Distribution of juvenile bluefin tunas in the North Atlantic: comparison between light based geolocations from internal and pop-up satellite archival tags.

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Summary

This study aims at comparing light based geolocations from internal and pop-up satellite archival tags implanted on juveniles Bluefin tunas, and to discuss their potential consequences for characterizing bluefin tuna migrations and habitat utilization.

From 2005 to 2010, 136 juvenile bluefin tunas were released in the Bay of Biscay with internal archival tags and 29 ones with miniaturized pop-up satellite archival tags. Archived information was recovered from 3 individuals tagged internally and from 15 individuals tagged with PSATs. For both types of tags, an SST-assisted Kalman filter was applied to the raw light-based geolocations. The seasonality of the distribution and movements of the juvenile bluefin tunas were analyzed.

We observed that during autumn months (start of the overwintering migration and maximal latitudinal error in light-based geolocation) the standard deviation of the geolocations is lower in average for internal archival tag data than for pop-up tags. The higher spatial dispersion of pop-up tag data position estimates is discussed in relation to the accuracy of the characterization of different migration patterns and habitat use. Despite the difference between both tagging types, these position estimates are considered reliable enough to build a habitat utilization index and to characterize winter migrations.

Introduction

Atlantic bluefin tuna (*Thunnus thynnus*) has been undergoing an important overexploitation in the last decades. For a more efficient management of the population, and in particular to address the issues related to stock structure definition and to interactions between tuna behaviour and catchability, archival tagging is one of the most useful tools.

Important discussion and progress were done during the last years regarding the stock structure, the migration patterns and the behaviours of North-Atlantic bluefin tuna (Walli, Teo et al. 2009; Galuardi, Royer et al. 2010; Galuardi and Lutcavage, 2012). Studies based on electronic tags have shown that spatial population structure and movements are more complex than previously thought. The researches dedicated to adult and preadult North-Atlantic bluefin tuna by means of electronic tagging allowed an important progress in the knowledge of their geographic distribution and vertical movements. However most of this new information corresponds to the West Atlantic basin and little information was obtained on the Eastern basin, particularly regarding juvenile individuals. In this study we present the first results on migrations and habitat use of juvenile Bluefin tunas in the Bay of Biscay and Eastern North Atlantic where two different types of archived data for their positioning are used and compared for migration and habitat use characterisation.

Materials and Methods

Electronic tagging of juvenile bluefin tunas presents several technical challenges, one of the major being the small size of the individuals, which limits the possibility of using pop-up satellite archival tags. On the other hand, recovery rates of conventional tags on juvenile bluefin tunas have always been low in the Eastern North Atlantic (i.e. below 5% according to ICCAT, 2008). For these reasons, in the present study it was chosen to use both tagging techniques: pop-up satellite archival tags for a

higher data recovery rate (in spite of the size limit of tagged individuals and of the more restrained amount of data retrieved), and a higher number of internal archival tags for the possibility to tag small fish, the higher time-definition of recorded data and the longer time-series.

From 2005 to 2010, 136 juvenile bluefin tunas were released in the Bay of Biscay with internal archival tags and 29 other ones with miniaturized pop-up satellite archival tags. Archived information was recovered from 3 individuals tagged internally and from 15 individuals tagged with PSATs. Two internal tags covered one year and the third one two years, adding up to 1350 days at liberty (mean 450), while pop-up tags lead to a total of 1971 days at liberty (mean 131), but only 9 individuals had more than two months at liberty due to premature releases.

For both types of tags, an SST-assisted Kalman filter (Lam, Nielsen et al. 2008) was applied to the raw light-based geolocations. The mean of the estimated standard deviation in archival data geolocation filtering during autumn was compared between both electronic tagging techniques. A month period was selected around the autumn equinox, because the equinoxes are the time period were the latitudinal error is highest during the year. The autumn is the period with highest number of pop-up data geolocations due to a high number of individuals tagged in the late summer and early autumn.

Results and Discussion

The mean errors are 0.29^0 in longitude and 0.36^0 in latitude for internal archival data geolocations. It is lower than pop-up archival data: 1.32^0 and 0.75^0 respectively. The internal archival tags have a wider light detection range and archive data more frequently, which allows a better light attenuation coefficient estimation each day. Moreover, estimated sea-surface light values can be checked by the user and skipped if necessary (Wilson, 2007). In the pop-up tags, due to information compression for transmission by satellite, the light data are processed internally, in addition to having a narrower light detection range. The lower accuracy of pop-up tag data could a priori cause some biases in the characterization of migration patterns. However, both types of position estimates were reliable to build a habitat utilization index, and the effects of the differences in geolocation accuracy were negligible. The recorded data allowed us to identify summer and winter hotspots of juvenile bluefin tunas in the Eastern North Atlantic: Bay of Biscay is the major summer hostpot, and winter hotspots comprise Azores Islands, Gulf of Cadiz, Grand Banks, and the Bay of Biscay. The timing of the spring and autumn migrations displayed important individual variability. We could characterize 13 winter migrations, of which 4 from internally tagged individuals and 9 from pop-up tagged individuals. These winter migrations are classified as resident (winter spent in the Bay of Biscay and surrounding waters, 6 winters), mid-Atlantic (important winter residence around the Azores islands, 6 winters) and transatlantic (winter residence in Grand Banks, 1 winter). The combined use of both electronic tagging techniques allows complementary in terms of data type: data from a few recoveries of internal archival tags with long times at liberty covering an entire year-cycle, can be analysed together with pop-up data in which shorter times at liberty correspond to more individuals.

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