	0.00	308.55	75.08	118.53
A3	11	2	0.00	12.34	1.41	3.73	0.00	617.09	91.15	209.30
A4	9	9	1.93	38.57	10.80	11.96	522.22	5656.69	1764.24	1554.43
A6	10	5	0.00	6.81	1.67	2.44	0.00	1388.46	292.09	451.89
A7	11	11	0.77	64.28	11.57	18.64	152.60	7970.79	1920.83	2260.36
B1	11	11	0.64	161.99	24.81	46.15	52.58	23141.01	4212.43	6494.01
B2	11	10	0.00	45.25	10.80	13.37	0.00	8227.91	1755.12	2382.62
B3	11	11	0.51	146.17	26.10	50.01	107.09	43846.16	7151.47	14897.15
B4	11	9	0.00	16.84	3.99	5.14	0.00	4207.42	855.83	1250.39
C1	11	10	0.00	17.10	7.20	6.81	0.00	9626.66	2164.71	3078.01
C2	11	10	0.00	26.61	8.61	7.84	0.00	2571.22	1123.62	815.46
C3	11	9	0.00	4.76	1.67	1.54	0.00	1905.79	370.13	545.61
C4	10	10	0.26	5.79	2.31	2.06	28.03	3471.15	703.10	1027.20
C5	11	6	0.00	2.96	0.77	1.03	0.00	890.03	283.48	326.16
C6	11	6	0.00	3.47	1.03	1.41	0.00	701.30	225.62	279.11
C7	1	1	11.44	11.44	11.44	0.00	4556.98	4556.98	4556.98	0.00
D1	11	10	0.00	17.10	3.73	6.04	0.00	8639.31	1241.77	2533.94
D2	11	11	0.39	10.54	3.47	3.21	68.52	1964.93	662.60	679.45
D3	11	7	0.00	1.67	0.26	0.51	0.00	154.27	54.51	53.87
D4	11	4	0.00	0.64	0.13	0.26	0.00	487.12	84.85	150.55
D5	6	2	0.00	2.06	0.39	0.77	0.00	1217.99	241.57	487.25
D6	11	6	0.00	1.93	0.64	0.64	0.00	674.95	195.54	226.14
E1	11	11	1.29	39.60	9.51	10.93	175.36	9050.70	1895.63	2573.54
E2	11	11	0.13	6.56	2.06	2.31	33.04	974.36	306.62	318.70
E3	11	11	0.00	1.54	0.77	0.51	38.57	763.65	301.09	221.25
E4	10	8	0.00	1.16	0.51	0.39	0.00	730.74	297.62	232.18
E5	10	4	0.00	9.00	1.03	2.83	0.00	11056.26	1184.05	3470.89
F1	11	11	0.64	9.90	3.21	2.96	132.93	1851.28	596.27	512.83
F2	9	8	0.00	0.77	0.26	0.26	0.00	91.79	42.43	27.00
F3	11	10	0.00	0.77	0.13	0.26	0.00	308.55	70.19	90.38
F4	11	10	0.00	17.74	3.86	6.04	0.00	16334.85	3766.97	5674.05
F5	11	10	0.00	6.56	0.77	1.93	0.00	5485.32	628.15	1613.96
F7	1	1	0.51	0.51	0.51	0.00	453.69	453.69	453.69	0.00
G1	10	9	0.00	0.90	0.51	0.26	0.00	231.41	107.86	76.49
G2	10	9	0.00	1.67	0.64	0.64	0.00	514.24	191.68	162.12
G3	10	9	0.00	4.76	0.77	1.41	0.00	968.45	216.75	300.70
G4	10	6	0.00	10.93	1.16	3.47	0.00	6373.93	676.49	2002.47
G5	10	5	0.00	5.27	0.51	1.67	0.00	4049.68	422.58	1274.81
H1	10	9	0.00	19.93	4.89	6.69	0.00	3134.32	909.31	1087.88
H2	10	10	0.00	4.37	0.90	1.29	18.51	771.37	326.29	325.77
H3	10	9	0.00	1.29	0.39	0.39	0.00	1107.17	225.11	321.66
H4	10	10	0.13	1.16	0.39	0.39	38.57	668.52	197.98	193.36
I1	10	10	0.77	32.01	7.20	9.77	273.19	16712.95	3907.49	5397.64
I2	10	10	0.00	1.03	0.51	0.39	19.28	797.98	273.19	247.99
I3	10	10	0.00	2.31	0.77	0.90	23.78	1969.43	527.10	708.89
I4	9	9	0.13	1.67	0.51	0.64	38.57	1633.50	438.65	617.74
I5	9	8	0.00	2.31	0.90	0.77	0.00	1573.59	522.22	516.43
L1	10	10	0.39	2.83	1.16	0.77	54.51	681.37	319.47	186.29
L2	10	10	0.39	3.99	1.67	1.29	40.63	1415.59	610.41	467.19
L3	9	8	0.00	1.16	0.64	0.39	0.00	925.64	348.02	271.39
L4	9	8	0.00	1.16	0.39	0.39	0.00	324.75	133.83	116.60
L5	7	5	0.00	0.51	0.13	0.13	0.00	257.12	80.48	88.71

we can not conclude that the species is absent from that area as only one haul was performed at each of these stations during the period of investigation. The highest estimated biomass and abundance of this species were from 10 to 50 m. TORTONESE (1965) reported great numbers of specimens on muddy bottoms from 50 to 400 m.

Apart from the investigated area, the species was also recorded in other parts of the Adriatic Sea. MILOJEVIĆ (1986) counted up to one hundred specimens in bottom trawl catches on muddy and muddy-detritic bottoms at depths from 70 to 150 m in the area of the open littoral of the eastern coast of the southern Adriatic. On the trawling bottoms along the western part of the southern Adriatic, the species was recorded as abundant (>1000 specimens in a total of 25 hauls) at depths to 700 m and in almost all hauls (UNGARO, 1995). In the area of the Jabuka Pit, on muddy and muddy-sandy bottoms at depths from 117 to 238 m, this species was one of the most common echinoderms (ŽUPANOVIĆ & JARDAS, 1989). Also, KARLOVAC (1959) recorded the species as common at depths from 77 to 256 m. Additionally, GAMULIN-BRIDA (1962, 1965) recorded this sea star in biocoenoses on muddy bottoms at depths from 110 to 226 m and in biocoenoses on deeper littoral bottoms in channels in the middle Adriatic region.

It is very difficult to compare abundance of the sand star on different sediments as during the Expedition different numbers of hauls were performed on each sediment and depth stratum. Also, there is no depth stratum that is present for all sediments that could make data more comparable.

Our investigation shows that the species was most abundant on sand-silt-clay, silty sand and sandy silt, and clayey silt and silty clay sediments at depths down to 50 m. At these depths on "relict" sand (sediment that settled during the last glacial and that was resedimented during the Holocene transgression) and on clayey "relict" sand *A. irregularis* was also present, but in smaller numbers and we can assume that it prefers sediments of smaller grain sizes. ZAVODNIK (2003) also ecologically classified this sea star as belonging to a group of species inhabiting fine sand and silt. It is interesting that on "relict" sand the biomass of the species was very similar at all depth strata, but the abundance was greater at depths over 50 m. Unfortunately, this kind of investigation does not give us an answer as to why in these areas the species is present in greater numbers but with specimens of smaller size.

Combining the above-mentioned previous records and the "Pipeta" Expedition data confirm that the sand star is very common and abundant in all parts of the Adriatic Sea and that it inhabits different types of sediment bottoms and a wide range of depths.

ACKNOWLEDGMENTS

The authors wish to thank the late Dr. Ante ŠIMUNOVIĆ, who collected the samples during the "Pipeta" Expedition.

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Received: 3 February 2009
Accepted: 25 March 2010

Distribucija i abundancija morske zvijezde *Astropecten irregularis* (Pennant, 1777) (Echinodermata, Asteroidea) na kontinentskoj podini sjevernog i srednjeg Jadrana

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SAŽETAK

Morska zvijezda *Astropecten irregularis* (Pennant, 1777) je uobičajena vrsta u Jadranskom moru. Glavni ciljevi ovog istraživanja su bili ustanoviti njezinu distribuciju, biomasu i abundanciju na kontinentskoj podini otvorenih voda sjevernog i srednjeg Jadrana na osnovi eksperimentalnog uzorkovanja pridnenom kočom za vrijeme 11 putovanja ekspedicije Pipeta (1985.-1994.). Obavljeno je 518 potega pridnenom kočom na 56 unaprijed određenih stalnih postaja uzduž deset transekata, na različitim tipovima sedimenta na dubinama od 10 do 430 m. Vrsta *A. irregularis* je zabilježena u 82,2% potega, s najvećim vrijednostima indeksa biomase i abundancije na dubinama od 10 do 50 m. Najdublje je zabilježena tijekom potega od 313,5 do 412,5 m. Iako je vrsta zabilježena na cijelom istraživanom području, najabundantnija je bila na nekim područjima najsjevernijeg dijela Jadrana, te vrlo abundantna na područjima uzduž zapadne obale. Najveće srednje vrijednosti indeksa biomase i abundancije su zabilježene na pijesku-siltu-glini, siltoznom pijesku i pjeskovitom siltu te na glinovitom siltu i siltoznoj glini.

Ključne riječi: *Astropecten irregularis*, Jadransko more, distribucija, abundancija