CHAPTER 2.1.1: YELLOWFIN TUNA	AUTHOR: IEO	LAST UPDATE: Nov. 10, 2006

2.1.1 Description of Yellowfin Tuna (YFT)

1. Names

1.a Classification and taxonomy

Species name: *Thunnus albacares* (Bonnaterre 1788)
Synonyms: *Germo albacares* (Bonnaterre 1788)
Neothunnus albacares (Bonnaterre 1788)
Scomber albacares (Bonnaterre 1788)
ICCAT species code: YFT
ICCAT names: Yellowfin tuna (English), Albacore (French), Rabil (Spanish)

Collette and Nauen (1983) classify yellowfin tuna as follows:

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

1.b Common names

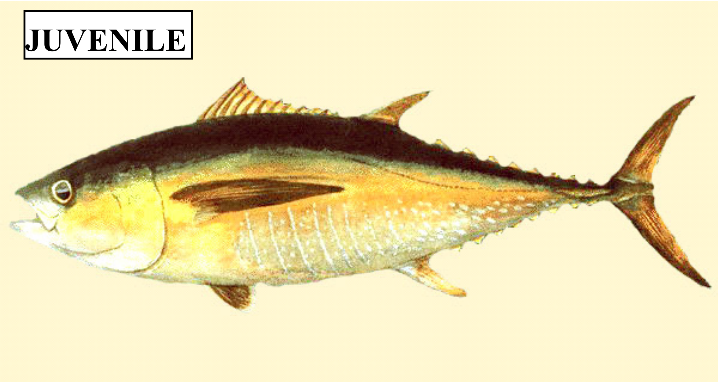
List of vernacular names according to the ICCAT (Anon. 1990), *Fishbase* (Froese and Pauly Eds. 2006) and FAO (*Food and Agriculture Organization*) (Carpenter Ed. 2002). Those marked with an asterisk (*) correspond to standard national names provided by ICCAT. The list is not exhaustive and some local names may not be included.

Angola: Albacora, Atum, Peixe-de-galha-à-ré, Rabão
Argentina: Aleta amarilla
Australia: Allison tuna, 'Fin, Yellowfin, Yellowfinned albacore
Barbados: Albacore
Benin: Gégú*, Guégou
Brazil: Albacora, Albacora da laje, Albacora de lage*, Albacora-cachorra, Albacora-da-lage, Albacora-de-laje, Albacora-lage, Albacora-lajeira, Alvacora, Alvacora-lajeira, Atum, Atum-amarelo, Atum-galha-amarela
Canada: Albacore à nageoires jaunes*, Allison's tuna, Autumn albacore, Yellowfin, Yellowfin tuna*, Yellowfin albacore
Cape Verde: Albacora, Albacore*, Atum albacora, Atum-de-barbatana-amarela, Atum-de-galha-à-ré, Chafarote, Chefarote (peces pequeños), Ielofino, Rabo-seco
Chile: Atún aleta amarilla
China (Peoples Rep.): 黃鰭金槍魚 (Huang ci jin ciang yu)
Chinese Taipei: 黃鰭鮪 (Huang ci wei)
Colombia: Atún aleta amarilla
Comorres: M'Bassi, Mibassi mibankundri
Côte d'Ivore: Albacore

Cuba: Atún aleta amarilla, Atún de aleta amarilla
Denmark: Gulfinnet tun, Gulfinnet tunfisk
Djibouti: Albacore, Yellowfin tuna
Dominican Rep.: Albacora **Dutch Antilles (Papiamento)**: Buni halfash
Ecuador (Galapagos Islands): Atún de aleta amarilla
Ecuador: Albacora
Fiji: Tuna, Yatu, Yellow-fin tuna
Finland: Keltaevätonnikala
France (La Réunion): Grand fouet, Thon jaune, Thon rouge
France (Martinique): Albacore, Z'aile jaune
France (Tahiti): A'ahí, A'ahi hae, A'ahi mapepe, A'ahi maueue, A'ahi 'oputea, A'ahi 'oputi'i, A'ahi patao, A'ahi tari'a'uri, A'ahi tatumu, A'ahi teaamu, A'ahi tiamatau, A'ahi vere, Otara
France: Albacore*, Thon à nageoires jaunes
Germany: Gelbfloβen-Thun, Gelbfloβen-Thunfisch, Gelbfloβenthun, Thunfisch*
Grenada: Guégou
Greece: Tonnos macropteros, Tonnos macrypteros
India: बुगुदी (Bugudi), गिदार (Gedar), कुपा (Kuppa), पीमप (Pimp), പൂവന് ചൂര (Poovan-choora), ગેદારા, சாக்கர் (Soccer), சோஸ்ஸர் (Soccer), ગેદર, Bokado, Bugudi, Gedar, Gedara, Howalla, Kannali-mas, Kelawalla, Kuppa, Pimp, Poovan-choora, Soccer, Yellow fin tuna, Yellowfin-tuna
Indonesia: Gantarangang, Gelang kawung
Iran: Ghidar
Italy: Tonno albacora, Tonno monaco, Tunnu monicu
Japan: Hatsu, Kihada*, Kimeji (young), Kiwada
Kiribati (Christmas Islands): Yellowfin tuna
Kiribati: Baewe, Báibo, Baiura, Te baewe, Te baibo, Te bairera, Te baitaba, Te ingamea, Te ingimea, Te inginea, Te kasi
Korea: Huang-da-raeng-i*
Madagascar: Lamatra
Malaysia: Ayam, Bakulan, Tongkol
Malta: Thon
Marshall Islands: Bwebwe
Mauritania: Albacore, Rabil, Thon à nageoires jaunes, Wockhandor, Yellowfin tuna
Mauritius: Long fin tunny, Thon à nageoires jaunes, Thon jaune, Yellow fin tuna
Mexico: Atún aleta amarilla (AFS), Atún de aleta amarilla, Rabil
Micronesia: Olwol, Taguw, Taguw peras, Taguw tangir, Yellowfin tuna
Morocco: Albacore*, Thon à nageoires jaunes, Thon tropical **Mozambique**: Albacora
Namibia: Albacore, Geelvin-tuna, Gelbflossenthun, Tuna
Netherlands: Geelvintonijn
New Zealand (Niue): Vahakula, Yellowfin tuna
New Zealand (Tokelau): Kahikahi, Kakahi, Takuo
New Zealand: Yellowfin tuna
Nicaragua: Rabil
Norway: Albacore, Albakor, Gulfinnet stØrje
Oman: Guiad, Jaydher
Palau (Trustee territories of the Pacific Islands): Tekuu, Tkuu, To'uo
Papua N. Guinea: Tetena keketina, Yellowfin tuna
Peru: Atún de aleta amarilla
Philippines: Albakora, Badla-an, Balarito, Baliling, Bangkulis, Bankulis, Bantala-an, Barelis, Bariles, Barilis, Bronsehan, Bugo, Buyo, Carao, Karaw, Kikyawon, Malaguno, Malalag, Oriles, Painit, Pak-an, Pala-pala, Panit, Panitto, Paranganon, Pirit, Tambakol, Tambakul, Tiklaw, Tulingan, Vahuyo, Yellowfin tuna
Poland: Albakora, Tunczyk zóltopletwy
Portugal (Azores): Albacora, Albacora de galha-à-ré, Alvacor, Galha-à-ré*, Galha amarela, Peixe de galha à ré, Yellow-fin tunny, Yellowfin tuna
Portugal (Madeira): Atum albacora
Portugal: Albacora*, Atúm albacora, Atúm amarelo, Atúm de barbacana amarela, Atúm de galha à ré, Atum rabil, Atum-albacora, Peixinho da ilho, Perinxinho da ilha
Qatar: Kababa
Roumania: Albacora, Ton galben

Russian Fed.: Жедтоперый тунец (Zheltoperyi tunets), Albacor, Tikhookeanskij, Zheltokhvostyj tunets
Samoa: Asiasi, Ta'uo
Samoa (American): To'uo
São Tomé and Príncipe: Atum oledê
Senegal: Albacore, Doullou-doullou, Thon à nageoires jaunes, Wakhandor, Waxandor
Serbia: Zutorepi tunj
Seychelles: Thon, Thon à nageoires jaunes, Ton zonn, Yellowfin tunny
Sierra Leone: Yellowfin tuna
Solomon Islands: Atu igu mera, Yellowfin tuna
Somalia: Yajdar-baal-cagaar
Spain (Canary Islands): Albacora, Rabil
Spain: Atún, Atún aleta amarilla, Hegats-hori, Rabil*
Sri Lanka: As geddi kelawalla, Howalla, Kelavai, Kelawalla, Pihatu kelawalla, Soccer
South Africa: Geelvin-tuna, Yellowfin tuna, Yellowfin tunny*
Sweden: Albacora, Gulfenad tonfisk
Tanzania: Jodari
Togo: Gegu, Thon
Tonga: Kahikahi, Yellow-fin tuna
Trinidad and Tobago: Albacore, Bonito, Yellowfin tuna
Tuamotu (French Polynesia): Kakahi
Turkey: Sarikanatorkinoz baligi, Sarikanatton baligi
United Kingdom (Saint Helena): Longfin, Yellowfin, Yellowfin tuna
United Kingdom: Allison's tuna, Autumn albacore, Pacific long-tailed tuna, Yellow-fin tunny, Yellowfin tuna
United States (Hawaii): Ahi, Allison tuna, Kahauli, Kanana, Maha'o, Palaha, Yellow-fin tuna fish
United States (Northern Mariana Islands): O'maguro, Tag-hu
United States: Allison tuna, Yellowfin, Yellowfin tuna*
Uruguay: Aleta amarilla
Venezuela: Atún aleta amarilla
Vietnam: Cá bò Vang, Cá Ngừ vây vàng, Yellowfin tuna

2. Identification



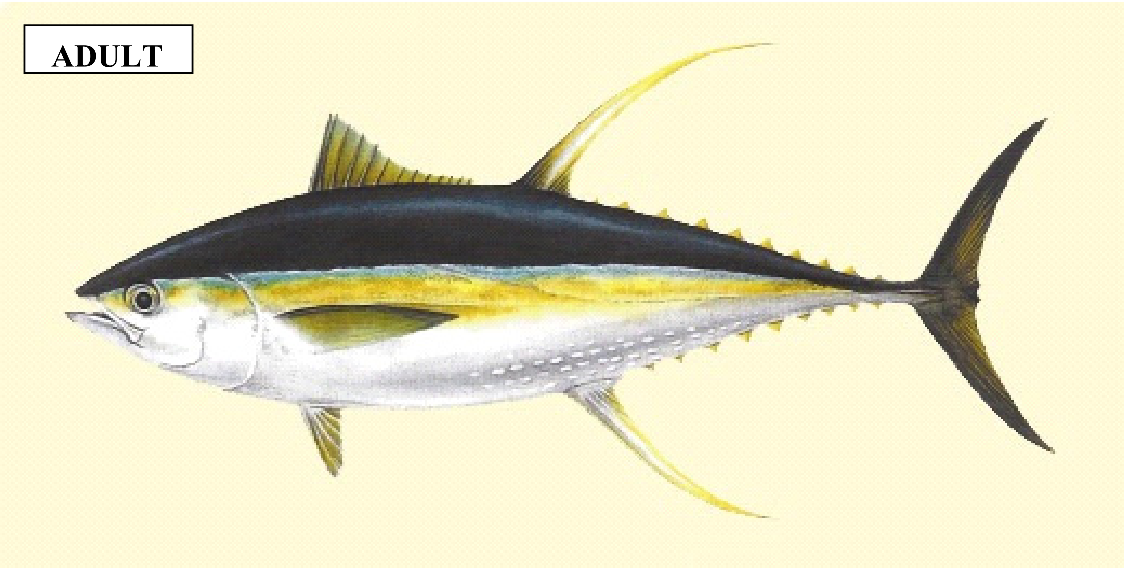


Figure 1. Drawing of a juvenile and an adult yellowfin tuna, courtesy of the IATTC (Inter-American Tropical Tuna Commission) and the SPC (Secretariat of the Pacific Community), respectively.

***Characteristics of* Thunnus albacares** (see **Figure 1** and **Figure 2**)

The largest recorded yellowfin tuna was 239 cm FL (*International Game Fish Association* 2001) and weighed 200 kg (Anon. 1994a).

Froese and Pauly Eds. 2006 give a maximum age of 8 years.

External characteristics:

- Long, slender, fusiform body, covered with small scales. Small head and eyes. The body is lightly compressed laterally.
- Small conical teeth in simple series.
- Two dorsal fins, separated by a small space.
- Some large specimens (from 120 cm to the fork) have a second dorsal fin and a very long anal fin, constituting up to 20% of the fork length. The pectoral fins are moderately long and generally reach the anterior edge of the second dorsal fin but not up to the end of its base (they normally make up 22 to 31% of the fork length).
- Very narrow caudal peduncle, with a very strong lateral keel on each side between two smaller keels.

- 11-14 hard radii on the first dorsal fin (the anterior ones are much larger than the others, giving the fin a concave appearance); 12-16 soft radii on the second dorsal, followed by 7-10 finlets; 30-36 soft radii on the pectoral fin; 11-16 radii on the anal fin, followed by 7-10 finlets (Richards 2006).
- 2 small interpelvic bifid protuberances.

Colour:

- Metallic blue-black back changing from yellow to silver-grey on the belly. Golden flanks.
- Shiny yellow rays with fine black edges.
- The first dorsal fin is an intense yellow colour, the second dorsal and the anal fins are light yellow. Anal fins sometimes silvery.
- Belly crossed with more than 10 vertical lines, alternating between continual and discontinuous, curving back towards the belly in the youngest specimens. These gradually disappear in adult specimens. The mid-ventral region shows no pattern of spots and lines.

Internal structure:

- Ventral view of the liver without striations, with the right lobe larger than the central and left ones; whilst in the bigeye tuna (*Thunnus obesus*, Lowe 1839) and the Albacore (*Thunnus alalunga*, Bonnaterre 1788) the central lobe is the largest.
- 85-95% of the specimens have a parasite in the nasal cavity (Nasicola klawei, Capsalidae; (Stunkard 1962), 12-14 mm in diameter, which is transparent and discoidal. This parasite worm never appears in T. obesus. This criterion is useful for distinguishing juvenile yellowfin tuna and bigeye tuna (Blache *et al.* 1970).
- Branchiospines in the first branchial arc: 26-34, lanceolate in shape; usually 27 or fewer.
- The cross-section in the middle of the body shows a pattern of red muscle more extended towards the back than in other tunas and in contact with the body surface (Sharp and Pirages 1978).
- Vertebrae: 18 precaudal and 21 caudal.
- Swim bladder present.

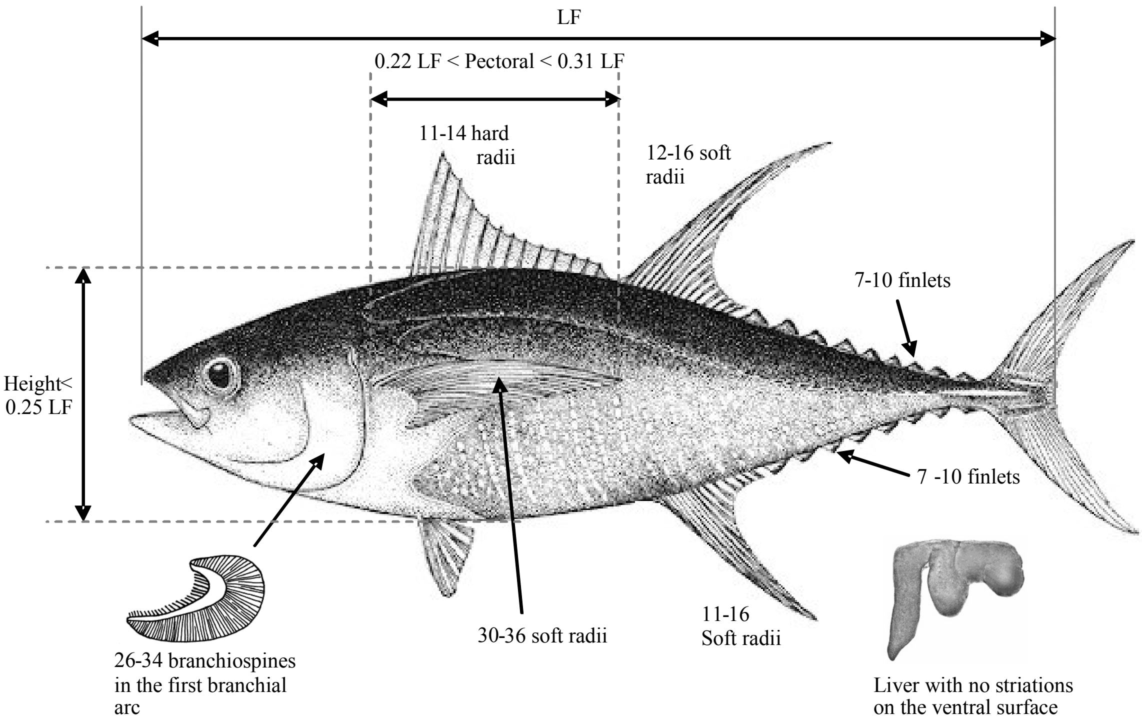


Figure 2. Diagram of the most important characteristics of *Thunnus albacares* (based on Collette 1995, *In* Froese and Pauly Eds. 2006. Modified by the IEO).

Distinguishing characteristics between yellowfin and bigeye tuna:

Yellowfin and bigeye tuna are frequently caught together with surface fishing gear, as it is easy to mistake the young of both species. Both the internal and external characteristics of these species of tunas vary with size and catch area.

The following tables summarise the distinctive characteristics of both species:

External characteristics	***Yellowfin tuna***	***Bigeye tuna***
Body morphology	Long, slender, fusiform body. Contour of the body straight between the second dorsal and caudal fin, and between the anal and caudal fin. Body height less than 25% of the FL.	Robust round body. Round body contour, creating a smooth dorsal curve and a ventral arc between the mouth and the caudal peduncle. Body height more than 25% of the FL.
Morphology of the head and eye	Width and length of the head shorter than those of a bigeye tuna of the same size. Eye diameter smaller than a bigeye tuna of the same size.	Width and length of the head longer than that of a yellowfin tuna of the same size. Eye diameter greater than a yellowfin tuna of the same size.
Anal fin and second dorsal fin	Longer radii than in the rest of adult tunas.	Relatively short radii.
Length and characteristics of the pectoral fin *For specimens smaller than 40 cm FL approximately*	Short, just reaching the base of the insertion of the second dorsal fin. Thick, rigid and round-edged.	Slightly longer, reaching the second dorsal fin. Thin, flexible and pointed at the tip.
Length and characteristics of the pectoral fin *For average sizes between 45 – 110 cm of FL*	Short, just reaching the base of the insertion of the second dorsal fin. Thick, rigid, like a razorblade.	Long, sticking out further than the second dorsal fin; this is not true of the second dorsal ray. Sharp, flexible, often curving downwards.

Colour	***Yellowfin tuna***	***Bigeye tuna***
Fresh	Bright yellow central strip on both sides of the body.	Metallic black-blue dorsal part and yellowy-purple flanks.
Pattern of vertical lines	Curving towards the ventral part. More than 10 continual dotted lines, alternating and slightly separated, extending from the tail to the lower part of the pectoral fin and over the lateral line.	Straight. Fewer than 8 irregular vertical lines very far apart and continual, with some lines of alternating dots. Most are found below the lateral line.
Rays	Shiny yellow with fine black edges.	Yellowish with thick black edges.

Internal characteristics	***Yellowfin tuna***	***Bigeye tuna***
Morphology and appearance of the liver	Right lobe longer and thinner than the central and left lobes. No striations on the ventral surface.	Lobes approximately the same size. Striations on the ventral surface.
Swim bladder present	Only occupies the front half of the body cavity.	Very well-developed, occupying almost the entire body cavity.
Parasites	85-95% of the specimens have a discoidal parasite in the nostrils *Nasicola klawei*.	*N. klawei* not found in the nasal cavity.

External characteristics of yellowfin tuna larvae:

- Small fresh specimens identified by the presence of a pattern of red spots (erythrophores) in the caudal area: 0-3 spots of red pigment in the dorsal margin of the caudal fin, close to the peduncle, and from 3-12 in the ventral margin (Ueyanagi 1966).
- Centre of the eye situated above the bodily axis (Nishikawa and Rimmer 1987).
- Absence of black pigmented spots in the margins of the caudal fin (Nishikawa and Rimmer op. cit.).

- A small black sport (melanophore) in the inner margin of the lower jaw (larvae > 4-4.5 mm of SL (standard length) which migrates to the outer margin when the fish grows. Black pigmentation on the outside of the upper jaw in larvae > 5.8 mm of SL (Richards and Potthoff 1973).
- First dorsal fin densely pigmented (Chow *et al.* 2003).

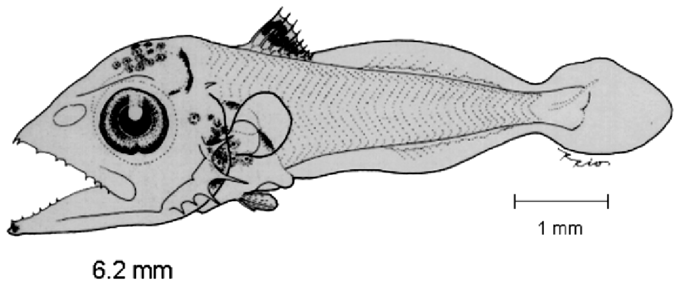


Figure 3. Standard length larva of yellowfin tuna measuring 6.2 mm (Beltrán-León and Herrera 2000 *In* Fishbase).

3. Biology and population studies

3.a Habitat

The yellowfin tuna is epi- and mesopelagic. This species is cosmopolitan, and is distributed in open waters of tropical and subtropical areas of the three oceans.

In areas where the concentration of oxygen is not a limiting factor, the distribution of yellowfin tuna in the water column is not set by the depth or the temperature, but by the relative change in water temperature with depth (Block *et al*. 1997, Brill *et al*. 1999).

Temperature: the yellowfin tuna generally limits its incursions into depths in which the water temperature does not fall more than 8º C with respect to the temperature of the surface layer. It spends more than 90% of its time in waters with a uniform temperature of around 22º C (Brill *et al*. 1999, Brill *et al*. 2005).

Depth: according to a study by Bard *et al*. (1999), the yellowfin tuna can reach depths of 350 m; however, both adult and juvenile yellowfin tuna spend most of their time in the surface layer, above 100 m. (Brill *et al*. 1999).

There are generally insignificant differences in depth distribution between day and night (Brill *et al*. 2005) (**Figure 4**).

Dissolved oxygen: a drop in oxygen content to 3.5 ml l^{-1} limits the vertical distribution of the yellowfin tuna (Brill 1994, Korsmeyer *et al*. 1996).

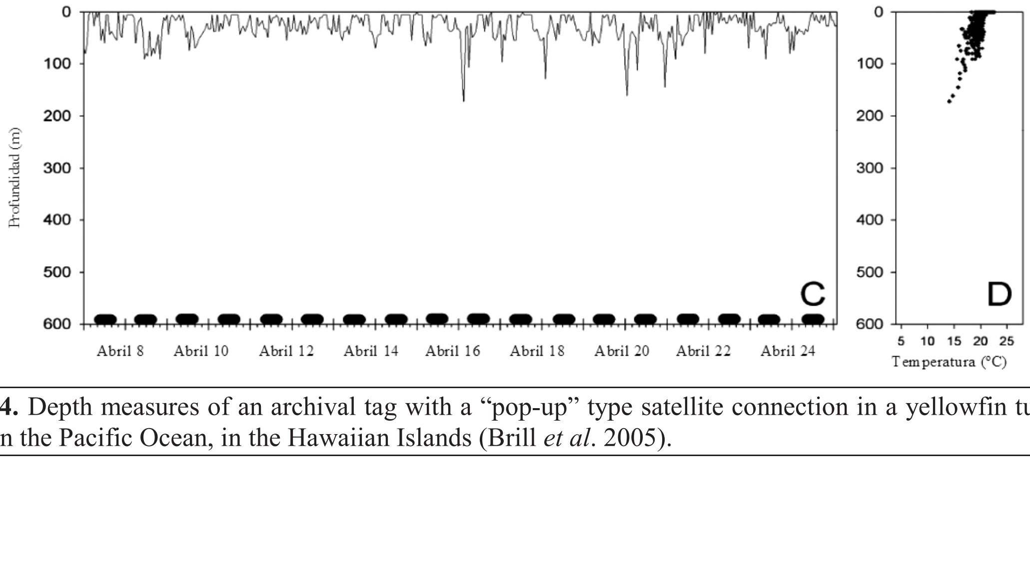


Figure 4. Depth measures of an archival tag with a "pop-up" type satellite connection in a yellowfin tuna adult tagged in the Pacific Ocean, in the Hawaiian Islands (Brill *et al*. 2005).

3.b Growth

The first models adopted by the ICCAT described the growth of the eastern Atlantic yellowfin tuna by applying two different equations according to the size of the specimens. Thus, for specimens between 35-65 cm of FL, the slow juvenile growth model was used, as presented by Bard (1984a), obtained using tag-recover techniques and, for specimens larger than 65 cm, the model used was that of Le Guen and Sakagawa (1973), obtained by modal progression.

The growth model currently adopted by the ICCAT is based on the modified von Bertalanffy equation (1938) as presented by Gascuel *et al.* (1992), confirming the existence of a growth curve marked by two stretches in the eastern Atlantic, already proposed in previous works (Cayré *et al*. 1988). According to this model, the yellowfin tuna has a slow juvenile growth phase (between 40 and 65 cm of FL) followed by a stage of rapid growth in the adult, with an inflection point situated 90 cm from FL between both stages. The succession of two stages during the recruiting phase seems to be related to the migratory character of this species.

In previous works, other authors (Albaret 1977, Bard 1984B, Fonteneau 1980) indicate that females could undergo a process of slowed growth in their adult stage, which would show different growth rates from sexual maturity.

Growth studies have been conducted in the western Atlantic using direct reading of age in otoliths and the first ray of the first dorsal fin (Driggers *et al*. 1999, Gaertner and Pagavino 1991, Lessa and Duarte-Neto 2004) applying von Bertalanffy's logarithmic growth model (op. cit.).

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

Growth equation	***Authors***	***n***	***Length range (FL in cm)***	***Methodology***	***Area***
$L_t = 37.8 + 8.93t + (137.0 - 8.93t)\left(1 - e^{-0.808t}\right)^{7.49}$	Gascuel *et al*. (1992)	-	40 – 170 cm	-	Eastern Atlantic (sexes combined)

* *Where L_t = length of the specimen at age t.*

3.c Biometric relationships

3.c.1 Size – weight equations

The size (FL)-weight (W) equation adopted for the yellowfin tuna was that proposed by Caverivière (1976), obtained with 6 487 specimens from the Atlantic Ocean and a range of sizes between 32-172 cm of FL (fork length), achieving results similar to those found by Tessier (1948) and Lenarz (1971). Caverivière (op. cit.) also obtained a size -weight relationship using the predorsal distance (PrD_1) as the metric unit.

Most of the equations found to date seem to indicate that there is no significant difference between sexes, so they are applied in combination. In 1980, Rodríguez *et al*. published a study with 2 844 from the central area of the eastern Atlantic, and reached the conclusion that size-weight relationships can be unified for both sexes of the yellowfin tuna both for round weight (RWT) and gutted weight (GWT). However, differences of 1% have recently been found in Brazilian waters between the equations obtained for males and females separately (Costa *et al*. 2005). In Venezuelan waters, Gaertner *et al*. (1992) also obtained a fork length-weight relationship, with 495 specimens of sizes under 115 cm.

Other size-weight relationships have been devised to obtain better estimates of catches in round weight from landed and processed catches. These include Davis (1991) which relates fork length with gutted weight and Lins Oliveira *et al*. (2005), which relates weight with the distance between the operculum and the caudal keel, which is the main catch data obtained in US ports for gutted specimens with the head and fins removed.

3.c.2 Conversion factors between weights and between sizes

In addition to the previous equations we have the gutted weight-round weight relationships, such as that of Morita (1973) for the whole Atlantic, and that of Choo (1976) with specimens from the Gulf of Guinea, since fishermen normally report the weight of fish without viscera or gills.

Of the various relationships between sizes we could highlight the one that relates fork length (FL) and predorsal distance (PrD_1) established by Caverivière (op. cit.), with 3 139 specimens, for the whole Atlantic, the validity of which was confirmed by Delgado de Molina *et al*. (1994B) with 4 259 specimens from the eastern Atlantic.

A series of different conversions have also been carried such as that of Scida *et al*. (2001) in the northwest Atlantic, making it possible to convert certain curved measurements into straight ones; since there were already precedents of these factors included in the US regulations for the Albacore. Lins Oliveira *et al*. (op. cit.) have obtained different conversion factors for yellowfin tuna caught in Brazilian waters.

Table 2. Different biometric relationships of the yellowfin tuna currently used by the ICCAT.

Equations and conversion factors	***Authors***	***n***	***Length range (cm)***	***Area***
Size - Weight				
$W = 2.153 \times 10^{-5} \times LF^{2.976}$	Caverivière (1976)	6 487	32 – 172 cm (FL)	Atlantic
Weight - Weight				
$RWT = 1.13 \times GWT$	Morita (1973)	313	46.9 – 169.5 cm (FL)	Atlantic
Size - Size				
$\log LF = 1.183 \log LD_1 + 0.269$	Caverivière (1976)	3 139	10 – 49.9 cm (PrD_1)	Atlantic

** Where W = weight; FL = fork length; RWT = round weight; GWT = gutted weight; PrD_1= predorsal distance*

3.d Maturity

In the eastern Atlantic, in the Gulf of Guinea, Albaret (1977) establishes early maturity size for females as PrD_1 = 32 cm, which value corresponds to a fork length of 108.6 cm and an age over 2 years. He also establishes a minimum early maturity size of PrD_1 = 28 cm, corresponding to a FL of 91.4 cm.

According to Schaefer (1998) in the western Pacific the early maturity size for 50% of females is 92 cm of FL, which corresponds to an age of approximately 2 years (Gascuel *et al.* 1992). For males, the minimum maturity size is lower than for females and for 50% of individuals it is 69 cm of FL. However, Sun *et al.* (2005) establish an early maturity size for 50% of females of 107.77 cm for the same area.

Table 3. Early maturity sizes for the Atlantic.

Maturity	***Reference***	***Area***
50% of mature females 108.6 cm	Albaret (1977)	Eastern Atlantic

3.e Proportion of sexes

Many studies have attempted to determine the proportion of sexes of the yellowfin tuna (Lenarz and Zweifel 1979, Postel 1955, Rossignol 1968, Yonemori and Honma 1976). Generally speaking, it has been observed that there is a higher proportion of males in sizes over 140 cm of FL (Albaret 1976). This author calculates a ratio of 1.59 and also found a predominance of females in sizes in the 130-140 cm of FL range. Cayré *et al*. (1988) observe a predominance of males from 150 cm upwards and a predominance of females in smaller fish. Different hypotheses have been put forward to explain this phenomenon, such as a differential growth rate, a naturally high female mortality rate or the fact that more males are caught, essentially because they are larger and therefore more vulnerable.

A study conducted by Capisano and Fonteneau (1991) in the eastern Atlantic of 13,978 specimens caught between 1974 and 1988 corroborates the results obtained by Albaret (op. cit.). For all the areas studied, the results show a higher percentage of females (52-58%) in the size range between 124 and 140 cm of FL and a sharp increase in the percentage of males in sizes greater than 140 cm of FL.

In the central area of the western Atlantic the conclusions are similar. Arocha *et al*. (2000) analysed the sex of 14 715 specimens of yellowfin tuna, and found once again that, over the 140 cm of FL mark, there is a sharp fall in the percentage of females with respect to males of yellowfin tuna, with more females in the remaining size intervals between 90 cm and 140 cm of FL.

New hypotheses have further been proposed to explain the concentrations of yellowfin tuna in the area inside the Gulf of Guinea (Bard and Finger 2001) after finding a significant proportion of large females. This phenomenon can be explained by the hypothesis that these are sedentary fish that spawn in summer close of the northern coast.

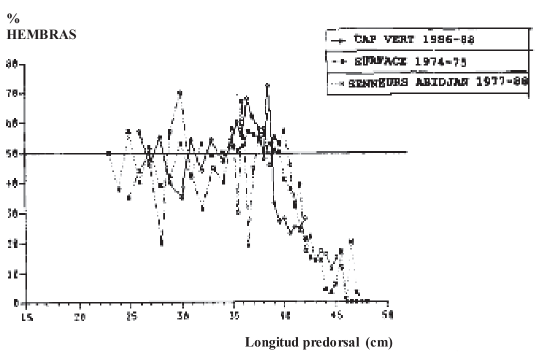


Figure 5. Percentage of yellowfin tuna females in the catches of several fleets operating in the eastern Atlantic (Capisano and Fonteneau 1991).

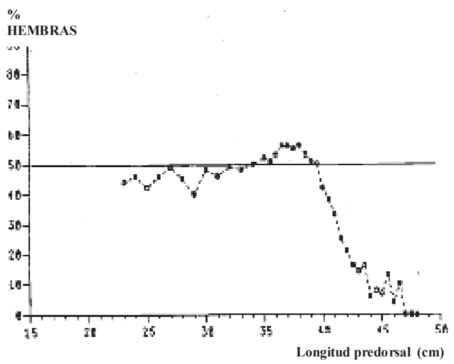


Figure 6. Average percentage (1974 to 1988) of yellowfin tuna females in catches in the eastern Atlantic (Capisano and Fonteneau 1991).

3.f Reproduction

Spawning

According to Albaret (1977), yellowfin tuna larvae are found in conditions corresponding to surface temperatures above 24º C, with a salinity of 33.4‰. More larvae are present at temperatures over 28º C with a salinity of 34-35‰.

The yellowfin tuna has an indeterminate pattern of reproduction which implies an asynchronous development of the oocyte, as can be seen in mature individuals, without a clear differentiation in the frequency of the distribution of the states of the oocyte (Arocha *et al*. 2000).

In the eastern Atlantic, the equatorial area from the coasts of Gabon (Gulf of Guinea) to 25º W is the main spawning area of the yellowfin tuna from October to March (Bard *et al*. 1991). In the region north of the Equator (Senegal-Guinea), the months of reproduction stretch from April to June (ICCAT Evaluation Group, 1993), which is confirmed by Delgado de Molina *et al.* (1994a). According to Vieira (1991) the yellowfin tuna's laying period is during the hot season in the islands of Cabo Verde, in the months of June to October, although there are certain variations from year to year.

The spatial-temporal distribution of active reproductive females in the Gulf of Mexico and the southeastern Caribbean Sea indicate two reproductive groups in the central area of the western Atlantic. According to Arocha *et al.* (op. cit.) these groups are different in size and in their laying period; a group of sizes smaller than 150 cm lays in the Gulf of Mexico in the months of May to August and a second group, with sizes from 150 to 170 cm, lays in the Caribbean Sea in the months of July to November. The females spawn by dispersion with an average of 46 layings per spawning period (Arocha *et al*. 2000, 2001), and the number of oocytes in each laying varies between 1.2 x 10^6 (specimen of 123 cm of FL) and 4.0 x 10^6 (specimen of 142 cm of FL).

Eggs and larvae

The eggs of this species are pelagic, spherical, transparent and float. The oocytes are between 0.90 and 1.04 mm in diameter (Mori *et al*. 1971) and do not have a fat globule. They incubate for 24-38 h. at 26º C.

Depending on its size, one specimen will lay between 5 and 60 million eggs a year (Cayré *et al*. 1988). Thus, the fecundity of a female yellowfin tuna per laying is estimated at between 1.2 x 10^6 oocytes in a specimen of 132 cm of FL and 4.0 x 10^6 oocytes in a specimen of 142 cm of FL (Arocha *et al*. 2000, 2001).

The larvae are pelagic, reaching a size of 2.7 mm of TL when laid. Their identifying features are the number of vertebrae (39), the absence of pigment in the front part of the brain, the usual presence of a small melanophore in the lower part of the jaw and pigmentation in the first dorsal fin. The embryo sac of the larvae is associated to the brain along the back, migrating up the ventral region to converge in the caudal region (Ambrose 1996, Richards 2006).

The embryo sac consists of two cylindrical bags 1.5 mm in diameter. Approximately two and a half days after laying, the larvae have already developed pigmentation patterns (Margulies *et al*. 2001).

The larval state lasts for 25 days (Houde and Zastrow 1993), it being considered that they reach the juvenile state when they measure 46 mm of SL (standard length) (Matsumoto 1962).

3.g Migrations

In the Atlantic Ocean, tagging and the analysis of catch data by size show that yellowfin tuna move at different rates all over this ocean (Anon. 2004).

To date, the yellowfin tuna is the species of tropical tuna that has been seen to make the largest migrations, meaning regular and periodic movements of a large part of the population (Bard *et al*. 1991).

Given that migratory behaviour varies with age, in migrations of this species one could consider not only specimens smaller than 50 cm of FL, but three size – age categories: juveniles (50-65 cm), pre-adults (65-110 cm) and adults (110-170 cm) (Bard *et al*. op. cit.) - in order better to understand the dynamics of this species in the Atlantic Ocean.

Specimens of up to 50 cm of FL remain in the coastal areas, and show moderate migratory habits (30 miles) (Bard *et al*. op. cit.). Some juveniles migrate westwards and follow seasonal trophic movements along of the coasts of the eastern Atlantic (Bard and Cayré 1986, Pereira 1986, Santos Guerra 1977) and the western Atlantic (Zavala-Camin 1976). For pre-adults, which are scarcely vulnerable to purse seine techniques, there seems to be a trend to migrate towards higher latitudes between Angola and Senegal and even to the Canary Islands and the Azores, which tallies with the observations made for juvenile yellowfin tuna. Migrations of pre-adult yellowfin tuna occur all over the Gulf of Guinea and follow similar patterns to that of juvenile yellowfin tuna (Bard *et al*. op. cit.). Pre-adults also form shoals in the Gulf of Guinea and follow cyclical seasonal migrations, in mixed shoals, in tropical waters depending on their productivity, with concentrations detected during the northern summer in Cabo López and Senegal, and during the northern winter in the equatorial zone. When they have reached sexual maturity, most specimens return to the spawning areas (Bard and Scott 1991, 1992; Fonteneau 1994), in particular, during the first quarter of each year (Foucher *et al*. 1998), and then migrate across the oceans from NW to SE along the tropical regions (Bard and Cayré *op. cit*., Maury *et al*. 1998). Adults make trophic migrations towards higher latitudes during the summer and genetic migrations across the ocean (Bard *et al*. 1991), at a rate of 10 miles per day, attaining average speeds of 1.74 miles per hour (Bard *et al*. 1987).

In the western Atlantic, on the southern and southeastern coast of Brazil, concentrations of juveniles can be observed close to the coast and larger specimens in further distant waters, in isolated shoals. Small specimens can be observed during the cold months of the year (May to October). In addition, the proportion of adults in the area is higher from August to April; and from May to July there is an increase in the proportion of juveniles, probably caused by the adults migrating towards the Venezuelan Caribbean for the breeding period in August and September (Costa *et al*. 2005). Zavala-Camin (1978) indicates that the adult yellowfin tuna makes six-monthly trophic migrations between the equatorial zones and the south and southeast of Brazil, in the periods of March to August and September to February.

Figure 7 shows the possible trajectories made by specimens of tagged yellowfin tuna. There is a notable flow of tagged individuals in both the northwest Atlantic and the southeast Atlantic. It can be observed that yellowfin tuna tagged in the Gulf of Guinea and in the Africa - Canary Islands region (juveniles and pre-adults) migrate relatively close to the coast, both north to south and vice versa. On the other hand, specimens tagged in the northern area of the fishery, on the American continent (fundamentally pre-adults and adults) display a migratory flow towards the Gulf of Guinea and the Caribbean Sea.

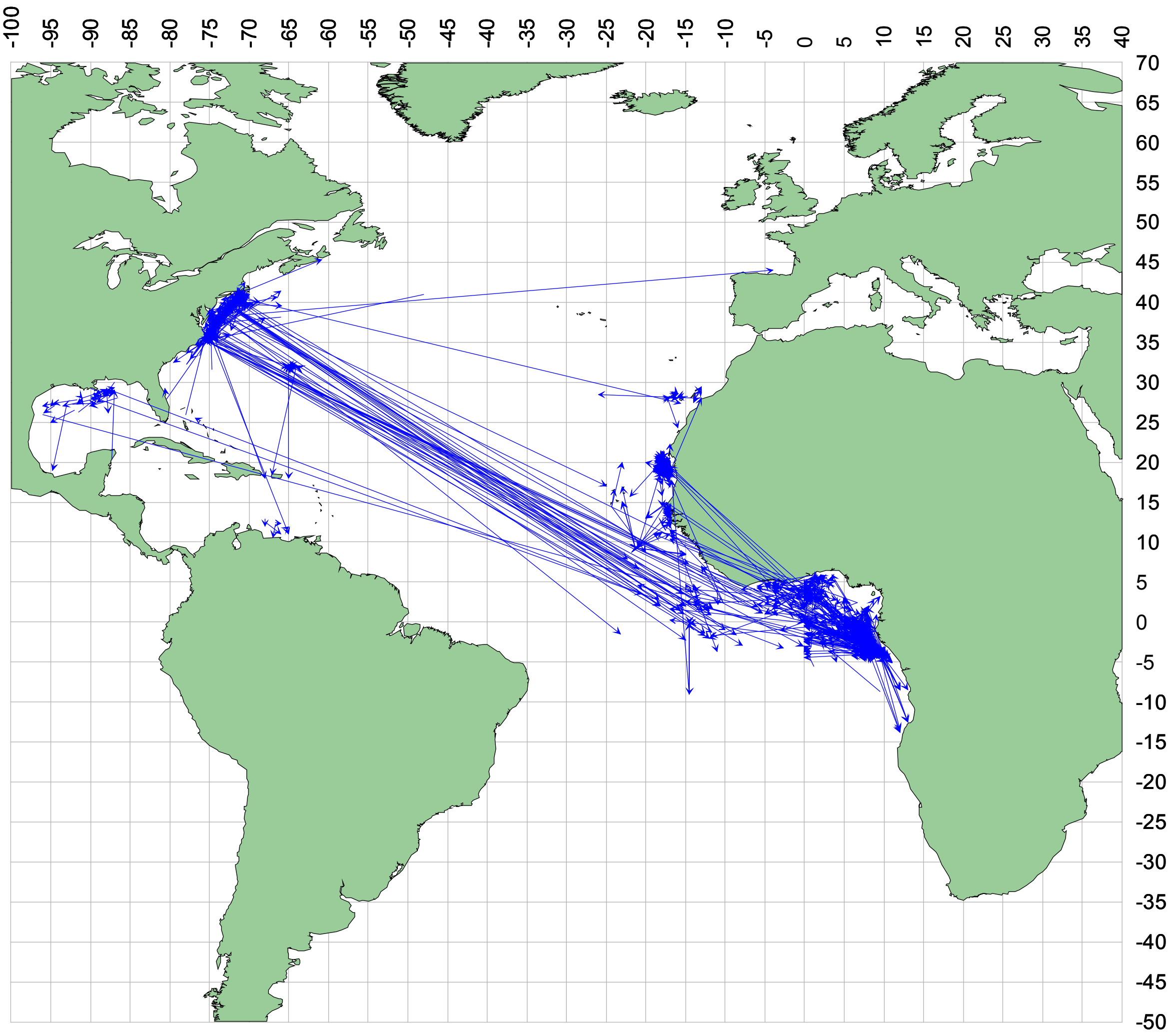


Figure 7. Horizontal movements of 1,711 specimens of tagged and recovered yellowfin tuna (ICCAT Secretariat).

3.h Diet

Yellowfin tuna, like other tuna species, is an opportunistic predator, and therefore its diet varies in spatial and temporal terms. According to Vaske and Castello (1998), the yellowfin tuna is a euriphagic predator, making no distinction in the type or size of its prey, although Lebourges-Dhaussy *et al.* (2000) affirm that micronecton is the main component of the oceanic diet.

The broad food spectrum of the yellowfin tuna's diet is evidence of its generalist eating habits in environments with low concentrations of organisms, like the oceanic pelagic regions. Nonetheless, in the south of Brazil it is possible to observe variations in the composition of the diet according to the time of the year. Teleosts and squid *Ornithoteuthis antillarum*, Adam 1957, are the staple diet during the winter, while hyperiid amphipods, *Brachyscelus crusculum*, Bate 1861, and *Phrosina semilunata*, Risso 1822, are the principal spring diet (Vaske and Castello op. cit.).

According to Ménard *et al*. (2000B), *Cubiceps pauciradiatus*, Günther 1872, has been observed in the stomachs of adult yellowfin tuna caught in free-swimming schools. According to this author, these driftfishes make up the largest component of the yellowfin tuna's diet for the eastern Atlantic. This is due to the stability shown by the juveniles of this species, which remain at a depth of 30-90 m without making vertical migrations. Juvenile yellowfin tuna prey on small mesopelagic fish, *Vinciguerria nimbaria* (Jordan and Williams 1895) (Ménard *et al*. op. cit., Roger and Marchal 1994).

3. i Physiology

Like all other tuna, the yellowfin tuna is a very active species. The capacity to conserve metabolic heat in the red muscle and in other regions of the body like the brain, eyes and viscera (local endothermia), a high metabolic rate and a modulated heart rate set tunas apart from all other species of fish. These specialisations enable them to swim fast and continually, reducing the thermal barrier to a minimum in order to exploit their habitat and simultaneously allowing them to expand their geographical distribution to high latitudes and to great depths in the ocean (Graham and Dickson 2004, Dickson and Graham 2004).

Tunas, including yellowfin tuna, have a highly developed circulatory system that includes a network of counter-current blood vessels (*retia mirabilia*), that reduce the loss of heat generated by the muscles and increase the efficiency of oxygen exchange (Graham and Dickson op. cit.). Cutaneous vascularisation is more developed in the genus *Thunnus* than in other tuna fish, and is indicative of a less important central vascular way and of its associated *retia* in adult tuna fish. The yellowfin tuna does not have well-developed central *retia* (Graham and Diener 1978, Sharp and Pirages 1978).

The size and state of development of the tuna also affect their capacity to conserve heat. Adults have a larger body mass and are able to conserve more heat, by thermal inertia, than juveniles (Brill *et al*. 1999, Maury 2005).

The P_{50} (Partial Oxygen Pressure, Po_2 required to achieve 50% saturation), between 20º and 30º C, is 2.8 to 3.1 kPa (21 to 23 mmHg) when balanced with 0.5% of CO_2 (Lowe *et al*. 2000).

The way tunas swim is characterised by a system of propulsion with a minimal lateral undulation and a concentration of power in the rapid oscillation from the caudal fin. Tunas are the only teleostes that swim in this way (Graham and Dickson op. cit.).

3.j Behaviour

Like all the other tunas, the yellowfin tuna is a gregarious species, tending to form shoals, either free-swimming or associated to FADs, different marine animals and underwater ridges. In the Pacific Ocean, the fishery of this species is associated to dolphins, which does not occur in any other oceans.

Adults generally form shoals of specimens of the same size. This behaviour also predominates in the juveniles which form shoals with specimens that do not necessarily come from the same breeding group in specific migration periods, (Zavala-Camin 1978).

Free-swimming schools of yellowfin tuna (not associated to FADs) tend to be made up of large individuals and to be monospecific (Ménard *et al*. 2000B), although mixed shoals can be found involving other species of tunas, such as the Skipjack tuna (*Katsuwonus pelamis*, Linnaeus 1758) (Pereira 1996).

In the eastern Atlantic the yellowfin tuna is often associated to a large variety of floating objects, including dead cetaceans, or some live animals. Studies by Ariz *et al*. (1993, 2006) show that the dominant species in catches is skipjack, which represents around 70%, followed by bigeye tuna and yellowfin tuna at around 15% each. Yellowfin tuna shoals associated to FADs mostly comprise small fish (under 5 kg), although there is a significant proportion of large individuals.

No trophic function has been identified for tuna fish in FADs. Small tuna concentrate under the FAD during the night and can form free-swimming schools during the day to feed, mainly off *V. nimbaria* (in the eastern Atlantic), which is a species not associated to FADs (Ménard *et al*. 2000a).

Shoals associated to objects sometimes also contain other species of fishes such as the wahoo (*Acanthocybium solandri* (Cuvier 1832), istiophorids, balistidae, or rainbow runner (*Elagatis bipinnulata* (Quoy and Gaimard 1825), dolphins, sea chubs, some species of shark, cetaceans and turtles. These species also appear in free-swimming schools, as can be observed in the work of Delgado de Molina *et al*. (2005). From this work it can also be deduced that these objects contain a larger amount of associated species, both in number and in weight, as in free-swimming schools.

In the Caribbean Sea the yellowfin tuna is associated with whale sharks and whales, with a certain seasonality that mainly depends of the appearance of these mammals in waters of the Caribbean (*Megaptera novaeangliae* (Borowski 1781), *Physeter macrocephalus*, Linnaeus 1758), with the exception of the resident populations (*Balaenoptera edeni*, Anderson 1789) (Gaertner and Medina-Gaertner 1999).

Multi-specific shoals of tuna form over undersea ridges, as shown by data obtained from catches made by tuna purse seiners in the eastern Atlantic, Ariz *et al.* (2002). The dominant species is the skipjack (59%), followed by the bigeye (22%) and finally the yellowfin tuna (19%). Although there is very broad range of variation depending on the years and the situation of the underwater ridges, catches have a specific composition similar to that obtained in FAD fisheries. The associations observed in the Azores on underwater ridges may be trophic in origin (Pereira op. cit.).

There is evidence to suggest that the FADs affect the dynamics and the structure of the shoals of tuna, their feeding ecology, and may act as a barrier against natural movements and migrations (Marsac *et al.* 2000). Furthermore, these effects seem to be more intense in relation to small species of tuna or large juveniles (Fonteneau *et al*. 2000), thus increasing the vulnerability and catch rates of the juvenile stocks, and could have serious implications for the structure of the population and the potential future reproduction of these species.

Unlike the situation in the eastern Pacific ocean, there are no yellowfin tuna fisheries associated to dolphins in the Atlantic Ocean.

3.k Natural mortality

Estimating natural mortality (*M*) is very important for managing stocks of marine creatures, although it is difficult to quantify.

The natural mortality coefficient used in the evaluations of Atlantic yellowfin tuna has been 0.8 for ages 0 and 1 (smaller than 65 cm of FL), and 0.6 for ages over 2 (Anon. 1984, Fonteneau 2005, Labelle 2003). Nonetheless, different authors indicate that it would be more realistic to consider a natural U-shaped mortality vector, because the *M* of the juveniles (high at the start of their lives due to predators) diminishes as they grow. After reaching a series of low values, *M* would rise progressively due mainly to the aging of the individuals (Anon. 1994b, Hampton 2000).

The preponderance of males from 140 cm of FL could be explained by a higher *M* for females (Anon. op. cit.).

The natural mortality vector by age used by the ICCAT for the Atlantic yellowfin tuna coincides with that used by the IOTC (Indian Ocean Tuna Commission). However, the values of M used by the SPC (Secretariat of the Pacific Community) and the IATTC (Inter American Tropical Tuna Commission) in their evaluations of this species differ substantially. Thus, in the latest evaluations of yellowfin tuna, the IATTC used quarterly values of M from 0.5 to 0.2, which were higher in individuals of up to 2 years of age (Hoyle and Maunder 2004).

4. Distribution and fishing

4.a Geographical distribution

They are widely distributed in tropical and subtropical waters of the Atlantic, Indian and Pacific oceans, and absent in the Mediterranean Sea (Collette and Nauen 1983). The geographical limits are between 45º - 50º N and 45º - 50º S. Their wide distribution explains the number and variety of fisheries that have developed throughout the world (**Figure 8**).

Juvenile yellowfin tuna stay in the equatorial region, in coastal areas, while pre-adults and adults reach out further into more oceanic waters.

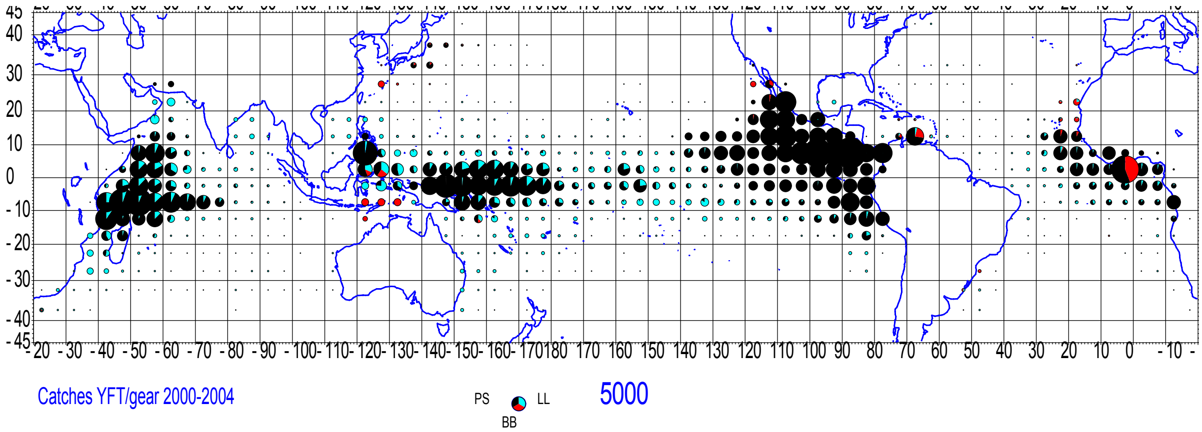


Figure 8. Yellowfin tuna fishing areas by several fleets between 2000 and 2004: longline (in blue, LL), purse seine (in black, PS) and bait boat (in red, BB) (courtesy of Alain Fonteneau 2006).

Distribution in the Atlantic Ocean: in the eastern Atlantic from the Netherlands to South Africa and in the western Atlantic from south of Canada to north of Argentina.

4.b Population / Structure of the stock

Up to 1993, two differentiated stocks of yellowfin tuna were considered in the Atlantic Ocean (Wise and Le Guen 1966): one in the east, along the African coasts, and another in the west, along the coasts of the American continent. Both stocks were separated arbitrarily by the 30ºW meridian. However, many authors point to exchanges between both of these based on catch data from longline vessels (Fonteneau 1981, Honma and Hisada 1971). Thus, in 1992, Bard and Scott proposed the existence of a single stock for the entire Atlantic Ocean based on recoveries in the Gulf of Guinea of adult specimens tagged off the American coasts (trans-oceanic migrations).

The 1993 ICCAT Working Group to evaluate Atlantic yellowfin tuna (Anon. 1994b) analysed two studies related to the structure of the stock (Bard and Hervé 1994, Fonteneau 1994) and revised long-term tag-recover data of adult specimens, with longline and surface gear, for the eastern and western areas of the Atlantic, and found that 86% of catches of yellowfin tuna and 83% of recovered tags for this species were from the eastern Atlantic. As a result, the working group reached the conclusion that the mix rate was high enough to be able to discard the hypothesis of two isolated stocks.

On the basis of these analyses it is considered that the evaluation of yellowfin tuna in the Atlantic should take place under the hypothesis of a single stock or panmictic population for the whole Atlantic, without ruling out the possible existence of degrees of populational structure and sub-populations homogeneised by migration, since there are four spawning areas: the Gulf of Guinea, the Gulf of Mexico, the southeastern Caribbean and Venezuelan waters (Arocha *et al*. 2000, Lang *et al*. 1994, Richards *et al*. 1990). The contribution of each of these areas to the population of Atlantic yellowfin tuna is still unknown.

This hypothesis of a single stock is backed up by the analysis of the tag-recover data from the United States Cooperative Tagging Center between 1956 and 1998. Of the 9,000 specimens tagged, especially in the Northwest Atlantic and the Gulf of Mexico, so far a total of at least 50 tags have been recovered corresponding to transatlantic migrations of adult fishes, all of which had migrated from west to east between 1987 and 1998 (Anon. 2004).

Genetic population studies have also provided interesting data on the differentiation of haplotypic sequences of specimens from different areas (Ely *et al*. 1999, Scoles and Graves 1993, Ward *et al*. 1994). The genetic study presented by Talley (2004) on alelic frequencies in sequences related with mitocondrial control and four microsatellite loci showed no substantial evidence of differentiation between larvae and juveniles from the Gulf of Guinea and larvae and adults from the Gulf of Mexico; although it does indicate that samples of fishes should be analysed from the Southeast of the Caribbean and Venezuelan waters.

4.c Description of the fisheries: catches and effort

Yellowfin tuna are fished throughout tropical Atlantic Ocean, between 45ºN and 40ºS with surface gear (purse seine, live bait and hand-line), and with longlines. Seine and live bait fisheries in the tropical eastern Atlantic are the most important in terms of catch and effort (Anon. 2004) (**Figure 9**).

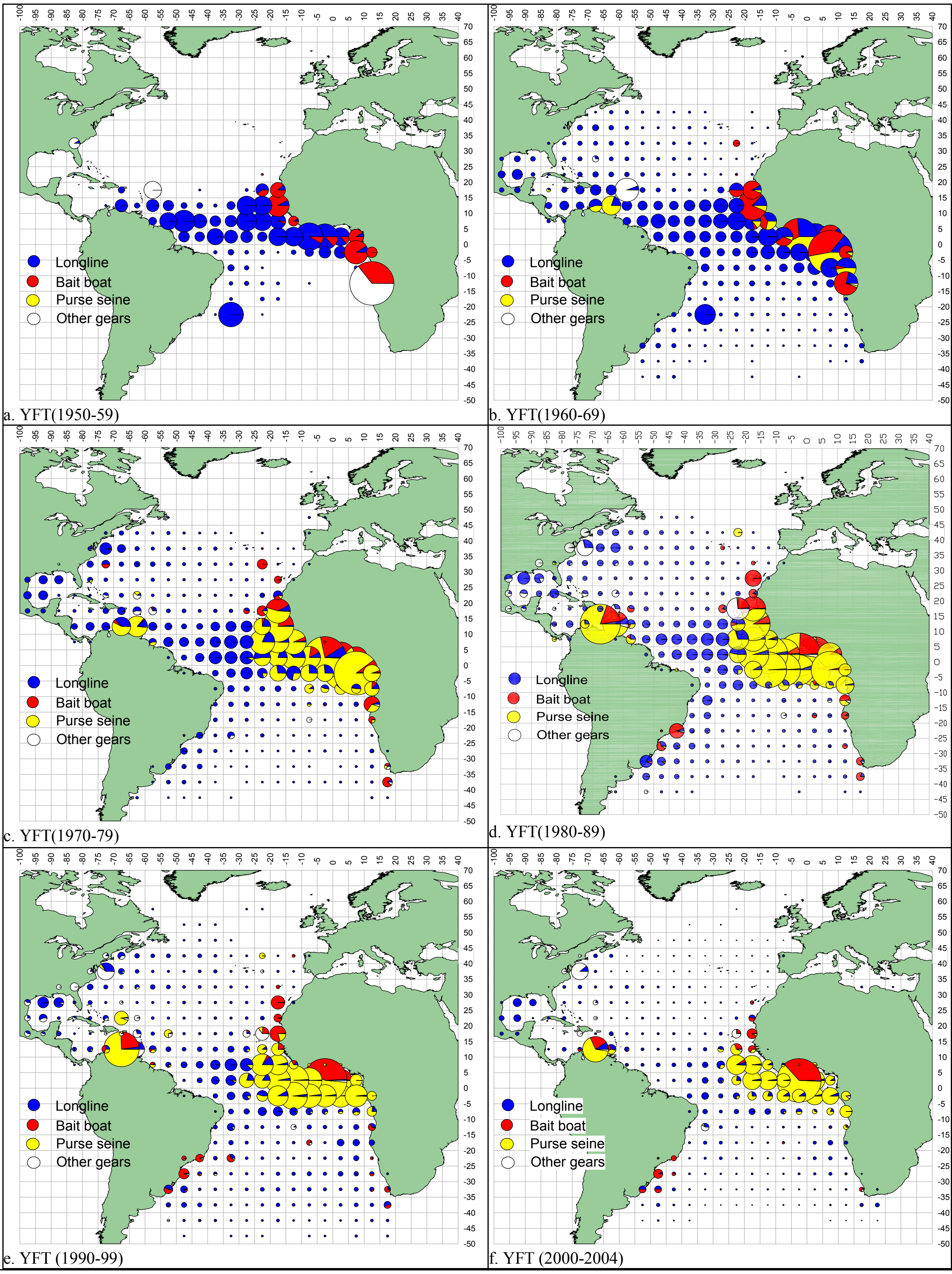


Figure 9. Geographical distribution of catches of the yellowfin tuna by main fishing gear and decades (ICCAT Secretariat).

Purse seine fisheries began in the eastern Atlantic in the early 1960s, and developed rapidly in the 1970s. From 1975 onwards, the fishing zone was gradually extended into the open sea, especially along the Equator. From 1991, the purse seiner fleets that fish in the eastern Atlantic (France, Spain, Ghana and NEI) started to alternate the traditional catching of yellowfin tuna in free-swimming schools with that of shoals associated to artificial FADs (Anon. 2004).

In free-swimming schools, the purse seiners catch large yellowfin tuna in the equatorial region during the first quarter of the year, coinciding with the spawning area and period. Fishing with FADs especially occurs in the first and fourth quarter of the year, with the skipjack the dominant species together with smaller numbers of yellowfin and bigeye tuna (Anon. 2004).

Yellowfin tuna catches in the eastern Atlantic purse seine fishery display a bimodal distribution in size classes, with modes close to 50 cm and 150 cm, but with very few intermediate sizes and a high proportion of large fishes (more than 160 cm). Fish caught in free-swimming schools weigh 34 kg on average, while those caught with FADs weigh 4 kg on average, (2002) which is an average overall weight of 18 kg (Anon. 2004).

In the western Atlantic, purse seine fisheries are far less important than in the eastern Atlantic, where they were only sporadically used between 1970 and 1980, and have operated in coastal areas from 1980, off the northern coast of Venezuela and in southern Brazilian waters. Sizes are lower there than in the east (from 40 to 140 cm), with an average weight of 14 kg and most have an intermediate size that is not bimodal (Anon. 2004).

For the entire Atlantic during the 1980s, total purse seine catches were more than 90,000 t, except in 1984, with a total of 74,000 t, achieving a maximum of 129 251 t in 1983. Catches in the 1990s began with a peak of 134,473 t in 1990, and fell progressively to reach 83,445 t in 1999. In 2004, catches fell to 61,800 t (Anon. 2004).

Figure 10 shows the distributions of sizes of yellowfin tuna caught by purse seine, with FADs and on free-swimming schools.

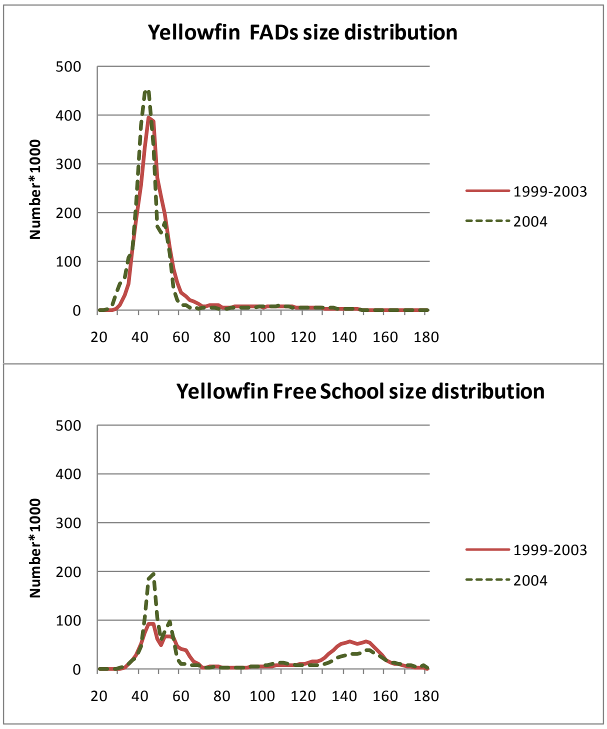


Figure 10. Size distribution of yellowfin tuna catches (in number) in the purse seine fishery, with objects and in free-swimming schools (Pianet *et al.* 2006).

There are several **live bait fisheries** in the eastern Atlantic that operate along the African coast. The most important fishery is based in Tema (where yellowfin tuna weighing an average of 2.5 kg are caught). There is another based in Dakar (with an average weight of 7 kg) and others operating in several Atlantic archipelagos (Azores, Madeira, Canary Islands and Cape Verde), with average weights of around 30 kg (Anon. 2005a).

In the western Atlantic, Venezuelan and Brazilian live bait boats catch yellowfin tuna together with skipjack and other small tunas.

Total live bait catches increased progressively from 8,080 t in 1980 to 21,842 t in 1988, and for the 1990s catches were over 18,000 t, with a peak of 24,405 t in 1999. For the period 2000-2004, catches were around the 20,000 t mark (Anon. 2006).

Figure 11 shows the distribution of sizes of yellowfin tuna caught by the live bait fisheries in Dakar.

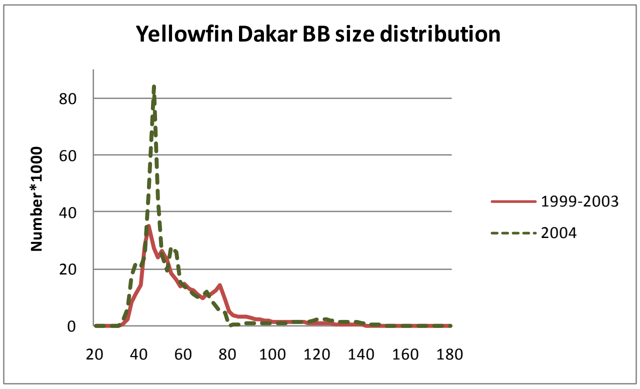


Figure 11. Size distribution of yellowfin tuna catches (in number) in the live bait fishery in Dakar (Pianet *et al.* 2006).

Longline fishing began at the end of the 1950s, and soon gathered importance, with significant catches made in the early 1960s. Since then, catches have fallen gradually. The degree of targeting of the yellowfin tuna varies from one fleet to another. In the Gulf of Mexico, U.S. and Mexican longliners target the yellowfin tuna, as do the Venezuelan vessels, although only seasonally. In the early 1980s, Japanese vessels and the Chinese Taipei fleet began to change their target species, abandoning the albacore and the yellowfin tuna and focusing their activity on bigeye tuna using bottom longline gear. Longline fisheries catching yellowfin tuna (with an average weight of 27-51 kg) are spread all over the Atlantic (Anon. 2004).

Figure 12 shows the size distribution of yellowfin tuna catches in the longline fishery.

Total catches show a marked fall throughout the Atlantic from 2001 onwards, in contrast with the increase in yellowfin tuna catches in other oceans around the world. Catches from surface fisheries in the Atlantic tended to fall from 2001 to 2004, while longline catches increased (Anon. 2005b).

In the eastern Atlantic, purse seine catches fell from 89,569 t in 2001 to 58,632 t in 2004, a reduction of 35%. In this same period, catches from live bait fishery fell by 23% from 19,886 t to 15,277 t. This fall was almost entirely due to the reduction in catches of the live bait boats of Ghana, which occurred due to a reduction in the effort and the respecting of the moratorium on fishing with FADs. Overall, catches from other fleets of live bait boats increased, and longline catches rose from 5,311 t to 10,851 t, an increase of 104% (Anon. 2005b).

In the western Atlantic, purse seine catches fell from 13,072 t to 3,217 t, a reduction of 75%. Live bait catches fell by 8%, from 7,027 t to 6,735 t, while longline catches increased from 12,740 t to 15,008 t, an increase of 18% (Anon. 2005b).

At the same time, the nominal effort of the purse seine fleet also fell. As an indication, it should be pointed out that the number of purse seiners of the European and associated fleet operating in the Atlantic fell from 46 ships in 2001 to 34 ships in 2004. Furthermore, the European and associated live bait fleet grew from 16 to 22 ships in the same period (Anon. 2005b).

The trend of the nominal catch rate based on purse seine data suggests that the catch per unit of effort has remained stable or has possibly fallen in the eastern Atlantic since 2001 and clearly fell in the western Atlantic.

Given that the efficiency of the effort seems to have continued to grow, it is thought that adjustments due to that change in efficiency will lead to a sharper fall. Likewise, average weights in European purse seine catches have gradually fallen since 1994, which is at least partly due to changes in selectivity associated to fishing over FADs (Anon. 2005b).

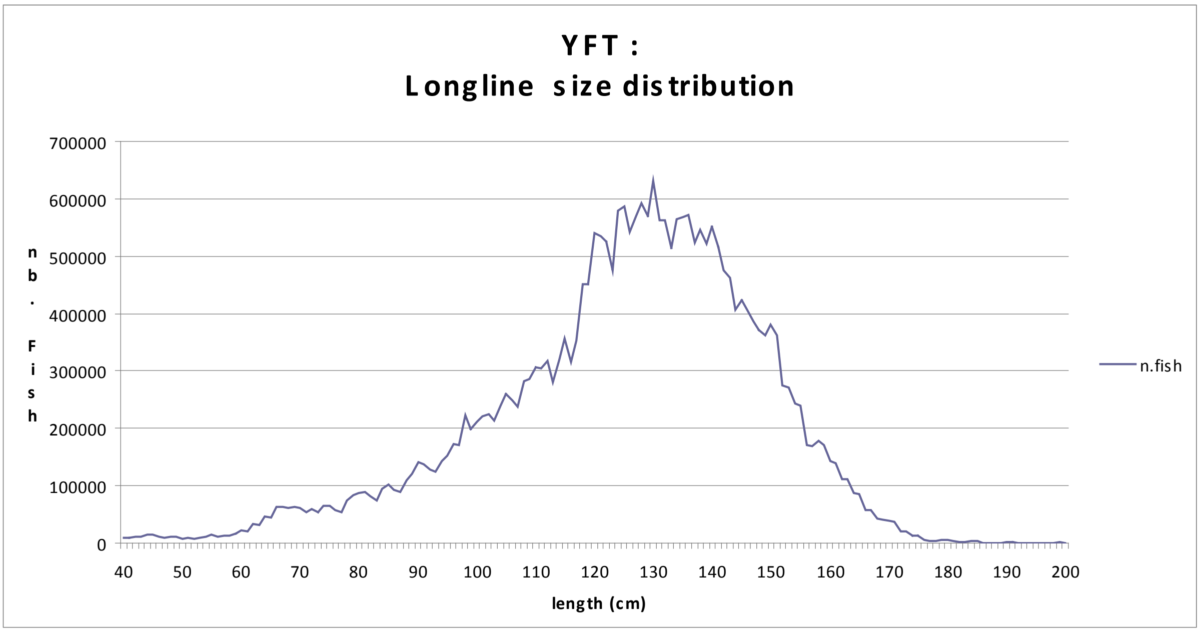


Figure 12. Size distribution of yellowfin tuna catches in the longline fishery.

4.d Catches by age

To evaluate yellowfin tuna stocks, the ICCAT uses catch data by age in the fisheries for which abundance indices have been obtained between 1970 and 2001 (**Figure 13**).

These show an increase in the ages of the specimens caught by the Japanese fleet (LL Jap), which could be related to its adopting bottom longline fishing. The European Community purse seine fishery (PS-EC) mostly catches yellowfin tuna aged between 0 and 1 years, with an increase in the number of juveniles caught in the early 1980s (Anon. 2004).

Catches are also analysed by age from other fisheries: purse seine (PS Ven) and longline (LL Ven) from Venezuela, rod and reel of the United States (RR USA), longline of the United States (LL USA), and the longline fisheries of the United States and Mexico that operate in the Gulf of Mexico (LL Mex+USA GoM), and Brazilian live bait and longline fisheries (LL Bras).

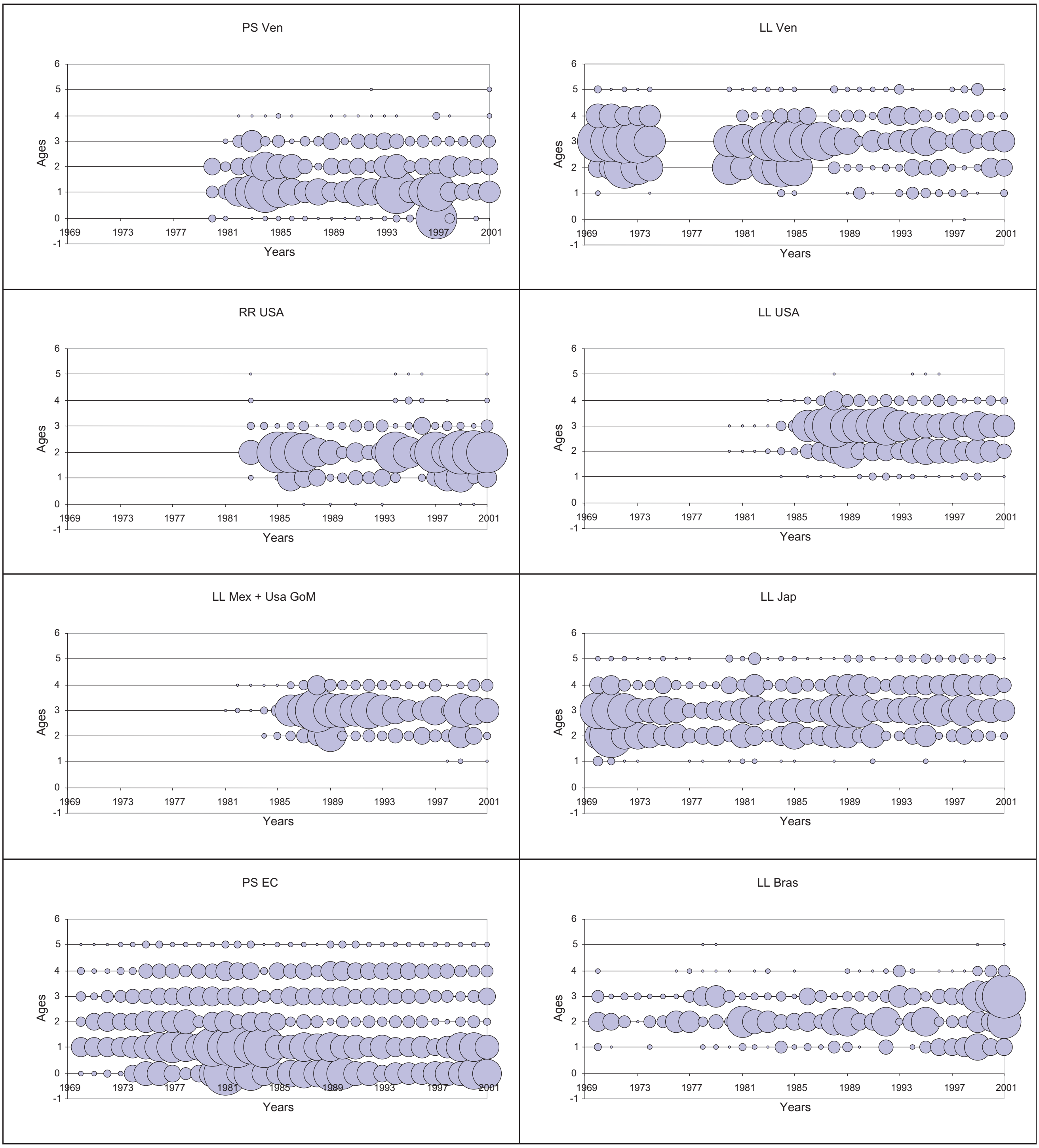


Figure 13. Yellowfin tuna catches by age and fishery between 1970 and 2001 (Anon. 2004).

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