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A photographic method to identify benthic assemblages based on demersal trawler discards

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ABSTRACT

Knowledge of the distribution of benthic assemblages is important for monitoring the environmental status of the seafloor and understanding the spatial pattern of demersal fish species and their essential habitats. This knowledge may allow for the enforcement of spatially explicit management approaches, such as those requested by the Marine Strategy Framework Directive. However, traditional methods for benthic fauna sampling are time consuming and expensive, especially when surveying wide areas and relying on expensive sampling platforms, such as research vessels. We developed and tested a photographic method based on mega-epifauna identification and quantification through the analysis of pictures of demersal trawler discards. The method was tested with samples collected in the Northern Adriatic Sea (Mediterranean Sea) at different spatial scales. In this framework, species compositions and abundance were determined through analysis of discard pictures. These samples were compared to those derived from discard samples simultaneously collected during field activities whose specific composition was analysed in the laboratory. The direct comparison between the photographic and laboratory data highlighted a significantly strong correlation in abundance estimates, although the photographic method was less effective for the detection of small-sized or hidden species. The multivariate comparisons of species-site matrices obtained with the two methods also showed a strong, significant correlation, and the spatial patterns of assemblages were significantly consistent. Our results indicate that epifauna discarded by commercial demersal trawlers can be efficiently characterized and quantified using the photographic method, thereby halving the time needed for sample processing and easing practical barriers for sample collection and storage. These data may be used to identify different benthic assemblages and their distributions. This approach could take advantage of ongoing monitoring of commercial fishing activities and/or direct involvement of the fishing industry to allow the collection of benthic species/assemblage data over a wide spatial scale and with a high spatial/temporal resolution, thus making use of fishing vessels as an efficient sampling platform for benthic habitat investigations.

1. Introduction

Over the last few decades, concern about the ecological significance of fishing effects on ecosystems has led to the development of the so-called Ecosystem Approach to Fisheries Management (EAFM) (Garcia et al., 2003; Garcia and Cochrane, 2005). In this context, increasing importance is given to studies focused on fishing effects on habitats, as well as the study and characterization of the habitats themselves (Garcia et al., 2003; Jennings and Kaiser, 1998). In particular, the study of Essential Fish Habitats (EFH), defined as "(...) those waters and substrate necessary to fish for spawning,

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breeding, feeding, or growth to maturity" (Gleason et al., 2013), has received growing attention in the scientific and management areas (Auster and Langton, 1998). The recognition of the value of EFH on the policy agenda was demonstrated by the Magnuson-Stevensen Fishery Conservation and Management Act (MFCMA). The MFCMA was enforced in the USA in 1996 and requires the identification of EFH designated for each managed species and the development of actions to conserve and enhance their protection. However, it is necessary to understand the association between fish and their habitats in order to define and characterize EFH (Kaiser et al., 1999); this link is increasingly considered to be important for sustaining fish production (Collie et al., 2000).

In the European context, the importance of protecting estuarine and marine habitats was confirmed by the enforcement of different policies (e.g., the Habitats Directive (92/43/EEC) and the recently adopted Marine Strategy Framework Directive (MSFD; 2008/56/EC)). The latter has the goal of achieving Good Environmental Status (GES) across Europe's marine waters by 2020 through the application of ecosystem-based management. In this Directive, benthic habitats and species are considered within Descriptor 1 (Biodiversity) and Descriptor 6 (Seafloor integrity), while the other descriptors mainly address the quantification of the pressures exerted on them (e.g., Descriptor 3–commercial fish and shellfish - in relation to fishing pressure).

The implementation of the MSFD highlighted the need for better data on habitat and benthic species distributions and revealed the presence of a relevant information gap in many European seas that needs to be filled with the next monitoring activities (Zampoukas et al., 2014). Moreover, the accurate spatial delineation of habitats is considered to be a fundamental step in establishing reference points for indicators and targets for the benthic domain because such attribute are known to inherently vary across habitats (Van Hoey et al., 2013).

Studies on benthic fauna are commonly conducted on infauna species rather than on megafauna because the sampling is easier and more accurate (Kaiser et al., 1998; Rodrigues et al., 2006 Zenetos et al., 2000). However, data acquisition is usually time consuming and costly in terms of sampling gear (e.g., grabs, semi-quantitative dredges), sampling platforms (i.e., research vessels) and sample processing. Accordingly, multitaxa field studies adopting such sampling approaches are rarely undertaken over broad spatial/temporal scales (ICES, 2011a).

In contrast, bottom-trawl surveys could be suitable for collecting data on a high range of benthic megaepifauna species over wide areas and serve as a valuable source of data for implementing the EAFM (Cotter et al., 2009) with a good taxonomic sufficiency of megaepifauna (Brind'Amour et al., 2014).

However, logistic and economic constraints limit the data collection of investigations on a wide spatial scale to a low spatial and temporal resolution. Moreover, the sampling scheme is most often conceived for the study of demersal fish abundance and distribution (e.g., random stratified sampling approach) and not for habitats.

Demersal gears (such as otter and beam trawls) allow for the collection of megaepifauna samples (Ellis et al., 2000; Froglia and Orel, 1971; Kaiser et al., 2004; Marano et al., 1989) and investigations into habitat-related demersal species' spatial distributions (Kaiser et al., 1999). Most often, megaepifauna samples are collected from the total catch following standardized procedures (standard sampling gears and hauls), and sample composition (i.e., species' abundance and biomass) is assessed directly on board (or in the laboratory in the case of time and logistic constraints). This sampling approach has also been applied to commercial fishing gears to characterize the discarded catch of demersal fishing activities; moreover, it was used to infer information on benthic assemblage compositions through observational or manipulative studies of fishing effects on the benthic domain (Hall-Spencer et al., 1999; Kaiser et al., 1999; Pranovi et al., 2001).

Thus, fishing vessels could be used to collect samples of benthic megaepifauna to characterize benthic habitats provided that the interaction of the fishing gear with the seabed is known and georeferenced samples are classified using standard procedures. Until now, the use of fishing vessels as a sampling platform for benthic discards (as a proxy to describe benthic assemblages) has received little attention, possibly due to barriers including, among others: (i) practical barriers for sample collection and storage; (ii) data with mixed taxonomic resolution (e.g., species and morphospecies, see Brind'Amour et al., 2014); (iii) the inherent fishery-dependent allocation of sampling sites; and (iv) lack of detailed information on commercial fishing gear/net features and the effects of the fishing gear on the selectivity for megaepibentic discarded species.

In this study, we report the development and testing of a photographic method capable of overcoming and controlling some of the above mentioned barriers for the use of fishing vessels. This approach is proposed as an alternative/complementary method (compared to the laboratory method) for the evaluation of benthic discard composition. It has been conceived to reduce the time needed for sample collection, species identification and abundance estimations, thus potentially increasing the sampling effort. Sampling activities were designed to assess the efficacy of the photographic method in revealing benthic species and their relative abundance in fishery discards, as well as discriminating benthic assemblage distributions compared to the "traditional" method based on the field collection of benthic samples from the fishery discarded catch and the later identification and quantification of abundance/biomass in the laboratory (hereafter called the "laboratory method"). The feasibility and merits/drawbacks of the photographic method compared to the traditional discard sampling and laboratory analysis were also investigated.

The study was developed in the Northern Adriatic Sea (Mediterranean Sea) and benefited from the collaboration with the fishing industry established in the framework of the GAP2 project and trawl survey activities performed in the area with a standard beam-trawl (i.e., rapido trawl) to assess flatfish (i.e., SoleMON trawl survey; Scarcella et al., 2014).

The aims of the study were as follows:

- To develop a photographic method to describe demersal trawler's discard compositions and relative abundance;
- To test and compare the performance of this method to the traditional laboratory procedure;
- To assess the efficacy of the photographic method in discriminating benthic assemblages and their spatial distributions compared to the traditional laboratory method.

2. Materials and methods

2.1. Study area

The study area is characterized by the predominance of soft bottoms, varying from sand to mud to detritic sediments with increasing distance from the coast (Brambati et al., 1983). The sediments' spatial pattern is mirrored by the complexity of the benthic assemblages (Gamulin-Brida, 1967), with a higher degree of heterogeneity as the spatial scale increases.

To evaluate the performance of the photographic method with increasing levels of assemblage heterogeneity, the comparison between the two sampling techniques (photographic vs. laboratory methods) was performed at two different spatial scales (i.e., local and regional). For this purpose, the "local spatial scale" was defined as the sub-portion of the Northern Adriatic Sea represented