

LENGTH-WEIGHT RELATIONSHIP, MONTHLY SIZE DISTRIBUTIONS OF LENGTH AND WEIGHT FOR SWORDFISH (*XIPHIAS GLADIUS* L.) CAUGHT BY LONGLINERS IN THE TYRRHENIAN SEA

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SUMMARY

The current study presents length-weight relationship and the monthly size distributions of length and weight classes for Mediterranean swordfish caught by Italian longline fishery operating in the Tyrrhenian Sea. The measurements collected on length and weight were obtained from 3.162 specimens sampled during the period from April to December 2018. This study, intended as pilot project, was carried out in the port of Porticello (Palermo-Santa Flavia), as part of the National Observation and Monitoring Programme 2018. The length-weight relationship parameters were obtained from the Lower Jaw Fork Length (LJFL) and Round Weight (RWT).

The length-weight equation obtained in this study is as follow and shows a good-quality correlation index of the estimates:

$$\mathbf{RWT = 9E^{-06} * LJFL^{3,0853} (R^2 = 0,9012)}$$

The authors intend to show that a wide range of swordfish catches is included between 100-140 cm indicating that the fishing effort has a significant impact on juvenile specimens. These results provide accurate information on swordfish catches in order to improve the data available for stock assessment studies and sustainable management of resources.

KEYWORDS: *Xiphias gladius*, size composition, length-weight relationship, LJFL, RWT, Mediterranean sea, longliners.

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1. Introduction

The swordfish (*Xiphias gladius* L.) is a large pelagic predator and a migratory fish found in the open waters of all oceans, including the Mediterranean Sea (Palko et al., 1981). It is a commercially important migratory fish heavily exploited in the Atlantic Ocean and the Mediterranean Sea (Tserpes et al., 2003; Froese and Pauly, 2016; Lombardo et al., 2017). Currently, the International Commission for the Conservation of Atlantic Tuna (ICCAT) considers swordfish populations in the North Atlantic and Mediterranean Sea to be two separate stocks so independent assessments and management recommendations are proposed for each area (Anon., 2003). According to ICCAT records, the biggest producers of swordfish in the Mediterranean Sea in recent years (2003-2014) are EU-Italy (45%), Morocco (14%), EU- Spain (13%), EU-Greece (10%) and Tunisia (8%). Since 1995, scientists have been raising the alarm on the status of Mediterranean swordfish and recommending management measures to remedy the situation.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is concerned about the considerable increase in swordfish catches in the Mediterranean Sea, which could constitute overfishing. The fishery traditionally catches many juveniles and also fish before they can reproduce, which is a major cause of concern for the stability of the population.

This study aims to provide LJFL-RWT relationship for the Mediterranean swordfish and to provide the monthly size distributions of length and weight classes, based on data reported from Italian longline fishery operating in the Tyrrhenian Sea and from the analysis of the biometric data collected on specimens of swordfish landed in the designated port of Porticello (Palermo-Santa Flavia). The Observers have been involved in a pilot project as part of the National Observation and Monitoring Programme 2018 funded by the Italian Ministry of Agricultural, Food and Forestry Policies (Mipaaf) - (General Directorate of Fisheries and Aquaculture), in order to collect biometric data and biological samples.

2. Materials and Methods

This work was carried out in Porticello (Santa Flavia, Palermo), which is one of the most important port of landing designated by the Mipaaf in order to report the catches of swordfish and Bluefin tuna.

A total of 3.162 measurements were obtained by the national observers involved by OCEANIS s.r.l. and the scientific staff of the Department of Life and Environmental Sciences (DiSVA) - Università Politecnica delle Marche, Ancona (Italy). Data were collected from April to December 2018 from both onboard observations and landings from the Italian fleet operating in the Mediterranean Sea by qualified marine biologists working in Sicily (Porticello).

The monitoring activity (sampling period from April to December 2018) of the swordfish fishery was carried out by observers daily. In collaboration with the maritime authority, for each specimen of swordfish, information on total catches were daily collected at every landing, noting several biometric measurements, such as:

- Lower Jaw-Fork Length (LJFL);
- Total Straight Length (TSL);
- Gill-Gutted Weight (GWT);
- Round Weight (RWT).

Specifically, LJFL (Lower Jaw Fork Length, nearest cm) which is defined as the distance between tip of the lower jaw of the fork of the tail (Miyake, 1990) and RWG (Round weight, nearest Kg) are here considered as distribution factors.

The monitoring activities were also carried out directly onboard the fishing vessels in order to collect biological samples (gonads, second anal fin, liver, blood sample, stomach).

The size data and the weight data were aggregate by 10 cm and 10 Kg intervals in order to estimate the monthly size distributions and, regarding length-weight relationship, the correlation factor (R^2) was used to evaluate the accuracy of the examined equation.

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3. Results and Discussion

Total catches observed during the landing activities in Porticello (Palermo-Santa Flavia)

From April 2018 to December 2018, intensive sampling was conducted at the landing site of Porticello (Sicily). Fig. 1 shows the distribution of the catches (N° of specimen of swordfish caught by longline fleet) collected per month, during the sampling period by the National Observers. The value of catches landed in July (1.215) accounts alone for 38,4% of the total. Two relevant peaks are observed in May-June (25,1% of the total) and August-September (31,1% of the total) period.

The distribution of 3.162 swordfish catches is represented on the basis of the size-length classes (cm), for range of 10 cm each (Fig. 2). The samples collected had total length ranging from 80 cm to 240 cm (LJFL) with a mean value of 131,7 cm.

36 specimen of swordfish were landed with size value below the limit of the undersized swordfish established by ICCAT.

The size-length classes included between 100 cm and 140 cm account for 70,0 % of the total catches. Classes above 140 cm all contribute to the remaining 30% of the total catch, especially for classes included between 210 cm and 240 cm, whose yield is very low.

Historically, juveniles represent a large fraction of Mediterranean swordfish catches. Fig. 3 represents the trend of the size-length classes (10 cm each) of swordfish landed by longliners per month, in which the scientific and monitoring activity of the national observers was carried out. As previously reported, the period of most important activity has been monitored between June and August, with a prominent peak observed in July. In this period, the length-frequency distribution shows that the highest abundance of size classes collected were included between 110 cm and 140 cm. Those parameters (lines drawn in different shades of blue) account for 66,0 % of the total catches landed from June to August 2018. In September, the distribution shows another important peak, this is relative to the landing of the smallest size class (100-110 cm, in green) of swordfish juveniles. The class 100-110 cm alone accounts for 45% of the total catches observed in September.

Fig. 4 shows the monthly length frequency distribution of LJFL for swordfish caught from longliners in 2018 season. From May to July (4.a, 4.b e 4.c), sampled fish ranged in size between 96 cm to 230 cm, with nearly all fish in two ranges, the first between 100 and 140 cm (63,0 %) and the second from 140 to 180 cm (31,0%). From August to December (4.d, 4.e, 4.f, 4.g, 4.h), size of collected fish ranged between 80 cm to 240 cm, with nearly all fish (82,5%) in the 100-140 cm range.

Fig. 5 reports the distribution of 3.162 swordfish catches on the basis of the weight classes (Kg), for range of 10 Kg each. The Round Weight has been considered in this study. The samples collected had total round weight ranging from 8 Kg to 164 Kg (RWG) with a mean value of 33,4 Kg.

11 specimen of swordfish were landed with round weight value below the limit of the undersized swordfish established by ICCAT.

The weight classes included between 10 Kg and 30 Kg account for 60,0 % of the total catches. Classes above 30 Kg all contribute to the remaining 40% of the total catch, especially for classes included between 80 Kg and >100 Kg, whose yield is very low.

Fig. 6 represents the trend of the weight classes (10 Kg each) of swordfish landed by longliners per month. As previously reported, the period of most intense activity, for all classes, has been monitored between June and August, with a prominent peak observed in July. In this period, the weight frequency distribution shows that the highest abundance of weight classes landed were included between 10 Kg and 30 Kg. Those parameters (lines drawn in different shades of blue) account for 51,4 % of the total catches landed in Porticello (Palermo-Santa Flavia). In the period from August to September 2018, a second peak is showed relative to the landing of the smallest weight class (10-20 Kg, in light blue) of swordfish juveniles. The class 10-20 Kg alone accounts for 44,3% of the total catches observed in August-September.

Fig. 7 shows the monthly weight frequency distribution of RWG for swordfish caught from longliners in 2018 season. From May to December (Fig. 7 a, b, c, d, e, f, g, h), fish sampled ranged in size between 8 Kg to 164 Kg, with nearly all fish (73%) in the 10-40 Kg range.

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Table 1 shows a summary of the descriptive statistics of the data used in the present study to determine the LJFL-RWT equation.

Fig. 8 shows the LJFL-RWT equation obtained in this study which is described by the following equation:

$$\mathbf{RWT = 9E^{-06} * LJFL^{3.0853} (R^2 = 0,9012)}$$

4. Conclusions

A total of 3.162 swordfish measurements (Lower jaw-fork length LJFL, Round Weight) caught and landed by the Italian longline fleet were observed and collected by national observers in order to appreciate the size distribution in length and weight classes of the monitored swordfish.

Regarding the monthly size and weight frequency distribution, our results showed a high percentage of small swordfish catches during all the sampling period, April-December (LJFL 100-140 cm and <40 Kg RWT) which, on the basis of our new findings regarding the size at first maturity of this species (data not included), should be well considered for further management scenario evaluations as the advice for the minimum catch-at-size. Results clearly demonstrated that a significant percentage of the landings, which was up to 70%, was composed by juveniles, during the sampling period of monitoring activity.

However, further studies and additional scientific data collection programmes focused on supplementary biometric correlations are needed to better clarify the differences between sex, areas, seasons and condition factor of this species in order to fill the gap of information for this important socio-economic species

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Table 1. Descriptive statistic of the data used in the present study.

Descriptive Statistics	LJFL-RWT dataset (n=3.162)	
	LJFL (cm)	RWT (Kg)
Mean	131,37	33,40
Median	126,00	26,00
SD	24,33	21,30
Min	80,00	8,00
Max	240,00	164,00
Number	3.162	3.162

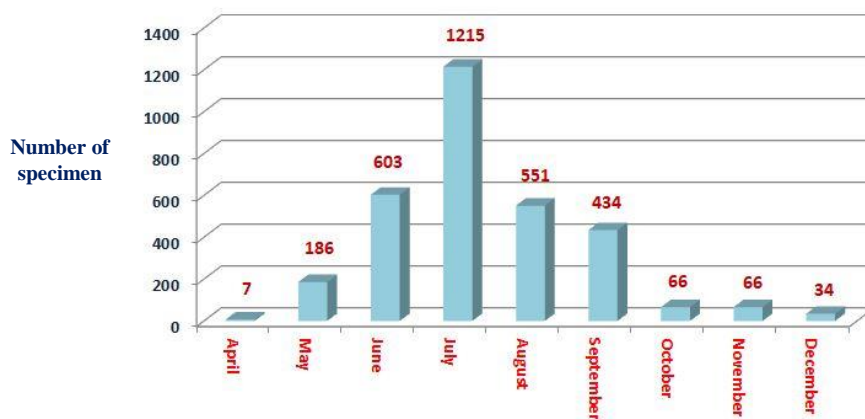


Fig. 1 - Specimens of swordfish caught by longline fleet and landed in the port of Porticello, during the sampling activities carried out by National Observers from April to December 2018

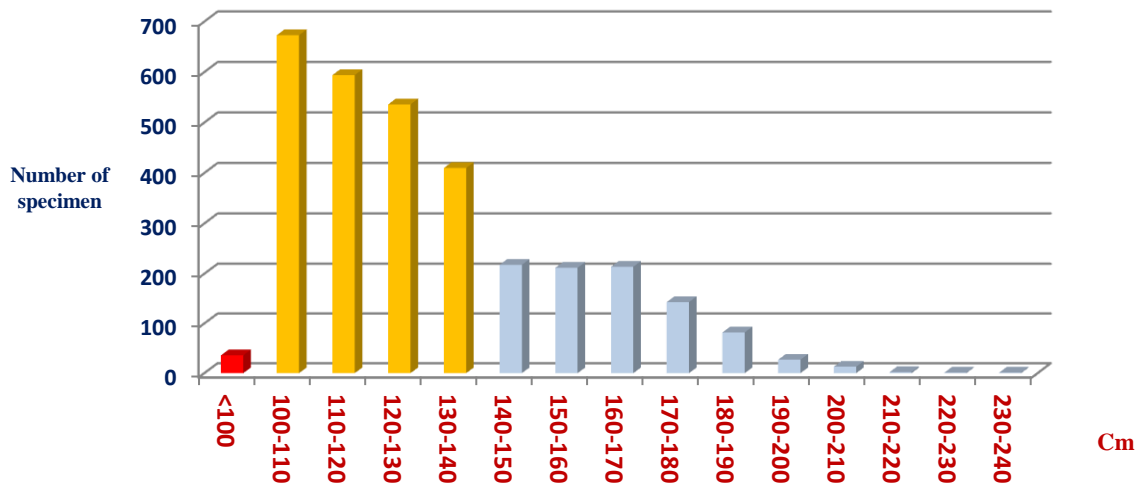


Fig. 2 - Size Distribution for lenght classes (cm) of catches landed in Porticello. In red undersized swordfish. In orange size-length classes included between 100-140 cm. In light blue remaining total catches.

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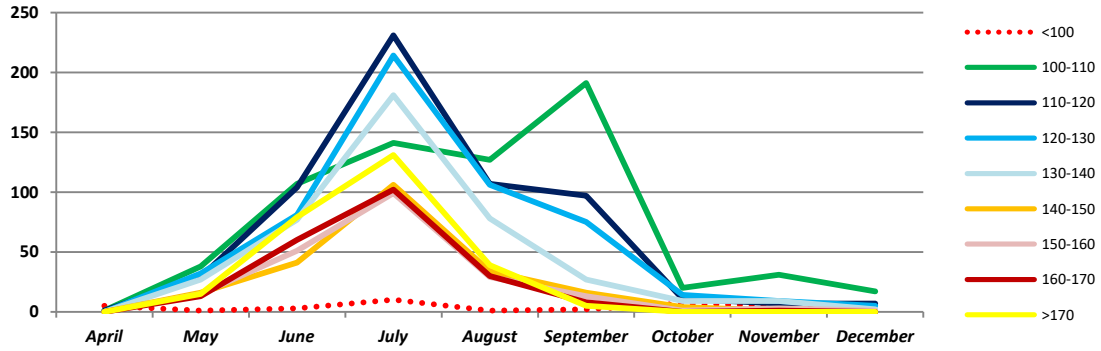


Fig. 3 - Monthly size distribution for length classes (cm) of catches landed in Porticello



Fig. 4(a, b, c, d, e, f, g, h) - Size distribution of length classes (cm) of catches per month

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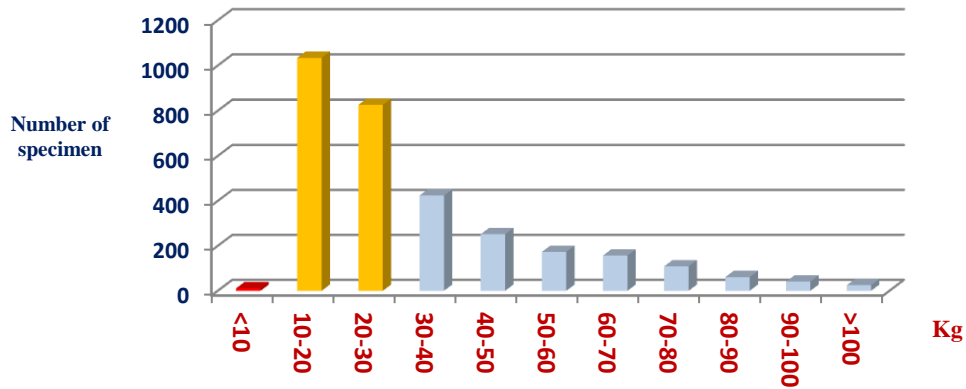


Fig. 5 - Distribution by weight classes (Kg) of catches landed in Porticello. In red undersized swordfish. In orange weight classes included between 10-30 Kg. In light blue remaining total catches.

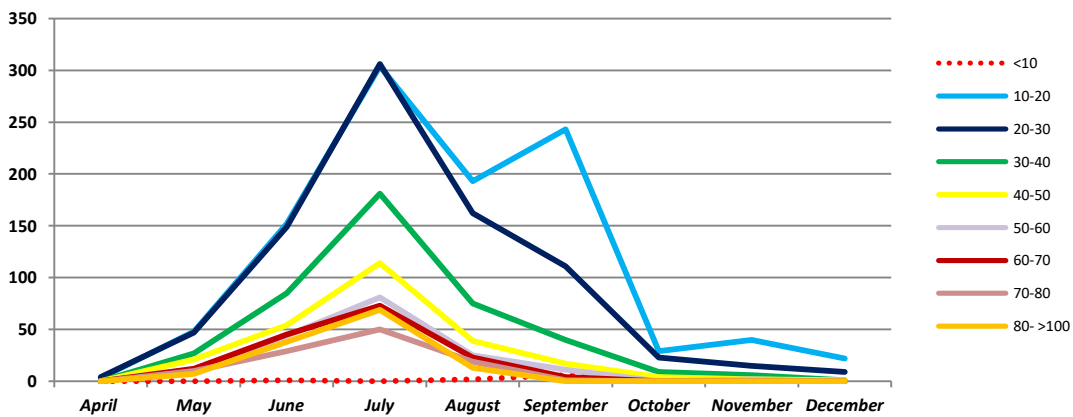
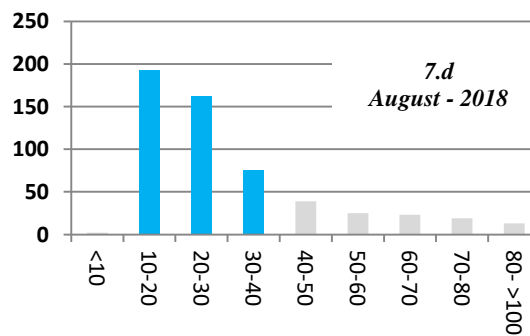
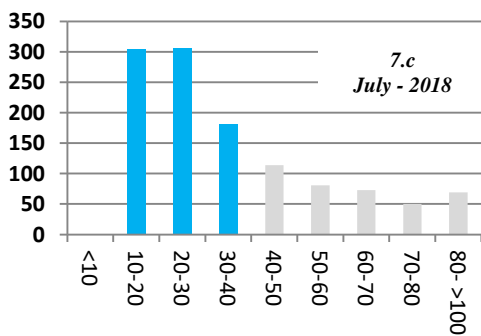
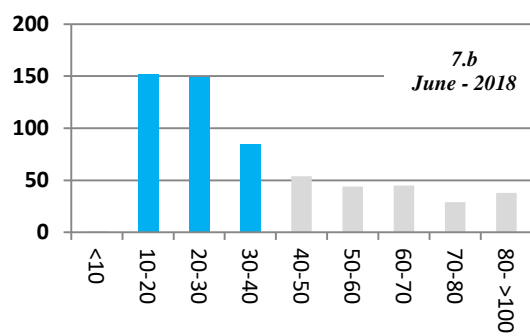
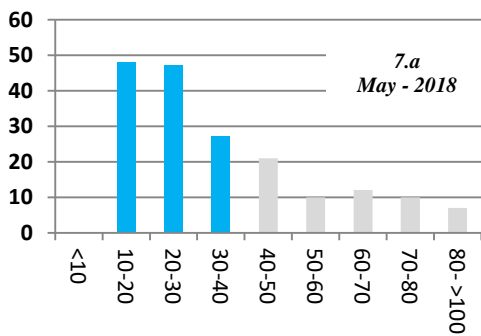


Fig. 6 - Monthly size distribution for weight classes (Kg) of catches landed in Porticello



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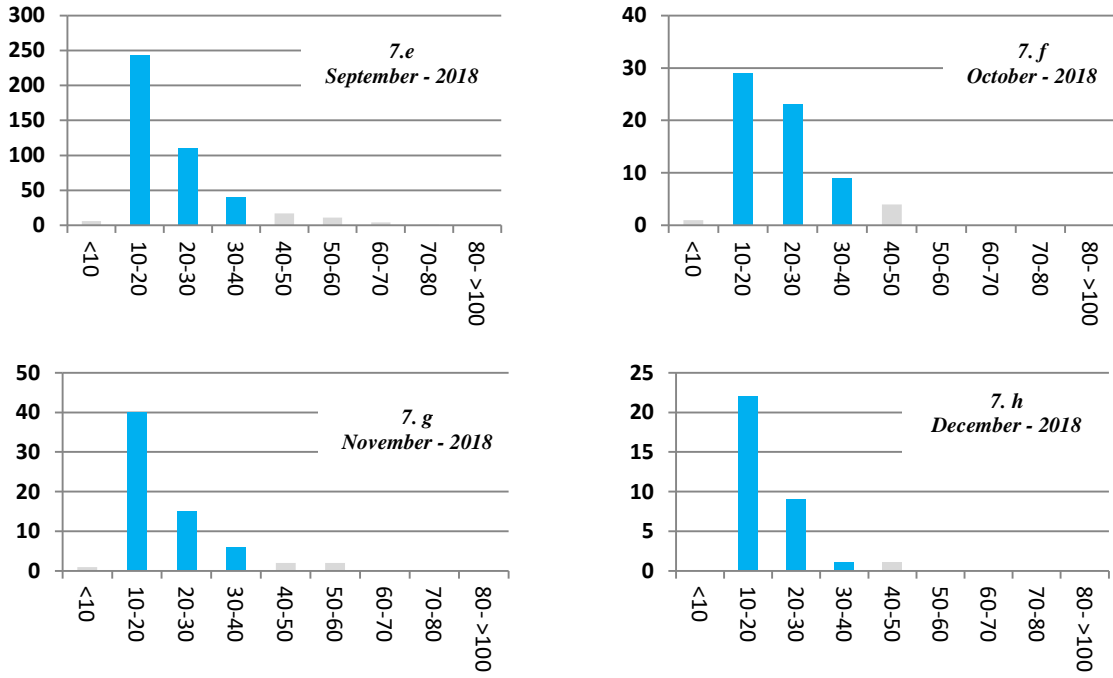


Fig. 7(a, b, c, d, e, f, g, h) - Size distribution of weight classes (Kg) of catches per month

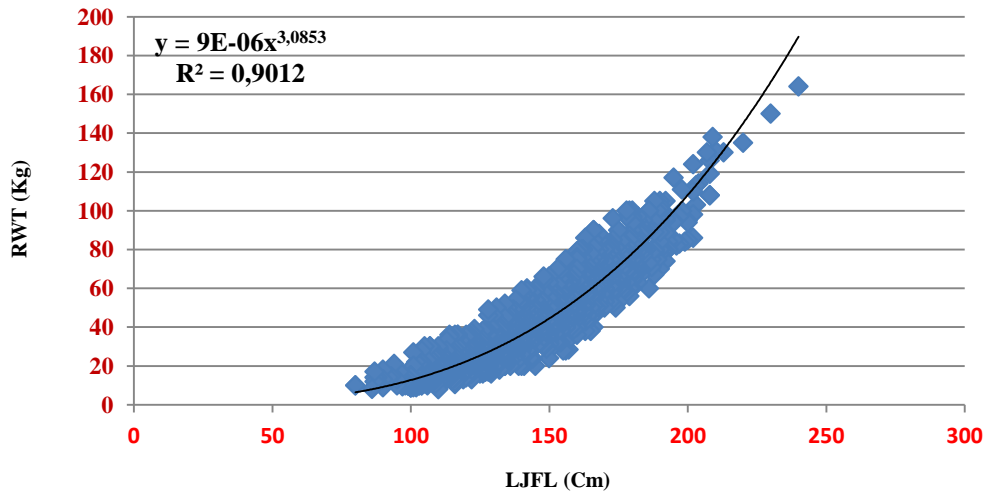


Figure 8. LJFL-RWT relationship ($RWT = 9E^{-06} * LJFL^{3.0853}$, $R^2 = 0,9012$) for the 2018 Mediterranean swordfish landed in Porticello (Palermo-Santa Flavia).

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