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Stock identity of horse mackerel (*Trachurus trachurus*) in the Northeast Atlantic and Mediterranean Sea: Integrating the results from different stock identification approaches

P. Abaunza[a,*], A.G. Murta[b], N. Campbell[c], R. Cimmaruta[d], A.S. Comesaña[e], G. Dahle[f], M.T. García Santamaría[g], L.S. Gordo[h], S.A. Iversen[f], K. MacKenzie[c], A. Magoulas[i], S. Mattiucci[j], J. Molloy[k], G. Nascetti[d], A.L. Pinto[b], R. Quinta[b], P. Ramos[b], A. Sanjuan[e], A.T. Santos[b], C. Stransky[l], C. Zimmermann[m]

[a] *Instituto Español de Oceanografía, P.O. Box 240, 39080 Santander, Spain*
[b] *Instituto de Investigaçao das Pescas e do Mar, Av. Brasilia, 1400 Lisboa, Portugal*
[c] *School of Biological Sciences (Zoology), The University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, UK*
[d] *Department of Ecology and Sustainable Economic Development, Tuscia University, Via S. Giovanni Decollato, 1, 01100 Viterbo, Italy*
[e] *Facultade de Bioloxía, Edificio de Ciencias, Universidade de Vigo, E-36200 Vigo, Spain*
[f] *Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway*
[g] *Instituto Español de Oceanografía, Avda. Tres de Mayo 73, 38005 Santa Cruz de Tenerife, Spain*
[h] *Facultade de Ciencias de Lisboa (IO/DBA), Bloco C-2, Campo Grande, 1749-016 Lisboa, Portugal*
[i] *Hellenic Centre for Marine Research, Institute of Marine Biology and Genetics, P.O. Box 2214, GR 710 013 Iraklio, Greece*
[j] *Department of Public Health Sciences, Section of Parasitology, "Sapienza" University of Rome, piazzale Aldo Moro n° 5, 00185 Rome, Italy*
[k] *The Marine Institute, Parkmore Industrial Estate, Galway, Ireland*
[l] *Bundesforschungsanstalt für Fischerei, Institut für Seefischerei, Palmaille 9, D-22767 Hamburg, Germany*
[m] *Bundesforschungsanstalt für Fischerei, Institut für Ostseefischerei, Alter Hafen Sü 2, D-18069 Rostock, Germany*

Abstract

Horse mackerel stock identification was carried out with the aim of obtaining management units that were meaningful biological entities and thus improving the management of the resource. The stock identification was made by integrating both established and innovative approaches such as genetic markers (allozymes, mitochondrial DNA, microsatellite DNA and SSCP on nuclear DNA), morphometry, parasites as biological tags, and life history traits (growth, reproduction and distribution), within the EU-funded HOMSIR project. The sampling covered almost the whole distribution range of horse mackerel through 20 sampling localities in Northeast Atlantic and Mediterranean Sea. Horse mackerel showed low levels of genetic differentiation, stable genetic structure over the study time and high levels of genetic variability. However, several approaches (morphometrics and parasites) support the separation between the Atlantic Ocean and the Mediterranean Sea in horse mackerel populations, although the most western Mediterranean area could also be mixed with the Atlantic populations. In the Northeast Atlantic, various stocks can be distinguished mainly based on morphometrics, parasites and life history traits: a "southern" stock is distributed along the West Atlantic coast of the Iberian Peninsula south to Cape Finisterre (NW Spain); a "western" stock, along the west coast of Europe from Cape Finisterre to Norway and the "North Sea" stock. These results implied the revision of the boundaries of the southern and western stocks as previously defined. Results also suggested that adult horse mackerel could migrate through different areas following the west coasts in the Northeast Atlantic (i.e. between Celtic Seas and northern North Sea). Horse mackerel from the Mauritanian coast is distinguished by its high growth rate and high batch fecundity. Based on the results from morphometric analysis and the use of parasites as biological tags, the horse mackerel population in the Mediterranean Sea is sub-structured into at least three main areas: western, central and eastern Mediterranean. In this contribution, we have integrated the fundamental findings of different approaches showing that the holistic approach is the appropriate way to identify horse mackerel stocks, on covering multiple aspects of the biology of the species and reducing the type I error in stock identification.

Keywords: *Trachurus trachurus*; Stock identity; Holistic approach; Northeast Atlantic; Mediterranean Sea; Natural marks; Life history traits

* Corresponding author. Tel.: +34 942291060; fax: +34 942275072.
E-mail address: pablo.abaunza@st.ieo.es (P. Abaunza).

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1. Introduction

The stock concept is fundamental to the management of fishery resources, given that it forms the basic unit on which population dynamic models are applied both to know its status and to adopt appropriate management measures to ensure its sustainability. Despite its importance, there is no unanimous definition of the concept of stock, since this depends on the aims proposed and the field of knowledge in which researchers have developed their work (Carvalho and Hauser, 1994). In general, the following concepts of stock can be distinguished, which vary depending on the degree of "integrity" to be considered: "genetic" stock, "phenotypic" stock, "contingent" and "harvest" stock (Gauldie, 1988; Secor, 1999; Carvalho and Hauser, 1994; Hare, 2005). Usually, stock identification studies are carried out with the aim of obtaining management units that are meaningful biological entities and thus reducing the uncertainty in the assessment models and/or improving the management of the resource (i.e. NRC, 1998). One of the definitions most widely accepted (see for example Waldman, 2005) is that made by Ihssen et al. (1981) in which a stock is defined as an intraspecific group of randomly mating individuals with temporal or spatial integrity. In general, the concept of stock has run parallel with the concept of population (Waldman, 1999), with the exception that the stock normally is used to refer to components of a species that are commercially exploited by fishing activities (Shaklee and Currens, 2003). The concept of stock will always be useful and its application will have a broader reach if it comes in response to a real natural phenomenon and not to a researcher's abstraction (Sinclair, 1988). That is to say, there should be a fundamental link between recruitment and the spawning population that brings it about, such that it constitutes a dynamic unit that is perpetuated in time. In this way, a coherent follow-up can be made over time both of the absolute abundance of the population and of the life history parameters (i.e. mortality, growth, reproduction and distribution) and other evolutionary processes. Therefore, identification of the geographical boundaries within which adults reproduce and the corresponding biological cycle which develops from the egg to the adult, is critical for effective management of resources (Mustafa, 1999).

The most successful way of focusing the problem of defining the limits of stocks is through a holistic approach (Begg and Waldman, 1999), involving a broad spectrum of complementary techniques (see Pawson and Jennings, 1996). For example, genetic methods may not be sufficient for defining the geographical limits of stocks, whereas methods based on phenotype provide insights into stock structure (Grant et al., 1999). In this way, the best possible picture can be obtained in response to the ecological, productive, evolutionary and operational requirements that the definition of stock may involve. The available methods that can be used to identify stocks have recently been compiled exhaustively in Cadrin et al. (2005).

Despite progress in the different methodologies applicable to stocks identification, the problem of defining the management units of the different species exploited commercially is far from being resolved (e.g. Lleonart and Maynou, 2003). One of these cases is that of horse mackerel (*Trachurus trachurus* (Linnaeus 1758)), a carangid species of commercial interest, with catches of over 500,000 t in the mid-1990s before declining to around 250,000 t in the period 2000–2002 (FAO, 2004). Horse mackerel is distributed throughout the Northeast Atlantic from Norway to the Cape Verde Islands, and in the Mediterranean Sea. Until 2004, the year in which data were available from the EU-funded project HOMSIR (QLK5-CT1999-01438) on horse mackerel stock identification, the stocks in the ICES area were defined mainly according to their spawning areas based on egg distribution, resulting in: the "western stock" (northeast continental shelf of Europe, from France to Norway); "North Sea stock" (North Sea area) and the "southern stock" (Atlantic waters of the Iberian Peninsula) (Fig. 1). However, there is no recognizable boundary in the distribution of eggs between the so-called western and southern horse mackerel stocks (ICES, 1999a). Special scientific attention had been focused on this stock definition, recognizing the uncertainties in the distribution limits and the lack of biological information to support such stock units (ICES, 1992,1999b). The few publications on horse mackerel stock structure in the ICES area either cover only a small part of the species' distribution areas, or the information is so scarce that it is not possible to delineate sub-populations. Nefedov et al. (1978) analysed muscle esterase allotypes and found differences between horse mackerel in the North Sea and those to the west of the British Isles, although their results seem rather tenuous (see Borges et al., 1993 for the discussion of the document). Borges et al. (1993), using plasma transferrin phenotypes, did not find any difference in samples collected throughout the Northeast Atlantic distribution area. More recently Karaiskou et al. (2004), using mitochondrial DNA, confirmed the lack of genetic differentiation in horse mackerel throughout its distribution area. Abaunza et al. (1995) used anisakid infestation levels as biological tags and found significant differences between the Cantabrian Sea and Galician waters, two areas that were considered to belong to the southern stock. An analysis of morphological variation by Murta (2000) showed some similarities between the Portuguese and the North African Atlantic coasts, which cast doubts on the southern boundary of the southern stock (see Fig. 1). Information on stock structure in the Mediterranean Sea is rather scarce (Lleonart and Maynou, 2003), although general fishery statistics already exist (Fiorentini et al., 1997). In the East-Central Atlantic, Maxim (1995) described the dynamics of the Saharo-Mauritanian stocks (Fig. 1).

There is more information on the basic biology of *T. trachurus*, and this can be used in the analysis of life history traits: growth, reproduction and distribution, to characterize management units. Abaunza et al. (2003) did a comprehensive review of horse mackerel growth and reproduction in which references can be found to most of the published work on the subject. Useful information on horse mackerel fishery distribution and migratory patterns can be found in Pawson (1995), Iversen et al. (2002) and ICES (2005) for horse mackerel in the Northeast Atlantic and in Maxim (1995) for Northwestern African coasts.

In order to learn more about horse mackerel (*T. trachurus*) stock structure throughout its distribution area and to fill in the lack of knowledge on this subject, the EU-funded HOMSIR project (QLK5-CT1999-01438) was designed bearing in mind