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The distribution of blue whiting west of the British Isles and Ireland

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ABSTRACT

Northern blue whiting is a small abundant pelagic gadoid that is widely distributed in the northeast Atlantic and one of the most commercially valuable species west of the British Isles and Ireland. Over the last two decades the northeast Atlantic stock has undergone dramatic changes in abundance. The stock size decreased dramatically from 2007 to 2011, but has since shown signs of recovery. Changes in recruitment levels have occurred almost simultaneously with unusual changes in the north Atlantic ecosystem and oceanography. These links may suggest a causal linkage and the possibility of improving our understanding of the recruitment and spawning stock distribution. Here we use a set of geostatistical indices to describe the temporal and spatial patterns of the northeast Atlantic blue whiting stock in spring of 2006–2014. Geostatistical indices were computed to investigate changes in the spatial distribution, dynamics and variability of the stock in terms of density and location. Indices revealed 3 different distribution patterns over the time series. Main concentrations were either found around Rockall (first years), west of the Hebrides (2008–2013) or in the southern survey area (2014). The distribution was found to be age structured, with young blue whiting mainly concentrated in shallower areas (<1000 m), along the shelf edge, and older specimens being more prominent in deeper waters (>1000 m). A general additive mixed model (GAMM) was used to model the distribution of blue whiting according to environmental conditions and location.

1. Introduction

Northern blue whiting (*Micromesistius poutassou* Risso, 1827) is a small abundant pelagic planktivorous gadoid that is widely distributed in the northeast Atlantic. It is of great commercial importance to a number of European countries (Payne et al., 2012). During the spawning season, the species is predominantly found between the west coast of the British Isles, Ireland and the Norwegian Sea (Bailey, 1982; Payne et al., 2012). Over the last two decades the northeast Atlantic stock has undergone dramatic changes in abundance (Payne et al., 2012). Due to a succession of unusually strong year classes in the late 1990s the stock increased substantially. This was followed by an equally drastic decrease in abundance after 2005, when the recruitment fell to low levels (Payne et al., 2012). It has been shown that these changes in recruitment occurred nearly simultaneously with unusual hydrographical changes in the north Atlantic ecosystem and oceanography (Hakkinen and Rhines, 2004; Payne et al., 2012), which might suggest a causal linkage (Hátún et al., 2009a,b). Trenkel et al. (2015) found differences in mean size at age and mass at age for blue whiting to be dependent on density, temperature and prey availability. Blue whiting spawn mainly during

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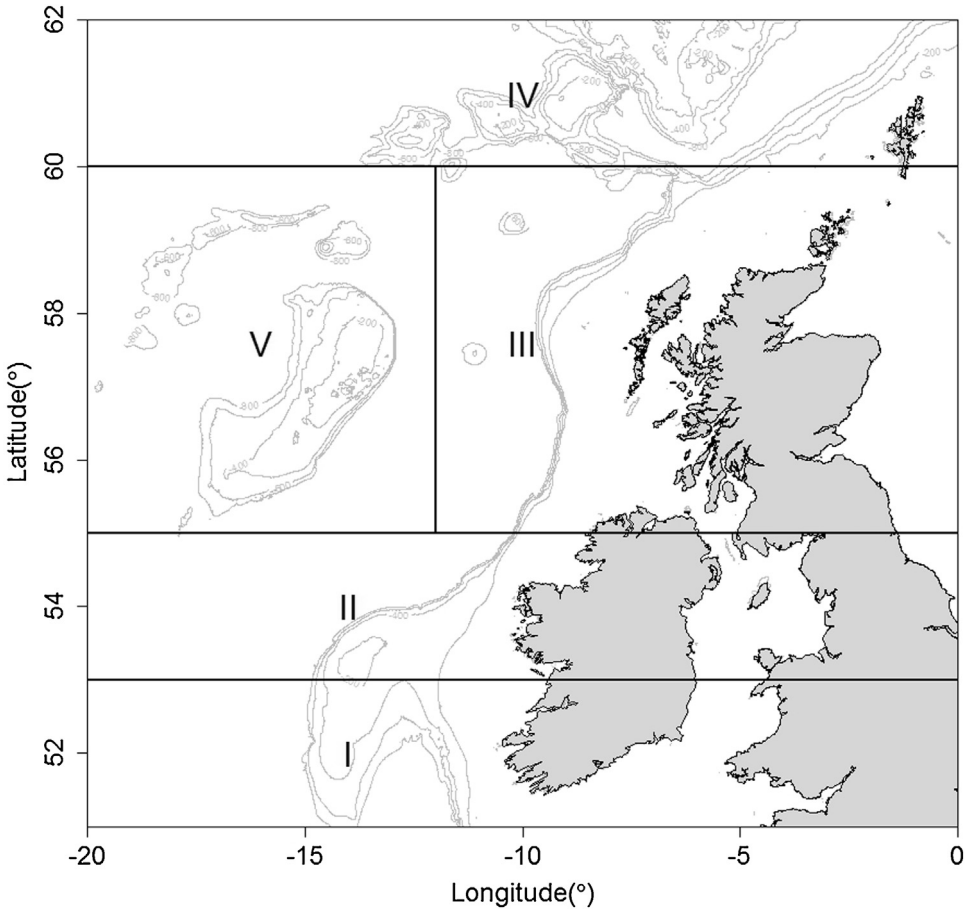

Fig. 1. Map of the survey area showing the 5 subareas west of the British Isles and Ireland: (I) south Porcupine, (II) west of Ireland, (III) Hebrides, (IV) Faroe Islands, and (V) Rockall area. Light grey lines show depth contours.

March and April along the shelf edge and banks west of the British Isles and Ireland (Bailey, 1982; Skogen et al., 1999; Hátún et al., 2009a) where oceanographic conditions are highly susceptible to change (Holliday, 2003). The location of the spawning area is sensitive to variations in temperature and salinity (Schmidt, 1909). The hydrographic conditions of the area are driven by the strength of the subpolar gyre, which brings either saline, warm waters or less saline, cold waters into the area (Hátún et al., 2009a).

Over the past 9 years the ICES coordinated International Blue Whiting Spawning stock Survey (IBWSS) has collected simultaneous fish abundance and environmental data west of the British Isles and Ireland at the same time in spring each year. A set of spatial indices was selected to describe inter-annual variability in different age groups of the blue whiting population, as observed during the surveys. Exploring these data and their spatial dependencies provides an overview into potential linkages between oceanographic or environmental variables and the distribution and abundance of blue whiting at different ages. Improved knowledge would not only facilitate survey planning, but also increase our understanding of the ecosystem on the western shelf which supports commercially and environmentally important fish stocks.

In the present study, spatial indices are used to describe the dynamics of different ages of northern blue whiting on their spawning grounds in relation to density, location, and environmental variables (e.g. Woillez et al., 2009a). A number of previous studies have successfully applied such indices to investigate distributional changes of a range of fish species over large temporal scales (e.g. Alvarez et al., 2001; Woillez et al., 2007; Honkalehto et al., 2011; Hughes et al., 2014). Given the zero-inflated and auto-correlated nature of acoustic density data, geostatistical spatial indices or individual based statistics are preferred as alternative quantitative methods as they can apply weights to each sample proportionally to its density (Bez and Rivoirard, 2001; Woillez et al., 2007; Woillez et al., 2009a). The objective here was then to derive these indices per age class within the population and investigate their potential links to environmental variables and differences over a time period where the stock size has experienced significant changes.

2. Material and methods

2.1. Acoustic and biological data

ICES coordinated scientific acoustic surveys on blue whiting have been conducted west of the British Isles and Ireland in March and April each year since 2004. The survey area extends from the southern Porcupine area (50°N) to the Faroe Islands (62°N), stretching eastwards just over the continental shelf and westwards to the Rockall area (Fig. 1). For stratification purposes the total survey area is divided into five subareas: (I) south Porcupine (south of 53°N); (II) west of Ireland (53–55°N); (III) Hebrides (55–60°N), east of 12°W); (IV) Faroe Islands north of (60°N); and (V) Rockall area (west of 12°W from 55 to 60°N) (Fig. 1). The present study used acoustic, biological and environmental data collected on the survey from 2006 until 2014. The data were collected on systematic horizontal transect lines designed to ensure a maximum synoptic coverage of the stock. The transect spacing was based on historic levels of abundance, ranging from 10 nmi in the core survey area (i.e. subarea III, Hebrides) to 30 nmi in areas expected to contain the