ICCAT Manual
INTERNATIONAL COMMISSION
FOR THE CONSERVATION OF ATLANTIC TUNAS
ICCAT CICTA CICAA

CHAPTER 2.1.4: ALBACORE	AUTHOR: AZTI	LAST UPDATE: Oct. 8, 2004

2.1.4 Description of Albacore (ALB)

1. Names

1.a Classification and taxonomy

Species name: *Thunnus alalunga* (Bonnaterre 1788)
Synonyms in use: *Germo alalunga* (Jordan and Evermann 1896)
ICCAT species code: ALB
ICCAT names: Albacore (English), Germon (French), Atún blanco (Spanish)

According to Collette and Nauen (1983), albacore is classified 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 used according to ICCAT and Fishbase (www.fishbase.org). Those with (*) are national standard names according to a survey conducted by ICCAT. The list is not exhaustive and some local names might not be included.

Albania: Ton pendgjate
Angola: Avoador
Argentina: Albacora
Australia: Albacore tuna, Longfin tuna
Azores Islands: Voador
Barbados: Bonito
Benin: Gégú*, Guégou
Brazil: Albacora, Albacora branca*, Albacorinha, Alvacora, Atum, Atum branco, Bandolim, Carorocatá, Carorocoatá,
Canada: Albacore*, Longfin tuna, Atlantic Albacore, Longfinned albacore, Longfin, Tuna
Canadian Québec: Germon, Germon Atlantique
Cape Verde: Asinha, Atum voador, Atum branco, Atum-de-galha-comprida, Peixe-maninha
Chile: Atún de aleta larga
Chinese Taipei: Chang chi we*
Colombia: Albacota
Côte d'Ivoire: Germon
Cuba: Albacora
Denmark: Albacore, Hvid tun, Tun
Dominican Republic: Albacora
Ecuador: Atún, Sierra
Finland: Valkotonnikala

France: Germon*, Thon Blanc
French Polynesia: Ikai pererau roa
Germany: Germon, Thun, Thunfisch*, Weisser Thun
Greece: Tónnos, Tonnos macropteros, Tónnos macrypyteros*, Tonos makrofteros, Tounnaki
Hawai: Ahí pahala, Albacore fish, Long-finned tuna
India: Albacore
Israel: Garmon
Italy: Aalunga, Alalonga, Alalongu, Alalunga, Alilonga, Lalonga, Liccia, Tonno*, Tonno bianco,
Japan: Binchô, Binnaga*, Tonbo
Kenia: Jodari
Korea: Nal-gae-da-raeng-i
Lebanon: T'oûn abyadh
Malta: Alalonga, Alonga, Tonn sekond
Martinique: Germon, Ton blan,
Mexico: Albacora, Atún blanco
Micronesia: Albacore, Taguw, Taguw peras, Taguw tangir,
Monaco: Ara lunga
Morocco: Germon
Namibia: Albakoor, Germon, Langflossenthun, Tuna
Netherlands: Tonijn, Witte tonijn
Netherland Antilles: Buni habrikos
New Zealand: Albacore, Albacore tuna
North Marianas: Tárákapw
Norway: Albakor, Stjørje
Oman: Guiad, Jaydher
Pacific Islands: Aáhi taria
Panama: Albacora
Papua-New Guinea: Albacore
Peru: Alalunga, Albacora, Atún de aleta larga
Philippines: Albacore, Albakora, Bayot, Bulis, Iliwon, Karaw, Kiyawon, Tulingan
Poland: Germon, Tunczyk bialy
Portugal: Voador*, Atum Branco, Atum de barbatana comprida, Ilhéu, Albacora, Àsinha, Atum, Atum voador
Puerto Rico: Albacora
Romania: Ton alb, Ton cu inotatoare lungi
Samoa: Apakoa
Senegal: Bonette
Serbia: Bijeli tunj, Dugoperajni tunj, Silac, Tuna
Sierra Leone: Albacore tuna
Somalia: Jodari
South Africa: Albacore, Albakoor, Langvin tuna, Longfin tuna, Longfin tunny*
Spain: Albacora, Atún, Atún blanco*, Barrilote, Bonito del Norte, Hegaluze
St. Helena: Bastard Albacore
Sweden: Albacor, Albacora, Albakore, Långfenad tonfisk, Tonfisk, Vit tonfisk
Tahiti: A'ahí tari'a
Tanzania: Jodari
Trinidad y Tobago: Albacore, Bonito
Tunisia: Ghzel
Turkey: Akorkinoz baligi, Ton baligi, Yazili orkinos
United Kingdom: Albacore, Albacore tuna, Longfin tunny
United States of America: Albacore, Longfin tuna
Uruguay: Albacora
USSR (former): Albakor, Al'bakor, Belokrylyj tunets, Belyj tunets, Dlinnoperyi tunets, Dlinnokryli tunets
Venezuela: Albacora*, Barrilote, Atún blanco
Vietnam: Cá ngir vây dài

2. Identification

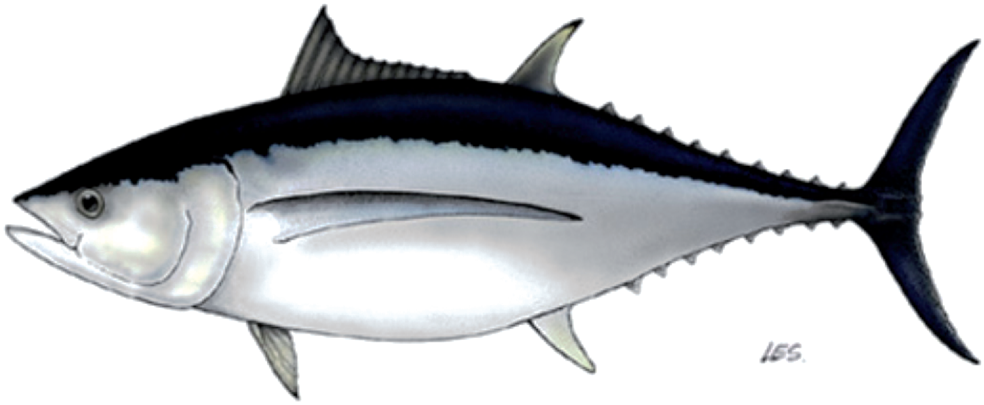

Figure 1. Drawing of an adult albacore by Les Gallagher (Les Gallagher: fishpics & ImagDOP University of the Azores).

Characteristics of *Thunnus alalunga* (see **Figure 1** and **Figure 2**).

Albacore is one of the smaller tuna species. Maximal length was established by Collete and Nauen (1983) in 127 cm and Le Gall (1974) estimated 130 cm as a likely maximal length in the Atlantic.

Regarding age, Le Gall (1974) estimated a theoretical longevity of 15 years; however, tagging experiments have shown that the oldest albacore ever recovered was less than 10 years old.

External:

- Elongated fusiform and robust body covered with small cicloid scales.
- Long pectoral fins (up to 30% of fork length or longer in fishes longer than 50 cm), reaching second dorsal inlets (or beyond second dorsal fin). However, they are relatively short in individuals shorter than 30 cm. Often confused with juvenile *T. obesus* which also has long pectoral fins but with rounded tips.
- Lack of stripes or spots distinguishes the albacore from other tuna.
- Caudal peduncle slender, keel on each side.
- Caudal fin relatively short, wide and strongly crescent-shaped, with a narrow white posterior margin, which is unique to this species.
- Greatest body depth at or slightly before level of second dorsal fin, deepest at a more posterior point than in other tunas. Second dorsal fin clearly lower than first dorsal fin.
- The back dorsal fin and anal fin are both soft rayed. Ventral fins are small.
- Dorsal spines (total): 11-14, dorsal soft rays (total): 12-16, anal spines: 0-0; anal soft rays: 11-16
- Vertebrae: 18 precaudal plus 21 caudal.
- Total gillrakers on first arch: 25-31. They are lancet-like.

Colour:

- Metallic dark blue on the dorsal side and silvery white on the ventral side; a faint lateral iridescent blue band runs along sides in live fish.
- First dorsal fin deep yellow, second dorsal and anal fins light yellow, anal finlets dark. Posterior margin of caudal fin white.

Internal:

- Liver striated on ventral surface (vascular network); divided into three lobes and central lobe is largest.
- Swimming bladder present but poorly developed, not evident in fish smaller than 50 cm fork length.

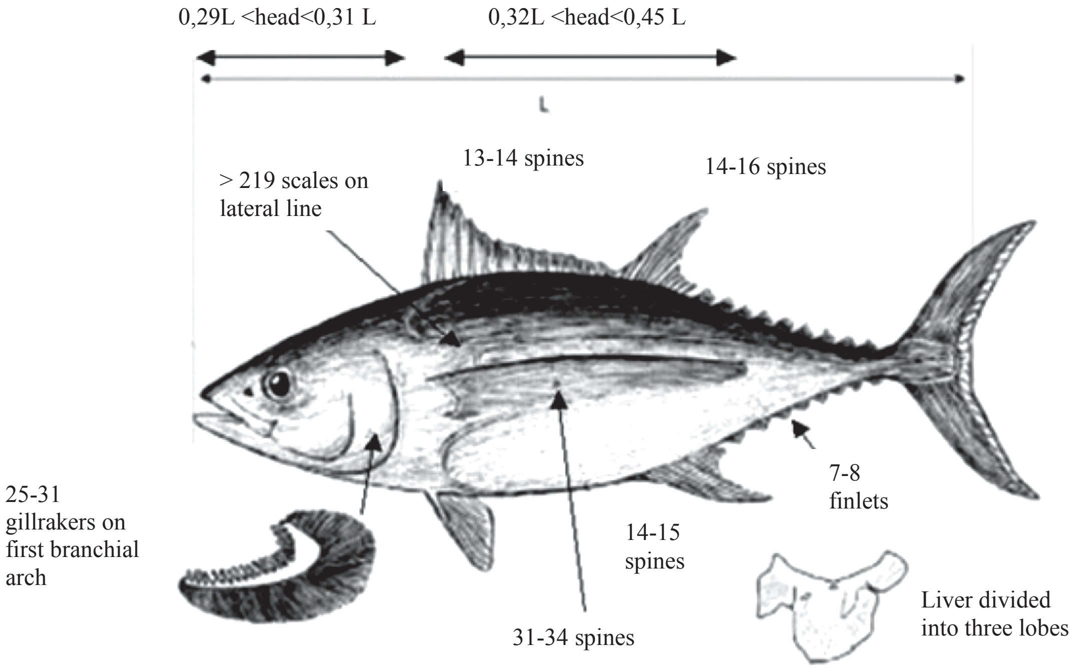

Figure 2. Diagram of the most outstanding characteristics of *Thunnus alalunga* after Santiago (2004).

External characteristics of albacore larvae

- Yolk-sac larvae are around 2,5 mm fork length.
- Unlike other tuna, albacore larvae are characterized by the lack of pigment in the caudal area (Nishikawa and Rimmer 1987).
- The head is big, representing 47% of standard length (Dicenta 1975) and pigmented on the central part.
- Teeth are sharply curved in the distal part.

3. Biology and population studies

3. a Habitat preferences

Epi and mesopelagic oceanic species, albacore seldom come close to shore and prefer deep, wide open waters.

Temperature is one of the most relevant environmental factors determining the distribution of albacore. Despite physiological adaptations common to other tuna (see Physiology chapter) which allow for some thermoregulation, albacore is a temperate tuna species and prefers cooler sea temperatures than more tropical species such as yellowfin tuna.

The thermal preferendum has been established in the 10-20ºC temperature range (Graham and Dickinson 1981, Laurs and Lynn 1991) although temperatures outside that range can be tolerated for short periods. Distribution of areas suitable for albacore in the North Atlantic can be seen in **Figure 3**.

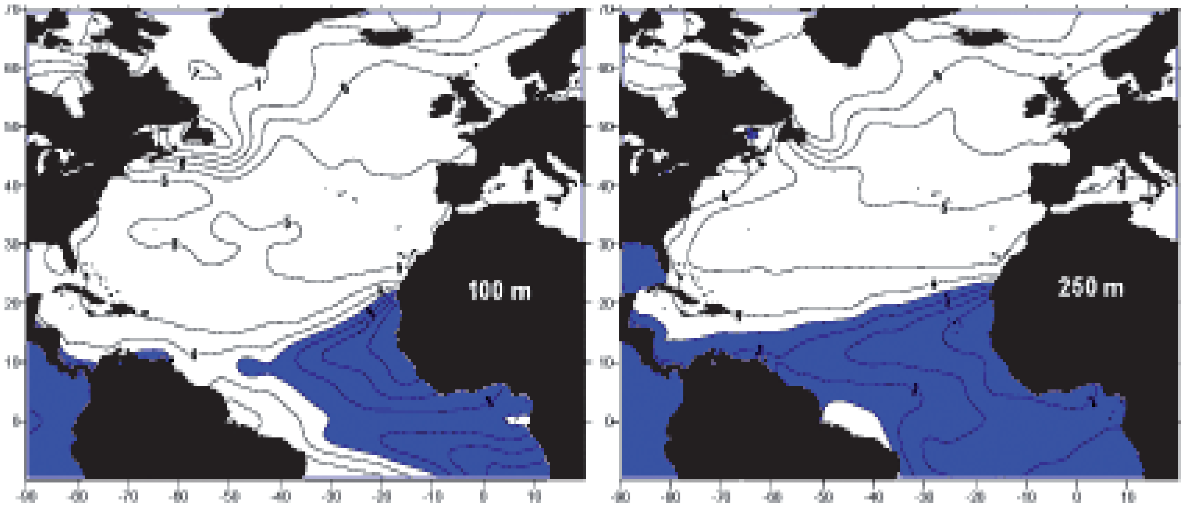

Figure 3. Yearly average temperature (ºC) at 100 m and 250 m depth in the North Atlantic. Areas in blue are not suitable for albacore (after Da Silva *et al.* 1994).

Albacore have been found to occur mainly in the temperature range of 14-20ºC off North-America (Johnson 1961, quoted by Penney *et al.* 1998), between 16-21ºC in the northeast Atlantic (Santiago 2004) and between 16-20ºC off South-Africa (Talbot and Penrith 1962, quoted by Penney *et al.* 1998). These thermal preferences appear to act as barriers to movements of albacores between different regions and separate populations such as north and south Atlantic stocks and the Atlantic and Indian populations (Penney *et al.* 1998).

Search for the optimal thermal preferendum seems to be the goal of the periodical vertical migrations that albacore undertake moving from warm surface waters to deep cooler waters. These vertical movements have been observed by acoustic telemetry (Laurs *et al.* 1980, Laurs and Lynn 1991) in the Northeast Pacific, where individuals 3-5 years old spent 80% of the time at 100 m, around the thermocline depth, and moved only occasionally to the mixing surface layer or to deeper waters (Laurs *et al.* 1980). It was also noted that albacore undertook vertical migrations with larger depth range during the day than during the night.

Depth distribution has been observed down to 450 m in the Pacific Ocean by Bard *et al.* (1999). Other authors have found that depth distribution in the Pacific ranges between 0-380 m (Bertrand *et al.* 2002).

Swimbladder grows allometrically, reaching its full development at sizes between 80-90 cm (Gibbs and Collette 1967). Therefore it is fully functional only in preadults or adults and young albacore have difficulties in controlling their buoyancy. This involves that the younger an individual is the less ability it has to move vertically in the water column.

Since the heat exchangers work less efficiently in the young ones and can't adjust their depth at will, they seem to be bound to stay at surface waters while adults can live in deeper waters. This anatomical characteristic has important implications for the type of fisheries that will develop: fleets operating with surface gear will target the juveniles while longliners catch the adults.

Dissolved oxygen: the high metabolic rates of tuna involve a high oxygen consumption. Graham *et al.* (1989) estimated the minimal oxygen concentration for this species in 3.7 ml/l (98 mmHg, 64% saturation at 15ºC).

According to this tolerance levels, large areas of the eastern Atlantic, South of 20ºN and extending towards Brazil, are not suitable for albacore at depths greater than 100m. At 250 m, this area extends further to the western Atlantic, reaching South American coasts (see **Figure 4**).

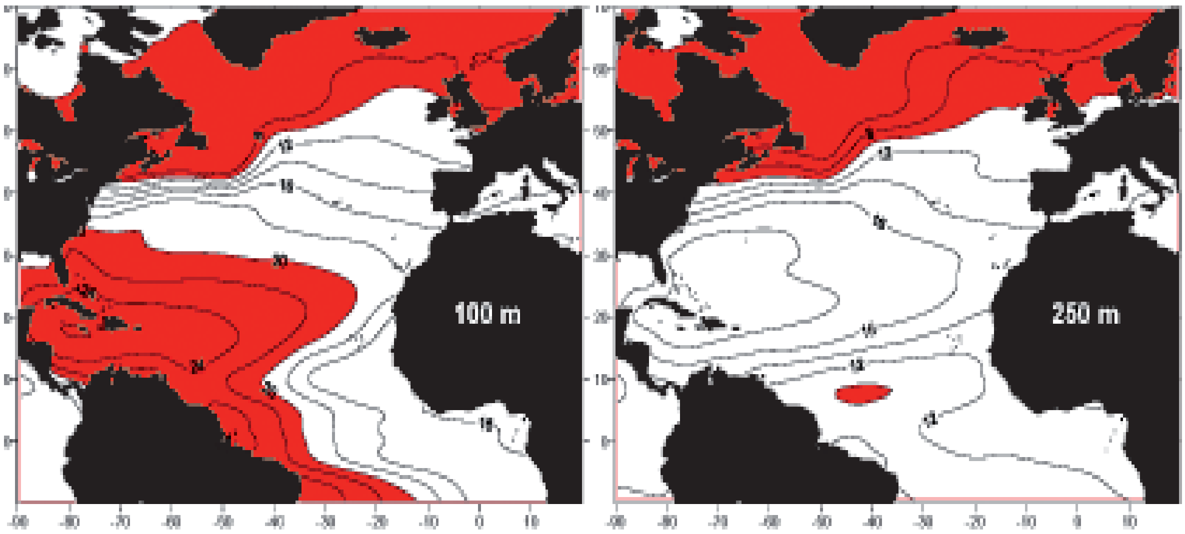

Figure 4. Yearly average dissolved oxygen (ml/l) at 100 m and 250 m depth in the North Atlantic. Areas in red are not suitable for albacore (after Da Silva *et al.* 1994).

3.b Growth

North Atlantic Albacore age determination and growth have been studied by means of different methodologies (i.e. otoliths, scales, vertebrae, spines, size frequency analysis and tagging). Depending on the authors and the methodology used, results vary to some extent (reviewed in Santiago 2004). The growth model adopted by ICCAT for North Atlantic albacore was obtained by Bard (1981) from spines analyses. However, when it comes to transforming catch-by-size into catch-by-age, ICCAT makes use of the equation derived by size frequency analysis using Multifan (Anon. 1996), which predicts similar mean lengths at age. Recently, Santiago (2004) proposed a new growth model integrating spines and tagging information ($L\infty$=122.198; K=0.209; t_0=-1.338).

In the south Atlantic, Lee and Yeh (1993) estimated a growth curve using spines, but Bard's (1981) growth equation for the North Atlantic stock was also used by ICCAT in the past. Lee and Yeh (2007) presented a revised growth curve based on the otolith's daily ring counts which was adopted to be used by ICCAT for transforming catch at size into catch at age. The estimated parameters of the von Bertalanffy growth models adopted by ICCAT are given in **Table 1**.

Regarding the Mediterranean albacore, recently a comprehensive study based on 1136 spine readings from albacore between 57 and 92 cm FL yielded the following von Bertallanfy growth parameter estimates: L_∞ = 94.7 cm; k=0.258 y^{-1}; t_0= -1.354 y (Megalofonou 2000).

Table 1. Growth parameters used by ICCAT for north and south Atlantic albacore ($L\infty$ in cm, K in y^{-1}, t_0 in y, Av.σ in cm).

Parameter estimates	*Reference*	*N*	*FL range (cm)*	*Methodology*	*Stock*
L_∞= 124.74; k= 0.23; t_0= -0.9892	Bard (1981)	352	46-113	Spines	North Atlantic
L_∞= 122.8; k= 0.217; p=8; Av.σ = 3.593; Ratio σ= 1.391	Anon (1996)			Size frequency (Multifan)	North Atlantic
L_∞=124.74; k= 0.23; t_0= -0.9892	Bard (1981)	352	46-113	Spines	South Atlantic
L_∞=142.28; k=0.145; t_0= -0.674	Lee and Yeh (1993)	353	85-117	Spines	South Atlantic
L_∞= 94.7; k=0.258; t_0= -1.354	Megalofonou (2000)	1136	57-92	Spines	Mediterranean
L_∞=147.5; k=0.126; t_0= -1.89	Lee and Yeh (2007)	344 125	51-130 81-117	Spines Vertebra	South Atlantic

•Av.σ is average standard deviation of length around length at age predicted by the Von Bertalanffy equation (Fournier *et al.* 1990).
•Ratio σ is σ of last age divided by σ of first age (Fournier *et al.* 1990).

3.c Length-Weight relationship

Until 1993, the general length-weight relationship adopted by ICCAT ($a=6.303 \times 10^{-6}$, $b=3.2825$) was the one developed by Beardsley (1971), based on fish that ranged from 60 to 115 cm FL. However, the first ICCAT Albacore Workshop (Anon 1990) recommended to build and properly document new area specific relationships based on a broader size range. The new length-weight relationships adopted by ICCAT for the northern, southern and Mediterranean stocks are shown in **Table 2**.

On the other hand, some length-weight relationships have recently been reported for Mediterranean albacore (Di Natale *et al.* 2005).

Table 2. Different albacore length-weight relationships currently used by ICCAT.

Equation	*Reference*	*N*	*FL range (cm)*	*Stock*
$W=1.339 \times 10^{-5} \times FL^{3.1066}$	Santiago (1993)	714	42-117	North Atlantic
$W=1.3718 \times 10^{-5} \times FL^{3.0973}$	Penney (1994)	1008	46-118	South Atlantic
$W=3.119 \times 10^{-5} \times FL^{2.88}$	Megalofonou (1990)	1742	55-89	Mediterranean

3.d Maturity

In general, there is a lack of exhaustive studies on Atlantic albacore sexual maturity. Lam Hoai (1970) estimated that first sexual maturity is reached at 75-85 cm FL, while Hayasi *et al.* (1972) assume sexual maturity occurs at 85 cm (around 13 kg). At present, for north and south Atlantic albacore it is assumed that 50% of the fish are mature at 90 cm or Age 5 (Bard 1981), and at 62 cm for Mediterranean albacore (**Table 3**, Arena *et al*. 1980).

Table 3. Sexual maturity assumed in ICCAT for Atlantic and Mediterranean albacore stocks.

Maturity	*Reference*	*Stock*
50% of mature fish at 90 cm (age 5)	Bard (1981)	North Atlantic
50% of mature fish at 90 cm (age 5)	Bard (1981)	South Atlantic
50% of mature fish at 62 cm	Arena et al (1980)	Mediterranean

3.e Sex ratio

According to Foreman (1980), for the Pacific tuna, and Bard (1981) for the Atlantic tuna, before sexual maturity is reached, there is a 1:1 sex ratio.

However, a higher presence of males in the larger length classes has been reported for *Thunnus alalunga* as well as for other species. As size increases, the proportion of males also increases up to a size where no females at all are found.

Bard (1981) concluded that this is due to differential growth and mortality. When sexual maturity is reached, the percentage of females per size decreases strongly, with a clear male prevalence in individuals longer than 85 cm. There are almost no females in sizes longer than 100 cm FL (Postel 1964, Bard 1981).

Megalofonou (1990) found a sex ratio of females to males in the Aegean Sea of 1:2.1 for a size range of 54 to 89 cm FL.

3.f Reproduction and first life stages

As the rest of the tuna, albacore does not show apparent sexual dimorphism in colour pattern or external morphological characters.

Spawning

They are multiple or batch spawners, shedding batches of hydrated oocytes, in separate spawning events, directly into the sea where fertilization occurs.

There is a close relationship between spawning and sea surface temperature: temperatures above 24ºC and a deep thermocline seem to stimulate maturation and reproductive activity in tunas. Apparently, spawning might be synchronised with high temperatures in order to enhance growth of eggs and larvae.

Spawning occurs in roughly the same offshore environments they normally inhabit. Albacore spawning areas in the Atlantic are found in subtropical western areas of both hemispheres and throughout the Mediterranean Sea.

Spawning grounds of the North Atlantic stock are found in waters offshore Venezuela, Sargassum Sea (Le Gall 1974, Nishikawa *et al.* 1985) and Gulf of Mexico (Richards 1969, 1984). In the South Atlantic, spawning occurs off the eastern Brazilian coast during the austral summer (Beardsley 1969, Koto 1969). In the Mediterranean, larvae have been found in several parts of the basin by numerous authors (Dicenta 1975, Lalami *et al.* 1973, Piccinetti and Manfrin 1993, García *et al.* 2002).

Spawning takes place during austral and boreal spring-summer. In the north Atlantic, reproduction events take place from April till September and some larvae are even found in the winter (Richards 1969, 1984), but the peak of spawning occurs around July.

Nocturnal spawning seems to be common among scombrids (as well as other groups of fishes) although there is not such evidence for albacore (reviewed in Schaefer 2001).

Eggs and larvae

Postel (1964) estimated fecundity in 2-3 million eggs per female.

Eggs are pelagic, spherical and transparent. Smaller than those of other tuna such as *Thunnus thynnus*, they are 0.84-0.94 mm of diameter and contain an oil globule of 0.24 mm of diameter. Yolk is homogeneous (Sanzo 1933).

Yolk-sac larvae are typically 2.5 mm when they hatch. Their differential characteristic, compared with the rest of tunas, is the lack of pigment in the caudal region (Nishikawa and Rimmer 1987).

Recruitment

Knowledge of the early life stages in tunas is very scarce. It is assumed that larval period is short. The beginning of the juvenile period has been established arbitrarily as to sizes escaping from plankton nets, around 2 cm (Bard 1981).

From 2 to 35-40 cm FL, juvenile tuna are not caught nor by plankton nets, commercial fishing or gamefish. Therefore, this life stage remains virtually unknown.

Young (immature) albacore first appear in surface catches when they are around 40 cm fork length. From this time on, it is easier to know their migratory movements both by observing the fisheries and by tagging experiments.

3.g Migrations

Albacore exhibit one of the longest fish migrations in the world. Although no migrations from the north to the south Atlantic have been recorded, some albacore have migrated from the north Atlantic to the Mediterranean and vice versa, and also transatlantic migrations have occurred (**Figure 5**). Nevertheless, albacore migration routes are still uncertain.

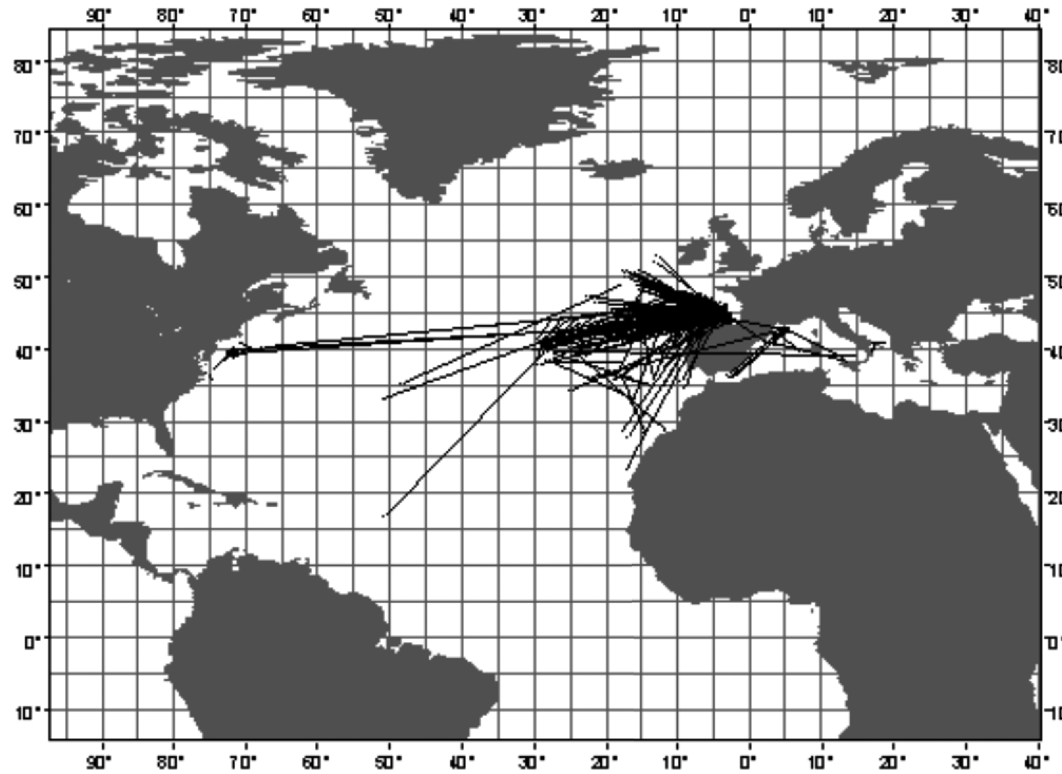

Figure 5. Horizontal displacement of 656 tagged and recovered albacore (Arrizabalaga *et al.* 2002).

In the North Atlantic, both juveniles and adults apparently spend winter time in the central Atlantic area (although they have been found in the east and the west as well). When water starts warming up in spring, young albacore start a trophic (feeding) migration, heading to highly productive waters in the northeast Atlantic part of their distribution range.

In May, tuna start to concentrate in surface waters near the Azores at 38ºN latitude and begin to move north in waters of 17-20ºC of temperature. Within a period of 1-2 months the population is located south-west of Ireland and in the Bay of Biscay (Ortiz de Zárate and Cort 1998). Although some authors hypothesised the existence of two different trophic migration routes for juvenile albacore, recent studies do not support that hypothesis (reviewed in Arrizabalaga 2003). At the beginning of autumn albacore starts migrating back to the mid Atlantic through the south of Portugal, the Canary Islands and Azores.

The trophic migration takes place for the first four years of their lifetime until they reach sexual maturity. Adult albacore, on the other hand, undertake reproductive migrations when summertime approaches. They migrate to their spawning grounds in the western part of north Atlantic (offshore Venezuela and Sargasso Sea) swimming at depths of 50-150 m.

Within the South Atlantic and the Mediterranean, very few tagging experiments have been made and therefore little is known about albacore migration patterns.

3.h Diet

Albacore are top carnivores and they opportunistically prey on schooling stocks of sardine, anchovy, mackerel and squid. Other authors have found that in the northeast Atlantic, albacore diet is mainly composed of fish, mainly *Trachurus trachurus* (Ortiz de Zárate 1987) and, to a lesser extent, of crustaceans (Hassani *et al.* 1997).

3.i Physiology

Tunas, including albacore, have a highly evolved circulatory system including countercurrent exchangers (*rete mirabile*) that act to reduce the loss of heat generated by increased muscular activity, allowing them to regulate their body temperature and ultimately, increase the efficiency of their muscles.

Regarding *Thunnus alalunga*, Graham and Dickson (1981) established that it is in the 11.5-18ºC temperature range where, thanks to this physiological adaptation, albacore are able to keep stable their red muscle temperature and, to a lesser extent, also white muscle temperature. Within this ambient temperature, average estimated temperature of red muscle was 20.7ºC. Outside that range, albacore shows a poorer thermoregulation capacity.

Additionally, albacore have higher blood pressure and volume than most of the other fish (Lai *et al.* 1987).

Regarding swimming speed, juveniles swim at 57 cm/s whereas adults swim at speeds slower than 45 cm/s (Dotson 1976). This high metabolic activity involves a high oxygen consumption. Bard (1982) estimated that albacore could not tolerate living in waters with an oxygen content lower than 2.5 ml/l. However, according to Sharp (1978), minimum tolerated values are 1.67 ml/l at 50 cm and 1.39 ml/l at 75 cm body length.

3.j Behaviour

In the Pacific Ocean, similar size albacore travel together in school groups that can be up to several miles wide. At the onset of the migration, (during the spring and summer months in the western Pacific Ocean), the young albacore form relatively small loose and broadly scattered groups. As the season progresses, the groups become more compact and contain greater number of schools. The more sedentary, older albacore typically form smaller, more compact and independent groups. In general terms, albacore schools are not as large or as dense as those of some other tuna species such as yellowfin or skipjack (Foreman 1980, Anon. 2001).

Although occasionally albacore may appear with some other tuna species, mixed species aggregations are not as frequent as they are among tropical tunas. Moreover, although some schools may be found in the vicinity of floating objects (Anon. 2001), the association with FADs is not as strong as in tropical tunas.

Knowledge about albacore vertical behaviour is very limited (Laurs *et al.* 1980, see "Habitat Preferences").

3.k Natural mortality

Natural mortality is assumed to be 0.3 per year for all year classes and for both the North and the South Atlantic stocks. The available tagging data for North Atlantic albacore do not allow for the reliable estimation of M as it is confounded with emigration from the main tagging area (i.e., Bay of Biscay). Ortiz de Zárate and Bertignac (2002) estimated a combined parameter: natural mortality plus emigration from the northeast Atlantic area was between 0.56 and 0.84. These estimates would not be inconsistent with the M value assumed by ICCAT.

More recently, Santiago (2004) compared natural mortality values obtained from different authors. Results were 0.322 and 0.325 according to Rikhter and Efanov (1976) and Pauly (1980) respectively and a vector of mortality of (0.541, 0.416, 0.351, 0.311, 0.285, 0.293, 0.318, 0.348, 0.385, 0.429, 0.486, 0.560) for ages 1-12 respectively following Chen and Watanabe (1988)'s method. This suggests that there is not enough reason to change the actual value assumed by ICCAT.

3.l Conversion factors

ICCAT´s databases and analyses make use of a number of formulae to convert between different types of measurements. In the case of albacore, relationships are shown in **Table 4** (see also "Length-Weight relationship" section).

Table 4. Conversion factors for Atlantic albacore.

Equation	*Reference*	*Geographical area*
$FL=3.6221 \times LD1^{0.9722}$	Bard (1981)	Gulf of Guinea

FL= Fork length (cm)
LD1= Pre-dorsal Length (cm)

4. Distribution and exploitation

4.a Geographical distribution

Widely distributed in temperate and tropical waters of all oceans, including the Mediterranean sea. Geographical limits are from 45-50 ºN to 30-40 ºS, but they are less abundant in surface waters between 10ºN and 10ºS (Collette and Nauen 1983). Its ample distribution explains the number and variety of fisheries that have developed throughout the world (**Figure 6**).

Adults (over 90 cm) appear in subtropical and tropical waters while immature albacore are found in temperate waters. In the Atlantic, the larger size classes (80 to 125 cm) are associated with cooler water bodies while smaller individuals tend to occur in warmer strata.

Distribution in the Atlantic Ocean: in the western Atlantic, they range from Nova Scotia to northern Argentina and in the east, from Ireland to South Africa.

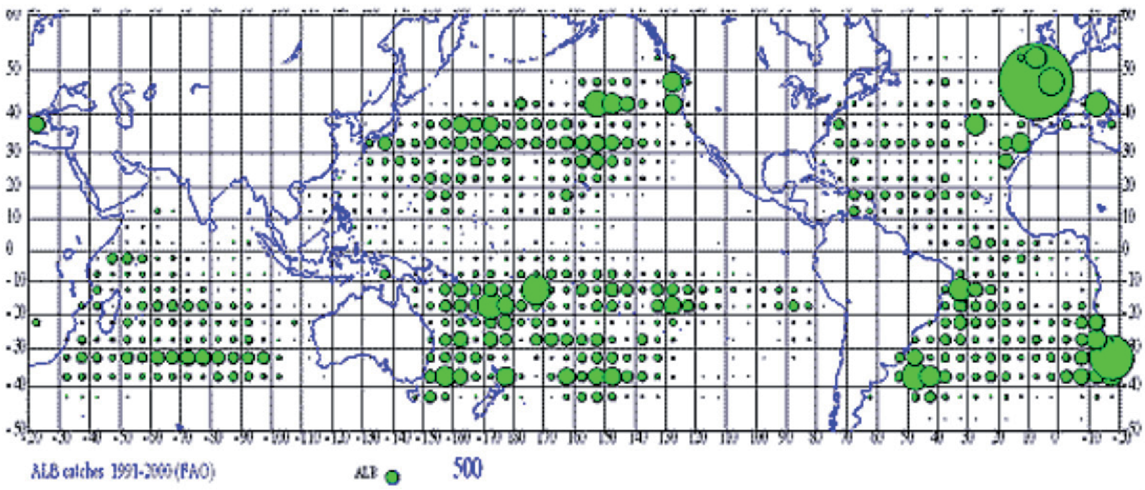

Figure 6. Geographical distribution of albacore from reported catches between 1991-2000 (courtesy of Alain Fonteneau).

4.b Populations/Stock structure

In the Atlantic Ocean, three stocks are considered for management purposes, a North Atlantic, a South Atlantic and a Mediterranean stock.

The northern and southern stocks were separated based on knowledge about spawning areas (Beardsley 1969; Koto 1969), spatial distribution of adults (Shiohama 1971, Uozumi 1996) and larvae (Ueyanagi 1971) and morphometric analyses (Ishii 1965). Afterwards, the existence of two different populations has been genetically confirmed using microsatellites (Takagi *et al.* 2001) and blood groups (Arrizabalaga *et al.* 2004). Moreover, there is a lack of evidence of migratory movements between the two hemispheres from tagging data.

The northern and southern Atlantic stocks are currently separated by the parallel 5ºN. Recent genetic analyses on albacore from the Gulf of Guinea (south of 5ºN) showed more similarity to northern than to southern albacore (Arrizabalaga *et al*. 2004), and albacore are caught as by-catch in equatorial latitudes by the tropical tuna purse seine fishery. However, it has been shown that the perception of the status of the stocks does not change significantly under alternative stock limits or under interstock migration hypothesis (Arrizabalaga 2003).

Although some authors suggested that there may exist more than one subpopulation in the North Atlantic area (possibly two), there is not enough scientific evidence to support this hypothesis and only one population is considered (reviewed in Arrizabalaga 2003).

The northern stock is considered to be independent from the Mediterranean stock based on the existence of an independent spawning zone in the Mediterranean (Dicenta 1975), different morphometrics (Bard 1981), different growth rates (Megalofonou 2000) and age of first maturity (Arena *et al.* 1980) and larvae distribution (FAO 1994). Tagging data are also concordant with this hypothesis, although some interstock migrations have been observed (Arrizabalaga *et al.* 2004).

4.c Description of fisheries: catches and effort

North Atlantic

The northern stock is exploited by surface and longline fisheries.

Surface fisheries mainly target juveniles and sub-adults (50 cm to 90 cm FL) that migrate swimming in surface waters. On the other hand, longliners catch adults and subadults (60-120 cm) moving in deeper waters. As for the geographical distribution of the fisheries, longliners concentrate their activity in the central Atlantic area whereas surface fisheries, nowadays taking the majority of the catches, mainly operate in the northeast Atlantic (Anon. 2004, **Figure 7**).

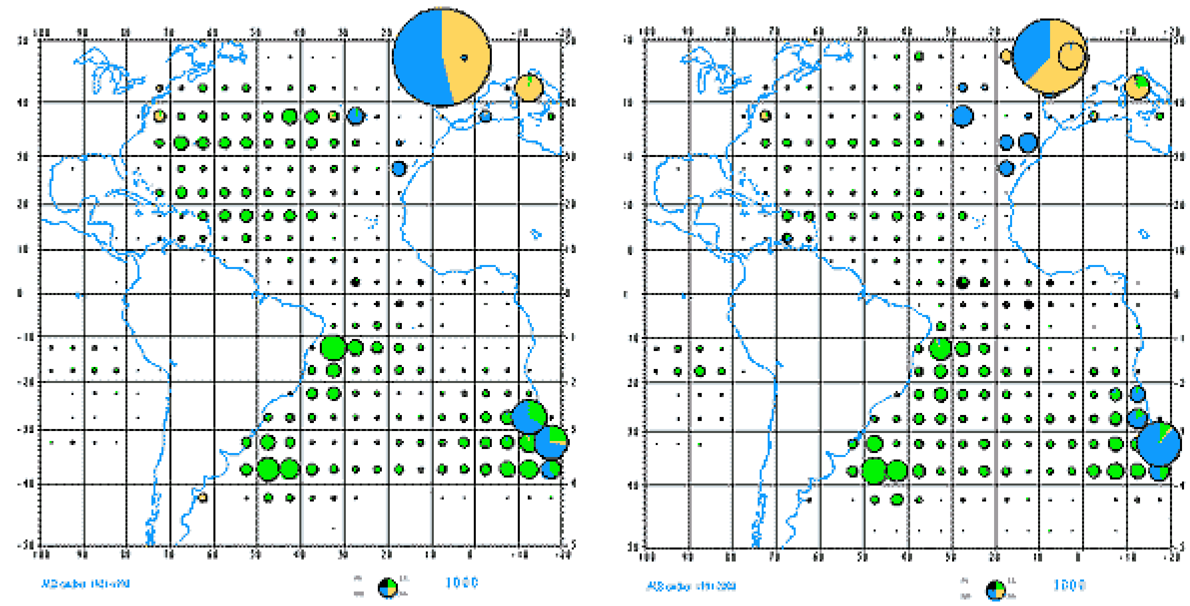

Figure 7. Catch distribution of albacore in the Atlantic Ocean and Mediterranean Sea for 1981-1990 (left) and 1991-2000 (right) disaggregated by fishing gears: PS (purse seine), LL (longline), BB (baitboat) and others (courtesy of Alain Fonteneau).

Traditional surface fisheries include Spanish trolling and baitboats, used mainly in the Bay of Biscay and adjacent waters. French trolling and baitboats were also important in the 1950-1960s and 1950-1970s, respectively. Other less important fisheries are Spanish and Portuguese baitboats operating in the Canary Islands and the Azores Islands.

New surface fishing gears, driftnets and pair pelagic/mid-water trawlers were introduced in 1987 in the Bay of Biscay and adjacent waters by EC-France. EC-Ireland and EC–United Kingdom joined the driftnet fishery at the beginning of the 1990s. Following an EC ban, due to the uncertainties on the effects these fishing gears might exert on both the ecosystem and on the dynamics of the albacore stock, the driftnet fishery stopped its activity in 2002.

Longline was introduced in the North Atlantic by the Japanese fleet in 1956, followed by other Asian fleets like Chinese Taipei and Korea and, to a lesser extent, Panama, Venezuela, Trinidad & Tobago, Cuba and the United States. The most important longline fleets (Chinese Taipei and Japan) changed their target to bigeye or moved to the South Atlantic, and at present albacore are caught mainly as by-catch by longline fleets operating in the central and western North Atlantic.

The total catch in the North Atlantic has shown a downward trend since the mid-1960s, largely due to a reduction of fishing effort by traditional surface (French) and longline (Chinese Taipei from 1987) fisheries. Nevertheless, the increased catch and effort by new surface fisheries since 1987 smoothed the general downward trend.

For the North Atlantic stock, catches were dominated by individuals of around 64 cm during the three time periods considered, although larger (mode around 75 cm) and smaller (mode around 50 cm) individuals were also an important part of the catch (**Figure 8**). These modes correspond to ages 1 to 3, mainly caught by troll and baitboat. In the latest period, the proportion of age 1 fish increased and the proportion of age 3 decreased with respect to the first period. On the other hand, the Chinese Taipei fishery catches large albacore (mode around 90 cm before 1987 and two peaks around 85 and 104 cm after 1987).

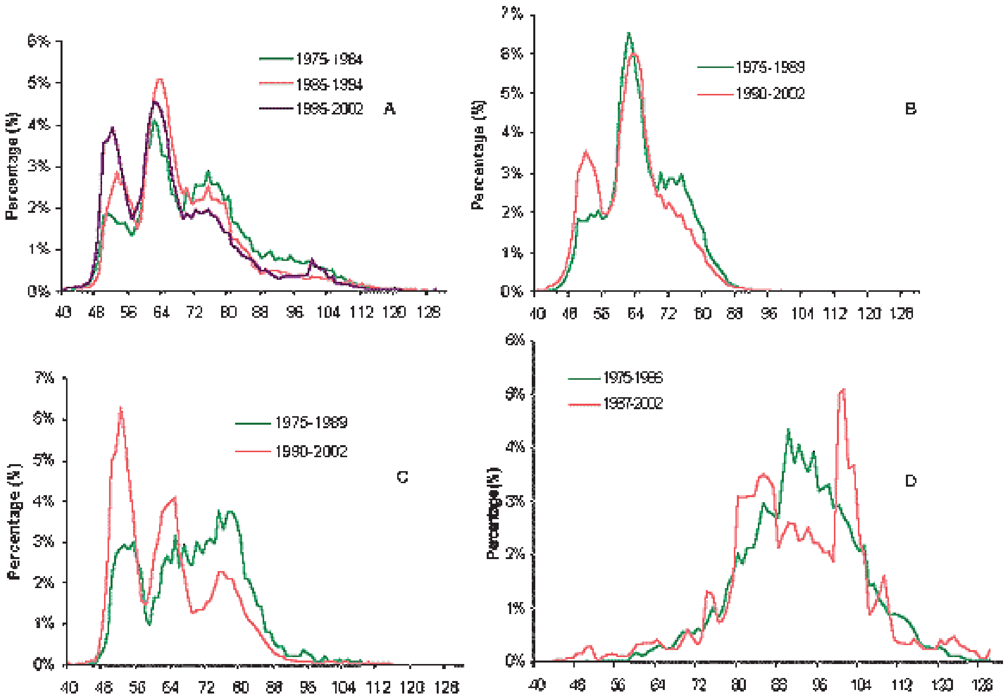

Figure 8. Size distribution of albacore catches in the North Atlantic stock: a) All fisheries, b) Trolling Spain, c) Baitboat Spain , d) Longline Chinese Taipei.

South Atlantic

The southern stock is mainly exploited by longliners. Catches taken by surface fleets have never exceeded 10,000 t per year. Only South Africa has a significant baitboat fleet whose catches represent 80% of the total catches made by surface gear. Other countries, such as Namibia, Brazil and Portugal, with baitboats, and Spain, the United States and France with purse-seiners catch southern albacore as well (Anon. 2004).

In the last five years, more than 90% of the total annual South Atlantic albacore landings were attributed to four fisheries, namely the surface baitboat fleets from South Africa and Namibia, and the longline fleets from Brazil and Chinese Taipei.

The surface fleets are entirely albacore directed and mainly catch juvenile fish (70-90 cm FL). These fisheries operate seasonally, from October to May, when albacore are available in coastal waters.

The longline fleets contain vessels that target albacore and vessels that take albacore as a by-catch in swordfish- or bigeye-directed fishing operations. On average, the longline vessels catch larger albacore (60-120 cm) than the surface fleets. The Chinese Taipei fleet expends substantial effort in the South Atlantic and the albacore catch (both directed and by-catch) by this fleet is about 56% of the global catch of South Atlantic albacore.

Surface and longline catches remained relatively constant at around 7,500 t and 20,500 t respectively since 1995-1999. This is due, in part, to the implementation of management regulations by some countries.

In 2000, South African baitboats recorded their lowest annual catch since 1983, due to the unavailability of albacore in near-shore waters. Brazilian longline albacore catches have declined in recent years due to a reduction of longline freezer vessels. Other albacore by-catches of note are made by Spanish, South African and Namibian longliners, with catches increasing steadily in recent years.

Catches in the South Atlantic stock tend to be of larger size: the majority of catch is composed of albacore between 70 and 90 cm during the three periods considered, although in the latter period a higher proportion of smaller fish (less than 65 cm) appears (**Figure 9**). The South African catches show a clear peak around 82 cm whereas the Chinese Taipei catches exhibit a wider size distribution with the majority of the fish between 70 and 110 cm.

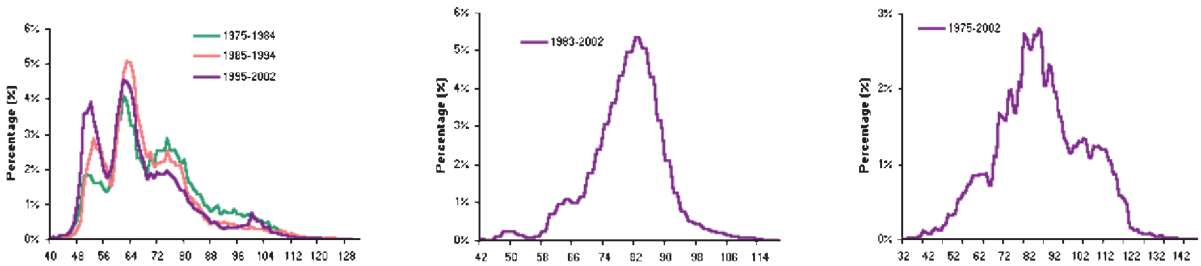

Figure 9. Size distribution (cm) of albacore catches in the South Atlantic: A) All fisheries, B) Baitboat South Africa, C) Longline Chinese Taipei.

Mediterranean

Italy and Greece are the countries mainly involved in the Mediterranean albacore fisheries, using driftnets, longline and purse seine. Albacore appears also as by-catch in French purse-seiners, coastal Spanish fleets and game fishing. The Spanish surface (trolling and baitboat) fleets catch albacore in the western Mediterranean in autumn after the season in the Bay of Biscay is over.

In general, the Mediterranean catches are highly uncertain. Estimated albacore catches, mainly by Italy and Greece, are still minor (less than 4,000 t) and do not show any significant trend over time. However, there is a lack of information concerning reported catches by many nations in recent years.

The trend of fishing effort of the various gears fishing for albacore in the Mediterranean Sea is still not possible to estimate, due to short time series and inadequate coverage of artisanal gears.

Information on size composition of the catch is also very limited.

4.d Catch-at-age

North Atlantic

It is clear that the first three age groups are those most represented in the catches, especially age 2 (**Figure 10**). There seems to be a decrease on the number of age 2 and age 3 fish in the last two years, and an increase in ages 1 and age 4 especially in the last year. Age 5 and older ages appeared relevant in the catches until 1986, when Chinese Taipei stopped a great part of its activity targeting this species in the North Atlantic.

South Atlantic

Unlike the North Atlantic stock, age 1 is hardly present in the catches except for a few occasional years (i.e. 1986, 1995; **Figure 10**). The rest of age groups are more evenly represented than in the North Atlantic stock. Ages 2 to 5 are the most abundant throughout the whole period, specially ages 3 and 4. However, the proportion of age 8 albacore catches is quite variable and are high some years.

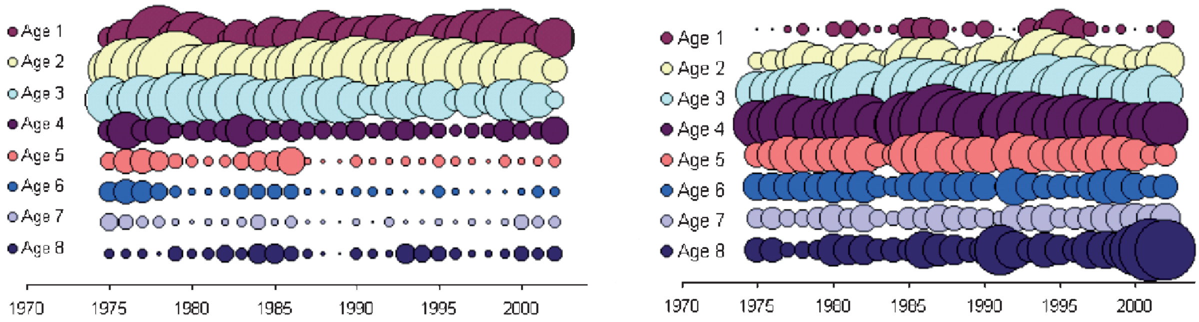

Figure 10. Catch at age of North Atlantic (A) and South Atlantic (B) albacore for the period 1975-2002 (Anon 2004).

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