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Functional diversity and adaptability of the Barents Sea fish community

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Functional diversity is widely recognized as an important driver of ecosystem functions, governing the adaptability of systems in the face of disturbance. Adaptability is a component of ecosystem robustness and resilience. We provide the first estimate of the functional diversity for the Barents Sea fish community, by combining the Joint Norwegian-Russian survey data from the whole Barents Sea with an extensive functional trait matrix (27 functional traits for 77 fish species). We show that the functional diversity remained stable in some areas in the period 2004-2009, whereas in other areas it showed consistent inter-annual variation, probably due to climatic fluctuations. Our analyses showed that persistent fields of high functional diversity were found in the central-west as well as along the Norwegian coast in the south-west, whereas the functional diversity was always low in the south-easternmost areas of the Barents Sea. Large inter-annual variations in the extent of the central field of high functional diversity were evident, encompassing a restricted area in cold years and expanding towards the high north in warmer years. Our findings suggest that functional diversity can be a valuable tool in the future resource management in the Barents Sea.

Keywords: Barents Sea, fish, functional diversity, functional trait

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Background

Northern marine ecosystems are experiencing major ecological alterations driven by environmental change associated with climate warming and fisheries (Overland and Stabeno, 2004, Brander, 2007, Bundy et al., 2009). In order to understand ongoing ecological change and manage marine ecosystems sustainably in a changing environment, reliable assessments of their functioning and vulnerability are necessary (Levin and Lubchenco, 2008). Ecosystems vulnerability to environmental perturbations depends on their adaptability, which is their ability to function under changing conditions (Walker et al., 1999, Levin and Lubchenco, 2008). Biodiversity promotes ecosystem adaptability by increasing the number of ecosystem functions that community members can perform (Loreau et al., 2001, Levin and Lubchenco, 2008).

Different measures of biodiversity have been proposed. In its simplest form, biodiversity has been defined as species richness (SR), i.e. the number of species in an ecosystem. Although such a measure of taxonomic diversity is relatively easy to obtain, it does not account for the functional variation between taxonomic units. Species attributes should be taken into account when studying diversity-functioning relationships. In order to account explicitly for diversity of biological attributes, measures of functional diversity (FD) have recently been developed (Petchey and Gaston, 2006). Functional diversity is defined as the range and value of those species and organismal traits that influence ecosystem functioning (Tilman, 2001). Various ways to calculate FD have been proposed; an early approach considered functional group richness (e.g. Tilman et al., 1997), but continuous measures have also been introduced (Petchey and Gaston, 2002, Laliberté and Legendre, 2010). These measures have been applied in plant community studies in particular, and the results suggest that FD affects ecosystem resource dynamics, productivity and stability (Díaz and Cabido, 2001). Also, FD measures allow to assess functional dispersion in a community, i.e. the degree of functional traits heterogeneity

among community members (Forest et al., 2007), which reflects the adaptability of the system discounted for the number of species present. FD is now widely accepted as a key driver of ecosystem functioning (Hooper et al., 2005).

Measuring the FD in marine assemblages is a challenging task due to the cost of collecting data and the lack of information on functional traits. Only a few studies have focused on FD in marine fish assemblages (e.g. Halpern and Floeter, 2008, Stelzenmüller et al., 2009). The fish communities of the Barents Sea have been recently characterized, and their biodiversity has been assessed, although without accounting for functional traits (Fossheim et al., 2006, Johannesen et al., 2012). This is the first work to assess the FD and to evaluate the adaptability of the fish community in the Barents Sea. We have chosen to study the period 2004-2009 due to availability of high-quality data from the whole area of interest.

Results

Although the spatio-temporal FD patterns largely followed those of simpler biodiversity measures like SR, approximately 14% of the variation in FD remained unexplained by SR. Regions of high FD, persistent between years, were observed in central areas and off the Norwegian coast in the south-western Barents Sea (Figure 1a). Regions with consistently low FD were found in the south-east throughout the study period. Some areas showed considerable interannual variation in FD (Figure 1b). These areas include the north-easternmost parts of the Barents Sea as well as a transition zone between the central and south-easternmost regions. We also identified a transition zone between the far south-west and central-west where FD was low throughout the study; this transition zone broadened in warm years. Also, the extent of the central field of relatively high FD showed major interannual variation. Functional dispersion (FD corrected for SR) was consistently high in the cool central-east and low in warm the western slope areas.

Discussion

This study demonstrates the potential use of FD to highlight high-biodiversity areas. Our analyses also identified areas where FD was low and subsequently areas less able to adapt to oncoming changes. In these areas, shifts may be more likely than in highly functionally diverse areas. Ecosystem shifts are non-linear in nature (Folke et al., 2004, DeYoung et al., 2008); they occur suddenly and may result in great changes at the ecosystem scale. Therefore, areas associated with low FD should benefit from reinforced monitoring and management measures.

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Figures

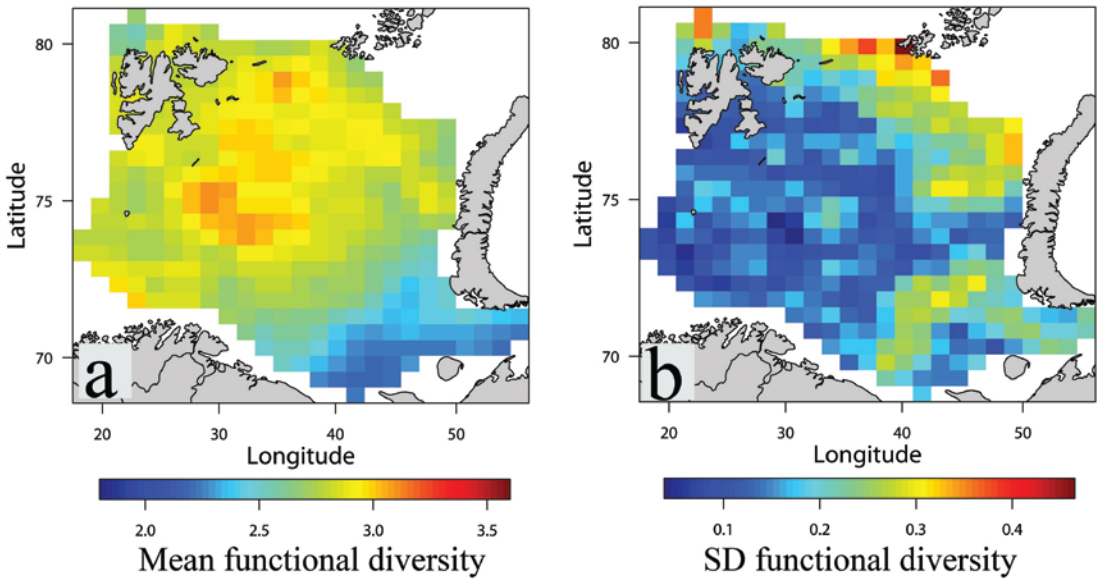

Figure 1. Functional diversity of the Barents Sea fish community. a) Mean values 2004-2009. b) Standard deviation 2004-2009.