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Evolution, crisis and new scenarios of the Italian swordfish harpoon fishery

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HIGHLIGHTS

- Swordfish harpoon fishing has a high social, cultural and historical importance.
- SWOT analysis allowed to suggest a management strategy.
- The contrast of IUUF is important to assure the survival of the harpoon fishing.

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ABSTRACT

The evolution of the Italian swordfish harpoon fishery as well as the crisis reasons and new related management actions were analyzed. Swordfish harpoon fishing has been practiced in Italian waters (Strait of Messina and nearby areas) since ancient times. During these centuries, it has maintained its artisanal features, although some technological innovations have been implemented during the last decades. The unsustainable competition with modern fishing activities (longlines, driftnets and related illegal gears) determined a drastic decrease of harpoon fleet: the number of vessels in the study area was 310 at the end of the 19th century and 13 in the 2016. The negative effects of the rapid increase of overall fishing effort on Mediterranean swordfish, during the second half of 20th century, have been in part attenuated by recent management regulations, such as the ban of driftnets and the temporal limitations to the use of longlines to avoid the catch of juveniles. Swordfish harpoon fishing is not comparable to other modern fishing activities in terms of catches or revenues, however it has a high social, cultural and historical importance and for these reasons the correct management of Mediterranean swordfish stock and this fishing activity are crucial points to be addressed. The analysis of current swordfish management actions and regulations as well as strengths, weaknesses, opportunities and threats highlights that illegal fishing is among the main threats for the survival of harpoon fishing.

1. Introduction

Swordfish, *Xiphias gladius* (Linnaeus, 1758), is a large pelagic fish, worldwide considered an important fishery resource, occurring in tropical and temperate and sometimes cold waters of Atlantic, Indian and Pacific Oceans as well as in Mediterranean and Black Seas. It is a highly migratory species (Palko et al., 1981), able to carry out large depth excursions up to 650 m, usually staying in deep water during daylight and near surface at night. According to Canese et al. (2008) and Romeo et al. (2009), in the central Mediterranean Sea, during the reproduction period, swordfish occurs near surface also during daylight, where it can approach mate and perform spawning. The genetic differentiation between Mediterranean and Atlantic populations (Magoulas et al., 1993; Kotoulas et al., 1995; Pujolar et al., 2002) suggested the need of a separated fishery management for Mediterranean swordfish stock, that is currently carried out by the International Commission for the Conservation of Atlantic Tunas (ICCAT). The most recent assessment of the stock status of Mediterranean swordfish stated that, over the last 25 years, the biomass appears to be rather stable at low levels, even if the fishing mortality levels have shown a declining trend since 2010, inferring that the stock is currently overfished (ICCAT, 2016a). According to ICCAT (2016a), one of the most important threats for the Mediterranean stock is the catch

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of undersized swordfish, in particular during albacore fishing in autumn and winter seasons.

The large amount of swordfish catches in Mediterranean waters is due to longline fishery (Tserpes et al., 2011; Mariani et al., 2015; ICCAT, 2016a), whereas the landings from gillnet or driftnet are low, after the driftnet ban and following regulations (e.g., EC Regulations 849/97, 1239/98 and 809/2007; ICCAT Rec. 03–04; GFCM Rec. 2005/3). Other fishing activities contributing to Mediterranean swordfish landings are harpoon, recreational fishing, tuna traps and purse seines (e.g. Akyol and Ceyhan, 2011; Romeo et al., 2015; ICCAT, 2016b).

The swordfish harpoon fishing has been practiced in the central Mediterranean sea (Strait of Messina and nearby areas) since ancient times (Sisci, 2005; Di Natale et al., 2005) and the first information on this activity probably arises to the Greek epic poem "Odyssey", composed by Homer at the end of the 8th century BC (Sisci, 2005). Moreover, according to Oppianus (II century BC), Polybius (II century BC) and Plinius (I century BC), the harpoon fishery has been a typical fishing activity of the Strait of Messina since more than two millenniums (Salvini, 1728; Di Natale et al., 2005). The Strait of Messina with nearby areas is the unique Italian location in which swordfish harpoon fishing is practiced. The old duel between man and fish, rooted in the life of local fishermen, has been based on the force of arms (row boats), harpooning ability and knowledge of swordfish behavior and currents. During these centuries, this fishing has maintained its artisanal features, although some technological innovations have been recently implemented. However, the competition with other modern gears (swordfish is one of the most important fish resource for Mediterranean fleets), the crisis of the artisanal fishing sector and the illegal fishing have jeopardized this activity.

Given the high cultural and social importance of the harpoon fishery in Mediterranean fishing tradition, the aim of the present paper is to analyze the evolution as well as the crisis reasons of the harpoon fishing, examining also the current management actions on swordfish in the Mediterranean Sea and the future scenarios for this activity.

2. Materials and methods

The analysis of the evolution of the swordfish harpoon fishery was carried out by collecting information on structural and methodology innovations adopted by fishermen during the last century, in terms of materials, boats, tools, techniques and tactics. Data were obtained by interviews to fishermen and direct observations onboard as well as by collecting historical information from bibliography.

The fleet capacity in 2016 was defined through the following parameters: total number of vessels, overall length (LOA), gross tonnage (GT), engine power (kW), age of vessels; they were recorded by field observations and consultation of the Archive of Fishing Licenses of the Directorate General for Fishery and Aquaculture of the Italian Ministry of Agriculture, Food and Forest Policies.

Data on harpoon catch and effort were collected from 2002 to 2015 within several studies and research projects carried out in the fishing ground of harpoon fishery (see Romeo et al., 2015), considering only the Sicilian vessels (more than half of the total Italian swordfish harpoon fleet). These data were recorded from fishermen's logbooks and by on-board scientific observers. Catch per unit effort (CPUE) in terms of biomass (kg * days at sea^{-1}) and abundance (n * days at sea^{-1}) for each year were calculated using the number of fishing days (days at sea) as unit of fishing effort (Di Natale et al., 2005; Romeo et al., 2015; Perzia et al., 2016).

In order to analyze the swordfish CPUE trend of Sicilian harpoon fishery, data from Di Natale et al. (2005) were also considered. The time series from Di Natale et al. (2005, years: 1976–2003) and our data (years: 2002–2015) were integrated merging data from the first time series up to 2001 to the second time series, resulting in a 40 ys long time series. These two time series were comparable because data were similarly collected from the same study area and analyzed using the same method (CPUE calculation).

Trends in swordfish CPUE (biomass, abundance) and average individual weight were analyzed using the Mann–Kendall test. The non-parametric Sen's method was used to quantify the slope magnitude of the trend. Analyses were carried out using Microsoft Excel Template MAKESENS developed by Salmi et al. (2002).

The same time series were further explored to ascertain the potential presence of abrupt changes in the mean, by using the sequential t-test analysis of regime shifts (Rodionov, 2004, 2006; STARS, v. 3.2). The algorithm was applied to the filtered time series calculated by removing red noise through a "pre-whitening" procedure based on the IP4 method (Rodionov, 2006) to take into account the effect of serial correlation on shift detection. The following setting of parameters was applied: cutoff length: 10 years; significance level at 0.05; Huber's weight parameter: 1.0.

In order to identify the Strengths, Weaknesses, Opportunities and Threats to the local harpoon fishery a SWOT analysis was performed. In this analysis, both the internal positive and negative factors (strengths and weaknesses) and the external positive and negative factors (opportunities and threats) were identified in order to suggest a management strategy (Lorance et al., 2011; Sigurðardóttir et al., 2015).

3. Results and discussion

3.1. Evolution of fleet, materials, fishing methods and tactics

The first detailed description of the ancient swordfish harpoon fishing in the Strait of Messina was provided by Polybius (II century BC), which reported that this activity was carried out by small vessels, having only two fishermen as crew, an oarsman and a harpooner, using an harpoon mounted on a wood (oak and fir) pole, tied to a long rope. Fishing tactic consisted in waiting swordfish along the usual fish route and throwing harpoon when the prey was near the boat. Later, lookout men on the high cliffs of the Calabrian coast began to cooperate with fishermen in sighting swordfish and giving information on the fish position and route. On the contrary, the presence of a shallow coast on the Sicilian side of the Strait of Messina slowed the development of this fishing activity in Sicilian communities. However, the harpoon fishing has evolved during time in a more organized fishing activity and, since 1500 AD, the introduction of new vessels and fishing tactics has allowed Sicilian fishermen to remedy this gap. In particular, the fishing tactic was based on the use of a large vessel, named "*feluca*", anchored along the Sicilian coast and equipped with an elongated mast (about 15–20 m), on the top of which a fishermen had the role of lookout, previously described (Fig. 1a). In addition to the sighting vessel *feluca*, a smaller and slender rowboat, named "*luntro*", was used to chase and harpoon swordfish and was equipped with four rows and a small mast (Maurolico, 1543). The crew of the *luntro* was made up of six fishermen: one lookout man, four oarsman and one harpooner (Fig. 1b). The lookout men of both *feluca* and *luntro* cooperated by shouting in order to guide the oarsmen towards the swordfish and to allow the harpooner to hit the prey, by an iron harpoon mounted on a wood (hornbeam) pole. Differently, fishermen continued to sight fish from the land in the Calabrian coast of the Strait of Messina. This general organization has been maintained up to the introduction of the first motorized vessel in 1957 (Di Natale et al., 2005).

The mooring of sighting boats along the coast has determined conflicts between fishermen for the use of the best fishing grounds,

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