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A new approach to species distributional indicators for the Marine Strategy Framework Directive (MSFD)

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ABSTRACT

We propose alternative fish-populations spatial indicators for use in the Marine Strategy Framework Directive (MSFD). Following Commission Decision 2010/477, we have applied two different spatial indicators to three fish populations with “slow type” life-history traits, i.e. slow growing like *Helicolenus dactylopterus*, or large bodied like *Merluccius merluccius* and *Lophius budegassa.* We tested their efficiency separately and combined. One of these indicators, the presence/absence of the population in sampling squares, had already been applied during the initial assessment of the MSFD in Spain. Another indicator, the geographical spread, is proposed here as a new monitoring tool for the MSFD in Spanish waters. The results demonstrate for the three populations analyzed that neither indicator was sufficient alone to describe the population spatial pattern or its evolution. Thus, the approach to implementing the MSFD indicated in Commission Decision 2010/477 is not sufficient to provide integrated information about the spatial behavior of the fish populations analyzed. Although numerical targets or threshold values cannot be set, directional targets could be proposed, based on the results of both indicators, if evaluation of them is extended to more species and more geographical areas. The analysis could be extended to other “slow type” populations within the fish community and also to different ecoregions. We propose an approach including the estimation of two different indicators to monitoring both the area occupied and the geographical spread of fish populations within communities, interpreting them together to generate a more complete picture of the spatial patterns of those populations. In spite of the difficulties in fixing numerical targets or thresholds, or in distinguishing between environmentally and human driven changes in the population spatial distributions, this approach helps to summarize fish spatial behavior. It improves information from the indicators applied alone and reduces the requirement for a large number of maps (except for some particular event or population). The proposed indicators can be readily used by managers and politicians.

1. Introduction

An ecosystem approach to fishery management (EAFM) (Gislason et al., 2000; Jennings, 2004; Pauly et al., 2011; Link, 2013 among others) is a critical cornerstone of the European Union Marine Strategy Framework Directive (MSFD). That is an ambitious directive (2008/56/EC) as described in its Article 3, which states as its goals: “*inter alia, promote the integration of environmental considerations into all relevant policy areas and deliver the environmental pillar of the future maritime policy for the European Union*”. The MSFD tries to encompass, under 11 descriptors (for more information see http://mcc.jrc.ec.europa.eu/), practically the entire policy relevant to the pressures and impacts on marine ecosystems. Citing Article 3 again, the policy has the “*ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive.*” This was summarized as the achievement of “Good Environmental Status” (GES).

The first of these 11 qualitative descriptors sets the goal of conservation of biodiversity with this text: “Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.”

Within this descriptor 1 (D1) are several criteria to be used by the Member States (MSs) to assess the extent to which good

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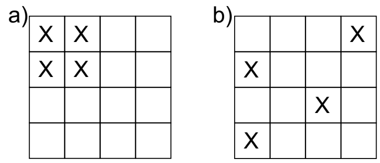

Fig. 1. Example of species distribution over a 4 × 4 grid of squares. Both a and b examples represent a percentage of presence in the squares equal to 25, but their degree of dispersion is very different, (a) being more aggregated and (b) more dispersed.

environmental status is being achieved. The first of these criteria is the "1.1 Species distribution" criterion. For mobile species this has been assessed by MSs using different methods to calculate the following required indicators: "1.1.1 distributional range" and "1.1.2 distributional pattern within the range," the latter only "*where appropriate*". The approaches to calculation of the species-level indicators for this criterion have differed even at regional and sub-regional scales in the Northeast Atlantic Ocean. Indicators have varied as a function of both the geographical area and the sampling method, although several of the approaches used are based on the IBTS Surveys (Greenstreet et al., 2012; ICES, 2013). In all cases, the estimation of the 1.1.1 indicator in the Northeast Atlantic Ocean has been based essentially on the presence/absence of the species in the sampling units considered. In the North Sea, Greenstreet et al. (2012) used a Singular Species Metric (SSM) index of "1.1.1 distributional range," defined as the proportion of ICES statistical rectangles surveyed in which a particular species was recorded in a given year. For further details on this approach see Greenstreet et al. (2012). These same authors used the mean:variance ratio as an "index of dispersion/contagion of ICES rectangles" for indicator "1.1.2 distributional pattern within the range," following the method indicated in Southwood (1978).

Within the same region (NE Atlantic), Portugal did not calculate a 1.1.1 indicator but did calculate indicator "1.1.2 distributional pattern within the range", as the proportion of hauls with presence of a species out of the total number of hauls performed in their annual trawl survey. They also used a χ^2 test with a 5% significance level to verify whether the value obtained in a given year was different from the previous year (MAMAOT, 2012).

France did not calculate any of these indicators in its initial evaluation for the Bay of Biscay (Jerome et al., 2011), while Spain used yet another approach. For indicator 1.1.1, a sampling grid of 10 × 10 nautical-mile squares was established. Each year, an index for a population considered was calculated as the percentage of sampled squares with positive records for individuals of that species. Time series of these percentages have been used to monitor spatial temporal trends in fish populations. This approach was followed in Spanish waters, including both Atlantic and Mediterranean areas. To estimate indicator 1.1.2, the presence in the squares within a depth stratum was calculated, taking into account the peculiarity of the sampling areas (Velasco et al., 2012).

As just described, several and different approaches have been used by each MS to calculate the indicators "1.1.1 distributional range", due to the heterogeneity of the sampling unit used, i.e. ICES rectangles, grid squares or hauls. All these approaches are based on the same idea, a calculation of the percentage of presence in sample units. However, none of those approaches give information about how a species, or, in the case of smaller areas, a population, is distributed in the environment, i.e. whether its distribution is aggregated or dispersed. To better illustrate this concept, we can consider, for example, the approach followed by Spain to calculate the indicator "1.1.1 distributional range." In that case the presence of a species in 25% of squares does not tell anything about how it is distributed in space (see example in Fig. 1). In fact, a species could be either aggregated or very dispersed and have the same index value (Fig. 1). Furthermore, unless a map is provided for each year of sampling, the indices would not summarize the spatial patterns of the populations studied for politicians or management decision makers.

Actually, none of the 1.1.1 indicators calculated by different MSs, if used alone, gives information on how fish populations are distributed in the study areas considered. Understanding the distributional pattern of a population is important for correct management and assessing its environmental status. This suggests that the calculation of the indicator "1.1.2 distributional pattern within the range" is always appropriate, although the Commission Decision 477/2010 specified to calculate it only "*where appropriate*." For these reasons, it would be valuable to provide additional indicators to support the information currently provided on presence versus absence and to interpret the results of all indicators together. That would more fully meet the requirements of descriptor 1.1 of Article 3 in the MSFD.

Therefore, we try, in the present study, to verify the efficiency of indicators 1.1.1 and 1.1.2, both separately and combined in our area. We seek to understand whether their use would satisfy the 1.1 "species distribution criterion" for three fish species with "slow type" life-history traits. We propose a new approach based on the 1.1.1 indicator already used by Spain combined with a new 1.1.2 indicator, namely the "geographical spread" (Rindorf and Lewy, 2012). This indicator has already been applied by other authors (Murawski and Finn, 1988; Marshall and Frank, 1994), who defined it as the average distance of sampled individuals to the center of gravity (COG) of species distribution. Where the COG is defined as the mean latitude and longitude of the species caught in each haul.

2. Rationale

The reason for testing the use of a combination of both indicators came from the need to answer the following questions:

i) Is the information provided by the 1.1.1 indicator alone sufficient to address the requirements of the "1.1 Species distribution criterion"? If this would be the case, the differences in geographical spread should never occur when the percentage of sample units with the species present remains constant (that is, there would be no cases in which the fraction of squares occupied by individuals of a species was constant through time *but* its geographical spread changed).
ii) Is the information provided by indicator 1.1.2 (geographical spread) alone, sufficient to address the requirements of the "1.1 Species distribution criterion", as in the case of Portugal? If that was the case, changes in area covered when geographical spread is constant should never occur (that is, there would be no cases in which the fraction of squares occupied by a species changed while the geographical spread remained constant).

If the answer to both of these questions is no, then an appropriate new 1.1.2 indicator should be used in combination with the 1.1.1 indicator to obtain information sufficiently exhaustive to assess criterion 1.1 of the MSFD.

3. Materials and methods

Data used were derived from the DEMERSALES bottom trawl survey (ICES code: SPNGFS) carried out annually in the 3rd–4th quarters since 1983 by the Spanish Institute of Oceanography in the southern Bay of Biscay. The survey is part of the ICES IBTS North Eastern Atlantic area (ICES Areas VIIIc and IXa) (Fig. 2).