SPATIAL DISTRIBUTION OF FISHING GROUND OF THE SPANISH ALBACORE (*THUNNUS ALALUNGA*) SURFACE FISHERY IN THE NORTHEASTERN ATLANTIC IN 2015 AND 2016

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SUMMARY

*Albacore (*Thunnus alalunga*) nominal catch rates were estimated from the monitored trips of the Spanish surface fishery during 2015 and 2016. The bait boat and troll fleet targeted albacore during summer and autumn seasons. Their spatial distributions were compared in relation to Sea Surface Temperature (SST) measured in the North East Atlantic off shore waters and the Bay of Biscay area. Range of the Sea Surface Temperature where catches were located, was estimated from SST satellite maps and the distribution of CPUEs by trip for both fleets and month for the two years respectively. In summer, there are two distinct regions according to range of SST and CPUEs by fleet, one warmer area in the Bay of Biscay and more temperate area in the off shore waters of NE Atlantic. Two distinct distribution areas were observed concerning fleet strategy. Bait boat catches were located in the Bay of Biscay, while troll catches were spread through the Bay of Biscay and NE Atlantic off shore waters. Likewise, SST range observed in 2015 and 2016 in the fishing areas was similar.*

RÉSUMÉ

*Les taux de prise nominale du germon (*Thunnus alalunga*) ont été estimés à partir des sorties ayant fait l'objet de suivi de la pêcherie de surface espagnole entre 2015 et 2016. La flottille de ligneurs et de canneurs a ciblé le germon en été et en automne. Leurs distributions spatiales ont été comparées à la température à la surface de la mer (SST) mesurée dans les eaux hauturières de l'Atlantique Nord-Est et dans la zone du golfe de Gascogne. La gamme de température à la surface de la mer des zones où les prises ont été réalisées a été estimée à partir des cartes satellitaires SST et de la distribution des CPUE par sortie pour les deux flottilles et par mois pour les deux années. En été, il existe deux différentes zones conformément à la gamme de SST et aux CPUE par flottille : une zone plus chaude dans le golfe de Gascogne et une zone plus tempérée dans les eaux hauturières de l'Atlantique Nord-Est. Deux différentes zones de distribution ont été observées en ce qui concerne la stratégie de la flottille. Les prises des canneurs se situaient dans le golfe de Gascogne alors que les prises des ligneurs s'étendaient dans le golfe de Gascogne et les eaux hauturières de l'Atlantique Nord-Est. De même, la gamme SST observée en 2015 et 2016 dans les zones de pêche était similaire.*

RESUMEN

*Se estimaron las tasas de captura nominal de atún blanco (*Thunnus alalunga*) a partir de mareas objeto de seguimiento de la pesquería de superficie española durante 2015 y 2016. La flota de cebo vivo y la flota de curricán se dirigieron al atún blanco durante el verano y el otoño. Se compararon sus distribuciones espaciales con la temperatura de la superficie del mar (SST) medida en el Atlántico nordeste en aguas de alta mar y en la zona del golfo de Vizcaya. Las zonas de temperaturas de superficie del mar en la que se localizaron las capturas se estimó a partir de mapas satélite STT y de la distribución de las CPUE por marea para ambas flotas y por mes para los dos año, respectivamente. En verano, hay dos regiones diferencias en función de la gama SST y de la CPUE por flota, una zona cálida en el golfo de Vizcaya y una zona más templada en las aguas de alta mar del Atlántico noreste. Se observaron dos zonas de distribución diferenciadas en la estrategia de la flota. Las capturas de cebo vivo estaban localizadas en el golfo de Vizcaya, mientras que las capturas de curricán se extienden por el golfo de Vizcaya y las aguas de alta mar del Atlántico noreste. Asimismo, la gama SST observada en 2015 y 2016 en las zonas de pesca fue similar.*

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KEYWORDS

Thunnus alalunga, troll fishery, bait boat fishery, spatial distribution, Northeast Atlantic, Bay of Biscay, SST, albacore, nominal CPUEs

1. Introduction

Albacore (*Thunnus alalunga*) is a highly migratory species living in the Atlantic, where two stock: North and South are identified. In spring and early summer, as the water temperature rises, immature albacore from North Atlantic stock migrates from the central Atlantic waters towards the north-eastern Atlantic and Bay of Biscay temperate surface waters (Aloncle et Delaporte, 1973; Bard, 1981; Ortiz de Zárate and Cort, 1998; Arrizabalaga, 2003) where forage prey are abundant (Pusineri *et al*., 2005; Goñi and Arrizabalaga, 2010).

Albacore inhabits pelagic habitats in the Northeastern (NE) Atlantic described by a number of physical variables such as temperature, salinity, oxygen content and chlorophyll that characterized particular water masses. The distribution of the albacore habitat varies over time at regional scale (i.e. Bay of Biscay) accordingly to climatologic and oceanographic features in the North Atlantic Ocean (Dufour *et al*., 2010).

The annual migratory behaviour of juvenile albacore drives the marked seasonality and spatial distribution of the Spanish surface fishery that target albacore during summer and autumn months in the NE Atlantic offshore waters and Bay of Biscay (Arrizabalaga *et al*., 2010; Bard and Santiago, 1999; Ortiz de Zárate *et al*., 2015; Ortiz de Zárate and Perez, 2016a). Bait boat and troll vessels target albacore in the Bay of Biscay and off shore waters in NE Atlantic. The albacore surface fishery represents an important resource from the socio-economical activity reported in the Spanish north-western and northern fishing ports.

Concerning the activity of both fleets, the number of boats involved varies among years; the annual averaged number is 520 vessels (88% troll and 12% bait boat). The troll vessels are of lesser tonnage (mean of 50 GRT) than those of bait boat (mean 120 GRT). The catch composition by age is mainly made up of immature albacore 1 to 4 age groups, corresponding to 50 to 90 cm fork length fish.

The aim of this paper is to present the monthly spatial variation of albacore nominal catch rates in weight per unit of fishing effort (CPUE) in relation to the observed SST in the area covered by the surface fleet respectively. The nominal CPUEs were derived from the bait boat and troll trips monitored during 2015 and 2016 fishing seasons, Moreover, a brief description of the evolution of fishing grounds based on the geographical distribution of the nominal CPUEs (kilograms (kg)/fishing days) is presented for both fleets for both years.

2. Material and Methods

The monitoring of the Spanish bait boat and troll fleets activity in 2015 and 2016 was done by means of collecting information through interviews to skippers at main fishing ports located along North western and the Cantabrian coast. The information collected from individual trip samples by fleet included: number of days at sea, number of fishing days, catch in number of fish and weight (kg) and an approximate location of catch by 1ºx1º degrees latitude and longitude, recording at least one position per trip.

The catch (kg) and effort (fishing days) from each individual trip within the same square 1º x 1º degree latitude and longitude were added by month and gear. Therefore a unique CPUE estimated value in that given 1º x 1º degree latitude/longitude square was represented in the monthly maps elaborated for each gear and year.

The monthly means of the daily Sea Surface Temperature product at 0.25° x 0.25° were obtained from E.U. Copernicus Marine Service Information (http://marine.copernicus.eu). Then were converted to Celsius degrees and were incorporated into the geographical distribution of CPUEs.

Qualitative information on thermal range of SST was deduced by visual inspection of the monthly maps representing the nominal CPUEs in weight (kg) distribution in accordance with distribution of sea surface temperature isotherms (SST) observed in the fishing area covered by fleets.

3. Results and Discussion

The information related to SST scaled by 1ºC that was observed for 2015 and 2016 was classified according to the geographical distribution of nominal CPUE estimated for troll and bait boat fleet and was presented in monthly intervals for the two distinct fishing areas (**Table 1)**. As shown, higher temperature were registered in the Bay of Biscay area during 2015 and 2016.

As overall, in the Bay of Biscay area, monthly catches taken by both fleets where found in the same range of temperatures, with an increase of sea surface temperature in the fishing area during August. On the other hand, in the NE Atlantic off shore waters only troll fleet operated in the two years. The sea surface temperature range estimate from the monthly range of SST measured across years was lower in the NE Atlantic than in the Bay of Biscay fishing ground. In general, catches by the two fleets were obtained in waters of SST ranging from 16°C to 22°C. In the study by Cosgrove *et al*.,(2014), with pop-up archival tags deployed on North Atlantic albacore fish, it was found that the mean temperature overall was 16.99ºC and ranged from 15.44ºC to 19.22ºC for individual tagged with pop-up archival tags deployed on North Atlantic albacore fish. The higher temperature described for the area of surface catches were explained by using the SST measurements.

The monthly spatial distribution of nominal catch rates for the troll fleet fishing in summer 2015 and 2016 are represented in **Figure 1a** and for the autumn season in **Figure 1b**, respectively. Overall SST patterns didn´t show differences between the two years. However the geographical distribution of CPUEs in June was different between years, more latitudinal displacement was observed in 2015. Additionally, in 2016 autumn months, it was noticed that albacore was found closer to the Irish and French shelf break. Catch rates in the Bay of Biscay varied from 2015 to 2016 and were lower than in the NE Atlantic. The decrease of the fishing effort by troll fleet in the Bay of Biscay has been documented since 2009 (Ortiz de Zárate and Pérez, 2016b).

The summer monthly spatial distribution of nominal catch rates for the bait boat fleet in 2015 and 2016 are represented in **Figure 2a** for summer season and in **Figure 2b** for the autumn months. As shown, all the fishing activity took place in the Bay of Biscay area in the two fishing years. This behaviour was similar to the distribution of fishing effort in 2012 and 2013, when catches concentrated mainly in the Bay of Biscay area closer to the coast line (Ortiz de Zárate *et al.,* 2015). In 2015, it was noticed some activity in June, that could be due to the availability of albacore in the Bay of Biscay, earlier in the fishing season, caused eventually by an earlier migration to the area as has been suggested by Dufour *et al*. (2010). In their study to search for the influence of environmental variability on migration phenology and spatial distribution of albacore described that the inter annual tendency is determined by seasonal regional SST dynamics, positive temperature anomalies in a given year are likely to produce earlier migrations from wintering to feeding areas in the Northeast Atlantic.

SST is an indicator of oceanographic features in the fishing grounds, however it doesn´t explain different spatial behaviour of fleets. Lezama-Ochoa, *et al*. (2010) postulated in their study that at an inter annual regional scale, albacore distribution, as inferred by CPUE, is driven by prey distribution. Importance of physical and biotic constraints may be altered and hence, physical constraints impact albacore tuna dynamics more dramatically than under non-extreme environmental conditions.

It can be concluded that a different fishing strategy by fleet was evident when observing the spatial distribution of the nominal CPUEs estimated by fleet, as presented in **Figure 1**, which described fishing operations by troll fleet and in **Figure 2** representing the bait boat fleet fishing operations.

The troll fleet operates in a continuous area: NE Atlantic and Bay of Biscay, while the bait boat fleet is confined to the Bay of Biscay. These geographical areas are characterized by different thermal features, with lower sea surface temperature in the observed range in the North East Atlantic area and higher sea surface temperatures in the in observed range in the Bay of Biscay area.

The dynamic of the habitat is important to understand the distribution pattern of albacore and the natural variation of the ecosystem. Habitat availability is subject to annual changes in the oceanic environment in NE Atlantic region. Nevertheless, an hypothesis based on operating strategies carried out by the two fleets and variables that interact into their profit should be investigated to understand annual fluctuations on yield by fleet.

Acknowledgements

The authors would like to thank all the IEO network sampling staff involved in the collection of fisheries data at main fishing ports in Galicia and Cantabrian coast. The work related to this document was partly supported by the IEO project PNDB 2016 funded by DG MARE of European Union.

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Table 1. Sea Surface Temperature (ºC) observed in the albacore fishing grounds during 2015 and 2016.

(a) 2015	Troll		Bait Boat
SST (ºC)	NE Atlantic	Bay of Biscay	Bay of Biscay
June	15 - 16		
July	16 - 20	19 - 20	18 - 20
Aug.	16 - 19	20 - 22	20 - 22
Sept.	14 - 18	19 - 21	20 - 21
Oct.	14 - 15	17 - 18	18
Nov.	15		

(b) 2016	Troll		Bait Boat
SST (ºC)	NE Atlantic	Bay of Biscay	Bay of Biscay
June	16 - 17	17 - 18	17 - 18
July	16 - 21	19 - 21	19 - 21
Aug.	16 - 19	20 - 22	20 - 22
Sept.	15 - 17	19 - 20	19 - 21
Oct.		17	18

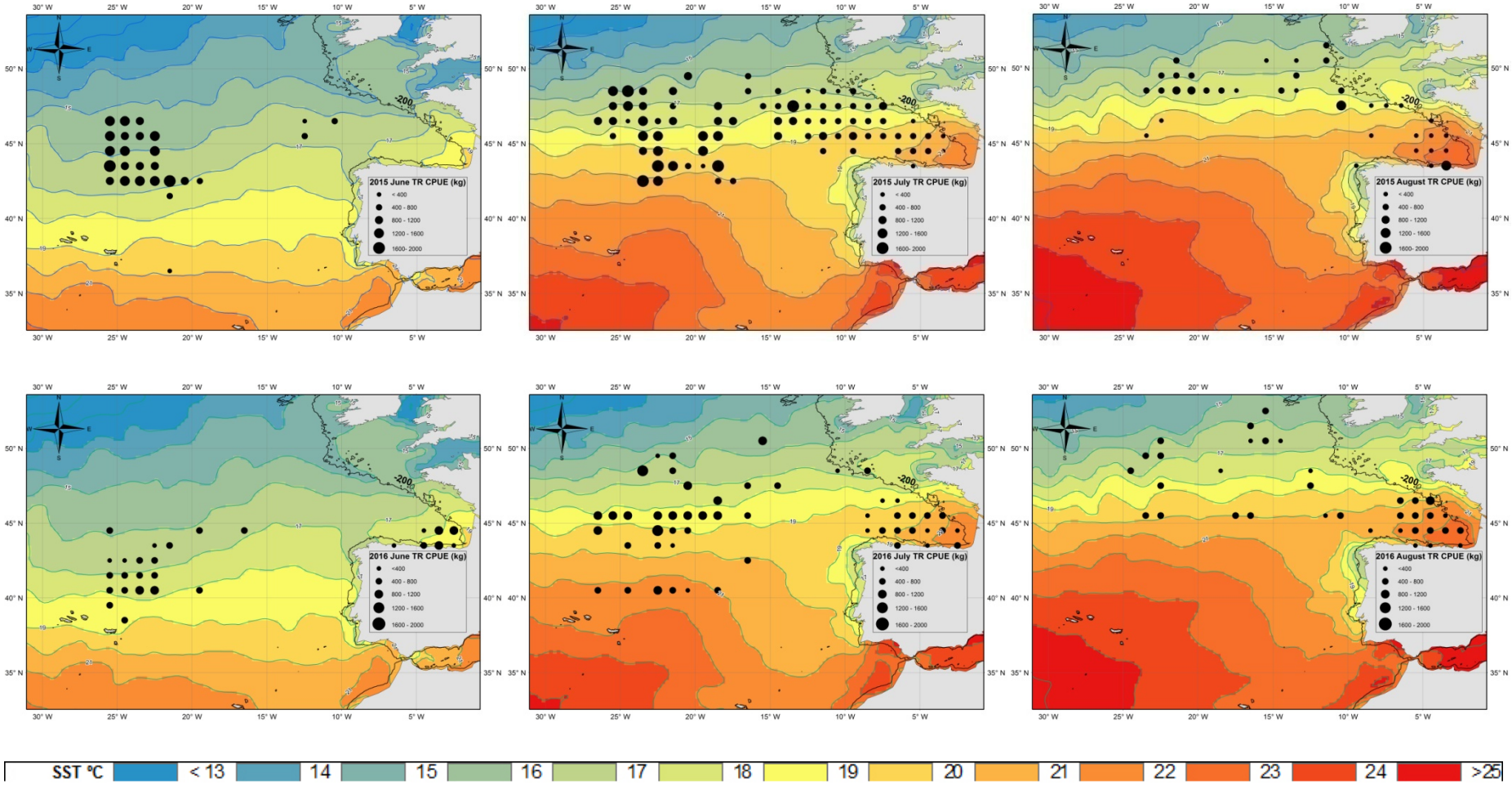

Figure 1a. Summer monthly spatial distribution of nominal CPUEs for troll fleet in 2015 and 2016 fishing season and observed SST in the area.

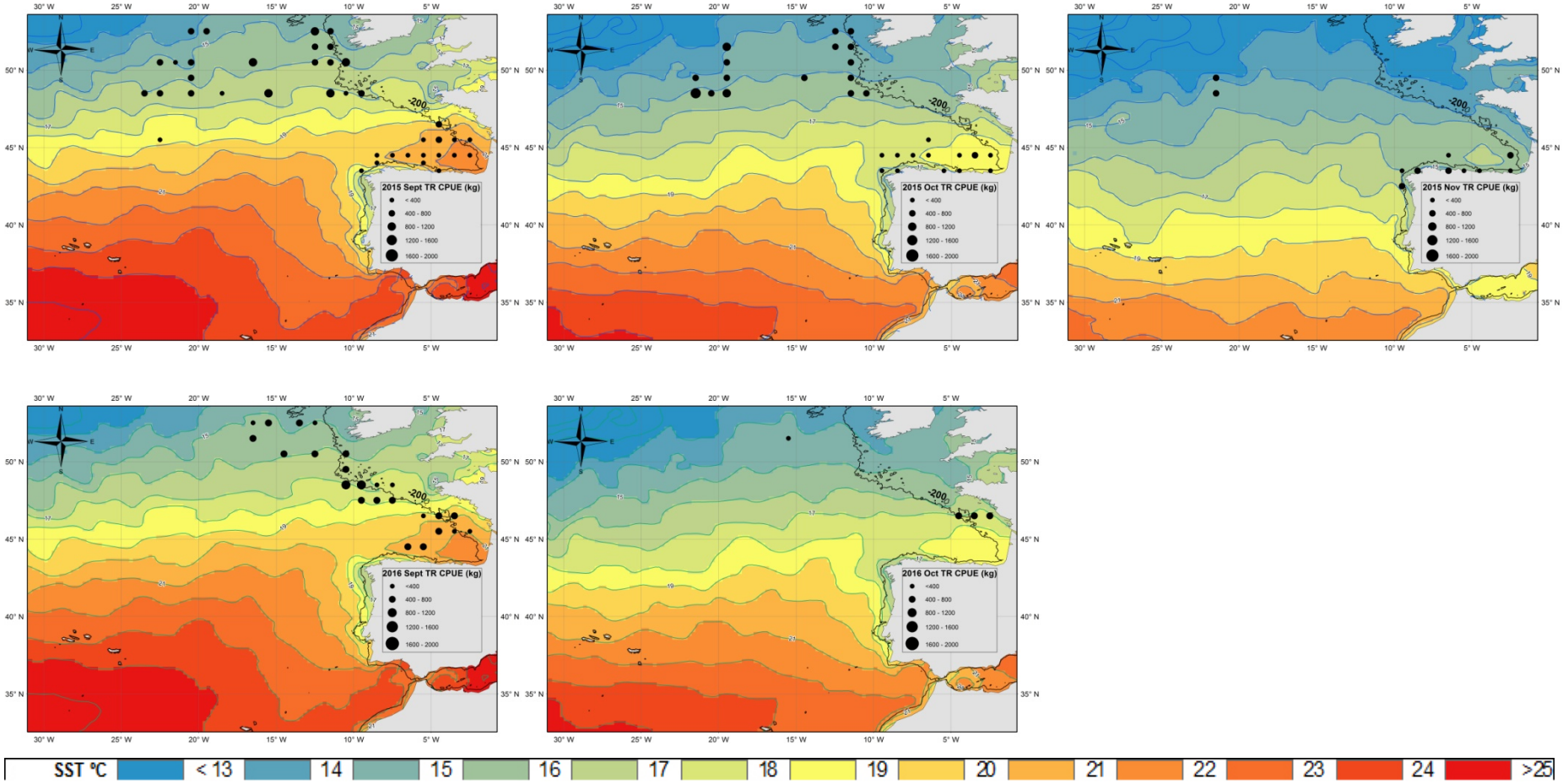

Figure 1b. Autumn monthly spatial distribution of nominal CPUEs for bait boat fleet in 2015 and 2016 fishing season and observed SST in the area.

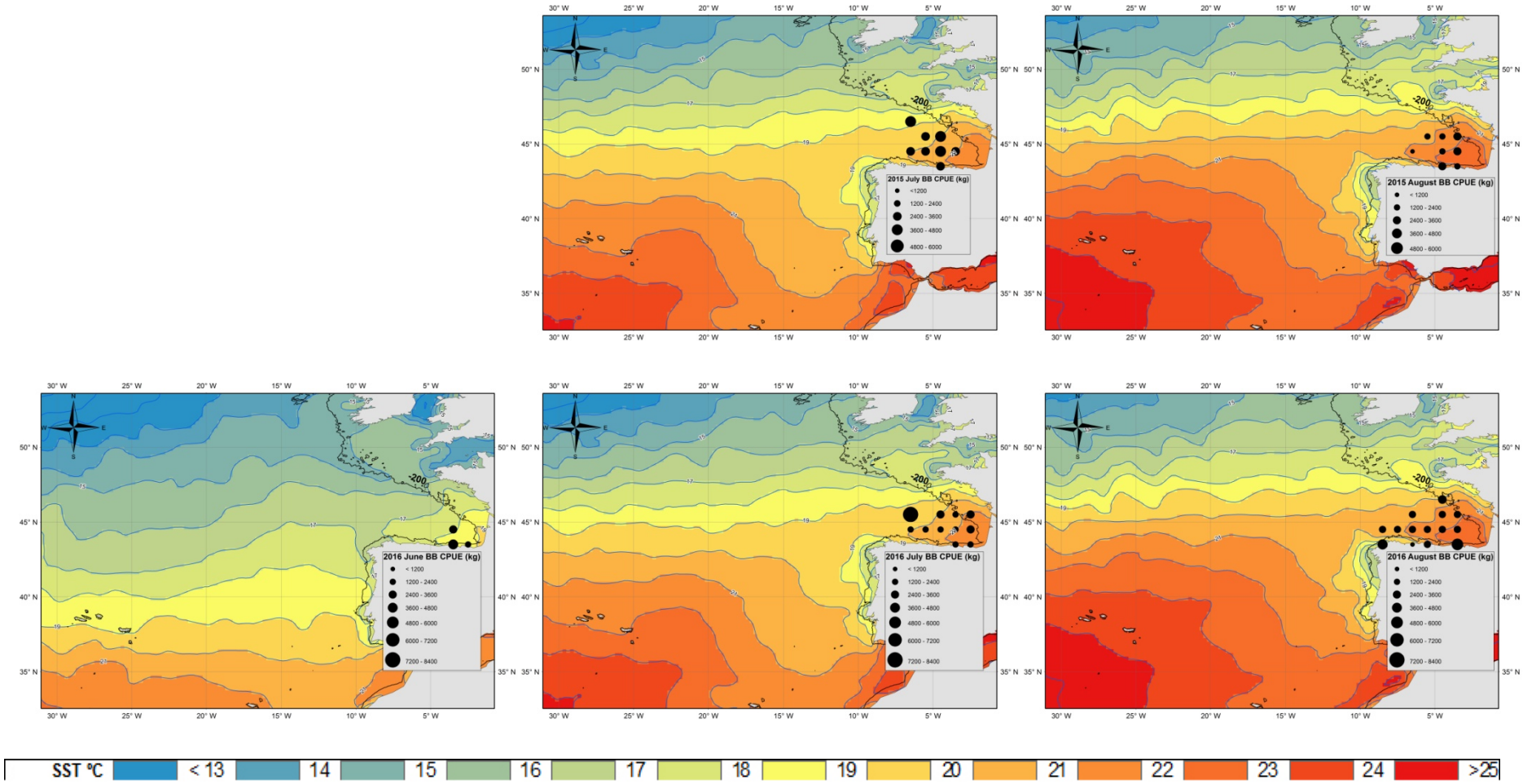

Figure 2a. Summer monthly spatial distribution of nominal CPUEs for bait boat fleet in 2015 and 2016 fishing season and observed SST in the area.

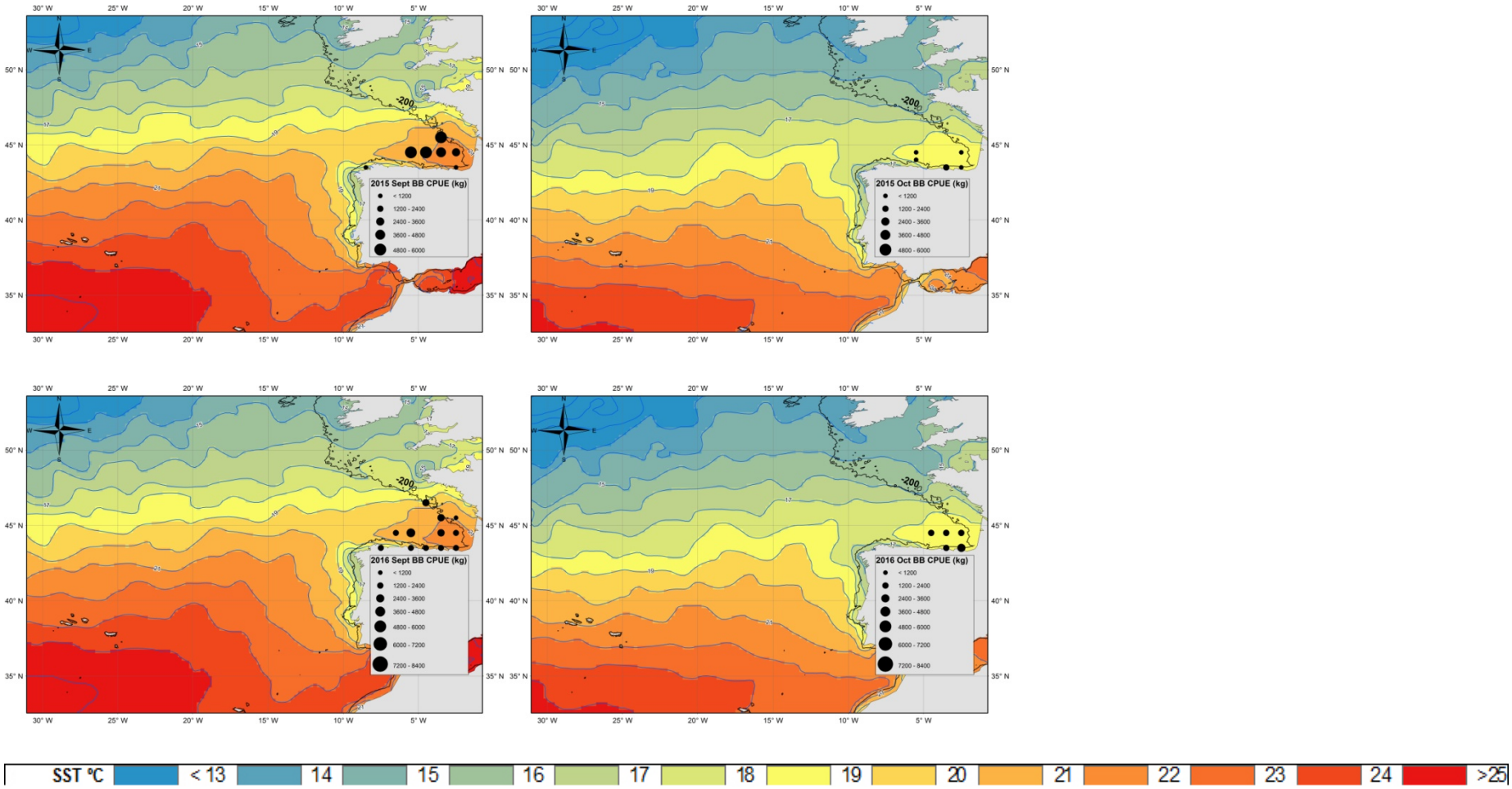

Figure 2b. Autumn monthly spatial distribution of nominal CPUEs for bait boat fleet in 2015 and 2016 fishing season and observed SST in the area.