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# "Rapido" trawl fishing in the Northern Adriatic: preliminary observations of the effects on macrobenthic communities

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*The "rapido", a kind of beam trawl, is used only in the Adriatic Sea. Preliminary results of a study on the impact of the "rapido" gear on macrobenthic communities in the Adriatic Sea (Chioggia-Venice) are presented. Experimental hauls were carried out at two sites (one prohibited to all trawl-fishing activity and one used for commercial fishing) at a distance of 2-3 nautical miles from the coast. With the aim of simulating the action of commercial fishing, either one or several consecutive passages were carried out. Results indicated that trawling produces a furrow about 7 cm deep in the bottom sediment, which disturbs macrobenthic communities. After experimental hauls, the mean abundance values at all stations showed statistically significant differences with respect to controls; no significant statistical differences were found in the commercial fishing area for biomass. Although fished and control areas did not exhibit significant differences two weeks after the experiments, analysis of the diversity indexes revealed that complete recovery had not occurred, since the control areas always had higher values than the fished areas. This study shows that gear such as the "rapido" has a very severe impact on benthic biocoenoses and that its use should, therefore, be better regulated.*

**Key words:** trawl-fishing, benthic communities, Northern Adriatic.

## INTRODUCTION

The morphological features of the Northern Adriatic basin are such, that it may be compared to an extensive trawlable platform. The flat sea bottom, with large areas completely devoid of any "obstacles", has always favoured the development of trawl-fishing. High inputs of fresh water (representing about one-third of all continental Mediterranean waters) along with their load of nutrients, mainly from the north-western coast, mean that this area is definitely eutrophic and thus capable of sustaining high levels of productivity (BOMBACE, 1990). A fish-rich sea with easy access to resources, inevitably leads to the presence of numerous fishing fleets resulting in heavy fishing - among the highest in Italian waters (ARDIZZONE, 1994). This pressure has gradually increased over the years until signs of overfishing of some species have become more evident.

Chioggia, located at the southern area of Venice Lagoon, is the most important fishing centre of the Northern Adriatic. Information collected from port authorities and fishing cooperatives shows 727 fishing licences for the district, 39% of which authorize trawling, 8% the "rapido" gear, and 17% the mid-water pelagic trawl; the district authorities have also issued 20 licences for beam trawl ("sfogliara"), although they are not regularly used by the local fleet. Vessels using the "rapido" gear total 56.

Many studies, most of which were carried out in the North Sea, have assessed the effects of trawl-fishing on sea bottom morphology and the marine benthos (BINI, 1968; BRIDGER, 1970; REISE, 1982; DE GROOT, 1984; ICES, 1988; REES AND ELEFTHERIOU, 1989; BEON, 1990; HUTCHINGS, 1990; BERGMAN AND HUP, 1992; JONES, 1992; HALL, 1994; KAISER and SPENCER, 1996a), providing evidence of considerable physical disturbance on the seabed, with emphasis on beam-trawling for its effects on both epifaunal and infaunal components (KAISER and SPENCER, 1996a). Furthermore, the patchy distribution of the fishing effort determines that some areas are more disturbed than others. In the area studied for this paper, little is known about either the characterisation of the sea bottom communities or the stress induced by bottom-trawling. In the Chioggia district, the two target species of the "rapido" gear are flatfishes (particularly *Solea* sp.) and Pectinids (mainly *Pecten jacobaeus* and *Aequipecten opercularis*, but *Chlamys* spp. as well). The former are exploited in shallow coastal waters between 3 and 5 nautical miles offshore (the use of the "rapido" is prohibited within the 3-mile limit), while the latter are fished at greater distances from the coast, even approaching Croatian territorial waters. The sole-fishing vessels mantain a constant target over the year, following their prey; those fishing for Pectinids, as their target is concentrated in patchy beds on detritic bottoms, tend to exploit one area until depletion of the resource occurs; they also change equipment (from "rapido" to other trawling gears) according to season.

The initial characterisation of the sea bottom community of the experimental area was performed by VATOVA (1940), VATOVA (1949), followed by ROSSI and OREL (1968), at a time when the fishing effort was not at today's levels. Within the framework of a research project regarding the effects of bottom fishing gears in the Adriatic Sea (Venetian area), some preliminary attempts to assess the short-term effects of the "rapido" trawling gear on macrobenthic communities displaced on the fishing grounds off Chioggia have been carried out. In this paper we will also introduce various elements to compare the percentage of the discard of "rapido" and otter-trawl.

## MATERIALS AND METHODS

### Fishing gear

The "rapido" appeared in the Chioggia fishing district in the early 1960s (PAGOTTO, 1975). The gear has been developed and refined over the years so that today, under normal conditions, four gears may be used simultaneously (Fig. 1). However, there are four boats in the Chioggia district which are able to use up to six gears at one time. The characteristics of the "rapido" are essentially the same throughout the basin (Fig. 2), although an interesting variation is found at Grado, where the fishermen use gear rigged with a chainmat for use on stony ground, as in the North Sea.

### Study area

The effects of the "rapido" on benthic macrofauna were studied in November-December 1994, with samplings taken immediately following experimental hauls and repeated two weeks later. This meant that an area not normally used for any type of trawling had to be identified, so as to verify natural evolutionary trends without further sources of disturbance from the outside. Eventually an area containing long-line mussel farms about 2 miles from the coast was chosen. The area in question, where navigation is prohibited, is about 3 miles north

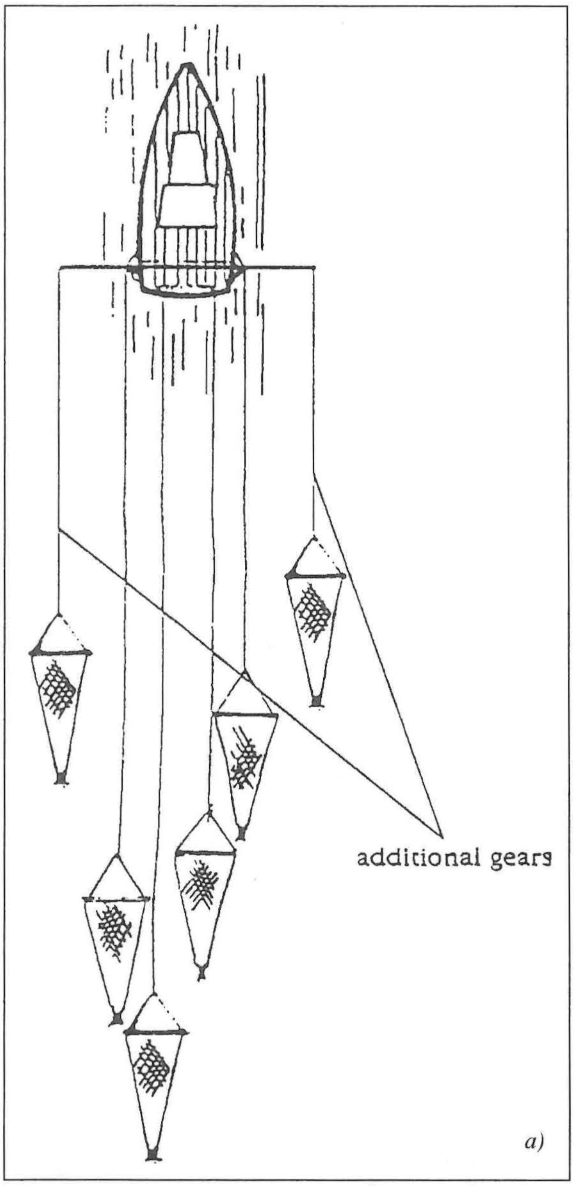




*Fig. 1 a) Vessel fishing with 4 (plus two additional gears) "rapido" (from FRONTINI, 1979; modified); b) Photo of a vessel with the "rapido" gear*

of the mouth of the port of Chioggia. Three experimental stations (1, 2 and 3) were set up inside the perimeter of one of the mussel farms (Fig. 3 and Table 1), at a depth of 14 m.

In order to compare results with an area actually used for trawling, an experimental station (no. 4) was set up at a depth of 17.5 m, approximately 1.5 miles from the mussel farm in a trawlable area.

## Trawling

The first experimental haul was carried out at station 1, using a 35-GT [gross tonnage] 385-HP commercial vessel equipped for the fishing of Pectinids. This haul was interrupted due to technical problems, and this strongly suggested a move to a more suitable experimental site. Nevertheless, we took samples of benthic macrofauna from this treated area. A few days later, experimental catches were carried out in stations 2, 3 and 4, using another commercial vessel (10 GT, 241 HP) equipped for the fishing of sole. Only one gear was used, in order to facilitate positioning operations and above all, to minimise the risk of encountering submerged obstructions.

Single hauls lasting 5 minutes (estimated speed 6 knots) were carried out at stations 2 and 4 and seven overlapping hauls were made in station 3, in order to simulate the considerable disturbance which occurs in the fishing grounds (Fig. 4).

## Sampling of benthic macrofauna

Immediately following the passage of the "rapido", the area was marked with small anchored buoys, enabling the divers to locate the site. After the hauls, samples were taken inside the area covered by the "rapido" (study area) and 5 m outside it (control area). A single control area was considered for stations 2 and 3 due to their proximity to each other (see Fig. 3). It should be pointed out, however, that, within the limitations due to the preliminary nature of this work, we decided not to collect samples before trawling in order to minimise the diving activity. At the end of sampling, submerged markers were positioned at stations 2 and 3 to allow precise identification of the area. All *in situ* operations in stations 2 and 3 were repeated two weeks later.

Five replicates of macrobenthic samplings from the bottom sediment were taken from each station. In order to obtain a precise positioning of the sampler in the trawl track, the samples were collected by a suction device (with a 1-mm mesh nylon bag) operated by divers using a 50x60 cm steel square plugged into the sediment (ca. 12 cm). However, this type of sampling may be biased, due to the many smaller organisms that can be forced through the relatively elastic mesh by the uplift of water.

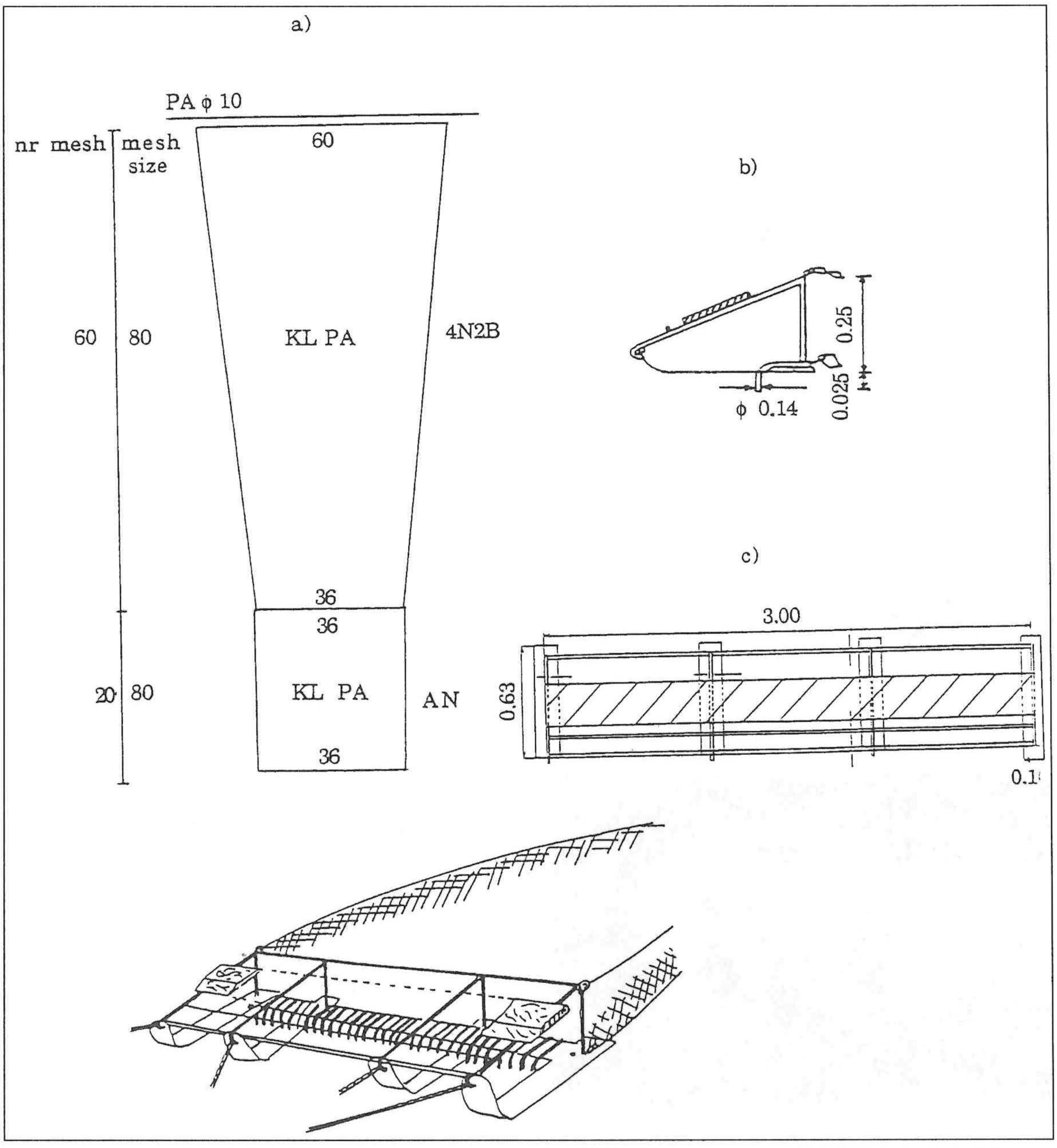



*Fig. 2. Typical "rapido" used in Adriatic: a) net arrangement. Abbreviations are referred to ISO Rules Nos. 1532 and 3169 (UNI M8, 1988); b) lateral view; c) upper view*

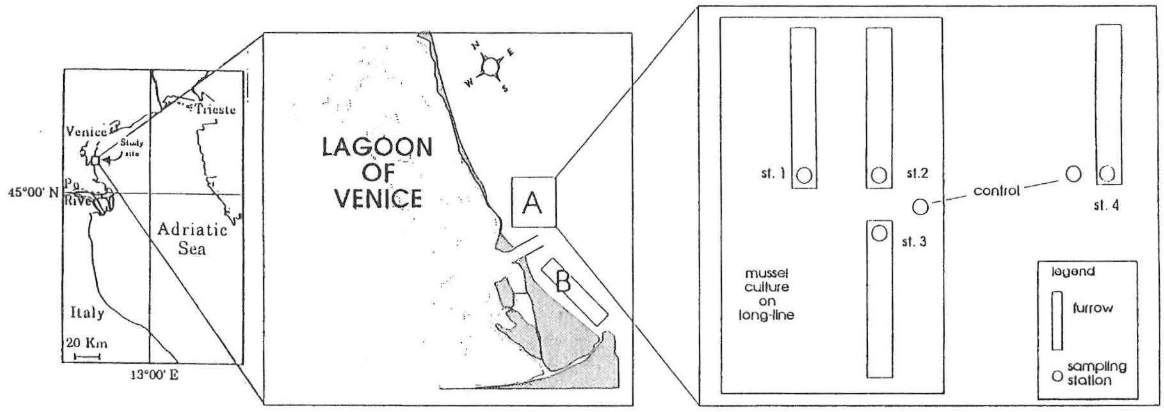



*Fig. 3. Scheme of location of experimental stations (zone A) and area of comparative tests between "rapido" and otter trawl (zone B)*

*Table 1. Experimental plan adopted in each station. For locations refer to Fig. 3; gear/vessel column reports the target of commercial vessel used in the different experimental hauls*

| Station | Position | Trawling impact | Gear/vessel | Sampling details (suction sampler) immediatly after hauls | Sampling details (suction sampler) after 14 days |
|---|---|---|---|---|---|
| 1 | inside mussel culture | 1 haul | Pectinids-fishing rapido | 2 replicates | - |
| 2 | inside mussel culture | 1 haul | Sole -fishing rapido | 5 replicates | 5 replicates |
| 3 | inside mussel culture | 7 hauls | Sole -fishing rapido | 5 replicates | 5 replicates |
| 2-3 control | inside mussel culture | none | Sole -fishing rapido | 5 replicates | 5 replicates |
| 4 | outside mussel culture | 1 haul | Sole -fishing rapido | 5 replicates | - |
| 4 control | outside mussel culture | none | Sole -fishing rapido | 5 replicates | - |

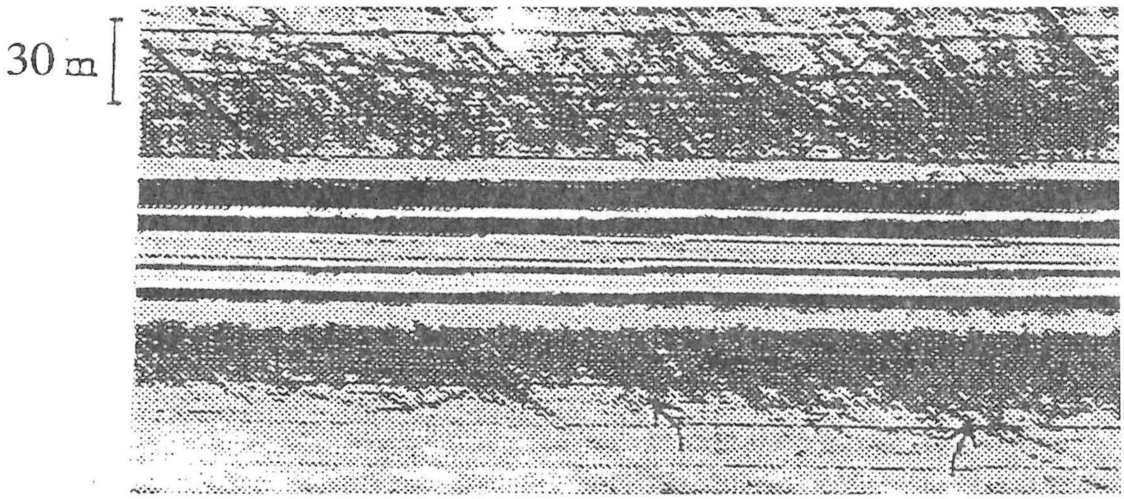



*Fig. 4. Side-Scan Sonar image of a stretch of sea-bottom off Chioggia (from Newton and Stefanon, 1975; modified). Clear traces left by the "rapido" give a significant picture of fishing effort*

All samples were kept in a freezer at a temperature of -15°C. All organisms collected were later separated and identified, according to species or, at least, genus level. Each taxon was then assessed in terms of abundance (number of specimens) and total biomass (wet weight, including the shell). Samples of sediment for grain-size analysis were collected in the control stations, using a manual sampler (diameter 4 cm). Each sample was treated with a $H_2O_2$ + distilled $H_2O$ solution (48 h at room temperature) in order to dissolve the organic fraction. After wet sieving on 63 mμ steel net, two subsamples were dried at 105 °C and subsequently weighed. The sandy fraction was then analysed with a multi-sieve instrument (nine sieves, range 0-4 $\phi$) to determine the weight of each sub-fraction.

### Statistical analyses

The STUDENT's t-test was used for comparisons between mean abundance and biomass values of the various samplings. The indexes of SHANNON and WEAVER (1963) and MARGALEF (1957) were used to calculate diversity measures. Sample variance was calculated using the 'jack-knife' method (SOKAL and ROHLF, 1981). Samplings at times 0 and 1 (two weeks later) inside the same station were compared using SORENSEN's (1948) index and the faunal similarity index (PEARSON and ROSENBERG, 1978). BRAY-CURTIS's (1957) similarity matrix was used to calculate abundance data (according to the $\sqrt{\sqrt{x}}$ transformation), since it is not influenced by contemporary absences. The same matrix was later used to reorder groups by MultiDimensional Scaling (MDS) (CLARKE and GREEN, 1988).

### Comparative hauls

In this paper, we also report the preliminary results of experimental hauls carried out monthly in an area south of the Chioggia port entrance (Fig. 3), one mile off the coast-line, from April to November 1994. The use of the same boat (the sole-fishing vessel of the "trawling" paragraph) equipped respectively with an otter trawl (Italian type), and a "rapido" (sole type), over the course of a few days permitted hourly catches and discard of the two gears to be compared.

## RESULTS

### Granulometry and biocoenoses

Analytical results revealed that the bottom sediment at all four experimental stations was similar, that is sandy pelite, although less sand (7.2% in weight) was found at station 4 than at the remaining stations (20% in weight). Grain size analyses were performed in order to characterize the sediment of the stations. Since previous research on similar gears showed that no evidence of the immediate effects of dredging on grain size could be seen as well as when the long-term effect was detected (ELEFTHERIOU and ROBERTSON, 1992; PRANOVI and GIOVANARDI, 1994; CURZI P., unpublished data), we decided not to collect samples after the passage of the gear.

Tables 2 and 3 (ANNEX) give the complete lists of all taxa found, as well as their abundance and biomass. Biomass data for station 1 were not registered. The sampling area mainly contained populations typical of mobile substrates. It may be described as containing 'coastal detritic biocoenoses' (PÉRÈS and PICARD, 1964), confirming the results of other authors (e.g., GAMULIN-BRIDA, 1974). In particular, the *Ophiura ophiura* facies was identified: it is common mainly near areas with abundant bivalves whose larvae are preyed upon by ophiuroids (GAMULIN-BRIDA, 1974). Some "Mixticoles" species can also be found linked to the nearby areas of transition to other biocoenoses.

Observations indicated that, in stations 1, 2 and 3, no transformations of the benthic population could be ascribed to the presence of the mussel farms - unlike the situation encountered elsewhere (KASPAR *et al.*, 1985; KLINK, 1991; GRENZ *et al.*, 1991; FREIRE *et al.*, 1992). Only once were abundant mussels found on the bottom, mainly along the shore side.

## Depth of penetration into sediment

The depth to which the sole fishing gear penetrated the bottom sediment was measured directly by divers after experimental sweeps. After a single passage, a furrow of 5-7 cm was observed (stations 2 and 4); multiple passages produced furrows 10-13 cm deep (station 3). Checks made two weeks later showed that the furrow in station 2 was completely filled in and could not be distinguished from the surrounding unfished area. In station 3, the depth of the furrow was more than halved (4-5 cm). It should be noted that no weather or sea conditions could have accelerated this process during the two-week period in question. During the experimental haul carried out in station 1 by the commercial vessel fishing for Pectinids, the presence of a series of small parallel tracks was found instead of only one true furrow. This could be related to different speed and/or small structure differences in the used gears.

## Effects on benthic communities

Comparisons between benthos samples from all four stations and their two control areas immediately after the experimental hauls revealed significant differences in both abundance and total biomass values, except for the biomass value of station 4 (Table 4). Two weeks later, however, these differences had disappeared in stations 2 and 3.

Specific richness and the SHANNON-WEAVER and MARGALEF indexes showed similar time trends (Fig. 5). Compared with corresponding control levels, these indexes always decreased immediately after the passage of the "rapido", whereas two weeks later they had almost reached previous levels, but were still slightly lower than control (at the same time). There were some small differences between control stations 2-3 and station 4, probably due to the presence of a greater amount of sandy fraction at the former. The differences between control 2-3 at time 0 and at time 1 may have been due to the disturbance caused by the passage of the trawl, even in nearby areas not directly fished, with a consequent reduction in diversity values (PRANOVI and GIOVANARDI, 1994), or to spatial differences in relocating the sample station. However, this trend is unclear and difficult to explain.

The SORENSEN and "affinity" indexes were calculated in order to analyse the time evolution of the affinity between the study and control areas (Fig. 6). Two weeks after the hauls, the affinity values increased, with the sole exception of the "affinity" index for station 3, in which a decrease was observed.

In order to complete the above analysis and to reorder the descriptive framework of the results, the data were then used for MultiDimensional Scaling. The reordination obtained with the abundance data is reported in Fig. 7. It is possible to distiguish three principal groups. One group is formed by samplings carried out immediately after the passage of the "rapido" inside st. 2 and st. 3, st. 4 differing slightly from the others. A second group is formed by the control data from stations 2, 3 and 4 at time 0, and a third by stations 2 and 3 and their controls at time 1. Station 1 lies in a completely different area from all the others, perhaps indicating that the gear behaved differently during fishing operations.

## "Rapido" - Otter trawl comparison

The experimental fishing sweeps made with the "rapido" and with the Italian-type otter trawl over the course of a few days, at the same stations, allowed the preliminary comparison of gear's "behaviour" during fishing activity.

In Fig. 8, the percentage of discard on total catch and the commercial catch of "rapido" and otter trawl for each month are reported. It should be noted that the percentage values of discard of "rapido" are always higher than 75% of the total catch.

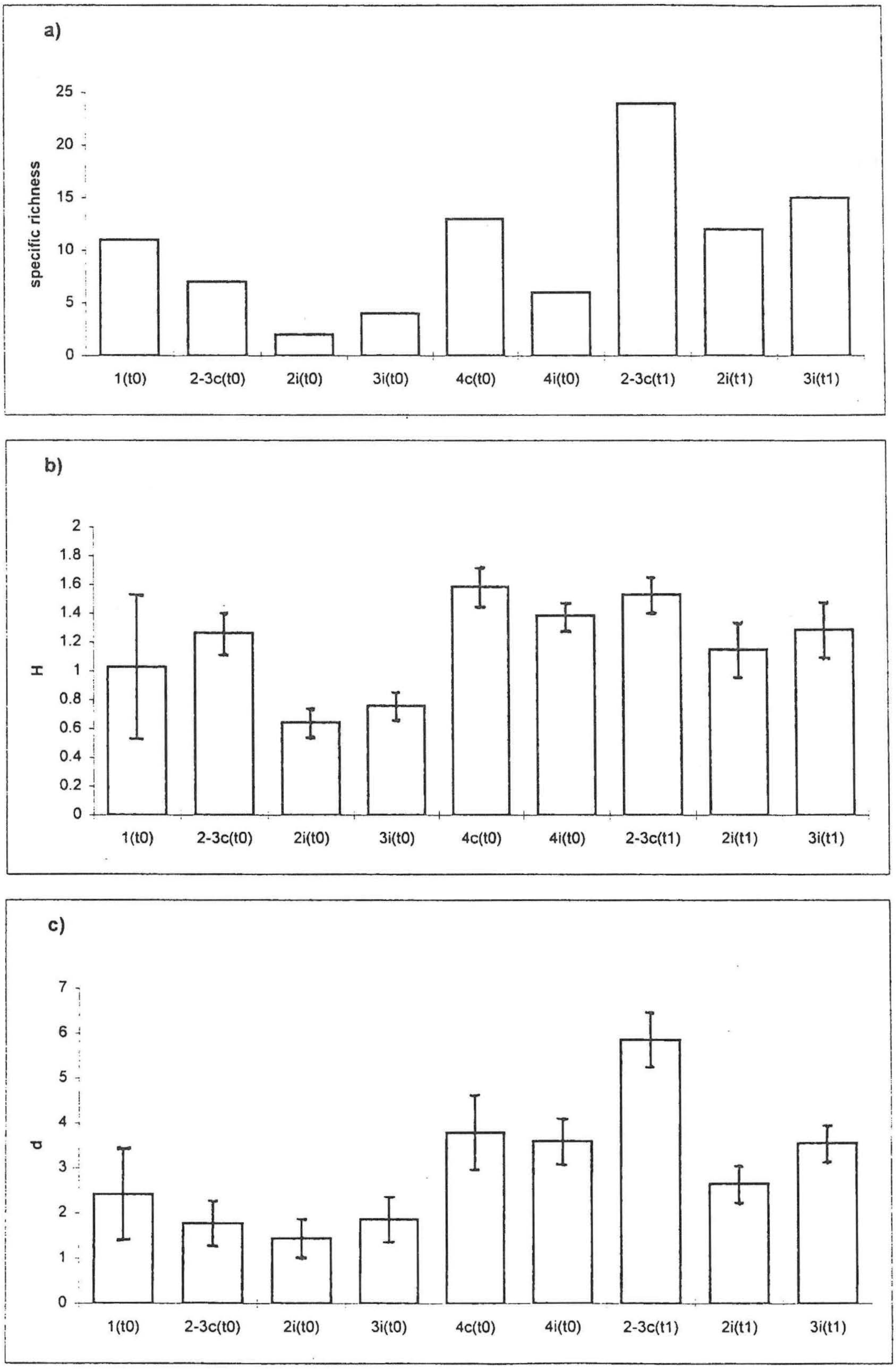



*Fig. 5. Trends of specific richness (a), Shannon index (b) and Margalef index (c) in experimental and control stations.*

*Table 4. Comparision between samples from studied and control areas according to STUDENT's t-test*

| Station | Abundance | | Biomass | |
|---|---|---|---|---|
| | t | p | t | p |
| 2 ($t_0$) | 4.060 | <.01 | 2.907 | <.05 |
| 3 ($t_0$) | 4.487 | <.01 | 2.936 | <.05 |
| 4 ($t_0$) | 2.970 | <.05 | 1.767 | n.s. |
| 2 ($t_1$) | 0.358 | n.s. | 0.580 | n.s. |
| 3 ($t_1$) | 0.108 | n.s. | 0.390 | n.s. |

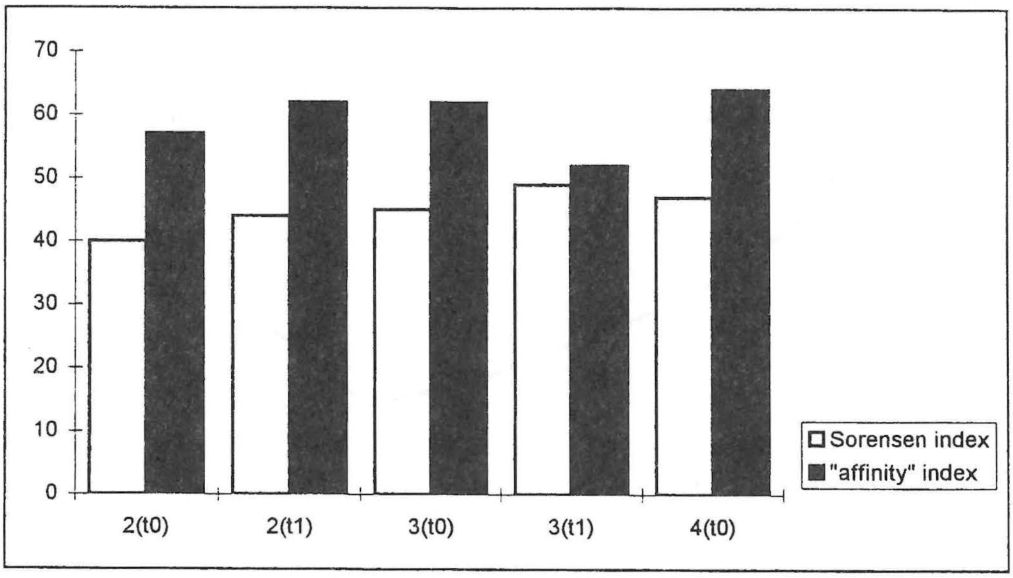



*Fig. 6. Comparison between study and control areas using Sorensen's index and faunal similarity index*

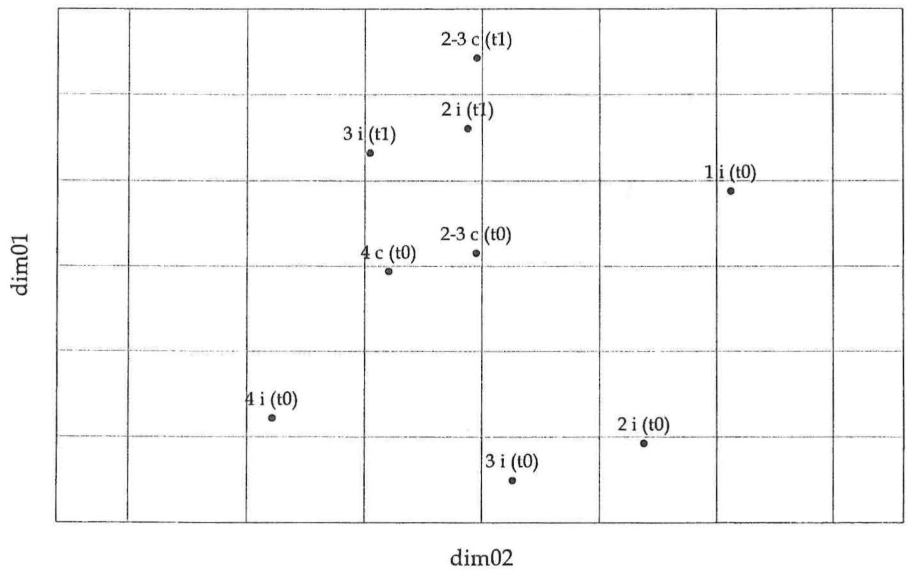


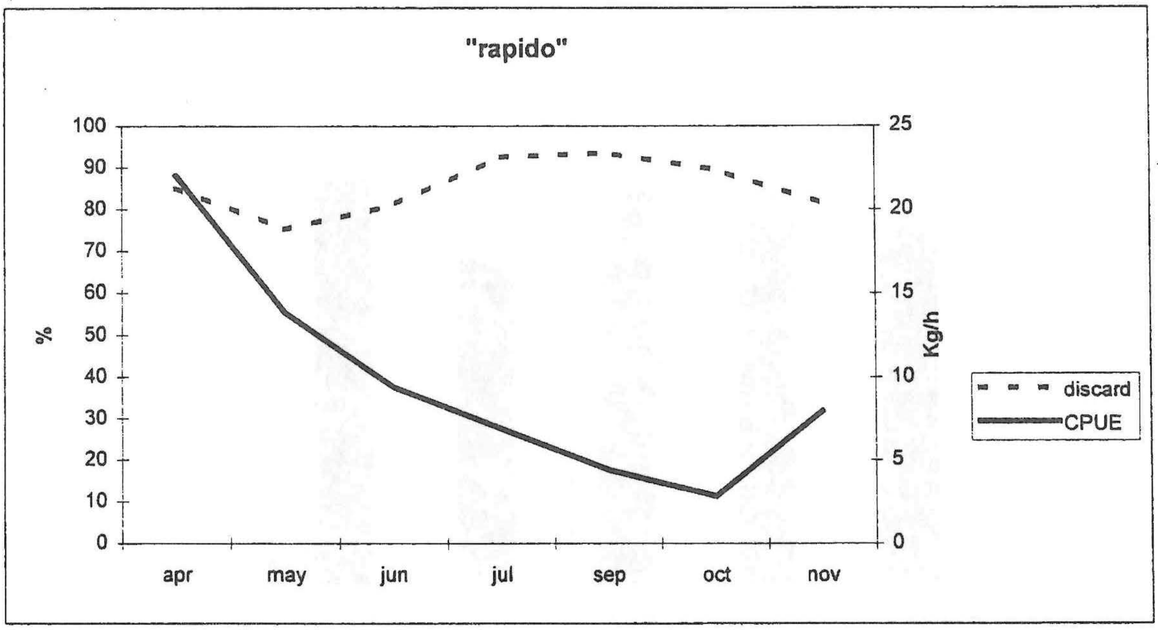

*Fig. 7. Results of MultiDimensional Scaling (stress = 0.085); i = inside study areas; c = control areas*

## DISCUSSION AND CONCLUSIONS

This study provided the opportunity to collect some preliminary data regarding the effects of "rapido" fishing activity on benthic communities.

### Physical disturbance

Differences were found between the physical disturbance produced by "rapido" for soles and "rapido" for Pectinids. The former produced furrows 5-13 cm deep, the latter pro-



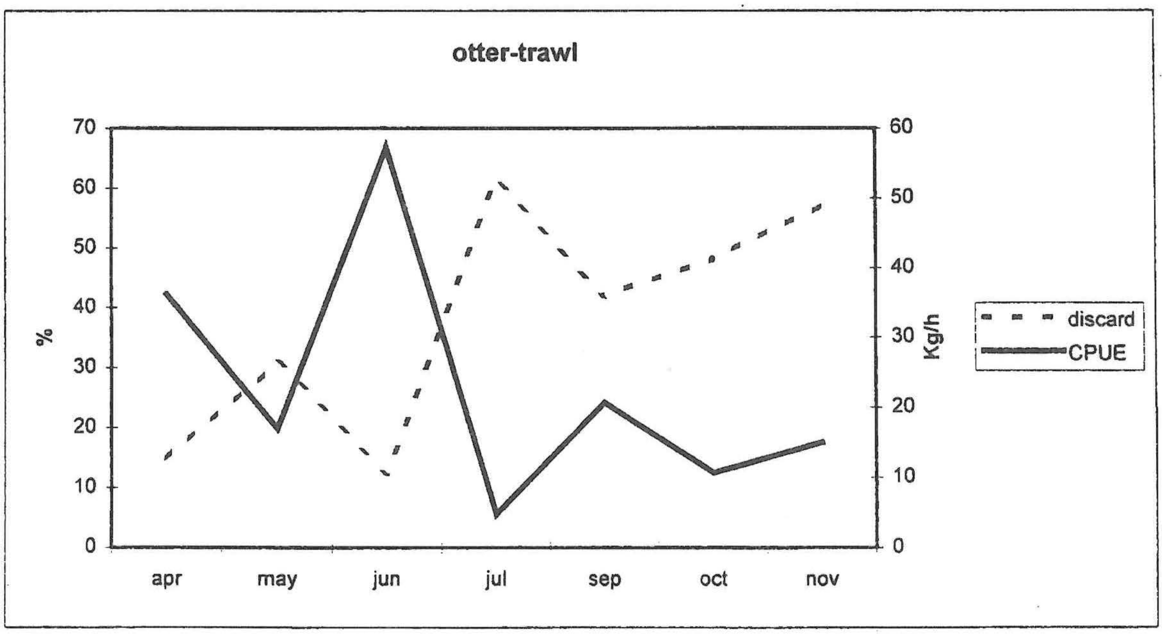




*Fig. 8. Comparison between discard (percentage on total catch) and commercial catch (CPUE) in "rapido" and otter-trawl, one mile off the Chioggia coast-line*

duced a series of small parallel tracks 2-4 cm deep. Other data from vessels catching Pectinids, operating on sandy sediment areas, showed that the by-catch was basically composed of epifauna and species living in the first few centimetres (mainly *Astropecten* sp., *Liocarcinus* sp., *Paguristes oculatus*, *Suberites domuncula*, *Aphrodite aculeata* and *Ophiura ophiura*), indicating that the "rapido" used for this type of fishing does not penetrate the sediment to any great extent. The differences in gear behaviours could be related to sediment type, as described for beam-trawling (BRIDGER, 1972; DE GROOT and LINDEBOOM, 1994), or to differences in fishing speed and gear set-up (i.e. inclination angle of the depressor), but more information must be collected regarding this matter.

The "rapido" activity affects the superficial layers of sediments. As shown by previous studies (CADDY, 1973; ELEFTHERIOU and ROBERTSON, 1992; PRANOVI and GIOVANARDI, 1994; KAISER and SPENCER, 1996a) it is impossible to detect changes in particle size-distibution immediately following the experimental hauls, but the bottom-trawling gears produce a resuspension of sediments and may cause the sediment to became unconsolidated (BRAMBATI and FONTOLAN, 1990; KAISER and SPENCER, 1996a).

The physical effects of "rapido" are comparable with those described for beam-trawls (BERGMAN and HUP,1992; DE GROOT and LINDEBOOM, 1994; KAISER and SPENCER, 1996a) and scallop dredges in the North Sea (ELEFTHERIOU and ROBERTSON, 1992).

## Effects on benthic fauna

Immediately following the experimental hauls, we registered a drastic reduction in specific richness, abundance and total biomass. The changes were due to the absence of less common and rare species, as emphasized by KAISER and SPENCER (1996a). After two weeks, the communities showed some degree of recovery, but large differences between the two temporal controls make its quantification very difficult. Nevertheless, the specific richness and diversity indexes values in the treated area were higher than those of the controls at time 0.

No substantial differences have been found between stations subjected to a single trawl and those subjected to several consecutive passages. BRYLINSKY *et al.* (1994) and KAISER and SPENCER (1996a) have demonstrated that the effects of trawl gears are not apparent in communities that are subject to frequent natural perturbations.

The effects on benthic communites of the Western Adriatic muddy coastal area (adapted to fluctuating environmental conditions, with high sedimentation rates) could be very different and lower from those of sandy offshore communities, living in a more stable environment. It would be interesting to compare data on actual benthos composition with data collected before the diffusion of "rapido" fishing activity. Unpublished data seem to indicate a remarkable decrease of epibenthic macrofauna (e. g. Porifera gen. *Geodia*). A similar effect on sponges has been demonstrated for the trawlable bottoms on the North West Shelf in Australia (SAINSBURY, 1988; HUTCHINGS, 1990; JONES, 1992).

Non-quantitative observations made on board commercial fishing vessels indicate that it takes quite a while (1-2 hours) to sort the whole catch, so that some non-marketable species could be dead when they are thrown back into the sea. In vessels catching Pectinids, the non-commercial/commercial catch ratio was found to vary from 1 to 3. It is therefore easy to evaluate the effects of such fishing on benthic communities by assessing the catch rate per vessel. However, recent studies on the beam trawl (KAISER and SPENCER, 1995; KAISER and SPENCER, 1996a; KAISER and SPENCER, 1996b) showed that damage to non-marketable species and their mortality rates vary considerably and are in close relation to the various taxonomic groups. These differential effects could be a source of change in benthic community subjected to the "rapido" fishing activity.

In conclusion, we believe that, in light of the results obtained here and the general situation of fishery in the Adriatic, great care should be taken in the management of its demersal fish resources. The ecosystem is showing signs of critical or at least accentuated distress.

An example of this is the situation of *Pecten jacobaeus*:

- over the years, it has disappeared from the main banks;
- it is occasionally recruited, as occurred in 1994 and 1995 (data from the wholesale fish market of Chioggia);
- quotas per day per man on board have been introduced;
- local, temporary measures on the marketable size have been introduced.

In regards to sole, fishing is most intense in late autumn, when this species migrates from its nursery areas in the lagoon and shallow coastal waters to deeper areas: these are generally specimens of class 0. In this case, specific measures restricting the use of the "rapido" near the coast in late autumn would appear to be useful.

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# "Rapido" kočarenje u sjevernom Jadranu: preliminarna opažanja utjecaja na makrobentosku zajednicu

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**SAŽETAK**

Dubinska povlačna dredža "rapido" se koristi jedino u Jadranskom moru. U radu se iznose prvi podaci o utjecaju ove ribolovne naprave na makrobentoske zajednice za područje Chioggia - Venecija.

Eksperimentalna vučenja dubinske, dredže "rapido" izvršena su u dva ribolovna područja : jednom, potpuno zaštićenom od ribolova, i drugom, u kojem je dozvoljeno ribarenje. Oba područja su bila udaljena 2-3 Nm od obale. U cilju simulacije gospodarskog ribolova dubinska dredža je izvlačena jedanput ili uzastopno nekoliko puta.

Dobiveni rezultati pokazuju, da uporaba ovog ribolovnog sredstva izravno utječe na morsko dno, izdubljujući morske sedimente do dubine od 7 cm, što oštećuje makrobentoske zajednice.

Nakon eksperimentalnih lovina, iznosi srednjih vrijednosti abundancije, za sve postaje, poprimile su značajne statističke različitosti u odnosu na kontrolno područje. U biomasi naselja, nisu utvrđene značajnije statističke razlike ribolovnog područja u kojem je komercijalni ribolov dozvoljen. Iako ribolovna i kontrolna područja nisu pokazala značajne razlike dva tjedna nakon izvršenih eksperimenata, analiza indeksa različitosti pokazuje da je potpuna obnova bentoskih zajednica izostala, budući da je kontrolno područje uvijek imalo više iznose u odnosu na ribolovno.

Preliminarni podaci ovih eksperimenata su pokazali, da ribolovno sredstvo "rapido" ima vrlo štetan utjecaj na bentoske zajednice i da bi ga zbog tih obilježja u Jadranskome moru trebalo učinkovitije regulirati.

*ANNEX - Table 2. Abundances of species collected during sampling with suction device in every station (i = inside study areas; c = control areas; $t_0$ = immediately after experimental hauls; $t_1$ = 2 weeks after experimental hauls)*

| | 1 i | 2 i | | 3 i | | 2-3 c | | 4 i | 4 c |
|---|---|---|---|---|---|---|---|---|---|
| | ($t_0$) mean (sd) | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_0$) mean (sd) |
| **COELENTERATA** | | | | | | | | | |
| Cl. Anthozoa | 1.1 (0.6) | - | - | - | - | - | - | - | - |
| **SIPUNCULIDA** | | | | | | | | | |
| *Aspidosiphon muelleri* Dies. | - | - | - | - | - | - | - | - | 0.7 (0.4) |
| **MOLLUSCA** | | | | | | | | | |
| Cl. Gastropoda | | | | | | | | | |
| *Euspira nitida* (Donovan) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Aporrhais pespelecani* (L.) | - | - | 1.1 (0.6) | - | 1.1 (0.6) | - | 0.7 (0.4) | - | - |
| *Hexaplex trunculus* (L.) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Nassarius pygmaeus* (Lamck.) | - | - | 1.1 (0.6) | - | - | 5.3 (2.3) | 2.0 (0.8) | - | 4.0 (2.3) |
| *Philine aperta* (L.) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Cylichna cylindracea* (Pennant) | - | - | - | - | - | - | 2.0 (1.2) | - | - |
| Cl. Scaphopoda | | | | | | | | | |
| *Dentalium vulgare* (Da Costa) | - | - | - | - | 1.1 (0.6) | - | - | - | - |
| Cl. Bivalvia | | | | | | | | | |
| *Nucula nucleus* (L.) | - | - | 3.3 (0.6) | - | 2,2 (0,6) | 3,3 (0,4) | 3.3 (0.9) | - | 3.3 (0.6) |
| *Anodontia fragilis* (Phil.) | 3.3 (0.6) | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Lucinella divaricata* (L.) | 1.1 (0.6) | - | - | - | - | - | - | - | - |
| *Tellimya ferruginosa* (Mont.) | - | - | - | - | - | - | 1.3 (0.8) | - | - |
| *Phaxas adriaticus* (Coen) | - | - | - | - | - | - | 1.3 (0.8) | - | - |
| *Tellina distorta* Poli | 3.3 (0.6) | 0.7 (0.4) | 4.4 (0.6) | - | 2.2 (1.2) | 1.1 (0.5) | 8.7 (1.9) | 1.3 (0.9) | 2.2 (1.2) |
| *Tellina nitida* Poli | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Abra alba* (Wood) | - | - | - | - | - | - | - | 0.8 (0.5) | 1.3 (0.5) |
| *Abra segmentum* (Recluz) | - | - | - | - | - | - | - | - | 1.1 (0.4) |
| *Pitar rudis* (Poli) | 3.3 (0.6) | - | - | - | 4.4 (0.6) | - | - | 0.7 (0.4) | 0.8 (0.5) |
| *Dosinia lupinus* (L.) | 1.1 (0.6) | - | - | - | 1.1 (0.6) | - | - | - | - |
| *Corbula gibba* (Olivi) | 7.0 (4.2) | 1.1 (0.5) | 68.7 (10.7) | 2.7 (1.2) | 101 (15.0) | 50 (15.1) | 102 (17.6) | 6.7 (2.8) | 40.7 (11.1) |
| **ANNELIDA** | | | | | | | | | |
| Cl. Polychaeta | | | | | | | | | |
| *Glycera unicornis* (Sav.) | 3.3 (0.6) | - | 1.1 (0.6) | - | - | - | 1.3 (0.5) | - | - |
| *Lumbrinereis* sp. | 3.3 (0.6) | - | 2.2 (1.2) | - | - | - | - | - | - |
| *Owenia fusiformis* Delle Chiaje | 3.3 (0.6) | - | - | 0.7 (0.4) | 1.2 (0.6) | 12.2 (1.0) | 4 (1.3 ) | 0.8 (0.5) | 3.3 (1.7) |
| *Amphictene auricoma* (O.F. Mull.) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| Nereidae | - | - | - | - | 1.2 (0.6) | - | 1.3 (0.4) | - | - |
| **ARTHROPODA** | | | | | | | | | |
| Cl. Crustacea | | | | | | | | | |
| *Macropipus depurator* (L.) | - | - | - | - | 1.2 (0.6) | - | - | - | 1.3 (0.5) |
| *Cymodoce truncata* (Mont.) | - | - | - | - | - | 1.1 (0.6) | - | - | - |
| *Ampelisca diadema* (Costa) | - | - | 17.8 (8.4) | - | 6.7 (2.6) | - | 4.7 (1.2) | - | - |
| Decapoda | - | - | 1.1 (0.6) | - | 1.2 (0.6) | - | 0.7 (0.4) | - | 1.3 (0.5) |
| **ECHINODERMATA** | | | | | | | | | |
| Cl. Holoturioidea | | | | | | | | | |
| *Thyone fusus* (O.F. Mull.) | - | - | - | - | 1.2 (0.6) | - | - | - | - |
| Cl. Asteroidea | | | | | | | | | |
| *Astropecten irregularis* (Linck) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| Cl. Ophiuroidea | | | | | | | | | |
| *Ophiothrix quinquemaculata* (D. Chiaje) | - | - | 1.1 (0.6) | - | - | - | 0.7 (0.4) | - | - |
| *Amphiura chiajei* Forbes | - | - | 1.1 (0.6) | - | 1.2 (0.6) | 1.1 (0.6) | - | - | 0.7 (0.4) |
| *Amphiura filiformis* (O.F. Mull.) | - | - | - | - | - | - | 0.7 (0.4) | - | - |
| *Ophiura grubei* Hell. | 6.7 (1.3) | 7.0 (3.3) | 103 (51.7) | 11.1 (2.5) | 43.0 (14.4) | 27.8 (6.6) | 30.0 (7.8) | - | 18.0 (6.5) |
| **TUNICATA** | | | | | | | | | |
| Ascidiacea | - | - | - | - | - | - | - | 0.8 (0.5) | 0.8 (0.5) |

*ANNEX - Table 3. Biomass values (g 0.3 m*$^{-2}$*) of species collected during sampling with suction device in every station (i = inside study areas; c = control areas;* $t_0$ *= immediately after experimental hauls;* $t_1$ *= 2 weeks after experimental hauls)*

| | 2 i | | 3 i | | 2-3 c | | 4 i | 4c |
|---|---|---|---|---|---|---|---|---|
| | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_1$) mean (sd) | ($t_0$) mean (sd) | ($t_0$) mean (sd) |
| **COELENTERATA** | | | | | | | | |
| Cl. Anthozoa | - | - | - | - | - | - | - | - |
| **SIPUNCULIDA** | | | | | | | | |
| *Aspidosiphon muelleri* Dies. | - | - | | - | - | - | - | 0.05 (0.00) |
| **MOLLUSCA** | | | | | | | | |
| Cl. Gastropoda | | | | | | | | |
| *Euspira nitida* (Donovan) | - | - | - | - | - | 0.09 (0.00) | - | - |
| *Aporrhais pespelecani* (L.) | - | 1.51 (0.01) | - | 1.56 (0.00) | - | 0.82 (0.00) | - | - |
| *Hexaplex trunculus* (L.) | - | - | - | - | - | 0.08 (0.00) | - | - |
| *Nassarius pygmaeus* (Lamck.) | - | 0.01 (0.01) | - | - | 0.02 (0.00) | 0.03 (0.04) | - | 0.09 (0.14) |
| *Philine aperta* (L.) | - | - | - | - | - | 0.03 (0.00) | - | - |
| *Cylichna cylindracea* (Pennant) | - | - | - | - | - | 0.01 (0.01) | - | - |
| Cl. Scaphopoda | | | | | | | | |
| *Dentalium vulgare* (Da Costa) | - | - | - | 0.05 (0.00) | - | - | - | - |
| Cl. Bivalvia | | | | | | | | |
| *Nucula nucleus* (L.) | - | 0.14 (0.17) | - | 0.04 (0.01) | 0.15 (0.18) | 0.15 (0.07) | - | 0.09 (0.03) |
| *Anodontia fragilis* (Phil.) | - | - | - | - | - | 0.02 (0.01) | - | - |
| *Lucinella divaricata* (L.) | - | - | - | - | - | - | - | - |
| *Tellimya ferruginosa* (Mont.) | - | - | - | - | - | 0.04 (0.00) | - | - |
| *Phaxas adriaticus* (Coen) | - | - | - | - | - | 0.02 (0.00) | - | - |
| *Tellina distorta* Poli | 0.02 (0.00) | 0.15 (0.24) | | 0.05 (0.00) | 0.01 (0.00) | 0.14 (0.22) | 0.18 (0.14) | 0.02 (0.00) |
| *Tellina nitida* Poli | - | - | - | - | - | 0.16 (0.00) | - | - |
| *Abra alba* (Wood) | - | - | - | - | - | - | 0.07 (0.00) | 0.06 (0.00) |
| *Abra segmentum* (Recluz) | - | - | - | - | - | - | - | 0.03 (0.00) |
| *Pitar rudis* (Poli) | - | - | - | 0.18 (0.12) | - | - | 0.04 (0.00) | 0.06 (0.00) |
| *Dosinia lupinus* (L.) | - | - | - | 0.07 (0.00) | - | - | - | - |
| *Corbula gibba* (Olivi) | 0.10 (0.00) | 10.63 (5.98) | 0.42 (0.64) | 16.11 (8.54) | 8.17 (5.87) | 13.67 (7.89) | 0.67 (0.56) | 4.74 (4.64) |
| **ANNELIDA** | | | | | | | | |
| Cl. Polychaeta | | | | | | | | |
| *Glycera unicornis* (Sav.) | - | 0.01 (0.00) | - | - | - | 0.30 (0.87) | - | - |
| *Lumbrinereis* sp. | - | 0.04 (0.01) | - | - | - | - | - | - |
| *Owenia fusiformis* Delle Chiaje | - | - | 0.02 (0.00) | 0.02 (0.00) | 0.96 (0.02) | 0.30 (0.3) | 0.03 (0.00) | 0.22 (0.00) |
| *Amphictene auricoma* (O.F. Mull.) | - | - | - | - | - | 0.02 (0.00) | - | - |
| Nereidae | - | - | - | - | - | 0.05 (0.00) | - | - |
| **ARTHROPODA** | | | | | | | | |
| Cl. Crustacea | | | | | | | | |
| *Macropipus depurator* (L.) | - | - | - | 0.04 (0.00) | - | - | - | 0.05 (0.06) |
| *Cymodoce truncata* (Mont.) | - | - | - | - | 0.01 (0.00) | - | - | - |
| *Ampelisca diadema* (Costa) | - | 0.04 (0.08) | - | 0.03 (0.01) | - | 0.01 (0.00) | - | - |
| Decapoda | - | 0.02 (0.01) | - | 0.01 (0.00) | - | 0.01 (0.00) | - | 0.02 (0.03) |
| **ECHINODERMATA** | | | | | | | | |
| Cl. Holoturioidea | | | | | | | | |
| *Thyone fusus* (O.F. Mull.) | - | - | - | 0.05 (0.00) | - | - | - | - |
| Cl. Asteroidea | | | | | | | | |
| *Astropecten irregularis* (Linck) | - | - | - | - | - | 0.45 (0.00) | - | - |
| Cl. Ophiuroidea | | | | | | | | |
| *Ophiothrix quinquemaculata* (D. Chiaje) | - | 0.01 (0.00) | - | - | - | 0.06 (0.00) | - | - |
| *Amphiura chiajei* Forbes | - | 0.07 (0.00) | - | 0.09 (0.00) | 0.08 (0.00) | - | - | 0.02 (0.00) |
| *Amphiura filiformis* (O.F. Mull.) | - | - | - | - | - | 0.01 (0.00) | - | |
| *Ophiura grubei* Hell. | 0.08 (0.08) | 0.81 (1.66) | 0.12 (0.08) | 0.31 (0.38) | 0.22 (0.16) | 0.16 (0.09) | - | 0.30 (0.00) |
| **TUNICATA** | | | | | | | | |
| Ascidiacea | - | - | - | - | - | - | 0.04 (0.00) | 0.04 (0.00) |