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Characterizing catches taken by different gears as a step towards evaluating fishing pressure on fish communities

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ABSTRACT

To implement an ecosystem approach to fisheries management, there is a need to characterize the total pressure exerted by fisheries at the community level. French onboard observer data were used to derive catch metrics and compare fishing distribution across community components between two sites in the Southern Bay of Biscay. Sample-based rarefaction curves were used to standardize metrics across different active and passive gears, and correct for sample size differences. Six metrics for species, length and functional catch composition were tested. Length and functional metrics were found the most relevant metrics to highlight differences in catches between gears, sites, and gear-site interactions. Significant differences were found between gears, mainly in mean length and proportion of piscivores. None of the gears had the most diverse catch across all metrics. Small differences were found between sites, mainly in length range and species richness.

1. Introduction

The ecosystem approach to fisheries (EAF) aims at maintaining ecosystem productivity for present and future generations by balancing multiple societal objectives (Garcia et al., 2003). One goal of fisheries management under an EAF is to keep fishing impacts on the ecosystem within acceptable limits, where the ecosystem structure and functioning is not threatened. The causal relationships formalized under the Driver–Pressure–State–Impact–Response (DPSIR) framework can help management. In particular, pressure can be adjusted by managers to keep the state of marine communities within, or move it towards, acceptable limits (Piet et al., 2006).

While methods exist and are commonly used to characterize fishing pressure on target populations, the limited knowledge on the biology and ecology and lack of fisheries data for most species imply that fishing pressures can not be characterized by fishing mortality or harvest rate at the community level (Piet et al., 2006). It has been hypothesized that both the total amount of fishing, and the way fishing pressure is distributed among ecosystem components determine fishing impacts on the community level (Garcia et al., 2012). Therefore, to develop an EAF, there is a need to characterize fishing pressure at the community level, i.e. the mortality caused by all fishing gears deployed in a given fishing ground on commercial and non-commercial species. Indicators are necessary tools to support this task as they provide information on the range and intensity of effort and mortality (Jennings, 2005; Piet et al., 2006). Two aspects of fishing pressure can be considered at the community level: fishing intensity and distribution across community components. In this study, we focus on how pressure is distributed across community components.

Pressures exerted on marine communities have long been considered only through the landings as declared by fishers and recorded on markets. However, landings represent only part of what is caught by fishers. Discards can make up a significant part of the catch, depending on the gear, area, season and species (Cornou et al., 2013; Hall et al., 2000), including for passive gears (Morandeau et al., 2014). Most individuals when discarded are dead, and even if few studies have been undertaken on the survival of species that are released alive, a high level of mortality is assumed (Hall et al., 2000; Revill, 2012). Onboard observer programmes were developed to address the need to identify and quantify the whole catch, distinguished between landings and discards (Alfaro-Shigueto et al., 2010; Attwood et al., 2011). By providing information on the amount, diversity and body size of the catch, onboard observer data are a valuable source to describe

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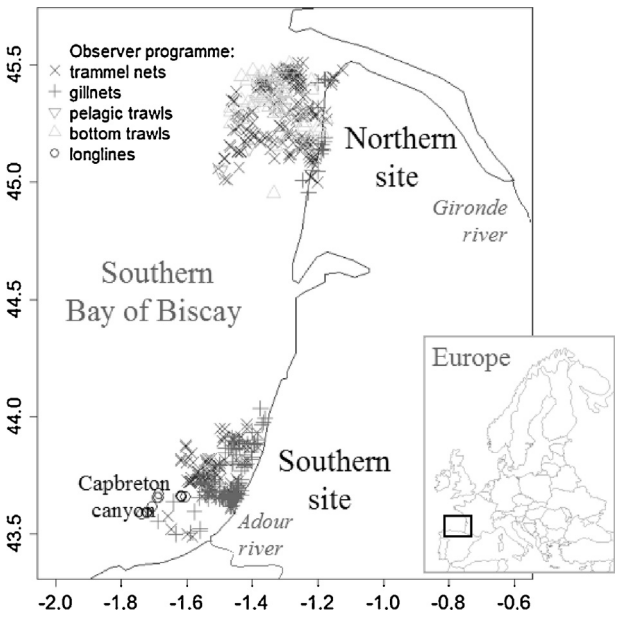

Fig. 1. Map of sampled fishing operations observed by gear onboard fishing vessels (2003–2012) in the Southern site and in the Northern site in the Southern Bay of Biscay (inset).

fisheries catches at the community level in its multiple dimensions such as species, length, and functional composition.

Onboard observer programmes further provide data on the characteristics and conditions of the fishing operations and on the main fishing metiers. Fishing mortality is likely to differ between gears (Piet et al., 2006). Therefore fishing pressure should be characterized by gear. Given the large diversity of gear characteristics, a gear can be defined at different levels of precision. The fishing method or gear group as defined by the European Union (EU) Data Collection Framework (DCF; European Union, 2008), e.g. bottom trawls or mid-water trawls, subsequently called 'gear' was chosen in this study.

The catch composition reflects both the selective properties of the gear and how it is operated, and the available fish community. In order to study the effect of the gear on the catch composition, we selected two sites in the Southern Bay of Biscay that are structurally and ecologically broadly similar, but differ in their exploitation though they are partly exploited by similar gears (see Section 2.1). Demersal and pelagic fisheries operate in both sites. In the most Southern site, the coastal area in ICES rectangle 16E8, the area located within 3 miles from the coast and part of the 3–6 miles band, is prohibited to bottom and pelagic trawlers (Fig. 1; Sanchez et al., 2013). This site is consequently mostly harvested by passive fishing gears (Fig. 1). In the second site located further North, the coastal area in ICES rectangle 19E8, trawling is allowed due to exemptions limiting the application of the trawling ban inside the 3 miles limit (Le Tixerant, 2006). This site is mostly exploited by active gears (Fig. 1). These study sites are well suited to test the relevance of metrics and highlight differences between gears and sites.

Data from the French onboard observer programme were used to compare the catch for all species between gears and sites. However, the onboard observer sampling plan was not established for this purpose, but for estimating discarded amounts per fishing métier. Therefore, the sample size was heterogeneous between gears and sites. Sample size is known to affect catch composition, especially its diversity (Magurran et al., 2011). Besides, different gears use different capture processes, mainly based on fish behaviour (Huse et al., 1999). A fishing operation from a given gear is not directly comparable with a fishing operation from another gear, especially when comparing passive and active gears. Therefore, metrics needed to be standardized before they could be compared.

The objectives of this study were: (i) to propose a method to standardize and compare the distribution of catches across community components between passive and active fishing gears based on different sample size, and (ii) to propose relevant metrics to characterize the catches that can highlight differences between gears.

2. Materials and methods

2.1. Study sites

The structure and sediments of the continental shelf in the Southern Bay of Biscay are homogeneous all along the coast of Aquitaine (Le Suavé et al., 2000). Sediments are mostly sandy, except in the deep environment of the Capbreton canyon, which is composed by a mix of rocks, coarse sediments and mudflats. This geological formation favours the presence of species and life stages which live in deeper areas, such as mature hake (*Merluccius merluccius*; Sanchez et al., 2000). The Southern Bay of Biscay is important for migratory species like meagre (*Argyrosomus regius*) in particular for feeding (Sourget and Biais, 2009). The Southern Bay of Biscay is also the geographic Northern limit of some species belonging to the Sparidae family (Quéro and Vayne, 2005). Habitats and associated communities of the two sites are influenced by the plume of major rivers: Adour River for the Southern site, Gironde for the Northern site (Fig. 1). River plumes provide habitat for spawning and feeding for many species such as hake, monkfish (*Lophius piscatorius* and *L. budegassa*), sea bass (*Dicentrarchus labrax*), common sole (*Solea solea*; Le Pape et al., 2003), turbot (*Scophthalmus maximus*), mackerels (*Scomber scombrus* and *S. colias*; Borja et al., 2002), anchovy (*Engraulis encrasicolus*; Borja et al., 1998). For those reasons, the two sites, situated 100 km apart, are considered ecologically broadly similar.

A major difference between the sites lies in the fact that, because of differences in access conditions for trawlers, they are harvested by different combinations of fishing gears. The Southern site is exploited by pelagic (purse seiners, baitboaters and pelagic trawlers) and demersal (gillnetters, longliners and pots) fisheries, most of which use passive gears. Pelagic species constitute the most abundant fish in the catch with mackerels, pilchard (*Sardina pilchardus*), horse mackerel (*Trachurus trachurus*), anchovy and tunas (*Thunnus alalunga* and *T. thynnus*). Pelagic species are caught by a few boats on a small number of trips. The main demersal target species are hake, monkfishes, sea bass, common sole, turbot and Sparidae. About 70% of all boats operating in this area are smaller than 12 m length and perform a large number of short fishing trips (Leblond et al., 2010). The Northern site, where trawling is allowed, is characterized by pelagic and demersal fisheries targeting the same species along with cephalopods (*Loligo spp, Sepia officinalis*), which deploy mostly active gears. Pelagic species are mainly exploited by pelagic trawlers. Demersal species are exploited by bottom trawlers and gillnetters, the latter are the most important metiers in this area (92% of the activity in number of months; Leblond et al., 2010). Eighty percent of the boats that fished at least once in this area in 2008 were longer than 12 m.

2.2. Onboard observer programme

Data from the French onboard observer programme contribute to the characterization of fishing pressure at the community level by providing information about the catch composition, as well as the characteristics and conditions of the fishing operation.