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Distribution and abundance of the species *Holothuria tubulosa* GMELIN, 1788 and *Holothuria forskali* DELLE CHIAJE, 1823 (Holothuria, Echinodermata) in the Adriatic Sea

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The data on the qualitative and quantitative distribution of the species Holothuria tubulosa *and* Holothuria forskali *as affected by bottom types and depth are presented. The material originates from the continental shelf of the Adriatic Sea collected during PIPETA research cruises.*

Biological material was collected with bottom trawl from the Italian commercial trawler PIPETA in the 1982-1995 period. For the estimation of the abundance of the species Holothuria tubulosa *and* Holothuria forskali *standard "swept area" method was used.*

The total mass and the number of individuals of these species were obtained from 833 hauls (21 cruises) of the bottom trawl over a surface area of 39808.2 km² of the Adriatic bottom.

Obtained results are indicative of the fact that there are some differences in the horizontal and vertical distribution between the species Holothuria tubulosa *and* Holothuria forskali *and that the abundance is affected by sediment type.*

Key words: *Holothuria tubulosa*, *Holothuria forskali*, Adriatic Sea, distribution, abundance

INTRODUCTION

The data on the species *Holothuria tubulosa* and *Holothuria forskali* in the Adriatic Sea, available up to now, are frequently a part of a large number of faunal and biocoenological studies of benthic invertebrates in the Adriatic. These studies were mainly concerned with the species distribution in relation to depth and sea bottom character (KOLOSWARY, 1936-37; MAYER, 1937; VATOVA, 1949; ZAVODNIK, 1960, 1980, 1992, 1997; ZAVODNIK *et al.*, 1981; GAMULIN-BRIDA, 1974; GRUBELIĆ, 1992, 1993; ŠIMUNOVIĆ, 1997; GRUBELIĆ and ŠIMUNOVIĆ, 1997).

The data on the biology of the studied species in the Adriatic are generally scarce (TORTONESE, 1965) whereas the data on the biology of relative species from temperate and tropical areas are far more numerous owing to their commercial importance which has recently been increased very much (CONAND, 1981; CAMERON and FANKBONER, 1986; CONAND and SLOAN, 1989).

STEUER (1936), SELLA, A. and M. (1940) gave the data on the abundance of the

species *Holothuria tubulosa* on the eastern Istrian coast.

Due to an increased interest for the exploitation of the species *Holothuria tubulosa* in the Adriatic, ŠIMUNOVIĆ and GRUBELIĆ (1998) carried out a qualitative-quantitative study of this species on different bottoms from Zadar to Dubrovnik in the eastern coastal Adriatic in the 1996-1997. The distribution of the species, its relative abundance, biometric characteristics, sexual cycle and species renewal after overexploitation in individual areas were established.

MATERIAL AND METHODS

The biological material was collected by the Italian commercial trawler PIPETA in 1982-1995 as follows: from the 1st to 6th cruise at nine fixed profiles or 47-53 stations, from 7th to 17th cruise at ten profiles or 50 stations, during the 18th cruise from 81 stations, during the 19th cruise from 104 stations and during the 20th and 21st cruise from 83 stations (Figs. 1, 2). Station planing (1-17 and 20-21 cruises) was systematic with additional stratification (sediment, depth). Cruises 18 and 19 were with station random sampling.

The weight of the by catch was measured by filling up a plastic box of 50 x 32 x 10.5 cm by the random sample method with epifaunal material collected by the trawl. The weight of a plastic box with epifauna was multiplied with the total number of boxes with epifauna collected during a single bottom trawl haul and the value was expressed in kg hour^{-1}. It was attempted to keep the technical-technological bottom trawl properties constant at all the stations wherefrom the material was collected.

A standard Italian bottom trawl was used (PICCINETTI, 1972).

Leaving apart the problems of species accessibility to bottom trawl at profiles and stations, but being well informed of the operating surface area of the bottom trawl in unit time (an hour), the "swept area" method was used for the estimate of the abundance of the species *Holothuria tubulosa* and *Holothuria forskali*, that is the following expression:

$$B=\frac{\bar{c}\cdot A}{a\cdot q}$$

where B = the abundance of the species in the surveyed area;
$\bar{c}$ = the average weight (kg) of the species per a haul hour;
A = the total surface of the surveyed area (km^2);
a = "swept area" by trawl in unit time (a = 0.077784 km^2);
q = "coefficient of vulnerability" of the species (q = 1).

Studies in the areas of distribution of *Holothuria tubulosa* and *Holothuria forskali* covered four different sediment types: "relict" sand, of an area of 12685.7 km^2; clayey "relict" sand of an area of 11046.7 km^2, sand-silt-clay (loam) of an area of 2163.6 km^2; part of the clayey silt and silty clay of an area of 13912.2 km^2.

The value of "coefficient of vulnerability" is usually chosen between 0.5 and 1. Consulting the literature we have used 1 (DICKSON, 1974).

The total mass of the species *Holothuria tubulosa* and *Holothuria forskali* in the area of their distribution was obtained by summing up all the weights of each of the species collected during 833 bottom trawl hauls. The total number of individuals of each species was obtained by summing up the numbers of individuals caught by 833 hauls. Values of the total mass and total number of specimens of the species *Holothuria tubulosa* and *Holothuria forskali* at individual depths were obtained in the same way. However, 818 trawl hauls were worked out since the data on depth were not available for 15 hauls.

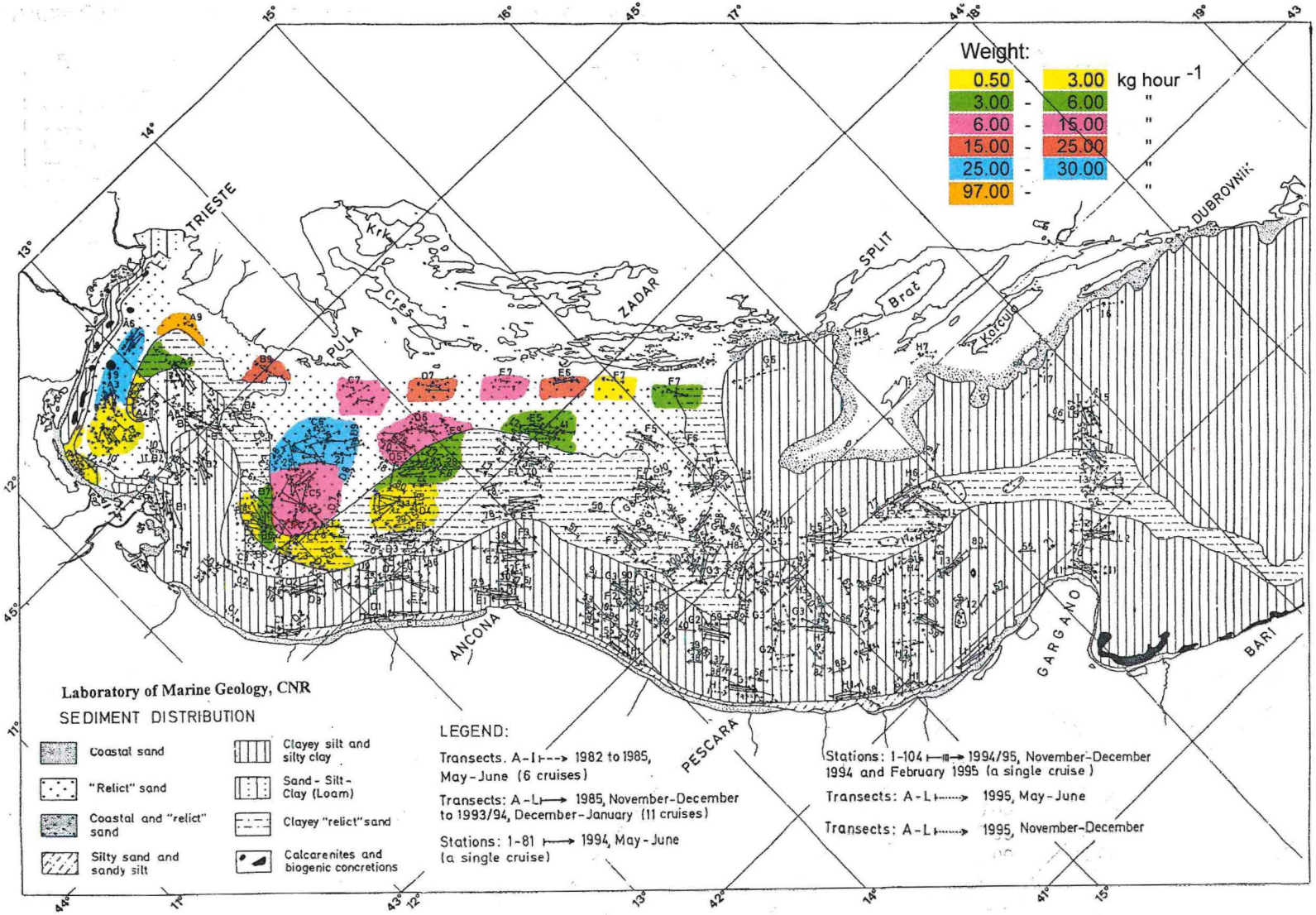

Fig. 1. Stations of PIPETA Expedition 1982 – 1995, plotted on the map of sediment distribution: average weight per a haul hour of the species Holothuria tubulosa *(kg h^{-1}) the map is after Laboratory of Marine Geology, CNR, Bologna)*

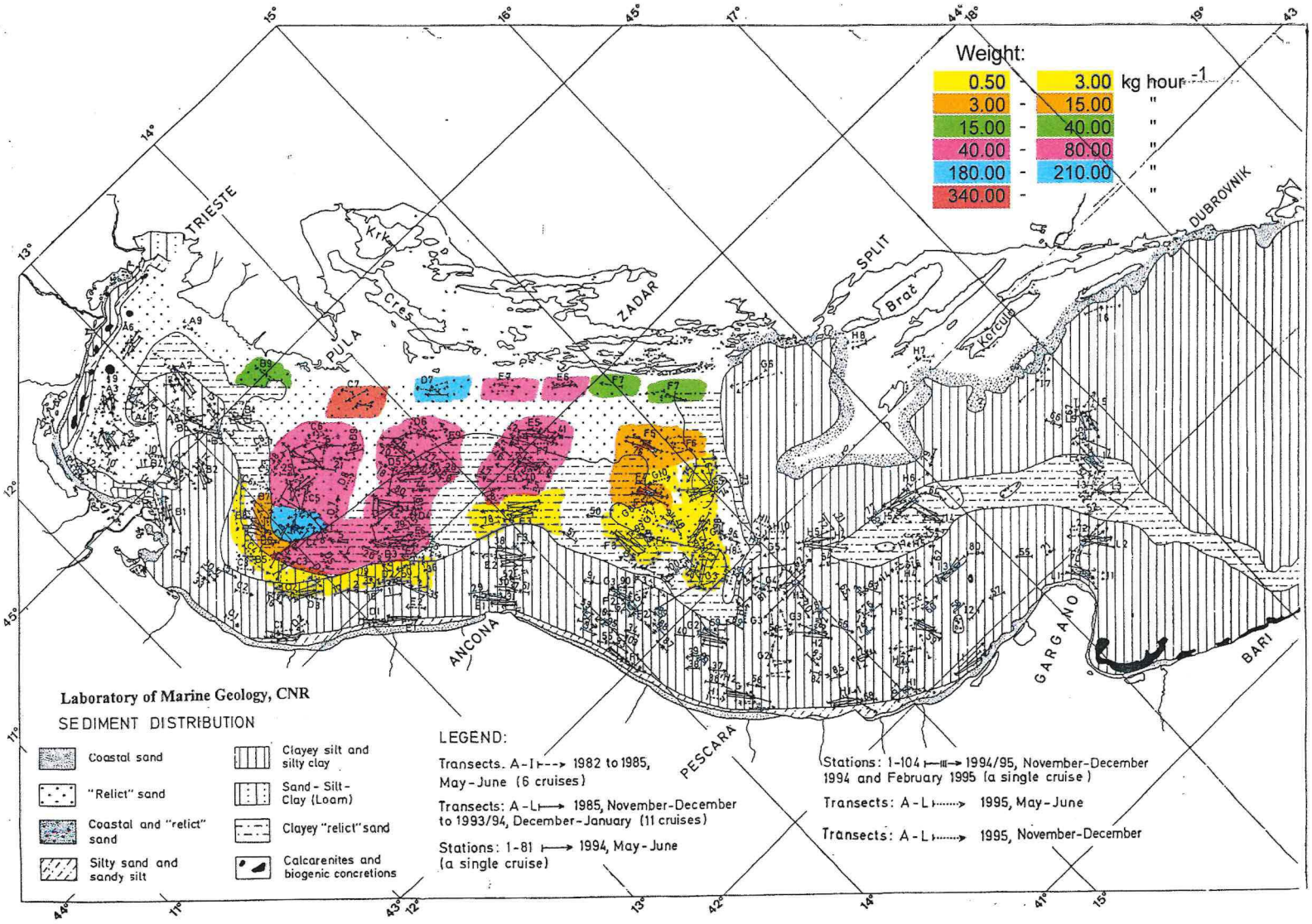

Fig. 2. Stations of PIPETA Expedition 1982 – 1995, plotted on the map of sediment distribution: average weight per a haul hour of the species Holothuria forskali *(kg h^{-1}) the map is after Laboratory of Marine Geology, CNR, Bologna)*

RESULTS AND DISCUSSION

The species *Holothuria tubulosa*

The total mass of the species *H. tubulosa* caught during our study amounted to 1834.37 kg. The largest quantity of this species was caught from the "relict" sand, 91.74 kg km^{-2}. The caught quantity of this species was considerably smaller on all other sediment types.

The total number of caught individuals was 9959 pieces with the highest presence on the "relict" sand, 492.72 km^{-2}, what was expected with respect to the mass proportion of the species (Table 1, Fig. 3).

Table 1. Total collected mass (kg) and average collected mass per km² (kg km^{-2}); total number of collected specimens and average number of collected specimens per km² (km^{-2}) of the species Holothuria tubulosa *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	TOTAL WEIGHT (kg)	AVERAGE WEIGHT (kg km^{-2})	TOTAL N^{O} OF SPECIMENS	AVERAGE N^{O} OF SPECIMENS (km^{-2})
"RELICT" SAND	1584.19	91.74	8508	492.72
CLAYEY "RELICT" SAND	243.94	13.69	1392	78.14
SAND-SILT-CLAY (LOAM)	5.34	0.95	51	9.08
CLAYEY SILT AND SILTY CLAY	0.90	0.04	8	0.33

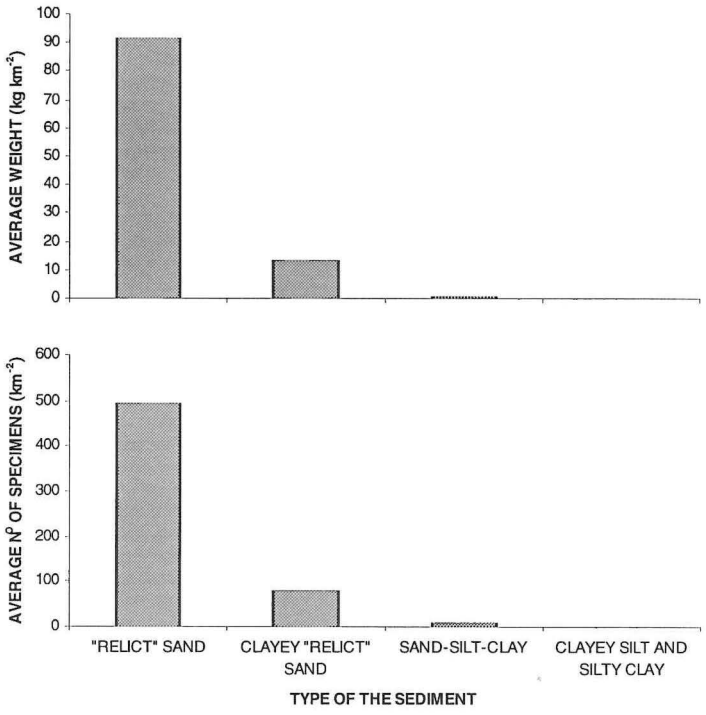

Fig. 3. Mass proportion and numerical proportion of collected specimens of the species Holothuria tubulosa *in relation to sediment type in the study area*

The data on the mass proportion (kg km^{-2}) of the species *H. tubulosa* by different depths, show it to be most abundant between 25 and 50 m depths. Half that value the species showes between 50 and 100 m depth, whereas its presence was almost negligible at greater depths. Between 10 (the least depth trawled) and 25 m the average collected mass was 11.40 kg km^{-2}.

Similar proportion was obtained for the number of individuals by different depths (Table 2, Fig. 4).

The estimated abundance of the species at individual sediment types was calculated by the "swept area" method. Results show that the species abundance was highest in the area of "relict" sand with 1163.81 tons. Compared to the abundance of the species *H. tubulosa* on

Table 2. Total collected mass (kg) and the average collected mass per km^2 (kg km^{-2}); total number of collected specimens and average number of collected specimens per km^2 (km^{-2}) of the species Holothuria tubulosa *in relation to depth in the study area*

DEPTH (m)	0 - 25	25 - 50	50 - 100	100 - 150
TOTAL WEIGHT (kg)	97.56	1094.74	564.91	0.43
AVERAGE WEIGHT (kg km^{-2})	11.40	44.54	22.98	0.08
TOTAL Nº	491	6135	2939	3
AVERAGE Nº OF SPECIMENS (km^{-2})	57.39	249.61	119.54	0.53

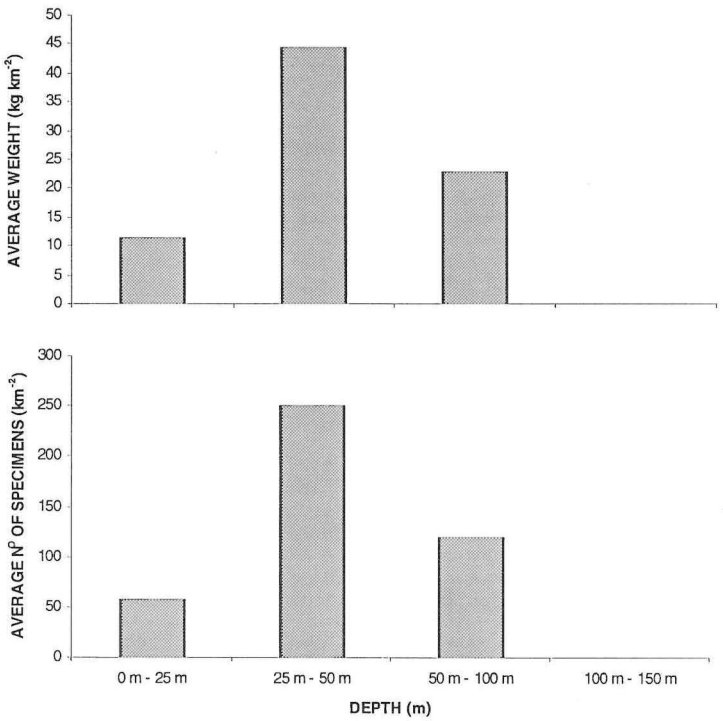

Fig. 4. Mass proportion and numerical proportion of collected specimens of the species Holothuria tubulosa *in relation to depth in the study area*

"relict" sand, species abundance on the clayey "relict" sand sediment was considerably less abundant whereas it was almost negligible on loamy and clayey silt and on silty clayey sediments (Table 3, Fig. 5). Standard deviation points to an uneven distribution of the species on individual sediment types in the study area (Table 3).

The data on the weight of individual specimens on different sediments show that heaviest specimens could be found in the areas of "relict" sand, 206.44 g (Table 4, Fig. 6).

Table 3. Estimated abundance (t) and standard deviation of the species Holothuria tubulosa *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	ESTIMATED ABUNDANCE (t)	STANDARD DEVIATION
"RELICT" SAND	1163.81	2024.72
CLAYEY "RELICT" SAND	151.28	533.22
SAND-SILT-CLAY (LOAM)	2.06	10.27
CLAYEY SILT AND SILTY CLAY	0.52	5.14

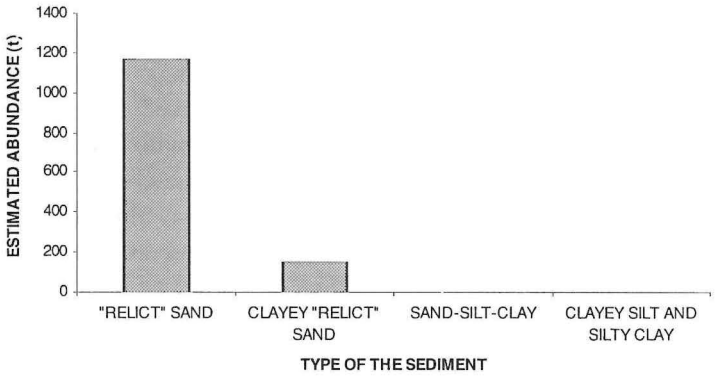

Fig. 5. Estimated abundance of the species Holothuria tubulosa *in relation to sediment type in the study area*

Table 4. Average weight (g) and standard deviation of specimens of the species Holothuria tubulosa *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	AVERAGE WEIGHT (g)	STANDARD DEVIATION
"RELICT" SAND	206.44	64.17
CLAYEY "RELICT" SAND	164.63	50.94
SAND-SILT-CLAY (LOAM)	106.00	55.04
CLAYEY SILT AND SILTY CLAY	112.48	38.63

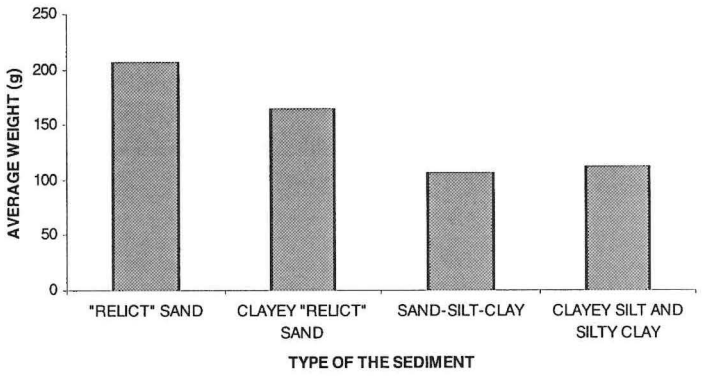

Fig. 6. Average weight of specimens of the species Holothuria tubulosa *in relation to sediment type in the study area*

The species *Holothuria forskali*

The total mass of the species *H. forskali* caught during our study amounted to 15 131.09 kg. Like in the species *H. tubulosa* the largest quantity was caught from the "relict" sand, 560.27 kg km^{-2}. On the clayey "relict" sand the caught quantity of this species was 305.13 kg km^{-2}, whereas it was almost negligible on the sand-silt-clayey (loamy) and clayey silt and silty clayey sediment.

The total number of caught individuals was 325 955 pieces with the highest presence on the "relict" sand (Table 5, Fig. 7).

The data on the distribution of the species *H. forskali* at different depths, show it to be most present between 50 and 100 m depths with 361.98 kg km^{-2}.

The greatest number of specimens of the species *H. forskali* was caught at the depth between 50 and 100 m (Table 6, Fig. 8).

The estimate of abundance of the species *H. forskali* showed it to be most abundant on "relict" sand with 7107.46 tons. It was very well represented on clayey "relict" sand whereas its abundance was almost negligible on loamy and clayey silt and silty clayey sediments (Table 7, Fig. 9). Standard deviation points to an uneven

Table 5. Total collected mass (kg) and average collected mass per km^2 (kg km^{-2}); total number of collected specimens and average number of collected specimens per km^2 (km^{-2}) of the species Holothuria forskali *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	TOTAL WEIGHT (kg)	AVERAGE WEIGHT (kg km^{-2})	TOTAL N^O OF SPECIMENS	AVERAGE N^O OF SPECIMENS (km^{-2})
"RELICT" SAND	9674.80	560.27	224493	13000.50
CLAYEY "RELICT" SAND	5435.21	305.13	100952	5667.45
SAND-SILT-CLAY (LOAM)	4.85	0.87	114	20.32
CLAYEY SILT AND SILTY CLAY	16.23	0.67	396	16.45

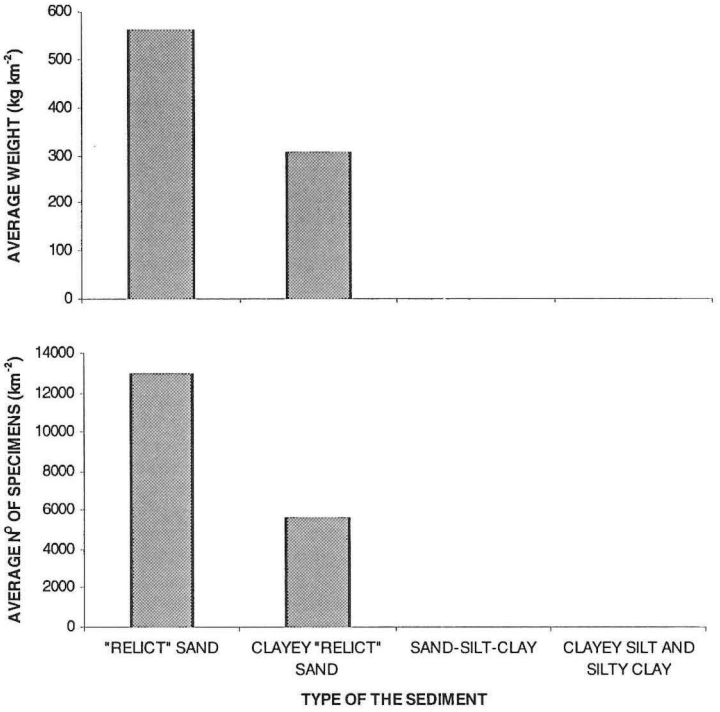

Fig. 7. Mass proportion and numerical proportion of collected specimens of the species Holothuria forskali *in relation to sediment type in the study area*

Table 6. Total collected mass (kg) and the average collected mass per km² (kg km⁻²); total number of collected specimens and average number of collected specimens per km² (km⁻²) of the species Holothuria forskali *in relation to depth in the study area*

DEPTH (m)	0 - 25	25 - 50	50 - 100	100 - 150
TOTAL WEIGHT (kg)	0	5781.10	8897.27	104.40
AVERAGE WEIGHT (kg km^{-2})	0	235.20	361.98	18.39
TOTAL N°	0	138199	180274	939
AVERAGE N° OF SPECIMENS (km^{-2})	0	5622.49	7334.24	165.42

distribution of the species *H. forskali* on individual sediment types in the study area like it does for the species *H. tubulosa* (Table 7).

The data on the weight of individual specimens on different sediments show that heaviest specimens could be found in the areas of "relict" sand. The average weight was 80.24 g (Table 8, Fig. 10).

Comparing the abundance of the species *H. tubulosa* to that of *H. forskali*, using t-test, it may be said that the abundance of *H. forskali* considerably exceeded that of *H. tubulosa* on

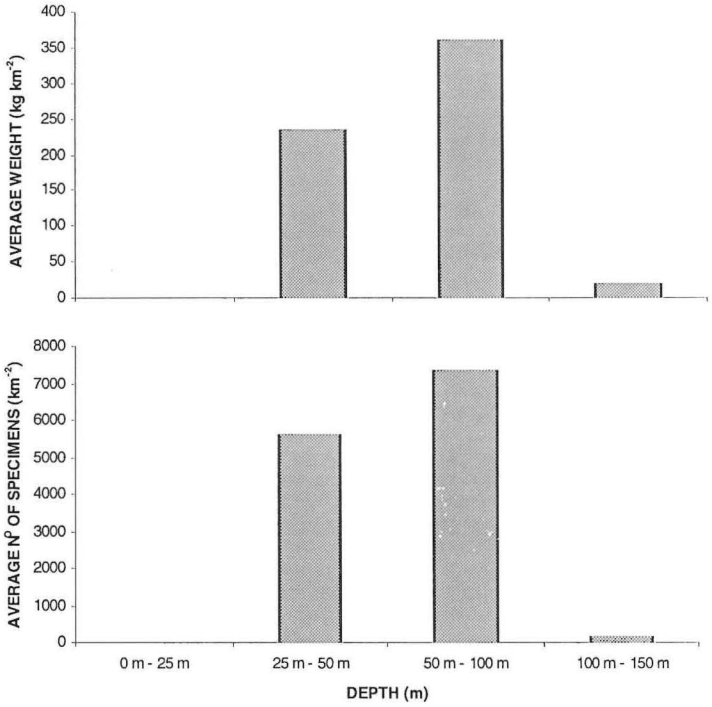

Fig. 8. Mass proportion and numerical proportion of collected specimens of the species Holothuria forskali *in relation to depth in the study area*

Table 7. Estimated abundance (t) and standard deviation of the species Holothuria forskali *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	ESTIMATED ABUNDANCE (t)	STANDARD DEVIATION
"RELICT" SAND	7107.46	12643.00
CLAYEY "RELICT" SAND	3370.72	7256.33
SAND-SILT-CLAY (LOAM)	1.87	7.00
CLAYEY SILT AND SILTY CLAY	9.37	66.32

"relict" sand, clayey "relict" sand and clayey silt and silty clay (Table 9, Fig. 11).

ŠIMUNOVIĆ and GRUBELIĆ (1998) reported that the species *H. tubulosa, H. polii* and *H. forskali* inhabit the 0 to 10 m depths in the coastal area. The species *H. tubulosa* is dominant (79%) in this littoral part. They also brought out that percentage presence of mentioned species considerably changes with the depth increase.

The studies carried out on the Adriatic continental shelf in the 1982-1995 period also show that the percentage ratio of the species *H. tubulosa* and *H. forskali* changes considerably in favor of the species *H. forskali* with the depth increase. Generally speaking the weight ratio is

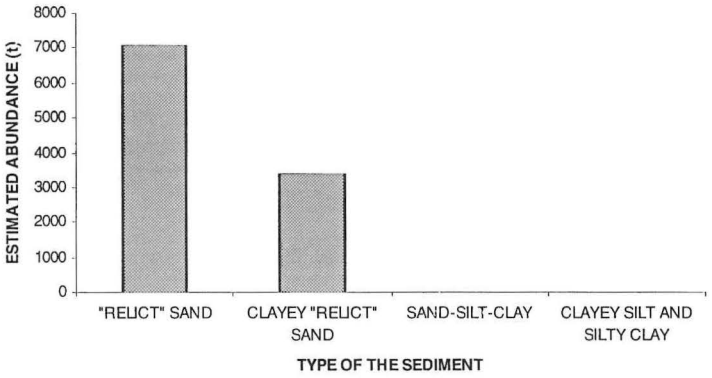

Fig. 9. Estimated abundance of the species Holothuria forskali *in relation to sediment type in the study area*

Table 8. Average weight (g) and standard deviation of specimens of the species Holothuria forskali *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	AVERAGE WEIGHT (g)	STANDARD DEVIATION
"RELICT" SAND	80.24	52.78
CLAYEY "RELICT" SAND	71.32	53.25
SAND-SILT-CLAY (LOAM)	49.77	36.71
CLAYEY SILT AND SILTY CLAY	43.86	13.99

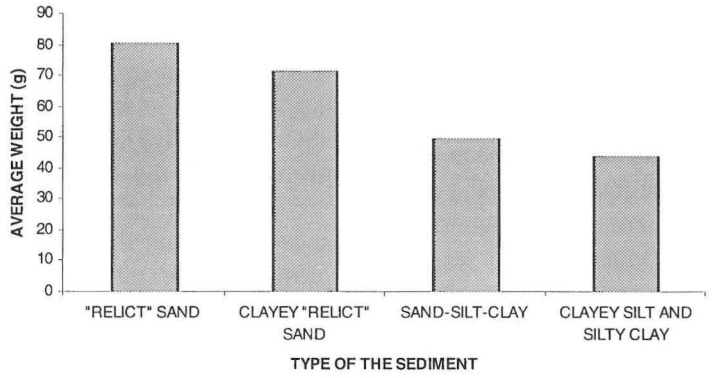

Fig. 10. Average weight of specimens of the species Holothuria forskali *in relation to sediment type in the study area*

Table 9. Estimated abundance comparison and t-values of the species Holothuria tubulosa *and* Holothuria forskali *in relation to sediment type in the study area*

TYPE OF THE SEDIMENT	ESTIMATED ABUNDANCE (t) *Holothuria forskali*	ESTIMATED ABUNDANCE (t) *Holothuria tubulosa*	t
"RELICT" SAND	7107.46	1163.81	6.92
CLAYEY "RELICT" SAND	3370.72	151.28	6.70
SAND-SILT-CLAY (LOAM)	1.87	2.06	0.13
CLAYEY SILT AND SILTY CLAY	9.37	0.52	2.34

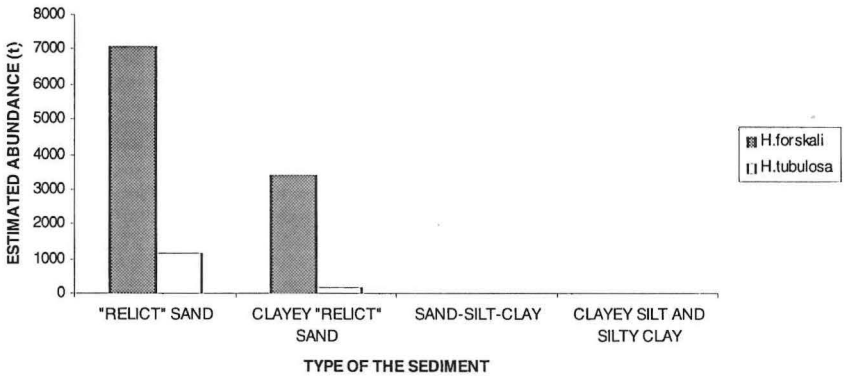

Fig. 11. Estimated abundance comparison of the species Holothuria tubulosa *and* Holothuria forskali *in relation to sediment type in the study area*

1:8 in favor of the species *H. forskali* and the ratio of the number of individuals is 1:32 in favor of the same species.

Obtained results are indicative of the fact that there are some differences in the horizontal and vertical distribution between the species *H. tubulosa* and *H. forskali* (Figs. 1 and 2). The greatest depth wherefrom the specimens of the species *H. tubulosa* were recorded was in a haul ranged from 115.5 to 130 m, and that wherefrom the species *H. forskali* was recorded was in a haul ranged from 132 to 166.5 m. None of these two species was recorded deeper than that even though the research of PIPETA expedition included the depths down to 430 m.

It was also established that they are rather unevenly distributed so that the abundance is different in different areas (Figs. 1 and 2).

CONCLUSIONS

The results obtained regarding *Holothuria tubulosa* and *Holothuria forskali* in the research area of continental shelf of the Adriatic show that these species are present on "relict" sand, clayey "relict" sand, sand-silt-clay, and clayey silt and silty clay sediments. The highest level of presence of the species was established on "relict" sand. Estimated abundance of the species indicate that *H. forskali* is much more present than *H. tubulosa* in the research area.

The species *H. tubulosa* show to be the most abundant between 25 and 50 m depth; the deepest point at which has been registered is in a haul ranged from 115.5 to 130 m. Furthermore, *H. forskali* was most present between 50 and 100 m depth; the deepest point at which has been registered is in a haul ranged from 132 to 166.5 m.

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Distribucija i abundancija vrsta *Holothuria tubulosa* GMELIN, 1788 i *Holothuria forskali* DELLE CHIAJE, 1823 (Holothuria, Echinodermata) u Jadranu

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SAŽETAK

U radu se iznose podaci o kvalitativnom i kvantitativnom rasprostranjenju vrsta *Holothuria tubulosa* i *Holothuria forskali,* u odnosu na tip dna i dubinu, na kontinentalnom šelfu Jadrana koji je obuhvaćen istraživanjem ekspedicije PIPETA.

Biološki materijal sakupljen je tijekom 1982. – 1995. godine dubinskom povlačnom mrežom (koćom) s talijanskim komercijalnim brodom PIPETA.

U procjeni abundantnosti vrsta *H. tubulosa* i *H. forskali* korištena je standardna "swept area" metoda.

Ukupna masa i broj primjeraka navedenih vrsta dobiveni su obradom materijala koji je sakupljen tijekom 833 potega (21 putovanje) povlačnom mrežom na površini od 39 808,2 km² u Jadranu.

Dobiveni rezultati pokazuju da postoje razlike u horizontalnoj i vertikalnoj rasprostranjenosti vrsta *H. tubulosa* i *H. forskali* i da abundancija vrste ovisi o tipu sedimenta i dubini.