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A multidisciplinary study of the immediate effects of mechanical clam harvesting in the Venice Lagoon

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In the Venice Lagoon, clam (*Tapes philippinarum*) harvesting is carried out mainly by means of a gear locally called "rusca", developed by local fishermen. The rusca consists of an iron cage, an outboard engine propeller, which produces a water flow directed onto the bottom suspending sediments and fauna, and a net bag where the clams are collected. The aim of this study was to provide an analysis of the immediate effects of rusca fishing on a wide spectrum of ecosystem compartments: sediment biogeochemistry, sediment resuspension, and macro- and meiofauna community. Rusca fishing produced a V-shaped furrow (about 60 cm wide and 7 cm deep) and a plume of resuspended sediment with a significant increase (up to two orders of magnitude greater than undisturbed areas) of suspended particulate matter (SPM) and increased C_{tot}, C_{org}, N_{tot}, and sulphide concentrations in the water column. Experimental rusca hauls significantly reduced macrofauna density, while no significant effect on meiofauna was detected. Results are also discussed in terms of basin-scale impact, attempting to compare natural and anthropogenic disturbance.

Keywords: fishing disturbance, mechanical clam harvesting, sediment plume, *Tapes philippinarum*, Venice Lagoon.

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Introduction

The minimization of negative effects, both direct and indirect, of fishing activities is perceived to be an important component of fishery management plans in heavily exploited ecosystems (Benaka, 1999). Mobile demersal gears (mainly trawl nets and dredges) produce disturbances which may exceed any other natural and anthropogenic disturbance on the marine continental shelf and slope (Watling and Norse, 1998). Demersal gears may scrape or plough the sea bed, suspend sediment, alter sediment and water biogeochemistry, change sediment texture, destroy bed forms, and remove or scatter non-target species (Watling and Norse, 1998; Collie *et al.*, 2000; Duplisea *et al.*, 2001). Even if the above-mentioned phenomena have been individually described to produce pervasive consequences, only a few multidisciplinary and integrated experimental studies have been conducted to assess, at least in the short term, the order of magnitude of all these effects of demersal fishing (see Kaiser *et al.*, 2002). This experimental approach could give the opportunity to fix in a single picture all the changes induced by fishing activity and to make inferences about their possible interactions.

One of the main environmental disturbances in the Venice Lagoon could result from the exploitation of Manila clams, *Tapes philippinarum*. The Manila clam was introduced in 1983 (Cesari and Pellizzato, 1985) as a cultured species and quickly spread to the whole lagoon, profoundly changing macrobenthic community composition (Pranovi *et al.*, unpubl.). Presently, more than 50% (40 000 tonnes) of clam production in Italy comes from the Venice Lagoon where about 600 fishing boats operate; a great expansion from only 1300 tonnes produced in 1990. According to the classification proposed by Kaiser *et al.* (2001), the intensity of commercial clam harvesting in the Venice Lagoon could be defined as "high", since it consists of large-scale harvesting using mechanical extraction devices and operating in restricted areas until the target species has been reduced to a level that is no longer economically viable for exploitation.

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At present, clam harvesting in the Venice Lagoon is carried out mainly by means of a gear locally called "rusca", the prototype of which was developed by local fishermen. The rusca consists of an iron cage, 60 cm wide, with two sledges which prevent it from sinking into the sediment, and a net bag where the clams are collected (Figure 1). The digging action is obtained by means of an outboard engine propeller (25 hp) which, located on the side of the boat, produces a water flow directed onto the sediment. The propeller wash is sufficiently powerful (in shallow water) to suspend bottom sediments and clams (and other invertebrates) into a plume in the water column. The clams are then collected in the net bag (see Figure 1). The fishing system allows the exploitation of all shallow (0.5−1.5 m deep) areas of the lagoon. The rusca is similar to the gear used by fishermen in the shallows of North Carolina to exploit bivalves, *Mercenaria mercenaria*, using a method described as "clam kicking" (Peterson *et al.*, 1987). Rusca is conducted in a sort of free access regime since, although rusca is an illegal gear, no effective control limitations are applied and about one-third of the whole lagoon is exploited at present (Provincia di Venezia, 2000).

An integrated sampling scheme was applied to assess the immediate effects of rusca on sediment structure, water

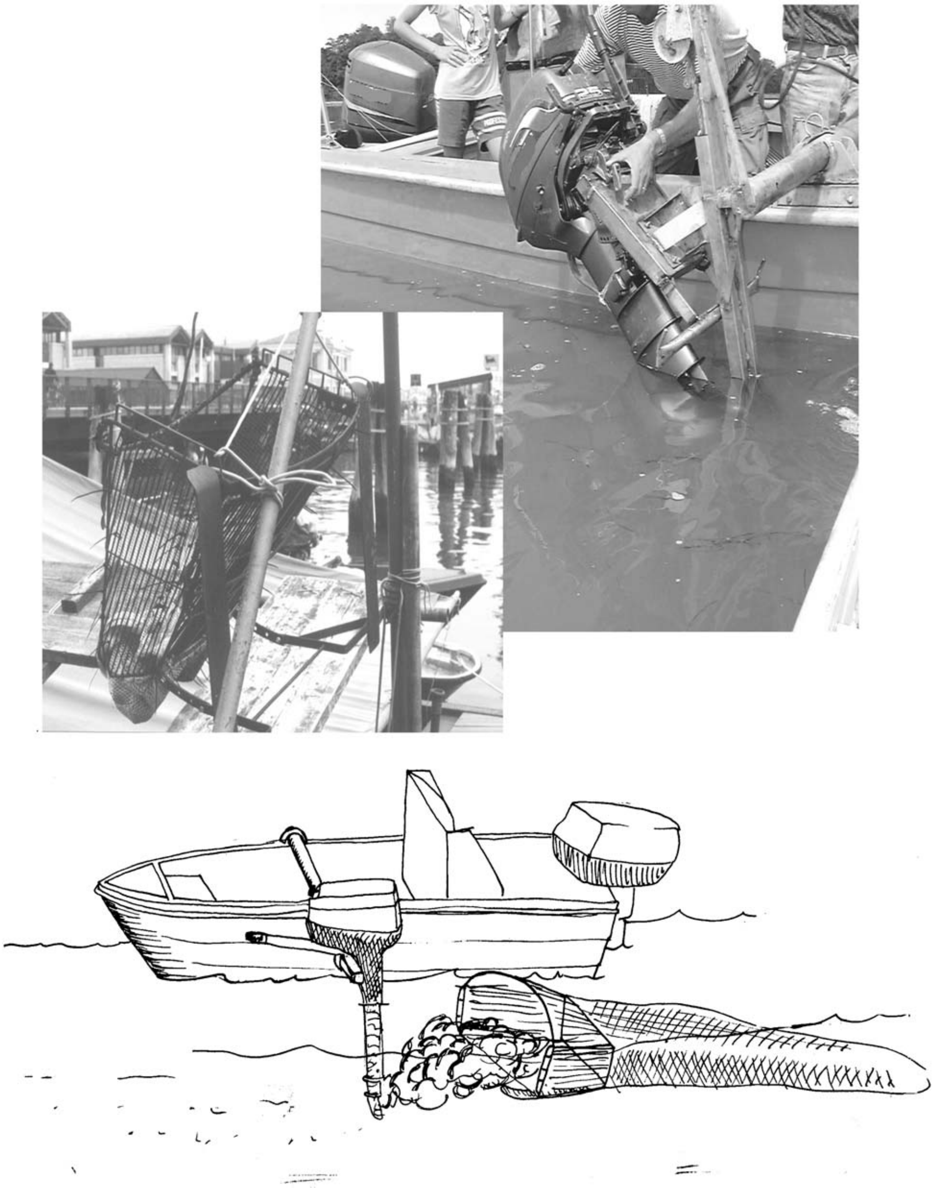

Figure 1. Rusca dredge and fishing technique.

column particulate load, and benthic community structure in the Venice Lagoon. In particular, we: (1) determined the digging depth of the fishing gear and quantified the sediment volume mobilized for unit of swept area; (2) analysed the immediate modifications induced on bottom morphology and texture and the plume characteristics; (3) examined the immediate effects on benthic community structure (macro- and meiofauna); and (4) described the efficiency and the behaviour of the gear during the fishing activity.

Materials and methods

The experimental area (mean depth 0.5−0.8 m) was located in the central basin of the Venice Lagoon, 2 km south of Venice city, on the east side of Sacca Sessola island. The substratum was predominantly silty sand with relatively flat and uniform topography. The area was not, at the time, exploited for the commercial harvesting of clams, although *Tapes philippinarum* was present in commercial densities. The experiment was carried out in October 2000, according to a "before−after" scheme. On the first day of sampling, samples were collected from two stations in the experimental area in order to provide a description of the undisturbed site (control samples). The following day, an experimental haul was carried out in the same area using a commercial boat equipped with the rusca. The track was marked during the experimental haul by placing some PVC sticks just behind the fishing gear in order to distinguish it during the following sampling procedures. Samples from the "treated" area were collected from inside the track at two different stations which were 30 m apart (see details below for each parameter considered).

Track morphology

The track morphology was investigated by means of a plastic comb (4 m wide) arranged with mobile teeth which rested on the bottom, obtaining an "image" of the seabottom profile. To verify the digging depth, markers were placed before dredging into the sediment along three different lines (each 2 m long) at different depths into the substratum (0−10, 11−15, 16−20 cm) and then the area was fished by the rusca.

Sediment parameters

In order to examine changes in sediment grain-size distribution that might be induced by the mechanical clam harvesting, two sediment samples were collected haphazardly by inserting a PVC cylinder (30 cm high × 3 cm diameter) into the sediment from each station, both before and after the experimental haul. In the laboratory, cores were sectioned into layers of 0−0.5, 0.5−6.0, and 6.0−12.0 cm depth for analysis. Each core section was first homogenized and then subsampled and analysed for particles 2−168 μm of diameter using a Coulter Counter Multisizer analysis. To extend the analysis to the coarser fractions of > 168 μm, a subsample was oven-dried at 45 °C, double washed with hydrogen peroxide (48 h at room temperature), oven-dried, sieved on a 62.5 μm sieve, and re-weighed. Each layer was analysed also for particulate organic Carbon (C_{org}), total Carbon (C_{tot}), and Nitrogen (N_{tot}) contents by using a CHN analyser (Carlo Erba NA 1500 Analyser). Samples were immediately frozen and preserved in the freezer at −20 °C.

Water parameters

In order to characterize the plume produced by the mechanical harvesting of clams, water samples were collected immediately after the experimental haul (within 10 s) from two different stations, directly sampling the suspended plume by means of a submerged pump. To analyse the sedimentation rate of the plume, samples were collected, respectively, 1, 2, 7, 17, and 37 min after the haul, following the drifting plume. Reference water samples were collected in the experimental area immediately before the experimental haul (within 5 min). Samples were transferred to the laboratory and immediately analysed for the 2−168 μm fraction by means of the Coulter Counter Multisizer analysis. Subsamples for carbon/nitrogen and nutrient analyses were immediately filtered on board using a vacuum system on Whatmann filters (GF/F), which were then preserved in the freezer at −20 °C. Organic Carbon (C_{org}), total Carbon (C_{tot}), and Nitrogen (N_{tot}) content were determined by using the CHN analyser. Nutrients were determined by using an Autoanalyser AA3. The sulphides in the water were determined according to the colorimetric method proposed by Quentin and Pachmayer (1961). To estimate the suspended particulate matter (SPM), 500−1000 ml of water was analysed by filtering it through pre-dried and pre-weighed Whatmann filters (GF/F), after which they were rinsed with 25 ml of distilled water. Filters were oven-dried overnight at 110 °C, cooled, and re-weighed. SPM was calculated by weight difference. Moreover, water samples were collected before and after the experimental haul for BOD_{25} estimation.

Benthic community

Macrobenthos samples were collected randomly in the sampling area before the experimental haul ($n = 6$); after dredging, samples ($n = 3$) were collected along the track. Samples were collected by scuba divers using a water-lift sampler (mesh bag size 1 mm, 0.2 m^2 sampling area, 25 cm in depth) and preserved in the freezer at −20 °C. Samples were treated with rose Bengal, and organisms were then separated and classified to the lowest practical taxonomic level. All organisms were counted and wet weight was recorded for each *taxon*.

The meiobenthic community was sampled by taking sediment cores before $(n = 6)$ and after $(n = 6)$ the experimental haul using a PVC cylinder (3 cm diameter, 10 cm depth). Samples were preserved in 4% buffered formalin. Each sample was washed in two sieves in order to collect the 2000−62.5 μm fraction and to remove formalin and most of the sediment. Meiofauna was then extracted using elutriation in fresh water with Ludox HS40 and decantation through a sieve. The main *taxa* were then identified.

Statistical analyses of the benthic community structure were done using Statistica 5.0 and the Primer 5.0 software packages.

Gear efficiency

In order to obtain a preliminary estimate of the rusca efficiency, 10 standardized − 50 m long − hauls were carried out in a subarea where the clam density was previously investigated by means of 10 replicate (0.1 m^2) Day grabs.

Results

Track morphology

The rusca produced a V-shaped track, 60 cm wide and, on average, 7 cm deep, as shown by the sediment profiles recorded by the comb method (Figure 2). The water flow produced by the engine propeller suspended bottom sediment, part of which accumulated in ridges on both sides of the track. The depth markers experiment confirmed previous data: the digging action did not exceed a depth of 10 cm. The bottom sediment analyses revealed the homogeneity of the first 12 cm of the cores. A single haul, which completely removed (on average) the first 7 cm of bottom sediment, produced no detectable changes in terms of sediment grain size. Indeed, the grain-size data, expressed as percentage by dry weight of the silt component (<62.5 μm), showed no significant differences, either between layers of the same cores or between treatments (Table 1). Also, the comparison between Coulter Counter analyses on samples collected before and immediately after the experimental haul showed no significant changes.

No significant changes were detected also in terms of sediment C−N content (Table 1). Only the C_{tot} showed a significant decrease $(p < 0.037)$ after the haul, when the first 12 cm were considered all together.

Water characteristics

Particle size distribution analyses showed a significant change (Mann−Whitney U test, $U = 3308$, $p < 0.001$) after the haul, resulting in a shift towards the coarser fractions (Figure 3). The observed distribution largely overlapped that recorded before the passage in the bottom sediment (Figure 3). The sedimentation rate analyses (with a measured current of 2.0 cm s^{-1}) showed that after about half an hour particle distribution in the water column was comparable with that recorded before the experimental haul (Figure 4). Immediately after the experimental haul SPM, C_{tot}, C_{org}, N_{tot}, sulphides, and BOD_{25} increased significantly due to the plume of suspended sediment produced by the fishing activity (Table 2). SPM and C_{tot} increased by two orders of magnitude; sulphides, which showed before the haul a concentration below detection limits, became detectable after the experimental haul (Table 2). Also, nutrient concentrations (NO_2, NO_3, NH_4, PO_4) showed an increase after the haul, although this was not statistically significant (Table 2).

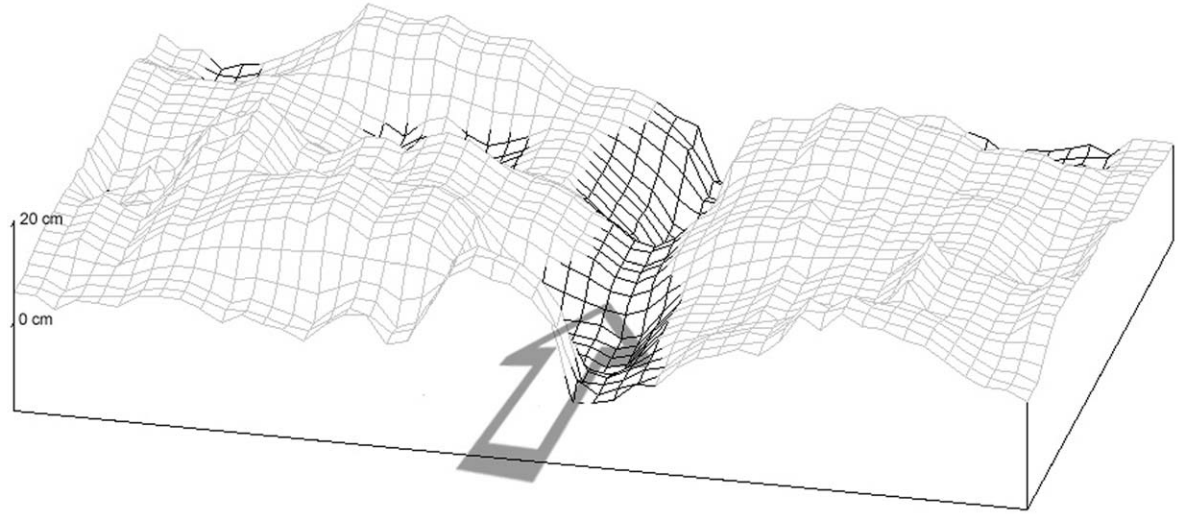

Figure 2. Rusca track shape rebuilt by means of five adjacent "comb" observations. Fishing direction is indicated by the arrow.

Table 1. Bottom sediment features recorded before and after the experimental haul. s.d. = standard deviation; p-level = significance level of comparison between the treatments (t-test), bold values are statistically significant.

		Layer I (0–0.5 cm)		Layer II (0.5–6.0 cm)		Layer III (6.0–12.0 cm)		Total (0–12.0 cm)	
	Time	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Muddy fraction (<62.5 μm)	Before	72.130	12.786	78.052	11.251	82.388	11.963	77.523	11.723
	After	66.033	6.933	68.572	7.267	77.252	4.916	70.619	7.699
	p-level	0.564	–	0.149	–	0.248	–	0.133	–
C_{tot} (mg g^{-1})	Before	0.525	0.077	0.541	0.040	0.577	0.016	0.548	0.046
	After	0.304	0.234	0.482	0.007	0.506	0.029	0.431	0.144
	p-level	0.121	–	0.121	–	0.121	–	**0.037**	–
N_{tot} (mg g^{-1})	Before	0.006	0.000	0.005	0.000	0.005	0.000	0.005	0.001
	After	0.009	0.006	0.023	0.024	0.005	0.001	0.012	0.014
	p-level	1.000	–	0.121	–	1.000	–	0.522	–

Benthic community

Macrobenthos

Univariate analyses (Table 3) revealed a significant decrease in the total number of individuals after the experimental haul, but no significant statistical difference in the total number of species nor in the total wet biomass was recorded. All this influenced the diversity indices, which showed a statistical significant increase after the haul (Table 3). The MDS ordination (stress = 0.01) showed a high heterogeneity of samples collected in the treated area, whereas the "before" samples all appear to be quite similar and closely grouped (Figure 5), as confirmed by the relative dispersion index which increased after the haul (Table 3). Among the 20 most important species (which represent more than 95% of total abundance), only the decapod *Diogenes pugilator* showed an increase in abundance after the experimental haul (t-test, p = 0.010).

Meiobenthos

All univariate indices showed no significant difference between treatments (Table 3). No clear trends were shown in the MDS ordination (stress = 0.09) but samples collected after the experimental haul were grouped less clearly than those collected before (Figure 6), as confirmed by the relative dispersion index which reached a higher value in the "after" samples (Table 3).

Fishing efficiency

The gear efficiency, estimated by comparing the clams caught by the rusca per unit of swept area and the clam density (by means of grab) in the bottom sediment before the experimental hauls, was found to be about 25% (Table 4). The comparison between clam biomass, recorded by using water-lift device both before (mean = 29.56 g m^{-1}, s.d. = 15.21) and after (mean = 11.29 g m^{-1}, s.d. = 5.73) the experimental haul, showed a biomass loss of about 60%. Total catch was dominated by debris (about 90% of total catch), mainly composed of bivalve shells. The discard/commercial ratio reached 2.5 (Table 4).

Discussion

Examination of rusca fishing effects on sediment structure showed that a single haul was insufficient to produce

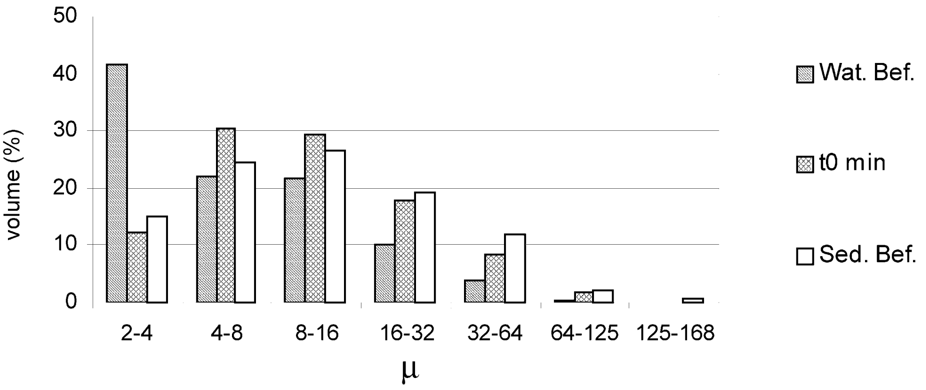

Figure 3. Comparison of grain-size distributions of suspended matter recorded in the water before (Wat. Bef.) and after (t0 min) the experimental haul. The bottom sediment grain-size distribution recorded before the experimental haul (Sed. Bef.) is also reported.

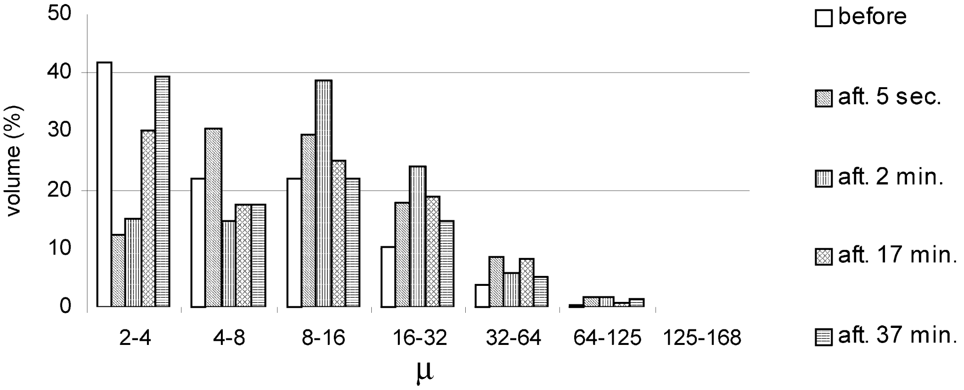

Figure 4. Comparison of grain-size distributions recorded in the plume immediately after the haul (aft. 5 s), after 2 min (aft. 2 min), after 17 min (aft. 17 min), and after 37 min (aft. 37 min). The grain-size distribution recorded in the water before the experimental haul is also reported (before). The p-levels (U Mann–Whitney test) of the comparison with the before sample were respectively: <0.001, <0.001, <0.05, and 0.36.

detectable alteration in sediment grain size; however, repeated resuspension events due to rusca fishing could produce the winnowing of the fine-sediment fraction causing a permanent change in sediment grain size owing to loss of fine material. This effect has been described for different kinds of fishing gear in the Venice Lagoon (Pranovi and Giovanardi, 1994) and at other sites (e.g. Watling *et al.*, 2001).

Immediately after resuspension, the rusca sediment plume was very similar to the sediment distribution on the sea bed recorded before the experimental haul, indicating that all fractions in the bed sediment grain-size population were entrained together. Within the first 40 min more than 90% of the sediment in the plume fell back onto the seabed confirming the results of Black and Parry (1999). Our experiments showed that rusca fishing affects the distribution of organic carbon in sediments and the concentration of suspended particulate matter (SPM).

Table 2. Water column parameters recorded before and after the experimental haul. s.d. = standard deviation; p-level = significance level of comparison between the treatments (t-test), bold values are statistically significant.

	Before		After		
	Mean	s.d.	Mean	s.d.	p-level
SPM (g l^{-1})	0.014	0.001	1.970	0.215	**<0.001**
C_{tot} (μmol l^{-1})	57.50	4.60	6038.40	376.10	**0.002**
C_{org} (μmol l^{-1})	29.70	10.70	753.70	218.10	**0.043**
N_{tot} (μmol l^{-1})	4.00	0.40	82.10	1.70	**<0.001**
Sulphides (μmol l^{-1})	0.00	0.00	5.00	2.83	**<0.001**
BOD_{25} (mg O_2 l^{-1})	1.38	0.06	17.10	2.12	**0.009**
NO_2 (μmol l^{-1})	0.35	0.11	0.91	0.44	0.166
NO_3 (μmol l^{-1})	2.65	1.34	18.13	24.02	0.439
NH_3 (μmol l^{-1})	6.03	6.20	18.98	19.51	0.433
PO_4 (μmol l^{-1})	0.02	0.02	0.58	0.60	0.276

Mechanical clam harvesting seems to produce a great impact on the macrobenthic community, although, as reported by other authors (Pranovi *et al.*, 2000; Watling *et al.*, 2001), a single fishing haul can affect the organism density but have no effects on the species richness. Direct removal, damage, displacement, or death of a proportion of benthic organisms induces changes in the community structure, as suggested by the increase of the community heterogeneity (see MDI). In the medium-term, this could produce a loss of more fragile species (*sensu* MacDonald *et al.*, 1996). Rusca fishing attracted scavengers to the disturbed furrows in the short term, as evidenced by *Diogenes pugilator* which increased in density in the furrow area just one hour after the haul, probably attracted by damaged or dead organisms. On the other hand, our data confirm results reported by Pranovi *et al.* (2000) and Schratzberger *et al.* (2002): a single fishing haul produces no detectable immediate effects on the meiofauna, but the modifications induced on the bottom sediment would presumably affect meiobenthic species in the short/medium-term, due to delayed effects mediated by sediment features. Unfortunately, we could not evaluate the recovery process, since the experimental area was disturbed by commercial fishing just few hours after the experimental dredging. These differences between macro and meiofauna could probably be explained in terms of differential vulnerability/catchability of the two components (meiofauna cannot be directly removed by the gear but only displaced by the water flow).

The comparison between the efficiency estimate obtained by gear/grab data (25%) and that calculated by using the water-lift device using before/after data (60%) shows that not all the resuspended clams were collected in the net bag nor caught by the gear. Displacement of organisms is probably greater for small non-target species, some of which could also be damaged by the direct contact with the gear or the propeller.

Table 3. Benthic community features (a, macrobenthic community; b, meiobenthic community) recorded before and after the experimental haul. s.d. = standard deviation; p-level = significance level of comparison between the treatments (t-test), bold values are statistically significant.

	(a) Macrobenthos					*(b) Meiobenthos*				
	Before		After			Before		After		
	Mean	s.d.	Mean	s.d.	p-level	Mean	s.d.	Mean	s.d.	p-level
Total number of individuals	1648.88	519.43	361.88	157.97	**0.005**	701.83	362.96	532.33	331.35	0.418
Total number of species	18.33	2.66	18.00	1.00	0.844	11.17	4.88	12.00	4.82	0.772
Wet weight biomass (g m^{-2})	48.75	21.05	25.51	5.36	0.116	–	–	–	–	–
Shannon Index	1.97	0.18	2.30	0.18	**0.037**	0.56	0.23	0.65	0.28	0.540
Eveness Index	0.68	0.05	0.80	0.08	**0.026**	0.24	0.09	0.27	0.09	0.548
Multivariate Dispersion Index	0.84	–	1.79	–	–	0.92	–	1.08	–	–

Our results on digging depth and morphology of the track allow a first estimate of about 0.06 m^3 of mobilized sediment per unit (m^2) of rusca-fished area. Although preliminary, the experimental data allow us to try some inferences about the possible impacts of mechanical clam harvesting at a basin scale. Combining efficiency experimental data with landing statistics and fleet description (Provincia di Venezia, 2000) it is possible to estimate that, on average, each fishing site is disturbed more than three times per year due to clam harvesting (Table 5). In total this amounts to about 25×10^6 m^3 y^{-1} of sediment suspended and about 12×10^3 kJ m^{-2} y^{-1} directly introduced in the water column (Table 5). Furthermore, the destabilization and the destruction of sediment structures, breaking natural sediment bonds (cohesiveness and biological bonding) may cause an increased likelihood of renewed suspension during natural storms (Black and Parry, 1999).

The resuspension caused by rusca fishing activity could be an important factor in determining food quality and quantity available to filter feeders as described by de Jonge

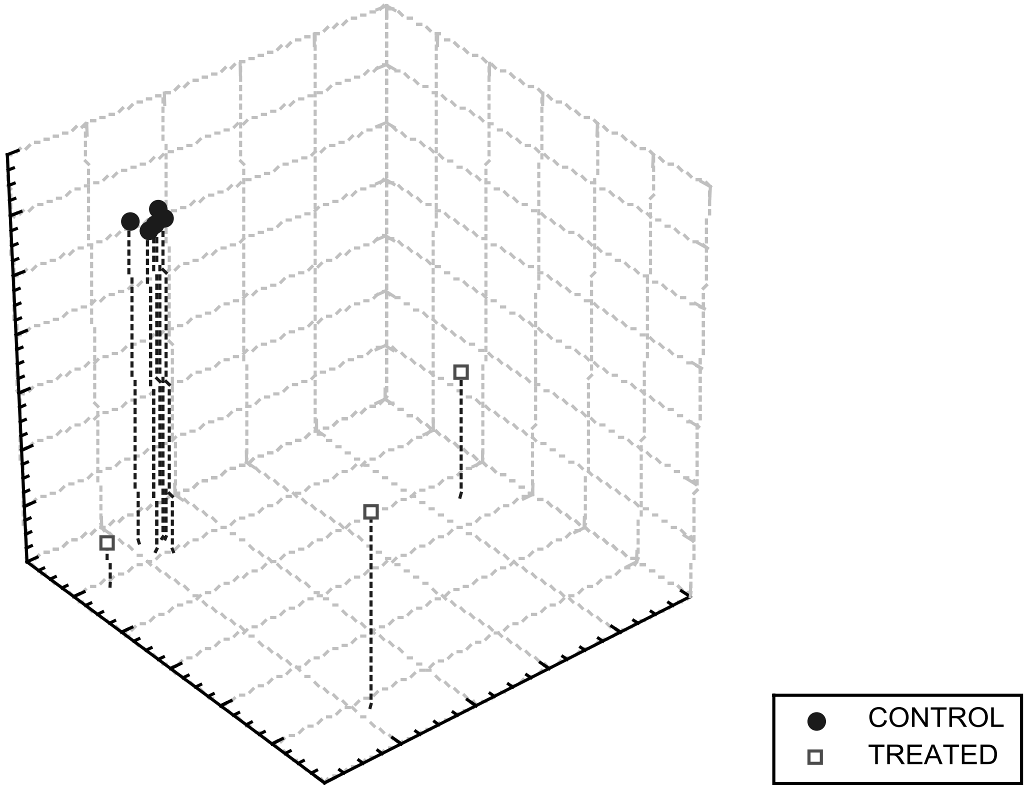

Figure 5. MDS ordination of macrobenthic community data. (●) Control: samples collected before the experimental haul; (□) treated: samples collected along the track after the experimental haul. Stress level = 0.01.

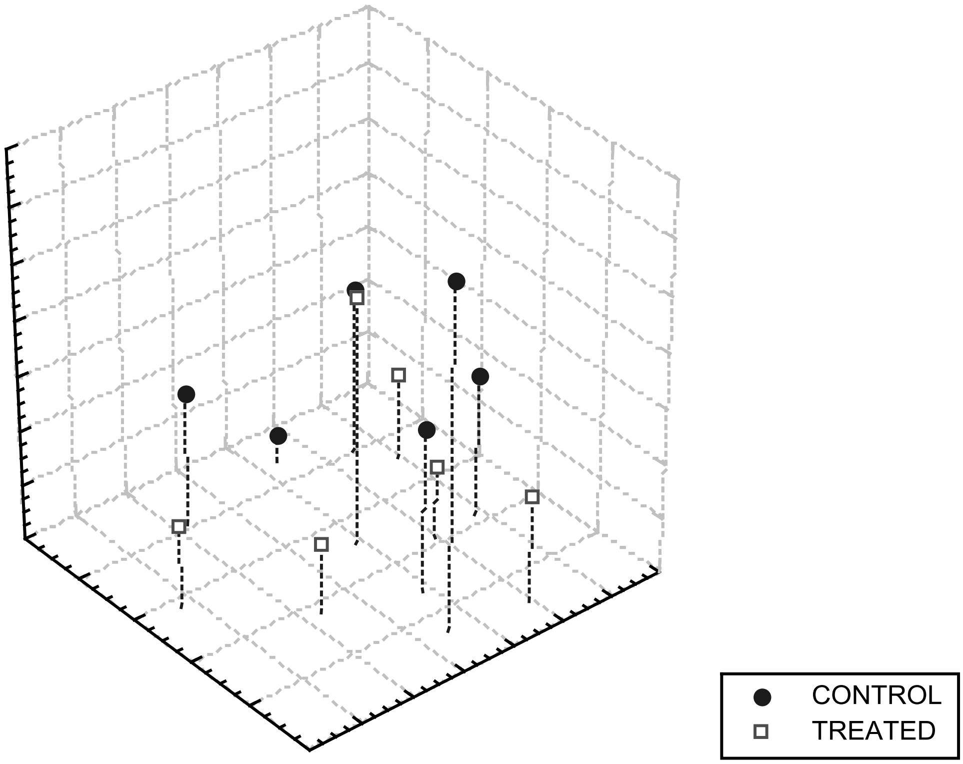

Figure 6. MDS ordination of meiobenthic community data. (●) Control: samples collected before the experimental haul; (□) treated: samples collected along the track after the experimental haul. Stress level = 0.09.

and van Beusekom (1992), for other resuspension sources. All this could explain the “Tapes paradox”, which is the apparent benefit of *Tapes* populations to exploitation. As reported by Pranovi *et al.* (2003), to sustain the huge clam biomass an external energetic input is required, because the concentration of the suspended food in the Venice Lagoon is occasionally below the threshold demanded by Manila clams.

One of the main effects of the resuspension activity is an increase in water turbidity (see also Black and Parry 1994), which could profoundly affect primary production (both in the water column and on the bottom). In the Venice Lagoon a significant increase in water turbidity has been recorded since the beginning of the 1990s (Sfriso and Marcomini, 1996).

Moreover, the resuspended sediment could be transported by natural hydrodynamics, e.g. tidal currents, and eventually reach deeper channels and be driven outside the lagoon. Even if the resuspended sediment is redeposited in other shallow areas, it would not be well stabilized and would therefore be more exposed to erosion processes. So

Table 4. Catch composition and efficiency of rusca dredge. s.d. = standard deviation.

	Wet weight (g m^{-2})	
	Mean	s.d.
Clam density (grab, n = 10)	17.82	23.97
Clam catch (n = 10)	4.55	4.89
Discard (n = 10)	11.36	5.83
Debris (n = 10)	222.54	82.92
Gear efficiency (%)	25.51	–
Discard/commercial ratio	2.50	–

Table 5. Mechanical clam fishery features.

Fishing ground clam density (kg m^{-2}) (Casale *et al.*, 2001)	0.37
Rusca dredge efficiency (%) (experimental data)	25.50
Lagoon clam production (MT) (Provincia di Venezia, 2000)	40,000.00
Exploitable area (km^2) (experimental data)	134.00
Exploited area (km^2)	428.60
Exploited/exploitable area	3.20
Mobilized sediment (m^{-3} m^{-2}) (experimental data)	0.06
Total mobilized sediment (10^6 m^3 y^{-1})	25,716.00
Organic carbon content (g C_{org} m^{-3}) (experimental data)	780.00
Resuspended energy per haul (kJ m^{-2})	3651.60
Yearly resuspended energy (kJ m^{-2} y^{-1})	11679.70

in the Venice Lagoon, sediment resuspension due to mechanical clam harvesting could produce an additional effect on the natural erosion of the shallow bottoms, which is at present one of the major points in the safeguard policy of the Venice Lagoon (Consorzio Venezia Nuova, 1996).

A larger-scale and long-term experimental approach, coupled to modelling of the fate of suspended particles in relation in their grain size and tidal current, could allow a better understanding of the whole sediment loss process related to mechanical clam harvesting.

Preliminary data on sediment resuspension after a storm event recorded in November 2001 (wind speed 18–19 m s^{-1}, direction N-NE), allowed us to compare rusca effects to storm induced resuspension: SPM due to the natural (caused by storm) resuspension (0.018 g l^{-1}, s.d. = 0.04) was one order of magnitude lower than the quantity recorded after the experimental fishing action. The analysis of time series (1992–2001) (Consorzio Venezia Nuova, unpubl.) revealed that, in the last decade, an average of 13.2 (s.d. = 11.7) events (at least 1 h of length) and 7.8 (s.d. = 6.8) events (at least 6 h in length) of wind with speed higher than 15 m s^{-1} have been recorded. Since data collected indicate that the *Tapes* fishing grounds are, on average, swept 3.2 times per year, on an annual basis mechanical clam harvesting produces a resuspension (measured in terms of SPM) at least comparable to that caused by large-scale events such as storms. Obviously, the comparison between disturbance from storms and fishing could give only an order of magnitude of the two phenomena, due to the different way in which this resuspension occurs: storm tends to have a simultaneous, broad-scale effect quite different from the patchy, localized effect of fishing.

Conclusions

- The experimental approach used in this study allowed us to describe the acute effects of rusca dredging on a wide spectrum of ecosystem compartments.
- Preliminary estimates based on the actual fishing effort and evidence from literature suggest that rusca induced disturbance could be comparable to natural disturbance on a basin scale, although this hypothesis needs further large-scale experimental studies.
- The free access system for the exploitation of Manila clams *Tapes philippinarum* could be considered an unsustainable activity for the Venice Lagoon and the rapid adoption of a "culture-based fishery" regime is a desirable target to ensure the management of production processes and to reduce the anthropogenic pressure on the lagoon environment.

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