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Invited Review Paper

Commercial bottom trawling as a driver of sediment dynamics and deep seascape evolution in the Anthropocene

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ABSTRACT

Fishing gear and techniques have evolved through the centuries, and particularly after the Second World War, towards a mass production industry in such a scale that it has placed many commercial stocks in a delicate or depleted status. Furthermore, certain fishing methods have other undesirable side effects on ecosystems and habitats. In this work, the known impacts of bottom-dragged gear on the seafloor are reviewed. Some of the least known issues are emphasized, namely, impacts on the physical properties of deep-sea sediments, resuspension, erosion, near-bottom turbidity and seabed morphology. Due to its recurrence, mobility and wide geographical extent, bottom trawling has become an effective driver on shaping the physical basis of benthic habitats: its composition, texture and morphology at scales from micro to the entire continental margin. It is concluded that trawling is comparable in its transforming power over seascapes to the effects of agriculture or deforestation on land.

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Introduction

Bottom trawling is the main method of capture of demersal resources, accounting for 22% of the global fish production (Kelleher, 2005) and up to 80% if only the high seas fisheries for benthic resources are taken into account (Gianni, 2004). The widespread and intensive use of towed bottom-fishing gear on the continental margins of the world has raised concerns about the sustainability of this practice and its impacts on ecosystems and habitats (Jones, 1992; Watling and Norse, 1998; Dayton et al., 1995; Dorsey and Pederson, 1998; Puig et al., 2012). Compilations of the literature on impacts by bottom trawling and dredging have been carried out by Rester (1999) or Johnson (2002). The impacts of bottom trawling on the health and sustainability of living resources and in the broader ecosystem accounts for the largest contributions to the volume of literature published so far on trawling impacts. This work focuses on the review of the impacts of bottom trawling with a particular emphasis on water column turbidity, sedimentary budgets and seafloor morphology on the deep sea.

Of particular concern is the fact that demersal fisheries have been continuously shifting from shallower to deeper areas in recent decades (Haedrich et al., 2001; Morato et al., 2006). Several offshore human activities such as waste dumping, mining, cable lying or warfare can produce acute impacts in localized sites of the deep seafloor. However, comparative assessments conducted by Eastwood et al. (2007) and Benn et al. (2010) have concluded that the contribution of bottom trawling to the disturbance of the deep-sea floor is notably higher than all other anthropogenic pressures combined, given the intensity, recurrence and wide geographical presence of commercial trawling. For reviews of anthropogenic impacts on the seafloor other than fishing activities, the reader is redirected to Glover and Smith (2003), Halpern et al. (2008) or Tyrrell (2011).

Since different trawling devices may produce different impacts, this work starts with a technical description of the main bottom trawling gear and its primary effects upon contacting the seafloor. Next, some hints on the history of trawling activities and its expansion to the deep-sea in recent decades are given, followed by a discussion on some implications of this offshore shift. The relevance of trawling effects on sediment dynamics of continental margins is reviewed in the following sections, starting with ‘‘Trawling-induced sediment resuspension’’. The resettlement of sediments thus mobilized open issues about its fate and the consequences for regional budgets of sediment and key elements such as carbon, next section deals with these aspects as well as the alterations of the physical properties of bottom sediments subject to chronic trawling. The last three sections address the modifications of the seafloor morphology at large scales or in its intrinsic relief, that is, the transformation of submarine landscapes under human pressure. Section ‘‘Biogenic habitats’’ focus on the threats posed to biogenic underwater habitats while the next section reviews the effects on soft muddy bottoms. In the last section, the previous two are integrated and put in relation with human-modified landscapes.

Characterization of bottom fishing gear

Generically speaking, ‘‘trawling’’ is any fishing technique involving the towing of a collecting device to harvest living resources. Diverse methods exist to keep the net/collector horizontally and vertically open as the gear is pulled by a moving vessel. Fishing boats can pull the nets at midwaters (pelagic trawling) or along the bottom (bottom trawling). Within bottom trawling, still two subdivisions are to be made in terms of distance to the seafloor. In ‘‘demersal trawling’’, the net is towed at a distance from the seafloor. However, most usual configurations involve a close contact of the trawling gear with the bottom, which is known as benthic or bottom trawling, the term we will use hereafter. Three major categories of bottom towed gears can be drawn: dredges, beam trawls and otter trawls. Many sub-types and ad hoc configurations of these exist and, in fact, the exact designs are often shaped in every detail to meet the requirements imposed by substrate type and life traits of the targeted species. Other fishing techniques such as caging, gillnetting and some types of long-lining are also laid in contact with the seabed but in these cases, impacts on the seafloor are mainly restricted to deployment/retrieval operations, when the nets and anchoring systems can be briefly dragged along the bottom. More detailed information on bottom fishing techniques can be found in von Brandt (1984) or Sainsbury (1996).

Dredges

In its simplest form, a dredge consist of a horizontal metal bar or blade that digs or scraps the seafloor owing to its weight and the strain exerted by a towing wire. Fig. 1 offers an overview of several common dredge setups. Bottom-dwelling living resources are collected in a bag connected to the advancing dredge. Dredge designs are very variable and often species-specific but nonetheless two big clusters can be outlined: epifaunal dredges that harvest animals living on the seafloor by scraping or slightly digging bottom sediments, and infaunal dredges that penetrate the seabed to some depth to collect buried animals such as clams or burrowing crustaceans.

The blade can be supplemented by ‘teeth’, forming a rake that bulldozes soft sediments, unburying and collecting burrowing animals.

As an example, the dredges used in the Atlantic coast of the US to catch oysters and crabs are equipped with a blade 0.5–2.0 m wide with teeth 10 cm-long (Steele et al., 2002). More than one dredge can be dragged at a time by a single ship.

In general, dredges are towed at less than 2.5 knots, becoming inefficient at higher speeds (Caddy, 1973; Dare et al., 1993). Owing to its weight and the resistance offered by the bar/rake, the use of dredges is usually restricted to shallow depths. As an exception, it is worth mentioning the offshore fisheries for scallops at 100–200 m depth. Given the natatory skills of scallops, these dredges are towed at speeds up to 5 knots (Steele et al., 2002) and also the size and weight of the ensemble is larger than in shallow water setups. Width of this particular dredge in the eastern US coast is 3–4.5 m and weighs 500–1000 kg according to Steele et al.