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EFFECTS OF SCALLOP DREDGING ON A BENTHIC COMMUNITY LIVING ON A SANDY BOTTOM IN THE ADRIATIC SEA

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RIASSUNTO

Effetti della pesca alla cappasanta ser una comunità bentonica presente su un fondale sabbioso dell'Adriatico.

L'Adriatico è l'unico mare italiano dove l'attrezzo a strascico denominato 'rapido' è utilizzato su vasta scala, sia per la pesca della cappasanta *(Pecten jacobaeus) e* deI canestrello *(Aequipecten opercularis)* nelle zone sabbiose al largo sia per la pesca dei pesci piatti *(Solea* spp. *e Platichthys flesus)* nei fondali fangosi sottocosta. Con questo studio ci si è proposto di valutare gli effetti del passaggio del rapido, a breve/medio termine (90 giorni), su una comunità bentonica (frazione meio e macrobentonica) in un'area sperimentale. L'impatto di tipo fisico provocato dal passaggio dell'attrezzo è risultato simile a quello descritto per altri tipi di reti da traino: un solco piatto tracciato sul fondale (visibile con l'impiego di un side-scan sonar), la perdita della frazione più grossolana dello strato superiore del sedimento, e la rimozione degli organismi appartenenti all'epifauna e dei detriti (conchiglie e concrezioni calcaree). Nella struttura della comunità macrobentonica si sono avute grosse modificazioni, maggiormente evidenti nel periodo immediatamente successivo al passaggio del rapido. Per quanto riguarda la comunità meiobentonica, è probabile che i cambiamenti siano stati provocati dall'impatto sul sedimento, e sono stati rilevati dopo una settimana dal passaggio dell'attrezzo.

ABSTRACT

In the Adriatic Sea, the use of 'rapido' gear is widespread for fishing scallops *(Pecten jacobaeus)* and queen scallops *(Aequipecten opercularis)* in sandy offshore areas, and flatfish *(Solea* spp. and *Platichthys flesus)* in muddy inshore areas. The aims of this study were to evaluate the immediate/short-term (90 days) effects of rapido dredging on the benthic community (meio- and rnacrobenthic fractions) in an experimental area. The physical disturbance produced by the rapido is quite similar to that of other towed gear: a flat track on the bottom (visible by means of side-scan sonar), depletion of the coarser fraction in the upper sediment layer, and removal of epifaunal organisms and debris (shells, calcareous concretions). Rapido dredging induces modifications in the macrobenthic community structure, being more evident immediately after the haul. Changes in the meiobenthic community, recorded after one week, are probably due to sediment disturbance.

Key words: bottom-trawling impact, community changes, macrobenthos, meiobenthos, Adriatic Sea

INTRODUCTION

Fishing is the most widespread human exploitative activity in the marine environment (Jennings & Kaiser, 1998) and is identified as the most ubiquitous agent in changing marine biodiversity (NRC, 1995).

Many fishing gears produce direct effects on population structure and habitats, which may vary greatly according to gear and habitat, and indirect effects on non-target species, which may lead to changes in community and habitat structure (Jennings & Kaiser, 1998).

Mobile, or active, demersal gear such as trawls and dredges, designed to maximise their contact with the bottom, have major environmental effects on the benthic community, epi- and infaunal organisms, and the physical environment. They scrape or plough the seabed, resuspend sediments by destabilising the bottom, and remove or scatter non-target species (Collie *et al.*, 1997; (Gilkinson *et al.*, 1998).

Studies of trawling effects (both short- and long-term) on benthic communities have often been hampered by the lack of suitable unfished control areas, which have great value as comparative tools (Kaiser & de Groot, 2000). At present, a substantial proportion of the sea bottom may be covered with trawl or dredge tracks in intensively fished areas, some zones being fished several times per year (Rijnsdorp *et al.*, 1998). The western portion of the Northern Adriatic may also be included among these areas (Ardizzone, 1994): approximate estimates indicate that the inshore area off the Lagoon of Venice is fished ten times per year by commercial vessels equipped with `rapido' gears (unpublished data).

In order to quantify the effects of fishing disturbance on the benthic habitat, a growing number of studies have been carried out using a BACI (Before vs. After, Control vs. Impact) experimental design (see Underwood, 1992). This approach has provided information about immediate short-term (a few months) (Thrush *et al.*, 1995; Tuck *et* al., 1998) and long-term (years) effects on the benthos (Hall-Spencer & Moore, 2000).

The aim of this study was to assess the short-term effects of rapido trawling on the benthic community. Immediate/short-term modifications induced by experimental rapido trawling on the meio- and macrobenthos of a sandy bottom area near a large wreck are reported, and the benthic community structures of fished and unfished areas are compared.

MATERIALS AND METHODS

The 'rapido' gear (Fig. 1) consists of a box dredge (3 m wide, 120 Kg in weight) rigged with teeth (5-7 cm long) along the lower leading edge and a net bag to collect the catch (Giovanardi *et al., 1998;* Hall-Spencer *et al.,* 1999*).* An inclined wooden board is fitted to the front of the metal frame, acting as a spoiler and keeping the gear, which is towed at a speed of 5 knots, in contact with the sea bed. It is used in the Adriatic for fishing scallops *(Pecten jacobaeus)* and queen scallops *(Aequipecten opercularis)* on sandy offshore bottoms, and flatfish *(Solea spp., Platichthys flesus)* on muddy inshore bottoms.

Fig. l: 'Rapido' gear.
Fig. I: Particolare del 'rapido'.

The experimental site was located at a depth of 24 m, near a 90-m-long wreck sunk in 1943 11 NM cast of the Lagoon of Venice in the North-Western Adriatic (Fig. 2). This allowed researchers to operate in an unfished area, with environmental features similar to those of the surrounding fishing grounds (see also Ball *et al.,* 2000). Such submerged structures may modify the local benthic community (Jennings & Kaiser, 1998*),* but their presence also prevents interference by intensive commercial fishing when experiments are in progress.

Side-scan sonar surveys (Model 260TH surface control unit, Model 272 TD " tow fish"; Edgetech Ltd.) were performed before and after experimental fishing in order to verify the absence of fishing activity around the wreck and to analyse track 'survival time' (Fig. 2).

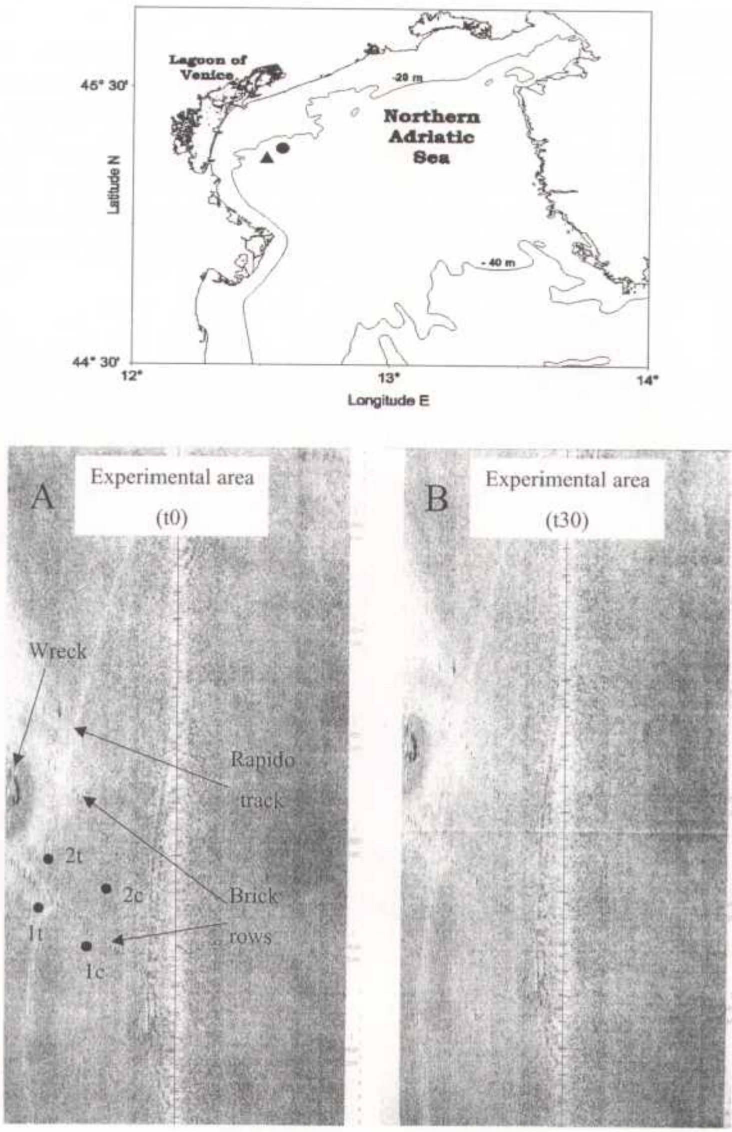


Fig. 2: Location of experimental area (●) and neighbouring fishing ground (▲). A) Side-scan sonar picture immediately after experimental haul. B) Side-scan sonar picture one month after experimental haul: track still clearly visible.

Fig. 2: Ubicazione dell'area sperimentale (●) e dei fondali di pesca adiacenti (▲). A) immagine dal side-scan sonar immediatamente dopo la pescata sperimentale. B) immagine dal side-scan sonar un mese dopo la pescata: il solco del passaggio dell'attrezzo è ancora ben visibile.

The experiment commenced in December 1998 and consisted of creating a treated plot (t) by means of a commercial 'rapido', and an adjacent untreated control plot (e). Samples were collected immediately before and after the experimental haul (cO and tO), after one week (c7and t7) and after one (c30 and t30) and three months (c90 and t90).

Macrobenthos samples were collected by scuba divers using a water-lift sampler (bag mesh size 1 mm, 0.3 m^2 area x 20 cm depth). Cores (5 cm diameter, 12 cm depth) were also collected for meiobenthos and grain size analysis. Macro- and meiobenthos samples were also collected in the commercial fishing ground near the experimental site (500 m) (Fig. 2). Macrobenthos and grain-size samples were stored at -15°C; meiobenthos samples were fixed in 4 (Yo buttered formalin. Each grain-size sample was treated with a H202-distilled water solution (for 48 h at room temperature) in order to eliminate the organic fraction. The two grain-size classes obtained on a 62.5-µm-sieve were dried at 105°C and 40°C respectively and then weighed. Macrobenthic organisms were separated and classified to their lowest practical taxonomic level. All specimens were counted and their wet weight was recorded for each taxon. Meiofaunal samples were first washed on a 63-µm-sieve to remove formalin and most of the fine sediment. Meiofauna was then extracted by elutriation in fresh water and decantation through the sieve. The main taxa were then identified.

A Bray-Curtis similarity matrix, applied to 'fix transformed data and followed by multi-dimensional scaling (MDS) (Kruskal & Wish, 1978) assessed the differences incommunity structure among the treatments.

Differences observed between sites were then tested by the `analysis of similarities' randomisation test - ANOSIM - (Clarke & Green, 1988). Analyses of community structure were performed using the Primer software package (Clarke & Warwick, 1994).

RESULTS

The pre-trawling side-scan sonar survey confirmed that the experimental area showed no traces of commercial fishing - which were instead obvious all around. The experimental track was still clearly visible three months after the haul (Fig. 2).

On the basis of grain-size analysis, the sediment of the experimental area makes up a sandy bottom. Cores collected immediately after dredging showed depletion of the coarser fraction (phi -0.5) in the upper layer (0-4 cm), whereas the bottom of the cores (10-12 cm) showed no changes between treated and control plots (Fig. 3).

Scuba diving observations showed that the rapido trawl did not produce a sharp furrow, but removed more than 50% of epifaunal organisms and debris along a flattened track. Debris, mainly composed of shells and calcareous concretions, was then redistributed in clumps along the track (Figs. 4 and 5). Underwater video recordings made after trawling showed that scavenging hermit crabs, brittlestars and gastropods were highly active along the track, where dead or damaged organisms were observed.

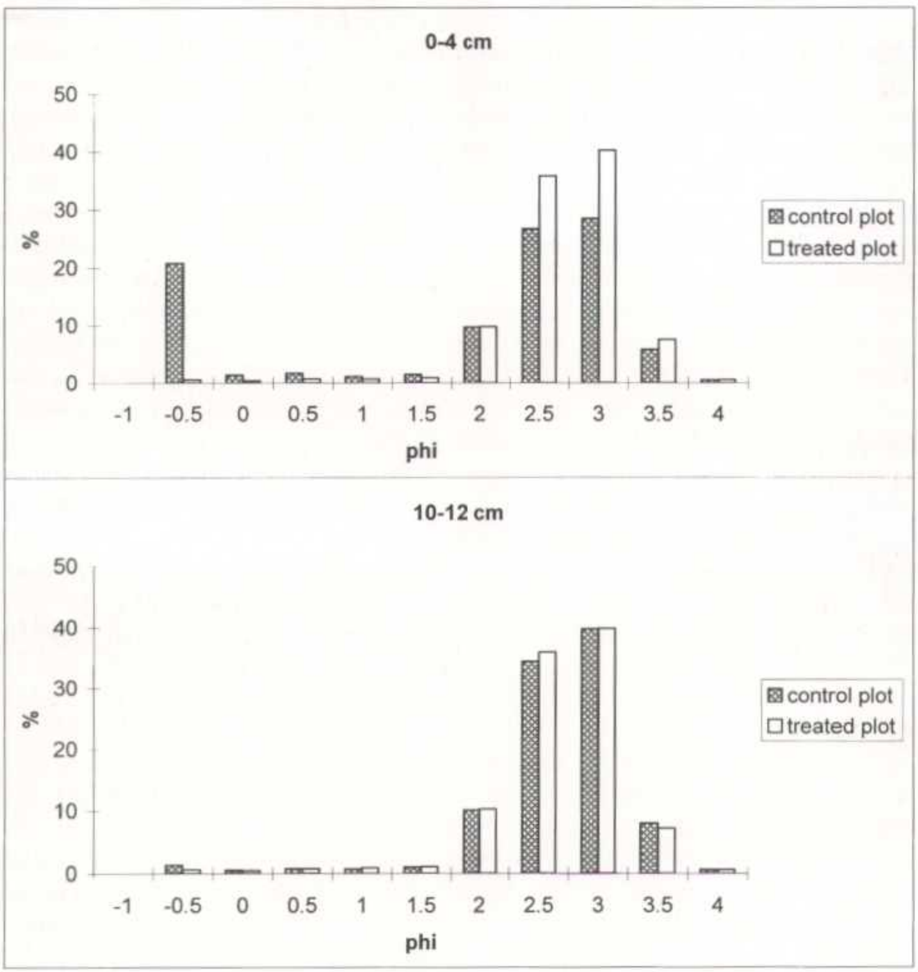


Fig. 3: Sediment grain size of samples collected before (top) and immediately after haul.

Fig. 3: Granulometria del sedimento dei campioni prelevati prima e immediatamente dopo la pescata.

Fig. 4: Picture of bottom before trawling.
Fig. 4: Immagine del fondo prima del passaggio del rapido.

Fig. 5: Picture of bottom soon after trawling.
Fig. 5: Immagine del fondo appena dopo il passaggio del rapido.

Macrobenthos

186 taxa belonging to 8 invertebrate phyla were identified (Annex 1).

In terms of abundance, the community was dominated by Annelida, Arthropoda and Mollusca; in terms of wet biomass, Mollusca prevailed (Fig. 6).

Fig. 7 shows total numbers of species and of individuals. The values recorded in the treated plot were always lower than those of the respective control. Differences were statistically significant (Mann-Whitney U-test) one and three months after the haul. After only one week, the treated plot showed a higher value, mainly due to an increase in Arthropoda and Echinodermata (see Fig. 6). The Margalef and ShannonWeaver indices followed the same pattern recorded for the total numbers of species and individuals (Fig. 8).

The values recorded in the fishing ground (f), for all parameters considered so far, were always significantly lower than those recorded in the control plot and quite similar to those in the treated plot one and three months after the haul.

MDS ranking of macrobenthic data (Fig. 9) showed differences among treated groups. Immediately after the experimental haul, samples were more scattered, whereas after three months they were more closely grouped. ANOSIM revealed statistically significant differences (p=0.04) among the treated groups.

Meiofauna

Analysis of meiobenthos revealed 32 taxa (Annex 2), of which Nematoda, Nemertini, Cirratulidae, Paraonidae, Sididae, Copepoda and Harpacticoida were the most important groups in terms of abundance.

Data collected showed an increasing trend in the treated plot as regards total number of species, which peaked after one month and then decreased; instead, the total number of individuals peaked after three months (Fig. 10).

The Margalef and Shannon-Weaver indices showed an increasing trend in the treated plot, with a peak one month after the haul (Fig. 11).

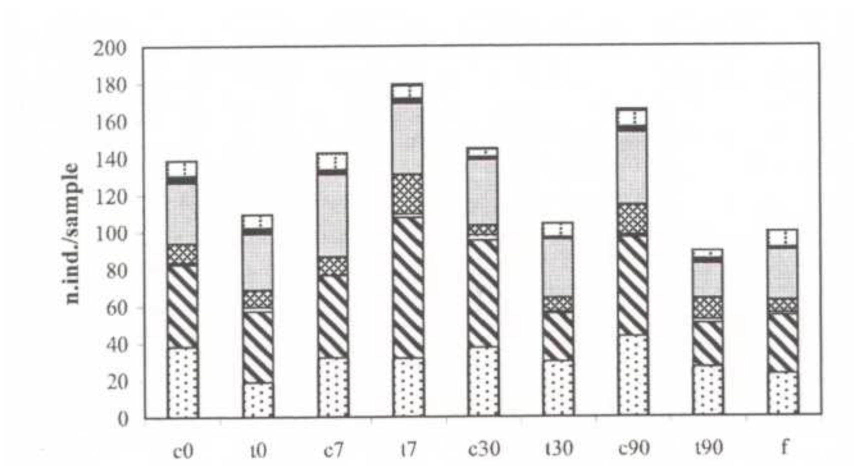
Values recorded in the fishing ground for total numbers of species and of individuals and the Margalef index were always higher (total number of individuals was statistically significant) than those of the control plot. The Shannon-Weaver index showed the lowest values, due to the prevalence of a few species (mainly Nematoda).

MDS ranking of meiobenthic data showed that the community structure changed with time, the samples collected one week after the haul being more scattered than those collected at tO and after one and three months (Fig. 12). ANOSIM revealed statistically significant differences (p=0.04) among treated groups.

DISCUSSION

Rapido trawling on a sandy bottom produces flattening of sediment seabed features, as described for other towed demersal gear (Thrush *et al.*, 1995; Currie & Parry, 1996; Kaiser & Spencer, 1996), leaving a track still distinguishable by side-scan sonar at least 3 months later.

A)



B)

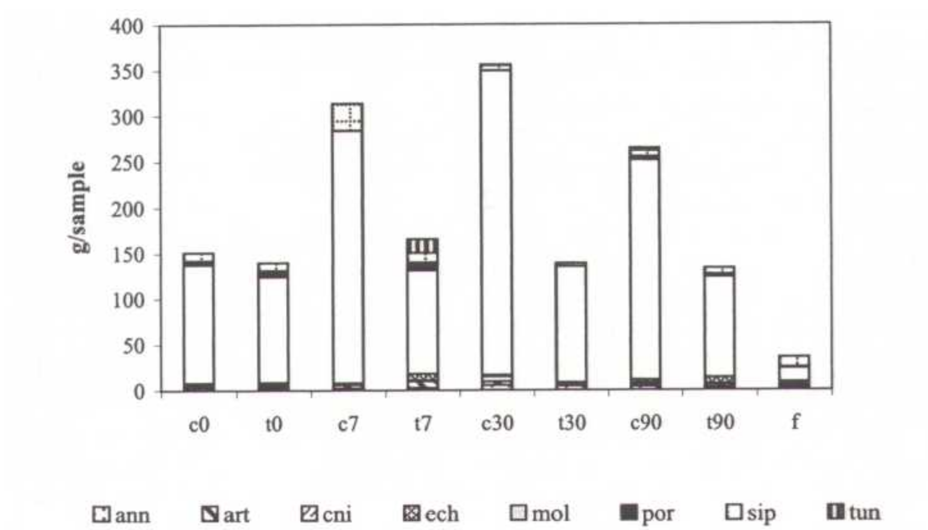
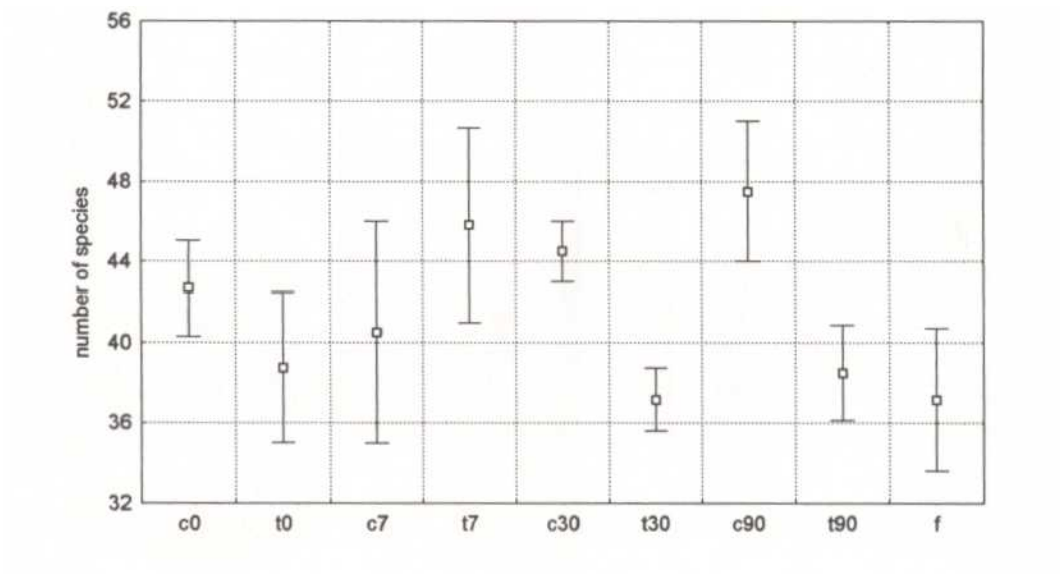


Fig. 6: Phyla distribution of abundance (A) and biomass (B) data in treated plot (tun = Tunicata, ech = Echinodermata, art = Artropoda, mol = Mollusca, ann = Annelida, sip = Sipunculida, por= Porifera)..

Fig. 6: Distribuzione dei phyla sulla base dei dati di abbondanza (A) e biomassa (B) nelle aree sperimentali (tun = Tunicates, ech = Echinodermata, art = Artropoda, mol = Mollusca, ann = Annelida, sip = Sipunculida, por = Porifera).

A)



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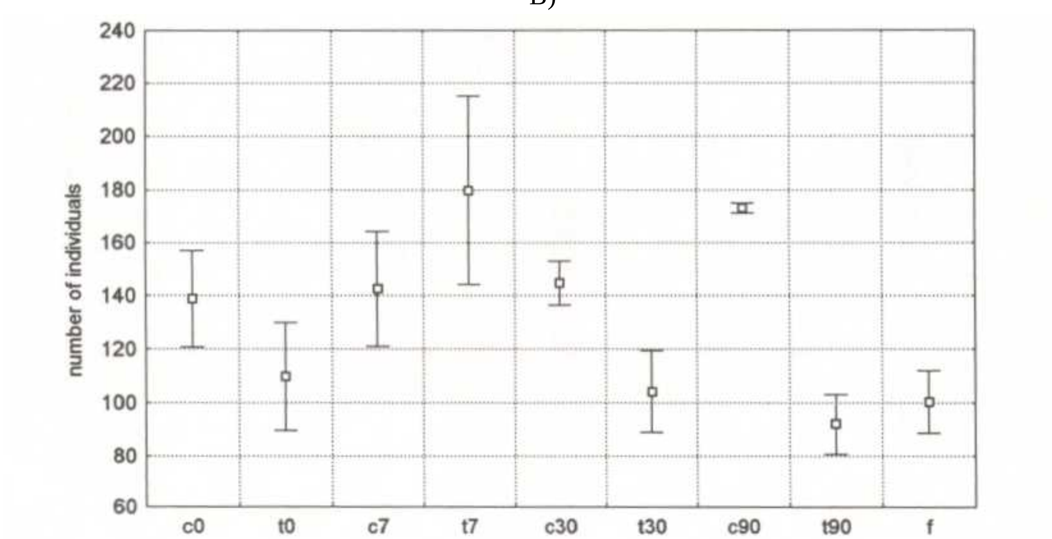
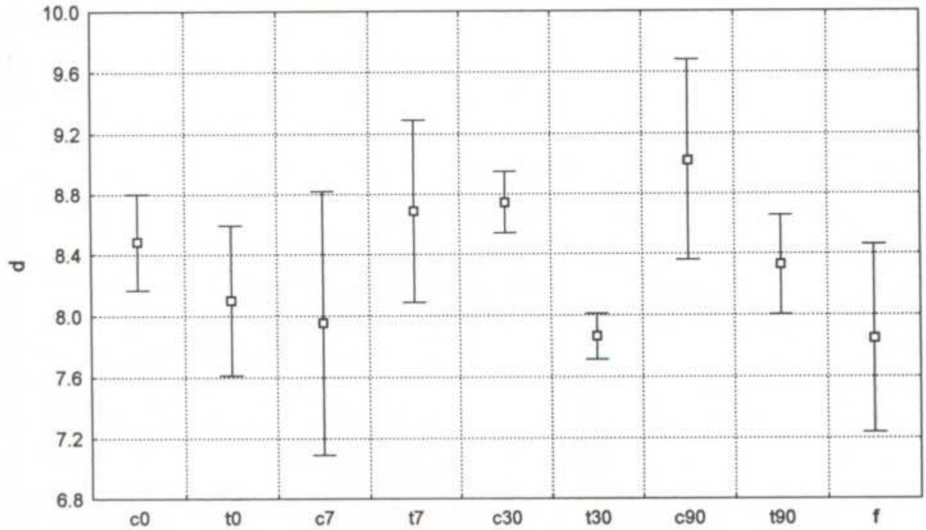


Fig. 7: Macrobenthos: total numbers of species (A) and of individuals (B) in treated plot.

Fig. 7: Numero totale delle specie macrobentoniche (A) e numero totale degli individui (B) nelle aree sperimentali.

A)



B)

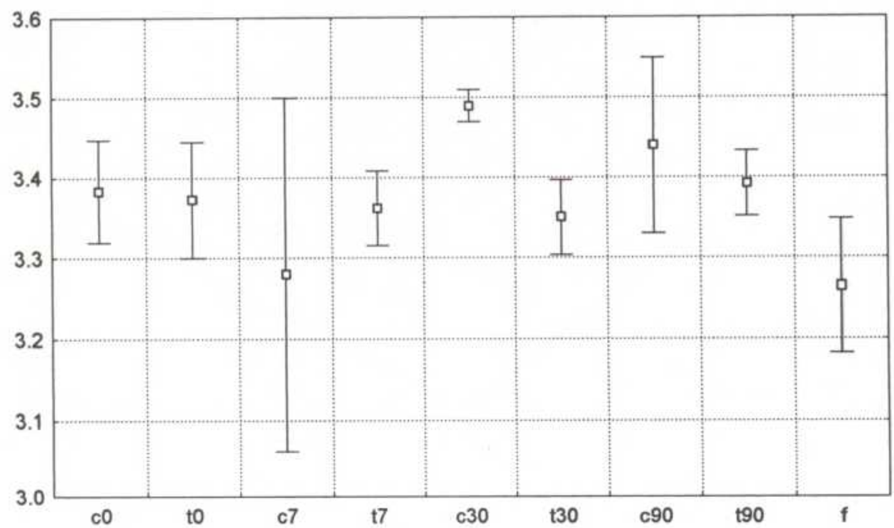


Fig. 8: Margalef (A) and Shannon-Weaver indices (B) of macrobenthos in treated plot.
Fig. 8: Indici di Margalef (A) e Shannon-Weaver (B) del macrobenthos nelle aree sperimentali.

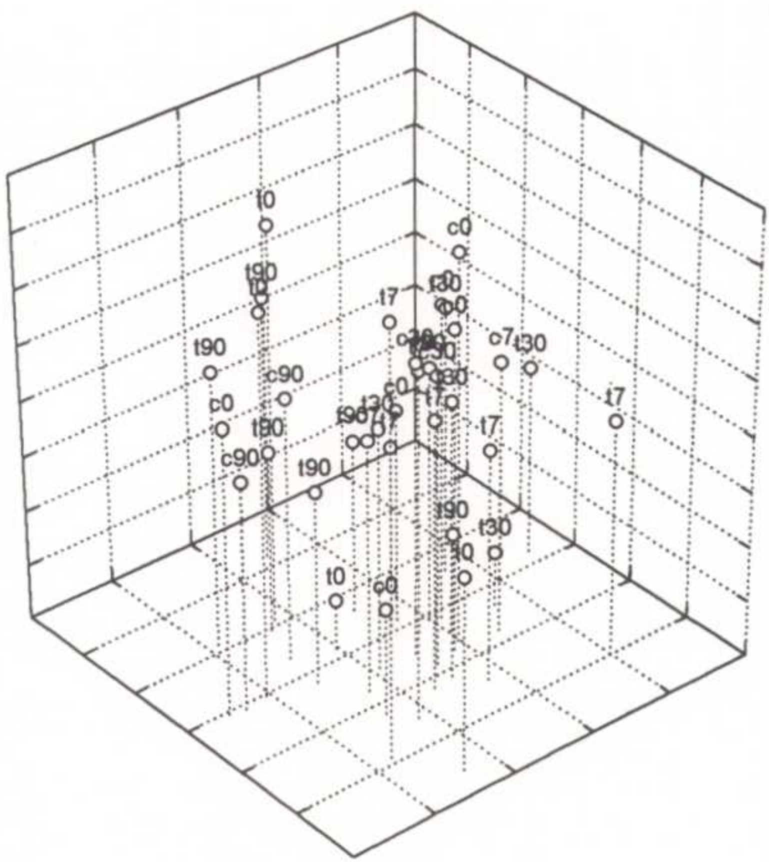
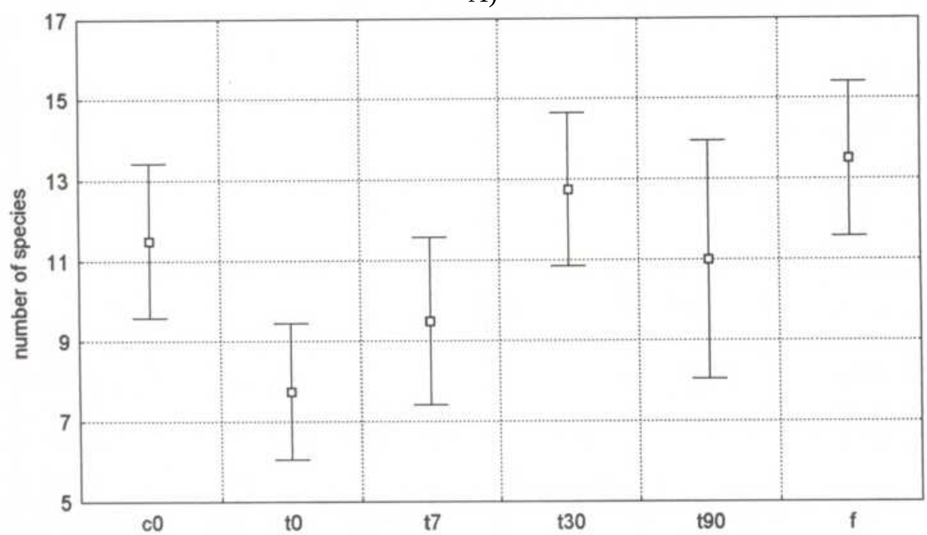


Fig. 9: MDS ranking of macrobenthic data (stress level = 0.10). All replicates are represented; numbers refer to stations; c=control, t= treated plot.

Fig. 9: Raggruppamento MDS dei dati del macrobenthos (livello stress = 0.10). Sono rappresentate tutte le repliche; i numeri sono riferiti alle stazioni; c=controllo, t=area di studio.

A)



B)

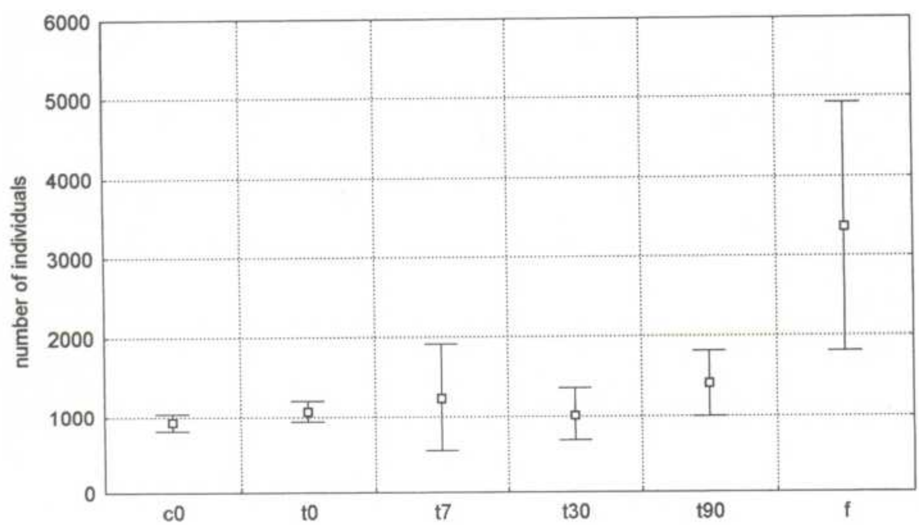
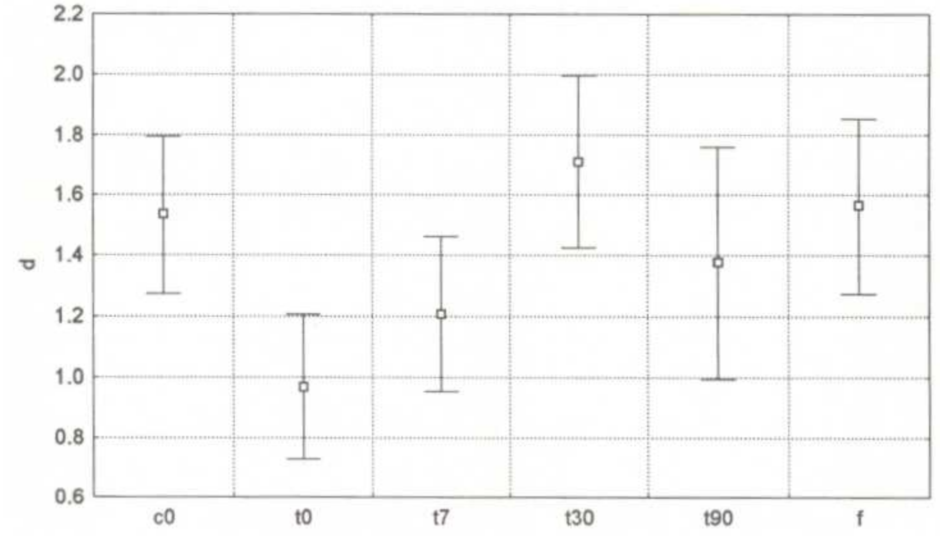


Fig. 10: Meiobenthos: total numbers of species (A) and individuals (B) in treated plot.

Fig. 10: Numero totale delle specie meiobentoniche (A) e numero totale degli individui (B) nelle aree sperimentali.

A)



B)

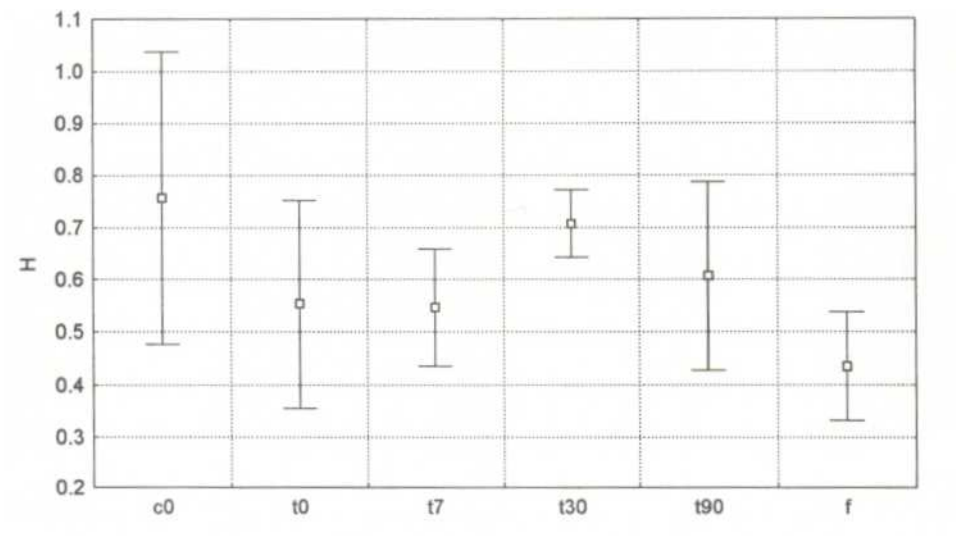


Fig. 11: Margalef (A) and Shannon-Weaver indices (B) of meiobenthos in treated plot.
Fig. 11: Indici di Margalef (A) e Shannon-Weaver (B) del meiobenthos nelle aree sperimentali

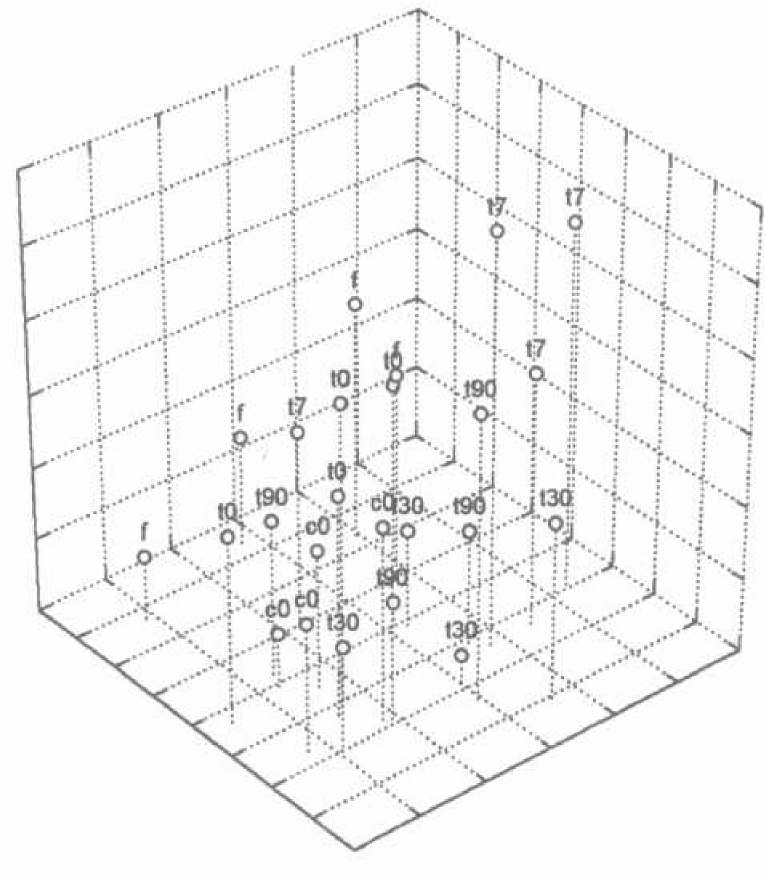


Fig. 12: MDS treated plots of meiobenthic data (stress level =0.020).

Fig. 12: Raggruppamento MDS dei dati del meiobenthos (livello stress =0.020).

The physical effects recorded along our experimental track were quite similar to those reported for shellfish dredges and heavy flatfish beam trawls in the North Sea (Hall, 1999). Moreover, the rapido produced obvious disturbance in the upper 4-6 cm of sediment, and diving observations revealed that dredging smoothed the substratum, with extensive redistribution of shells and calcareous concretions on the sediment surface.

The consequences of this type of disturbance on benthic fauna are poorly known (Kaiser & Spencer, 1996), although they probably influence settlement and colonization, and damage or kill epifauna living on shells and organic debris. On a flat sandy bottom, empty shells may play an important ecological role in structuring the epibenthic community, since these biogenic structures often act as substrates for sessile organisms (mainly sponges and ascidians) which then allow settlement by a wide range of mobile species, producing "multi-species clumps" (Fedra *et al.*, 1976; Stachowitsch, 1991).

Rapido trawling causes pronounced disturbance in the macrobenthic community, with great differences in the total numbers of species and individuals and in diversity indices.

Immediately after the haul, all considered parameters showed lower values in the treated plot than in the control one. After one week, the number of taxa and total number of individuals increased in the treated plot (significantly comparing with t0), and then fell again, reaching t0 values. This was mainly due to an increase in the numbers of 'scavengers' (e.g. *Paguristes oculatus)* and opportunistic species (e.g., *Syllis cornuta, Pisidia longimana, Labidoplax digitata)* profiting from the greater avail ability of food along the disturbed sediment track. These species may then leave the track when food availability decreases.

Instead, the diversity increase recorded in the control plot after three months was probably related to seasonal changes in the benthic community. Analysis of the community structure indicated high dispersion of samples collected immediately after dredging, probably due to increased heterogeneity among samples as a result of disturbance caused by the gear (see Kaiser & Spencer, 1996). After three months heterogeneity decreased, and the treated plot community structure approached that of the control.

The experimental design adopted was very conservative, since commercial exploitation involves repeated trawling in the same area and produces considerable disturbance. This was demonstrated by comparing the unfished control and neighbouring fishing ground, where lower densities of Porifera, Mollusca and Annelida were recorded, as reported for other locations (see Fig. 4) (Sainsbury, 1988; Bergman & Hup, 1992; Eleftheriou & Robertson, 1992; Hall-Spencer *et al.,* 1999).

Meiofauna is often employed in pollution monitoring surveys (Coull & Chandler, 1992; Somerfield et al., 1994), due to its high sensitivity to chemical disturbance (Warwick, 1993). Our data allow a preliminary description of effects induced by rapido trawling on this component of the benthic system. Immediately after trawling, the number of taxa and the Margalef, Shannon-Weaver and evenness indices all showed a decrease. Then those values increased and peaked after one month, when the diversity measures became comparable or higher than those recorded in the control plot. Analysis of community structure indicated higher dispersion one week after the haul. This pattern may be due to the fact that fishing did not produce direct effects on meiofauna (which would be visible at t0), but disturbance was mediated by sediment reworking which later induced structural changes.

CONCLUSIONS

This study proves that, on an undisturbed (unfished) 25-m-deep sandy bottom, rapido tracks may persist for up to three months. This information is useful for any future estimate of total areas swept by commercial rapido fleets in the Adriatic. Disturbance effects induced on the benthic community also persist for a few months. Analysis of community structure also highlighted the different behaviour between macrofauna (directly damaged by the gear) and meiofauna (indirectly damaged and showing delayed effects), as also revealed by data from the fishing ground. Studies like the present one need to be integrated with large-scale surveys in order to provide a practical mechanism for assessing the wider ecological effects of trawl-fishing (Thrush *et al.*, 1995; Jennings & Kaiser, 1998).

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REFERENCES

ARDIZZONE G. D. 1994. An attempt of a global approach for regulating the fishing effort in Italy. *Biol. Mar. Medit., 1:* 109-113.

BALL B., MUNDAY B. & TUCK 1. 2000. Effects of otter trawling on the benthos and environment in muddy sediments. In *Effects of fishing on non-target species and habitats: biological, conservation and socio-economic issues. (M.J.* Kaiser, & S.J.de Groot eds.). Blackwell Science, Oxford, 399 pp: 69-82.

BERGMAN M.J.N. & HuP M. 1992. Direct effects of beam-trawling on macrofauna of a sandy sediment in the southern North Sea. *ICES J. Mar. Sci., 49:* 5-13.

CLARKE K.R. & GREEN R.H. 1988. Statistical design and analysis for a `biological effects' study. *Mar Ecol. P S.,* 46: 213-226.

CLARKE K.R. & WARWICK R.M. 1994. *Change in marine communities: an approach to statistical analysis and interpretation.* Natural Environmental Research Council, UK, 144 pp.

COLLIE J.S., ESCANERO G.A. & Valentine P.C. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. *Mar Ecol. P S., 155:* 159-172.

COULL B.C. & CHANDLER G.T. 1992. Pollution and meiofauna: field, laboratory and mesocosm studies. *Oceanogr. Mar Biol. Ann. Rev.,* 30: 191-271.

CURRIE D.R. & PARRY G.D. 1996. Effects of scallop dredging on a soft sediment community: a large scale experimental study. *Mar. Ecol. P S.,* 134: 131-150.

ELEFTHERIou A. & ROBERTSON M.R. 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. *Neth. J. Sea Res.,* 30: 289-299.

FEDRA K., OLSCHER E.M., SCHERÜBEL C., STACHOWITSCH M., WURZIAN R.S., 1976. On the ecology of a North Adriatic benthic community: distribution, standing crop and composition of the macrobenthos. *Mar. Biol.,* 38: 129-145.

GILKINSON K., PAULIN M., HURLEY S. & SCHWINGHAMER P. 1998. Impact of trawl door scouring on infaunal bivalves: results of a physical trawl door/dense sand interaction.
J. exp. Mar. Biol. Ecol., 224: 291-312.

GIOVANARDI O., PRANovI F. & FRANCESCHINI G. 1998. "Rapido" trawl-fishing in the Northern Adriatic: preliminary observations on effects on macrobenthic communities. *Acta Adriatica 39:* 37-52.

HALL S.J. 1999. *The effects of fishing on marine ecosystems and communities.* Blackwell Scientific, Oxford, 274 pp.

HALL-SPENCER J.M., FROGLIA C., ATKINSON R.J.A. & MOORE P.G. 1999. The impact of Rapido trawling for scallops, *Pecten jacobaeus (L.),* on the benthos of the Gulf of Venice. *ICES) Mar. Sci., 56:* 111-124.

HALL-SPENCER, J.M. & MOORE, P.G. 2000. Impact of scallop dredging on maerl grounds. In *Effects of fishing on non-target species and habitats: biological, conservation and socio-economic issues. (M.J.* Kaiser, & S.J. de Groot eds.) Blackwell Science, Oxford, 399 pp: 105-116.

JENNINGS S. & KAISER M.J. 1998. The effects of fishing on marine ecosystems. *Adv. Mar. Biol.,* 34, 351 pp.

KAISER M.J. & SPENCER B.E. 1996. The effects of beam-trawl disturbance on infaunal communities in different habitats. *J. Anim. Ecol.,* 65: 348-358.

KAISER M.J. & DE GROOT S.J. 2000. Effects of fishing on non-target species and habitats: biological, conservation and socio-economic issues. Blackwell Science, Oxford, 399 pp.

KRUSKAL J.B. & WISH M. 1978. Multidimensional scaling. *Sage Pub.,* Beverley Hills, CA.

NATIONAL RESEARCH COUNCIL (NRC) 1995. Understanding marine biodiversity: a research agenda for the nation. National Academy Press, Washington, DC.

RIJNSDORP A.D., BUIJS A.M., STORBECK F.&VISSER E. 1998. Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms. *ICES J. Mar. Sci.,* 55: 403-419.

SAINSBURY K.J. 1988. The ecological basis of multispecies fisheries and management of a demersal fishery in tropical Australia. In *Fish population dynamics. (J.A.* Gulland ed.) Wiley, Chichester, 349-382.

SOMERFIELD P.J., GEE J.M. & WARWICK R.M. 1994. Soft sediment meiofaunal community structure in relation to a long-term heavy metal gradient in the Fal estuary system. *Mar. Ecol. P S.,* 105: 79-88.

STACHOWITSCH M., 1991. Anoxia in the Northern Adriatic Sea: rapid death, slow recovery. In *Modern and ancient continental shelf anoxia.* (R.V Tyson & T.H. Pearson eds.). Geological Society Special Publication No. 58, 119-129.

THRUSH S.F., HEWITT J.E., CUMMINGS VJ & DAYTON P.K. 1995. The impact of habitat disturbance by scallop dredging on marine benthic communities: what can be predicted from the results of experiments? *Mar. Ecol. P S.,* 129: 141-150.

TUCK I.D., HALL S.J., ROBERTSON M.R., ARMSTRONG E.&BASFORD D.J. 1998. Effects of physical trawling disturbance in a previously unfished sheltered Scottish sea loch. *Mar Ecol. P S.,* 162: 227-242.

UNDERWOOD A.J. 1992. Beyond BACI: the detection of environmental impacts on population in the real, but variable, world. *J. Exp. Mar. Biol. Ecol.,* 161: 145-178.

WARWICK R.M. 1993. Environmental impact studies on marine communities: pragmatical considerations. *Aust. J. Ecol.,* 18: 63-80.

Annex 1: List of macrobenthic taxa.
Allegato 1: Elenco delle specie macrobentoniche

		PORIFERA
	Adocia simulans (Johnston)	*Suberites carnosus* (Johnston)
	Alectona millari Carter	*Suberites domuncula* (Olivi)
	Raspaciona aculeata Topsent	
	CNIDARIA	
	SIPUNCULIDA	
	Aspidosiphon mulIeri Dies	*Sipunculus rudes* L
	Phascolosoma vulgare Blainville	
	MOLLUSCA	
Poliplacophora	*Acanthochitona* sp.	
Gastropoda	*Acteon tornatilis* (L.)	*Gibbula magus* (L.)
	Bittium scabrum (Olivi)	*Gibbula racketti* (Payraudeau)
	Bolinus brandaris (L.)	*Lunatia pulchella* (Risso)
	Calyptrea chinensis (L.)	*Mange/ia costulata* (Blainville)
	Capulus hungaricus (L.)	*Melanella* sp
	Ceratostoma erinaceum (L.)	Muricidae
	Cerithiopsis tubercularis (Montagu)	*Nassarius incrassatus* (Stroem)
	Cylichna cylindracea (Pennant)	*Nassarius pigmaeus* (Lamarck)
	Diodora graeca (L.)	*Natica haebrea* (Martyn)
	Diodora gibberula (Lamarck)	*Naticarius stercus-muscarum* (Gmelin)
	Diodora italica (Defrance)	*Ocinebrina aciculata* (Lamarck)
	Fusinus rostratus (Olivi)	*Ocinebrina edwardsi* (Payraudeau)
	Hexaplex trunculus (L.)	*Turbonilla lactea* (L.)
Bivalvia	*Abra* sp.	*Kellia suborbicularis* (Montagu)
	Acanthocardia aculeata (L.)	*Laevicardium oblongum* (Chemnitz)
	Acanthocardia echinata (L.)	*Lucinella divaricata* (L.)
	Acanthocardia tuberculata (L.)	*Modiolarca subpicta* (Cantraine)
	Aequipecten opercularis (L.)	*Modiolus barbatus* (L.)
	Anomia ephippium (L.)	*Nucula nucleus* (L.)

(continua)

		Arca noe L.	*Paphia aurea* (Gmelin)
		Callista thione (L.)	*Phares legumen* (L.)
		Chamelea gallina (L.)	*Pitar rudis* (Poli)
		Chlamys varia (L.)	*Pododesmus patelliformis* (L.)
		Clausinella brongniartii	*Psammobia feryensis* (Gmelin)
		Corbula gibba (Olivi)	
		Donax sp.	*Striarca lactea* (L.)
		Euspira guillemini (Payraudeau)	*Tapes decussatus* (L.)
		Flexopecten proteus (Dillwyn)	*Tellimya ferrugginosa* (Montagu)
		Gastrochaena dubia (Pennant)	*Tellina* sp.
		Hiatella arctica (L.)	*Thracia papyracea* (Poli)
		ANNELIDA	
	Polychaeta		
	Errantia	Aphroditidae	*Lagisca extenuata* (Grube)
		Aponuphis bilineata (Baird)	*Lumbriconereis* sp.
		Arabella geniculata (Claparède)	*Lvsidice ninetta* Audouin & Milne Edwards
		Arahella iricolor (Montagu)	*Marphysa bellii* (Audouin & Milne Edwards)
		Ceratonereis costae (Grube)	*Marphysa sanguinea* (Montagu)
		Doryillea sp.	*Melinna palmata* Grube
		Drilonereis filum (Claparède)	*Nematonereis unicornis* Schmarda
		Eteone sp.	*Nereis* sp.
		Euclymene sp.	*Neanthes succinea* (Frey & Leuchart)
		Euclvmene santanderensis (Rioja)	*Odontosyllis* sp.
		Eunice pennata (O.F. Müller)	*Onuphis eremita* Audouin & Milne Edwards
		Eunice vittata (Delle Chiaje)	*Phyllodoce* sp.
		Eunicidae	*Phyllodoce lineata* (Claparède)
		Euphrosine foliosa Audouin & Milne Edwards	*Phyllodoce madeirensis* (Langerhans)
		Glycera alba (O.F. Müller)	*Phvllodoce mucosa* (Oersted)
		Glycera unicornis Savigny	*Platynereis dumerilii* (Audouin & Milne Edwards)

(continua)

	Galathea intermedia Lilljcborg	*Processa* sp.	
	Hippolytidae	*Squilla mantis* Fabricius	
	Ilia nucleus (L.)	*Sycionia carinata* (Brunnich)	
	Inachus dorsettensis (Pennant)	*Thoralus chranchii* (Leach)	
	Isopoda	*Thoralus sollaudi* (Zariquiey Cenarro)	
	Liocarcinis maculatus (Risso)	*Thoralus* sp.	
	Liocarcinus pusillus (Leach)	*Upogebia tipica* (Nardo)	
	Lysiosquilla eusebia Risso	Xanthidae	
	ECHINODERMATA		
Holothuroidea	*Cucumaria plancii* (Brandt)	*Labidoplax digitata* (Montagu)	
Echinoidea	*Psammechinus microtuberculatu,* (Blainville)		
Ophiuroidea	*Amphipholis squamata* (Delle Chiaje)	*Ophiura albida* Forbes	
	Amphiura cherbonnieri (Lyman)	*Ophiura ophiura* (Lamarck)	
	Amphiura chiajei Forbes	*Ophiura* sp.	
	Ophiotrix fragilis (Abild.)		
	TUNICATA		
	Ascidia mentula (Muller)	*Phallusia mamillata* (Cuvier)	
	Microcosmus sulcatus Coquebert	*Pyura* sp	

Annex 2: List of meiobenthic taxa.
Allegato 2: Elenco delle specie meiobentoniche

	PLATHELMINTHES	
	Turbellaria	
	NEMERTINI	
	ASCHELMINTHES	
	Kinorhyncha	Nematoda
	ANNELIDA	
Polychaeta		
Errantia	Aphroditidae	Nereidae
	Eunicae	Phyllodocidae
	Glyceridae	Syllidae
	Nephthydidae	
Sedentaria	Cirratulidae	Poeciloehaetidae
	Magelonidac	Sabellidae
	Maldanidae	Serpulidae
	Paraonidae	Spionidae
	Paraonidae (larve)	Terebellidae
	ARTHROPODA	
Crustacea	Anisopoda	Gammaridae
	Apseudidae	Harpacticoida
	Calanoida	Polyphemidae
	Copepoda (Nauplius)	Sididae
	Cypridinidae	
Chelicerata	Halacaridae	
	TENTACULATA	
	Phoronis mülleri Selys-Long	

	Glyceridae	*Sthenelais* sp.	
	Goniada sp.	Syllidae	
	Harmothoe imbricata L.	*Trypanosyllis coeliaca* Claparède	
	Harmothoe sp.		
Sedentaria	Amphictenidae	Maldanidae	
	Arenicola marina (L.)	*Pectinaria auricoma* (O.F. Müller)	
	Aricia sp.	*Petaloproctus terriculosus* Quatrefages	
	Ariciidae	*Phylo kupferi* (Ehlers)	
	Caulleriella zetlandica (Mc Intosh)	Sabellidae	
	Cirriformia filigera (DelleChiaje)	*Terebella lapidaria* L.	
	Lanice conchvlega (Pallas)	Terebellidae	
	Maldane glebiflex Grube		
	ARTHROPODA		
Crustacea	Caprellidae	*Paguristes oculatus* (Fabricius)	
	Gammaridae	*Pagurus cuanensis* Bell	
	Anisopoda	*Pagurus bernhardus* (L.)	
	Apseudes latreillei (Milne Edwards)	*Parthenope massena* Roux	
	Alpheus glaber (Olivi)	*Philocheras bispinosus* (Hailstone)	
	Anapagurus brevicarpus A. Milne Edwards & Bouvier	*Philocheras sculptus* (Bell)	
	Athanas nitescens Leach	*Philocheras* sp.	
	Caridea	*Pilumnus hirtellus* (L.)	
	Clibanarius erythropus (Latreille)	*Pilumnus inermis* A. Milne Edwards & Bouvier	
	Corvstes cassivelaunus (Pennant)	*Pilumnus spinifer* H. Milne Edwards	
	Cymodoce truncata (Montagu)	*Pinnotheres pisum* (L.)	
	Ebalia edwardsii Costa	*Pisidia longimana* (Risso)	
	Ebalia granulosa Milne Edwards	*Processa macrodactyla Holthuis*	
	Ethusa mascarone (Herbst)	*Processa macrophthalma* Nouvel & Holthuis	
	Eurynome aspera (Pennant)	*Processa modica* Williamson & Rochanaburanon	

(continua)

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