CHAPTER 2.1.9: SWORDFISH	AUTHORS: N. ABID and M. IDRISSI	LAST UPDATE: Nov. 13, 2006

2.1.9 Description of Swordfish (SWO)

1. Names

1.a Classification and taxonomy

Species name: *Xiphias gladius* (Linnaeus 1758)
Synonyms used (Nakamura 1985):

Xiphias gladius, Bloch 1786
Xiphias imperator, Bloch & Schneider 1801
Xiphias rondeletti, Leach 1818
Phaethonichthys tuberculatus, Nichols, 1923
Xiphias estara, Phillips 1932
Tetrapterus imperator, Rohl 1942
Xiphias thermaicus, Serbetis 1951
Xiphias gladius estara, Whitley 1964

ICCAT species code: SWO
ICCAT names: Swordfish (English), Espadon (French), Pez espada (Spanish)

According to Hureau and Monod (1973), the swordfish is classified as follows:

- Phylum: Vertebrates
- Subphylum: Gnathostomes
- Superclass: Fish
- Class: Osteichthyes
- Sub-class: Actinopterygians
- Superorder: Teleostes
- Order: Perciforms
- Suborder: Scombroids
- Family: Xiphiidae
- Genus: Xiphias
- Species: *Xiphias gladius*

1.b common names

Below is a list of the common names used according to the FAO. This list is not exhaustive and certain local names may not be included.

Albania: Peshku shtize
Algeria: Pez espada
Angola: Agulha, Agulhão, Espadarte, Peixe-agulha
Argentina: Pez espada
Australia: Broadbill, Broadbill swordfish, Swordfish
Azores: Swordfish, Agulhão, Espadarte
Belgium: Swordfish
Brazil: Aguilhão, Espadarte, Espadarte-meca, Meka, Peixe espada

Can Br Colum: Swordfish
Canada: Broadbill swordfish, Swordfish, Espadon
Cape Verde: Espadarte, Furão, Peixe ferro , Peixe-ferro, Espadon, Espadão, Espadarte, Espadim-azul, Peixe-agulha
Chile: Albacora, Pez espada
China:Chien-chi-yu , Ki-hi-khu , Tinmankhu
Cuba: Emperador, Pez espada
Denmark: Sværdfisk
Djibouti: Sword fish, Espadon
Ecuador: Pez espada
Estonia: Swordfish
Faeroe Islands: Svørðfiskur
Finland: Miekkakala
Former USSR: Mech-ryba, Mechenos, Meshvenosouiye
France: Espadon
Germany: Schwertfisch
Greece: Xifias, Xiphías
Japan: Meka, Mekajiki
Hawaii: Broad-bill sword-fish, A'u ku
Iceland: Sverðfiskur
India: Sword fish, Kunga, Tadmachhi, Mas-hibaru, Kuthirameen, Tadmasa
Indonesia: Toda Todak
Ireland: Swordfish, An colgán
Italy: Pei spa, Pesce spada, Pesce spate, Pesse spada, Pisci spada, Pisci spata, Pisci spatu, Puddicinedda, Spadon, Spadottu, Spateddu
Kiribati: Te rakuika, Te sakula
Rep Korea: Whang-sae-chi
Lebanon: Sankeh
Libya: Abucef
Madeira: Peixe-agulha
Malta: Pixxispad, Spada
Marshall Islands: Lokjan
Martinique : Varé, Espadon
Mauritania: Sword fish Espadon Poisson porte-épée
Mauritius: Swordfish Espadon
Mexico: Pez espada
Mozambique: Espadarte
Namibia: Swaardvis, Schwertfisch
Netherlands: Zwaardvis
New Zealand: Broadbill, Broadbill swordfish, Swordfish, Paea
Nicaragua: Pez espada
Niue: Swordfish, Haku
Norway: Sverdfisk
Oman: Kheil al bahar
Papua N Guin: Broadbill swordfish, Swordfish
Peru: Pez espada
Philippines: Big-ho, Big-ho', Bigo, Bigok, Dugso, Malasugi Malasugi, Malasugi, Dugho, Swordfish, Sibingan, Malasugi, Malasugue, Manumbuk, Palmbela, Dogso, Lumod, Malasugi, Mayas-pas
Poland: Wlócznik
Portugal: Agulha, Agulhao, Catana, Espada, Espadarte, Peixe agulha, Peixe espada, Peixe-agulha
Romania: Peste cu spada, Peste-spada
Seychelles: Swordfish, Espadron
Slovenia: Meèarica
Somalia: Daanbeeri
South Africa: Swaardvis, Broadbill, Swordfish,
Spain: Emperador, Aja para, Chichi spada, Espada, Espardarte, Pez espada
Sri Lanka: Kadu kpooara
St Helena: Swordfish
Sweden: Svärdfisk
Tahiti: Ha'ura
Tanzania: Nduwalo, Sansuli

Togo: Hatalikofi, Espadon
Tuamoto Islands: Hakura
Tunisia: Bou sif.
Turkey: Kiliç baligi
Ukraine: Mech--ryba
United Kingdom (UK): Broadbill, Swordfish
United States of America: Broadbill, Broadbill swordfish, Swordfish
Venezuela: Pez espada
Vietnam: Broadbill swordfish, Cá Mũi kiếm, Ho cá mui kiem

2. Identification

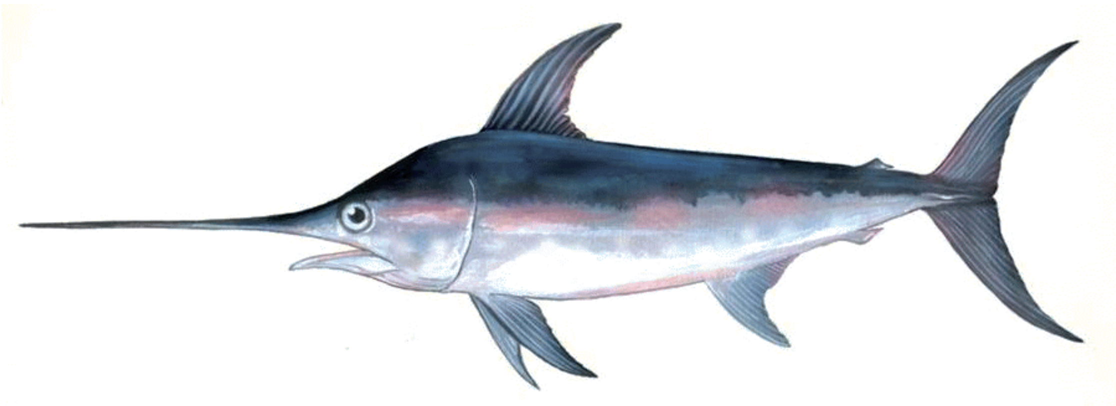

Figure 1. Drawing of an adult swordfish (*Xiphias gladius*) (By Wendy Williams, Fisheries and Oceans, Canada).

Characteristics of *Xiphias gladius* (see Figures 1 and 2)

The largest recorded swordfish was 455 centimetres (cm) long to the fork, and weighed a total of about 537 kilograms (kg) (IGFA 2001). In the Mediterranean, individual fish rarely weigh more than 230 kg, but can weigh up to 320 kg in the Atlantic (Nakamura 1985).

The maximum age for this species is estimated at 10 years in the Mediterranean (Aliçli 2001), but tagging studies have shown that some swordfish can live up to 15 years.

External appearance

- The body is long and cylindrical;
- In adult fish, the upper jaw extends into a very long flat sword;
- The eyes are large;
- Young fish up to 1 m long have small teeth which virtually disappear when they reach adulthood;
- The dorsal and anal fins are both made up of two widely separated parts in adults, but these are continuous in young and juvenile fish;
- The first dorsal fin is much larger than the second; the first has 34 to 49 soft rays, the second dorsal fin has 4 to 6 soft rays;
- The first anal fin is larger than the second; the first anal has 13 to 14 soft rays, and the second 3 to 4;
- The second anal fin is slightly further forward than the second dorsal fin;
- The pectoral fins are somewhat rigid, and each is situated on the lower part of the two flanks, with 16 to 18 rays;
- There are no pelvic fins;
- The adult fish's caudal fin is croissant-shaped; in the young fish it is indented into the fork;
- There is a single pronounced side keel on each side of the caudal peduncle;
- The anus is close to the source of the first anal fin;

- The lateral line is absent in adults, but recognisable in specimens 1 metre (m) long, gradually disappearing as they grow;
- Adult fish do not have scales, but young fish less than 1 m long do have scale-like structures that gradually disappear as they grow;
- They have 26 vertebra, of which 15 or 16 are precaudal, and 10 or 11 are caudal;

During the pre-adult phase swordfish undergo drastic changes as they grow, affecting the shape of the body, the sword and particularly the dorsal, anal and caudal fins **(Figure 2)**.

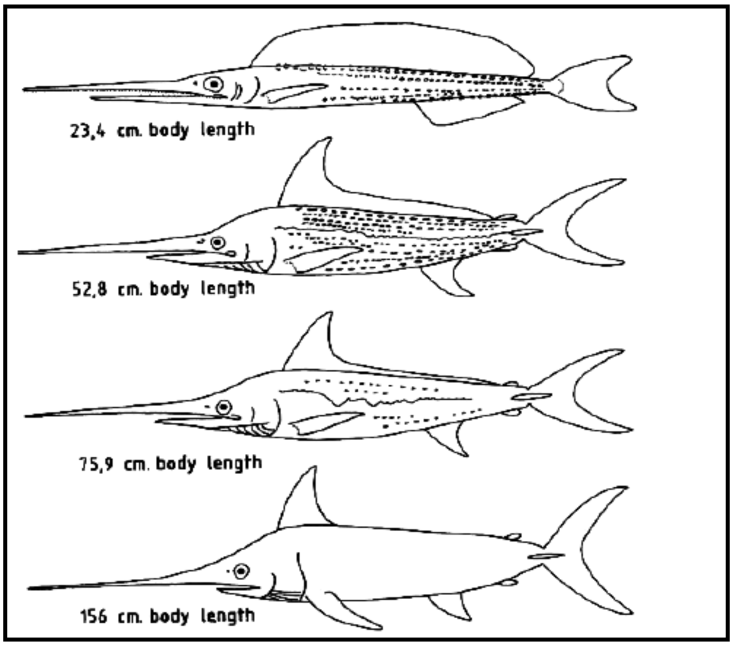

Figure 2. Morphological changes affecting the swordfish's body as it grows (Nakamura 1985).

Colour:

- The back and flanks are brown-black; they tend towards light brown on the ventral part;
- The first dorsal has a blackish brown membrane; other fins are brown or blackish brown.

Internal structure:

- No branchiospines;
- Large gills;
- Swim bladder present.

External characteristics of the larvae

According to Bertolini *et al.* (1956)

- The larvae are 4 mm long at birth;
- They are characterised by a long pigmented yolk sac;
- The tail is partially covered in melanophores;
- Melanophores are present on the head and trunk;
- The teeth are clearly visible during the post-larval phase.

3. Biology and population studies

3.a Preferred habitat

This is an oceanic species, but is sometimes to be found in coastal waters, generally above the thermocline (Collette 1995). The swordfish is the species of billfish with the greatest tolerance to temperature (5 to 27°C), but is often found in surface waters at temperatures over 13°C (Nakamura 1985).

In the northwest Pacific, the preferred temperature range is from 18 to 22° C (Frimodt 1995). In this region, swordfish are to be found from the surface down to depths of 550 m (Takahashi *et al*. 2003). Nonetheless, they can sometimes occasionally dive to depths of at least 650 m (Nakamura 1985).

3.b Growth

Several authors have studied swordfish growth using different methods. Berkeley and Houde (1983); Tsimenides and Tserpes (1989); Megalofonou and De Metrio (1989); Megalofonou *et al*., 1990; Tserpes and Tsimenides, 1995; Ehrhardt *et al*. 1996; Aliçli *et al*. 2001) have estimated the age of swordfish from spines of the anal fin. Some authors have determined the age of this species from otoliths (Radtke and Hurley, 1983; Wilson and Dean, 1983; Megalofonou *et al.* 1990, 1995 *in* Tserpes *et al.* 1995). Haist and Porter (1994) have estimated lengths at age from Multifan analyses of size data. Beckett (1974) studied the growth of the Atlantic swordfish by analysing the vertebrae. The ICCAT Standing Committee on Research and Statistics (SCRS) used a growth curve based on adjusting the Gompertz function to tag-recovery data (Anon. and Restrepo *in* Porter, 1994).

All these authors have shown a sexual dimorphism of growth in this species; males grow more slowly and reach a lower asymptotic size than females. Growth is very rapid during the first year of the lifecycle and then slows down considerably. Studies have also concluded that Mediterranean swordfish reach a lower asymptotic size than Atlantic swordfish.

The different growth models used currently by the SCRS in the stock assessments of this species are summarised in **Table 1**.

Table 1. Growth parameters used by the SCRS for Atlantic and Mediterranean swordfish.

Growth parameters	*Reference*	*N*	*LJ-FL (cm)*	*Method*	*Stock*
Sexes combined $L_t = 238.58\,(1 - e^{-0.185\,(t+1.404)})$	Tserpes and Tsimenides (1995)	1100	62-210	Spines	Med.
Sexes combined $L_t = \left[464.54^{3.2678} - (464.54^{3.2678} - 0.0001^{3.2678})e^{-0.023(3.2678)\,t}\right]^{1/3.2678}$	Arocha *et al.* (2003)	4209	63-262	Spines	North Atl.
Males $L_t = \left[300^{3.921} - (300^{3.921} - 0.0001^{3.2678})e^{-0.00465(3.921)\,t}\right]^{1/3.921}$	Arocha *et al.* (2003)	1817	63-246	Spines	North Atl.
Females $L_t = \left[375.49^{2.976} - (375.49^{2.976} - 0.0001^{2.976})e^{-0.00734\,(2.976)\,t}\right]^{1/2.976}$	Arocha *et al.* (2003)	2392	74-262	Spines	North Atl.
Sexes combined $W_t = 305.56 \times \exp[-4.6335 \times \exp(-0.3058\,t)]$ $L_t = 44.2237 \times W_t^{0.29257}$	Anon. (1989)	85	7-360 lbs	Tagging	North-South Atl.

3.c Length-weight ratios

Several size-weight ratios were established for swordfish. Most of them were based on the data of gill-gutted weight (after the viscera and gills have been removed) of the sampled individuals (De Metrio *et al.* 1987; Tsimenides and Tserpes 1989; Mejuto *et al.* 1993; Gouveia *et al.* 1994; de la Serna *et al,* 1995; Hattour 1996).

For the Mediterranean swordfish, Mejuto and de la Serna (1993) have developed a size-weight relationship that allows direct conversion of an individual's size to its corresponding live weight.

Tserpes *et al.* (2003) updated the size-dressed weight relationship for the Mediterranean swordfish based on a sufficiently large sample and the largest possible size range (n=24668 FL: 50-248 cm). The estimated parameters are as follows: $a=1.76 \times 10^{-6}$; $b=3.378$; $r^2= 0.92$. These authors recommend using this relationship to convert size to weight.

The parameters of this relationship show no statistically significant differences between males and females. Nonetheless, differences were observed between areas and between seasons, according to the degree of dressing and the fish condition factor.

Table 2 shows the different length-weight relationships currently used by the SCRS for Atlantic and Mediterranean swordfish.

Table 2. Size-weight relationships used by the SCRS for Atlantic and Mediterranean swordfish.

Growth parameters	*Reference*	*N*	*LJ-FL (cm)*	*Stock*
$GWT = 5.70 \times 10^{-6} \times LJ - FL^{3.16}$	De Metrio (1987)	462	64-205	Mediterranean
$RWT = 8.90493 \times 10^{-7} \times LJ - FL^{3.554738}$	Mejuto and de la Serna (1993)	1006	62-237	Mediterranean
$DWT = 4.592 \times 10^{-6} \times LJ - FL^{3.1370}$	Turner (1987)			Northwest Atlantic
$RWT = 4.203 \times 10^{-6} \times LJ - FL^{3.2133}$	Mejuto *et al.* (1988)	2569	80-253	Centre-North Atlantic
$RWT = 3.433 \times 10^{-6} \times LJ - FL^{3.2623}$	Mejuto *et al.* (1988)	4049	93-251	Northeast Atlantic
$GWT = 1.24 \times 10^{-5} \times E - FL^{3.04}$	Amorim *et al.* (1979)	1173		Southwest Atlantic
$GWT = 4.3491 \times 10^{-6} \times LJ - FL^{3.188}$	Mejuto *et al.* (1988)	3600	89-266	Southeast Atlantic

LJ-FL: length from lower jaw to fork
E-FL: length from eye cavity to fork
RWT: round weight
DWT: dressed weight (after the viscera and part of the head and fins removed)
GWT: gutted weight

3.d Sexual maturity

To date, few studies have been made on the sexual maturity of the swordfish. In the Mediterranean, De Metrio *et al.* (1989) found that females of this species reach maturity at a size of about 130 cm long. De la Serna *et al.* (1996) estimated the size of initial sexual maturity ($L_{50\%}$) of female swordfish at 142 cm LJFL.

North Atlantic swordfish mature at a size of 179 cm (Arocha *et al.* 1996), while South Atlantic swordfish reach sexual maturity at about 156 cm long (LJFL) (Hazin *et al.* 2002). Males reach maturity a year earlier than females (De Metrio *et al.* 1989, de la Serna *et al.* 1996). Based on different macroscopic indicators Mejuto & García-Cortes (2007) concluded that the reproductive activity of females appears to be related to the temperatures in the epipelagic layers and is largely restricted to the warm tropical regions of the western Atlantic. In addition, the size at first maturity of females was estimated at 146 cm (LJFL). Furthermore, the results indicate the segregation of the Atlantic swordfish between regions of intense reproduction and regions with sporadic seasonal or non-existent reproduction.

Before 2007, these authors suggested a notable difference in the size of first sexual maturity among the different stocks (North Atlantic, South Atlantic and Mediterranean). These differences are much more marked in females than in males (Hazin *et al.* 2002). However, according to more recent information for the Atlantic (Mejuto & García-Cortes (2007) these differences may be smaller than was previously thought.

The sizes at first sexual maturity ($L_{50\%}$) adopted by the SCRS for Atlantic and Mediterranean swordfish are indicated in **Table 3.**

Table 3. Estimated size at first sexual maturity for Atlantic and Mediterranean swordfish.

Maturity	***Reference***	***Stock***
50% of the females are mature at 142 cm (3.5 yrs)	de la Serna *et al*. (1996)	Mediterranean
50% of the females are mature at 179 cm (5 yrs)	Arocha, *et al.* (1996)	North Atlantic
50% of the females are mature at 156 cm	Hazin, *et al.* (2002)	South Atlantic
50% of the females are mature at 156 cm	Mejuto & García-Cortes (2007)	North Atlantic

3.e Sex ratio

This biological parameter for swordfish has been studied by a number of authors. In the Mediterranean, the overall sex ratio is generally 1:1 (De Metrio 1995). Females predominate in catches of fish over 150 cm and almost 100% of fish are over 190 cm (De Metrio 1995, de la Serna *et al.* 1996; Orsi Relini *et al.* 1999, Srour *et al.* 2003).

In the Atlantic, the overall sex ratio is also 1:1. Females predominate in sizes over 170 cm and represent almost 100% of the catches of fish over 225 cm (Suzuki *et al.* 1991 and Arocha *et al.,* 1996). In the Pacific, females also predominate in sizes over 170 cm (Mejuto *et al.* 2003).

These authors observed spatio-temporal variation in the trends of this parameter in the different areas (Atlantic, Pacific and Mediterranean), which would be linked mainly to the different behaviour between the two sexes, dictated either by reproduction (de la Serna *et al.* 1993; Arocha *et al.* 1993; Tserpes *et al*. 2001) or feeding (Hoey 1992).

Taking these spatio-temporal variations into account, Mejuto *et al.* (1998) defined three sex ratio schemes for swordfish according to their biological behaviour. One model is characterised by a low percentage of females measuring between 120 and 180 cm, followed by an increase to a high percentage. This is the typical situation in breeding areas. One model gives 50% of females between 100-150 cm, followed by an increase in females to a high percentage, characteristic of the feeding areas, and a last model, situated between these two, that characterizes the transition areas.

3.f Reproduction and early stages of the lifecycle

Spawning

As for the other species of tunas, swordfish spawning is strongly influenced by environmental factors, especially surface temperature. In the Atlantic, swordfish generally spawn ideally at temperatures from 23 to 26°C (Beardsley 1978; Rey 1988).

In the northwest Atlantic, swordfish spawn all year round, with a peak in reproductive activity between December and June (Beardsley 1978; Arocha 1996). The traditional spawning areas of this species are in the Gulf of Mexico, south of the Sargasso Sea, east of the Antilles, in the Strait of Florida and along the southeast coast of the United States (Beardsley 1978; Rey 1988; Arocha 1996). New spawning areas have recently been identified between 10°-15°N latitude and 30°-40°W longitude (Mejuto *et al*. 2003). In the South Atlantic, spawning occurs along the southern coast of Brazil between 20 and 30°S latitude, from November to March (Amorim *et al*. 1980)**.**

In the Mediterranean, swordfish spawn mainly around the Balearic Islands, in the centre and south of the Tyrrhenian Sea, in the Ionian Sea and in the Strait of Messina (Beardsley 1978; Rey 1988). Recently, Tserpes *et al.* (2001) noted new spawning areas of this species in the Levant basin.

Eggs and larvae

Swordfish eggs are pelagic, 1.6 to 1.8 millimetres (mm) in diameter and are found close to the surface of the water (Palko 1981). Arocha *et al.* (1996) estimated the average fecundity of North Atlantic swordfish at 3.9 x 10^6 eggs per female. For Mediterranean swordfish, fecundity has been estimated at 1.6 x 10^6 eggs (Cavallero *et al*. 1991).

Larvae are often found in waters with temperatures above 24°C (Nakamura 1997). They are generally found a few metres below the surface of the water during the day, but can sink to a depth of 30 m during the night (Nishikawa 1974). Larvae over 10 mm feed almost exclusively on the larvae of other species (Kailola 1993).

Recruitment

The recruitment of Atlantic swordfish seems be strongly correlated to atmospheric indicators, especially the Winter North Atlantic Oscillation Index (Winter NAO), and oceanographic indicators, in particular the northwest Gulfstream current (NWGS) (Mejuto 2003).

In effect, a positive NAO cycle would cause the movement of large water masses towards the northeast and therefore the eggs and larvae would tend even more to move to higher latitudes with a colder DCWLS (Deeply Convected Water in the Labrador Sea). On the other hand, a negative NAO would probably lead to the eggs and larvae retained in areas with the most appropriate physical conditions for development and survival during the critical first stages of life for the larvae and pre-recruits (Mejuto 2003).

Seasonal differences of SST have been also related to the growth rate of swordfish recruits in the eastern Mediterranean (Peristeraki *et al.* 2007).

3.g Migrations

The results of the tagging programmes conducted in the North and South Atlantic indicate that swordfish move significantly between the relatively hot subtropical waters and the temperate waters of the North and South Atlantic (Anon. 2006) **(Figure 3)**. However, traditional tagging has not shown any movements across the Equator (Garcia-Cortés *et al*. 2003).

On the other hand, the results of these programmes have not shown the existence of extensive transatlantic migration of this species (Brown, 1995; Garcia *et al*. 2003; Sperling *et al.* 2005) but these observations are limited by problems associated with the use of conventional tags. Nonetheless, the analysis of the gonad-somatic indices of female swordfish caught in the Atlantic area adjacent to the Strait of Gibraltar did show a genetic migration of this species during the second quarter of the year from the Atlantic to the Mediterranean, and a second trophic migration in the opposite direction (El Hannach 1987; De la Serna *et al*. 1990).

During the ICCAT Swordfish Stock Structure Workshop (Anon. 2006), the group discussed the tests available on biological markers, fisheries-dependent data (catch, CPUE and size distribution) and genetic information, as well as computer simulation studies. The results of the research presented in the Workshop generally supported the stock structure currently assumed for Atlantic swordfish although no specific definition of stock boundaries could be defined amongst the South Atlantic, North Atlantic and Mediterranean stocks.

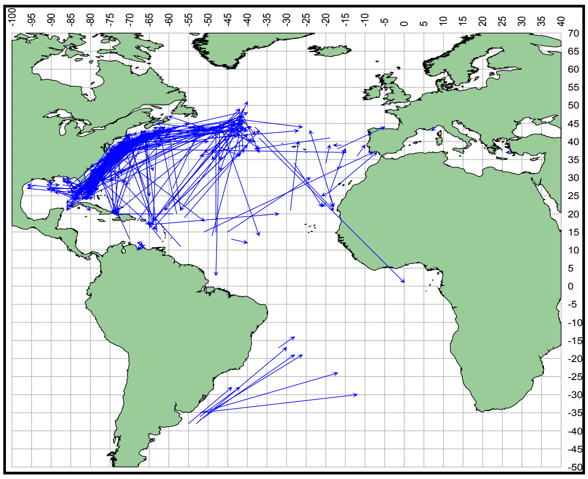

Figure 3. Swordfish migrations based on tagging data of the ICCAT Secretariat (Anon. 2006).

3.h Eating habits

Swordfish diet composition studies have been observed in the East Atlantic (Moreira 1990; Clarke *et al.* 1995; Hernández-García, 1995), North Atlantic (Scott & Tibbo, 1968; Stillwell & Kohler 1985; Guerra *et al.* 1993; Chancollon *et al,* 2006;), Mediterranean Sea (Bello 1991), and Pacific (Markaida & Sosa-Nishizaki 1998). The species changes its eating habits at a very early age, moving from a diet based on copepods to one based almost entirely on fish (Vedel Tanning 1955). Adult swordfish are diurnal feeders rising close to the mixed surface layer at night and descending to deeper waters during the day to feed on pelagic fish and squid (Beardsley 1978).

The adult diet varies considerably with habitats and seasons (Beardsley 1978) which is reflected in the predominance of variable prey observed in different studies. In some studies, fish dominated the diet (El Hannah 1987; Gouveia 1992; Baretto *et al.* 1996) while other studies indicated a predominate consumption of cephalopods (Stillwell and Kohler 1985, Hernández–García 1995). Smaller prey is generally eaten whole, while larger prey are often observed with visible slash marks on the rostrum. Goode (1883) first reported swordfish striking at schools of fish with their swords until a number of fish were killed. More recently Scott & Tibbo (1968) also recognized similar slash marks on prey items, although it is still unclear when and how often the sword is used during feeding.

3.i Physiology

Swordfish possess a highly specialised heating system similar to the counter-current heat exchanger in tunas which specifically warms the eyes and the brain up to 10-15°C above ambient water temperature (Carey 1982, Fritsches *et al.* 2005). The warming of the retina thus significantly improves the ‘flicker fusion frequency’ or the temporary resolution of movement allowing the swordfish to detect prey movement more effectively than if the eye operated at ambient seawater temperature. The combination of brain and eye warming allow swordfish to exploit an expanded thermal niche and hunt effectively in very deep and cold waters.

Like the majority of large pelagic animals, swordfish have a specialized anatomy for rapid swimming. However, swordfish differ from tunas in the percentage of white and red muscle (Graham *et al.* 1983). Whereas tunas possess a high percentage of red muscle rich in mitochondria and myoglobin for prolonged swimming without fatigue, swordfish muscle has a higher percentage of white muscle more suited for sudden burst activity. An adult swordfish can swim at a speed of 24.9 metres/second (m/s).

3.j Behaviour

Adult swordfish are generally solitary and are not known to form schools in open ocean environments (Vedel Taning 1955), but large groups can be found in the Mediterranean (Maintre *et al.* in el Hannah 1987). According to Marc in el Hannah (1987), the swordfish become gregarious during the spawning periods and form aggregations of several individuals.

Acoustic detection techniques have shown that swordfish stay near the surface at night, but return to depths of up to 600 m during the day (Carey 1981).

3.k Natural mortality

In the absence of documented studies on the natural mortality of swordfish, the SCRS continues to consider, for the stock assessment in the Atlantic and the Mediterranean, that this mortality is equal to 0.2.

In the Mediterranean, the natural mortality could be higher due to the relatively short life expectancy of this species. This mortality could also be lower due to the absence of potential predators such as blue marlin in this sea (Anon. 1997).

3.l Conversion coefficients

Considering that many size-weight relationships are based on the dressed or gutted weight of the fish, the conversion of the catch at size to catch at size in round weight thus makes it necessary to use the corresponding conversion factors of dressed or gutted weight to round weight. Several conversion factors depending on the fishing area are currently used by the SCRS (**Table 4).**

Table 4. Conversion factors among the different types of weight for swordfish.

Equation	*Reference*	*Geographical area*
$RWT = 1.3333 \times DWT$	Turner (1987)	Northwest Atl.
$RWT = 1.3158 \times DWT$	Mejuto *et al.* (1988)	Central-East Atl.
$GWT = 0.8009 \times RWT$	Amorim *et al.* (1979)	Southwest Atl.
$RWT = 1.140 \times GWT$	Mejuto *et al.* (1988)	Southeast Atl.
$RWT = 1.12 \times GWT$	Anon. (2004)	Mediterranean

RWT: Round weight
DWT: Dressed weight
GWT: Gutted weight

4. Distribution and fishing

4.a Geographical distribution

This is a cosmopolitan species found in the tropical and temperate waters of all the oceans, between 45°N and 45°S, including the Mediterranean Sea, the Black Sea and the Marmara Sea (Palko *et al.* 1981). The very broad geographical distribution area of swordfish explains the large number of fisheries that have developed in all the world's oceans **(Figure 4).**

Variation in the vertical distribution by size and sex is observed. Large individuals are found in cold waters and those weighing less than 90 kg rarely frequent waters with temperatures below 18°C. In addition, males are more abundant than females in warm waters (Beardsley 1978).

Distribution in the Atlantic Ocean: In the west, the fisheries are distributed from latitudes at the level of Canada to those located at the level of Argentina, and from the east of Norway to South Africa (ICCAT. 2003).

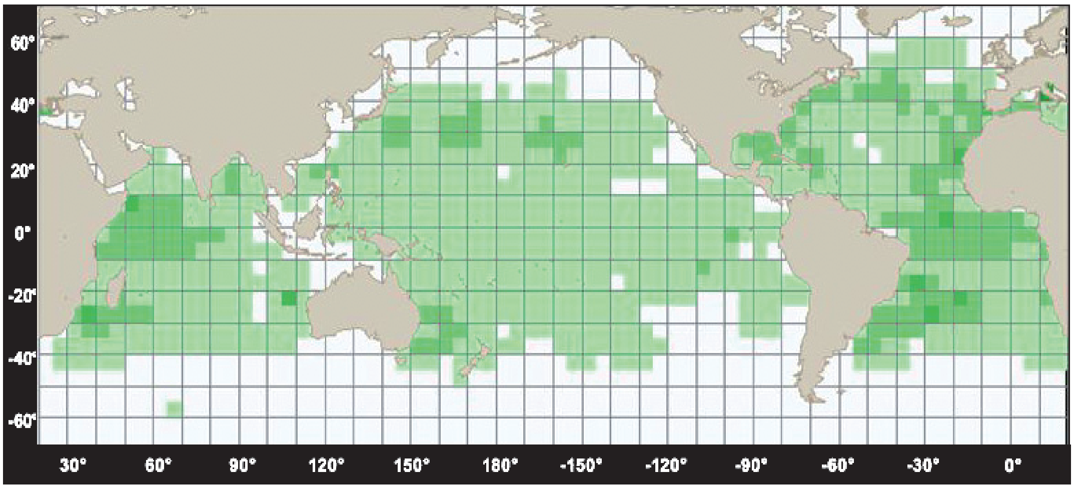

Figure 4. Geographical distribution of average catches of swordfish by longliners for the period 1996-1998 (Courtesy of Alain Fonteneau).

4.b Populations / Stock structure

In order to assess and manage swordfish stocks, the ICCAT considers the existence of three distinct management units: North Atlantic, South Atlantic and Mediterranean Sea.

The most recent results of biological and genetic studies and tagging programmes clearly support these hypotheses. Thus, the size of initial sexual maturity of swordfish differs significantly between the Mediterranean and the Atlantic (see Section 3.d). Likewise, growth parameters differ significantly between the Atlantic and Mediterranean stocks (Tserpes *et al.* 1995; Arocha *et al*. 1996).

Moreover, the consideration of three stocks is also based on the identification of three distinct spawning areas for this species, one in the Mediterranean (Beardsley 1978; De la Serna *et al*. 1990; Tserpes 2002), and the other two in tropical waters in the northwest Atlantic (Beckett 1974; Arocha 1996) and the South Atlantic (Amorim *et al*. 1980).

On the other hand, the most recent results of genetic studies consolidate the current structure of the stocks adopted by the ICCAT. Alvarado *et al*. 1999; Kotoulas *et al*. 2006; Reeb *et al*. 2006, Cimmaruta *et al*. 2006, have shown the existence of a significant difference in the genetic structure of swordfish among the populations of the four regions: North Atlantic, South Atlantic, Mediterranean and Indian Ocean, with a Mediterranean population significantly distinct from the others.

Recent tagging results also support the hypothesis of two distinct Atlantic stocks - the North and South stocks - due to the lack of trans-equatorial migration (Garcia-Cortés *et al*. 2003).

Several studies point to exchanges between the different stocks considered, the rate and geographical delimitation of which are still little known. The ICCAT currently considers a line of demarcation of the stocks of the North and South Atlantic, situated at latitude 5°N. Nonetheless, some authors consider that the mixing area between these two stocks is located much further north, between 10 and 20°N (Chow *et al.* 2003; Chow 2006).

Besides, exchanges also seem to exist between the Mediterranean and the northeast Atlantic, but their importance varies in terms of time and area. Some authors consider that the mixing area between these two stocks lies beyond 10°W, i.e. to the west of the limit currently established by ICCAT (Vinas *et al*. 2006). These results support the hypothesis according to which swordfish carry out trophic and genetic migration between the Mediterranean and the Atlantic through the Strait of Gibraltar (de la Serna *et al*. 1990, De la Serna *et al*. 1992).

Finally, recent research results presented in 2006 at the workshop on the structure of swordfish stocks in the Atlantic and Mediterranean generally support the stock structure currently postulated for Atlantic swordfish. The

Committee also concluded that the precise delimitation between the North Atlantic, South Atlantic and Mediterranean stocks cannot be improved without reinforcing collaborative and multidisciplinary research (ICCAT. 2007).

4.c Description of fisheries: Catches and fishing effort

North Atlantic

The North Atlantic stock is mainly fished with longline and by surface fishing gears. Longline fisheries that directly target swordfish are relatively recent. They have been operational since the end of the 1950s and the early 1960s. The main fleets directly targeting this stock are EC-Spain, the United States and Canada. Other fisheries catch swordfish as by-catch or in an opportunistic way, especially Chinese Taipei, Japan, Korea and EC-France. Harpoon fishing has been used since the end of the 19th century (ICCAT 2005a, **Figure 5**).

The average swordfish catch in the North Atlantic during those years has been estimated at 12,300 t. Catches made since 1998 are below this level. 2004 catches were about 40% lower than the maximum level recorded in 1987. This declining trend in swordfish catches since 1998 is partly due to the implementation of the regulatory measures recommended by ICCAT, but also to shift of some fleets towards the South Atlantic or out of the Atlantic. Certain fleets, especially those of Canada, EC-Portugal, EC-Spain, and the United States, have even changed their target species to search for other tuna species, including sharks, making the most of market conditions and catch rates of these species that are relatively higher than those of swordfish (Anon. 2004).

The swordfish fishery has undergone new changes over the last few years. Thus, from February 2000 to December 2003, Japanese vessels were obliged to throw back all swordfish as their quota had been reached. The United States has banned or restricted pelagic longline fishing to certain areas and periods in order to avoid accidental catches of juvenile swordfish (Anon. 2004).

Since 2002, the Canadian longline fishing season has been extended to November, following the introduction of the individual quota system. Another technological change experienced by this fishery involves replacing many traditional European multifilament longline vessels with monofilament longliners which has made it possible to increase hook efficiency (Anon. 2004).

South Atlantic

The longline fleets directly targeting swordfish in the South Atlantic are those of Brazil, Namibia, South Africa, Uruguay and Venezuela. Before 1980, total swordfish catches were relatively low and did not exceed 5,000 tonnes. Since then, catches have progressively increased to 21,780 t in 1995, which is a similar level to that in the North Atlantic (ICCAT 2005a; **Figure 5**).

This increasing trend in catches was partly due to the shift in fishing effort to the South Atlantic from the North Atlantic, but also from other oceans. Since 1998, swordfish catches reported a declining trend, and did not exceed 12,553 t in 2003. This reduction was partly attributed, among others, to the implementation of ICCAT regulatory measures, the shift of fleets towards other oceans, and to changes in target species (ICCAT 2005a).

Mediterranean

The Mediterranean swordfish fishery is characterised by its high catch rate. The average annual catch of this species in this sea is on the order of 14,500 t (1984-2001), similar to that in the North Atlantic. This is probably due to the very high productivity of this sea. Furthermore, it is likely that the potential reproduction area of the Mediterranean basin is relatively more extensive than in the Atlantic (Anon. 2004).

The main fishing gears used to catch swordfish are longline, representing 47% of the total catch, and drift gillnets. Accidental catches are also made using harpoons, traps, and in recreational fisheries. The surface longline is used throughout the Mediterranean, while gillnets especially are mainly used in Italy, Morocco and Turkey. The main swordfish producers in the Mediterranean over the last few years (1997-2001) are Italy (44%), Morocco (23%), EC-Greece (10%) and EC-Spain (9%) (ICCAT 2005a; **Figure 5**).

The total catches of this species increased in the period 1965 to 1972, stabilised between 1973 and 1977, then resumed their increasing trend again to a maximum of 20,365 t in 1988. Since then, catches have fallen and since 1990 have oscillated between 12,000 and 16,000 t (ICCAT 2005a).

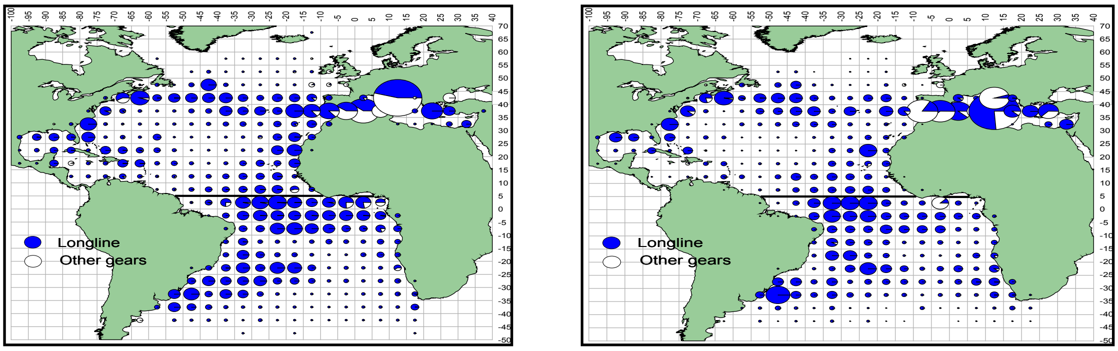

Figure 5. Geographical distribution of swordfish catches by the main gears (Left panel: 1990-1999; Right panel: 2000-2003) (ICCAT 2005a).

4.d Description of the fisheries / Catch by age

North Atlantic

Catches are usually dominated by individuals aged between 1 to 4 years, with a predominance of age 2 fish, representing on average 26 % of the total catches **(Figure 6A)**.

South Atlantic

Catches are clearly dominated by fish aged from 2 to 5 years. The age 3 group is the largest, comprising 26.5% of the total catches **(Figure 6B)**.

Mediterranean

Fish aged 1, 2 and 3 are predominate in the catches, especially the age 2 group, which represents on average 35% of the total catches **(Figure 6C).**

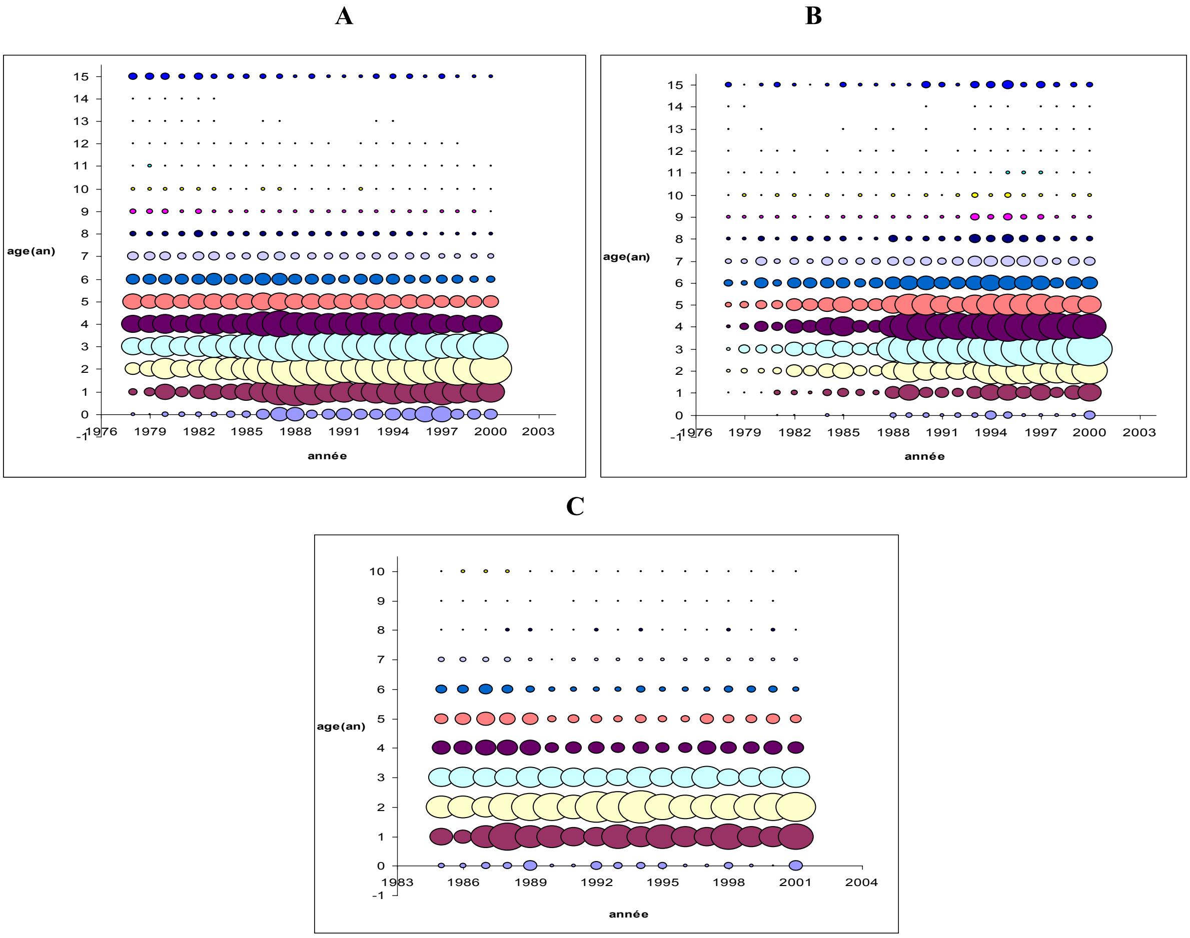

Figure 6. Catches by age in the North Atlantic (A) and south Atlantic (B) for the period 1978-2000 and in the Mediterranean (C) for the period 1985-2001 (Anon. 2004).

5. Bibliography

ALIÇLI, T. Z., and I. K. Oray. 2001. Age and growth (*Xiphias gladius* L., 1758) in the eastern Mediterranean sea. Col. Vol. Sci. Pap. ICCAT, 52(2): 698-707.

ALVARADO BREMER, J. R., J. Mejuto, J. Gomez-Marquez, F. Boan, P. Carpintero, J. M. Rodriguez, T. W Creig and B. Ely. 1999. Hierarchical analysis of swordfish mitochondrial DNA substructure within the Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 49(1): 457-466.

AMORIM, A., C. Arfeli, A. Gonzalez Garces, and J. C. Rey. 1979. Estudio comparativo sobre la biología y pesca del pez espada, *Xiphias gladius L*. (1758) obtenidos por las flotas española y brasileña. Col. Vol. Sci. Pap. ICCAT, 8(2): 496-503.

AMORIM. A. F. and C. A. Arfelli. 1980. Reproduccion del pez espada (*Xiphias gladius* L 1758) en el sudeste y sur del brasil. Col. Vol. Sci. Pap. ICCAT, 9(3): 624-626.

ANON. 1989. Report of the Second ICCAT Swordfish Workshop. Col. Vol. Sci. Pap. ICCAT, 29:71-162.

ANON. 1997. Rapport de la deuxième réunion du groupe de travail AD HOC CGPM/ICCAT sur les stocks de grands pélagiques de la Méditerranée. Col. Vol. Sci. Pap. ICCAT, 46(3): 165-291.

ICCAT. 2003. Report for Biennual Period, 2002-2003, Part I. 207 pp.

ANON. 2003. Report of the 2002 Atlantic swordfish stock assessment session. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1289-1415.

ANON. 2004. Report of the 2003 ICCAT Mediterranean swordfish stock assessment session. Collect. Vol. Sci. Pap. ICCAT, 56(3): 789-837.

ICCAT. 2005a. Report for Biennual Period, 2004-2005, Part I. 238 pp.

ANON. 2004. Rapport du Comité Permanent pour la Recherche et les Statistiques (SCRS). ICCAT, 2005.- Rapport de la période biennale, 2004-2005, I[e] Partie.

ANON. 2005b. Statistical Bulletin. Vol. 34.

ICCAT. 2007. Report for Biennual Period, 2006-2007, Part I. 254 pp.

ANON. 2006. Rapport du Comité Permanent pour la Recherche et les Statistiques (SCRS). ICCAT, 2007.- Rapport de la période biennale, 2006-2007, I[e] Partie.

ANON. 2006. Report of the 2006 Atlantic swordfish stock assessment session. Collect. Vol. Sci. Pap. ICCAT, 60(6): 1787-1896.

AROCHA, F., and D. W. Lee. 1993. Preliminary observations on sex ratio and maturity stages of the swordfish, *Xiphias gladius*), in the northwest Atlantic. Collect. Vol. Sci. Pap. ICCAT, 40 1): 425-432.

AROCHA, F., and D. W. Lee. 1996. Maturity at size, reproductive seasonality, spawning frequency, fecundity and sex ratio in swordfish from the Northwest Atlantic. Collect. Vol. Sci. Pap. ICCAT, 45(2): 350-357.

AROCHA, F., C. Moreno, L. Beerkircher, D. W. Lee and L. Marcano. 2003. Update on the growth estimates for the swordfish, *Xiphias gladius*, in the Northwestern Atlantic. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1416-1429.

BARRETO, M. A., L. A Marcano, J. J Alio, X. Gutierrez, and A. Zerpa. 1996. Alimentación del pez espada, *Xiphias gladius*, en el area del Caribe Venezolano. Collect. Vol. Sci. Pap. ICCAT, 45(2): 337-342.

BEARDSLEY, J. L. 1978. Report of the swordfish workshop held at the Miami laboratory southeast fisheries center, National Marine Fisheries Service Miami Florida. June 7-9. Col. Vol. Sci. Pap. ICCAT, 7(1): 149-158

BECKETT, J. S. 1974. Biology of swordfish, *Xiphias gladius L*., in the northwest Atlantic Ocean. Proceedings of the international Billfish symposium, Kailua-kona, Hawaii, 9-12 August 1972. Part 2. Review and contributed papers. pp: 103-106. July 1974.

BELLO, G. 1991. Role of cephalopods in the diet of swordfish, *Xiphias gladius*, from the Eastern Mediterranean Sea. Bulletin of Marine Science 49(1-2): 312-324.

BERKELEY, S. A and E.D. Houde. 1983. Age determination of broadbill swordfish, *Xiphias gladius*, from the Straits of Florida, using anal fin spine sections. U.S. Dep. Comm., NOAA, Tech. Rep. NMFS, 8: 137-143.

BERTOLINI, F., U. D'Ancona, E. Padoa Montalenti, S. Ranzi, L. Sanzo, A. Sparta, E. Tortonese and M. Vialli, 1956. Uova, larve e stadi giovanili di Teleostei. Fauna Flora Golfo Napoli Monogr. 38:1-1064.

BROWN, C.A. 1995. Preliminary examination of size and location data for United States tagged and recaptured swordfish. Collect. Vol. Sci. Pap. ICCAT, 44 (3): 217-224.

CAREY, F. G. and B. H. Robison, 1981. Daily patterns in the activities of swordfish, *Xiphias gladius*, observed by acoustic telemetry. Fish. Bull. 79(2): 277-292.

CAREY, F. G. 1982. A brain heater in the swordfish. Science 216(4552): 1327-1329.

CAVALLERO, G., HAS. Potoshi, and A. Cefaii. 1991. Fertility, gonad-somatic index and catches of eggs and larvae of *Xiphias gladius* in the southern Tyrrhenian Sea. Col. Vol. Sci. Pap. ICCAT, 35(2): 502-507.

CLARKE, M. R., D. C. Clarke, H. R. Martins, and H. M. Silva. 1995. The diet of swordfish (*Xiphias gladius*) in Azorean waters. Arquipel Life Marine Science 13A: 53-69.

CHANCOLLON, O., C. Pusineri, V. Ridoux. 2006. Food and feeding ecology of Northeast Atlantic swordfish (*Xiphias gladius*) off the Bay of Biscay. ICES Journal of Marine Science 63: 1075-1085.

CHOW, S., and K. Nohara.2003. Further implication on boundary between north and south Atlantic stocks of the swordfish (*Xiphias gladius*). Collect. Vol. Sci. Pap. ICCAT,55 (4): 1719-1722.

CHOW, S. 2006. Marked genetic difference between the north and south Atlantic stocks of the swordfish (*Xiphias gladius*) revealed by a single nucleotide polymorphism at CaM intron locus.

CIMMARUTA R., M. Paoletti, P. Bondanelli, M. N. Santos, A. Garcia and G. Nascetti. 2006. Genetic structure of Mediterranean and Atlantic swordfish investigated using allozymes and RFLPs.

COLLETTE, B. B., 1995. Xiphiidae. Peces espada. p. 1651-1652. In W. Fischer, F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter and V. Niem (eds.) Guia FAO para Identification de Especies para lo Fines de la Pesca. Pacifico Centro-Oriental. 3 Vols. FAO, Rome.

DE LA SERNA, J. M and E. Alot. 1990. Considerationes relativos a los desplazamientos efectuados por el pez espada (*Xiphias gladius*) en el area del estrecho de Gibraltar y otras observaciones relacionados con biología de la reproducción. Col. Vol. Sci. Pap. ICCAT 32(2): 353-359.

DE LA SERNA, J. M., E. Alot, and J. Mejuto. 1992. Analysis preliminar del sex ratio por clase de talla del pez espada (*Xiphias gladius*) en el area atlantica proxima al estrecho de Gibraltar. Collect. Vol. Sci. Pap. ICCAT, 39 (2): 514-521.

DE LA SERNA, J. M., E. Alot, and M. D Godoy. 1993. Analisis preliminar del sex ratio por clase de talla del pez espada (*Xiphias gladius*) capturado con palangre de superficie en el Mediterráneo occidental. Collect. Vol. Sci. Pap. ICCAT, 40(1): 141-148.

DE LA SERNA, J. M., D. Ovejero, and J. M. Ortiz De Urbina. 1995. Una relacion talla (LJFL)-peso canal (DW) de pez espada (*Xiphias gladius*) para el mediterráneo occidental. Collect. Vol. Sci. Pap. ICCAT, 44(1): 221-225.

DE LA SERNA, J. M., J. M. Ortiz De Urbina, and D. Macias. 1996. Observations on sex ratio, maturity and fecundity by length class for swordfish (*Xiphias gladius*) captured with surface longline in the western Mediterranean. Collect. Vol. Sci. Pap. ICCAT, 45(1): 115-139.

DE METRIO.G., and P. Megalofonou. 1987. Catch, size distribution, growth and sex ratio of swordfish (*Xiphias gladius L*) in the Gulf of Taranto. FAO Fisheries report 394: 91-102.

DE METRIO, G., P. Megalofonou, S. Tselas, and N. Tsimenides. 1989. Fishery and biology of the swordfish (*Xiphias gladius, L.* 1758) in Greek waters. FAO rapport sur les pêches n°412. pp: 135-145.

DE METRIO, G. 1995. Characterization of large pelagic stocks in the Mediterranean. EEC project XIV/MED/91-102. Description of the project and synthesis of the research on swordfish. Collect. Vol. Sci. Pap. ICCAT, 44(1): 318-329.

EHRHARDT, N. M. 1996. On the age and growth of swordfish in the northwest Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 44 (2): 84-88.

EL HANNACH, A. 1987. Données biologiques et écologiques sur l'espadon (*Xiphias gladius*) L.1758 à partir de la pêcherie marocaine dans le détroit de Gibraltar. Thèse de Doctorat, spécialité halieutique. ENSA, Rennes, France. 162 p.

FRIMODT, C., 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, England. 215 p.

FRITSCHES, K. A., R. W. Brill, and E. J Warrant. 2005. Warm eyes provide superior vision in swordfish. Current Biology 15(1): 55-58.

GARCIA CORTES, B., and J. Mejuto. 1988. Premeros datos sobre la biología de la reproducción del pez espada (*Xiphias gladius* L) de las areas 35-45 N, 10-10W (Bil-94) Collect. Vol. Sci. Pap. ICCAT, 27: 164-177.

GARCIA-CORTES, B., J. Mejuto and M. Quintans.2003. Summary of swordfish (*Xiphias gladius*) recaptures carried out by the Spanish surface longline fleet in the Atlantic Ocean: 1984-2002. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1476-1484.

GOODE, G. B. 1883. Materials for a history of the sword-fishes. Rep. U.S. Commer. Fish. 8: 287-394.

GOUVIA, L. 1992. Swordfish (*Xiphias gladius*) fishery experiment in Madeira EEZ. Collect. Vol. Sci. Pap. ICCAT, 39(2):477-483.

GOUVEIA, L., and J. Mejuto. 1995. Some biometric data from the swordfish (*Xiphias gladius L.*) in the areas off Madeira. Collect. Vol. Sci. Pap. ICCAT, 44(3): 132-134.

GUERRA. A., F. Simon, A. F. Gonzalez. 1993. Cephalopods in the diet of swordfish, *Xiphius gladius*, from the northeastern Atlantic Ocean. In: T. Okutani, R.K. O'Dor, and T. Kubodera (eds.) Recent advances in cephalopod fisheries biology, 159-164. Tokai University Press, Tokyo.

HATTOUR, A., 1996. The fishing of the swordfish (*Xiphias gladius*) in Tunisie: Analyse préliminaire of the relationship size-weight. Collect. Vol. Sci. Pap. ICCAT, 45(1): 145-151.

HAZIN, F. H. V., H. G. Hazin, C. E. Boeckmann, P. Travassos. 2002. Preliminary study on the reproductive biology of swordfish, *Xiphias gladius* (Linnaeus 1758), in the southwestern equatorial Atlantic ocean. Collect. Vol. Sci. Pap. ICCAT, 54(5): 1560-1569.

HERNÁNDEZ-GARCÍA, V. 1995. The diet of the swordfish *Xiphias gladius* Linneaus 1758, in the central east Atlantic, with emphasis on the role of cephalopods. Fisheries Bulletin 93(2): 403-411.

HOEY, J. 1991. Sex ratio for western north Atlantic swordfish. Collect. Vol. Sci. Pap. ICCAT, 35(2): 429-436.

HUREAU, J. C and T. H. Monod. 1973. Catalogue des poissons de l'Atlantique du nord-est et de la Méditerranée. C.L.Y.F.N.A.M. UNESCO. 683 p.

KAILOLA, P. J., M. J. Williams, P.C. Stewart, R.E. Reichelt, A. McNee and C. Grieve, 1993. Australian fisheries resources. Bureau of Resource Sciences, Canberra, Australia. 422 p.

KOTOULAS, G., J. Mejuto, A. Antoniou, G. Tserpes, C. Piccineti, P. Peristeraki, P. Kasapidis, B. Garcia-Cortes, K. Oikonomaki, J.M. De la Serna and A. Magoulas. 2006. Genetic structure of the swordfish *Xiphias gladius* at a global scale using microsatellite markers.

MEGALOFONOU, P and G. De Metrio. 1989. Stima dell'eta e dell'acccrecimento di *Xiphias gladius*, L del Mar Egeo mediante lo studio dei raggi rmi della pinna anale. XXI. Congresso della Societa Italiana di Biologia Marina.

MEGALOFONOU, P., J. M. Dean and G. De Metrio. 1990. First results on the aging of juvenile swordfish, *Xiphias gladius* L., from the Mediterranean Sea, using otoliths. Collect. Vol. Sci. Pap. ICCAT, 33: 163-167.

MEJUTO, J., S. Iglesias, J. C. Rey, E. Alot, and B. Garcia. 1988. Relaciones talla-peso del pez espada, (*Xiphias gladius L*) en las areas BIL-94 y BIL-95, por estratos espacio temporales. Collect. Vol. Sci. Pap. ICCAT, 27: 214-221.

MEJUTO, J., and J. M De la Serna.1993. A preliminary analysis to obtain a size weight relationship for the Mediterranean swordfish (*Xiphias gladius*). Collect. Vol. Sci. Pap. ICCAT, 40(1): 149-154.

MEJUTO, J., J. M. De la Serna, and B. Garcia. 1998. Some considerations on the spatial and temporal variability in the sex ratio at size of the swordfish (*Xiphias gladius*). Collect. Vol. Sci. Pap. ICCAT, 48(1): 205-215.

MEJUTO, J. 2003. Recruit indices of the north Atlantic swordfish (*Xiphias gladius*) and their possible link to atmospheric and oceanographic indicators during the 1982-2000 period. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1506-1515.

MEJUTO, J., and B. G. Cortes. 2003. A description of a possible spawning area of the swordfish (*Xiphias gladius*) in the tropical northwest Atlantic. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1449-1458.

MEJUTO, J., and B. G. Cortes. 2003. Size segregation, sex ratios patterns of the swordfish (*Xiphias gladius*) caught by the Spanish surface longline fleet in areas out of the Atlantic and methodological discussion on gonadal indices. Collect. Vol. Sci. Pap. ICCAT, 55(4): 1459-1475.

MOREIRA, F. 1990. Food of the swordfish, *Xiphias gladius* Linnaeus, 1758, off the Portuguese coast. Journal of Fisheries Biology. 36: 623-624.

NAKAMURA, I. 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop. 125(5):65 p.

NAKAMURA, I., 1997. Xiphiidae. Swordfishes. In K.E. Carpenter and V. Niem (eds.) FAO Identification Guide for Fishery Purposes. The Western Central Pacific.

NISHIKAWA, Y. and S. Ueyanagi, 1974. The distribution of the larvae of swordfish, *Xiphias gladius*, in the Indian and Pacific oceans. p. 261-264. In Proceedings of the international billfish symposium, Kailua-Kona, Hawaii, 9-12 August, 1972. Part. 2. Review and contributed papers. US Department of Commerce, NOAA Technical Report, NMFS SSRF 675.

ORSI RELINO, L., G. Palandri, F. Garibaldi, C. Cima, M. Relini, and G. Torchia. 1999. Biological parameters of the Mediterranean swordfish derived from observations in the Ligurian Sea. Collect. Vol. Sci. Pap. ICCAT, 49(1): 397-406.

PALKO, B. J., G. L. Beardsley and W. J. Richards. 1981. Synopsis of the biology of the swordfish, *Xiphias gladius* Linnaeus. NOAA Technical Report NMFS Circular 441/FAO Fisheries Synopsis No. 127.

REEB, C. A. and B. Block. 2006. Ten microsatellite loci show that Mediterranean swordfish are genetically unique from other populations worldwide.

REY, J. C. 1988. Comentarios sobre las areas de reproduccióon del pez espada, (*Xiphias gladius*) en el Atlántico y Mediterráneo. ICCAT, Collect. Vol. Sci. Pap. 27: 180-193.

SAMBILAY, V. C., Jr., 1990. Interrelationships between swimming speed, caudal fin aspect ratio and body length of fishes. Fishbyte 8(3):16-20.

SCOTT, W.B. and S.N. Tibbo. 1968. Food and feeding habits of swordfish, *Xiphias gladius*, in the western North Atlantic. Fisheries Research Board of Canada 25: 903-919.

SROUR, A., N. Abid, J. M. De la Serna, J. Mª. Ortiz of Urbina. 2004. Preliminary Analysis of the spatial and temporal variability in the sex ratio at size of the Swordfish (*Xiphias gladius L.*) caught by the Moroccan drift net fishery. Collect. Vol. Sci. Pap. ICCAT, 56(3): 921-924.

Stillwell, C.E. and N.E. Kohler. 1985. Food and feeding ecology of the swordfish *Xiphius gladius* in the western North Atlantic Ocean with estimates of daily ration. Marine Ecology 22: 239-247.

SUZUKI, Z., and N. Miyabe. 1991. Preliminary study on reproducing observed sex ratio by size for Atlantic swordfish. Collect. Vol. Sci. Pap. ICCAT, 35(2): 459-464.

TAKAHASHI M, H. Okamura, K. Yokawa and M. Okazaki 2003. Swimming behaviour and migration of a swordfish recorded by an archival tag. Marine and Freshwater Research, 2003, 54, 527-534.

TAL SPERLING, A., J. D.Neilson, E. H. Carruthers, and H. H. Stone. 2005. Compilation and analyses of Canadian conventional tagging data for swordfish (*Xiphias gladius*), 1961-2004. Collect. Vol. Sci. Pap. ICCAT, 58(4): 1483-1494.

TSERPES, G., and N. Tsimenides. 1995. Determination of age and growth of swordfish, *Xiphias gladius L.* 1758, in the eastern Mediterranean using anal-end spines. Fish. Bull. 93: 594-602.

TSERPES, G., P. Peristeraki and S. Somarakis. 2001. On the reproduction of swordfish (*Xiphias gladius L*) in the eastern Mediterranean. Col. Vol. Sci. Pap. ICCAT, 52(2): 740-744.

TSERPES, G., P. Peristeraki, A. Di Natale and A. Mangano. 2003. Length-weight relationships for Mediterranean swordfish. Collect. Vol. Sci. Pap. ICCAT, 55(1): 85-90.

TSIMENIDES, N., and G. Tserpes. 1989. Age determination and growth of swordfish, *Xiphias gladius L.*, 1785 in the Aegean Sea. Fish. Res., 8(1989): 159-168.

TURNER. 1987. Length to weight and weight to length conversions for swordfish in the western north Atlantic and Gulf of Mexico. Document No. 86/11 presented at the 1986 NMFS/SEFC swordfish assessment workshop.

VEDEL TANING, A. 1955. On the breeding areas of the swordfish (*Xiphias gladius*). Papers in marine biology and oceanography, suppl. to Vol. 3 of Deep Sea Research, pp: 438-450.