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Combining sale records of landings and fishers knowledge for predicting métiers in a small-scale, multi-gear, multispecies fishery

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ABSTRACT

Stock management should be guided by assessment models that, among others, need to be fed by reliable data of catch and effort. However, precise data are difficult to obtain in heterogeneous fisheries. Specifically, small-scale, multi-gear, multispecies fisheries are dynamic systems where fishers may lively change fishing strategy (i.e., métier) conditioned by multiple drivers. Provided that some stocks can be shared by several métiers, a precise categorization of métiers should be the first step toward métier-specific estimates of catch and effort, which in turn would allow a better understanding of the system dynamics. Here we propose an approach for predicting the métier of any given fishing trip from its landing records. This approach combines the knowledge of expert fishers with the existing sales register of landings in Mallorca (Western Mediterranean). It successfully predicts métiers for all the 162,815 small-scale fishery fishing trips from Mallorca between 2004 and 2015. The largest effort is invested in the métiers Cuttlefish/Fish and Spiny lobster, landings peak for Cuttlefish/Fish and Dolphinfish and revenues for Spiny lobster and Dolphinfish. Métier predictions also allowed us to describe the temporal (seasonal and between-year) trends experienced by each métier and to characterize the species (commercial categories) that are specific to each métier. Seasonal variability is by far more relevant than between-year variability, which confirms that at least some fishers are adopting a rotation cycle of métiers along the year. Effort (fishing trips), landings and gross revenues decreased in the last 12 years (2004–2015). The approach proposed is also applicable to any other fishery for which the métier for a fishing trip sample is known (e.g., on-board observers or logbooks), but relying on fishers expertise points more directly to fishers' intention. Thus, métier predictions produced with the proposed approach are closer to the actual uses of fishers, providing better grounds for an improved management.

1. Introduction

Most fisheries are not homogeneous but consist of a variety of vessels and activities that differ greatly in terms of, among many other factors, vessel size, gears used, technology employed, fishing grounds reached, and degree of expertise of the fishers. All these factors are also highly dependent on the market characteristics the fishery delivers to, and on a range of social aspects such as local culture and the availability of capital investment (Therkildsen, 2007). While all these factors are affected by the targeted fish stocks, they are also affecting the stocks themselves.

Conventional fisheries data collection, advice, and management usually target single-stocks. At this basis, assessing fishing mortality throughout the relationship between catch and effort may be affordable

for homogeneous, monospecific fleets. Nevertheless, this approach has long been recognized as inadequate when applied to heterogeneous fisheries, which are subjected to interactions between subsets of fishing units (e.g., métiers), and across species (Marchal, 2008). Biased estimation of fishing mortality may result from naïvely pooling catch/effort across heterogeneous units (i.e., ignoring between-métier differences). This fact is recognized, for example, for multi-fleet, multi-species bio-economic models (e.g., MEFISTO model; Lleonart et al., 2003), which are specifically designed for including specific input of effort and catchability for every fishing unit (e.g., métier) considered. Accordingly, not only more accurate predictions of the stock dynamics can be obtained but also better predictions for different métier-specific management decisions can be provided.

Several steps have been undertaken in the past to explicitly

incorporate the heterogeneity of the fishing activities within the cycle of observing, assessing, forecasting, and managing fisheries. A common sense solution is to identify units as homogeneous as possible. ICES (the International Council for the Exploration of the Sea) considers three types of fishing unit: the fleet, the fishery, and the métier (ICES, 2003). A fleet is a group of vessels sharing similar characteristics in terms of technical features and main activity. A fishery is a group of fishing trips targeting the same assemblage of species/stocks, using similar gear, during the same period of the year and within the same area. Nevertheless, fleet and fishery are often too heterogeneous from a managing perspective. Conversely, the concept of métier is specifically aimed to define a homogeneous subdivision of, either a fishery by vessel type or a fleet by type of fishing trip. Specifically, a métier is characterized by the use of a single gear targeting a specific group of species. It usually operates in a given area during a given season, within which each boat deploys a similar exploitation pattern; i.e., the species composition and size distribution of the catches taken by any vessel working in a particular métier will be approximately the same (Alarcón-Urbistondo, 2002; Deporte et al., 2012; Mesnil and Shepherd, 1990). Provided that different métiers can share several target stocks, the total effort and catches upon a stock can only be properly estimated after combining all the involved métiers targeting this stock.

In the Mediterranean, the small-scale fleet (SSF) is very relevant socially, economically and has a long history (Stergiou et al., 2006). Around 80% of the registered boats in the European Mediterranean belong to this fleet and these are currently employing about 100,000 people (Maynou et al., 2011). The number of small-scale boats operating at the Spanish Mediterranean has been estimated in 1,462 in 2015 (STECF, 2016). The fleet in the Balearic Islands (GSA05; Geographic Sub Area 5 of the General Fisheries Commission for the Mediterranean) follows a similar pattern: it comprises 337 boats, being 85% small-scale (which employ 700 people), 12.5% trawlers and the rest corresponding to different modalities (data for 2012; Grau et al., 2015). It is noticeable that the number of small-scale boats is experiencing a decreasing trend (345 boats in 2009 and 278 in 2015; Grau et al., 2015). This trend may result from both, the implementation of measures aimed to reduce effort and the decrease of fish price (Morales-Nin et al., 2010). Nevertheless, this trend is impaired with landings, which remain around 400 tons/year (Morales-Nin et al., 2010).

A peculiarity of most SSF is that some boats may use several fishing systems, which are lively alternated during the year according to the availability of resources, market demand, and other factors, such as management policies (e.g., closing seasons), local environmental characteristics and interaction with other fishing gears (Maynou et al., 2011; Salas and Gaertner, 2004). Therefore, SSF not only constitutes a relevant fraction of the fishing activity in some areas but also is particularly heterogeneous and thus, challenging from a managing perspective.

Despite its importance worldwide, SSF practices have been generally subject to little attention by the scientific community and managers when compared to the industrial fishing sector. Therefore, there is an objective need for delineating métiers in such fisheries. However, this is in practice a more challenging goal than expected. The approaches used in the past to identify métiers either (i) make use of existing records on the technical features of fishing trips (e.g., gear and mesh size used, fishing grounds visited, season, boat characteristics), which may be available from fishers' logbooks, (Marchal et al., 2006; Ulrich et al., 2001), or inferred from interviews with fishers (Christensen and Raakjær, 2006; Neis et al., 1999), or (ii) are intended to ascertain the métiers used by retrospectively examining the landings (Deporte et al., 2012; Marchal, 2008).

In this paper, we propose to combine some of the advantages of all these approaches. Using the small-scale fleet from Mallorca Island (Western Mediterranean) as case study, we demonstrated how fishers' expertise can be combined with the relatively recent implementation of electronic register of landings in order to elucidate the métiers

practiced by a particularly heterogeneous fleet. The specific aim of this work is not only to select and test a numerical algorithm for predicting the métier a given boat has practiced from the corresponding sale record, but also to up-scale the predictions of métiers to the entire fleet, which will provide an accurate, quantitative description of catches and effort for each métier. Thereby, more precise assessment of the fishing mortality of all the exploited stocks by the small-scale fishery will be obtained after more precise delineation of the métiers, which in turn should contribute to improve the management of the fishery. Information on the gear/fishing tactic, the main species exploited, the characteristics of the vessels involved plus background on the métier-specific temporal trends in catch, effort, gross revenues, as well as between-métier interactions for the period 2004–2015 are provided.

2. Material and methods

2.1. Métiers and data

The small-scale fleet in Mallorca is conducted by vessels less than 10 gross tons (Decree 17/2003 of February 21, from the Balearic Islands Government), with 1–3 hand decks, and operating close to the base harbor. This definition is consistent with other EU level definitions such as the Council Regulation (EC) No 1198/2006 of 27 July 2006 ('small-scale coastal fishing' means fishing carried out by fishing vessels of an overall length of less than 12 m and not using towed gear as listed in Annex I of Commission Regulation (EC) No 26/2004 of 30 December 2003 regarding the fishing vessels register of the Community). Specifically, trawlers and large seiners are not considered here as SSF. Less than 1 day outings are compulsory and some combinations of fishing gears in the same fishing trip are not permitted. More details on the fishery management on this fleet are provided elsewhere (Morales-Nin et al., 2010).

In Mallorca, the commercialization of all the landings (i.e., SSF, trawlers and seiners) is made through a single central fishing wharf (*OPMallorcaMar*), which is a cooperative composed by all the boat's owners in the island. In addition, fishers are associated in guilds by port (*Confraries*), which in turn are associated in the Balearic Fishers Federation (*Federació Balear de Confraries de Pescadors*). The landings are arranged in standard boxes by the fishers and auctioned daily in decreasing prices. An automatic selling procedure, implemented since 2004, registers for each box, among other data, the commercial category, the weight in kilos, the price and the name of the boat. The personal data of the fisher are encrypted in accordance with the terms of a confidentiality agreement.

The time series (2004–2015) resulting from the daily sale records, provides a valuable information on the fishing activities, and how they change at different time scales (e.g., seasonal and decadal). However, some potentially confounding factors hinder the usefulness of such database for fishing management. For example, some species might be sold as more than one commercial category, e.g., small, medium and large hake (*Merluccius merluccius*); boxes with mixed catches can correspond to different commercial categories depending on the vim of the auctioneer; and boats could have changed their name (and owner) along the time series of data. Nevertheless, one of the major drawbacks is that the métier used for obtaining the catch is not provided.

We propose to use fishers' knowledge in order to infer the métier for any fishing trip. The proposed strategy (Fig. 1) started with selecting a representative sample of fishing trips. The list of catches (i.e., the list of the daily sales of a given boat) of those sampled fishing trips were then presented to a number of experts (fishers), who were asked to label them with the métier/s (from a closed list) that they thought had most probably been used to get such a combination of catches. This sample of labeled records was then used for selecting, parametrizing and testing the success of a range of classification algorithms. Finally, the best algorithm was used for up-scaling métier's predictions from the sample to the entire time series (2004–2015) of sales from the daily boat records.