The blue jack mackerel biology and the use of otoliths for stock identification

The blue jack mackerel, Trachurus picturatus (Bowdich, 1825) is the main pelagic fish captured by local fisheries in the Macaronesian islands of Azores and Madeira (Santos et al., 1995; Magalhães et al., 2007). Nevertheless, its distribution area covers the north-east Atlantic, eastern central Atlantic, Mediterranean and the Black Sea. It has a schooling behavior and it mainly feeds on crustaceans (Colloca et al., 2004). Fluctuations in the catches of blue jack mackerel between 2005 and 2007 were registered in Portuguese mainland. This fact was corroborated by the captures performed on a scientific ship. The blue jack mackerel is an economically important resource, especially in the Macaronesian islands of Azores and Madeira, where is the main pelagic fish species being caught by the local fisheries. Blue jack mackerel is caught in Portugal with different types of fishing gears, namely drag, siege and polyvalent (DATAPESCAS, 2014). This species has suffered in 2014 a decrease in landings on Portugal mainland and in Madeira but an increase in the Azores compared to the year 2013. The horse mackerel landed in mainland Portugal during the years 2012, 2013 and 2014 was, respectively, 3152.2, 2036 and 1784.2 tons. For Madeira values were 272.9, 340.4 and 294.2 tons, respectively. In the Azores the values were 569.7, 545.6 and 775.6 tons, respectively. The quantities presented as estimated landings on the mainland are by weight off of water and include withdrawals and rejections. In the case of the Autonomous Regions, the landings estimates refer to the quantities of fish traded in auction. (DATA PESCAS, 2014). Natural fluctuations are difficult to explain due to the fact that population dynamics of this fish species are still unknown and stock identification studies are lacking. However previous published studies on biological traits showed that the growth rates, age at first maturity and the reproductive season varies in specimens from Madeira, Azores and Canary islands and adjacent waters of Western Europe (Shaboneyev and Ryazantseva, 1979; Isidro, 1990; Jesus, 1992; Gouveia, 1993). Nevertheless, there is no information about the migratory movements and mixing between the individuals from distinct geographical areas. Therefore, it is not clear if each of these locations correspond to several regional spawning grounds, or whether the fish spawn in a single area and migrate afterwards to the European coasts. Furthermore, fisheries models are difficult to perform on small pelagic migratory species.

Appropriate spatial management and resource sharing arrangements depend on knowing whether fisheries in different areas should be regarded as a single stock or whether there are a number of smaller, essentially non-mixing, population units. The populations of marine pelagic fishes, in particularly the migratory ones, such as the blue jack mackerel, may be erroneously considered homogeneous population units because they show broad geographic distribution, large population sizes and high migratory movements (Ward et al., 1994; Gonzalez et al., 2008; Hutchinson, 2008). Nevertheless, these fish species often have a cryptic population structuring with subtle differences in spawning behavior, foraging areas, self- recruitment and mechanisms of near-shore retention larvae, among others . Stock identification studies could clarify population units that are meaningful biological identities and thus reducing the uncertainty in the assessment models and improve the management of the resource (Abaunza et al., 2008; Correia et al., 2011). Fisheries management guidelines that disregard or misidentify these population differences may contribute to the depletion of fish stocks increasing the probability of species extinction or making the resource economically irrelevant for exploitation (Ruzzante et al., 2006; Helfman, 2007). This fact is of particular concern because *T. picturatus* is a high valuable economical species in fisheries but it is also, as other small marine pelagic fish, an essential trophic resource for larger pelagic fish (e.g. tuna, swordfish, sharks) and sea mammals (e.g. dolphin and seals) (Pierce et al., 1994; Santos et al., 1995; Niklitschek et al., 2010; Fernández et al., 2011).

The catches of blue jack mackerel in recent 10 years are on average 1860 t. The blue jack mackerel is mostly landed by the artisanal fleet using purse-seines and since 1990, through an auto regulation adopted by the fishers' association and based on market restrictions, the catches have been relatively stable. This stability of the catches is mostly observed at S. Miguel Island, where around 70% of the annual catches are taken. A continuous decline in consumer demands lead to the catch limits adopted by the fleet, which explains the reduction observed in the landings in recent years (ICES, 2012).

Stock identification of fish is also fundamental for understanding the population dynamics of a species in an ecological sense (Tracey et al., 2006). There are a wide variety of methods applied in fish stock identification, such as body morphology and meristic, parasites, geo-chemical signatures and genetics (Cadrin et al., 2005).

Otolith shape may vary according to geographical site, depth and/or other environmental factors (De Vries et al., 2002; Cardinale et al., 2004).

Otoliths are acellular inner-ear fish structures formed by calcium carbonate (CaCO3) in the mineral form of aragonite (90%) and a protein matrix keratin-type, called otolin (10%) (Degens et al., 1969; Elsdon et al., 2008). During otolith formation, different chemical elements can be incorporated in their structure (Gillanders and Kingsford, 2003). The main elements presented in the otoliths are: calcium, carbon and oxygen. Other elements (e.g. Sr, Ba, Mn, Mg) occur in the otoliths structure ,but at lower (> 100 ppm) or even trace (< 100 ppm) levels of detection (Campana, 1999). The aquatic environment has a strong influence on the otolith structure (Campana and Thorrold, 2001), which has the capacity to act as a natural marker of some properties of aquatic ecosystems (Gillanders and Kingsford, 1996;Bath et al.,2000; Elsdon and Gillanders, 2003). This is particularly valid if fish reside in a particular environment long time enough to incorporate a detectable chemical tag in their otoliths (Elsdon et al., 2008). Chemical bulk analysis acts like a tag of the environment inhabited by fish over the entire life (Campana et al., 2000; Elsdon et al., 2008).

There are two key properties of the otolith that underlie the use of its elemental composition as a natural marker: (1) unlike bone, the otolith is metabolically inert; therefore newly deposited material is neither resorbed nor reworked after deposition (Campana and Neilson, 1985); and (2) trace element uptake onto the growing otolith reflects the physical and chemical environment (Fowler et al., 1995; Gallahar and Kingsford, 1996), albeit with significant physiological regulation (Kalish, 1989; Farrell and Campana, 1996). Otolith elemental fingerprints can be able to discriminate well among fish that have grown up in different environments. (Campana et al., 2000; Thorrold et al., 1998).

Otolith chemistry is an effective method to assess stock structure, migration patterns and connectivity between spawning/nursery areas and adult populations

(Elsdon et al., 2008). Furthermore, the use of otolith elemental signatures has proven particularly useful to study population structure and to discriminate stocks in high gene flow systems where environmental heterogeneity exists (Bradbury et al., 2008; Smith and Campana, 2010).

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