Marine Policy 62 (2015) 134–143

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

The need for fine-scale assessment of trawl fishing effort to inform on an ecosystem approach to fisheries: Exploring three data sources in Mediterranean trawling grounds

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ARTICLE INFO

Article history:
Received 23 March 2015
Received in revised form
8 September 2015
Accepted 11 September 2015

Keywords:
Small-scale effort estimation
Trawling impact
Sustainable resources
Good environmental status
Mediterranean

ABSTRACT

Aiming to estimate fishing effort at a small-scale that can be linked to benthic ecosystem disturbance (including target and non-target communities and habitats), three approaches were compared in 4 Mediterranean areas subjected to different trawl effort: (i) information from the fishery (fishermen interviews and daily sales' records), (ii) Vessel Monitoring System (VMS) data and (iii) Side-Scan Sonar (SSS) records. Fishery data proved a useful baseline to characterise effort in the fishing grounds, VMS described in detail the dynamics of the fleet and SSS provided evidence of small-scale trawl activity. This paper examines the strengths and weaknesses of these 3 methods regarding their feasibility to assess the effort distribution at the smallest possible scale, but with a broad application. The findings highlight the need for accurate fishing effort estimations to evaluate trawling disturbance on ecosystems to ensure both healthy benthic ecosystems and sustainable exploitation of target species populations.

1. Introduction

Trawling must be adequately managed to simultaneously minimise the overexploitation of resources and benthic ecosystem degradation [1]. Many studies have demonstrated that towed gears chronically alter benthic ecosystems, including target and non-target species and habitats (e.g. [2–5]. Moreover, many target species are overexploited, indicating the inefficiency of past management strategies [6–8]. Facing this failure in management, there is an urgent need to advance in the implementation of an Ecosystem Approach to Fisheries (EAF) globally through regional management plans.

The European Marine Strategy Framework Directive (MSFD), [9], requires Member States to monitor marine ecosystems subjected to disturbance and achieve a Good Environmental Status (GES) by 2020 [9]. To accomplish this ambitious goal, accurate information on current threats to marine ecosystems is urgently needed, including detailed knowledge of the level of fishing effort that threatens the integrity of ecosystems [10–12]. Related to this, the aim of EAF is to avoid surpassing a critical threshold for ecosystem degradation. In this context, it is of paramount importance to estimate fishing effort at a small scale linked to the variability of biological communities [7,13]. However, this is not an easy task, and few of the existing approaches for effort estimation have a fine spatial scale resolution [14–16]. The need for fine scale effort estimations grows in importance in the Mediterranean, where the traditional management of demersal fisheries is centred on the limitation of effort and regulation of minimum landing size [17,18].

In this study, three different approaches to estimate the spatial distribution of trawling effort were comprehensively analysed: data from the fishery, Vessel Monitoring System (VMS), and Side Scan Sonar images of the seafloor (SSS). Fishery data is a direct way to record fishing effort (e.g. days at sea and number of operational vessels per month) and this information allows to describe fleet dynamics, seasonality of landings, etc. [19,20]. Legislation to monitor European fishing vessels movement using a satellite VMS was introduced in 1998 by the European Commission [21] and, after a series of modifications, since 2012 it applies to all vessels over 12 m [22]. These VMS devices installed in every vessel

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http://dx.doi.org/10.1016/j.marpol.2015.09.012
0308-597X/

records its position at least every 2 h, and this information is then transferred to the local fisheries authorities. VMS has become an important source of spatial and temporal effort estimations [23–25] and has improved our knowledge on the geographical distribution of fishing fleets [26–29]. SSS images record the trawl marks on the sediment caused by the "doors" of the fishing gear, showing the parallel and equidistant marks made by the two "doors" that unambiguously reveal the presence of trawlers. The SSS is also frequently used to define sediment morphology and for describing and detecting small-scale and patchy distribution of benthic structures and habitats [30–35]. Nevertheless, although this geophysical method may be considered as an efficient tool for indirectly estimating the trawling effort by a geo-acoustic mapping system, few studies exist that quantify the density of trawl tracks on the sediment to estimate the fishing effort [36–40].

These three methods were used in 2 areas in the Mediterranean (in the coasts of Spain), while only two methods were used in the other 2 areas (in the coasts of Italy and Greece). With a few exceptions, the otter trawl fleets from the Italian and Spanish ports operate within their own fishing grounds (i.e. there is no movement of vessels between fishing grounds), bounded by the fleets from the neighbouring ports. Fishing grounds are located from 50 m to 900 m depth. Spanish trawlers generally return to port every day with 6–8 h of effective fishing activity, and Italian trawlers follow a similar pattern with 10–12 effective fishing hours per day [37,38]. Greek trawlers operate with different dynamics, moving across several fishing areas under Greek jurisdiction. Trawlers might return every evening to sell their landings in the nearest port or in the harbour offering the best income. Otherwise, they might stay at sea for up to two days [41].

As trawling management in the Mediterranean is mainly based in effort control, the fine-scale effort estimation could be an essential input for fisheries management aiming to achieve sustainable exploitation of resources and healthy ecosystems. Thus, the principal goal of the study is to examine the three approaches used to estimate fishing effort and to analyse their strengths and limitations. The final aim of the study is to highlight the importance of small spatial scale effort estimation to link trawling activities with their effects on benthic ecosystems.

2. Material and methods

2.1. Case studies

The present study was carried out in four Mediterranean coastal areas: one in Italy, Liguria Coast (LC); one in Greece, Eastern Ionian coast (IC); and two in Spain, the Catalan coast (Cap de Creus-CC) and the Murcia coast (Cabo de Palos-CP) (Fig. 1). These areas are located between 40 and 90 m deep and have muddy/muddy-sand homogeneous habitats except for CP that has gravelly-sand and maërl habitats [35]. All the areas are in trawling grounds except for a section of CC area that is within the MPA of Cap de Creus (CC-MPA), where trawling activity is prohibited [42].

2.2. Fishing effort estimations

The fishing effort data analysed varied between countries. In Italy and Greece only fishery data and SSS trawl tracks were used to estimate the effort. In the two Spanish areas, where VMS data was available, data from the three methods were analysed.

2.2.1. Fishery data

The fishing effort was estimated by combining official records including daily sales in each port with data collected from interviews with fishermen. Interviews were conducted in the most representative local ports from each area during March 2009. All trawl vessels captains from each port considered for the study were asked to mark on a map the fishing grounds they mainly visited. Also, fishermen had to describe if they changed fishing grounds on a seasonal basis following the life cycle of target species. Taking into account this information, the species' composition of landings recorded during the daily sale provided evidence on the fishing grounds visited by each vessel (Fig. 2). This approach was based on knowledge on the habitat preferences by the main target species [43]. The daily sale records were also used to determine the number of days these vessels had actually worked on these fishing grounds.

Trawling effort was estimated as total active fishing days per month within the fishing ground. The Gross Tonnage (GT) was included in the effort estimations as different vessel characteristics have different impacts on benthic communities. The GT is considered by the EU DG MARE [22] as the most appropriate fishing capacity parameter to categorize the vessels. GT data from the trawling fleet for the period 2007–2009 were obtained from the official censuses from the Fisheries Ministry in each country.

The final fishing effort was estimated in each fishing ground as follows:

$$GT * \text{fishing days/month} \quad (1)$$

2.2.2. Satellite information: VMS data

The VMS data from the Spanish fleets operating in CC and CP were provided by the Secretaría General de Pesca (MAGRAMA) of the Spanish government. The data analysed included daily records from 2007, 2008 and 2009. Only information from trawlers known to be fishing within the studied fishing grounds in CC and CP (from

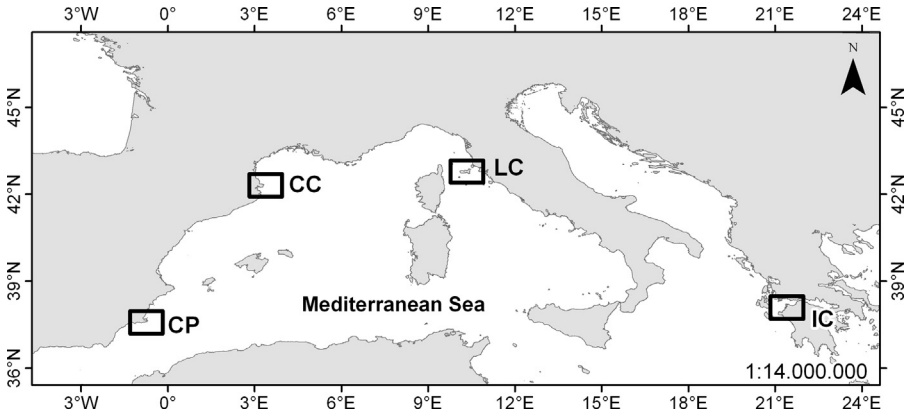

Fig. 1. Location of the four study areas: two in Spain (CP and CC), one in Italy (LC) and one in Greece (IC).