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Impacts of maintenance channel dredging in a northern Adriatic coastal lagoon. II: Effects on macrobenthic assemblages in channels and ponds

Massimo Ponti*, Andrea Pasteris, Roberta Guerra, Marco Abbiati

Centro Interdipartimentale di Ricerca per le Scienze Ambientali (C.I.R.S.A.), Università di Bologna, Via S. Alberto, 163, 48100 Ravenna, Italy

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ABSTRACT

Coastal lagoons are ephemeral habitats whose conservation requires human intervention, such as maintenance dredging of inner channels. Dredging can reduce the abundance of benthic species due to the removal of individuals with the sediment, modify sediment properties, and resuspend fine sediment, nutrients and pollutants, which can lead to eutrophication, hypoxic events and increasing toxicity. Both direct effects in the dredged channel and possible indirect effects in surrounding shallow areas could be expected. This study assesses the effects of the channel maintenance dredging, performed between October 2004 and August 2005, on the invertebrate assemblages both in channels and adjacent ponds in the northern Adriatic coastal lagoon of Pialassa Baiona. The lagoon is affected by eutrophication, chemical and thermal pollution from wastewater treatment and power plants. Three impacted sites were located in the dredged channel and three in the adjacent interconnected shallow water ponds, while three non-impacted sites were located in a channel and in a pond far from the dredged area. Replicate samples were collected from each site one time before and one time after the dredging operations. Despite the extent of the intervention, effects of the dredging on macrobenthic assemblages were detected only within the dredged channel, while in the surrounding ponds no clear and unequivocal effects were found. In particular the dredging could have promoted the increase of the abundance of the polychaete *Streblospio shrubsolii* in the southern and central parts of the dredged channel and the increase in abundance of the amphipod *Corophium insidiosum* in the northern side, compared to the controls. Instead, species diversity was reduced in the central and northern parts of the dredged channel. These effects on the macrobenthic invertebrate assemblages could be related to the observed changes of sediment characteristics, contamination and toxicity. Overall, direct effects on benthic assemblages in the dredged channels were more detectable than the possible secondary effects in the surrounding shallow ponds, where the higher spatial heterogeneity can mask any relevant effects.

1. Introduction

Conservation and management of coastal lagoons often requires direct human intervention. To prevent siltation and to maintain the hydrodynamic features of lagoonal systems, periodical dredging of lagoon openings and channels is needed. Dredging activities may have four principal short-term effects on benthic assemblages (Quigley and Hall, 1999 and references therein): (1) reduction of number of species richness and abundances directly related to the disturbance event; (2) change in sediment properties (e.g. grain size) modifying relevant habitat features; (3) resuspension of fine sediment and associated nutrients, organic matter and pollutants, which can lead to eutrophication, hypoxic events and increasing toxicity; and (4) habitat loss and ecosystem function reduction. Over long-term some other effects on macrobenthic assemblages could be also expected due to: (1) increased water circulation and oxygenation; (2) acceleration of geochemical processes (e.g. organic mater mineralization); and (3) new available space for larval settlement and recruitment.

Dredging operations are generally performed in channels, and seldom in the shallow water bottoms. Resuspension of fine sediments due to the dredging operations could increase turbidity and sedimentation rates for hundreds of meters in the surrounding areas. Albeit unintended, sediment fallout my affect benthic communities (Wilber et al., 2007).

To assess the impact of any human activities on the structure of benthic invertebrate assemblage, spatial and temporal scales of

* Corresponding author at: Laboratori di Scienze Ambientali, Università di Bologna, Via S. Alberto 163, 48100 Ravenna, Italy.
E-mail address: massimo.ponti@unibo.it (M. Ponti).

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variability of the assemblages has to be taken into account (Boyd et al., 2003; Josefson et al., 2008; Dauvin, 2008).

This study assesses the effects of maintenance channel dredging performed from October 2004 to August 2005 on macrobenthic assemblages in both channels and ponds in the northern Adriatic Italian coastal lagoon of Pialassa Baiona, using a sampling design based on the "before/after and control/impact" (BACI) approach (Green, 1979; Underwood, 1992). Changes in the abundance of numerically dominant taxa, species diversity and assemblage structure in response to dredging in the muddy sandy sediments were compared with appropriate control sites both in channels and ponds. Observed changes were related to the concomitant alteration of sediment characteristics, contaminant concentrations and toxicity, which are analysed in detail in Guerra et al. (2009).

2. Materials and methods

2.1. Study area and description of the dredging activities

This study was carried out in the Pialassa Baiona (44° 30′ N, 12° 15′ E), a eutrophic microtidal lagoonal system located along the northern Adriatic coast of Italy (Fig. 1). This area was declared a wetland of international importance under the Ramsar Convention in 1981, and is included among the sites of Community interest (pSCIs, "Habitat" Directive 92/43/EEC). At present the lagoon is exploited for recreational fishing, Manila clam (*Ruditapes philippinarum*) harvesting, regulated hunting, leisure and cultural activities such as canoeing, guided walking tours, and bird watching. The lagoonal system includes brackish and fresh water shallow ponds, with an average depth of 1 m, completely or partially isolated by embankments and crossed by a network of artificial channels dug since 1850. Channel depths range from 1 m to 8 m in the landward and seaward sides, respectively. The lagoon is connected to the sea by a channel connecting it to the Ravenna harbour. The lagoon covers an area of about 10 km^2, the tidal range can exceptionally exceed 1 m, vast shallow areas may emerge during low tides. Sediments vary from sandy to muddy (sand range from 12.1% to 89.5% in weight) according to the occurrence of active sedimentation processes or relict sand dunes. The southern area of the lagoon receives wastewater from urban and industrial sewage treatment plants, and from two thermal power stations (Ponti et al., 2005). Overall water turnover in the lagoon has been estimated in 3 days.

The macrobenthic invertebrate assemblages inhabiting muddy and sandy bottoms mainly include spionid and capitellid polychaetes, tubificid oligochaeets, amphipods, bivalves and gastropods. Although Pialassa Baiona is one of the most anthropogenically disturbed coastal lagoons in the Mediterranean Sea, given its proximity to important urban, industrial and harbour areas, it hosts a relatively diverse benthic assemblages (Ponti et al., 2008). Phytoplankton blooms and intense growth of seaweeds (*Ulva* sp., *Enteromorpha* sp., *Gracilaria* sp.) have been frequently observed during the summer, especially in the southern part. Dystrophic crises were often recorded in the summer, which can affect the structure of the benthic assemblages, mainly reducing the abundance of amphipods (Ponti and Abbiati, 2004). From 1958 to 1976 Pialassa Baiona was heavily impacted by industrial pollution. Mercury, polycyclic aromatic hydrocarbons (PAHs), and synthetic polymers were among the most important pollutants which now contaminate the sedimentary compartment (Fabbri et al., 1998, 2000, 2003; Abbondanzi et al., 2005). Superficial sediments are still contaminated, with a total mercury load ranging from 0.13 to 250 μg g^{-1} dry weight (Trombini et al., 2003).

The main channels of the lagoon are periodically dredged to favour the water flow and exchange with the sea. From October 2004 to August 2005 Baccarini Channel, one of the main channels that crosses the lagoonal system, was dredged by draglines and excavators placed on a floating pontoon, in order to re-establish original depth, restore embankments and improve water circulation. Dredging intervention was done along 4000 m of the channel,

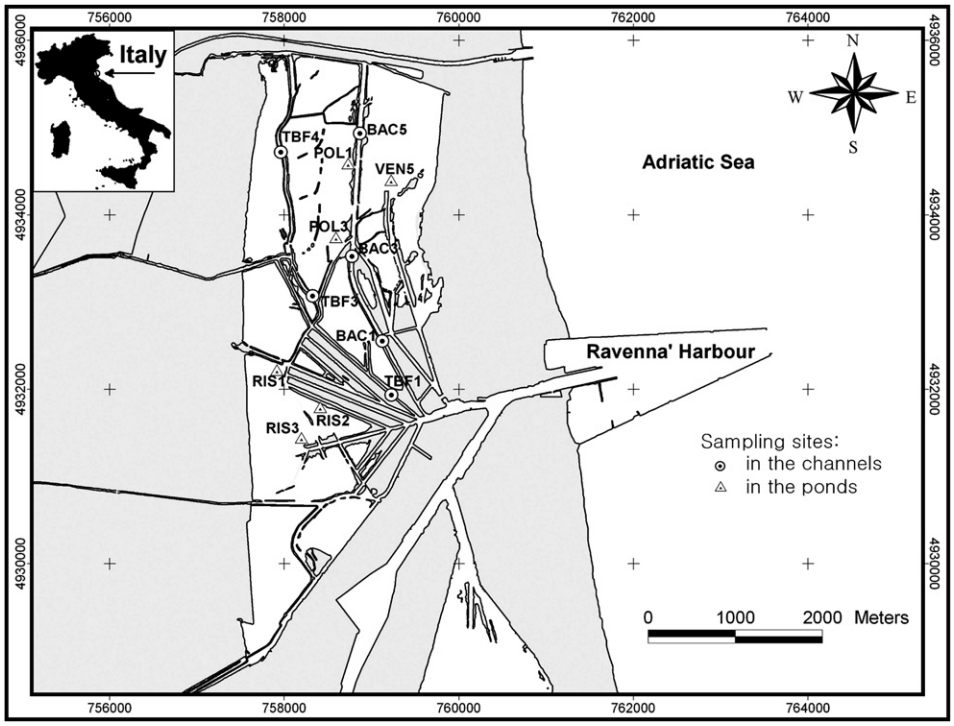

Fig. 1. Map of Pialassa Baiona lagoon, showing sampling sites located in channels as circles, and ponds as triangles (geographic grid UTM 32T, European Datum 1950).