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Effect of commercial trawling on the deep sedimentation in a Mediterranean submarine canyon

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ABSTRACT

In order to study sediment accumulation rates in the Palamós submarine canyon (Northwestern Mediterranean) during the last century, three sediment cores were extracted from the canyon axis at depths of 450, 1200 and 1750 m respectively, where instrumented moorings were previously located. Estimated sedimentation rates based on ^{210}Pb and ^{137}Cs profiles suggest that the contemporary trends of sediment transfer and accumulation in the canyon may be different from secular trends. During the seventies, a two-fold increase of the sediment accumulation rate took place at the 1750 m depth site. This change has been associated to trawling activities and is attributed to the rapid technical development that the local trawling fleet underwent during the seventies. The surroundings and rims of submarine canyons are frequently targeted by commercial trawling fisheries, an activity that may enhance the input of resuspended particles into canyons, and eventually trigger sediment gravity flows. Our results suggest that the effects of trawling over the dynamics of the seafloor may extend further and deeper from the fishing grounds, eventually extending to bathyal depths. Hence the anthropogenic influence on the sedimentary budget of some deep submarine environments may be more important than previously thought.

1. Introduction

Due to the widespread and intensive use of towed bottom-fishing gears on the continental margins of the world, the impact of this activity over the ecosystems and living resources has become a cause of social and economic concern, and consequently has encouraged considerable research and debate (e.g. Caddy, 1973; Auster et al., 1996; Company et al., 2003; Cartes et al., 2004; Devine et al., 2006). Furthermore, trawling fisheries are continuously shifting from shallower to deeper areas in pursuit of new fishing grounds (Haedrich et al., 2001; Cartes et al., 2004). The deep seafloor, being in general a physically stable environment in comparison with more turbulent and unstable shallower depths, is also much more sensible to artificial disturbances, both from an ecological (Collie et al., 2000) and a sedimentary (Theil and Schriever, 1990) point of view. Attempts to quantify the resuspension and redistribution of sediments caused by commercial trawling have been mainly localized in estuarine and coastal environments (Brambati and Fontolan, 1990; Schoellhamer, 1996; Ruffin, 1998; Black and Parry, 1999) and the continental shelf (Churchill, 1989; Palanques et al., 2001; Durrieu de

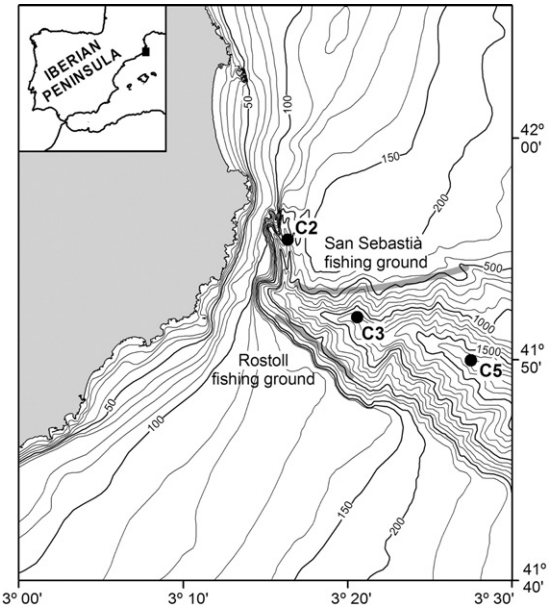

Fig. 1. Bathymetric map of the Palamós submarine canyon showing the location of the sediment cores. The main fishing (trawling) grounds along the canyon walls are also shown.

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Madron et al., 2005; Karageorgis et al., 2005), while deeper domains remain understudied.

The multidisciplinary project CANYONS (Palanques et al., 2005), was designed to study the extent, spatio-temporal variability and ecological repercussions of water and particle fluxes in the Palamós submarine canyon. The Palamós Canyon (Fig. 1) is one of the most prominent topographic features in the NE Spanish margin. The canyon head cuts the continental shelf at the 90 m depth contour, 3 km from the coastline. The axis extends for about 45 km along a WNW–ESE direction, gradually broadening towards its maximum depth at 2200 m.

The CANYONS field experiment took place from March to November 2001 and involved measurements of downward fluxes and composition of particulate matter by means of sediment traps (Martín et al., 2006), as well as horizontal suspended particle fluxes through coupled turbidity and current meter measurements (Martín et al., 2007). In order to complement these results, on May 2002 three sediment cores were collected from the Palamós canyon axis at the mooring sites. The aim of this paper is to study the influence of trawling on sediment accumulation rates estimated from ^{210}Pb and ^{137}Cs concentration profiles in the sediment cores.

2. Methodology

A multiple corer (Bowers and Connelly) with four acrylic tubes (inner diameter = 9 cm) was used to retrieve the sediment cores, which will be hereinafter referred to as C2 (450 m depth), C3 (1200 m depth) and C5 (1750 m depth) (Fig. 1). Sediment cores were subsampled into 1 cm-slices, which were kept frozen at −14°C in sealed plastic bags until analysis. Water content and dry bulk density were determined by weight before and after drying at 40 °C. A vertical slab of undisturbed sediment (2.2 cm thick) was removed from one of the core tubes for X-radiographic analysis. Grain size distributions were determined by using a settling tube and a Sedigraph 5100D (Micromeritics) for the 50–2000 μm and <50-μm fractions, respectively (Giró and Maldonado, 1985). Total carbon content was determined in dried samples using a LECO CN-2000 auto-analyzer. Organic carbon was calculated as the difference between total and inorganic carbon, the latter measured with a LECO CC-100 module. Carbonate content was estimated as 8.33 times inorganic carbon.

^{210}Pb activities were determined through measurement of its effective daughter, ^{210}Po, in equilibrium with ^{210}Pb in sediment samples following state-of-the-art techniques (Nittrouer et al., 1979). Activities of ^{137}Cs and ^{226}Ra (i.e. supported ^{210}Pb) were measured by γ-counting of dried, homogenized samples in calibrated geometries for $2–3 \cdot 10^5$ s on a high purity intrinsic germanium detector. ^{210}Pb-derived sediment accumulation and mixing rates were calculated based on a one-dimensional, steady-state constant ^{210}Pb flux/constant sedimentation model constrained by the ^{137}Cs concentration profiles (Cochran, 1985; Masqué et al., 2003; Sánchez-Cabeza et al., 1999).

Historical data of the Palamós harbor trawling fleet was obtained in order to test the impact of this anthropogenic activity in the accumulation of sediment inside the canyon. Engine power was used

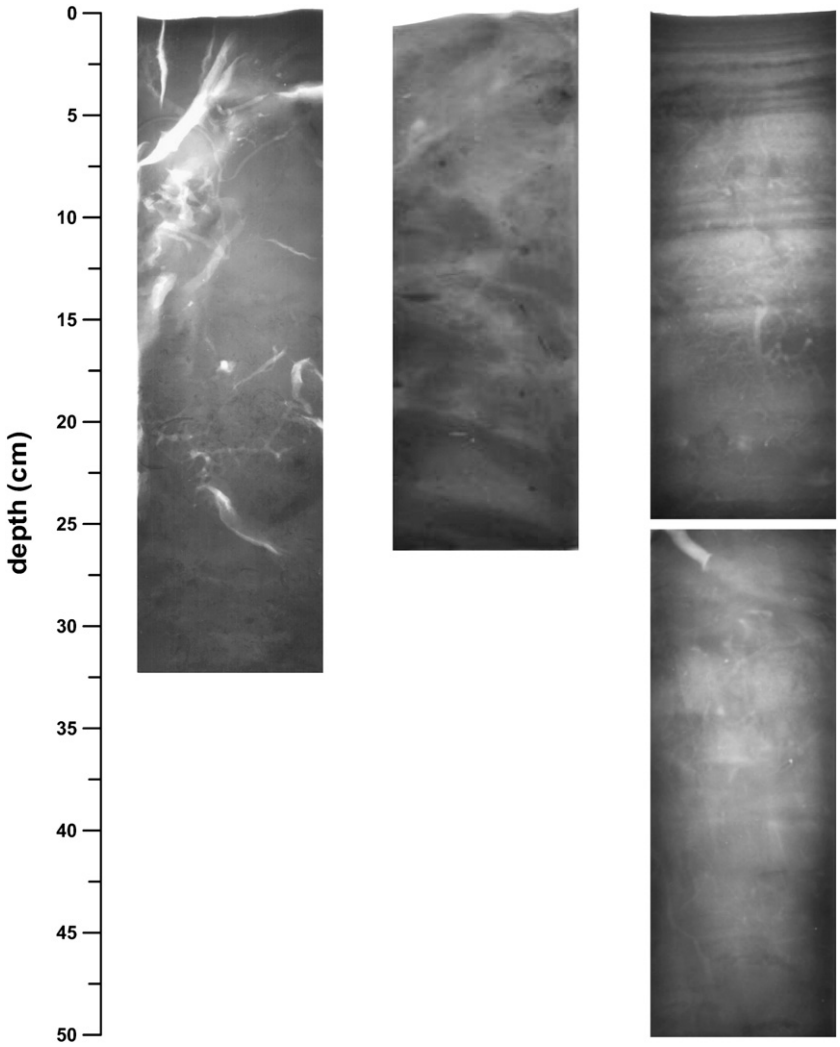

Fig. 2. Positive X-radiograph of cores C2 (450 m depth, canyon head), C3 (1200 m depth, canyon axis) and C5 (1750 m depth, canyon axis) from Palamós Canyon.