PREDATION BY TROPICAL TUNAS ON SARDINELLAS POSSIBLE INDUCED CHANGES IN TUNAS POPULATIONS BY INCREASE OF SARDINELLA ABUNDANCE.

by
F. X. BARD and A. HERVE
ORSTOM scientists at CRO, Po BP V 18, Abidjan Côte d'Ivoire.

Abstract :

This paper investigates the possibility of predation by tropical tunas on Sardinella in the Ivorio-Ghanaian upwelling, using two methods: (i) A review of past works on stomach contents; (ii) A survey of spatio-temporal distribution of catches of tuna boats operating in northern Gulf of Guinea. Conclusion is that predation by tunas on these Sardinellas does not seems systematic and therefore would be moderate. A possible reason could be that Sardinella stay in upwelling waters where they are not easily available to tunas.

Resumé :

Ce document examine les possibilités de prédation des thons tropicaux sur les Sardinelles de l'upwelling ivoiro-ghanéen, en utilisant deux méthodes:(1) Une revue des travaux passés sur les contenus stomacaux ; (2) L'examen des distributions spatio-temporelles des captures des thoniers opérant dans le Golfe de Guinée. La conclusion est qu'il semble que la prédation des thons sur ces Sardinelles n'est pas systématique et resterait donc modérée. La raison en serait que les Sardinelles demeurent dans les eaux d'upwelling où elles sont peu accessibles aux thons.

1. Introduction

The neritic ecosystem linked to the Ivorio-Ghanaian upwelling includes large populations of small neritic/pelagic fish. In the vicinity of this upwelling, lie the oceanic waters of the Gulf of Guinea which constitutes another ecosystem, including population of tropical tunas. These tunas, mainly yellowfin (Thunnus albacares) and skipjack (Katsuwonus pelamis) are actively fished by purse seiners and baitboats. An increase of the biomass of small pelagic fish, particularly S.aurita, occured since 1984 in the ecosystem of the coastal upwelling. This event raises the following questions, related to the degree of coupling between the two ecosystems: What is the amount of predation by tunas on this potential source of food ?. Has such a predation increased with the biomass of S. aurita, and consequently did it change the behaviour of tuna population in the northern Gulf of Guinea ?. This document is an attempt to answer to these basic questions.

2. Methods

We used two approaches :

First, reviewing the available scientific literature on tropical tuna feeding habits, in the Eastern Tropical Atlantic. We have reviewed these documents, from the standpoint of predation on small neritic/pelagic fish and particularly Sardinellas. All these works rely on stomach contents analysis.

Second, examining the spatio-temporal distribution of tuna catches from the two main gears exploiting tropical tuna in this Eastern Atlantic: Purse seiners and baitboats. These two fleet are fishing in the Gulf of Guinea since the 1970 years, and particularly the oceanic area of the Gulf of Guinea, close to the upwelling. The hypothesis set is that a possible concentration of tuna, induced by the increase of S. aurita biomass since 1982, could attract a concentration of tuna boats, changing the behaviour of the fleets, as compared to the previous fishing pattern.

3. Tuna Stomach Contents

The current sizes of the two main tropical tuna species, yellowfin and skipjack in Eastern Atlantic are shown in figure 1. Size of such fish are large enough, for being able to forage on small neritic/pelagic fish. Stomach contents of these tuna have been analysed by several authors in the past 30 years. Cayré and al. (1988) review all these authors in a synthesis which confirms the very opportunistic nature of tuna feeding habits. Among these authors, the most relevant, because pertaining to the northern part of Gulf of Guinea, are the ones from Dragovitch (1970, 1972) and Marchal (1959). We add the work of Bard and Pezennec (1991) which was already designed to address the problem of neritic species in the tuna diet.

A general conclusion is that small neritic/pelagic fish have been relatively rarely observed in the stomach of yellowfin and skipjack in this area. Tuna preys, highly variable, are mainly fish living in the pelagic oceanic waters. But about

the small neritic fish observed, small Carangids are more frequently observed than Clupeoids. Curiously the only two sizeable occurrences of Sardinellas in the stomachs of yellowfin tuna have been observed in the coastal area close to Guinea (Conakry) by Marchal and much later by Bard and Pezennec.

It has to be noted that the observations of the various authors do not cover all the spatio-temporal strata where contact between tuna and Sardinella could occur. On an other hand, the stomach contents of tuna caught by purse seiner have been much more analysed than the one from baitboat. Indeed there is a particular bias for such analysis for baitboat fish. In fact, this gear uses mainly small Clupeoids as bait; For Tema based baitboats it is anchovy (Engraulis encrasicholus) (Kwei and al, this volume). Keeping in mind these reservations, the low occurrence of Sardinella in the tropical tuna stomaches is still noteworthy.

4. Distribution of Tuna Caches from Fishing Fleet

The tuna fishing area where the influence of the Ivorio-ghanaian upwelling can be significant has been defined by Stretta (1988). He defines a transition boundary at 3 degrees North, where the mixing of waters issued from coastal upwelling and waters issued from equatorial upwelling occurs. Therefore, the area where the predation of tunas on the small neritic/pelagic fish from coastal upwelling could be the highest, stretches between the coast and the latitude 3°N. In longitude the limits are set at Cap Palmas at West and 2° East. (Figure 2). In this area did the increase of Sardinella aurita biomass, induced a particular concentration of tunas ?. And in such a case was it reflected in the behaviour of the tuna boat?.

Tuna fleet which fished the Gulf of Guinea are described by Fonteneau and al, (1988). For our purpose, the two tuna fleet which continuously fished the above defined area, from the past up to now, are the international fleet of purse seiners based in Abidjan, and the Tema based baitboat fleet.

4.1 Purse seiners fishing data.

The purse seiner fleet targets the yellowfin tuna, but skipjack is also currently fished. The fishing gear allows to catch the whole range of sizes of yellowfin and skipjack, (Figure 1). Some catches of bigeye (T obesus) also occur. From 1969 to 1975, the purse seiners fished continuously in the coastal area. Since 1976, fishing effort of purse seiners expanded to the equatorial area and fishing in the coastal area became more seasonal, only when concentration of yellowfin or skipjack justified it.

Total catches of the whole international fleet of purse seiners, for years 1969-1990 in the contact area defined above are shown in a synthetic way in figure 3. A regular fishing pattern in the area appears for years 1969 to 1981. Later catches in the Ivoirian side of the area occured sporadically. Catches in the Ghanaian side became nearly nil. These changes in the spatio-temporal fishing pattern can be explained as follows :

From 1969 to 1981, fishing in the coastal waters was free, as it was international waters. The purse seiners fished in the waters east of Cap Three Point. But important catches off the Ivoirian coast were also possible, during years 1980-81 particularly. On 1982, as a consequence of a «gunship effect», fishing in Ghanaian waters became negligible. On an other hand the Ivorian waters stayed open and fishing took place with noticeable results on some years, such as 1987. It is therefore possible to select the Ivorian coastal area, west of Cap Three Point for checking the hypothesis of tunas aggregations induced by the increased abundance of Sardinelle since 1982.

But as a matter of fact, a reversed effect is observed. On 1985, year of very strong cohort of Sardinella aurita (Pezennec 1994), catches of tuna are weak. As a general pattern, from 1982 to 1990, years when the abundance of S. aurita was plentiful, catches of tuna in the selected area remained weak.

A complementary analysis is possible, by selecting only the catches of large yellowfin, bigger than 30 Kg, (the adults fish). Such yellowfin tuna are large enough to swallow Sardinella or others small neritic/pelagic fish of any size. Unfortunately these data are only available by 5°x5° squares and month, thus covering area larger than the contact area defined in figure 2. Examination of catches in CWP Squares 4 0000 and 1 0000 show that catches of large yellowfin increased slightly since 1986 to a medium level during the recent years.

Conclusion from analysis the purse seine data are therefore somewhat puzzling: The general catches in the vicinity of the upwelling decreased in recent years, but among them the proportion of large fish may have increased. One fact however, can affect this conclusion: The tuna purse seine cannot be used in water depth lower than 200 m, because of size of the net, and therefore no catches are possible on continental shelf. Fonteneau (1991, p 315) shows the precise position of some purse seine close to Côte d'Ivoire: It is remarkable that density of sets is higher at the edge of continental shelf .

4.2 Baitboat fishing data

Tema based baitboat fleet always targeted on skipjack, operating with a very constant strategy over the past years. Fishing grounds are in the inner part of Gulf of Guinea, with some seasonal changes (Figure 2). The size range of the fish is shown in figure 1. The majority of fish is less than 8 kg. It is mainly skipjack but also young yellowfin and bigeye tunas which live in mixed schools. Such fish can predate on young Sardinella or others small pelagic fish like anchovy (E. encrasicolus), roughly less than 10 cm. Figure 5 shows the geographic distribution of baitboat catches from 1984 to 1992. It can be observed that these distribution are very constant over the years. When compared to the similar data for years 1969-82 synthetised by Fonteneau and al (1988, p 96), there is no difference at all.

Conclusion is that the distribution of baitboat catches do not exhibit any clear change that could have been induced by the increase of the small Sardinella

and anchovy abundance. This is particularly interesting, because, on the contrary of the purse seiners, the baitboats can fish over the continental shelf, even close to the coast if necessary.

5. Discussion

These different approaches used, each having its own limitations, produce partial conclusions :

(i) The predation of tuna on Sardinella in the Notrh of Gulf of Guinea seems to be not very common.

(ii) The recent increase of S aurita abundance, and maybe anchovy too, does not seems to have brought a particular increase of predation by tropical tunas in Gulf of Guinea, as reflected by movements of tuna boats. But purse seiners cannot fish on continental shelf. Baitboats do not fish the larger tunas able to swallow the larger Sardinella (and others small pelagics)

A possible explanation of this phenomenon could be, that in the considered area, the Sardinellas remain generally unavailable to tropical tunas. Now, it is possible compare with the results of Laurs and al. (1984) on the distribution of albacore tuna (Thunnus alalunga) alongside the California upwelling. Remote satellite sensing of sea colour showed that albacore stay in blue oceanic waters close to the eddies of green waters from upwelling in which they do not enter. The interpretation is that the albacore, which rely on visual contact for feeding in clear blue waters are not able to chase in the upwelling green and turbid waters.

In the case of the Ivorio-ghanaian upwelling, the same effect is possible. Tropical tuna feed using mainly visual detection (Havard Duclos, 1972). The Sardinellas, staying close to the coast would be not vulnerable during the upwelling season. But if they move ouside of the protection of green turbid waters, they are eaten by the tuna, which are waiting in clear blue water. Some observations support this interpretation :

(i) In Ghana and Côte d'Ivoire, a canoe fishery using gill net named «nifa-nifa», developed in Ghana since 1974 (Mensah and Doyi, 1992) then Côte d'Ivoire in 1984 (Amon Kothias and al. 1992). These nets target and catch large fish (billfishes, sharks and tunas). The nets are generally set at the limit between green and blue waters.

(ii) Small pelagic fish have been observed sometimes relatively far offshore Ghana and Côte d'Ivoire , in schools , on which large yellowfin tuna were actively foraging (and purse seiner actively fishing). It has been the case in September 1993 for Spanish mackerel (Scomber japonicus) off Cape Three Points. And similarly during 1994 off Côte d'Ivoire in August for Sardinella and September for anchovies.

(iii) Another casual observation made at Dakar in July 1988 strengthen this theory: After a strong upwelling, a relaxation of the upwelling occured, bringing

oceanic water abnormally close to the coast (Roy Pers. Com.). Yellowfin tuna moved inshore very close to the coast, feeding on anchovies crammed close to the beach (Samba, Pers. Com..). This event, clearly recorded as unusual, is a a contrario demonstration of the normal behaviour of tuna which do not enter easily in upwelling waters.

Eventually it can be reminded that during warm season when blue oceanic warm and clear waters cover the neritic zone (see Aman, this volume), Sardinellas are known to stay close to the sea bottom on the edge of the continental shelf. That is another way of protection against predation.

The conclusion that predation of tunas on Sardinellas seems not regular in this area, (and maybe others) converge with the conclusion of Cayré and Roy (1986) which, examining the same area did not find any clear relationship between the cooling of waters (taken as index of planctonic production) and a tuna abundance index.

6. Conclusion

As a general conclusion, it seems that predation by tropical tunas on Sardinella and other small pelagics linked to the upwelling ecosystem is not systematic, essentially because the tunas do not chase easily in coastal upwelled turbid waters. But tunas forage on Sardinella if they move in blue clear water. And maybe tuna could enter for short periods in green waters. Food web is complete, when tunas move off the continental shelf where purse seiners fish tunas. This conclusion is consistent with the opportunistic character of tropical tuna feeding behaviour.

Conclusions achieved here are however based on indirect observations. Systematic observation of stomach contents from tunas caught at close range of the coast of Ghana and Côte d'Ivoire could be done. The most obvious fishing gear to be used should be the «nifa nifa» gill nets.

The last conclusion is that, if food transfer between the two ecosystems, the upwelling one and the oceanic one, is not achieved through systematic regular predation on Sardinella. And other small neritic/pelagic fish, less abundant but more mobile could be involved, such as small Carangids. But a systematic coupling remains possible through other ways, such exportation of macro-zooplankton drifting towards oceanic ecosystem within upwelled waters. (Binet, 1991).

A final paradox is that predators having advantage of Sardinella abundance increase in this upwelling ecosystem could be the dolphins (Delfinus sp,...) Their abundance seems to have increased off Côte d'Ivoire during recent years and they are commonly observed at proximity of Sardinella schools by fishermen. Echolocation of dolphins makes them able to chase in turbid waters.

REFERENCES

Amon Kothias J B, F X Bard et A. Hervé, 1992. - Description des pêches et des statistiques de poissons-porte épée au port d'Abidjan, 1987-1992. SCRS/92/148 10p

Bard F X et O Pezennec 1991 - Analyse des contenus stomacaux des albacores (T.albacares) pêchés à la senne dans le Golfe de Guinée. ICCAT Rec Doc Sci 35(2) : 1-7.

Binet D. 1991 Dynamique du plancton dans les eaux côtières ouest-africaines: ecosystèmes équilibrés et déséquilibrés. In Cury et Roy Eds. Pêcheries Ouest Africaines . Variablité, instabilité et changement. Editions de l'ORSTOM :117-136.

Cayré P. and C. Roy 1986. Variabilité des rendements en albacore (T.albacares) et listao (K. pelamis) en relation avec les anomalies interanuelles de la température de surface. ICCAT Rec.Doc.Sci. 25 :67-76.

Cayre P. J.B. Amon Kothias, T. Diouf et J. M. Stretta- 1988. Biologie des thons. Chap.6 In Fonteneau et Marcille Eds. ressources, pêche et biologie des thonidés tropicaux de l'Atlantique Centre Est. FAO Doc Tech Peches 292 :157-268.

Dragovitch A and T Potthof 1972 - Comparative study of food of skipjack and yellowfin tunas of the coast of West Africa. Fish Bull NOAA/NMFS 70(4) :1087-1110.

Dragovitch A. 1970 - The food of skipjack and yellowfin tunas in the Atlantic Ocean. Fish. Bull. NOAA/NMFS 68(3) : 445-460

Fonteneau A, T Diouf et M. Mensah 1988 - Les pêcheries thonières de l'Atlantique Tropical Est Chap 4 In Fonteneau et Marcille Ibid : 33-110.

Fonteneau A. 1991 - Pélagiques côtiers, pélagiques hauturiers et fluctuations environnementales: Quelques éléments de comparaison In Cury et Roy Eds. Pêcheries Ouest Africaines (...) Editions de l'ORSTOM : 311-319

Havard Duclos F. 1972 - Synthèse Ethologique sur les thons. CNEXO Rap. Sci. et Tech. N° 6, 30p.

Laurs R.M., Fielder P., Montgomery D.1984- Albacore tuna catch distributions relative to environmental features observed by satellite. Deep Sea Res. 31 :1085-1099.

Marchal E. 1959 - Analyse de quelques contenus stomacaux de Neothunnus albacora (Lowe). Bull IFAN 21(3) :1123-1136.

Mensah M.A. and Doyi B.A 1992 The billfish fishery in Ghana ICCAT SCRS/ 92/75. 14p ICCAT Workshop Billfish Program.

Pezennec O. 1994 -Instabilité et changements de l'écosystème pélagique côtier ivoiro-ghanéen: Variabilité de la ressource en Sardinelle, faits, hypothèses et théorie. Thèse Université Brest, 250 p.

Stretta J M, 1988 - Environnement et pêche thonière en Atlantique Tropical Oriental Chap. 7 In Fonteneau et Marcille (ibid).

CAPTION OF FIGURES

Figure 1 : (A-Upper figure) Total catches, in metric tons, of yellowfin in Eastern Tropical Atlantic by 2cm length classes. Source : ICCAT. SCRS 1992 Report.
(B-Lower figure) Length frequencies by 1 cm classes of tuna caught by Tema based baitboats, as sampled randomly for size and species 1984-1992.

Figure 2 : Map of fishing grounds of Abidjan based purse seiners and Tema based baitboats. The defined area of interaction between the coastal upwelling ecosystem and the oceanic ecosystem is shown. See text.

Figure 3 : Synthetic representation for years 1969-1990 of the purse seiners total catches in the area interaction as mapped in figure 2. The size of the circle is proportional to the catch. White sectors are yellowfin, striped sectors are skipjack, black sectors are bigeye.(Source Fonteneau).

Figure 4 : Captures in tons of large yellowfin (category +30 Kg) for years 1980-1991 in the 5x5 degree squares(CWP 1 0000 and 4 0000) including the Ivorio-Ghanaian upwelling. Catches by the whole fleet of purse seiners based in Abidjan. After 1991 these complete data are not available.

Figure 5 : Maps by 1x1 degree squares of the catch of skipjack and small tunas by Tema based baiboats for years 1984-1992 . Source: logbooks collected by FRUB and CRO.

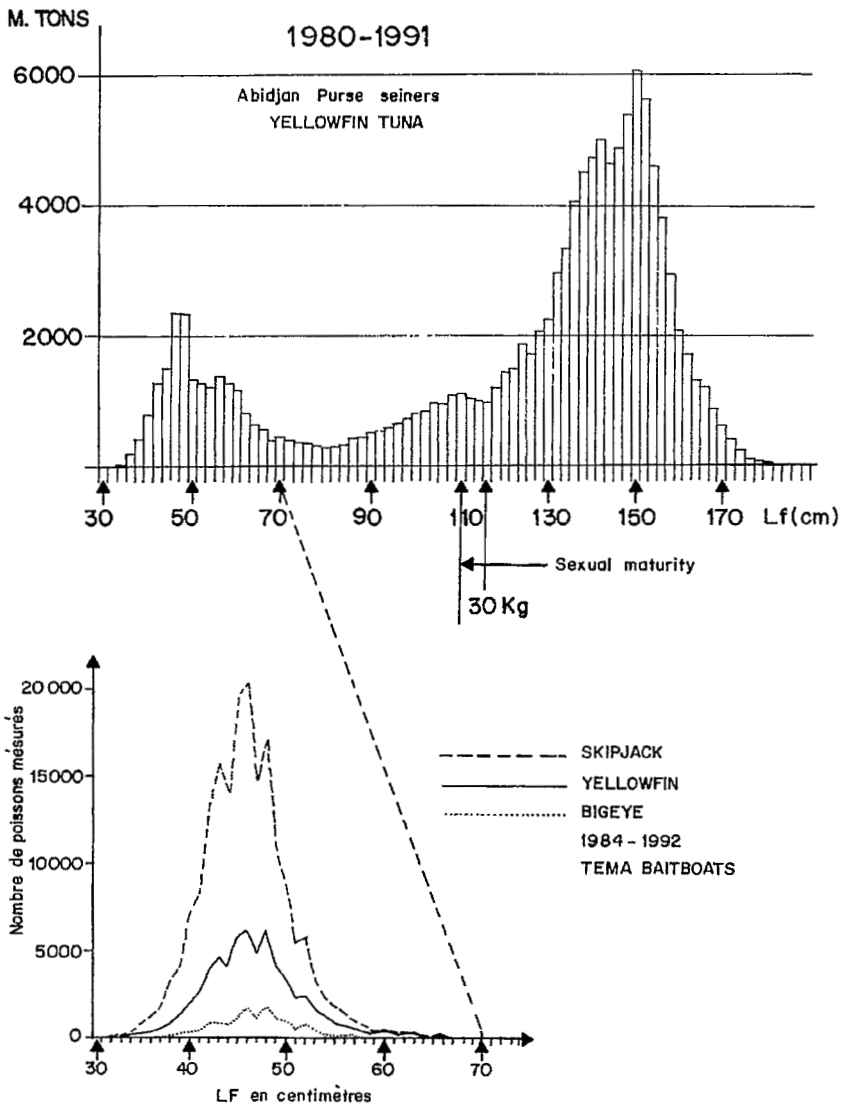

Figure 1 : (A-Upper figure) Total catches, in metric tons, of yellowfin in Eastern Tropical Atlantic by 2cm length classes. Source: ICCAT. SCRS 1992 Report.
(B-Lower figure) Length frequencies by 1 cm classes of tuna caught by Tema based baitboats, as sampled randomly for size and species 1984-1992.

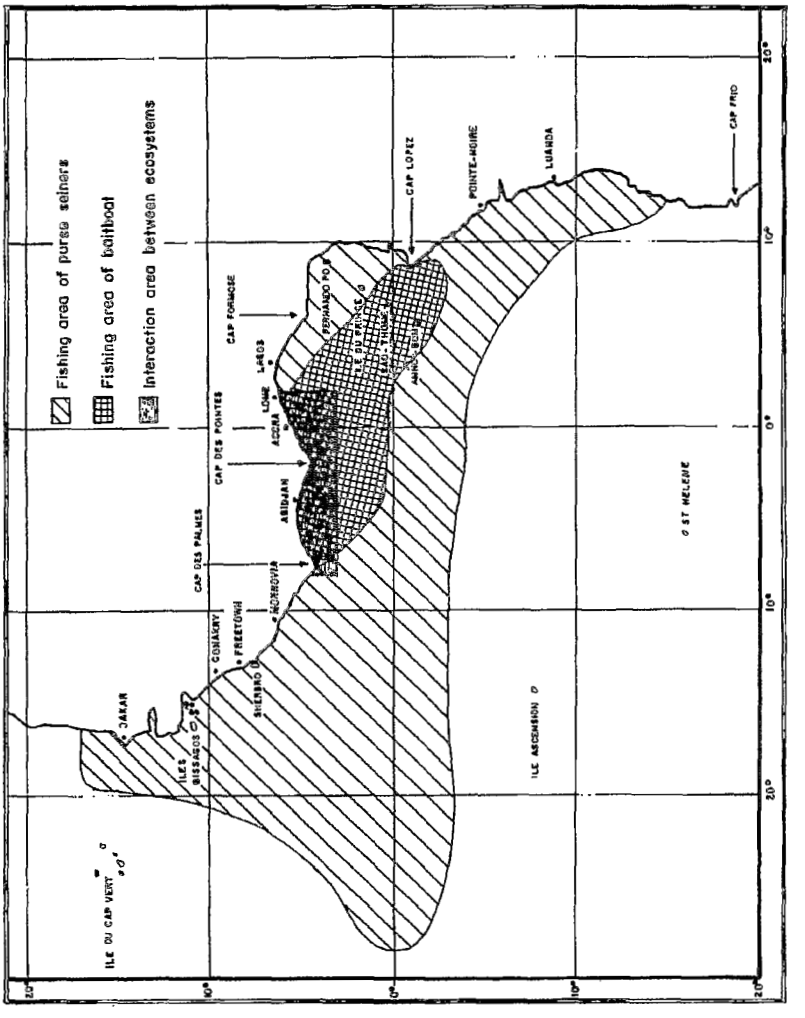

Figure 2 : Map of fishing grounds of Abidjan based purse seiners and Tema based baitboats. The defined area of interaction between the coastal upwelling ecosystem and the oceanic ecosystem is shown. See text.

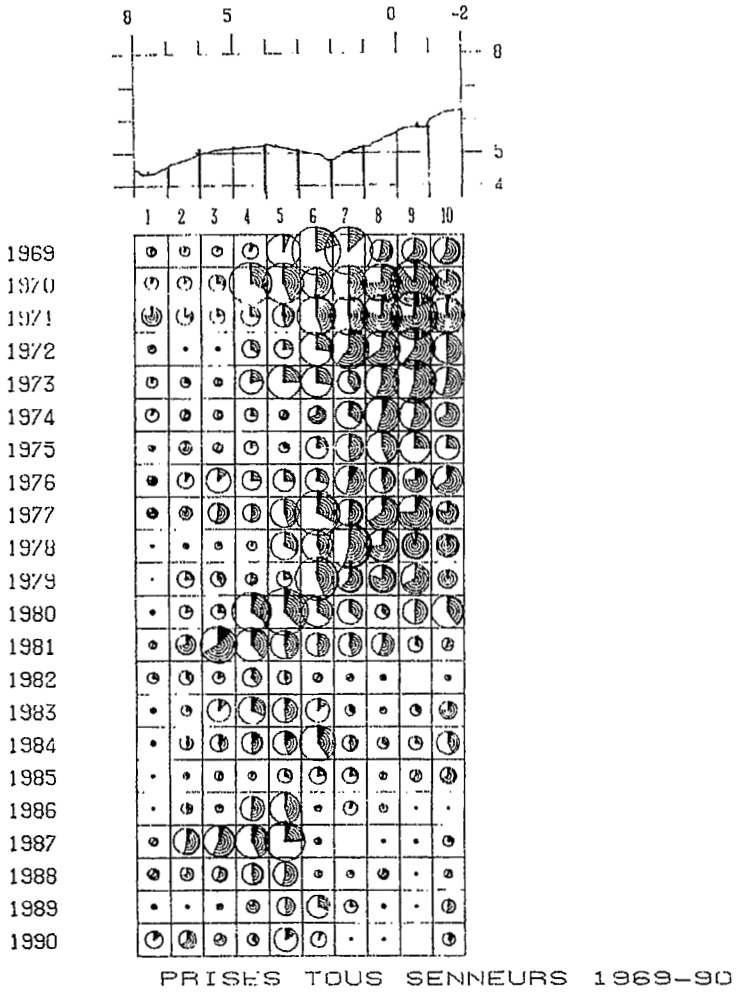

Figure 3 : Synthetic representation for years 1969-1990 of the purse seiners total catches in the area interaction as mapped in figure 2. The size of the circle is proportional to the catch. White sectors are yellowfin, striped sectors are skipjack, black sectors are bigeye.(Source Fonteneau).

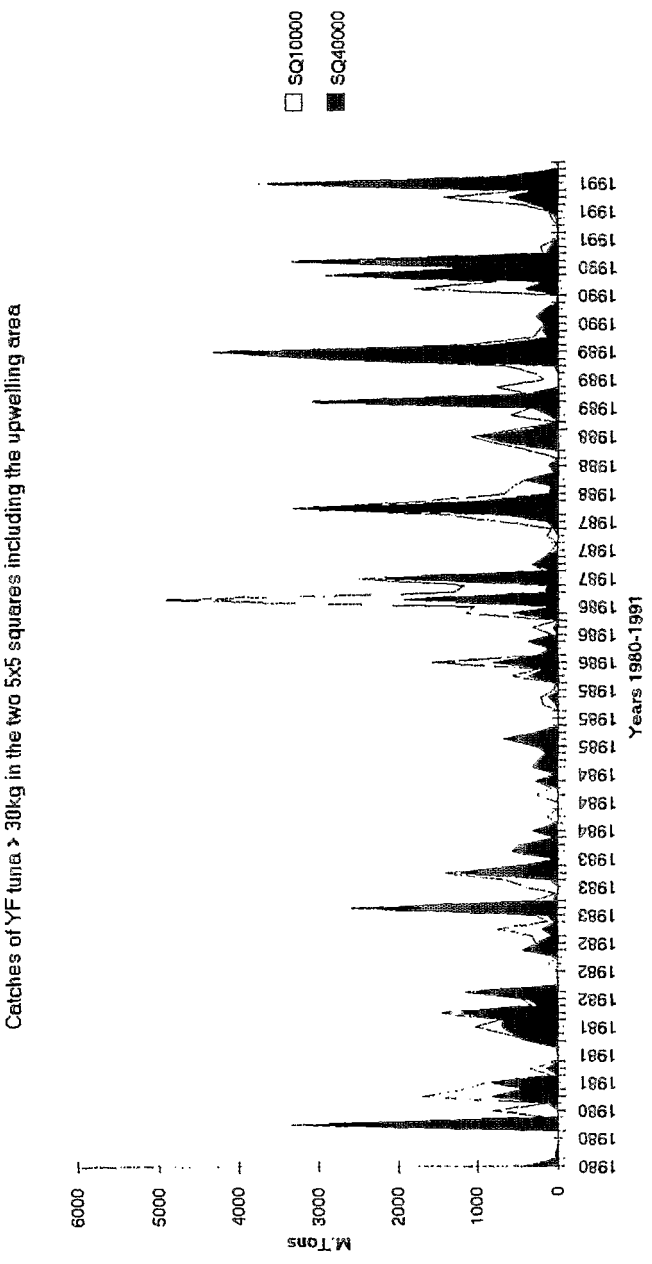

Figure 4 : Captures in tons of large yellowfin (category +30 Kg) for years 1980-1991 in the 5x5 degree squares(CWP 1 0000 and 4 0000) including the Ivorio-Ghanaian upwelling. Catches by the whole fleet of purse seiners based in Abidjan. After 1991 these complete data are not available.

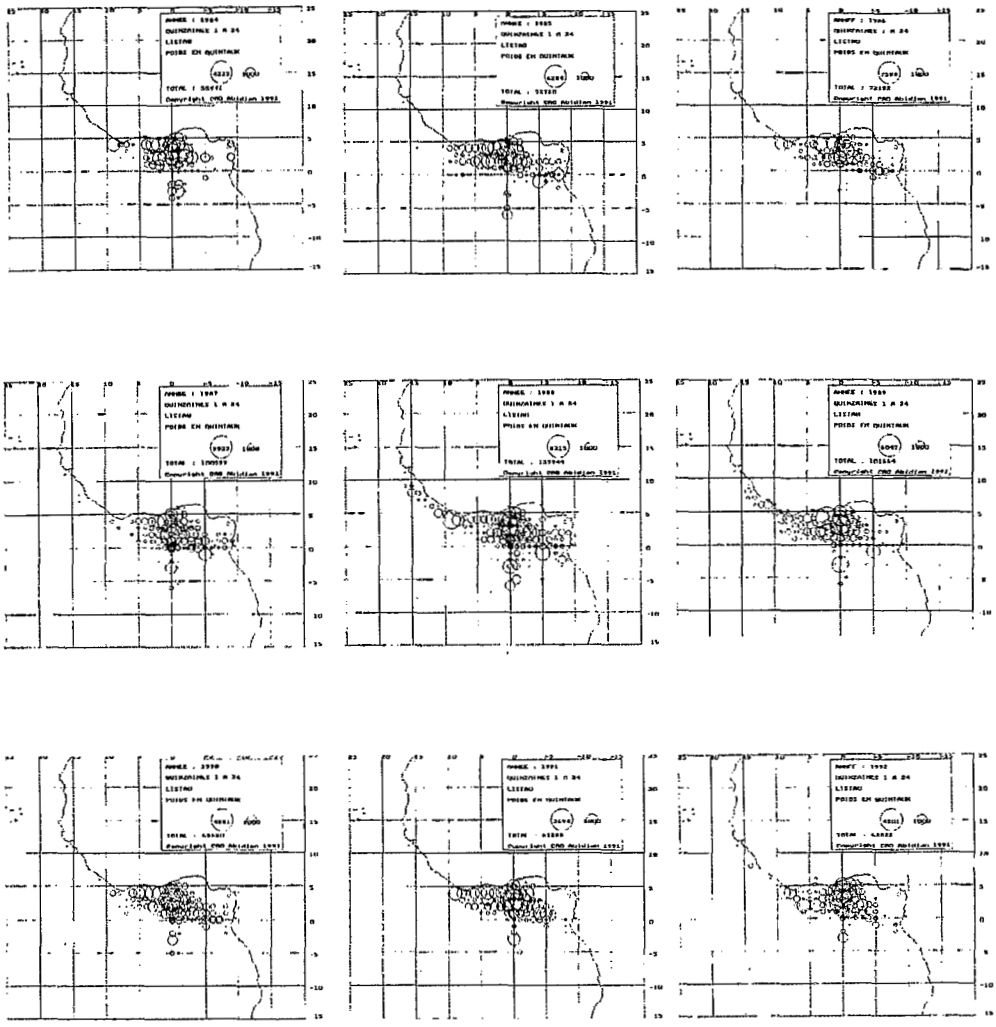

Figure 5: Maps by 1x1 degree squares of the catch of skipjack and small tunas by Tema based baiboats for years 1984-1992 . Source: logbooks collected by FRUB and CRO.