ABSTRACTS BOOK

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Environmental forcing on blue whiting year-class strength in the Porcupine bank (NE Atlantic)

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ABSTRACT
The highest abundance of age-0 blue whiting Micromesistius poutassou in the Porcupine Bank since 2001 was observed in 2020. Various environmental parameters, namely chlorophyll concentration, surface salinity, temperature, ocean currents, and wind data were used to study their potential impact on the blue whiting eggs and larvae survival. Our results showed that in 2020, during the blue whiting-spawning season (March-April), the calm wind situation along with weaker ocean currents above the Porcupine Bank helped to accumulate phytoplankton biomass, thus promoting secondary productivity. The optimal salinity concentration, as well as surface temperature during this time, helped the buoyancy of eggs and larvae to the food-rich surface, thus improving the larval condition and enhanced the survival rate, which in turn resulted in the highest year-class recruitment since 2001.

KEYWORDS
blue whiting, recruitment, 0-group, survival, chlorophyll, salinity, temperature, wind mixing index, ocean current.

INTRODUCTION
The Porcupine Bank (ICES Divisions 7c and 7k) is located at the western edge of the north-eastern Atlantic shelf west of Ireland, between 51-54°N and 11-15°W (Thébaudeau et al., 2016), and comprises a major spawning area for blue whiting Micromesistius poutassou (Risso, 1827). In this region, blue whiting spawn during March and April between 300 to 600 m depth (Hillgruber and Kloppmann, 1999); however, most larvae occurr within the upper 40 m (Kloppmann et al., 2002). Although temporal and spatial match and mismatch of fish larvae with their potential prey organisms, as well as prey abundance, are considered the main factors regulating the year-class strength in marine fish populations (Lasker 1975), different environmental forcings also influence the survival rate of larvae and thus, the year-class recruitment. Lasker (1975) and Lewis et al. (1994) showed that strong wind-mixing disrupts layers of high prey concentrations and reduce the energy transfer efficiency from phytoplankton production to higher trophic levels. Hillgruber and Kloppmann (1999) showed that during high storm activities, larvae survival is poor due to turbulence-induced malnutrition. Miesner and Payne (2018) showed that the optimum salinity window for blue whiting spawning is between 35.3-35.5 PSU. Therefore, it is evident that different environmental forcings play a vital role in the survival rate of blue whiting larvae.

In 2020, the abundance of year-class recruits (total lenght < 20 cm) of Micromesistius poutassou was the highest in the record from 2001-2020, implying that there must be some environmental conditions in the spawning season which determined the high survival rate of the larvae. Therefore, in this present study, we test the hypothesis that the exceptional year-class strengh of Micromesistius poutassou in 2020 is related to the optimal environmental conditions in the spawning season (March-April). In particular, we describe how the sea surface temperature, salinity, chlorophyll (as a proxy of biological productivity), wind mixing index and ocean currents influence the high year-class recruitment in 2020.

MATERIALS AND METHODS

A Spanish bottom trawl research survey has been carried out annually (September) since 2001 in the Porkupine Bank (Figure 1) to study the distribution, relative abundance and biological parameters of commercial fish. The survey covered an area extending from 12° W to 15° W longitude and from 51° N to 54° N latitude, following the standard methodology for the IBTS North Eastern Atlantic Surveys (ICES, 2017). Bottom trawls were carried out on board the R/V Vizconde de Eza, a stern trawler of 53 m and 1800 Kw, using a Baca-GAV 39/52 with a cod-end mesh size of 20 mm. The insets in Figure 1 show the in situ data of the abundance and distribution of year-class blue whiting recruits in 2020.

To analyse the impact of environmental forcing on fish abundance, satellite remote sensing L4 product of chlorophyll-a concentration (hereafter CHL) as well as sea surface salinity (hereafter S), temperature (hereafter SST) and ocean currents data from the IBI numerical model were downloaded from the Marine Copernicus Service (https://marine.copernicus.eu/) for 2020. The ERA5 wind field at 10 m was downloaded from the Copernicus Climate Data Store (https://cds.climate.copernicus.eu/). The wind mixing index (hereafter WMI) was calculated as the cube of wind speed, following Cuttitta et al. (2006). SST and WMI anomaly maps were calculated.

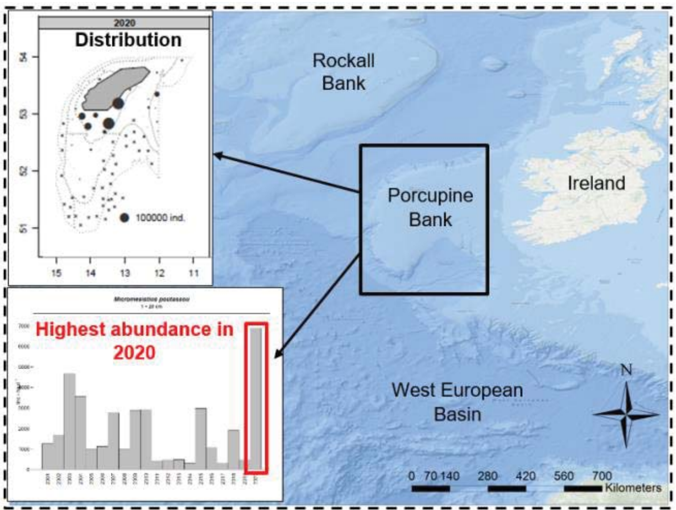

Figure 1. Study area map showing the location of Porcupine Bank along with the abundance and distribution of year-class blue whiting recruits in 2020.

RESULTS AND DISCUSSION

The concentration of CHL in the ocean is considered as a proxy of phytoplankton biomass that can be related to fish production. CHL concentrations above 0.2 mg/m3 indicate the presence of sufficient planktonic life to sustain fisheries (Butler, 1988). Though it is evident from Figure 2 that during March 2020, the concentration of CHL was limited to the coast of Ireland implying lower productivity offshore, in April, the concentrations increased largely above the Porcupine Bank, which created favorable conditions for primary and secondary productivity, thus, benefiting blue whiting larvae with a favorable feeding environment.

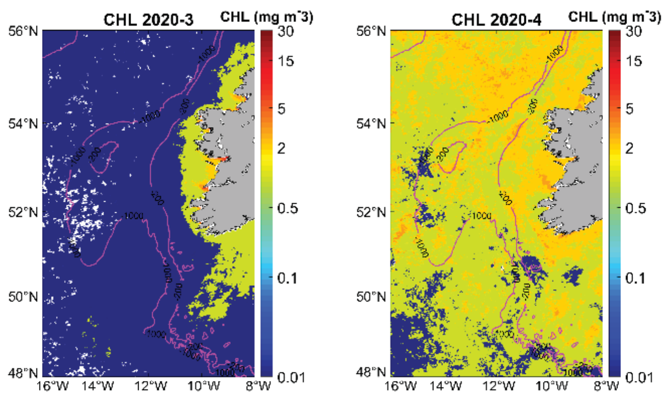

Figure 2. Monthly means of CHL concentrations during March and April 2020.

Blue whiting eggs are positively buoyant at their initial stage and their density increases during egg development, which helps them to maintain a stable bathypelagic distribution (Adlandsvik et al., 2001). Blue whiting larvae passively ascend through the water column towards the food-rich surface (Adlandsvik et al., 2001). However, the buoyancy of eggs and larvae and their vertical distribution are affected by the water density. Changes in salinity and temperature, thus in water density, can alter the ascent of larvae from their spawning depth towards the food-rich surface waters which are critical for their survival (Miesner and Payne 2018). During the 2020 spawning period, above the Porcupine Bank, the salinity ranged from 35.3-35.5 PSU (Figure 3) which is exactly the optimum salinity window for blue whiting spawning (Miesner and Payne 2018). Furthermore, the SST anomaly maps (Figure 4) showed negative anomalies during March that began to move from zero to slightly positive anomalies in April, implying that the water density of this region was becoming favorable for the blue whiting larvae, helping them to ascend passively through the water column to reach the surface where they could feed.

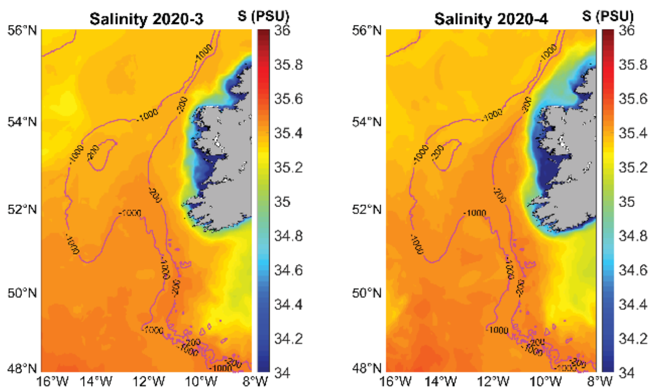

Figure 3. Monthly means of S during March and April 2020.

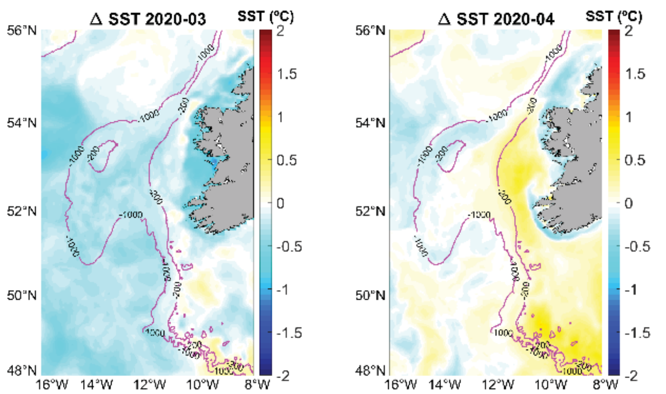

Figure 4. SST anomaly maps in March and April 2020.

Figure 5 shows the WMI anomalies whereas Figure 6 shows the mean ocean current velocity during the spawning season. It is evident that during this time, WMI anomaly was negative, implying a calmer than average situation. Moreover, above the Porcupine Bank, the ocean current was weaker than the northern and southern parts of the bank. Both environmental conditions resulted in higher prey concentrations and better feeding opportunities/success for blue whiting larvae, ensuring better larval conditions and enhanced survival during the critical first life span.

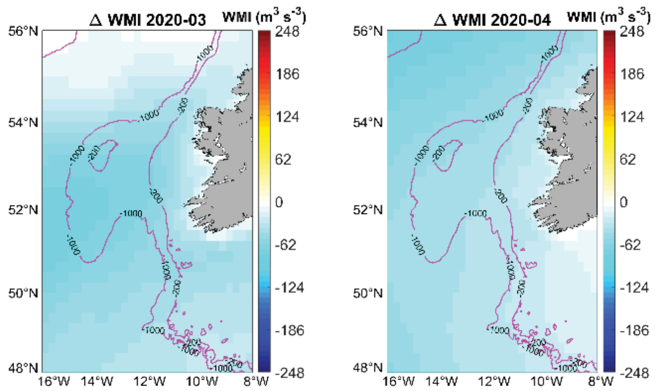

Figure 5. WMI anomaly maps in March and April 2020.

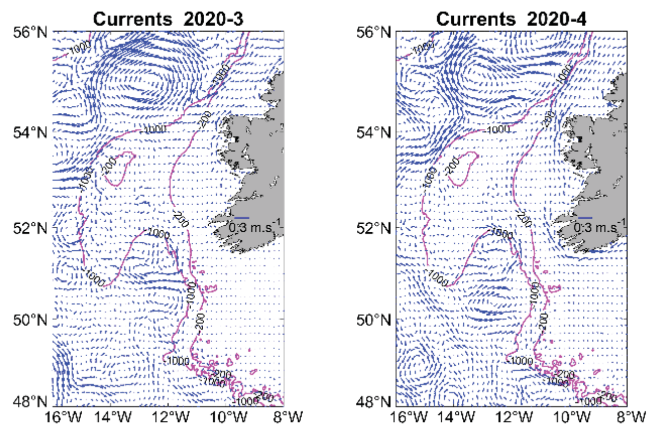

Figure 6. Monthly mean surface current maps in March and April 2020.

CONCLUSIONS

The calmer oceanic environment as a result of weak ocean currents and calm winds over the Porcupine Bank helped accumulate phytoplankton biomass thus triggered secondary productivity in this region, which in turn improved the availability of prey organisms. During this time, optimal salinity concentrations, as well as surface temperature, helped larvae to ascend to the food-rich surface and hence led to better feeding success. All these environmental forcings improved the condition of blue whiting larvae resulting in higher larval survival rates and consequently greater recruitment success in 2020.

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