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Characterization and cartography of some Mediterranean soft-bottom benthic communities (Ligurian Sea, Italy)*

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SUMMARY: Soft-bottom benthic communities were studied along the Western coast of the Ligurian Sea with a new approach using both videocamera surveys and collected samples. The preliminary distribution of soft-bottoms and the definition of the limits and status of seagrass beds were carried out in September 1991, using an underwater vehicle provided with a videocamera and towed by a boat. Moreover, 90 benthic samples were collected at 5-40 m depth in order to characterize the macrobenthic soft-bottom communities. Six soft-bottom benthic assemblages and two sea grass biotopes (*Cymodocea nodosa* and *Posidonia oceanica*) were revealed by means of underwater images and multivariate analysis (TWINSPAN) on samples collected. The communities inhabiting the infralittoral sandy and coarse sediments corresponded to those previously described in the Mediterranean Sea, whereas a large complex transition between sandy and muddy communities was recognized on circalittoral soft-bottoms. Information obtained with this approach was used to draw a map of the investigated areas at 1:10,000 scale. The employment of the two techniques was cost effective for both time and research effort.

Key words: macrobenthic communities, soft-bottom, *Posidonia* beds, underwater videocamera, TWINSPAN, cartography, Mediterranean Sea.

RESUMEN: CARACTERIZACIÓN Y CARTOGRAFÍA DE ALGUNAS COMUNIDADES BENTÓNICAS DE FONDOS BLANDOS (MAR DE LIGURIA, ITALIA). – Las comunidades bentónicas de fondos blandos se estudiaron a lo largo de la costa oeste del Mar de Liguria con una nueva aproximación, utilizando videocámaras y tomando muestras. La distribución de los fondos blandos así como la definición de los límites y estados de las praderas se realizaron en Septiembre de 1991, utilizando un vehículo submarino provisto de una videocámara y remolcado con un bote. Aproximadamente unas 90 muestras fueron recolectadas entre 5 y 40 m de profundidad para caracterizar las comunidades macrobentónicas de fondos blandos. Las imágenes submarinas y los resultados del análisis multivariante (TWINSPAN) aplicado sobre las muestras recolectadas revelaron seis agregaciones bentónicas de sustrato blando y dos biotopos de pradera (*Cymodocea nodosa* y *Posidonia oceanica*). Las comunidades que habitan el infralitoral arenoso y de sedimento grueso se corresponden con las previamente descritas en el Mediterráneo, no obstante, se reconoce una compleja transición entre las comunidades de arenas y de fangos en los fondos blandos circalitorales. La información obtenida mediante esta aproximación fue utilizada para configurar un mapa de las áreas estudiadas a escala 1:10.000. La utilización de ambas técnicas fue rentable en términos de tiempo y esfuerzo invertidos.

Palabras clave: comunidades macrobentónicas, fondos blandos, praderas de *Posidonia,* videocámara submarina, TWINSPAN, cartografía, Mar Mediterráneo.

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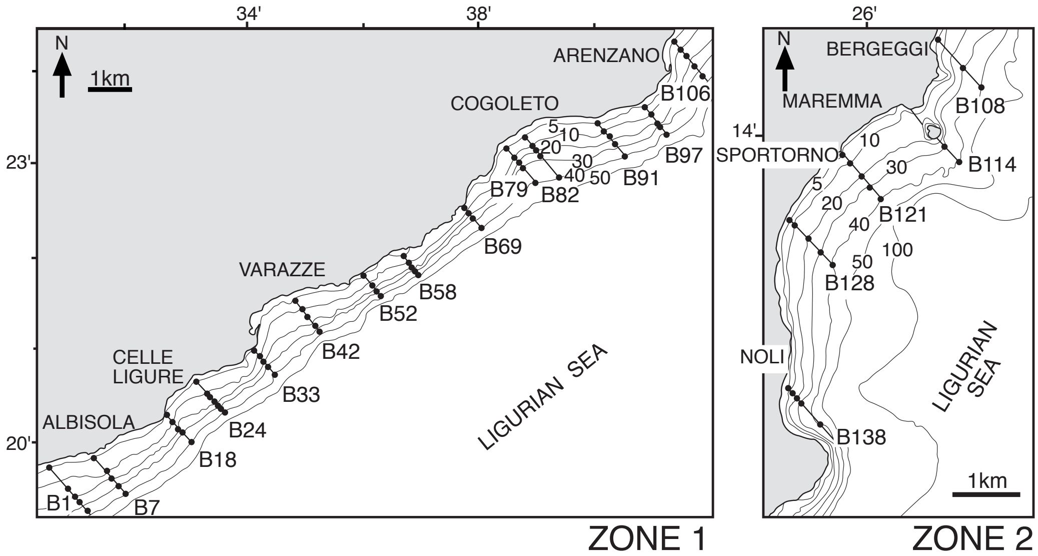

FIG. 1. – Study area. Dots indicate benthic sampling stations. Full squares indicate stations where sediment for grain size analysis was also collected.

INTRODUCTION

During the last few years, cartography of benthic communities has been used succesfully in environmental management, such as planning parks and productive areas, and as a tool for detecting regression phenomena of interesting biotopes such as beds of *Posidonia oceanica* (Ardizzone, 1992; Ardizzone *et al*., 1993).

The charting process previously needs the careful definition of biological units that thereafter should be easily recognised. Afterwards, one of the problems in charting biological data is the definition of major discontinuities in an environmental continuum.

Mediterranean benthic communities were described from a qualitative and quantitative point of view by Peres and Picard (1964) and Picard (1965) respectively. Such assemblages are described by the presence of characteristic species and generally extend over wide areas, even though there is often local overlapping due to the presence of mixed sediments (Bourcier *et al.,* 1979; Guille, 1970; Gambi and Fresi, 1981; Falciai *et al.,* 1983; Fresi *et al.,* 1983; Nodot *et al.,* 1984; Gravina, 1986; Dounas and Koukouras, 1992). These transitional zones where species from both assemblages coexist have been defined as "ecotone", and sometimes an increase in the number of species and individuals has been observed (Bellan Santini, 1985). Moreover, the local abundance of a species in circalittoral biocoenoses has lead to the description of some "degradation facies" resulting from anthropogenic effects (Salen Picard, 1981; 1985). In this view, identification of assemblages as proposed by Pérès and Picard (1964) is very difficult.

Both the "degradation facies" proposed by Salen Picard (1982) and the transition zones characterized by mixed communities have been reported for the Ligurian Sea (Albertelli and Cattaneo, 1985; Albertelli *et al.,* 1985; Albertelli and Rossi, 1986; Gravina, 1986; Morri *et al.,* 1990).

This paper is an attempt to characterize infralittoral and circalittoral soft-bottom communities with a new mixed approach: the "classical" bionomical study with the collection of benthic samples and the information obtained by underwater images recorded by a vehicle towed by a boat.

MATERIALS AND METHODS

Study area

The study areas were two zones with a steep and rocky coastline located in the west Gulf of Genoa from 5 to 40 m depth (Fig. 1). The first zone (ZONE 1), about 15 km in length, is located between Albisola (Savona) and Arenzano (Genoa); the bottom is steep down to 50 m depth, but more gentle down to 100 m depth. The second zone (ZONE 2), about 8km in length, is located further to the west, between Bergeggi (Savona) and Noli Ligure (Savona). There, the continental platform is so narrow that the bottom is very steep and the 100 m bathymetric very close to the coastline.

Underwater images and charting methodology

Bottom investigation was carried out using an underwater towed vehicle provided with a videocamera, and connected by a cable to a boat, where the images of the bottom were observed and recorded. The vehicle was located at a distance of 1-10 m on the bottom with a shot range of 1.5-15 m. Boat, cable and telecamera can be considered as a system unit, so that coordinates of recorded images can be compared to those detected by GPS on the boat if a little delay is considered.

Bottom images were recorded along 106 and 35 transects orthogonal to the coast in the zone 1 and zone 2 respectively. Observations along transects allow the best interpolation of discontinuous images of benthic communities located on a depth gradient. In order to produce a cartography map with a scale of at 1:10,000 transects were arranged at 150-200 m intervals, corresponding to 1/50-1/25 on the cartography scale, as suggested by previous experiences (Ardizzone, 1992).

Images recorded are interpreted before mapping and the information content is related to the restitution scale. For example, several characteristics of the *Posidonia* bed can be reported on maps at 1:500-1:5,000 scales (Meinesz *et al.*, 1983), whereas only two main categories (*Posidonia* bed and *Posidonia* “dead matte”) can be reported at lower resolution, as in the case of the present study. At this scale other seagrasses such as *Cymodocea nodosa,* were easily recognizable and mapped (Ardizzone, 1992). On the contrary, this method is not useful to identify soft-bottom communities which are mainly composed of infauna.

One problem arising in mapping biological data is the definition of spatial boundaries between communities that generally lie along a continuum. At some point, two ecological units can be inserted one in the other: this is the case of the upper limit of *Posidonia* meadows that often is composed of *Posidonia* patches on soft-bottom. In such cases if the restitution scale is 1:10,000, it may be appropiate to report only the biotope with a coverage more than 50%. Somewhere else, seagrass coverage could be continuous but with very low densities as reported in many cases for *Cymodocea nodosa*. In this case the *Cymodocea* meadow should be detected only if there are at least 50 shoots in a square meter. Furthermore, statistical analysis on faunal samples collected on bottoms partially colonized by the seagrass can support visual observations.

Sampling methodology

During the same period, a total of 90 soft-bottom samples were collected along 19 transects between 5-40 m depth for faunal analysis (Fig. 1). At shallow depth (down to 15 m) on compact fine sand, macrobenthos was collected using a 50 litre dredge with a mouth of 0.59 x 0.23 m, as proposed by Picard (1965). To get information on a single sampling point the dredge was externaly covered with a sackcloth to fill it immediately (Picard, 1965). The same instrument was used also on bottoms colonised by *Cymodoca nodosa*. Finest silty sediments located below seagrass beds were collected using the Van Veen grab covering an area of 0.1 m^2 (three replicates equivalent to about 50 litres of volume). Furthermore, in some representative sampling stations the same grab was used to collect sediment for grain size analysis (Fig.1).

Macrobenthic fauna retained by a 0.5 mm mesh was fixed in 10% formol and sorted in the laboratory. Sediments were frozen as suggested by Holme and McIntyre (1984) and grain size analysis was performed by sieving through 2 mm and 0.063 mm meshes to sort gravel, sand and silt-clay fraction respectively (Wentworth, 1922).

Data analysis

Identification to species level was done for the majority of zoobenthic taxa to produce an abundance matrix. In order to get equal information from different systematic groups a selected matrix was prepared after elimination of species with less than 0.5% abundance inside each group, such as: molluscs, polychaetes, sipunculans, crustaceans, echinoderms, and cephalocords. TWINSPAN analysis (Hill, 1979) was performed on this matrix to point out the affinity between sampling stations. Mean and standard deviation of diversity values (H’) (Shannon and Weaver, 1949), evenness (J) (Pielou, 1975) and redundance (R) (Patten, 1962) were then

TABLE 1. – The systematic groups collected during the study.

DEPTH (m)	5-10		11-20		21-30		31-40	
Number of sampling stations	30	%	16	%	19	%	20	%
Molluscs individuals	4020	51.92	1351	30.16	1180	20.99	684	25.24
species	114	33.33	99	29.64	91	28.44	51	24.76
Polychaetes individuals	1828	23.61	2043	45.60	2554	45.44	1819	67.12
species	115	33.63	139	41.62	139	43.44	106	51.46
Amphipods individuals	512	6.61	239	5.33	307	5.46	33	1.22
species	40	11.70	31	9.28	36	11.25	12	5.83
Decapods individuals	872	11.26	241	5.38	197	3.50	62	2.29
species	47	13.74	40	11.98	31	9.69	24	11.65
Isopods individuals	30	0.39	9	0.20	1	0.02	1	0.04
species	9	2.63	6	1.80	1	0.31	1	0.49
Tanaids individuals	59	0.76	32	0.71	28	0.50	20	0.74
species	2	0.58	2	0.60	4	1.25	2	0.97
Echinoderms individuals	108	1.39	121	2.70	120	2.13	40	1.48
species	9	2.63	11	3.29	11	3.44	6	2.91
Mysids individuals	9	0.12	7	0.16	73	1.30	2	0.07
species	4	1.17	4	1.20	5	1.56	2	0.97
Leptostracans individuals (n.d.)	0	0.00	4	0.09	2	0.04	0	0.00
species	-	-	-	-	-	-	-	-
Cumaceans individuals (n.d.)	5	0.06	1	0.02	4	0.07	4	0.15
species	-	-	-	-	-	-	-	-
Pycnogonids individuals (n.d.)	1	0.01	0	0.00	3	0.05	0	0.00
species	-	-	-	-	-	-	-	-
Coelenterates individuals (n.d.)	9	0.12	16	0.36	25	0.44	6	0.22
species	-	-	-	-	-	-	-	-
Nemerteans individuals (n.d.)	2	0.03	13	0.29	14	0.25	6	0.22
species	-	-	-	-	-	-	-	-
Turbellarians individuals (n.d.)	7	0.09	0	0.00	12	0.21	1	0.04
species	-	-	-	-	-	-	-	-
Sipunculans individuals	273	3.53	397	8.86	1097	19.52	30	1.11
species	1	0.29	1	0.30	1	0.31	1	0.49
Phoronids individuals (n.d.)	1	0.01	2	0.04	1	0.02	0	0.00
species	-	-	-	-	-	-	-	-
Tunicates individuals (n.d.)	5	0.06	0	0.00	0	0.00	2	0.07
species	-	-	-	-	-	-	-	-
Cephalocords individuals	2	0.03	4	0.09	3	0.05	0	0.00
species	1	0.29	1	0.30	1	0.31	1	0.49
TOTAL INDIVIDUAL	7743	100.00	4480	100.00	5621	100.00	2710	100.00
TOTAL SPECIES	342	100.00	334	100.00	320	100.00	206	100.00

computed for each group of sampling stations resulting from multivariate analysis.

Ecological preferences of the species were detected from the literature (Picard, 1965; 1971; Febvre Chevalier, 1969; Massé, 1970; 1971; Bourcier *et al.*, 1979; Nodot *et al.*, 1984; Zavodnik *et al.*, 1985; Salen Picard, 1985; Dauvin, 1988; Bianchi *et al.*, 1993a; 1993b; 1993c; Somaschini *et al.*, 1994) and ecological affinity of the resulting groups of stations was obtained summing the abundance data of species belonging to the same ecological group.

Finally, results of TWINSPAN were put into a GIS (ARC/INFO) to produce the cartography of the area. Limits of *Posidonia* meadows and soft-bottom were obtained from the discontinuities observed with videocamera using methods suggested in the previous chapter (at least 50% of coverage for *Posidonia* and at least 50 shoot/m2 for *Cymodocea*). With this procedure we obtained a map with polygons pertaining to two main classes; the first grouping all types of seagrass meadows and the second all the other soft-bottom benthic communities. This last set of polygons was subsequently classified according to the TWINSPAN results with the following "maximum likelihood" procedure: a Thiessen polygon (ESRI, 1991) was first generated around each sampling station; each polygon thus contained only one sampling station and was assigned to the class of the sampling station as derived from the TWINSPAN. By intersecting these polygons with those defined by the limits obtained with videocamera, they were then classified according to a "majority rule": if most of a

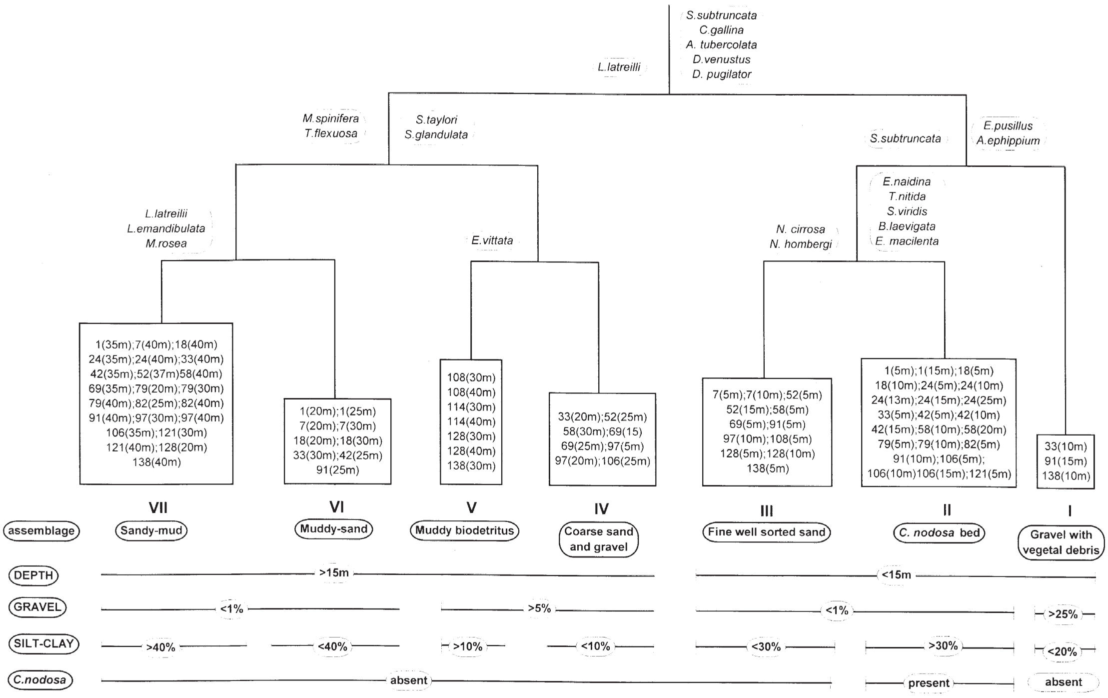

FIG. 2. – Cluster (Q mode) resulting from TWINSPAN. Indicator species identified by the analysis are reported. The most important features of biotopes are indicated below.

"videocamera" polygon fell within a certain class of Thiessen polygon then it would take on that certain class.

RESULTS

Faunal composition

A total of 20,554 individuals belonging to 575 macrozoobenthic species was collected (Tab.1). Molluscs turned out to be the most abundant and diversified taxon at shallow depth (5-10m), whereas polychaetes were more important on deeper bottoms (11-40m depth). Although crustaceans, mainly amphipods and decapods, were less important as far as species and individuals are concerned, they were constantly present along the depth gradient.

Structural analysis

Result of TWINSPAN on a selected set of 85 samples and 188 species revealed the presence of seven groups of sampling stations, primarily ordered according to bathymetry and subsequently to sediment texture (Fig.2, 3). The first distinction was between samples located above and below 15 m depth. At the shallow depth, samples of coarse sediments with vegetal debris (I assemblage) were different from sandy samples (II and III assemblages). Similarly, at greater depths coarse sediment samples (IV and V assemblages) differed from finer ones (VI and VII assemblages). Finally, at the shallow depths the remaining two groups of stations reflected respectively the presence (II assemblage) and the absence (III assemblage) of *Cymodocea* beds. The IV assemblage was composed of coarse sediment samples mostly located

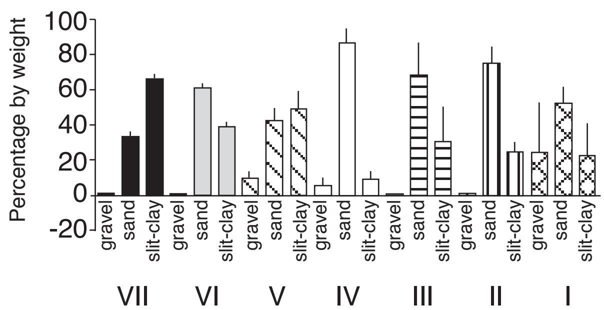

FIG. 3. – Percentage composition by weight and standard deviation (vertical bars) of sediment texture in the seven benthic assemblages.

TABLE 2. – The twenty most important species ranked in order of abundance (nº of individual collected) for the assemblages (I-VII) identified by TWINSPAN (see text). For each species the ecological group is reported: FS: fine sandy bottom; GR: gravellicolous; IN: indicator of instability; MB muddy bottom; MI: mixticolous; PB: *Posidonia* bed; RB: rocky bottom; UK: Unknown; WE wide ecological distribution. Mean values and standard deviation of some structural parameters are given for each assemblages.

	I			II			III			IV	
FS	*Phyllodoce mucosa*	112	FS	*Spisula subtruncata*	1354	FS	*Diogenes pugilator*	343	IN	*Aspidosiphon muelleri*	813
RB	*Spirobranchus polytrema*	106	RB	*Amphiglena mediterranea*	452	WE	*Exogone naidina*	312	UK	*Pseudofabriciola analis*	357
IN	*Aspidosiphon muelleri*	104	FS	*Chamelea gallina*	434	FS	*Spisula subtruncata*	193	GR	*Parapionosyllis labronica*	351
PB	*Atylus guttatus*	76	IN	*Tellina nitida*	316	IN	*Aspidosiphon muelleri*	162	WE	*Exogone maidina*	188
RB	*Gammarella fucicola*	34	IN	*Corbula gibba*	219	FS	*Chamelea gallina*	149	GR	*Sphaerosyllis taylori*	144
PB	*Bittium reticulatum*	30	WE	*Ericthonius punctatus*	204	UK	*Cyclope neritea*	145	GR	*Calyptraea chinensis*	100
RB	*Platynereis dumerilii*	30	RB	*Rissoa monodonta*	182	IN	*Chone filicaudata*	94	GR	*Plagiocardium papillosum*	98
UK	*Jujubinus striatus*	30	FS	*Donax venustus*	153	FS	*Chone collaris*	89	GR	*Sphaerosyllis glandulata*	73
GR	*Calyptraea chinensis*	29	FS	*Diogenes pugilator*	141	UK	*Pseudofariciola analis*	74	RB	*Pomatoceros triqueter*	63
PB	*Smaragdia viridis*	27	RB	*Rissoa paradoxa*	138	GR	*Diplodonta apicalis*	73	GR	*Ophiura albida*	62
GR	*Athanas nitescens*	23	RB	*Platynereis dumerilii*	136	FS	*Donax semistriatus*	67	GR	*Pisione remota*	52
GR	*Sphaerechinus granularis*	23	FS	*Acanthocardia tuberculata*	126	FS	*Donax venustus*	56	GR	*Protodorvillea kefersteini*	51
PB	*Thoranus cranchii*	22	PB	*Hyppolyte inermis*	110	FS	*Bathyporeia guilliamsoniana*	33	RB	*Aora spinocordis*	45
UK	*Cyclope neritea*	21	UK	*Bela laevigata*	110	IN	*Capitella capitata*	30	IN	*Corbula gibba*	43
RB	*Promatocerus trinquete*	19	IN	*Capitella capitata*	85	IN	*Corbula gibba*	29	UK	*Euspira nitida*	41
PB	*Hippolite inermis*	13	GR	*Calyptraea chinensis*	72	GR	*Anapagurus laevis*	27	GR	*Kefersteinia cirrata*	39
PB	*Rissoa violacea*	12	FS	*Nassarius pygmaeus*	64	UK	*Bela ginnania*	25	GR	*Tellina donacina*	36
UK	*Bela laevigata*	10	GR	*Ophiura albida*	58	FS	*Acanthocardia tuberculata*	24	MI	*Lumbrinereis gracilis*	36
FS	*Philocheras bispinosus*	8	RB	*Tritaeta gibbosa*	58	GR	*Pontocrates arenarius*	23	UK	*Divaricella angulifera*	33
GR	*Maera grossimana*	7	UK	*Tricolia speciosa*	56	RB	*Leptochelia savignyi*	22	UK	*Syllidia armata*	32
H'	Diversity	3.39±0.54			3.07±0.62			2.9±0.83			3.28±0.72
J	Evenness	0.66±0.09			0.7±0.13			0.7±0.13			0.73±0.14
R	Redundance	0.45±0.16			0.39±0.12			0.41±0.12			0.37±0.12
N	Species Number	66.00±13.00			35.65±14.19			34.00±20.93			62.50±29.80

	V			IV			VII	
IN	*Aspidosiphon muelleri*	390	WE	*Exogone naidina*	413	IN	*Thyasira flexuosa*	453
GR	*Sphaerosyllis taylori*	75	WE	*Micronephtys sphaerocirrata*	57	WE	*Exogone naidina*	422
GR	*Microdeutopus versiculatus*	70	MB	*Turritella communis*	51	IN	*Lumbrinereis latreilli*	419
GR	*Calyptraea chinensis*	59	IN	*Aspidosiphon muelleri*	33	RB	*Amphiglena mediterranea*	363
GR	*Anapagurus laevis*	55	MB	*Scolaricia typica*	30	IN	*Aspidosiphon muelleri*	295
UK	*Leptomysis cfr. lingvura*	47	WE	*Siphonoecetes dellavallei*	29	RB	*Pseudofabriciola analis*	178
GR	*Ophiura albida*	43	GR	*Anapagurus laevis*	24	IN	*Corbula gibba*	112
WE	*Exogone naidina*	36	IN	*Corbula gibba*	21	FS	*Nephtys cirrosa*	98
WE	*Siphonoecetes dellavallei*	35	MI	*Levinsenia gracilis*	13	MI	*Levinsenia gracilis*	96
GR	*Plagiocardium papillosum*	35	GR	*Hippomedon massiliensis*	13	IN	*Lumbrinereis emandibulata mab.*	82
IN	*Lumbrinereis latreilli*	33	MI	*Apseudes acutifrons*	12	WE	*Tharyx marioni*	80
WE	*Lumbrinereis gracilis*	24	WE	*Spio decoratus*	11	UK	*Magelona cfr. rosea*	76
IN	*Corbula gibba*	22	MI	*Timoclea ovata*	11	RB	*Platynereis dumerilii*	69
IN	*Syllis cornuta*	22	GR	*Calyptraea chinensis*	11	IN	*Myrtea spinifera*	67
UK	*Pseudofabriciola analis*	22	MB	*Poecilochaetus serpens*	10	IN	*Paralacydonia paradoxa*	67
IN	*Eunice vittata*	19	MB	*Harpinia antennaria*	9	GR	*Calyptraea chinensis*	66
WE	*Micronephtys sphaerocirrata*	16	MI	*Pagurus prideauxi*	5	IN	*Chaetozone setosa*	62
WE	*Amphipholis squamata*	16	UK	*Liocarcinus maculatus*	5	UK	*Timoclea ovata*	62
UK	*Abludomelita aculeata*	16	MB	*Leiochone clypeata*	5	MB	*Tharyx heterochaeta*	59
WE	*Prionospio cirrifera*	13	FS	*Scoloplos armiger*	5	WE	*Lumbrinereis gracilis*	56
H'	Diversity	4.1±0.51			3.37±0.90			3.68±0.38
J	Evenness	0.85±0.010			0.81±0.2			0.82±0.13
R	Redundance	0.29±0.10			0.44±0.25			0.32±0.13
N	Species Number	50.00±26.83			36.67±14.75			37.08±18.33

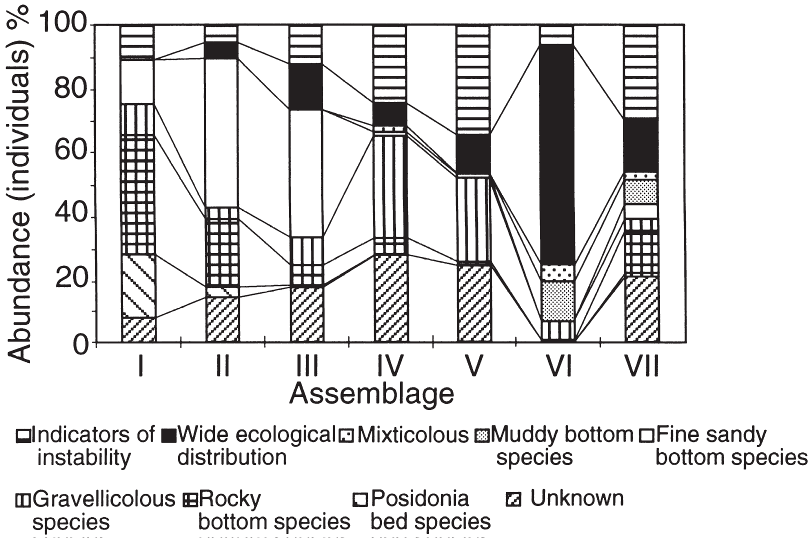

FIG. 4. – Percentage composition (number of individuals) of ecological groups as detected by the autoecology of species collected in the seven assemblages.

between 15 m and 25 m depth, whereas the V assemblage included deeper bottoms (30-40 m depth) with a higher fine fraction. Finally, the last two assemblages represented the deep samples, at 20-40 m depth (VI and VII assemblages) which differed in the silt-clay fraction.

Concerning the faunal composition of the seven assemblages, the first twenty species ranked in order of abundance and their ecological preferences are reported in Table 2 together with the mean values of some structural parameters for each assemblage. Although in assemblage I (gravel with vegetal debris) sandy-bottom and gravellicolous species were present, the most important ecological groups were rocky bottom and *Posidonia* species (Fig. 4). The diversity was high due to the presence of many rare species. Assemblage II (*C. nodosa* bed) was dominated by sandy bottom species which largely coexist with rocky bottom ones due to the presence of *C. nodosa*. The diversity was higher than for unvegetated sandy bottoms. Assemblage III (fine well sorted sand) fine sandy-bottom species were largely dominant and the lowest values of both biodiversity and species richness were encountered. In the Assemblage IV (coarse sand and gravel), gravellicolous species and those indicating instability were dominant. The fauna was very rich in species. Similarly, in Assemblage V (muddy biodetritic bottoms) species indicating instability and those having wide ecological distribution were found to be the most abundant and the diversity value was the highest. Assemblages VI and VII corresponded to heterogeneous mixed sediments and were respectively characterized by widely distributed species (circalittoral muddy-sand bottoms) and species indicating instability (circalittoral sandy-mud bottoms). The diversity values were intermediate between sandy (II and III) and detritic bottoms (IV and V).

CARTOGRAPHY

Maps resulting from image data and sampling analysis are shown in Fig.5. In ZONE 1, *Cymodocea* beds (Assemblage II) were extensively widespread from 5 m to about 20 m depth, where they sometimes bordered upon *P. oceanica* beds. *Posidonia* beds extended from 5 m to 25 m depth and were bordered by dead matte (an aggregation of roots and rhizomes persisting after the death of the leaves) on their lower limit. Infralittoral soft-bottoms not colonized by seagrass consisted of fine well sorted sand with *Diogenes pugilator* and *S. subtruncata* (Assemblage III), and coarse sand and gravel with *S. taylori* and *S. glandulata* (Assemblages IV) in the erosion channels inside the *P. oceanica* beds. In some restricted areas, an abundant local deposit of vegetal debris on coarse sediments was inhabited by a community characterized by *E. pusillus* and *A. ephippium,* with *P. mucosa* and *S. polytrema* as the dominant species (I assemblage). Below the seagrass beds, mixed

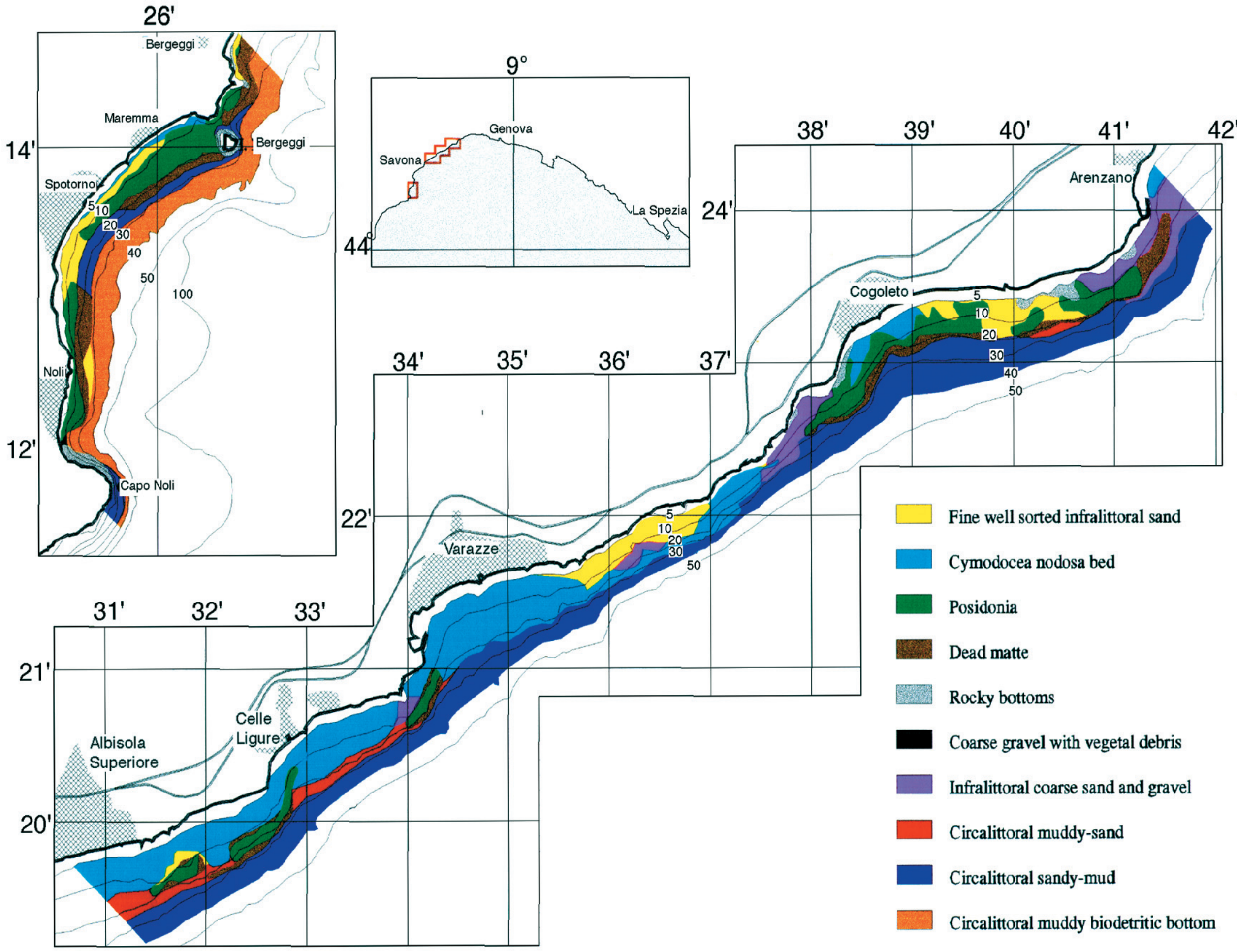

FIG. 5. – Cartography of benthic assemblages identified during the study.

sediments with sand and silt-clay extended from 25 m down to 30 m depth and were dominated by *E. naidina* and *T. communis* (Assemblage VI). At greater depth the community was dominated by *T. flexuosa* and *L. latreilli* (Assemblage VII). In the area off Cogoleto these muddy bottoms extended upward to 20 m depth, bordering upon the dead *Posidonia matte*. In the ZONE 2, the *Posidonia* beds were far more widespread than *Cymodocea* ones. The community with *T. flexuosa* and *L. latreilli* (VII assemblage) lay immediately below the dead *Posidonia* matte and the muddy-sand bottoms with *E. naidina* and *T. communis* (Assemblage VI) were replaced by the muddy-biodetritic community with *E. vittata, S. taylori* and *M. versiculatus* (Assemblage V).

DISCUSSION AND CONCLUSIONS

The employment of two techniques such as the classical bionomical approach and the analysis of underwater images allowed us to draw the maps of two areas of the Western Ligurian Sea up to 40 m depth.

Classical sampling strategy such as the collection of samples by means of dredges and grabs on soft-bottoms and of scuba divers on hard bottoms are always valid systems to get information for drawing bionomical maps at a scales up to 1:500. For scales between 1:500 and 1:50,000, a mixed approach, based on information obtained both by benthic sampling methods and underwater video images, revealed itself to be mostly effective in terms of both time and expense (Ardizzone, 1992). In fact, on soft-bottoms the video images can supply some information (ripple-marks, organic debries, large benthic invertebrates), but they are inadequate to characterize the benthic communities. In such case, the analysis of benthic samples remain the most exhaustive supply, but a preliminary investigation of soft-bottoms with an underwater vehicle and video-camera is useful to settle the sampling design.

In the present study, information on the *Posidonia* beds (extension, dead matte) obtained by video images was reported on a 1:10,000 map together with results of statistical analysis on samples collected. With this last procedure shallow infralittoral bottoms were found to be inhabited by fine well sorted sand community (III) which borders upon *Posidonia* and *Cymodocea* beds (II). Intermatte channels inside the *Posidonia* meadows were characterized by the community of coarse sand and gravel (IV), even if the community structure changes when a significant deposit of vegetal debris occurs (I). Circalittoral bottoms were inhabited by three main communities corresponding to muddy-biodetritic sediments (V), muddy-sand (VI), and sandy-mud (VII).

In general, some considerations about the definition and classification of infralittoral and circalittoral soft-bottom communities arise from this study. On infralittoral bottoms, a fine well-sorted sand community largely corresponds to that reported by Pérès and Picard (1964) and many authors reporting on the Mediterranean coasts (Picard, 1965; Massé, 1972; Falciai *et al*., 1983). When *C. nodosa* densely colonizes fine sand, the increase of spatial heterogeneity and therefore of microhabitat availability leads to an increase in diversity and abundance causing a differentiation in community structure (True Shlenz, 1965; Giangrande and Gambi, 1986; Lanera and Gambi, 1993). Consequently, in the case studied, *C. nodosa* can be considered a key-stone species of the infralittoral zone (sensu Paine, 1966). A similar consideration has already been reported for *Posidonia oceanica* (Sarda, 1991; Somaschini *et al*., 1994).

Bottoms of coarse sand and gravel, characterized by *Sphaerosyllis taylori, Sphaerosyllis glandulata, Parapionosyllis labronica,* and *Calyptraea chinensis,* are more abundant between 10 m and 20 m depths in the intermatte channels inside *Posidonia* beds. This assemblage is very similar to that of coarse sand and gravel exposed to bottom currents (SGCF) (Pérès and Picard, 1964; Picard, 1965; Dauvin, 1988). The community composition changes if a large amount of vegetal debris is deposited on gravels, with *Phyllodoce mucosa, Echinociamus pusillus, Anomia ephippium, Spirobranchus polytrema* and many amphipods increasing in importance.

A more complex situation was observed in the circalittoral zone, down to the lower limit of the *Posidonia* beds. Pérès and Picard (1964) and Picard (1965) reported the presence of different circalittoral assemblages, such as coastal detritic (DC), muddy detritic bottoms (DE), terrigenous muds (VTC), and shelf-edge detritus (DL) (Peres, 1967). The three different assemblages characterising the upper part of the circalittoral zone of the investigated areas do not overlap with those previously described by Peres and Picard.

A difficulty in defining soft-bottom circalittoral communities has been reported already by other authors: large overlapping of soft-bottom circalittoral communities was observed along the French coast (Bourcier *et al*., 1979; Nodot *et al*., 1984); Salen Picard (1981;1982) described many degradation facies of coastal detritic (DC) and muddy detritic bottoms (DE); and Guille (1970) observed many transition zones among these assemblages so that he recognized only one circalittoral soft-bottom community with many sub-communities or "facies". A large transition zone between sandy and muddy bottoms, mainly characterized by widely distributed species has been observed by Febvre Chevalier, 1969; Gambi and Fresi, 1981; Falciai *et al*., 1983; Fresi *et al*., 1983; Zavodnik *et al*., 1985; Gravina, 1986.

Effects of alteration in benthic communities also became evident through the analysis of the *Posidonia* meadows. In both zones, the inferior limit of the *Posidonia* beds is composed of dead matte. Its presence is evidence of a progressive change in community distribution and can be the result of alterations in the sedimentological equilibrium. A comparison with previously collected data from ZONE 1 shows that only 20 years ago living *Posidonia* was present where the dead "matte" is today (Drago and Albertelli, 1976).

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