Artisanal Fishery And Sustainable Management Of Stock Of Blue Marlins, Makaira Nigricans In Marine Waters Of Cote d'Ivoire.

SORO Yaya, OUATTARA N'Golo, DIAHA N'Guessan Constance, N'DA Konan

Abstract: This study focuses on the small-scale artisanal fishery that captures blue marlins (Makaira nigricans) in Cote d'Ivoire. The sizes, weights and quantities landed of this species were approached according to the marine seasons and fishing areas. These fishermen, mostly Ghanaians, use canoes (12 to 17 m) as craft, and drifting gillnets (4800 to 5400 m) to catch fish. The choice of fishing area depends on the direction of the current. When the current flows westward, fishing takes place in the east, and vice versa. These choices have the advantage that, at the return, the driving force is developed in the direction of the current. In either case, the net is arranged perpendicularly to the direction of the current to act as a filtering barrier. In the absence of marine current, the net is arranged perpendicularly to the north-south axis. The Man-Whitney test applied to maturity states following seasons and fishing areas showed a significant difference ($P < 0.05$). Sector A2 (offshore waters in front of Abidjan, Grand Bassam and Jacqueville) would be conducive to the capture of mature individuals during warm seas. On the other hand, during upwelling, fishing should be favorable to sector B (offshore waters in front of Grand-Lahou and Fresco) where adult marlins are accessible. Capturing M. nigricans on the continental shelf should be discouraged, as recruits abound in this area to feed and shelter from large offshore predators.

Keywords: Cote d'Ivoire, artisanal fishing, blue marlins, upwelling, marine seasons, fishing areas

INTRODUCTION

A global study of "small-scale fisheries" throughout the world has identified the common denominators of characterization of artisanal fisheries [1]. Thus, 65% of countries define it according to the size of the boats with boats ranging from 5 to 15 meters; others are based on the gross tonnage, the motive power or the type of gear used. Artisanal fishing therefore has as its main characteristic to be diversified and multifaceted [2]. According to this diversification in its definition, artisanal fishing employs 12 million people in the world, and industrial fishing half a million [3]. Ivorian production of fish products was estimated at 43 532 tons in 2005 [4]. Artisanal fishing accounted for 59% and industrial fishing 39%. The contribution of aquaculture remains very low (2%). On the other hand, the work of [5] indicated all provenances, that landings of sea fish alone accounted for 85% of the Ivorian consumption of fish, about 184 000 tons. This predisposes certain species to overexploitation. In line with sound management of certain marine species, the ICCAT (International Commission for the Conservation of Atlantic Tunas), based in Spain, is committed to ensuring the protection of tuna and neighboring species in the Atlantic Ocean.

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Among these species, the blue marlin Makaira nigricans is subject of particular attention. Poor fishing practices and non-respect of seasons and breeding grounds are major factor in the extinction of some fish species. Artisanal fisheries have so far been poorly monitored and catch estimates are considered to be well below reality. The objective of this study is therefore to identify the fishing technologies and methods deployed by marine craftsmen to catch this fish on the one hand and to focus on the size of the catches to learn more on their states of maturity according to the seasons and fishing sectors.

1. MATERIAL AND METHODS

1.1. Study area

The continental shelf is located in the Gulf of Guinea and is one of the centers of the eastern fractions of the Atlantic Ocean. This Oceanic fraction, limited to 30 ° West longitude, lies between the equator and 20 ° North latitude [6]. The gulf of Guinea is a narrow and enlarged equatorial region on the Atlantic Ocean. It receives heat from the continents (harmattan) to bring it to the South in winter, between the end of November and the middle of March, and the tropical regions of the Atlantic Ocean, the monsoon, to the North. This meridian heat transport passes through the Gulf of Guinea where it creates important climatic variations. Cote d'Ivoire, despite a coastline 550 km long, has a very narrow continental shelf of 10 200 km ². Between the littoral and the isobaths 50 m, some rocky accidents exist in the west. Moreover, between isobaths 50 and 100 m, the rock banks and reefs of a height of about 6 m extend in parallel to the coast [4]. The bottoms of the continental shelf are muddy at the mouths of rivers and sandy or sandy muddy elsewhere; which is conducive to trawling. In this part of the sea, the warm surface water disappears during the cold season, which also brings up the deep water that enriches the upper layer of mineral salts (upwelling). The coast of Cote d'Ivoire, which extends from Cap of Palms (8 ° W) to the west to Cape of the Three Points (2 ° 30 W) to the east, is the site

of a high variability of climatic parameters Oceanographic [7].

1.2 Fishing sectors

Fishing in a responsible manner means taking a quantity that cannot jeopardize the renewal of fish stocks, whether they are pelagic, demersal, coastal or offshore. Artisanal fishing, which is diverse and comprises several trades, corresponds to an evolution of the traditional activity of the subsistence fishery [8]. It takes place both on the continental shelf (between 8 and 12 km from the shore) and offshore (between 5 and 10 km beyond the slope). Some coastal towns such as Abidjan, Assinie, Grand-Bassam, Grand-Lahou, Jacqueville and Fresco are used as benchmarks to indicate fishing areas for marine craftsmen (Figure 1). Thus, sector A1 corresponds to the continental shelf of the maritime portions located in front of Abidjan, Grand-Bassam and Jacqueville. Fishing takes place in this area with canoes equipped or not with ice crates during the months of January to April and from August to October. In sector A2, fishing takes place at sea level in May. This sector is the area offshore, in front of the same cities as sector A1. Sector B corresponds to offshore waters, in the maritime portion in front of Grand-Lahou (Gd-L.) and Fresco. Fishers operate in this area only during the months of June and July. The offshore waters in front of Assinie represent Sector C, where fishing occurs only in November and December.

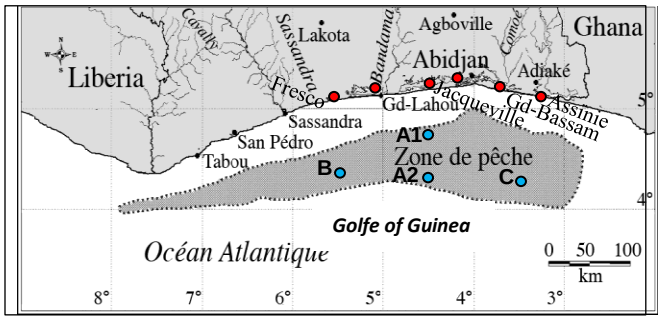

Figure 1 – *Study environment showing the cities used as landmarks and the different fishing sectors (A1, A2, B and C) Gd-Lahou (Grand-Lahou); Gd-Bassam (Grand Bassam); Fishing area (zone de pêche) [11].*

Location of cities used as landmarks
Fishing sectors

1.3 Fishermen

Artisanal fisheries in the marine environment of Cote d'Ivoire are now practiced exclusively by Ghanaians. These latter are represented by two ethnic groups (Fante and Gans). The catching gear used varies according to ethnic groups. The Fante use as fishing net, Watcha (rotating net), Patekou (drifting gillnet) and Achakoi (gillnet drifting sardinella). The Gans, equipped with very large canoes (17 to 19 m) able to embark 10 to 12 fishermen, use only longlines as catching gear. In this study, only fishers using the drift gill net (Fante) were surveyed, as it is the only gear capable of artisanally capturing blue marlins in large numbers. Most of these fishermen live in a village in the Bay of Bietri in Abidjan. The crews of the fishing units are recruited in the villages at the level of their country of origin, on a family basis or legitimized by the community, in order to preserve the cohesion of the group. In return, the payment of the crew is also made to the village at the end of the contract.

1.4 Fishing gear

1.4.1 Canoes

Like the other countries of the gulf of Guinea, boats operating in the Ivorian marine environment are all made of improved monoxyl or monoxyl wood. The technological evolutions within the pirogue fishing have led to the motorization, idea undertaken from 1959 by [9]. African canoes are still used, even in the most dynamic fisheries, despite numerous projects of replacement by so-called improved boats. In the Gulf of Guinea, the large canoe "Fante" called "patekou" (Figure 2) has a range that extends from Sierra Leone to the Congo [10]. It is this last pirogue (patekou) that was used by marine craftsmen (8 fishermen / canoe) to capture blue marlins in the exclusive economic zone of Cote d'Ivoire.

Figure 2*: Canoe Fante, user of drift net*

1.4.2 Drifting gillnet

Drifting gillnet is the main gear used by artisanal fishermen (Fante) to capture blue marlins inhabiting the pelagic area of the gulf of Guinea. This net, which is a combination of several sheets of threads (Fig.3), has a size which is variable and depends on the number of sheets sewn end to end, one after the other.

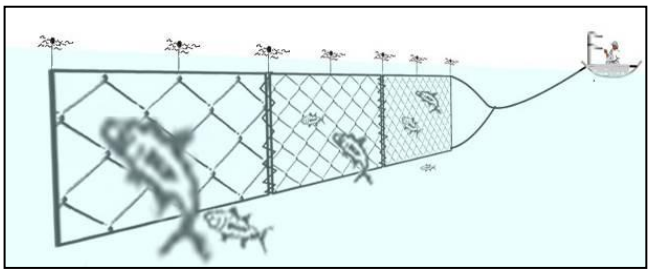

Figure 3 *– Gillnet drawing in derivation in water [11]*

1.4.3- Approaches of statistical analysis

Correspondence analysis (AC) is a statistical method that allows to analyze and to describe graphically in a synthetic way contingency tables, in which at the intersection of a line i and a column j, we find the values of the population that fit both in the characteristics of the row and the

column. Also known as "geometric analysis of data" or "analysis of correlations", the AC allows to analyze multi-varied data and to visualize them in the form of point clouds in geometric spaces [12]; [13]. This analysis is called exploratory and allows discovering relationships between variables without having preliminary hypotheses. The CA consists of replacing a family of variables with new maximum variance variables, uncorrelated two by two, which are linear combinations of the original variables. These new variables, called Eigen variables, define factorial plans which serve as a basis for a flat graphical representation of the initial variables. The interpretation of the results is generally limited to the first two factorial planes, provided that these explain the major part of the cloud variance of the initial variables. The main interest of the CA is to offer the best possible visualization of the multi-varied data, by identifying the plane (s) in which the dispersion is maximum, thus highlighting the closest relations and distance between the variables. The main components are the orthogonal axes that structure the data and account for this maximum variance. To interpret the graph, it is necessary to consider only the relative positions of the points of the same cloud with respect to an axis [14]. Interpretation was made of the state of maturity of blue marlins captured by fishing area. The conditions enumerated by [14] for forming and interpreting point clouds are:

- If the angle between two points is acute (< 90º), the two modalities of the row and column variables attract.
- On the contrary, if the angle is obtuse (> 90º), the modalities repel.
- If the angle is straight, the modalities do not interact.

Moreover, two variables that attract and are close to one another are positively correlated, while two variables that repel each other are negatively correlated. Orthogonality between two variables reflects the absence of linear correlation. Graphically, the more a point is removed from the origin, the greater its contribution to inertia [14]. The graphic study should only cover sufficiently represented variables. Correspondence analysis (CO) was applied to the numbers of blue marlins captured by fishing sector (A1, A2, B and C) according to the sea seasons (hot seasons (SC) and cold seasons (SF)) and the state Of maturity of these fish (mature (Ma) and immature (Ima)). This analysis should lead to the identification of fishing areas favorable to capture of mature blue marlins (sizes > 170 cm). In relation to the marine seasons, the sectors that cause the capture of small individuals will also be listed. An analysis of variance (ANOVA) was used to compare the mean values of the numbers and weights of blue marlins captured by fishing sector. The Man-Whitney test was also used in software R.2 to compare the numbers of blue marlins captured by fishing areas and seasons.

2. RESULTS

2.1- Organization of a fishing trip

For a fishing trip, all the boats (canoes) leave the place of residence (Vridi Canal) between 10 am and 12 pm, according to the different fishing places to be explored (Assinie, Abidjan, Jacqueville, Grand-Lahou and Fresco). In order to reach the fishing zones without losing their way, the fishermen have adopted certain orientations which they follow on the compass during their journey towards a fishing area :

- East: Abidjan to Assinie (Compass: 170 ° East);
- West: Abidjan to Grand Lahou (210-240 ° West);
- Abidjan, in the direction of the mouth of the Comoe (Compass: 340 ° East).

Once at the fishing grounds, around 4 pm and 5 pm, the different teams disperse in the same area so that they can monitor each other. The laying of the net takes place between 7 pm and 9 pm according to the time of arrival of each crew, and the lift from 4 am, depending on the distance to reach Abidjan fishing port. The duration of a fishing trip varies between 24 and 72 hours, depending on the profitability of the fishery, and the distance at which the fishing ground is explored. Canoes equipped with an ice box can spend 1 to 3 days. However, those who do not have an ice tank are obliged to carry out a one-day tide to prevent their catches from being damaged.

2.2 -The canoes

The introduction of the outboard engine from 1950 has revolutionized fishing activity in the Gulf of Guinea. The engine has made it possible to increase fishing time, exploit new areas (too remote previously) and the migration of fishermen from one region to another. The locally built monoxyl canoes (nanakrou canoes) are cut in a tree trunk called Samba (Triplophyton scleroxylon). Depending on the size and use of the craft, the hull is enhanced by additional plating. At the level of the walls, are fixed transverse boards intended to serve as benches, and to consolidate the canoe. These boards can also serve as bridges on which the net rests. Used in the driftnet fishery as catching gear, the Fante canoes range in size from 15 to 17 m, heights between 0.80 and 0.90 m and widths between 1.5 and 1.8 M. The paddle used as a rudder has a variable length between 4.60 and 5.30 m. These craft vehicles are manufactured either in Cote d'Ivoire or in Ghana. In the case of a canoe manufactured in Ghana, the ready-made craft is transported by lagoon and sea to Cote d'Ivoire. A well-made canoe can last on average 15 years. The patekou canoes, like the other large canoes that go to sea, are equipped with a 40 Cv outboard motor. To date, the motorization rate is 100% at the level of artisanal fishermen who use the gill net in Cote d'Ivoire. These canoes are equipped with compartments or holds used for various purposes:

- the first compartment in front is used for cooking;
- the second, which is median and larger, receives large fish
- the third is reserved for small fish.

The steady decline in fishing yields has led artisanal fishermen to set up ice crates in their canoes, so that they can retain their catches beyond two days. In 1976 appeared the first ice canoes coming from Saint Louis [15]. The canoe rate reaches 97% in Cote d'Ivoire during the warm seasons (March to May and November to December).

2.3- The drifting net

The constituent unit of gillnet, which is the groundwater, has a length of 200 m and a depth of drop which varies between 10 and 25 m. The drifting net is constituted by a juxtaposition of several sheets of netting, the number of which is variable from 24 to 26. The length of a sheet being 200 m can be deduced from the total length of a drifting gill net 800 to 5200 m). Each web unit has characteristics of its own, in terms of mesh and yarn used for its manufacture. The stitches have sides which vary between 35 and 55 mm with a diameter of between 12 and 21 mm. Each sheet is made with a uniform filament diameter (monofilament) and uniform side meshes. However, the diameter of the yarn used in the making of a sheet depends on the width of the meshes. The larger the mesh size, the larger the wire used to make them. For a slip of 45 mm stitches, the fishermen use the wire of diameter 18 mm for its manufacture. On the other hand, for a 35 mm mesh, they opt for a wire with a diameter of 12 mm. The mesh net is thus formed of small mesh (35 mm), medium mesh (45 mm) and large mesh (55 mm) mesh. In this combination of detachable sheets after each fishing trip, the fishermen choose to arrange them alternately. If the first sail unit that is connected to the canoe is 35mm mesh, the second is 40mm mesh, comes the third with 45mm, the fourth with 50mm and the fifth with 55mm mesh. This arrangement is repeated until the desired length is reached by the owner of the drift gill net. In their diversity related to the size of the yarn and the meshes, each of the layers is particularly adapted to catch a given group of species and / or a given size class of fish. The upper rope of the net (usually polypropylene) is supported by floats at regular intervals (150 spread over every 200 m), and on the bottom rope, also made of polypropylene, there are lead weights of 80 g / At regular intervals over each 200 m) which distend the entire branch gill net. The weight of the unit of lead is most often defined according to the surface of the craft and certain environmental conditions (current, swell, depth, etc.). Between the floats there are 7 to 8 storm lights throughout the large sheet of drifting gillnets. The light emitted by these lamps is captured by the radar system of the boats; which allows them to avoid damaging the device set up. Also, these storm lights serve as guides for fishermen when they want to control the water table over its entire length.

2.4- Fishing sectors and techniques

2.4.1- Selection of the fishing sector

The great atmospheric structures, whose privileged direction is essentially zonal, impose an intense zonal circulation on the superficial layers of the ocean. Thus, the Eastern wind regime in the gulf of Guinea drives hot surface waters westward along the equator [17]. Under these conditions, fishing activities take place in the east of Abidjan (Assinie). On the other hand, the sub-surface circulation, which is essentially conditioned by the equatorial sub-current, flows eastward into the heart of the thermocline. When the intensity of this current prevails, the marine craftsmen operate in the West of Abidjan (Grand-Lahou and Fresco). Once at the chosen fishing location, when the net is put into the water, the engine is switched off and the dugout canoe is drained passively in the direction of Abidjan by the marine current during the fishing process. This passive transport under the effect of the current contributes to reducing the distance to be traveled towards Abidjan, after the lifting of the fishing net. The choice of the fishing location is therefore a function of the direction of the current and not of any orientation in the direction of maximizing the catches. In the absence of wind and (Stable water), fishing occurs preferentially in the vicinity of Abidjan, Grand-Bassam and Jacqueville, either on the continental shelf or offshore.

2.4.2- Arrangement of the gillnet

In the tropics, the warming of superficial water bodies is more intense. This makes the heat gain positive for these oceanic waters, unlike the mid- and high-latitude regions. This equatorial heating creates a zone of low pressures towards which the masses of air flow. The positioning of the net at sea for a fishing action is therefore a function of the direction of movement of the wind and therefore of the sea currents. The regime of the currents before the Ivory Coast is generally represented by a simple circulation going from West to East and known as the current of Guinea. This current is considered quasi permanent, but undergoes seasonal variations of intensity, notably an increase in speed during the cold marine season (July to September). They thus cause a layer of transport surface East of 10 to 20 m thick bounded down by the thermocline. Under these current conditions evolving towards the east, the net is arranged in the north-south direction, perpendicular to the direction of the marine current (Figure 4). In the absence of wind and therefore of marine current, the net is arranged in the east-west direction, perpendicular to the north-south axis (Figure 5).

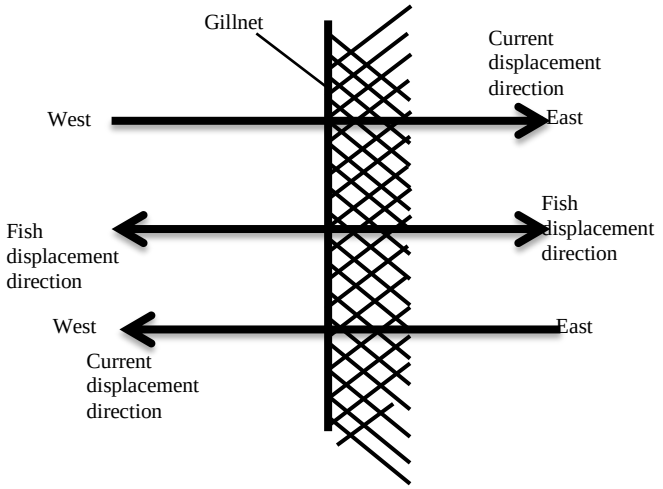

Figure 4 *– Gillnet arrangement in the presence of wind and marine current*

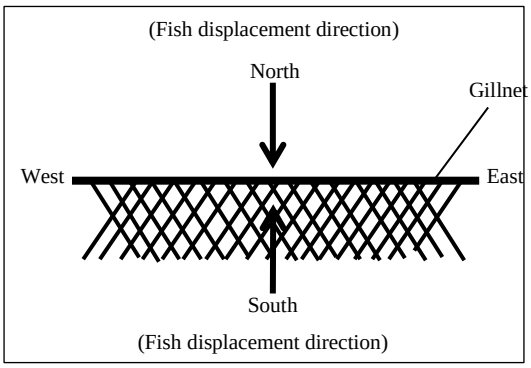

Figure 5 *– Gillnet arrangement in absence of wind and marine current.*

2.5- Fishing areas and blue marlins caught

The two-dimensional diagram (Figure 6) shows some approximations between the fishing areas and the states of maturity of the blue marlins caught in these different fishing areas. This distribution was made on the basis of the frequencies observed per fishing season (A1, A2, B and C) and the maturity states of blue marlins (Mature: Ma and Immature: Ima). The numerical values correspond to the coordinates of the points which encompass both the seasons (SC and SF) and the maturity states of the fish (Ma and Ima). These values subjected to the Chi² test show a difference significantly (dl = 9 and p < 0.001). In this figure, axis 1 establishes the highest rate of variance or inertia (81.54%). This horizontal axis allows the observation of mature blue marlins (Ma) in both hot season (SC) and cold season (SF) over sectors A1, A2 and B. Below same axis, only sector C is observed with immature individuals (Ima), in both the hot (SC) and cold (SF) seasons. In the same figure, axis 2 (vertical) shows the lowest variance (18.23%). This axis isolates on the left side, only cold seasons (SF), with mature (Ma) and immature (Ima) sockets in sectors A1 and B. On the right side of this axis, one notices (Ma) and immature (Ima) catches only at sector A2 and C. Looking at the dispersion of clouds of points, the point of sector A1 and the point formed by The couple SF and Ima are close to the origin of the axes. These points are therefore not sufficiently represented. The groupings by clouds through the angles that form the different points between them were made only with the values sufficiently represented. The angle formed by each of the pairs of points following [(A2-SC: Ma), (B-SF: Ma) and (C-SC: Ima)] with the origin is acute (<90 °).

- These variables that attract each other within and close to each other are positively correlated. The three groups of variables thus formed have been interpreted as follows:
- Group 1 is formed by A2, SC and Ma. This would mean that fishing takes place in sector A2 during warm seasons (SC), and the blue marlins caught are mostly mature (Ma). Out of 90 fishes caught in this area (sector A2), 66 are mature (73.33%) compared to only 24 immature (26.67%);
- Group 2 is formed by B, SF and Ma. In this group, fishing takes place in sector B during cold seasons (SF) and the catch Constituted of mature blue marlins (Ma). Of a total of 223 fish caught in this area (sector B), 163 are mature (73.09%) and only 60 immature (26.91%);
- Group 3 is formed by C, SC and Ima. Blue marlins are therefore caught at sector C during hot seasons (SC), with catches predominantly made up of immature fish. Of the total catches made in this area (305 blue marlins), 223 blue marlins are immature (73.11%) and 85 have reached maturity (26.89%).

The Man-Whitney test, a nonparametric test applied to these values following groupings, shows a significant difference (P < 0.05). Through this diagram, it appears that during warm marine periods, mature blue marlins are accessible at sector A2. This sector is the maritime portion situated at the level of the offshore waters, in front of cities like Abidjan, Grand-Bassam and Jacqueville. Sector C (offshore waters of Assinie) is in favor of catching immature blue marlins (fish of less than 150 cm in size) during the same season. In the cold marine period, mature blue marlins are accessible in Area B (offshore waters in front of Grand-Lahou and Fresco).

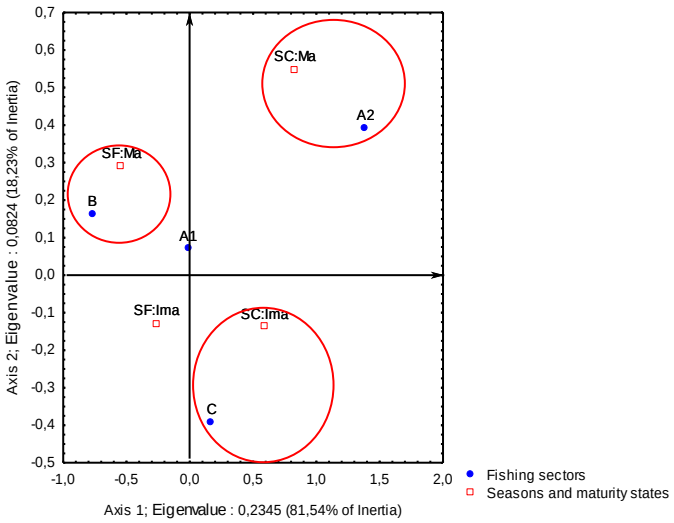

Figure 6 *– Correspondence analysis diagram showing maturity of fish catch (Ma : mature, Ima : immature) according to the fishing sectors (A1, A2, B and C) and the marine seasons (SC: hot season; SF: cold season).*

2.6- Size and weights by sector

The largest number of blue marlins was recorded in sector C (311 fish, 35.39%), followed by sector A2 (202 fish or 23.02%), followed by sector A1 (196 fish, or 22.39%) and sector B with 168 fish, or 19.20%. The weights of the numbers captured were grouped by fishing sector. Sector C comes in first with 20 455.44 kg (27.86%), followed by sector B with 20 137.10 kg (27.43%), followed by sector A2 (17 402.3 kg, or 23.70%) and finally sector A1 with 15 421.71 kg (21%). Sector C with the largest number of blue marlins is the most significant. On the other hand, sector B, which had the smallest number of fish, occupies the second place in the grading of the catches.

3- DISCUSSION

3.1- Canoes

The size ranges of the canoes used in Cote d'Ivoire fall within the range defined by some authors who stated that wooden canoes vary in size from 4 to 18 meters [18]; [2]. The high rate of motorization at canoe level in the study area could be explained by the fall in catch rates, the emergence of offshore areas, or seasonal migrations to other high-yielding fishing grounds. The use of these engines has revolutionized artisanal fisheries, as according to [19] and [20], the availability of fishing gear and engines itself affects fishing operations and opportunities for access to fisheries resources. The high rate of ice crates observed during the months of March to May and November-December is due to the scarcity of the resource at the level of the artisanal fishing strata. Indeed, the aforementioned months are included in the warm marine seasons of the Gulf of Guinea [21]; [22]. These seasons, characterized by the absence of manifestation of the upwelling phenomenon, are unfavorable to high densities of distribution of blue marlins and other minor tuna in the environment.

3.2- Selection of fishing technical and sector

Depending on the country, the shape of the canoes varies according to the use made of it. In Cote d'Ivoire, the Fante canoes are mostly larger (15 to 17 m) than those observed by [18] in the Senegalese artisanal fishery (4 to 18 m). The proportionality established between the size of the stitches and the diameter of the yarn used in their garments is due to the fact that large mesh holds large fish. Thus, if a large fish is meshed with a small diameter wire, the catch may escape due to the breaking of the wire. The disposition of the net perpendicular to the current direction is linked to the fact that the fish in the marine environment are either drained by the current or move countercurrent. By arranging the net in parallel with the marine current, it would lose its role as filtering barrier and would obviously record very few catches. In the absence of wind and sea current, the East-West grid pattern perpendicular to the North-South axis is explained by the fact that oceanic water bodies move regularly from the North To the south or south to the north, bringing with them a relatively large number of marine organisms. These different fishing areas have been recorded on the basis of their hydro dynamism and geomorphology. Indeed, these zones contain little difference in level, and therefore conducive to the use of the drifting gillnet. The choice of sailing against the current towards the fishing site is linked to the fact that the canoe is empty and therefore easier to move under these conditions. After the fishing activity, the pirogue and crew are propelled in the direction of the current. These provisions are favorable to fuel economy, since the motive power is developed in the same direction as the marine current. In absence of wind, and therefore of marine current (stable water), fishing takes place in the vicinity of Abidjan, Grand-Bassam and Jacqueville. These fishing places close to Abidjan as a point of sale of catches by excellence are advantageous for the teams since the less they go away, the more fuel they save.

3.3- Fishing areas and blue marlins caught

The largest number of blue marlins captured at sector C is due to favorable temperature conditions. Indeed, in the Of November and December where fishing takes place in this area, water temperatures exceed 27 ° C. Blue marlins are better suited to warm waters, unlike cold waters [23]. That is what Justifies catching the large number of fish in Area A2 which is explored in May, included in the Great Marine Hot Season. Sector B had the highest fishing pressure and recorded the smallest number of fish caught. The marine craftsmen fish in this environment in June-July. The month of July being part of the great cold season was an obstacle to the mass arrival of the blue marlins in this sector. The analysis of variance applied to the parameters studied by fishing sector shows a significant difference ($p < 0.001$). This could be explained by the unequal distribution of fishing effort among the various fishing communities. Thus, the annual variation in the catch rate would be linked to the fluctuation of the physicochemical parameters that determine the spatial and temporal distribution of aquatic organisms [24]. During upwelling, these parameters favor the proliferation of phytoplankton and zooplankton, thus forming a center of attraction for a varied range of aquatic species and size. It is these hydrological conditions that enable upwellings ecosystems to provide plus de 40 % des captures des pêcheries mondiales, tout en ne représentant que moins de 3 % de la surface de l'océan mondiale [24]. Seasonal fluctuations that disrupt the distribution of fish as a whole affect the rate of departures at sea and therefore catchability. At the end of this study, Sector A2, and more particularly Sector C, emerges as being the most profitable in terms of the numbers of fish caught. However, in view of the sizes of blue marlins landed by fishing site, sector C visited during the warm season shows a predominance of small fish. The blue marlins caught in sector B in the cold season are certainly few, but largely large. The sizes of blue marlins subjected to the Mann-Whitney test according to the marine seasons showed a significant difference ($p = 2.255 \times 10\text{-}15 < 0.05$). Fish caught during upwelling periods are predominantly larger than those captured during warm seasons.

3.4 - Rational management of blue marlins stock

The reconciliation between fishing area A2 and the warm season (SC) is due to the fact that the marine craftsmen explore this sector in the month of May, which is included in the great warm marine season. The capture of mature blue marlins at this location would be linked to the upwelling approach (July to September) that attracts all size ranges of fish and other organisms in the marine waters of Cote d'Ivoire. The group formed by sector B and the cold season find its reasons in the fishing period which is included in the upwelling. When this phenomenon happens, surface water becomes cold and rich in nutrients, favoring the proliferation of the zoo and phytoplankton, which in turn attract minor tuna, blue marlins and especially large ones. Adult blue marlins in high concentration during these cold marine periods are linked to the fact that they have the ability to regulate body temperature through the thermogenic organ and continue to feed in that cold and trouble water environments. Area C is positively correlated with warm season and immature blue marlins because this area is visited by marine craftsmen only in November and

December, which is a small hot season. The presence of immature blue marlins in this area is due to the relatively high water temperature during this period [21]; [22] and therefore favorable to the arrival of these small fish. In view of these different fishing sectors, with a view to a rational management of the stock of blue marlins in this part of the gulf of Guinea, it would be desirable for fishermen to visit the sectors favorable to the capture of mature individuals. For example, during the warm seas, the blue marlin fishery should be authorized only in sector A2, namely the waters beyond the slope, opposite Abidjan, Grand-Bassam and Jacqueville. On the other hand, in the cold-water period (upwelling), fishermen can only be authorized in sector B, which is the maritime portion located offshore and in front of Grand-Lahou and Fresco. Depending on the fishing season, it would be desirable for marine craftsmen to target blue marlins in cold periods, which have predominantly adult catches, in contrast to warm seasons

4- CONCLUSION

Artisanal fishermen operating in Cote d'Ivoire choose the fishing sector according to the direction of the sea current. Following this direction and the sea seasons, they fish both on the continental shelf and offshore. Given the size of the catches, the warm seasons favor the catch of mostly immature individuals, both offshore and on the continental shelf. Upwelling periods are conducive to the capture of mature blue marlins. Generally, it is clear that offshore fishing offers more potential for capturing large marlins, as opposed to the continental shelf where the juveniles of these fish come to feed and shelter themselves from large offshore predators. Rationally and sustainably harvesting this resource would be tantamount to banning the capture of blue marlins on the continental shelf as the majority of the population in this stratum hasn't spawn yet. Collecting a large proportion of juvenile's means drastically reducing the population of future spawners, a condition favorable to specific extinction cases.

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