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Managing recreational fisheries through gear restrictions: The case of limiting hook size in the recreational fishery from the Balearic Islands (NW Mediterranean)

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ABSTRACT

Enforcing a minimum legal fish size is a possible policy rule for managing recreational fisheries. However, success of such rules highly depends on an effective reduction of a mortality of released under-sized individuals. A very high post-release mortality is currently observed for certain species, which cancels any benefit of fish size limitation. Here we explore the effectiveness of limiting both gear characteristics and fish size. This management approach is aimed at biasing catches toward legal-sized individuals and minimizing the catches of under-sized fish. Specifically, size selection of fishes induced by hook size was evaluated for the near-shore boat recreational fishery from the Balearic Islands (NW Mediterranean). First, we evaluated the effects of different hook sizes on catch (number of individuals and species composition) and yield (biomass). Results showed how the number of captures was significantly reduced when using large hooks but bigger specimens and more valued species were caught. Moreover, the total yield remained unchanged, and the incidence of under-sized fish was significantly reduced. Second, the comparison of selectivity curves (i.e., logistic curves relating fish size and probability of being fished) corresponding to different hook sizes showed differences between two groups of species: those with small-mouth area, such as *Coris julis* or *Diplodus annularis* and those with larger mouth areas like *Serranus scriba*. Small-mouth species tend to display larger selectivity: the curves for each hook size are steeper, and there is more of a split between the curves. The results presented here motivated the authority in charge of managing the recreational fishery at the Balearic Island to stipulate a minimum legal hook size. The trade-offs of this rule between angler interest and conservation goals are discussed.

1. Introduction

Landings data from recreational fisheries have not traditionally been considered for analyzing the crisis in global fish stocks (Cooke and Cowx, 2004). However, there is a growing awareness that recreational angling represents an important pressure on fish stocks that must be taken into account when managing marine resources (Cox et al., 2002; Sutinen and Johnston, 2003; Williams and Blood, 2003). Moreover, recreational fishing has been considered one of the more complex and difficult to understand predator–prey systems of nature, since social, economical and ecological factors interact (Cooke and Cowx, 2004, 2006; Lewin et al., 2006; Arlinghaus et al., 2007).

On the Balearic Islands (NW Mediterranean), the number of recreational anglers has increased from 19,000 marine licenses in 1999–2000 to the current number of 40,000 (unpublished data from Direcció General de Pesca, Govern de les Illes Balears). This trend is related to an increased awareness of the requirement to have a license to fish and to a true increase in the number of anglers. It has been estimated that 10% of the population of Majorca Island participates in recreational fishing activities (Morales-Nin et al., 2005). Total recreational captures have been estimated at 1209 tons per year, which represents 27% of the landings from the artisanal commercial fleet (Morales-Nin et al., 2005).

Negative impacts on targeted species of freshwater and marine recreational fisheries around the world have been clearly demonstrated (Lewin et al., 2006). Concerning the case of the Balearic Islands, Coll et al. (2004) evaluated the changes in the catch per unit effort (CPUE) resulting from lot of sport-spear tournaments since 1975 and demonstrated how the abundance and size of the Serranid *Epinephelus marginatus* (L.) have decreased as a consequence of this activity. Ordines et al. (2005) showed that sites with lower fishing pressures presented higher species richness and abundance than exploited sites. Most recently, Cardona et al. (2007) reported that the boat angling pressure on *Posidonia oceanica* (L.) Delile mead-

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ows may be related to a decrease in the abundance of the fish inhabitants.

Enforcement of a minimum legal fish size as a way to reduce fishing mortality in early life-history stages has been considered an important tool for the management of recreational fisheries (Lewin et al., 2006; Arlinghaus et al., 2007). In the Balearic Islands, there are a number of species targeted by the recreational anglers for which a minimum legal size limit has been stipulated (UE Regulation 1967/2006, from the council of 21st December 2006, and other local regulations). Moreover, daily bag limitations, amount of gear limitations (i.e., number of rods and hooks), seasonal closures, marine protected area establishments and, more recently, minimum hook sizes, are used by the local administration to manage the recreational fishery from the Balearic Islands.

Specifically, the existence of a minimum legal fish size is expected to result in a significant increase in the number of fish released (Bartholomew and Bohnsack, 2005; Alós et al., 2009). The usefulness of this regulation depends on species-specific factors, such as good survival rates and successful maturation and reproduction capability of the released fish (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005; Cooke et al., 2005, 2006; Arlinghaus et al., 2007; Coggins et al., 2007). In species with high post-release mortalities of under-sized fishes, the existence of a minimum size could be useless (Coggins et al., 2007; Alós et al., 2009). In such cases, the focus should be on enforcing gear limitations that bias the catches toward legal-sized fish. This goal can be achieved by limiting the hook size and the bait type and/or size (Alós et al., 2009).

The size selectivity of captured fishes caused by changes in gear configuration has been extensively studied in commercial long-line fisheries, especially regarding the differences in hook size (Cortez-zaragoza et al., 1989; Otway and Craig, 1993; Erzini et al., 1996; Erzini and Castro, 1998; Stergiou and Erzini, 2002; Halliday, 2002). Furthermore, methodological aspects for accurate modelling of selectivity curves have been developed for various commercial fisheries (Ralston, 1990; Sousa et al., 1999; Millar and Fryer, 1999; Millar, 2000; Huse and Soldal, 2000). Regarding recreational fisheries; however, few studies have dealt with the relationship between hook size and fish size (Carbines, 1999; Cooke et al., 2005; Grixti et al., 2007; Rapp et al., 2008; Alós et al., 2008a,b), and only recently has this methodological approach been adapted (Alós et al., 2008a).

The goal of this study is twofold. First, for all species pooled, we evaluated the hypothesis that the use of larger hook size results in catches including fish of larger size. We analyzed the trade-offs for the angler of the proposed limitation of the hook size in terms of species composition and total yield. Second, we analyzed species-specific patterns for four common species and described the relationship between fish size and catchability using five hook sizes. Finally, the trade-offs between angler interest and conservation goals were discussed relative to implementing a minimum hook size regulation.

2. Materials and methods

2.1. Sampling method

A total of 33 angling trips were taken throughout the Majorca Island waters (NW Mediterranean) from March 2004 to August 2005. Angling session units consisted of continuous gear-controlled fishing by a single angler for 30 min from a drifting boat. Angling sites were randomly selected and ranged at water depths between 10 and 35 m with bottoms characterized by a mixture of rock and *P. oceanica* beds. The number of sampling units per angling trip was variable and depended on the number of volunteer anglers (i.e., from 2 to 4 anglers) and the duration of the angling trip (i.e., from 2 to 6 units per day and angler). Each volunteer angler used the same hook size during the entire angling trip.

The experimental angling rig was composed of a nylon main-leader (0.26 mm diameter) equipped with four black iron–nickel "J" hooks of the same size and weighted 100 g. For the purpose of the study, five different hook sizes were used (Fig. 1). Their dimensions are shown in Table 1. Hooks were attached by a 20-cm-long hook-line to the main-leader. This experimental angling rig was attached in a rod-mainline of conventional nylon (0.30 mm diameter). Anglers used a rod with a hand-operated reel. Baits were similar-sized frozen shrimps, *Palaemonetes varians*. Both gear characteristic and bait type used during the experimental angling sessions are those commonly used by the local anglers.

Each fish caught was identified to species and measured (total length to the nearest mm). Angler, capture hour (hours after sunrise) and depth (m) were recorded. The weight (g) of each fish was estimated using the appropriate length–weight relationship previously reported by Morey et al. (2003) for species in Balearic waters.

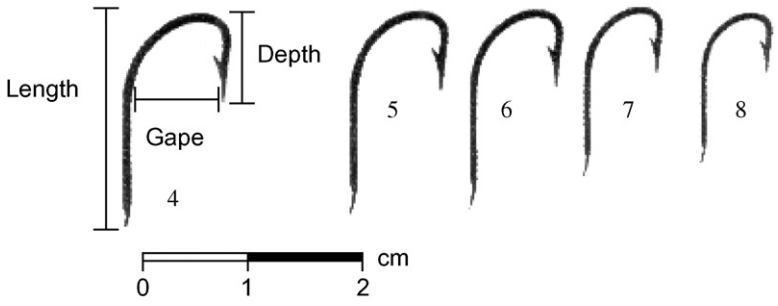

Fig. 1. Image of different sizes of the conventional "J" hook type the hooks used in the experimental angling sessions.

Table 1
Dimensions of each hook size used in the experimental angling sessions. Hook manufacturer sizes ranged from size 4 (H4, the largest) to size 8 (H8, the smallest). Means ± standard deviations ($n = 10$) of the gape, depth and length are presented in millimetres. Hook dimensions were collectively used as a measure of gear size.

Hook dimension	Hook 4 (H4)	Hook 5 (H5)	Hook 6 (H6)	Hook 7 (H7)	Hook 8 (H8)
Gape	7.30 ± 0.03	6.59 ± 0.02	6.24 ± 0.04	5.68 ± 0.05	5.55 ± 0.03
Depth	7.92 ± 0.04	7.46 ± 0.05	6.72 ± 0.03	6.25 ± 0.05	5.71 ± 0.04
Length	20.79 ± 0.06	18.18 ± 0.05	17.19 ± 0.06	14.90 ± 0.08	14.38 ± 0.04