UPDATE OF THE FRENCH AERIAL SURVEY INDEX OF ABUNDANCE FOR 2018

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SUMMARY

The French aerial survey over the Gulf of Lions provide an important fisheries independent index for the stock assessment of eastern Atlantic bluefin tuna (EABFT, Thunnus thynnus*). The present manuscript reminds the methodology employed for the survey and provides the update of the index for the year 2018, which displays a decrease compared to previous years. The year 2018 was characterized by relatively warm waters and a lack of strong northern wind events in the Gulf of Lions; the potential effect of the environmental conditions on the decrease observed is shortly discussed.*

RÉSUMÉ

Les prospections aériennes françaises dans le golfe du Lion fournissent un important indice indépendant des pêcheries pour l'évaluation du stock de thon rouge de l'Atlantique Est (EABFT, Thunnus thynnus*). Le présent manuscrit rappelle la méthodologie employée pour la prospection et fournit la mise à jour de l'indice pour l'année 2018, qui montre une diminution par rapport aux années précédentes. L'année 2018 a été caractérisée par des eaux relativement chaudes et un manque de vents forts du Nord dans le golfe du Lion ; l'effet potentiel des conditions environnementales sur la diminution observée est brièvement discuté.*

RESUMEN

La prospección aérea francesa en el golfo de Leon proporciona un importante índice independiente de la pesquería para la evaluación del stock de atún rojo del Atlántico oriental (EABFT, Thunnus thynnus). *Este documento recuerda la metodología utilizada en la prospección y proporciona una actualización del índice para el año 2018, que muestra un descenso en comparación con años anteriores. El año 2018 se caracterirzó por aguas relativamente cálidas y una ausencia de eventos de viento del norte fuerte en el golfo de León; se debate brevemente el efecto de las condiciones medioambientales en el descenso observado.*

KEYWORDS

Juvenile Atlantic bluefin tuna; Northwest Mediterranean
Fisheries independent abundance index; Aerial survey

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1. Introduction

The French aerial survey index has been integrated for the first time in the base case VPA of the Eastern Atlantic bluefin tuna (EABFT, *Thunnus thynnus*) stock assessment in 2017. This index is important for the stock assessment. It is one of the two fisheries-independent index included in the stock assessment. The index started in 2000 and has been updated yearly since then, with the exception of 2004-2008. It also covers young fishes from the northeast Mediterranean Sea, for which information is scarce, particularly since the enforcement of the recovery plan limiting the catch of fish below 30kg. Therefore, even if the geographical coverage of juvenile areas is not complete as it only covers the Gulf of Lions (GoL), it provides insights into stock dynamics that cannot be captured by indices covering adults. This index is currently integrated within the Management Strategy Evaluation (MSE) process developed within ICCAT. Indices used for stock assessment and part of the MSE process should be updated yearly to be made available to the SCRS Bluefin species group. The present document provides the update for the year 2018.

2. Materials and method

2.1 Reminder of the French aerial survey protocol

The protocol of the French aerial surveys has been described in details into several papers (Fromentin *et al.*, 2003; Bonhommeau *et al.*, 2010; Bauer *et al.*, 2015; Rouyer *et al.*, 2018; Rouyer *et al.*, 2019). It is just provided here as a reminder. Aerial surveys have been carried out since 2000, excepted in 2004-2008 due to a lack of funding. The survey takes place from early-August to mid-October over the Northwestern Mediterranean Sea, in the Gulf of Lions. This period and location is favourable to school detections as EABFT are at the surface in relation to feeding and/or foraging activity.

Depending on weather conditions, up to 20 flights per year were conducted onboard a Cessna C skymaster 337 “push pull” aircraft at 1000 feet above sea level. One pilot and up to three scientists could embark on this aircraft. From 2012 to 2013 a larger plane, a Cessna Caravan 208 ISR, allowed for an IT and video specialist as well as two scientists. Greater flight times were possible, enabling to fly over the whole Gulf of Lions within one day against two with the Cessna skymaster 337. The plane was flying higher, 1500ft, and a high resolution, gyro-stabilized video-camera allowed to record the flight and to obtain accurate geolocation and images for specific school detections.

The aerial surveys take place around noon when the sun is at its highest to limit sun reflection on the sea for better detection conditions for the observers. To obtain optimal spotting conditions, flights are constrained to specific weather, sunny sky and low wind speed (<10nm/h), to avoid confusion between schools and whitecaps. Four different routes were defined for the surveys (**Figure 1**), which were comparable in length 667, 648, 580, and 700 km for route 1-4 respectively. The inter-transect distance of 13.8 km reduces chances of double counting schools on subsequent transect line. The aircraft flies at the constant speed of about 200 km/h and these routes can be then flown in less than 5 hours including distance between airport and transect. Initially, for each flight, the route was randomly selected. However, practical constraints such as weather conditions often interfer in that process. The transect sections with unsuitable conditions (clouds and/or breaking waves) were skipped. When the route could not be selected randomly, special attention was paid to maximizing the spatial coverage of the area and to evening out the amount of times the different routes were flown.

Tuna schools were spotted by 1 to 3 trained scientific observers, from both sides of the plane/transects. While these teams changed over time, an overlapping period always allowed for the new members of the team to get appropriately trained to ensure the standardization of school types attribution. A GPS was used to record the position of the plane and detected tuna schools. Each detected school was then attributed to a type “tiny”, “small”, “medium”, “large” or “aggregation” for high concentrations of schools. The spotting conditions such as the wind strength (beaufort scale) and the number of observers onboard were recorded. During the early years, when the density of school was low, perpendicular distances from the plane were initially estimated by taking the GPS position of the school location. However, as the density of schools detected increased over time, it became impossible for the plane to move above the location of each school to take its GPS position. Therefore, distances estimates were then realized using marks on the arms supporting the wings, which were set-up to represent pre-defined ground distances (200, 400, 800, 1200, 1800 and 3600m) at the altitude of 300m.

2.2 Density estimate

The analysis of the aerial survey data was based on the distance sampling theory (Buckland *et al.*, 2005; Thomas *et al.*, 2006). In the distance sampling theory the transects, here the routes, are defined within a given area, here the Gulf of Lions. The object of interest, here a tuna school, is recorded along the route, which is surveyed several times during a given period. The theory allows that some, perhaps many, of the objects remain undetected and that variation in detection due to environment or observer could occur, as soon as n, L and w are accurately measured. According to the line transect theory, w is estimated through a detection function, which is a model fitted to the histogram of the perpendicular distances of the detections.

The line transect approach aims to estimate the detection probability per distance (detectability P) and thus to calculate the percentage of sighted and non-sighted objects. The density estimate is given by:

$$\widehat{D_i} = \frac{n_i}{2wLP}$$

The detectability P, also known as observability or sightability, is obtained by fitting a 'detection function' to the histogram of distances. It allows to account for other variables, such as school type or environmental conditions (e.g. wind). The shape of the detection function generally is a monotonically decreasing curve, showing a shoulder under which detection remains almost certain and is unaffected by other variables.

The mean density, $\overline{D}$, from r replicates is estimated as follows:

$$\overline{D} = \frac{1}{r}\sum_{i=1}^{i=r} \widehat{D_i}$$

The variance between replicates is estimated as:

$$Var(D) = \frac{1}{r(r-1)}\sum_{i=1}^{i=n} (\widehat{D_i} - \overline{D})^2$$

Time series of densities were computed for each model using an Horvitz-Thomson-like estimator, implemented in the R package *Distance* (Miller *et al.*, 2017).

3. Results

3.1 Update of the index

The update through to 2018 of the French aerial survey index displayed a decrease in 2018 (**Figure 2**). The 2018 density was about four times as little as in 2016, the year with the highest records to date. This decrease followed the decrease in 2017. The 2018 density was comparable to the average density of the 2009-2012 period.

4. Discussion

Environmental conditions are known to affect the spatial distribution of bluefin tuna in the GoL, through foraging in relationship to frontal structures and mixed layer depth (Royer *et al.*, 2005). This can translate into changes in the horizontal and vertical behaviour of EABFT in the GoL, affecting its detectability and availability to the survey (Bauer *et al.*, 2017). Such effects could be accounted for in the index of abundance, using suitable habitat approaches to derive the probability of occurrence in the survey area and at the surface, depending on environmental conditions (Druon *et al.*, 2011, 2016). The GoL substantially cools down with events of strong northern winds (Mistral and Tramontane). Such events occur regularly in summer, which keep the GoL water

relatively cold compared to its neighboring areas. The year 2018 was characterized by a lack of strong northern winds during the summer and by warm waters that lasted until October. Such an event was also detected in 2015, a year with relatively lower densities for the 2014-2018 period, and contrasted with 2016 when the density reach its highest to date. The year 2018 also corresponds to a difficult year for the local longline fishery, whose catches were made much later than for an average year. As for any other abundance index, this suggests that variable environmental conditions affect availability over the surveyed area and that it should be investigated to be accounted for by the index.

Acknowledgments

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Figures

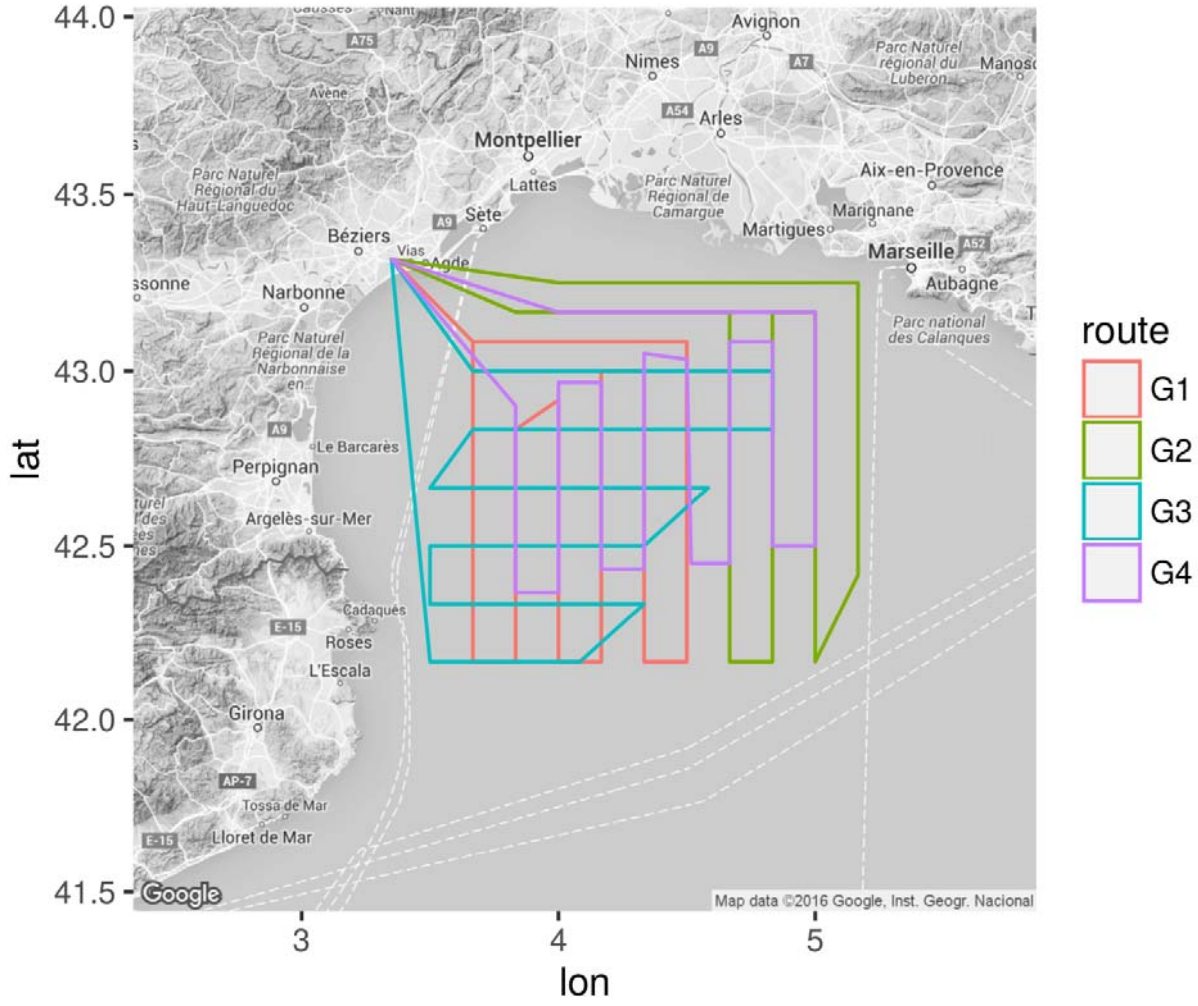

Figure 1. Maps of the different routes followed for the aerial surveys above the Gulf of Lions in the Northwestern Mediterranean.

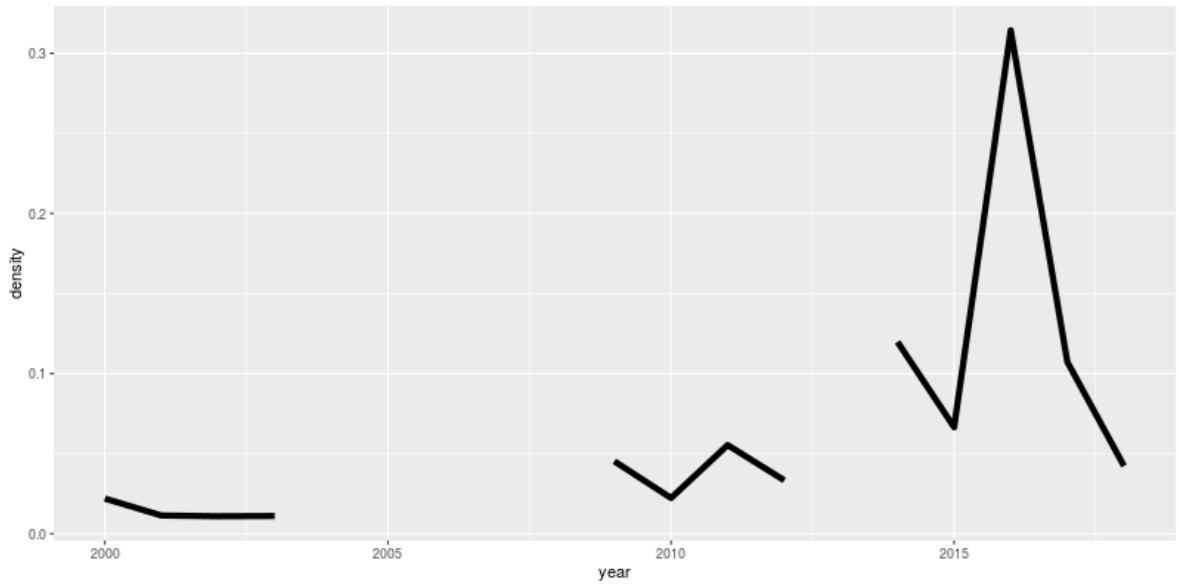

Figure 2. Estimated density of schools over time, from 2000 through to 2018.