CHAPTER 2.1.6: BLUE MARLIN	AUTHORS: F. AROCHA and M. ORTIZ	LAST UPDATE: Sept. 4, 2006

2.1.6 Description of Blue Marlin (BUM)

1. Names

1.a Classification and taxonomy

Species name: *Makaira nigricans* (Lacepède 1802)
Synonyms in use: none
ICCAT species code: BUM
ICCAT names: Blue marlin (English), Makaire bleu (French), Aguja azul (Spanish)

According to Nakamura (1985), blue marlin is classified as follows:

- Phylum: Chordata
- Subphylum: Vertebrata
- Superclass: Gnathostomata
- Class: Osteichthyes
- Subclass: Actinopterygii
- Order: Perciformes
- Suborder: Xiphioidei
- Family: Istiophoridae

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.

Azores Islands: Espadim azul
Barbados: Marlin
Benin: Ajètè, Adjètè
Brazil: Agulhão preto*, Agulhão, Marlim-azul
Canada: Makaire bleu *
Cape Verde: Espadim-azul, Espadarte, Blue marlin
China: 大西洋藍槍魚
Côte d'Ivoire: Espadon*
Cuba: Aguja casta, Abanico, Voladora
Denmark: Atlantisk blå marlin
Dominican Republic: Aguja azul, Marlin azul
Finland: Sinimarliini
France: Makaire bleu*
Germany: Blauer Marlin
Italy: Marlin azzurro, Marlin blu
Japan: Nishikurokajiki*
Korea: Nog-sae-chi
Martinique: Makaire bleu, Varé
Mexico: Marlín azul*
Morocco: Espadon*
Namibia: Blou marlyn
Netherlands Antilles: Balau blanku

Norway: Blå marlin
Portugal: Espadim-azul*, Espadarte-sombra
Puerto Rico: Blue marlin
Romania: Marlin albastru
South Africa: Blou marlin*
Spain: Marlin azul*
Trinidad y Tobago: Maman-balatre, Blue marlin
Uruguay: Marlin azul*
United Kingdom: Atlantic blue marlin*
United States of America: Atlantic blue marlin*
Venezuela: Aguja azul*, Marlin azul

2. Identification

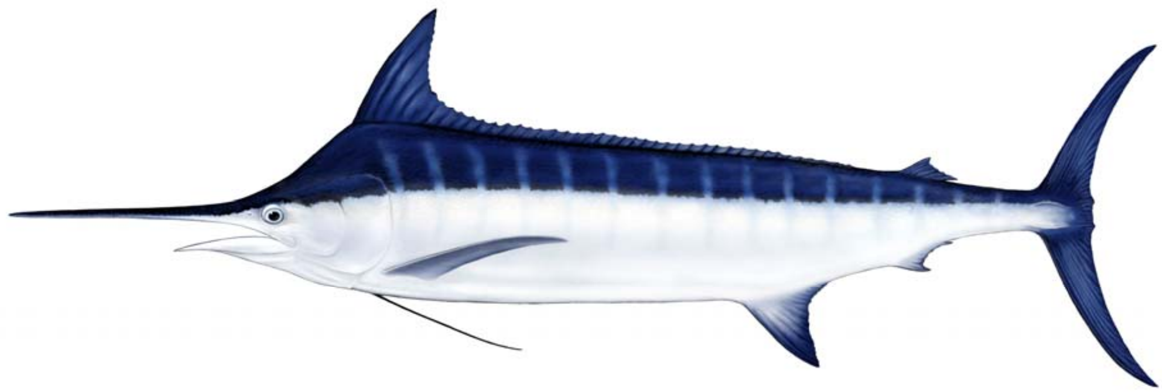

Figure 1. Drawing of an adult Atlantic blue marlin by Les Gallagher (Les Gallagher: fishpics).

***Characteristics of* Makaira nigricans** (see **Figure 1** and **Figure 2**)

Blue marlin is one of the large billfish species. Maximal size was reported by Robins and Ray (1986) in 910 kg, and 450 cm. Common sizes in the northwestern Atlantic are 180-300 cm lower jaw to fork length (LJFL) (Goodyear and Arocha 2001).

Regarding age, Hill *et al.* (1989) estimated maximum ages of 27 years for females and 18 years for males using anal fin spine sections of Pacific blue marlin from waters around Hawaii. Tagging experiments have shown that the longest time–at large of Atlantic blue marlin ever recorded was 11 years (Ortiz *et al.* 2003).

External:

- Elongated and not strongly compressed body, covered with densely imbedded scales ending in one or two long sharp points.
- Upper jaw prolonged into a long stout spear with round cross-section.
- Head profile (nape) between preorbital region and origin of first dorsal fin very steep.
- First dorsal fin long and low posteriorly, height of anterior part smaller than body depth.
- Pelvic fins shorter than pectoral fins.
- Caudal peduncle with double keels on each side, with a caudal notch on the dorsal and ventral surface.
- Two separated anal fins, first anal 13-15 rays, and second anal fin with 6-7 rays.
- Dorsal spines: 41-43 rays in first fin, 6-7 rays in second fin.
- Lateral line forming a reticulated system, evident in young fish, obscure in adults.
- Anal opening close to anterior origin of first anal fin.
- Vertebrae: 11 precaudal plus 13 caudal.
- No gillrakers, jaws and palatines with small teeth in adults.

Color:

- Dark blue on dorsal side, chocolate-brown laterally, and silvery white ventrally; several rows of vertical bars on sides, each bar composed of pale blue round spots on body.
- First dorsal fin membrane blue-black, lacking fin spots, remaining fins brown to black.

Internal:

- Gonads are symmetrical.
- Swimming bladder present, made up of many bubble-shaped, small chambers.

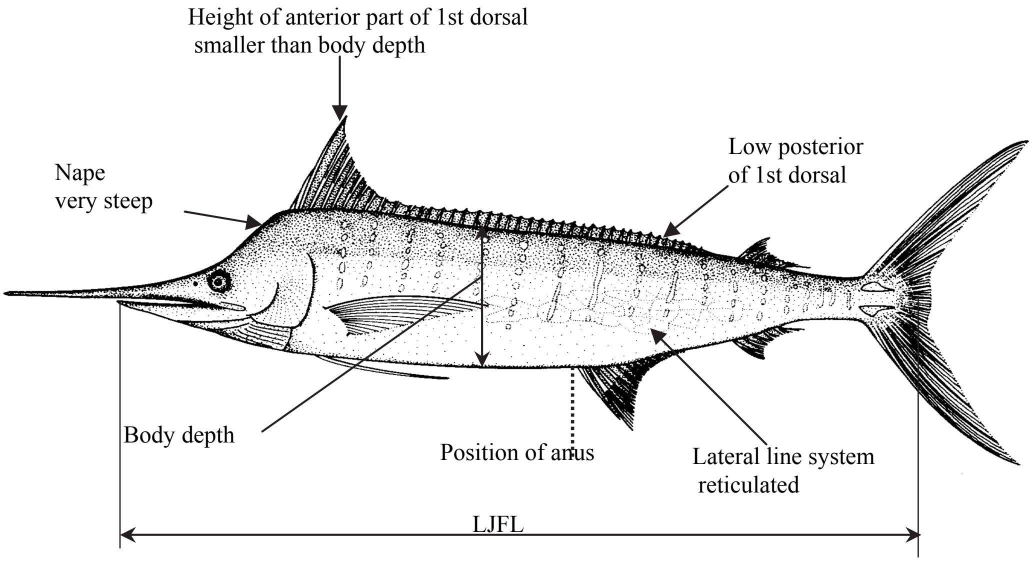

Figure 2. Synthesis of the most outstanding characteristics of *Makaira nigricans* (image by FAO).

External characteristics of blue marlin larvae

- Yolk-sac larvae unknown.
- Smallest known larvae of Atlantic blue marlin are 2.9 mm SL (Sponaugle *et al.* 2005). Body short and deep, snout short, eyes are large. Presence of large spine over eyes, and large preopercular spines. Pigmentation consists of chromatophores of any number and shape in lower jaw (its position may help differentiate between other species of billfish [Luthy *et al.* 2005]), as well on dorsal surface of braincase. Pigmentation increases as larvae grow. The head is big, representing around 40% of standard length. Teeth are large and tusk-like.
- Larvae >20 mm SL, no elongation of snout is observed, sail-like dorsal fin develops, preopercular spines reduce in size and disappear, caudal fin forks, pelvic fins become large. Pigmentation on dorsal fin develops in anterior part and 3 spots along base of fin (Gehringer 1956; Bartlett and Haedrich 1968).
- Juveniles (>200 mm SL), no upper bill present, fang-like teeth disappear, eye diameter becomes smaller, head spines become short and disappear with growth, first dorsal remains sail-like, pelvic fins remain long and narrow, lateral line forming a network pattern become visible (Caldwell 1962; Luckhurst *et al.* 2006).

3. Studies on biology and population

3.a Habitat preferences

An epipelagic oceanic species, blue marlin is often found in wide open blue waters with surface temperatures between 22-31°C. In the Atlantic Ocean, adults are commonly found in the tropics within the 24°C isotherm. However, habitat preferences of billfish are poorly known compared with tuna, one of the main reasons are the difficulties in holding these species in captivity. Therefore much of the information obtained recently is derived from modern electronic tag technology.

Temperature preferences for Atlantic blue marlin has been recently investigated from time-series analyzed for short-term (<40 days) habitat utilization using pop-up archival transmitting tags, and acoustic and pop-up satellite tags (PAT, PSATs) (Graves *et al.* 2000; Kerstetter *et al.* 2003; Saito *et al.* 2004). Results suggests blue marlin associate with the epipelagic zone and spends over 80% of its time in water temperatures ranging from 26-31°C. Although, it was also noted that blue marlin undergo frequent, short duration dives that allows them to cross temperature 14°C below of the sea surface temperature like those encountered in the study of the equatorial Atlantic (29°C [Saito *et al.* 2006]). Another study, utilizing short and long-term (7-90 days) pop-up archival transmitting tags, deployed 79 PSATs in several areas of the Atlantic between 2002 and 2004 (Goodyear *et al.* 2006), results indicated that blue marlin showed a mean minimum temperature preference of 17.4°C, but minimum observed temperature of 9°C was recorded for one tagged fish. Other studies suggest that the thermal preference for this species appears to be the warmest waters available in the open ocean, and it is hypothesized that the acceptable lowest temperature for blue marlin is around 15°C (Saito *et al.* 2006), which coincide with the bimodal distribution of blue marlin CPUE in the Atlantic, with one peak at 15°C and another at the highest temperature in which blue marlin were caught, 30°C (Goodyear 2003).

Depth distribution, from PAT and PSAT data, has indicated that blue marlin spent most of the time in warm near surface waters (<25 m) in the northwestern and equatorial Atlantic (Kerstetter *et al.* 2003; Saito *et al.* 2004). Results from the PAT and PSAT studies indicated that the species display frequent short duration vertical dives from surface waters to depths >300 m. However, most of the dive descents ranged from 100 to 200 m. The study of Goodyear et al. (2006) indicated that blue marlin often made deep, short duration dives below 800 m, and mean dive depths was 318.6 m estimated from 48 tagged fish, most of which occurred between 200 and 300 m.

Dissolved oxygen requirements for marlins are poorly known. However, Prince and Goodyear (2006) proposed that the minimal oxygen concentration for billfish is 3.5 ml/l, defining it as the hypoxic threshold for these species. Their contention was partly supported by measurements of oxygen consumption of juvenile sailfish which indicated that this species has the high oxygen consumption and associated metabolic rates typical of tropical tunas (Idrisi *et al.* 2002; Brill 1996).

3.b Growth

Preliminary work has been done investigating hard parts (otoliths and dorsal spines) of blue marlin for use in age and growth studies; research found significant relationship between length and both the radius and ring count of the hard parts examined (Prince *et al.* 1984). Larvae grow exponentially at a daily instantaneous growth rate of 0.086-0.125, but growth rates appeared to be habitat specific (Sponaugle *et al.* 2005). Based on analysis of daily otolith ring counts of juvenile fish, Atlantic blue marlin reach 24 cm LJFL in about 40 days, and about 190 cm LJFL in 500 days (Prince *et al.* 1991). Pacific blue marlin are estimated to reach ages of 27 years for females and 18 years for males using anal fin spine sections of Pacific blue marlin from waters around Hawaii (Hill *et al.* 1989); although this spine aging technique has not been validated. However, periodicity of ring formation in marlins for age validation has been recently initiated (Drew *et al.* 2005). Blue marlin can reach up to 450 cm TL, and exhibits sexually dimorphic growth patterns; females grow larger than males (Robins and Ray 1986; Wilson *et al.* 1991). Somatic growth of male Atlantic blue marlin slows at about 100 kg round weight (Wilson *et al.* 1991), males do not exceed 150 kg, while females can reach up to 910 kg. An estimate of longevity of 27+ years can be ascribed to blue marlin based on hard part aging techniques (Hill *et al.* 1989). The maximum time at large recorded for Atlantic blue marlin was about 11 years (Ortiz *et al.* 2003). There is no existing growth model adopted by ICCAT for blue marlin.

3.c Length-Weight relationship

Until 1992, the sex specific length-weight relationships adopted by ICCAT were the ones developed by Prince and Lee (1989), based on male fish that ranged from 147.3 to 246.0 cm LJFL, and female fish that ranged from 149.8 to 331.5 cm LJFL. Later, in the second Billfish Workshop, Prager *et al.* (1994, 1995) revised existing data on length and weight to produce new equations for the length-weight and weight-length conversions, and created a new set of equations to estimate LJFL from several length measurements. The new length-weight relationships adopted by the ICCAT Billfish Workshop for the blue marlin stock are shown in **Table 1**.

Table 1. Different blue marlin length-weight relationships currently used by ICCAT.

Equation	*Reference*	*N*	*Sex*	*LJFL range (cm)*
$RWT = 2.4682 \times 10^{-6} LJFL^{3.2243}$	Prager *et al.* (1995)	1978	Male	23.0-378.5
$RWT = 1.9034 \times 10^{-6} LJFL^{3.2842}$		3267	Female	23.0-277.0
$RWT = 1.1955 \times 10^{-6} LJFL^{3.3663}$		5245	Combined sex	23.0-378.5

3.d Maturity

In general, there is a lack of exhaustive studies on blue marlin sexual maturity. Erdman (1968) ascribe that blue marlin attains sexual maturity at around 45 kg (180 cm LJFL), based from samples obtained in the waters of Puerto Rico and Virgin Islands. Later, de Sylva and Breder (1997) assumed sexual maturity to occur when females reached 120 kg (237.9 cm LJFL). Recently, Arocha and Marcano (2006) estimated that 50% of females are mature at 256.43 cm LJFL based on macroscopic and microscopic assessment of gonad samples caught between 5°N and 25°N. The available sexual maturity estimates for the Atlantic blue marlin stock are shown in **Table 2**.

Table 2. Different sexual maturity estimates available for Atlantic blue marlin stock.

Maturity	*Reference*
50% of female fish mature at 256.43 cm LJFL	Arocha and Marcano (2006)
First maturity of female fish at 180 cm LJFL	Erdman (1968)
First maturity of female fish at 237.9 cm LJFL	de Sylva and Breder (1997)

3.e Sex ratio

According to de Erdman (1968), the annual average male:female sex ratio was 4:1, obtained from 328 fish in the waters around Puerto Rico and Virgin Islands. However, a monthly change in the sex ratio was observed between July and September. From July to August, the male:female sex ratio was not different than the expected 1:1, but in September, the male:female sex ratio shifted towards 4.5:1.

In a recent study on the biology of billfish in the western central Atlantic (5°N-25°N), sex ratio at size of blue marlin (n=7776) displayed a seasonal pattern between trimesters (Arocha 2006). Within the Caribbean Sea, during the second, third and fourth trimesters, the proportion of females increased with size from 20% at 170 cm LJFL to more than 75% at sizes >250 cm LJFL. In the first trimester, the proportion of females increased up to 40% at sizes <200 cm LJFL. In the Atlantic side, north of the Island of Barbados, the proportion of females was less than 20% for female sizes between 160 and 200 cm LJFL.While south of the Island of Barbados, the proportion of females was around 50% for female sizes of 150-200 cm LJFL. In general, as size increases, the proportion of females also increases up to a size (>275 cm LJFL) where very few males are found.

In the South Atlantic, the estimated male:female sex ratio was 1.15:1, obtained from 43 specimens (Amorim *et al.* 1998).

These studies, conducted in the western Atlantic, revealed that blue marlin display a differential spatial and seasonal sex ratio pattern; it also indicated that in the months when the sex ratio was different from the expected 1:1 ratio, males were more prevalent at sizes <200 cm LJFL. However, the sex ratio issue has never been formally addressed in any of the ICCAT Billfish Workshop.

3.f Reproduction and first life stages

As the rest of the billfishes, blue marlin do not show apparent sexual dimorphism in color pattern or external morphological characters.

Spawning

Blue marlin are batch spawners, shedding batches of hydrated oocytes in separate spawning events (de Sylva and Breder 1997), most likely directly into the sea where fertilization occurs.

Spawning occurs in roughly the same offshore environments they normally inhabit. Blue marlin spawning areas in the Atlantic are mainly found in the tropical western areas of both hemispheres.

Spawning grounds in the Atlantic are poorly known. In the North Atlantic, spawning females and larvae have been found in waters of the Straits of Florida (United States), Puerto Rico, Bahamas, Jamaica, and Bermuda (Erdman 1968; Caldwell 1962; Serafy *et al.* 2003; Luthy 2004; Luckhurst *et al.* 2006). Spawning females have been recorded off Puerto Rico, and more recently off Bermuda. Spawning sites inferred from larvae collections have been reported from the Straits of Florida, Exuma Sound (Bahamas), and from juvenile fish captured off Jamaica and off Bermuda. In the equatorial Atlantic (5°N-5°S), spawning takes place in the waters of northeastern Brazil (Travassos *et al.* 2006). In the South Atlantic, spawning recorded from reproductively active females and larvae collections occur off the southern Brazilian coast between 10-30°S (Ueyanagi *et al.* 1970; Amorim *et al.* 1998).

Spawning take place during austral spring-summer and boreal summer. In the North Atlantic, reproduction events take place from May till October, but the peak of spawning seem to occur around June-July. In the equatorial Atlantic (7°N-20°S), spawning seem to occur during June-August; and in the South Atlantic, reproduction events take place from November till April.

Eggs and Larvae

Batch fecundity for female fish between 227 and 290 cm LJFL was estimated to be 3.600.960 to 6.769.060 oocytes per female (Travassos *et al*. 2006).

Eggs are pelagic, spherical and transparent; whole hydrated oocytes are between 0.9-1.8 mm in diameter and contain an oil globule measuring about 0.30 mm in diameter (Travassos *et al.* 2006; Luckhurst *et al.* 2006). Yolk is not homogeneous (de Sylva and Breder 1997).

Yolk-sac larvae unknown, but could be around 2 mm SL. Smallest known larvae of Atlantic blue marlin are 2.9 mm SL, and were caught off the Straits of Florida (Sponaugle *et al.* 2005).

Recruitment

Knowledge of the early life stages in billfishes is very scarce. It is assumed that larval period in blue marlin is short due to fast growth during this period (Sponaugle *et al.* 2005).

From 2.9 to 22.6 mm SL blue marlin larvae are caught by neuston nets (Serafy *et al.* 2003; Luthy 2004; Sponaugle *et al.* 2005). Juveniles >200 mm SL, are rare events, occasionally collected by nightlight and dip net (Luckhust *et al.* 2006), and on stomach contents of tunas, and other billfish.

Young (immature) blue marlin first appears in the catches when they are around 50 cm LJFL. From this time on, it is easier to know their migratory movements both by observing the fisheries and by tagging experiments.

3.g Migrations

Blue marlin display extensive movements in the Atlantic, as revealed by the release-recovery vector of tagged recaptured fish (**Figure 3**). Most of which indicate trans-equatorial and inter-oceanic movements from the Atlantic into the Indian Ocean (Ortiz *et al.* 2003). Nevertheless, blue marlin migration routes are still uncertain.

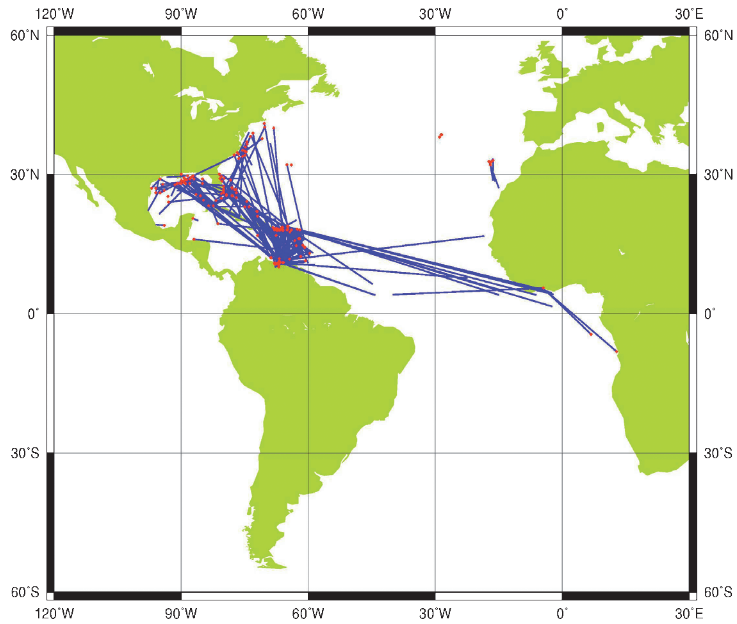

Figure 3. Horizontal displacement of 596 tagged and recovered blue marlin (source Ortiz *et al.* 2003).

The western North Atlantic is where most of the tag and release of blue marlin has taken place. Significant movement is observed between the US mid-Atlantic coast, and the Gulf of Mexico to Venezuelan waters. In general, most of the tagged recaptured fish has occurred in the same general area as the point of release (Puerto Rico, Virgin Islands, La Guaira-Venezuela). The few transatlantic and trans-equatorial movements represent about 5% of the documented blue marlin recaptures. The longest distance travelled was recorded from a blue marlin tagged and released in Delaware (USA) in the west North Atlantic and recaptured off Island of Mauritius in the Indian Ocean. The travelled a distance was 14893 km after 1108 days at large (Ortiz *et al*. 2003).

It has been hypothesized that the concentration of blue marlin in the southern Caribbean Sea, correspond to spawned fish moving towards feeding ground to restore energy, as observed from the movement trajectories from tagged recaptured fish off northern Venezuela and the high proportion of stomachs with food items, showing no signs of active spawning activity (Arocha and Marcano 2006).

Within the South Atlantic, very few tagging experiments have been made and therefore little is known about blue marlin movement patterns in the area.

3.h Diet

Blue marlin are apex predators that feed near the surface and are known to feed in deeper water than other billfish. They opportunistically prey on schooling stocks of flying fishes, small tunas, dolphinfish, and squids. In the southern Caribbean Sea, blue marlin diet is composed mainly of the squid, *Illex coindetti*, followed by *Sardinella aurita*, and *Dactylopterus volitans* (Garcia de los Salmones et al. 1989). In the waters off Bahama, Puerto Rico and Gulf of Mexico, most prey items include all sizes of dolphinfish (*Coryphaena*), frigate mackerel (*Auxis*), and deep sea fishes like *Pseudoscopelus* (Nakamura 1985). Other prey items include scombrid fishes (including bigeye tuna weighting about 50 kg), snake mackarels, and octopods.

In the North and tropical Atlantic, about 85% of the diet was of fish prey and most of the rest prey items were composed of cephalopods. Among prey fish, species of the families Gempylidae followed by the Scombridae comprised about 66% in importance, and the rest was formed by prey species of the families Exocotidae and Alepisauridae (Satoh *et al.* 2004).

In the western equatorial Atlantic, the most important prey fish for blue marlin was the pomfret, *Brama brama*, the snake mackerel, *Gempylus serpens*, and *Dactylopterus volitans*. Among the cephalopod prey, the squid, *Ornithoteuthis antillarum* was the most important prey item followed by the squid *Omastrephes bartrami* and the octopod, *Tremoctopus violaceus* (Junior *et al.* 2004).

3.i Physiology

Billfishes, like tunas, have anatomical and physiological adaptations for continuous swimming, and cranial endothermy (brain and eyes) which facilitate foraging at different depths. Blue marlin, like the other billfish, feature a thermogenic organ situated beneath the brain and close to the eyes that generates and maintains elevated temperatures in the cranial region (Block 1986). This thermogenic organ or 'brain heater' facilitates the deep diving behaviour in marlins by permitting ocular and physical functions at low temperatures.

Additionally, recent research into the vision of blue marlin indicates that the eyes are specifically adapted for the low light levels encountered during diving (Fritsches *et al.* 2003).

Regarding swimming speed, the available data come from analysis of minimum straight line distances calculated from PSAT data on adult blue marlin (Graves *et al.* 2002; Kerstetter *et al.* 2003). Average displacements were estimated between 0.73 and 0.95 nmi/hr from point of release.

3.j Behaviour

Blue marlin, like all marlins, are not schooling fish. They are considered rare and solitary species.

Advances in research behaviour of billfishes have been slow due to the difficulty of holding them in captivity and the lack tracking technology for long term monitoring (Holland 2003). However, traditional tags and PSAT information, along with biological information on spawning sites and season, as well as feeding habit information can help in identify reproductive behaviour patterns.

The spawning sites (because spawning grounds are poorly known) in the northern Caribbean Sea (Puerto Rico and Virgin Islands) and Bahamas appear to concentrate spawning fish during the summer that move into the warm waters of the area from feeding grounds in the northeastern coast of the United States, the Gulf of Mexico and the southern Caribbean Sea; after spawning, fish move back to the feeding grounds. Larvae and juvenile fish collections around spawning sites and along the pathway to/from spawning sites (Bahamas, Jamaica) help to support the reproductive behaviour of adult fish associated with spawning in the western central Atlantic. However, little is know of the reproductive behaviour in other parts of the Atlantic.

Knowledge about blue marlin vertical behaviour has been suggested from PAT and PSAT studies (Goodyear 2003; Goodyear *et al.* 2006; Kerstetter *et al.* 2003; Saito *et al.* 2004, see "Habitat Preferences").

3.k Natural mortality

No reliable estimates of natural mortality rates are available. Tagging data are insufficient for that effort. Estimating M from growth parameters is limited because they have not been estimated. Natural mortality based on the estimated longevity would rand range from 0.15 to 0.30, but would only reflect total mortality, unless there is no fishing. However, based upon body size, behaviour, and physiology, estimates of adult fish would likely be fairly low (Anon. 1994, 1998).

In the study of Goodyear and Prager (2001), an estimate of Z=0.36/year was obtained from the work of Wilson et al. (1991), which coupled with surplus-production model estimates of *F* from blue marlin's ICCAT stock assessment averaged 0.31/year, giving an estimate of M=0.05/year. However, estimates of absolute *F* from surplus production models are often highly imprecise (Prager 1994), and based on biological considerations, authors believed it was unrealistically high.

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 blue marlin, relationships are shown in **Table 3** (see also "Length-Weight relationship" section).

Table 3. Conversion factors for blue marlin (TL: Total length; PAL: Pectoral-anus length; PFL: Pectoral-fork length.

Equation	*Sex*	*N*	*Length range (cm)*	*Reference*
$LJFL = -3.563 + TL \times 0.784$	Female	69	250-490	Prager *et al.* (1995)
$LJFL = 19.182 + TL \times 0.691$	Male	153	200-330	
$LJFL = 2.000 + TL \times 0.763$	Combined sex	258	30-500	
$LJFL = 19.464 + PAL \times 2.707$	Female	123	34-120	
$LJFL = 93.600 + PAL \times 1.600$	Male	249	35-90	
$LJFL = 61.656 + PAL \times 2.156$	Combined sex	453	30-120	
$LJFL = 9.725 + PFL \times 1.252$	Female	243	80-270	
$LJFL = 14.651 + PFL \times 1.209$	Male	387	100-220	
$LJFL = 7.696 + PFL \times 1.261$	Combined sex	732	65-280	
$LJFL = 17.419 + PDL \times 1.726$	Female	140	85-190	
$LJFL = 36.500 + PDL \times 1.500$	Male	276	66-150	
$LJFL = 9.836 + PDL \times 1.772$	Combined sex	482	60-190	
$LJFL = 10.000 + EOFL \times 1.091$	Female	113	130-300	
$LJFL = 9.095 + EOFL \times 1.095$	Male	104	135-210	
$LJFL = 8.887 + EOFL \times 1.096$	Combined sex	250	120-300	
$LJFL = 10.254 + DFL \times 1.198$	Female	115	125-280	
$LJFL = 4.302 + DFL \times 1.231$	Male	125	115-200	
$LJFL = 7.152 + DFL \times 1.212$	Combined sex	271	100-280	
$DWT = 1.20 \times RWT$	Combined sex	-	-	ICCAT *Field Manual* (1990)

PDL: Pectoral-second dorsal length;
EOFL: Eye orbit-fork length;
DFL: Dorsal-fork length;
DWT: Dressed weight).

4. Distribution and exploitation

4.a Geographical distribution

Blue marlin are widely distributed in subtropical and tropical waters of the Atlantic Ocean, and occasionally in Atlantic temperate waters. Geographical limits are from 50ºN to 45ºS, but they are less abundant in waters of the eastern central Atlantic and the south central Atlantic (**Figure 4**).

Adults (>150 cm LJFL) appear in temperate, subtropical and tropical waters while juvenile blue marlin (<100 cm LJFL) are found in tropical waters. In the Atlantic, the larger size classes (>200 cm LJFL) can be associated with cooler water bodies while smaller individuals tend to occur in warmer strata.

In the western Atlantic, important concentrations are present in the United States southeast coast, Gulf of Mexico, the north and eastern Caribbean Sea, the western equatorial area, and along the Brazilian coast through to 30°S. In the eastern Atlantic, important concentrations are in the Gulf of Guinea and adjacent areas. Important concentrations occur across in the equatorial Atlantic.

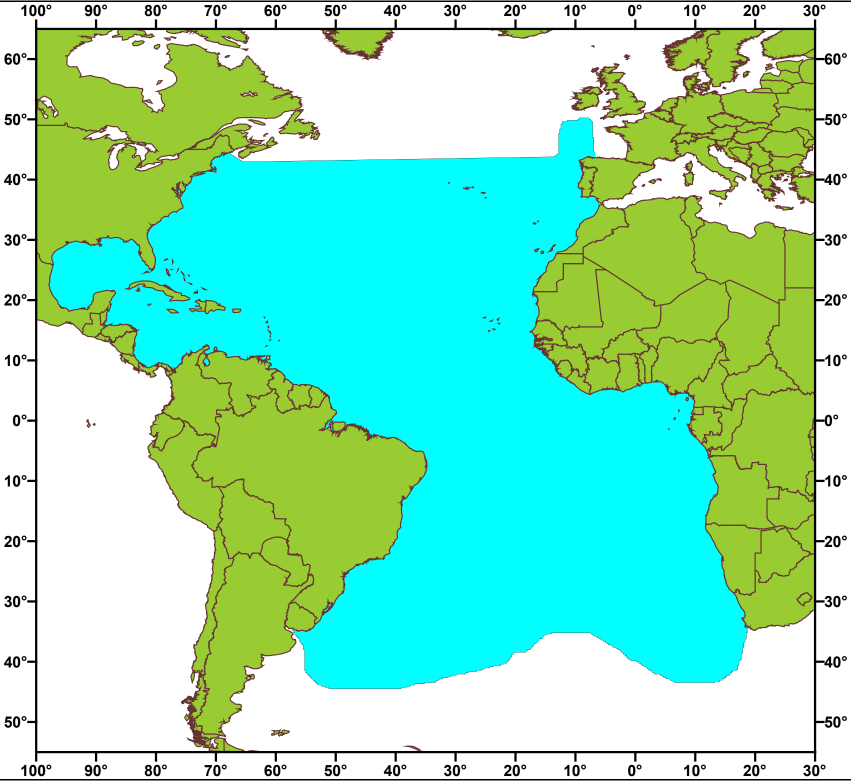

Figure 4. Geographical distribution of blue marlin from reported catches between 1970 and 2004 (source: ICCAT).

4.b Populations/Stock structure

In the Atlantic Ocean, one stock is considered for management purposes.

Originally, ICCAT recognized two stocks separated at the 5°N latitude. The stock boundary was based on the distribution of catch, the seasonally displaced of spawning areas north and south of 5°N, and that no fish tagged north of 5°N had been captured south of that latitude.

In recent years, detailed genetic analyses using mitochondrial and nuclear markers have shown no evidence of genetically based stock structure within the Atlantic, and analyses of samples north and south of 5°N do not reveal significant heterogeneity (Graves and McDowell 2003). Therefore, ICCAT considers an Atlantic wide stock for blue marlin (Anon. 2001).

4.c Description of fisheries: catches and effort

Billfishes are primarily the target of recreational and sport fisheries around the world, and blue marlin is one of the top-prize species. However, some local and artisanal fisheries exist for marlins, particularly in the west coast of Africa, the Caribbean Islands, and coastal regions of Central and South America. There are no large commercial fisheries targeting Atlantic blue marlin, nonetheless, billfishes (including blue marlin) are caught as by-catch in the longline and purse seine tuna fisheries in the Atlantic Ocean.

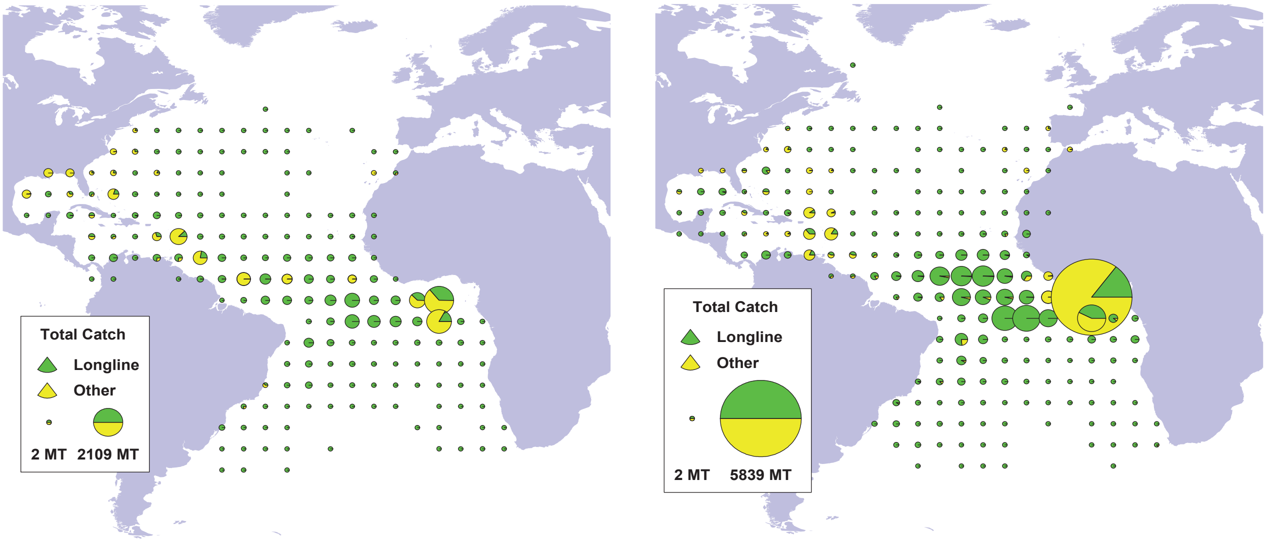

Figure 5. Catch distribution of blue marlin in the Atlantic Ocean for 1980-1989 (left) and 1990-1999 (right) disaggregated by main fishing gears, longline and others.

Blue marlin catches concentrate mainly in the tropical areas (**Figure 5**). By-catch of blue marlin in the tuna longline fleets accounts on average for 80% of the total estimated catch (Anon. 2006a). Purse-seine by-catch is mainly in the Gulf of Guinea. Artisanal and local fisheries use primarily surface-drift gillnets (Arocha 2006), but in recent years surface longlines attached to moored buys that act as fishing attracting devices (FADs) have been introduced in some Caribbean islands (Reynal *et al.* 2006). Sport and recreational fisheries are concentrated in the U.S. Atlantic east coast and in the Caribbean islands. In South America, sport fisheries are present off Venezuela and Brazil. In the East Atlantic, the main recreational fisheries for blue marlin are in Madeira and Cape Verde Islands (Harvey 2002).

The total catch of Atlantic blue marlin increased rapidly with the introduction of the longline fleets in 1956, reaching the highest catches by the early 1960s, with estimated catches over 9,000 t in 1963. By 1967, catches dropped below 3,000 t and remained between 2,000 and 3,000 t until the end of the 1980s. In 1995-97, catches increased to 5,000 t; since then, they have dropped to about 2,500 t (**Figure 6**). Because marlins are not a target species, estimates of blue marlin catch by the longline fleets are uncertain and likely underestimated (Anon. 2006a). Moreover, in recent years due to management regulations, most of the blue marlin by-catch is release or discarded at sea (Anon. 2006b), that, combined with low coverage by observers, hinder even further the ability to get reliable estimates billfish catches. Catches from coastal artisanal fisheries, mainly gillnet have increased in recent years, however it may reflect a better reporting rather than an increase catch, particularly from the of west African coast and Caribbean islands (N'goran *et al.* 2001; Arocha 2006). Sport fisheries catch shows a decline from 300 t in the early 1980's to less than 50 t in 2000. This decline is in part due to the switch of recreational fisheries towards predominant catch-&-release activities. Blue marlin catch split approximately equally between North and South Atlantic until 1990s when catches in the South Atlantic increased up to 70% of the total catch (Anon. 2006).

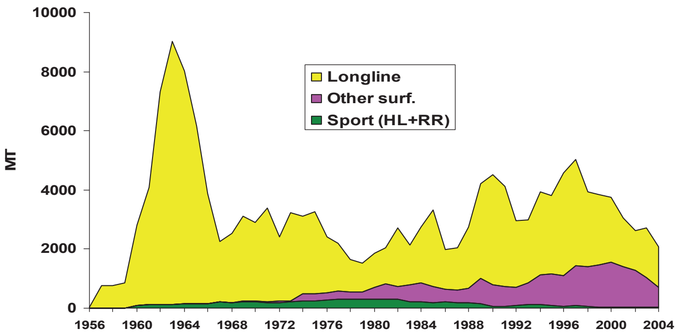

Figure 6. Blue marlin estimated total catch by main gears, 1956–2004.

4.d Catch-at-size

There are no estimates of catch-at-age for blue marlin. Size (in LJFL) distributions of catch by main gear show that the longline fisheries catch smaller blue marlins (115 to 295 cm 95% percentile, with a median of 195 cm) compared to recreational fisheries (165 to 355 cm 95% percentile, with a median of 235 cm), and gillnet fisheries (170 to 325 cm 95% percentile, with a median of 235 cm) (**Figure 7**). However, the gillnet size sampling is restricted to few years (1997-1999). For the longline fisheries, the mean size of blue marlin caught has declined with the years from 210 cm (1970s) to 190 cm in the 1990's.

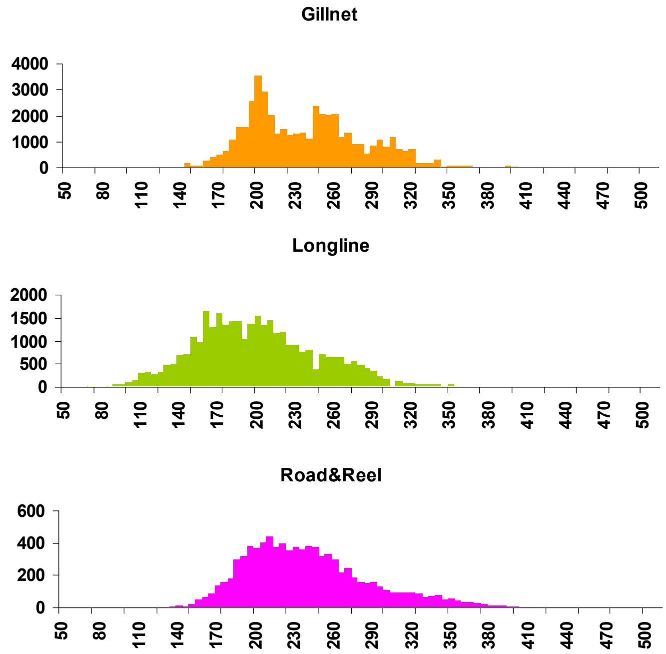

Figure 7. Size (LJFL cm) frequency distribution of blue marlin by main gear.

5. Bibliography

ANON. 1994. Report of the Second ICCAT Billfish Workshop. Collect. Vol. Sci. Pap. ICCAT, 41: 587.

ANON. 1998. Report of the Third ICCAT Billfish Workshop. Collect. Vol. Sci. Pap. ICCAT, 47: 352.

ANON. 2001. Report of the Fourth ICCAT Billfish Workshop. Collect. Vol. Sci. Pap. ICCAT, 53: 375.

ANON. 2006. Report of the Data Preparatory Meeting for the 2006 Billfish Assessment (Natal-RN), Brazil. Collect. Vol. Sci. Pap. ICCAT, 59: 1-123.

ANON. 2006b. Report of the 2006 ICCAT Billfish Stock Assessment. Collect. Vol. Sci. Pap. ICCAT, 60(5): 1431-1546 (2007).

AMORIM, A.F., C.A. Arfeli, J. N. Antero-Silva, L. Fagundes, F. E. S.Costa, R. Assumpção. 1998. Blue marlin (*Makaira nigricans*) and White marlin (*Tetrapturus albidus*) Caught off the Brazilian Coast. Collect. Vol. Sci. Pap. ICCAT, 47: 163-184.

AROCHA, F. 2006. Los peces de la familia Istiophoridae capturados por las flotas de Venezuela: Aspectos biológicos, pesquerías y gestión pesquera. Trabajo de ascenso para profesor asociado presentado en la Universidad de Oriente, 141 p.

AROCHA, F. and L. Marcano. 2006. Life history characteristics of *Makaira nigricans, Tetrapturus albidus*, and *Istiophorus albicans* from the eastern Caribbean Sea and adjacent waters. Pgs. 587-597 In J. Nielsen, J. Dodson, K. Friedland, T. Hamon, N. Hughes, J. Musick and E. Verspoor, Eds. Proceedings of the Fourth World Fisheries Congress: Reconciling Fisheries with Conservation. Amer. Fish. Soc. Symp. 49, Bethesda, Maryland.

BARTLETT, M.R. and R.L. Haedrich. 1968. Nueston nets and South Atlantic larval blue marlin (*Makaira nigricans*). Copeia 1968: 469-474.

BLOCK, B.A. 1986. Structure of the brain and eye heater tissue in marlins, sailfish, spearfish. J. Morphol., 190: 169-189.

BRILL, R.W. 1996. Selective advantages conferred by the high performance physiology of tunas, billfishes, and dolphin fish. Comp. Biochem. Physiol., 113: 3-15.

CALDWELL, D.K. 1962. Postlarvae of the blue marlin, *Makaira nigricans*, from off Jamaica. Los Angeles Contributions in Science, Number 53: 1-11.

DE SYLVA, D. and P.R. Breder. 1997. Reproduction, gonad histology, and spawning cycles of north Atlantic billfishes (*Istiophoridae*). Bull. Mar. Sci., 60(3): 668-697.

DREW, K., D.J. Die and F. Arocha. 2005. Current efforts to develop an age and growth model of blue marlin (*Makaira nigricans*) and white marlin (*Tetrapturus albidus*). Collect. Vol. Sci. Pap. ICCAT, 59(1): 274-281.

ERDMAN, D.S. 1968. Spawning cycle, sex ration, and weights of blue marlin off Puerto Rico and the Virgin Islands. Trans. Am. Fish. Soc. 97(2): 131-137.

FRITSCHES, K.A., N.J. Marshall and E.J. Warrant. 2003. Retinal specializations in the blue marlin: eyes designed for sensitivity for low light levels. Mar. Freshwater Res., 54: 333-341.

GARCIA DE LOS SALMONES, R., O. Infante and J.J. Alio. 1989. Reproducción y alimentación del pez vela, de la aguja blanca y de la aguja azul en la region central de Venezuela. Collect. Vol. Sci. Pap. ICCAT, 30: 436-439.

GEHRINGER, J.W. 1956. Observations of the development of the Atlantic sailfish *Istiophorus americanus* (Cuvier), with notes of an unidentified species of istiophorid. Fish. Bull. 57: 139-171.

GRAVES, J.E., B.E. Luckhurst and E.D. Prince. 2002. An evaluation of pop-up satellite tags for estimating postrelease survival of blue marlin (*Makaira nigricans*) fron recreational fishery. Fish Bull. 100: 134-142.

GRAVES, J.E. and J.R. McDowell. 2003. Stock structure of the world's istiophorid billfishes: a genetic perspective. Mar. Freshwater Res., 54: 287-298.

GOODYEAR, C.P. 2003. Spatio-temporal distribution of longline catch per unit effort, sea surface temperature and Atlantic marlin. Mar. Freshwater Res., 54(4) 409-417.

GOODYEAR, C.P. and F. Arocha. 2001. Size composition of blue and white marlin taken in selected fisheries in the western North Atlantic. Collect. Vol. Sci. Pap. ICCAT, 53: 249-257.

GOODYEAR, C.P., and M.H. Prager. 2001. Fitting surplus-production models with missing catch data using ASPIC: evaluation with simulated data on Atlantic blue marlin. Collect. Vol. Sci. Pap. ICCAT, 53: 146-163.

GOODYEAR, C.P., Luo, J., Prince, E.D., Serafy, J. E. 2006. Temperature-depth habitat utilization of blue marlin monitored with PSAT tags in the context of simulation modeling of pelagic longline CPUE. Collect. Vol. Sci. Pap. ICCAT, 59: 224-237.

HARVEY, G. 2002. Portraits from the deep. World Publications, Winter Park FL (USA). 208 pp.

HILL, K.T., C.M. Cailliet, and R. L. Radtke. 1989. A comparative analysis of growth zones in four calcified structures of Pacific blue marlin, *Makaira nigricans*. Fish Bull. 87: 829-843.

HOLLAND, K. 2003. A perspective on billfish biological research and recommendations for the future. Mar. Freshwater Res., 54: 343-348.

HORODYSKY, A.Z., D. Kerstetter, R.J. Latour and J.E. Graves. 2005. Habitat utilization and vertical movements of white marlin (*Tetrapturus albidus*) released from commercial and recreational fishing gears in the western North Atlantic Ocean: inferences from short-duration pop-up satellites tags (PSATs). SCRS/2005/034.

IDRISI, N., T. Capo, S. Luthy and J. Seraphy. 2002. Behaviour, oxygen consumption and survival of stressed juvenile sailfish (*Istiophorus platypterus*) in captivity. Mar. fresh. Behav. Physical. 36: 51-57.

JUNIOR, T.V., C.M. Vooren and R.P. Lessa. 2004. Feeding habits of four species of Istiophoridae (Pisces: Perciformes) from northeastern Brazil. Environ. Biol. Fish. 70: 293-304.

KERSTETTER, D.W., B.E. Luckhurst, E. D. Prince and J.E. Graves. 2003. Use of pop-up satellite archival tags to demonstrate survival of blue marlin (*Makaira nigricans*) released from pelagic longline gear. Fish. Bull. 101: 939-948.

LUCKHURST B.E., E.D. Prince, D.G. Snodgrass, E. B. Brothers and J. K. Llopiz. 2006. Evidence of blue marlin (*Makaira nigricans*) spawning in Bermuda waters and elevated mercury levels in large specimens. Bull. Mar. Sci. 79: 691-704.

LUTHY, S.A. 2004. Billfish larvae of the Straits of Florida. PhD Thesis presented at the University of Miami, 112 p.

LUTHY, S.A., R.K. Cowen, J.E. Serafy and J.R. McDowell. 2005. Toward identification of larval sailfish (*Istiophorus platypterus*), white marlin (*Tetrapturus albidus*), and blue marlin (*Makaira nigricans*) in the western North Atlantic Ocean. Fish. Bull. 103: 588-600.

MATHER, F.J., A.C. Jones and G.L. Beardsley. 1972. Migration and distribution of white marlin and blue marlin in the Atlantic Ocean. Fish. Bull. 70: 283-298.

NAKAMURA, I. 1985. An annotated and illustrated catalogue of marine sailfishes, spearfishes and swordfishes known to date. FAO Species Catalogue Vol.5. Billfishes of the World. FAO Fish. Synop. No.125: 65pp.

N'GORAN, Y.N., J.B. Amon-Kothias, y F.X. Bard. 2001. Captures d'Istiophorides (voilier *Istiophorus albicans*, marlin bleu *Makaira nigricans*, marlin blanc *Tetrapturus albidus*) et effort de pêche des filets maillants dérivants operant en Côte d'Ivoire. Collect. Vol. Sci. Pap. ICCAT, 53: 272-280.

ORTIZ, M., E.D. Prince, J.E. Serafy, D.B. Holts, K.B. Dary, J.G. Pepperell, M.B. Lowry and J.C. Holdsworth. 2003. Global overview of the major constitutent-based billfish tagging programs and their results since 1954. Mar. Freshwater Res., 54: 489-507.

PRAGER, M.H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fish. Bull., 92: 374-389.

PRAGER M.H., D.W. Lee and E.D. Prince. 1994. Length and weight conversion equations for Atlantic blue marlin, white marlin, and sailfish from the North Atlantic. Collect. Vol. Sci. Pap. ICCAT, 41: 325-330.

PRAGER M.H., D.W. Lee and E.D. Prince. 1995. Empirical length and weight conversion equations for blue marlin, white marlin, and sailfish from the North Atlantic. Bull. Mar. Sci., 56: 201-210.

PRINCE, E.D. and D.W. Lee. 1989. Development of length regressions for Atlantic Istiophoridae. Collect. Vol. Sci. Pap. ICCAT, 30: 364-374.

PRINCE, E.D., D.W. Lee, C.A. Wilson and J.M. Dean. 1984. Progress in estimating age of blue marlin, *Makaira nigricans*, and white marlin, *Tetrapturus albidus*, from the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Collect. Vol. Sci. Pap. ICCAT, 20: 435-447.

PRINCE, E.D., D.W. Lee, J.R. Zweifel and E. B. Brothers. 1991. Estimating age and growth of young Atlantic Blue Marlin *Makaira nigricans* from otolith microstructure. Fish. Bull. 89: 441-459.

PRINCE, E., R. Cowen, E. Orbesen, S. Luthy, J. Llopiz, D. Richardson and J. Serafy. 2005. Movement and spawning of white marlin (*Tetrapturus albidus*) and blue marlin (*Makaira nigricans*) off Punta Cana, Dominican Republic. Fish. Bull. 103: 659-669.

PRINCE, E.D. and C.P. Goodyear. 2006. Hypoxia-based habitat compression of tropical pelagic fish. Fish. Oceanogr., doi:101111/j.1365-2419.2006.oehold999.x.

REYNALD, L., A. Monthieux, J. Chantrel, A. Lagin, J.J. Rivoalen and M.H. Norbert. 2006. Premiers elements sur la biologie et la peche du marlin bleu (*Makaira nigricans*) autour des DCP ancres en Martinique. Collect. Vol. Sci. Pap. ICCAT, 59: 303-314.

ROBINS, C.R. and G.C. Ray. 1986. A Field Guide to Atlantic Coast Fishes of North America. Houghton Mifflin: Boston.

SAITO, H., Y. Takeuchi and K. Yokawa. 2004. Vertical distribution of Atlantic blue marlin obtained from pop-up archival tags in the tropical Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 56: 201-211.

SATO, K., K. Yokawa, H. Saito, H. Matsunaga, H. Okamoto, Y. Uozumi. 2004. Preliminary stomach contents analysis of pelagic fish collected by Shoyo-Maru 2002 research cruise in the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 56: 1096-1114.

SPONAUGLE, S., K.L. denit, S.A. Luthy, J. E. Serafy. 2005. Growth variation in larval *Makaira nigricans*. J. Fish Biol., 66:822-835.

TRAVASSOS, P, C. Martins, P. Pinheiro, F. Hazin. 2006. Prelimary results on reproductive biology of blue marlin, *Makaira nigricans* (Lacépède, 1803) in the tropical West Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 60(5): 1636-1642.

UEYANAGI, S., S. Kikawa, M. Uto and Y. Nishikawa. 1970. Distribution, spawning, and relative abundance of billfishes in the Atlantic Ocean. Bull. Far. Seas Fisheries Research Laboratory 3: 15-45.

WILSON, C.A., J.M. Dean, E.D. Prince, and D.W. Lee. 1991. An examination of sexual dimorphism in Atlantic and Pacific blue marlin using body weight, sagittae weight, and age estimates. J. Exp. Mar. Biol. Ecol. 151: 209-225.