TAPES PHILIPPINARUM (ADAMS & REEVE) HARVESTING EFFECTS ON SEDIMENT SETTLEMENT RATES AND EROSION PROCESSES IN THE LAGOON OF VENICE (ITALY).

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Abstract
Tapes philippinarum harvesting by means of mechanical and hydraulic dredging systems heavily affects the benthic habitats and the water column as huge amounts of sediments are resuspended. In the present paper the results obtained in three areas of the lagoon of Venice (Italy) are compared in order to quantify such effects and to highlight the different impacts occurring in the free clam-harvesting areas against the clam-farming ones. In field the sediment settlement rates were measured by means of sedimentation traps and the changes of bottom level were recorded by means of suitable devices fixed to the sediment surface. Results proved that clam-farming areas were affected by a minor sediment loss. In addition, marine seagrasses appeared to significantly favour the sedimentation and trapping of resuspended particles.
Keywords: Bivalves, Sedimentation, Erosion

Introduction
Tapes philippinarum (Adams & Reeve, 1950) was introduced in the lagoon of Venice in the early 1980s for economical proposes. In a few years' time it colonized large lagoon areas triggering an intense and indiscriminate harvesting activity. Until the late 1990s, harvesting areas, boat efforts and number of employees were not regulated, producing dramatic consequences for the environmental conditions. Since 2000 the local authorities have promulgated a plan for the management of clam resources in order to safeguard the ecosystem and to guarantee the maximum sustainable yield [1]. The main idea was to turn the free clam-harvesting into clam-farms, identifying suitable areas for this activity. The present paper aims at describing the effects of both free clam-harvesting and clam-farming activities on the sedimentation rates and bottom erosion.

Materials and Methods
Three areas were identified in the lagoon of Venice: one north of the Venice historical centre (northern area), the second in the central (central area) and the third in the southern (southern area) parts of the lagoon. The northern and central areas were still characterized by free clam-harvesting whereas the third was among the first licensed zones. Two sites were chosen in each area in order to have a harvesting/farming area and a control area. In each site a sedimentation trap, which collects settling sediments [2], and a device, to measure changes in bottom level [3], were placed. The sites were monitored monthly from February 2001 to January 2002.

Results and discussion
The results showed that the northern area (Fig. 1), with 268 kg dwt m^{-2} y^{-1} in the control site and 735 kg dwt m^{-2} y^{-1} in the harvesting site, was affected by a high sediment settlement so highlighting the strong impact of clam-catching. As in this part of the lagoon the water residence time is quite high, it can be considered that the resuspended sediments settled in almost the same zone where they were removed. On the other hand, the central area is characterized by a high water renewal, so the resuspended sediments are mainly lost seawards. In fact, in such area, the annual sedimentation (control: 119 kg dwt m^{-2} y^{-1}; harvesting site: 282 kg dwt m^{-2} y^{-1}) was, approximately, 2-3 times as low as in the northern one, although the harvesting pressure was even higher. In the site of the southern area, where clams are farmed, the sedimentation rates were not significantly different from the control one (control: 266 kg dwt m^{-2} y^{-1}; farming site: 257 kg dwt m^{-2} y^{-1}). In the farming area the low harvesting impact (1 harvest per m^{-2} in two years instead than 10-15 harvests per m^{-2} each year, as in the free clam-harvesting areas) and the role of seagrasses to avoid sediment loss were observed to be relevant. In fact, sedimentation rates were strongly different only in spring, because of seagrass unrooting inside the farming area, whereas in the other period sedimentation rates were similar (Fig. 1). In addition, the dense seagrass populations growing all around the farming area reduced the loss of fine sediments which were resuspended during the farming activities. Although the different sedimentation rates observed in the fishing and control areas, all the studied sites, on a yearly basis, showed an increase of the bottom level and hence a depositional trend; only few observations had negative values. Because a significant loss of fine material was recorded in other studies [1, 2, 3], these results probably depend on the fact that the selected stations were placed in areas low affected by the lagoon hydrodynamics or inside seagrass meadows. However, the results show that, in general, the sedimentations rates were significantly higher in the harvesting areas than in the control areas, whereas no significant differences between the clam-farming area and the control one were found. The planning of seeding and harvesting activities can be a really efficient tool to reduce the sediment resuspension. Moreover, the presence of seagrass meadows around the clam-farming areas can contrast the loss of fines reducing the environmental impact of such activities.

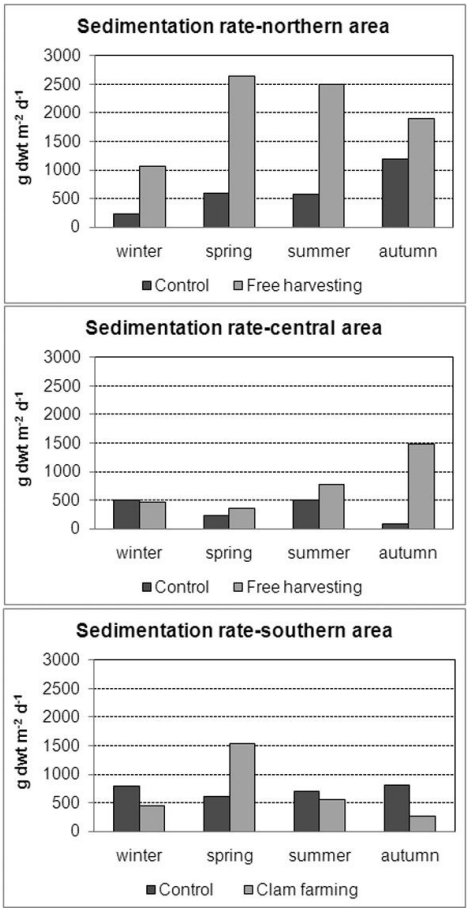

Fig. 1. Seasonal means of the sedimentation rates in the studied areas.

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