ICCAT Manual

ICCAT CICTA CICAA

INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS

| CHAPTER 2.1.3: SKIPJACK TUNA | AUTHOR: IEO | LAST UPDATE: Nov. 10, 2006 |
|---|---|---|

## 2.1.3 Description of Skipjack Tuna (SKJ)

### 1. Names

#### *1.a Classification and taxonomy*

**Name of species**: *Katsuwonus pelamis* (Linnaeus 1758)
**Synonyms:** *Euthynnus pelamis* (Linnaeus 1758)
*Gymnosarda pelamis* (Linnaeus 1758)
*Scomber pelamis*, (Linnaeus 1758)
**ICCAT species code**: SKJ
**ICCAT Names:** Skipjack (English), Listao (French), Listado (Spanish)

According to Collette & Nauen (1983), skipjack tuna is classified in the following way:

- Phylum: Chordata
- Subphylum: Vertebrata
- Superclass: Gnathostomata
- Class: Osteichthyes
- Subclass: Actinopterygii
- Order: Perciformes
- Suborder: Scombroidei
- Family: Scombridae
- Tribe: Thunnini

#### *1.b Common names*

List of vernacular names used according to the ICCAT (Anon. 1990), *Fishbase* (Froese & Pauly Eds. 2006) and the FAO (*Food and Agriculture Organization*) (Carpenter Ed. 2002). Names asterisked (*) are standard national names supplied by the ICCAT. The list is not exhaustive, and some local names may not be included.

**Albania**: Palamida
**Angola**: Bonito, Gaiado, Listado
**Australia**: Ocean bonito, Skipjack, Striped tuna, Stripey, Stripy, Watermelon
**Barbados**: Bonita, Ocean bonito, White bonito
**Benin**: Kpokú-xwinò*, Kpokou-Houinon, Kpokúhuinon
**Brazil**: Barriga-listada, Bonito, Bonito de barriga listada*, Bonito rajado, Bonito-barriga-listada, Bonito-de-barriga listada, Bonito-de-barriga listrada, Bonito-de-barriga riscada, Bonito-listado, Bonito-listrado, Bonito-oceânico, Bonito-rajado, Gaiado
**British Indian Ocean Territory**: White bonito, Banjo, Barriolet, Oceanic bonito
**Canada (British Columbia)**: Skipjack, Skipjack tuna
**Canada**: Ocean bonito, Oceanic bonito, Skipjack*, Skipjack tuna, Striped bonito, Thonine à ventre rayé*
**Cape Verde**: Bonito, Bonito-de-barriga listada, Cachorreta, Canela, Gaiado, Gaiado ou Melancia, Judea, Melancia
**Chile**: Atún, barrilete, Cachorreta, Cachureta, Cachurreta
**China (People's Rep.)**: 鰹 (Jian), 正鮪 (Jheng wei), Jian, Liù tiáo zhú gùn
**Chinese Taipei**: 柴魚（cai yu), 正鰹（jheng jian), 煙仔虎 (yan zai hu), Then chien*, Toh khun
**Colombia**: Barrilete
**Comoros**: Pweré
**Côte d'Ivoire**: Listao

**Cuba**: Atún, Bonito listado, Merma
**Denmark**: Bugstribet bonit, Bugstribet bonnit
**Djibouti**: Machaket
**Dominican Republic**: Bonito
**Ecuador**: Picosa, Rayada
**Egypt**: Tunna
**Fiji**: I' a seu
**Fiji Islands**: Skipjack tuna
**Finland**: Boniitti
**France**: Bonite, Bonite à ventre rayé*, Bonitou, Bounicou, Listao
**French Polynesia**: Atu, Bonito
**Germany**: Bauchstreifiger Bonito, Bonito, Echter Bonito*, Thunfisch
**Greece**: Ρίκι, Τονοπαλαμίδα, Λακέρδα, Παλαμίδα, Lacérda, Palamída, Pelamis, Pelamys, Riki, Tonina, Tonopalamida
**Guinea:** Makréni
**Hawaii**: Aku, Aku kina'u, Skipjack tuna fish
**India**: बुगुदी (Bugudi), Choora, ചൂര (Choora), Gedar, गिदार (Gedar), Bokado, Bonito, Bugudi, Kalabila-mas, Kali-phila-mas, Kuppa, कुपा (Kuppa), Metti, Oceanic skipjack, Skipjack tuna, Skiy jack, Striped tuna, Stripped tuna, Varichoora
**Indonesia**: Cakalang, Kausa, Tjakalong, Tjakalong lelaki, Tjakalong merah, Tjakalong perempuan, Wandan
**Iran**: Havoor-e-masghati
**Isle of Man**: Bonito
**Israel**: Balanida
**Italy**: Culurita, Impiriali, Nzirru, Paamia, Paamitun, Palamatu, Palametto, Palamida, Palamitu, Palamitu imperiali, Palometta, Tonnetto, Tonina de Dalmazia, Tonnetto striato
**Japan**: Club mackerel, Hongatsuo, Katsuo*, Katsuwo, Magatsuwo, Mandagatsuwo, Mandara
**Kenya**: Jodari, Sehewa, Skipjack
**Kiribati (Christmas Islands)**: Skipjack tuna
**Kiribati:** Te ati, Te atu
**Korea**: Ga-da-raeng-i*, Gang-go-deung-so, Da-raeng-i
**Korea (Rep. of.)**: Da-raeng-i, Ga-da-raeng-i, Ga-da-ri, Gang-go-deung-so, Ka-da-raeng-i, Ka-da-raeng-o, Mog-maen-dung-i, So-young-chi, Yeo-da-raeng-i
**Madagascar**: Bonite, Bonite à ventre rayé, Diodary, Lamatra, M'bassi
**Malaysia**: Aya, Bakulan, Kayu, Tongkok, Tongkol jepun
**Maldive Islands**: Godhaa, Kadumas, Skipjack tuna
**Malta**: Palamit, Pelamit, Plamtu, Plamtu imperjali
**Marshall Islands**: Chilu, Lojabwil
**Martinique**: Bonite à ventre rayé, Bariolé
**Mauritania**: Bonite à ventre rayé, Listado, Listao, Skipjack
**Mauritius Islands** : Bonite à ventre rayé, Bonite acumine
**Mexico**: Barrilete, Barrilete listado, Listado
**Micronesia**: Garengaap-garengaap, Katsuo, Ligaasimwai, Liyaubesh, Skipjack tuna
**Monaco**: Bonita, Bunita
**Morocco**: L'bakoura, Listao
**Mozambique**: Gaiado
**Namibia**: Bauchstreifiger bonito, Bonito, Echter Bonito, Gestreifter Thunfisch, Pensstreep-tuna, Tuna
**Netherlands Antilles (Papiamento)**: Buni karèt, Buni porko
**Netherlands (Holland)**: Gestreepte tonijn
**New Caledonia**: Bonite à ventre rayé, Bonite folle, Mwaali
**New Zealand (Niue)**: Takua, Skipjack tuna
**New Zealand (Tokelau)**: Atu, Nakono, Tuikaufoe
**New Zealand**: Bonito, Skipjack, Skipjack tuna, Skipper, Striped bonito, Striped tunny
**Nicaragua**: Listado
**Norway**: Bonit, Bukstripet bonitt, Stripet pelamide
**Oman**: Sadah, Shewa, Thoqaibeh
**Palau (Trust territories of the Pacific Islands)**: Katsuo, Tuna
**Papua N. Guinea**: Skipjack tuna, Striped tuna, Tjakalang
**Peru**: Barrilete

**Philippines**: Agtun, Bangkulis, Bankulis, Bariles, Barilis, Batala-an panit, Bolis, Budlis, Budlisan, Bulis, Buslugan, Golyasan, Gulyaman, Gulyangan, Gulyasan, Karaw, Ocean bonito, Palawayan, Panit, Pawayan, Poyan, Pundahan, Puy-yan, Puyan, Rayado, Sambagon, Skipjack, Skipjack tuna, Sobad, Striped tuna, Tangi, Tulingan, Turingan
**Poland**: Bonite, Bonito
**Portugal (Azores)**: Bonito*, Gaiado, Ocean bonito, Skipjack tuna
**Portugal (Madeira)**: Gaiado
**Portugal**: Atum-bonito, Bonito, Bonito de ventre raiado, Bonito-de-barriga listada, Gaiado, Gayado, Listado, Sarrajao, Serra
**Reunion**: Bonite calou, Bonite ventre rayé
**Romania**: Palamida, Palamida lacherda, Ton dungat, Ton zebrat
**Russian Fed.:** Katsuo, Malayj tunets-bonito , Okeanskij bonito, Polosatyi tunets, Polosatyj tunets*, Skipdzhek
**Samoa**: Atu, Faolua, Ga'ogo
**Sao Tomé and Prín.**: Atum judeu
**Senegal**: Bonite à ventre rayé, Kiri-kiri
**Seychelles**: Bonite folle, Ton rayé
**Sierra Leone**: Skipjack tuna
**Slovenia**: Èrtasti tun
**Solomon Islands**: Atu, Skipjack tuna
**Somalia**: Jaydar dhiiglow, Sehewa
**South Africa**: Bonito, Katunkel, Lesser tunny, Ocean bonito, Oceanic bonito, Pensstreep-tuna, Skipjack*, Skipjack tuna, Watermelon
**Spain (Canary Islands)**: Bonito, Listado
**Spain**: Alistado, Atún de altura, Bonita, Bonito de altura, Bonito de vientre rayado, Bonito del sur, Bonitol, Bonítol de ventre ratllat, Lampo, Listado*, Llampua, Palomida, Skipjack
**Sri Lanka**: Balaya, Bonito, Scorai
**Sweden**: Bonit
**Surinam**: White bonito, Oceanic bonito
**Tahiti**: 'Authopu, A'u, Atu, Auaeroa, Auhopu, Auhopu tore, Kopukopu, Pa'amea, Pa'amoa, Pirara, Poarahi, Tari'a'uri, Tau, Tohe'o'o, Toheveri, Tore
**Tanzania**: Sehewa, Zunuba
**Tonga (Polynesia)**: 'Atu, Skipjack tuna
**Trinidad and Tobago**: Bonito, Macrio, Skipjack
**Tuamotu (French Polynesia)**: Auhopo, Toheveri
**Tunisia**: Bonite, Boussenna, Ghzel
**Turkey**: Çizgiliorkinoz baligi, Çizgiliton baligi
**United Kingdom (Santa Helena)**: Bonito
**United Kingdom**: Atlantic bonito, Bonito, Ocean bonito, Skipjack, Skipjack tuna, Striped bellied bonito, Striped bellied tunny
**United States (North Marianas)**: Anga-rap, Yárengaap, Kacho
**United States**: Arctic bonito, Bonito, Mushmouth, Ocean bonito, Oceanic bonito, Oceanic skipjack, Skipjack, Skipjack tuna*, Skippy, Striped bonito, Striped tuna, Victor fish, Watermelon
**Venezuela**: Barrilete, Bonito, Bonito oceánico, Listado*
**Vietnam**: Skipjack tuna, Cá Ngừ vằn
**Yemen**: Af muss, Dabub, Hargheiba

**2. Identification**

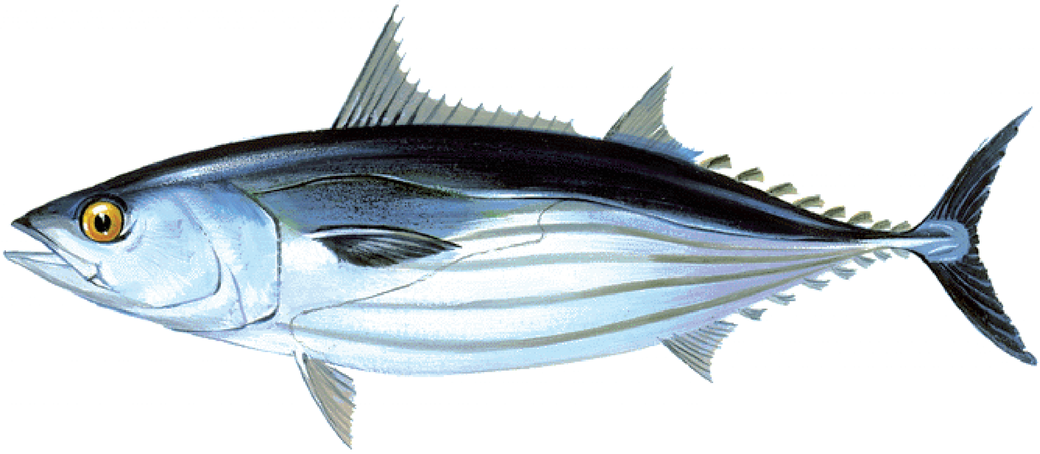


**Figure 1.** Drawing of an adult skipjack tuna, courtesy of the FROM (*Fondo de Regulación y Organización del Mercado de los productos de la pesca y cultivos marinos*/Fund for Regulation and Organisation of the Market in fishery products and marine crops) – Ministry of Agriculture, Fisheries and Food, Spain (Anon. 1985).

***Characteristics of* Katsuwonus pelamis** (see **Figure 1** and **Figure 2**)

The maximum recorded size is 108 cm (34.5 kg weight) according to Collette & Nauen (1983), although maximum sizes in catches tend not to exceed 80 cm (8-10 kg).

The maximum age cited for this species is 12 years (Froese & Pauly 2006).

**External characteristics:**

- Fusiform, elongated and rounded body.
- Single row of small, conical teeth.
- Without body scales except for corselet and lateral line.
- Two dorsal fins separated by a narrow interspace (no larger than the eye).
- First dorsal with 14-17 spines and second dorsal with 12-16 soft radii, followed by 7-10 finlets. The pectoral fin is short, with 24 or 32 radii. Anal fin composed of 13-17 soft radii, followed by 6-8 finlets (Richards 2006).
- Prominent keel on either side of the caudal fin base, between two smaller keels.
- Interpelvic process small and bifid.

**Colour:**

- Dark purplish blue back. Lower sides and belly silvery.
- 4 to 6 very conspicuous longitudinal dark bands which in live specimens may appear as continuous lines of dark blotches.

**Internal characteristics:**

- Branchiospines on first branchial arc.
- Vertebrae: 20 precaudal and 21 caudal.
- Swim bladder absent.

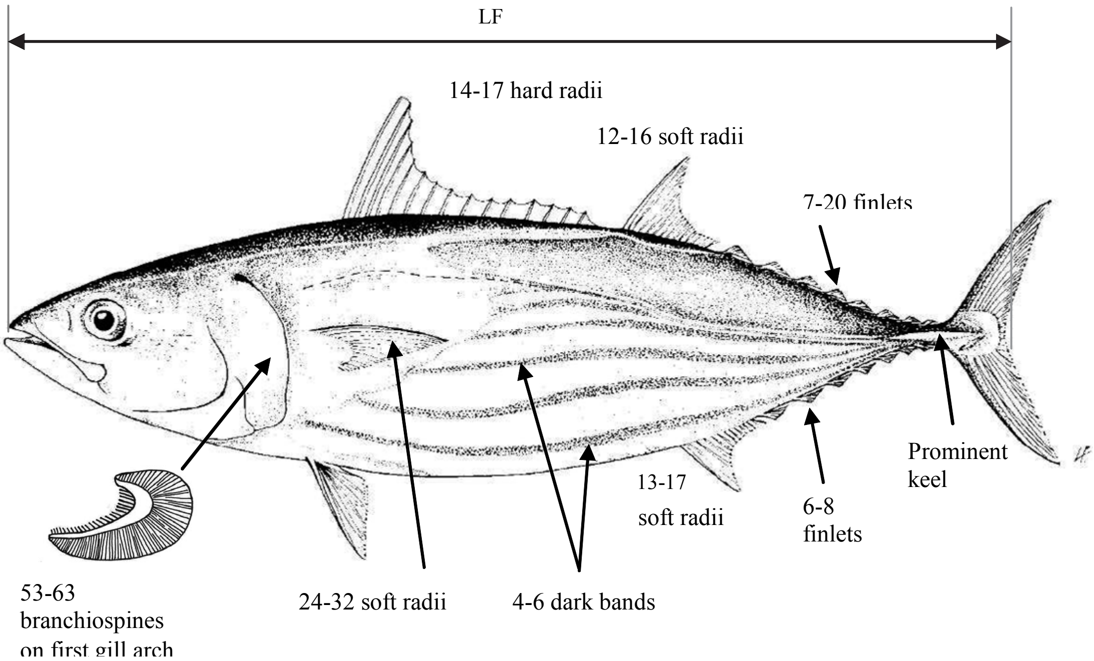



**Figure 2.** Diagram of outstanding features of *Katsuwonus pelamis* (based on Collette 1995, *In* Froeser & Pauly Eds. 2006. Modified by the IEO).

**External characteristics of skipjack larvae**

- Narrow body.
- Small, fresh specimens are diagnosed by the presence of a pattern of red marks (erythrophores) in the caudal region (Uyeanagi 1966).
- Superficial melanophore (black pigmentation) in the anterior region of the brain, present in larvae > 4 mm SL (standard length).
- Absence of black pigmentation from isthmus to anterior part of anus.
- Occasional black pigmentation on the dorsal edge of the caudal peduncle. Several blotches of black pigmentation on the ventral edge of the caudal fin (Dicenta 1975) and occasional black pigmentation on the dorsal edge of the caudal peduncle.
- Melanophore on the end of the lower jaw. The end of the upper jaw points noticeably down towards the lower jaw (from 7.8 mm of TL).
- Slight black pigmentation (Chow *et al.* 2003) on first dorsal fin, in larvae > 8 mm of SL.

**3. Biology and population studies**

***3.a Habitat***

Epipelagic species generally inhabiting open waters. Aggregations of this species tend to be associated with convergences, boundaries between cold and warm water masses, outcrops and other hydrographic discontinuities (Collette & Nauen 1983).

**Temperature:** skipjack tuna can be found in waters with temperatures ranging from 15ºC to 30ºC, but they normally inhabit waters where the surface temperature is between 20ºC and 30ºC (Forsbergh 1980). They generally dive only to depths where the water temperature does not reach more than 8ºC below the temperature on the surface layer (Brill *et al*. 2005).

**Depth:** depth distribution ranges from the surface to about 260 m during the day, remaining close to the surface during the night (Collette & Nauen op. cit.).

**Dissolved oxygen:** Barkley *et al.* (1978), Cayré (1987) and Evans *et al*. (1981) established 3.0-3.5 ml $l^{-1}$ (5 ppm) as minimum values of dissolved oxygen in water for the skipjack tuna habitat where temperature and other variables are not limiting factors. This factor generally restricts skipjack tuna to waters above the thermocline (Sharp 1978).

Notwithstanding the values cited above, in an experiment Levenez (1982) reported recordings of skipjack tuna with acoustic tags in which brief dives as deep as 400 m were observed, with temperatures below 14ºC and an oxygen level close to 1.5 ml $l^{-1}$.

### *3.b Growth*

In the course of the International Skipjack Year programme (Anon. 1986) conducted between 1979 and 1982, various growth models were analysed for the eastern Atlantic (Antoine *et al*. 1982, Bard & Antoine 1986, Chur *et al*. 1986) and differences were found in growth rates depending on the year and the zone of the survey. It was concluded from these analyses that fish in equatorial zones (Gulf of Guinea) grow more slowly than those in subtropical zones (Senegal-Cape Verde) (Cayré 1979, Cayré *et al*. 1986a). This seasonal and geographic variability of growth has been confirmed by studies of modal size progressions (Bard & Antoine op. cit., Cayré *et al*. 1986b) and analyses of tagging data (Bard & Antoine op. cit., Cayré *et al*. 1986b).

For the equatorial zone (5ºN-5ºS), with a constant year-round temperature and scanty trophic resources, the ICCAT uses the parameters from the von Bertalanffy equation (1938) proposed by Bard & Antoine (op. cit.), which describe slow growth in the region of 1 cm/month for the range of sizes fished in this area.

As regards the northern tropical zone (Cape Verde – Senegal), the equation of Cayré *et al*. (op. cit.), used by the ICCAT until 1999, was compared with other growth equations for the western and eastern Atlantic (Anon. 1999). It was found that the fast growth rate suggested by these authors for the first year (15 cm/year on average, peaking in summer) exceeded the average annual growth rate proposed by all other studies (**Figure 3**). In 2006, Hallier & Gaertner presented a new study on growth in this zone based on the tagging data from Senegal and Mauritania.

In the western Atlantic there are also differences depending on year and zone (Batts 1972, Carles-Martin 1975). In the case of the South-East Caribbean zone, where the sizes caught are larger than in the eastern Atlantic, the ICCAT uses the model presented by Pagavino & Gaertner (1995) based on modal progression analysis (MULTIFAN) of the six-year data set. Two annual recruitments have been observed. In the case of southern Brazilian waters, the model used is one formulated by Vilela & Castello (1991) and supported by Matsura & Andrade (2000), who conducted growth studies based on data from the reading of cuts on the first ray of the first dorsal fin.

**Table 1.** Growth parameters used by the ICCAT for skipjack tuna ($L_t$ in cm, t in years).

| ***Growth equations*** | ***Authors*** | ***n*** | ***Length range (FL in cm)*** | ***Methodology*** | ***Stock/Zone*** |
|---|---|---|---|---|---|
| $L_t = 80.0\left(1-e^{-0.322t}\right)$ | Bard & Antoine (1986) | 341 | 40 – 65 cm | Tagging | Equatorial eastern Atlantic (sexes pooled) |
| $L_t = 87.12\left(1-e^{-0.218(t+2.09)}\right)$ | Vilela & Castello (1991) | ? | ? | Radii | Western Atlantic (Southern Brazil) (sexes pooled) |
| $L_t = 94.9\left(1-e^{-340t}\right)$ | Pagavino & Gaertner (1995) | ? | 38 – 96 cm | MULTIFAN (size frequency analysis) | Western Atlantic (Caribbean) (sexes pooled) |
| $L_t = 97.258\left(1-e^{-0.251t}\right)$ | Hallier & Gaertner (2006) | 222 | 40 – 65 cm | Tagging; Meta-analysis | Eastern Atlantic (Cape Verde-Senegal) (sexes pooled) |

**Where Lt =length at age t.*

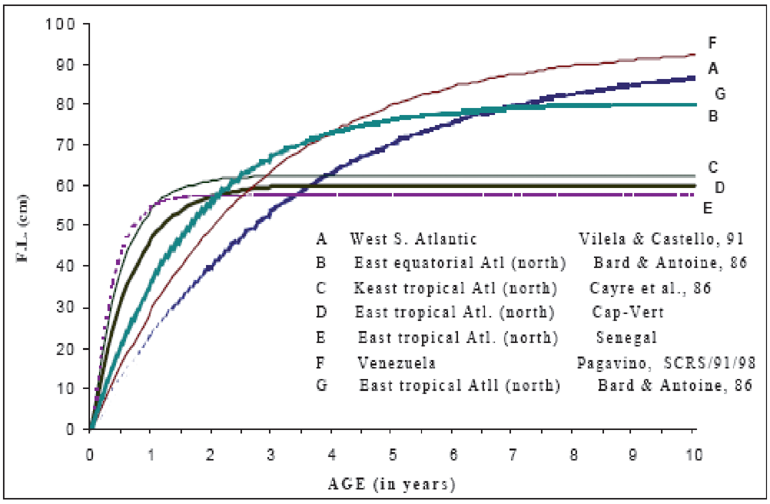



**Figure 3.** Comparison of some growth curves proposed by several authors (Anon. 1999).

### *3.c Biometric relationships*

Since 1986 a single size (FL)-weight (W) relationship has been used for skipjack tuna in the Atlantic Ocean. This equation, defined by Cayré & Laloë (1986), is applied to males and females alike.

Before this research, the equations used were ones formulated by Lenarz (1971) and Pianet (1974), which were accepted by the ICCAT until 1986. The values found by Amorim *et al.* (1981) in south-east Brazilian waters were similar to these.

The latest works published by Brazilian scientists (Vilela & Castello 1991) with skipjack tuna from that zone agree with the relationship cited by Amorim *et al.* (op. cit.).

**Table 2.** Biometric size-weight relationship currently used by the ICCAT.

| *Equation* | *Authors* | *n* | *Length range (FL in cm)* | *Stock* |
|---|---|---|---|---|
| $W = 7.480 \times 10^{-6} \times FL^{3.253}$ | Cayré & Laloë (1986) | 14 140 | 32 – 78 cm | Atlantic |

** Where W=weight; FL=fork length*

### *3.d Maturity*

On the basis of histological studies of skipjack tuna in the tropical Atlantic, Cayré & Farrugio (1986) concluded that the skipjack is an opportunistic breeder, given that it is capable of reproducing wherever water conditions are suitable. According to these authors, the size at first maturity is 42 cm for females and 45 cm for males in the eastern Atlantic, including Brazilian waters.

According to Vilela & Castello (1993), the size at first maturity in the South-West Atlantic is 51 cm for females and 52 cm for males, corresponding to an age of 2 years.

The size established at first maturity for skipjack caught in Canary Island waters and off the west coast of Africa, where at least 40% of individuals are mature, is around 47 cm for females and 50 cm for males (García Vela & Santos Guerra 1984).

A study conducted by Hazin *et al.* (2001) in the equatorial zone of the Atlantic Ocean established the size at first maturity as 45 cm for females and 48 cm for males.

**Table 3.** Sizes at first maturity in the Atlantic.

| ***Maturity*** | ***Reference*** | ***Area*** |
|---|---|---|
| 40% mature females measuring 47 cm | García Vela & Santos Guerra (1984) | Eastern Atlantic |
| 40% mature males measuring 50 cm | García Vela & Santos Guerra (1984) | Eastern Atlantic |
| 50% mature females measuring 42 cm | Cayré & Farrugio (1986) | Eastern Atlantic and Brazil |
| 50% mature males measuring 45 cm | Cayré & Farrugio (1986) | Eastern Atlantic and Brazil |
| 50% mature females measuring 51 cm | Vilela & Castello (1993) | Southwestern Atlantic |
| 50% mature males measuring 52 cm | Vilela & Castello (1993) | Southwestern Atlantic |
| 50% mature females measuring 45 cm | Hazin *et al*. (2001) | Atlantic |
| 50% mature males measuring 48 cm | Hazin *et al*. (2001) | Atlantic |

### *3.e Proportion of sexes*

There are numerous studies on the ratio of sexes in skipjack tuna. The conclusions are similar in all cases and differ substantially from those for other tunas like the yellowfin or the bigeye. In this case there is a slight but non-significant predomination of the female for practically all size categories. Differences have not generally been found in the ratio of sexes in the different size categories or in different fishing areas (Castello & Habiaga 1989, Cayré 1981, Ramos *et al*. 1991).

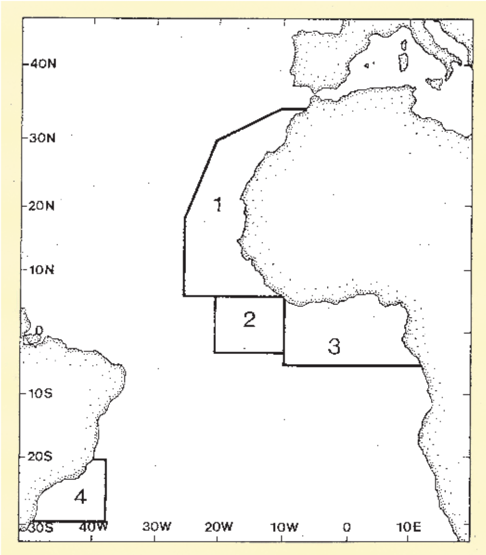
Cayré (op. cit.) conducted an important study on the West African coast from the equator to 20ºN and reported a ratio of 0.953 (males/females). In other words, males and females were in almost equal proportion irrespective of the size considered, although there was a tendency towards abundance of males in the categories over 60 cm FL.

García Vela & Santos Guerra (1984) analysed 1781 specimens in the region of the Canary Islands and the West Coast of Africa and found a ratio of 0.896 (males/females) in the size range 38-78 cm FL.

In South-West Brazil, Jablonski *et al*. (1984) analysed 3429 gonads and found that the number of males was significantly greater than the number of females only in the months of November-December and in April (peak breeding periods) and only in the size categories 45-49 cm and 60-64 cm FL.

Cayré & Farrugio (1986) analysed 16 720 specimens by zone between 1977 and 1983. They found that in island areas there were peculiarities such as an imbalance in favour of females in the Azores and the Canary Islands in some months of the year, and that excepting the size category 35-39 cm FL there were no differences in the ratio of males to females (0.990), with males predominating only in sizes exceeding 60 cm FL. **Figure 4** shows the areas sampled by Cayré & Farrugio (op. cit.), and the table next to it shows the proportion of sexes found in these areas and the numbers of specimens analysed. Pereira (1986) confirmed this hypothesis, reporting a ratio of sexes of 0.697 (males/females), which was especially high in categories over 45 cm FL.

These data are similar to those reported by Orange (1961) in the Pacific Ocean and by Stéquert (1976) in the Indian Ocean, except that the balance of sexes inclines towards males from 75 and 55 cm FL upwards, respectively.




| Zonas | Nº total de ejemplares | Proporción de sexos |
|---|---|---|
| 1 | 7731 | 0.961 |
| 2 | 1115 | 1.375 |
| 3 | 3137 | 1.064 |
| 4 | 2743 | 1.100 |

**Figure 4.** Areas chosen for a survey of proportions of sexes in skipjack tuna (Cayré & Farrugio 1986).

### *3.f Reproduction*

Skipjack tuna breed opportunistically throughout the year over wide areas of the Atlantic.

*Spawning*

According to various authors, spawning in a school is a synchronised process. However, it is also the case that skipjacks at the reproductive stage are observed in all waters where the surface temperature is at least 24ºC. Thanks to a very rapid process of sexual maturing and consequently rapid oocyte hydration, skipjacks are able to reproduce as soon as they find water conditions favourable (Cayré & Farrugio 1986, Vilela & Castello 1993). This strategy allows for more efficient utilisation of oceanic regions that are favourable to spawning and larval growth (Vilela & Castello op. cit.).

In the eastern Atlantic skipjacks spawn over a wide area on either side of the equator, from the Gulf of Guinea to 20º-30ºW. Spawning occurs all the year round, peaking between November and March (Anon. 1999). The work by Cayré & Farrugio (op. cit.) shows how spawning seasons differ according to the zone. In the north of this area (Guinea Bissau, Senegal, Cape Verde, Mauritania, Canary Islands, Morocco, Azores) spawning is spread over the second and third quarters of the year, while in the southern part (Sherbro, Liberia, Ivory Coast, Ghana and Cape Lopez) spawning mainly takes place during the fourth and first quarters.

In the western Atlantic there is a spawning area off Brazil, from December to March peaking in January and February, north of the 20ºS parallel and probably limited by the south-flowing Brazil current; the other area is located in the Gulf of Mexico and the Caribbean.

*Eggs and larvae*

Like those of other tunas, the oocytes of this species float; they are spherical and transparent and normally contain a single, gold-coloured fatty globule (Brock 1954, Yabe 1954, Yoshida 1966) of variable size. Diameters range from 0.80-1.17 mm (Richards 2006).

Skipjack batch fecundity is between 255,000 and 1,331.000 eggs which they have incubated for 24 hours (Ambrose 1996) and the number of eggs by specimen and year is from 7-76 million.

### *3.g Migrations*

The movements of this species are influenced by environmental conditions (temperature, salinity, nutrients, etc.) and by their tendency to group around floating objects of any kind, which may attract mixed schools of this and other tuna species such as young yellowfin (*Thunnus albacares,* Bonnaterre 1788) and bigeye (*Thunnus obesus,* Lowe 1839). The average speed of migration observed in the skipjack is 2.8 miles/day (Bard *et al*. 1991).

In the first six months following their release, skipjacks tagged in the Equatorial African zone (35-55 cm FL) have been seen to cover large distances, following the coastline from Cape Lopez to Cape Trois Pointes and carrying on as far as Liberia. Other fish have been sighted moving in the opposite direction from Cape Trois Pointes to Cape Lopez, and six months later a relatively large number of specimens have reached the northern tropical zone off Senegal, or even off the Canary Islands, returning later to Liberia and Cape Lopez (Cayré *et al.*, 1986b). Miyabe & Bard (1986) noted movements south-westward from the middle of the Gulf of Guinea in October (as far as 5ºN and 20ºW), suggesting a wide spread of this species, in mixed schools, from the Gulf of Guinea to various other zones in the month of February. They also found that some specimens migrated from the equatorial zone in April, reaching Dakar and the Canary Islands in July-August.

Skipjacks tagged in the northern tropical area (35-60 cm FL), in the Senegal – Cape Verde Islands zone, travel towards the Liberia zone during the first six months following release.

When they reach 60 cm FL, they present different patterns of seasonal migration, which appears to commence between the second and fourth quarter of the year. The largest are the first to abandon the fishing zones after approximately one year (Cayré *et al.* 1986b).

In the Brazil area of the southwestern Atlantic seasonal north-south movements have been detected, with specimens reaching the feeding grounds in summer (Matsura & Andrade 2000); however, there is no record of migrations from East to South-West (Cayré *et al.* op. cit., Miyabe & Bard op. cit.). Rinaldo *et al.* (1981) further observed movements from the Guyana zone to waters of Martinique and the Dominican Republic. Andrade *et al.* (2005) noted a strong influence of environmental factors on the movements of this species in this part of the ocean.

**Figure 5** shows the skipjack tuna migrations recorded in the ICCAT data base. For the Atlantic as a whole, there are only two East-West transatlantic migrations on record. In the eastern Atlantic, migrations generally follow the coastline, both North-South and South-North, and westward in the equatorial zone. In the western Atlantic there is very little information from tagging, and the only migrations on record are from South to North along the Brazilian coast and minor movements in the Caribbean.

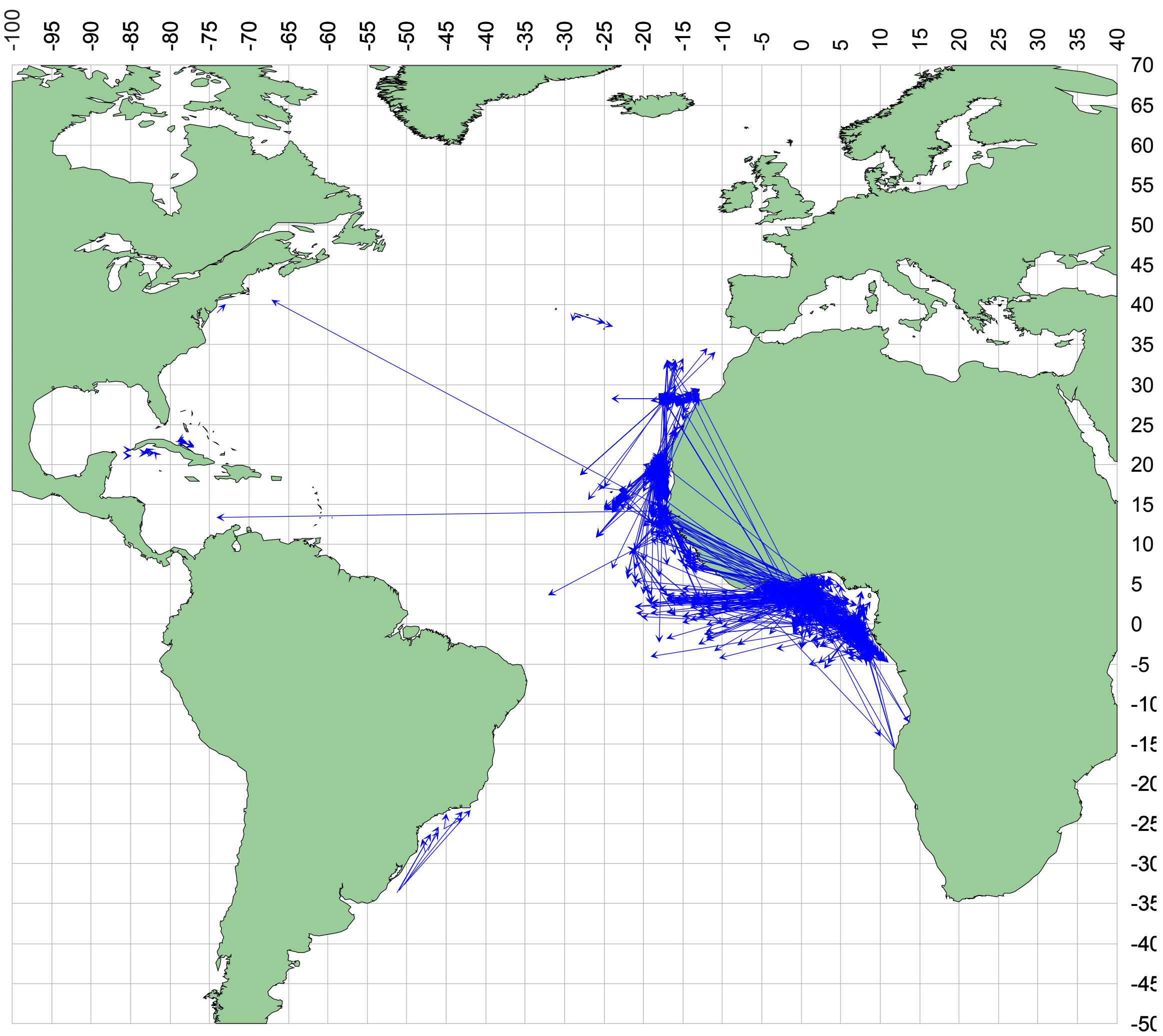



**Figure 5.** Horizontal movements of 5,990 tagged and recaptured specimens (ICCAT Secretariat).

***3.h Diet***

Like other tunas, the skipjack tuna is an opportunistic predator, and hence its diet varies in time and space. According to Lebourges-Dhaussy *et al*. (2000) micronekton is the largest component of tuna's oceanic diet, and according to Roger & Marchal (1994) the skipjack's principal prey are fish, cephalopods and crustaceans. Some authors cite a broad trophic spectrum for skipjack tuna since this species actively seeks out its food, which is normally distributed in schools.

It has been reported that skipjack tuna caught by purse seine fishers in the eastern Atlantic fed on small mesopelagic fish, chiefly *Vinciguerria nimbaria* (Jordan & Williams 1985), and cephalopods (Ménard *et al.* 2000b). A study conducted in the Canary Islands zone in the month of July (Olaso *et al*. 1992) showed that in terms of biomass the predominant prey are fish (99%), the most important being young specimens of *Macroramphosus scolopax* (Linnaeus 1758), and other fish such as *Trachurus* spp., Rafinesque 1810, *Scomber japonicus*, Houttuyn 1782 or *Sardina pilchardus* (Walbaum 1792).

In the Brazilian zone the main components of the skipjack's diet are, in descending order of importance, *Maurolicus muelleri* (Gmelin 1789), *Engraulis anchoita,* Hubbs & Marini 1935 (these two fish species make up about 60% of volume intake) and *Euphausia similis,* G.O. Sars 1885. These species are abundant in the south-eastern-southern pelagic region. Less frequent are *Thysanoessa gregaria,* G.O. Sars op. cit., and *Loligo* sp., Lamarck 1798 (Castello – mimeo).

Cannibalism occurs among skipjack tuna; there is a minor incidence of depredation on their own young, and therefore it is considered a casual occurrence (Zavala-Camin 1983).

### *3.i Physiology*

Like all tunas, this is a highly active species. Tunas differ from all other fish in their ability to retain metabolic heat in the red muscle and in other areas of the body such as the brain, eyes and viscera (local endothermia), a high metabolic rate and frequency-modulated cardiac output. These specialised features equip tunas for sustained rapid swimming, minimising the thermal barrier to exploitation of their habitat while allowing them to spread geographically into high latitudes and to reach considerable ocean depths (Graham & Dickson 2004, Dickson & Graham 2004).

Tuna, including the skipjack, possess a highly-developed circulatory system including a network of counter-current blood vessels (*retia mirabilia*), which reduces muscle-generated heat loss and improves the efficiency of oxygen exchange (Graham & Dickson op. cit.). In skipjack tuna the red muscle is traversed by a long central *retia* with numerous arterioles and venules, and by a small lateral *retia* with a limited surface area for heat exchange (Sharp & Pirages 1978, Graham & Diener 1978).

The ability of tuna to retain heat is also affected by size and stage of development. Adult tuna possess more mass and are able to retain more heat by thermal inertia than young specimens (Brill *et al.* 1999, Maury 2005).

Skipjack tuna have a low affinity for $O_2$; the $P_{50}$ (partial oxygen pressure, $Po_2$, required to attain 50% saturation) at between 20º and 30ºC is 2.8–3.1 kPa (21-23 mmHg) when balanced with 0.5% $CO_2$, which is why they are found in temperate, oxygen-rich surface waters (Lowe *et al*. 2000).

The swimming motion of tunas is characterised by a system of propulsion with minimal lateral undulation and concentration of thrust in rapid oscillation of the caudal fin. Tuna are the only teleosts to swim in this way (Graham & Dickson op. cit.).

### *3.j Behaviour*

Like all tuna, skipjacks tend to form schools, either independently or in association with floating objects, marine animals or seamounts.

The tendency to stick always with the same school is species-dependent. In the case of skipjack tuna, there is a high incidence of interchange among schools. More than 63% of individuals may abandon a school at any time and join another; the rate varies according to the zone, conditions and time of year (Bayliff 1988, Hilborn 1991).

Free schools (those not associated with objects) of skipjack tuna tend to be monospecific (Ménard *et al*. 2000a), although there are also schools where skipjacks associate with other tuna species such as bigeye, albacore (*Thunnus alalunga* (Bonnaterre 1788)) or yellowfin (Pereira 1996). Size distribution does not seem to differ between free and object-associated schools (Ariz *et al.* 2006).

In the eastern Atlantic skipjack tuna are frequently associated with a large variety of floating objects including dead whales, or with some living animals. Ariz *et al.* (1993, 2006) noted that the predominant species in catches is the skipjack, which accounts for around 70%, followed by bigeye and yellowfin accounting for about 15% each. Again, there is no difference in sizes between skipjack caught with objects and those fished in free schools.

In the case of tuna, the tendency to associate with floating objects (of any kind) does not appear to serve a trophic purpose. Small tuna congregate beneath the object at night then spread out during the day to feed, normally on *V. nimbaria* (in the eastern Atlantic), a species not associated with objects (Ménard *et al*. 2000b).

Object-associated schools may include other species such as wahoo (*Acanthocybium solandri* (Cuvier 1832)), istiophoridae, balistidae, rainbow runner (*Elagatis bipinnulata* (Quoy & Gaimard 1825)), coryphaenidae, kyphosidae, some shark species, cetaceans and turtles. These species are also found in free schools, as reported in the work of Delgado de Molina *et al*. (2005), which also suggests that more species, in terms of both weight and numbers, are attached to object-associated schools than to free schools.

In the Canary Islands and Senegal a kind of fishing is practised which is known as "*pesca sobre manchas*", in which the fishing vessel acts as a floating object. This kind of association between school and fishing vessel can go on for several months, during which several vessels fish the same school, even outside the normal fishing season (Ariz *et al*. 1995, Delgado de Molina *et al.* 1996, Hallier & Delgado de Molina 2000, Fonteneau & Diouf 1994).

According to Pereira (op. cit.), in the months from August to October, in Azores waters skipjack and bigeye tuna associate in mixed schools along with whale sharks (*Rhincodon typus*, Smith 1828). In the Caribbean, skipjacks associate with whale sharks and whales. This association is seasonal, depending as it does on the arrival of whales in Caribbean waters: (*Megaptera novaeangliae* (Borowski 1781), *Physeter macrocephalus*, Linnaeus 1758), excepting resident populations (*Balaenoptera edeni*, Anderson 1789) (Gaertner & Medina-Gaertner 1999).

Multispecific tuna schools congregate over seamounts according to data on catches by purse seine tuna fishers in the eastern Atlantic (Ariz *et al.* 2002). The predominant species is skipjack (59%), followed by bigeye (22%) and lastly yellowfin (19%). The range of variation is very broad, but with due allowance for the year and the location of the seamounts, the specific composition of catches tends to be similar to that obtaining in catches associated with drifting objects. The associations observed around seamounts in the Azores may be of trophic origin (Pereira op. cit.).

There is evidence to suggest that objects affect the dynamics and the structure and feeding ecology of tuna schools, and possibly act as a barrier to natural movements and migrations (Marsac *et al.* 2000). Moreover, these effects seem to be stronger in the case of small tuna species or the young of large tuna (Fonteneau *et al*. 2000); this augments the vulnerability and the rate of capture of young stocks and could have serious repercussions on the population structure and the future breeding potential of these species.

### *3.k Natural mortality*

Estimation of natural mortality is extremely important for management of stocks of marine species, but it is difficult to quantify.

The natural mortality ($M$), estimated using the empirical equation of Rikhter & Efanov (1976) and based on size at maturity, is 0.77/year (Vilela & Castello 1993). Fonteneau & Pallarés (1999) assumed a constant $M$ of 0.8, the value adopted by the ICCAT for the Atlantic Ocean. This is comparable to the values recorded in the Pacific Ocean (Bayliff 1977, Kleiber *et al*. 1983, Forsbergh 1987) and is close to the references for local rates of 0.6 found in the Atlantic (Bard & Antoine 1986, Fonteneau 1986).

The IATTC assumes a value of $M$=1.5 on a yearly basis (Maunder 2002) in its assessments of skipjack tuna in the East Pacific Ocean. On the basis of tagging data, Hampton (2000) reported that natural mortality rates in the Pacific were much higher for skipjack tuna measuring less than 40 cm and more than 70 cm FL.

## 4. Distribution and fishing

### *4.a Geographical distribution*

This is a cosmopolitan species found in schools in tropical and subtropical waters of the three oceans. It is not found in the eastern Mediterranean or the Black Sea. Its geographical limits are 55º-60ºN and 45º-50ºS. It is most abundant in the region of the equator all the year round and in the tropics during the warm season. This wide distribution accounts for the number and variety of fisheries that have developed all around the world (**Figure 6**).

Distribution in the Atlantic Ocean: in the eastern Atlantic from Ireland to South Africa, and in the western Atlantic from Canada to northern Argentina.

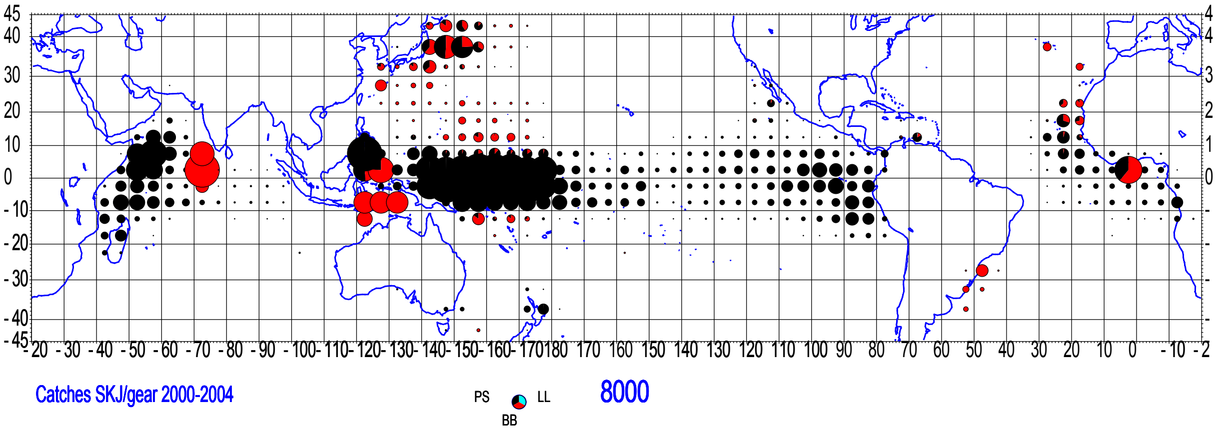



**Figure 6.** Skipjack tuna zones fished by several fleets between 2000 and 2004: longline (in blue, LL), purse seine (in black, PS) and bait boat (in red, BB) (courtesy of Alain Fonteneau 2006).

### *4.b Population / Structure of stock*

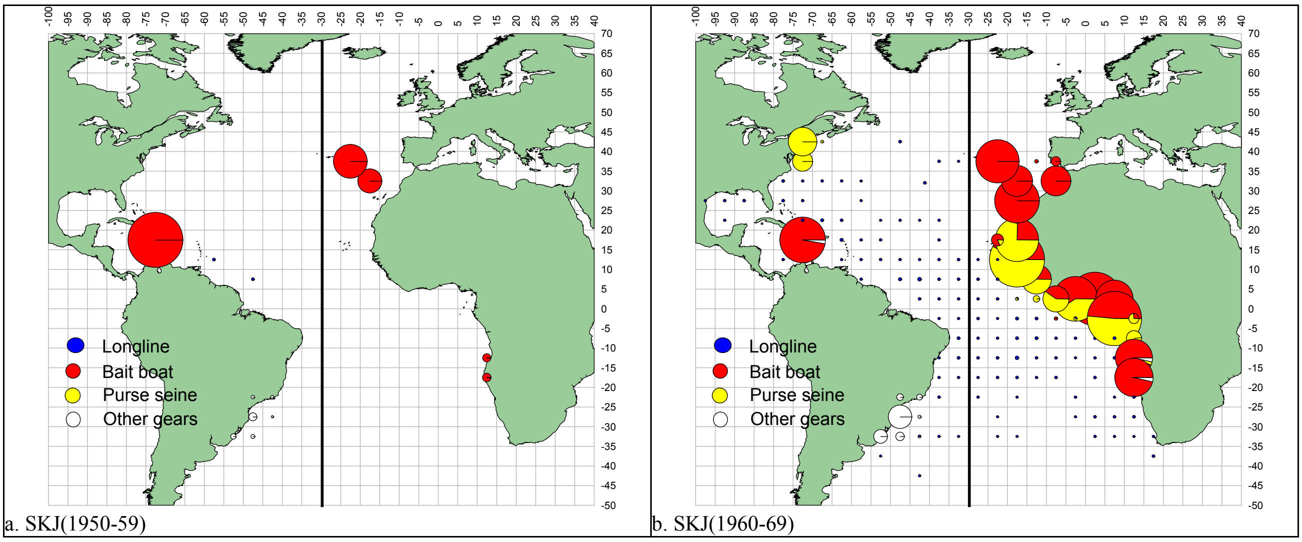
Stocks can be divided into two distinct units in the East and the West of the Atlantic Ocean, separated by the meridian at 30ºW (a dividing line set when fisheries were coastal). However, some migrations and longline fishery records have shown the presence of young skipjack tuna along the equator, west of 30ºW and only 1000 nautical miles from the Brazil fisheries, which could imply a degree of mixing (Anon. 1999).

The two-stocks hypothesis still stands despite the fact that purse seine fisheries have expanded westwards along the equatorial band (Anon. 2005b), reaching as far as Brazil. This is due to factors such as the existence of a spawning zone to the north of the Brazilian fishery (20ºS) independent of the eastern Atlantic spawning zones, limited by the southward-flowing current and environmental restrictions (Anon. 1999).

There are two fishing grounds in the western Atlantic: one off southern Brazil and the other off the coast of Venezuela and around Cuba. These grounds are about 3000 nautical miles apart. There is a spawning zone north of the 20ºS parallel, probably limited by the south-flowing Brazil current; the other spawning zone is in the Gulf of Mexico and the Caribbean. This could indicate the existence of two population units in the western Atlantic, although the hypothesis is not conclusive.

### *4.c Description of fisheries: catches and effort*

Skipjack tuna are mostly caught with surface gear throughout the Atlantic, mainly by baitboat and purse seine vessels, although there are small numbers of incidental longline catches (**Figure 7**).



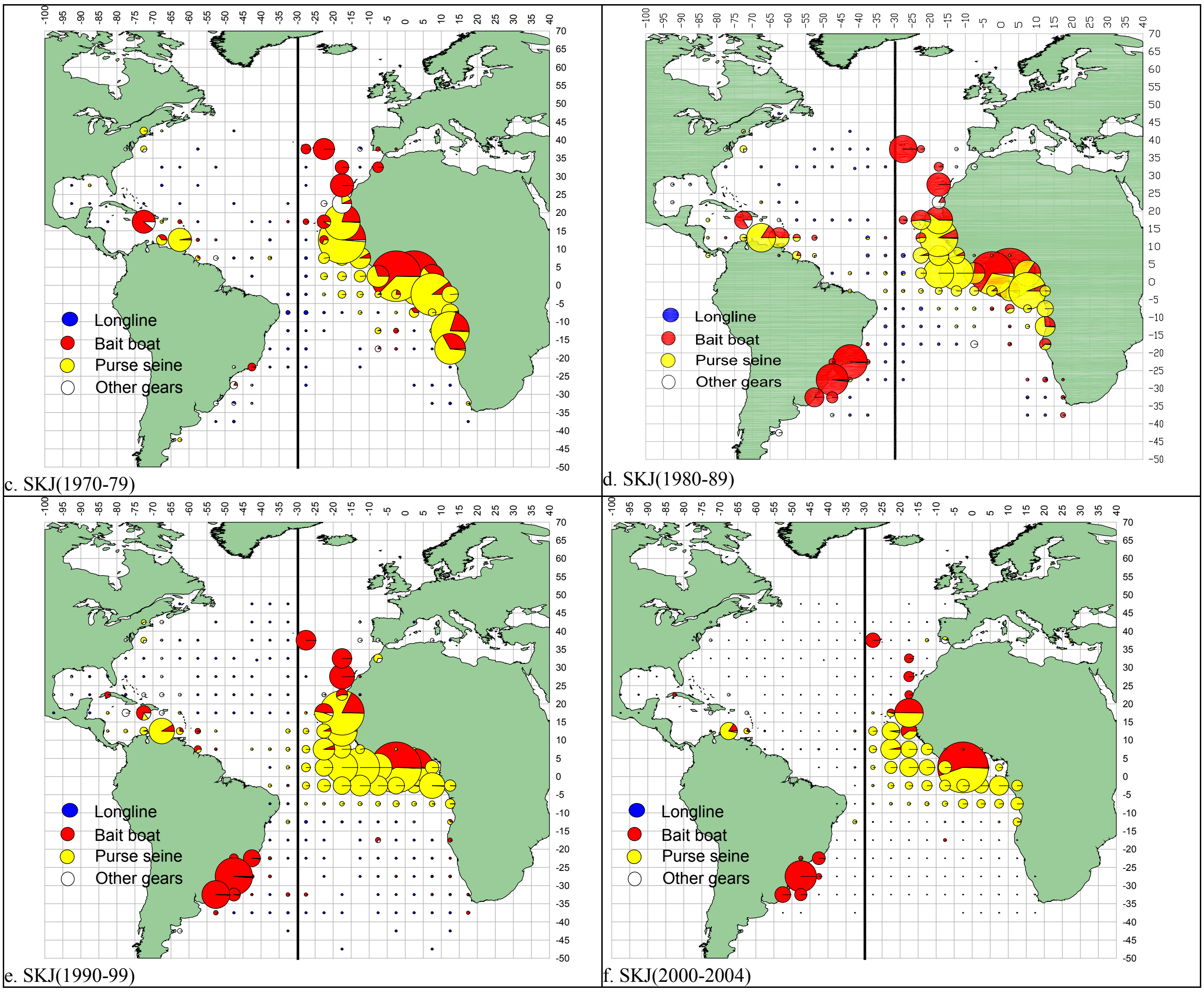



**Figure 7.** Geographical distribution of skipjack catches by principal gears and decades (ICCAT Secretariat).

*Eastern Atlantic*

**Purse seine fishing** began in the eastern Atlantic in the early 1960s and saw rapid growth in the 1970s. Starting in 1975, the fishing zone gradually expanded towards the high seas, especially at the equator. From 1991, purse seine fleets fishing in the eastern Atlantic, EC-France, EC-Spain, Ghana and NEI (Vanuatu, Malta, Morocco, Belize, Guinea and San Vicente) began to alternate traditional yellowfin and skipjack fishing with catches from schools associated with artificial floating objects (Anon. 2005a).

In the eastern Atlantic in the early 1970s, skipjack catches reached 48,000 t, 63% of which were from purse seine fisheries. In the early 1980s catches rose to 100,000 t with the same proportions for purse seiners, but in 1985 there was a considerable drop in purse seine catches as the bulk of the French and Spanish fleet moved into the Indian Ocean (Anon. 1999).

This fishery underwent major changes in 1991 with the introduction of artificial floating objects (FADs) and the consequent westward expansion of purse seine fishing up to 30ºW in latitudes close to the equator, following the drift of these objects. This has brought about an increase in the catchability of skipjack tuna and in the proportion of the stock that is exploited (Anon. 2005a).

Today, the principal fisheries are purse seine, especially EC-Spain, EC-France, NEI and Ghana. Catches in the eastern Atlantic in 2004 totalled 134,000 t, that is, a 15.8% increase on the average for 1999-2003. In the same year, purse seine fisheries accounted for 64.5% of total catches in the eastern Atlantic (Anon. 2005a).

The **second most important fishery** at this time is **baitboat fishing** in Ghana, EC-Spain and EC-France. The principal target species of this fishery is bigeye tuna, in which the rod-and-line vessel acts as bait, locating and fishing a school (composed of bigeye, yellowfin and skipjack) throughout the fishing season, in waters of Senegal, Mauritania and the Canary Islands (Anon. 2005a).

From the 1980s through to 2004, catches in the eastern Atlantic exhibited no particular trend, fluctuating between 24,000 t in 2002 and 48,000 t in 1988, with an annual average of 37,000 t for the period (Anon. 2006).

A document on a Spanish programme of observers on board purse seiners, presented at the 2005 meeting of the SCRS, shows that in the period 2001-2005 the average rate of skipjack discards on FADs in the eastern Atlantic is estimated at 42 kg per tonne of skipjack landed (Anon. 2006).

**Figure 8** shows the size distribution of skipjack tuna, in numbers, for the eastern and western Atlantic.

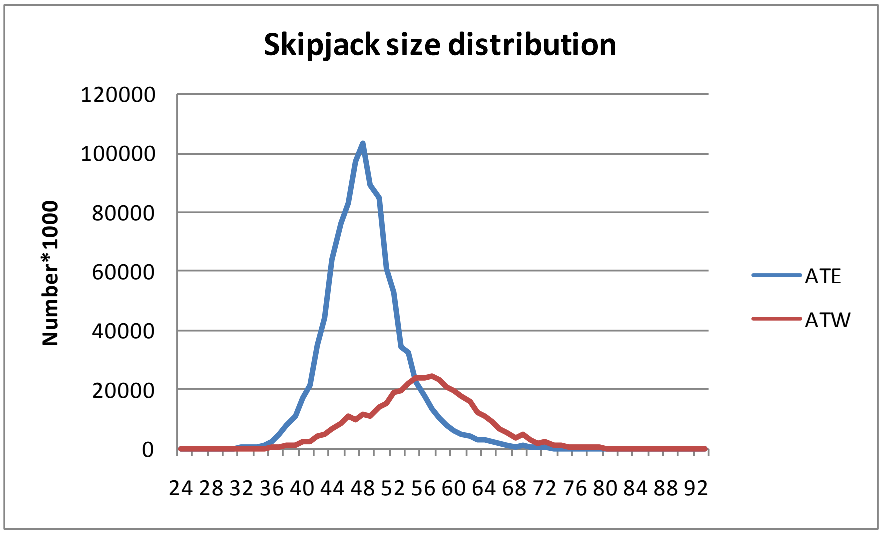



**Figure 8.** Size distribution of skipjack tuna for the eastern and western Atlantic (average for 1980-1998) (Anon. 1999).

*Western Atlantic*

The **first fishery** to be developed in the western Atlantic was **baitboat fishing**, in the 1950s. It is that fleet that has traditionally made the largest catches, and the Brazilian baitboat fishery is the most important in the West. This is partly due to the fact that, given its oceanographic features (inter alia, a pronounced thermocline at a depth of 50 m) and the presence of skipjack tuna nearly all the year round (albeit with a greater abundance in the summer months), the southern region of Brazil is a zone of high potential vulnerability to surface skipjack fishing (Anon. 1999).

Since approximately 1991, Ghanaian purse seine and baitboat fisheries have been using a technique involving fish aggregation devices (FADs). Similarly, baitboat fleets in Senegal and the Canary Islands fish on banks of tunas in a variant of baitboat fishing in which the vessels themselves are used as FADs. The use of these techniques has apparently improved fishing efficiency and has helped to increase catches of bigeye tuna (Anon. 2003, Fonteneau & Diouf 1994).

Starting in 1979, a baitboat rod-and-line fishery was established in the southeastern region. It enjoyed rapid development and the number of vessels reached 92 in 1982. In subsequent years (between 1985 and 1996) the number of vessels fell by almost half, and catches fluctuated between 16 200 (1978) and 25 100 t (1985). Catches appear to have stabilised at over 20 000 t in 1996-2004, with a historical maximum of 26 500 MT in 1997. Catches vary widely depending on the season, rising in summer and falling in winter. In 2004 baitboat catches off Brazil accounted for 85.6% of total skipjack tuna catches in the eastern Atlantic. The distribution in frequency of skipjack sizes is unimodal (**Figure 8**), the predominant sizes in catches being between 48 and 62 cm (Meneses de Lima *et al*., 2000).

**Purse seine fishing**, whose catches are much smaller than baitboat catches, is carried out mainly by the Venezuelan fleet and sporadically by Brazil. According to Gaertner & Gaertner-Medina (1988), because of catchability problems (depth of thermocline, current strength, oxycline, etc.), Venezuelan purse seiners often use the services of rod-and-line vessels (which use baitboat) to keep schools on the surface; these authors assert that thanks to this cooperation the number of empty hauls by purse seiners has fallen dramatically. The historical maximum for Venezuela was recorded in 1984, with 16,500 t; however, annual catches never exceeded 7,000 t from 1995 to 2004 (Anon. 2006).

According to the ICCAT (Anon. 2006), there are no quantified data on the effective fishing effort exerted on skipjack tuna in the eastern Atlantic. Nonetheless, it is assumed that the growth of fishing potential with the introduction of on-board technological improvements and the development of fishing around floating objects has improved the efficiency of the various fleets. A comparison between skipjack size distributions for the eastern Atlantic before and after the introduction of FADs supports this assumption inasmuch as there is an observable increase in the proportion of small specimens in catches.

The total catches for all Atlantic fisheries in 2004 came close to 161,000 t, which is an increase of almost 12.9% on the average for the 5 preceding years. Over the last 25 years, the historical maximum was 203,000 t in 1991 and the historical minimum 111,000 t in 1980. However, it is believed that reported catches may be somewhat underestimated, considering the discards of small tunas, including skipjack, by purse seine fleets using objects and by some baitboat fleets in the equatorial zone of the eastern Atlantic (Anon. 2006).

Catches of large skipjack tuna are larger in the western Atlantic (with a mode around 52 cm) than in the eastern Atlantic (where the mode is around 45 cm), and the proportion of small fish in the catch size structure is greater in the equatorial than in the temperate zone.

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