

1. Introduction

Migrations within regions and between regions and neighboring countries are an inherent nature of the artisanal fishery in Ghana. Several factors induce migration of canoe fishermen; these include movement of fish schools, distribution and abundance of fish and social and economic factors (Koranteng, 1990). The most important for internal migration is the movement of sardinellas that depends on the upwelling season. The spatial and yearly variability of the seasonal phenomena implies variations on canoe's distribution along the coastline. These movements of fishermen affect the fishery statistics. Since 1987, the Research Utilization Branch of the Fisheries Department has taken over monthly censuses on the beaches involved in the survey for collecting catch and effort data. The analysis of these data should allow to measure the extent of the migration phenomenon and to improve the statistical system. The monthly data have not been adequately analyzed yet, but this first description underlines some problems met in the estimation of fish production for small-scale fisheries.

2. The survey system

Developed in 1972 with FAO, the survey system on artisanal fishery has not been basically modified since this period (Koranteng, 1989). Taken over by the Fisheries Department, the statistical system depends on two services: fieldwork by Marine Branch and processing data by the Research and Utilization Branch at Tema. Censuses operating out of the fishing villages are taken every two or three years since 1969. These frame surveys, which give a description of the artisanal fleet, allow to select the landing beaches for catch effort sampling by an appropriate statistical design and to calculate the raising factors for the estimation of fish production by region.

The artisanal fishery in Ghana is characterized by a large number and a great dispersion of the landing beaches. The fleet made up of over 8 000 canoes spread over more than 250 fishing villages along the coast. The survey system based on a statistical design is notable by its extent (35 recorders, 67 sampled beaches) and its rigor in the control of the fieldwork. The statistical design corresponds to a stratified three-stage sample survey system (Banerji, 1974). The strata, defined by three qualitative variables combined: region, month and gear, take account of heterogeneity between regions, seasonal variability and technological characteristics.

The four regions correspond roughly to the demographic distribution of principal ethnic groups (Figure 1) :

- Volta with Ewe people, characterized by beach seine ;
- Greater Accra, with Ga people, characterized by line ;
- Central region, with Fantis, characterized by purse seine and set net ;
- Western region, with a miscellaneous ethnic group, less typical of one gear.

Five main categories of fishing gear are distinguished: ali/poli/watsa, beach seine, line, set net and drift gill net.

The different units of the three-stage sample are:

- primary units: the landing beaches;
- secondary units: the sampling days;
- and tertiary units: the canoes.

Each stage follows a sampling design:

- probability proportional to the size of sampling units for landing beaches;
- all working days for two weeks every month;
- systematic basis for canoes.

With the probability proportional to the size design, fishing villages (primary units) with large numbers of canoes get better chances of being included in the sample. Effort and catch data are collected on secondary and tertiary units. For the processing of data, three raising factors are used (Table 1):

- the factor 1, for daily estimates, depends on the total number of trips ($M_{ab,ij}$) and the number of sampled canoes ($m_{ab,ij}$);
- the factor 2, for monthly estimates, depends on the number of fishing days (D) and the number of sampling days (d);
- the factor 3, for regional estimates, depends on the number of canoes in region (N_{ah}) and the number of canoes in sampling centers ($N_{ah,i}$).

3. Impact of fishermen migration on fishery statistics

The numbers of canoes per region and per landing beaches used in the regional raising factor are given by the frame survey from one, two or three years ago. These surveys, undertaken during the period of lower migration, reflect the canoe distribution observed during one month, generally January or February. In fact, the artisanal fishermen follow the migrating fish by moving from village to village several times in the course of the fishing season (Koranteng, 1994). The figures used in the third raising factor change consequently and the migration phenomena may induce a bias in the monthly statistics per region. If the whole canoe fleet is invariable on overall regions, we can suppose that national statistics are exact. However, this is incompatible with the reasons that cause fishermen migration. If migration is explained by the variation of fish abundance and that fishermen move with the fish migration, taking account of a regional stable fleet during

Total catch/sampling day/sampling center/gear

a: region
 h: gear
 i: landing beach
 j: day
 k: canoe
 M: number of total trips
 m: number of sampled trips
 y: catch

$$\hat{Y}_{ah,ij} = \frac{M_{ah,ij}}{m_{ah,ij}} \sum_{k=1}^{m_{ah,ij}} y_{ah,ijk}$$

Total catch/month/sampling center.

D: number of fishing days in the month
 d: number of sampling days

$$\hat{Y}_{ah,i} = \frac{D}{d} \sum_{j=1}^d \hat{Y}_{ah,ij}$$

Total catch/month/region/gear:

N: total number of canoes
 n: number of sampling centers

$$\hat{Y}_{ah} = \frac{N_{ah}}{n_{ah}} \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N_{ah,i}}$$

TABLE 1 : Unbiased estimates of catch in the case of sampling units selected with probability proportional to size.

time might misestimate total catches: migrant canoes are associated with less productive regions and the most productive regions with an underestimated regional fleet (Ferraris, 1993).

In the case of a change in the frame survey, the bias in the results may be quantified by the following formulas (Banerji, 1974) :

Let the total catch/month/region/gear calculated with the frame survey :

$$\hat{Y}_{ah} = \frac{N_{ah}}{n_{ah}} \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N_{ah,i}}$$

Let N'_{ahm} the number of canoes with the gear h during the month m in the region a and $N'_{ahm,i}$ the number of canoes during the month in the sampling center i. The right estimate of total catch/month/region/gear is :

$$\hat{Y}'_{ahm} = \frac{N'_{ahm}}{n_{ah}} \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N'_{ahm,i}}$$

The bias between these two estimates is given by:

$$\hat{Y}_{ah} - \hat{Y}'_{ahm} = \frac{N_{ah}}{n_{ah}} \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N_{ah,i}} - \frac{N'_{ahm}}{n_{ah}} \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N'_{ahm,i}}$$

If the migration is limited within the region ($N'_{ahm} = N_{ah}$), the bias may be calculated with the number of canoes observed during the month in the sampling centers :

$$\hat{Y}_{ah} - \hat{Y}'_{ahm} = \frac{N_{ah}}{n_{ah}} \left(\sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N_{ah,i}} - \sum_{i=1}^{n_{ah}} \frac{\hat{Y}_{ah,i}}{N'_{ahm,i}} \right)$$

In the case of migration between regions, the total number of canoes in the region at the month i must be evaluated. The monthly censuses established since 1987 by the FRUB on the sampled beaches give an estimate of the number of canoes in the center i using the gear h during the month m. The estimation of the monthly canoes number by region implies to evaluate the migration between regions. If the 67 beaches involved in the monthly censuses, which have been chosen at random, are representative of overall landing beaches of the region, the variation observed on the sampled sites may then be applied at all the sites to evaluate the size of the fleet in the region at each month :

$$\hat{N}'_{ahm} = N_{ah} \frac{\sum_{i=1}^{n_{ah}} N'_{ahm,i}}{\sum_{i=1}^{n_{ah}} N_{ah,i}}$$

This expression is right if the non sampled beaches in the region have the same migratory rate that the sampled beaches.

To evaluate the biases in the results, it is then necessary to identify the main changes occurred in the distribution of canoes recorded during the frame survey and to study the migratory floods. A great variation in the number of canoes during the year or between the years covered by the same survey may have an impact on the monthly statistics. The data analysis of frame surveys and monthly censuses gives a first idea about the dynamics of the fishery.

4. Analysis of the census data

Frame surveys

The structure of regional fleets, illustrated by the data of surveys undertaken in 1986, 1989 and 1992, shows a relative stability (Figure 2). The regions present the characteristic gears of their dominant ethnic groups. For the country as a whole, there is no significant difference among the five major types of marine canoe fisheries: ali, poli, watsa, set net and line (respectively in 1989: 1112, 1181, 1391, 1300 and 1114 canoes). The artisanal fleet is dominated by the big canoes using the nets for small pelagic species, particularly sardinellas and anchovy. As the sardinellas can constitute as much as 40% of total domestic marine fish production, the present paper will examine in some detail the category ali/poli/watsa (APW). These three gears, which were distinguished during the 1989 census, are not separated for the catch and effort data because of the joint using of nets by the fishermen. During the census, each canoe is classified in the gear that has been mostly used for fishing at the time of survey. The recorder, during the collect of catch and effort data, can have difficulties to know the kind of net used for the fishing trip if the fisherman can use the different nets simultaneously (like poli+watsa) or at different time in the course of the fishing season. These three kinds of net are considered all together but it would be relevant to analyze more detailed the fluctuations of the number of canoes with each gear during the fishing season and the number of canoes using the different nets.

In 1992 (Table 2), the fleet is 8% up on 1989 (8688 canoes/8052 canoes). This increase, due to entry in the fishery of new canoes, is not equally distributed among the regions: the Volta and Greater Accra regions show a deficit (respectively -7% and -24,5%) at the opposite of Central and Western regions that show a benefit (+24,4% and +47,9%). These differences between regions are the results of an internal migration. Contrary to 1992, the variation of the whole fleet between 1986 and 1989 is decreasing (-1,9%) with a deficit for the two western regions and a benefit for the eastern regions. The comparison of the two intervals of time shows the same similarity between the regions: in the first period (86-89), the canoes go from west (Western + Central) to east (Volta + Greater Accra) and in the second (89-92), from east (Volta + Greater Accra) to west (Western + Central). All regions and all gears are concerned by the variations. These fluctuations may be explained by the migration (for instance when the total number of canoes changes in the region) but also by changes on the gear using at the different time of the surveys. These variations may then reflect the temporal variability within the year. Three categories of gear show a well-marked tendency from 1986 to 1992: ali/poli/watsa and drift-gill net that respectively decrease of 13% and 45% and set net that undergoes an increment of 40%. The variations observed in 1989 are confirmed by the 1992 frame survey. The number of ali/poli/watsa canoes decreases only in the eastern regions and the number of set net canoes increases in overall regions.

The analysis of these data confirms the existence of migratory floods between regions within Ghana and probably, to explain the big variation of the whole fleet, between Ghana and foreign countries. The diminution of ali/poli/watsa nets may also be linked to the increment of set nets. It is possible that with the gradual depletion of the «wawa» tree from which canoe are dug out, worn out larger canoes are not been replaced fully, particularly ali/poli/watsa and drift-gill net canoes (Seini, 1994). The large crews of these canoes may have changed one's occupation and taken a new fishing tactic, the set net. The problem consists to analyze if these modifications reflect a general tendency observed in the course of years between two surveys or a temporal phenomenon observed at the time of the surveys. The evolution of the numbers of canoes given by the monthly censuses in the sampling centers must allow to verify the representativity of the census results on the period covered by the same survey for the calculus of statistics .

	1986	1989	1992
REGION			
VOLTA	529	546	507
CREATER ACCRA	3016	3154	2381
CENTRAL	2866	2717	3381
WESTERN	1803	1635	2419
GEAR			
Ali/Poli/Watsa	3969	3684	3458
Beach Seine	797	852	775
Set Net	1852	1874	2586
Line	1004	1114	1040
Drift Gill Net	450	366	249
Others	142	162	580
TOTAL	8214	8052	8688

TABLE 2 : Comparison of 1989, and 1992 canoe census results : number of canoes by region and by gear.

5. Monthly censuses

Each landing beach is characterized by the number of monthly active canoes classified in the gear mostly used at each month. For example, the figure 3 shows the profiles observed in Winneba between 1987 and 1991 and underlines the kind of problems met in the analysis of these patterns. The large fluctuations on the figure 3a with the zero values are difficult to explain: why more than fifty canoes would suddenly stop their activity ?

As few enumerators counted only canoes for the gears that they take catch and effort data from and ignored the other canoes, it is difficult to distinguish between «zero» count (i.e. no canoe) and «no records» in the data base: all the values equal to zero are finally transformed in missing value (cf. Figure 3b for Winneba). This means that the number of canoes does not give the exact number of canoes in the sampling sites as some gears may have been omitted. Winneba, which belongs to the central region, is characterized by gears for small pelagic species (ali, poli et watsa), set net and line. The survey, undertaken in 1989 between March 13th and 28th, gives the following figures: 9 canoes with ali, 60 with poli, 10 with watsa (APW=79), 68 with set net and 10 with line. These numbers are variable on the time between the two frame surveys from 1989 to 1992. The number of APW canoes shows the largest variations with peaks that concerned more than one hundred canoes during short periods. Because of the joint using of gears, the evolution of a gear could be explained by an another gear. The same canoe can use different gears depending on the species available. Several cases of mixed using between set net and line or between drift gill net and set net have been noticed by the recorders. The complementary of the profiles APW and line in 1990 and 1991 in Winneba could point out this problem of fishing efforts transfer. This must be confirmed by a specific survey to see if a same canoe can use the two gears.

The evolution of the number of canoes with APW per region is visualized by the average of the number of canoes by beach calculated with the 67 sampled beaches recorded in the monthly censuses (Figure 4). The figure 4.a shows the variations in the arithmetic mean of the number of canoes for the centers where are sampled the canoes with APW. As well as we have seen with the frame survey data, APW canoes are more characteristic in Central and Greater Accra regions. Temporal variability is well marked for Central and Western regions, the two regions at the West of the coastline where the sardinella season starts. The profiles of these regions are not complementary: an increase in a region doesn't correspond to a decrease in another, but the sharp rises during the sardinella season seem synchronous. With the probability proportional to size sampling design, the landing beaches with large number of canoes have a bigger weight in the calculus of the mean . It is then better to use the median to estimate the average number of canoes by beach. The median respects the variability of the sample: 50% of sampled beaches have more canoes than the median and 50% have a number of canoes less than the median. The figure 4b shows that the

peaks of the figure 4a are due to some beaches but are not observed on overall sampled beaches of the corresponding region. The difference between the mean and median profiles gives an idea on the intra-regional variability. The mean is sensitive to the extremes but the range of variations observed in each region is lost with the median. The profiles with mean or median confirm the tendency seen with the frame survey: an increase of the number of APW canoes in the western region as the number of canoes in the Greater Accra region decreases. The sharp fluctuations that occur annually in Central and Western regions reflect changes on canoe distribution and are important to consider for the statistics calculus. The median for the Central region shows the peak observed during the major sardinella season: the increase of number of canoes with APW is observed on the majority of the sampled sites of this region. The fluctuations observed in the western region with the arithmetic mean are not true for all sites of the region. It is then not right to apply the average deviation measured on the sampled sites to the whole region because of the intra-regional variability and necessary to identify the different types of profile occurred in a same region.

The temporal variability of the ali/poli/watsa fleet is measured with the standard deviation of the monthly number of canoes (using APW) calculated by beach and by year. The table 3 gives the minimum and maximum standard deviations by region. These values show the disparity between the centers (differences between minimum and maximum for a same region) and the extent of the canoes movement: few beaches have an average departure in number of canoes from their yearly mean greater than 50 canoes. The minimum and maximum standard deviations show that some beaches have a very small variation and that the movements of canoes have not the same magnitude according to the year. Some beaches with the greatest variability are selected to analyze their profile. As this kind of canoe is not characteristic of the Volta region, the beaches of this region are not taken into account. The figure 5 illustrates the variation in the number of canoes with APW for six beaches :

Greater Accra: Tema and Accra.

Central region: Elmina and Winneba

Western region: Sekondi and Shama

The two beaches by region, chosen because of their variations in number of canoes operating the gear «ali/poli/watsa» among the beaches recorded during the monthly censuses, do not show parallel or complementary profiles: Tema has a relative stability when the fleet of the beach «lighthouse» in Accra is fluctuating, with a deficit of more than one hundred canoes during the year 1990. Winneba, in the east part of the Central region, is more stable than Elmina with some peaks at the beginning and the end of the year; in 1990 and 1991, an increase observed at Winneba corresponds to a decrease at Elmina. Elmina shows two similar years, 1989 and 1990, with a maximum in July and a minimum in November. In 1988, the pattern is different and very variable. At Sekondi, in the Western region where the major sardinella season starts, the fleet increases strongly from July to September (during the major upwelling) and the sharp rise

during the early part of the sardinella season is recurrent from year to year. At Shama, this kind of variations in the fleet is not observed. The extension of the fishing season in 1990 and 1991 is compatible with the extend of the minor upwelling and the good production of sardinella in the west part of the Gulf of Guinea (Pezennec, 1994).

	YEAR	MIN	MAX
VOLTA	1987	0,0	2,0
	1988	0,4	1,1
	1989	0,3	13,4
	1990	0,5	8,1
	1991	0,0	2,1
CENTRAL	1987	2,2	25,3
	1988	5,4	60,7
	1989	0,5	49,5
	1990	1,3	54,5
	1991	0,7	46,8
GREATER ACCRA	1987	0,0	46,0
	1988	1,2	36,7
	1989	0,5	43,7
	1990	0,0	19,9
	1991	0,0	42,9
WESTERN	1987	0,0	54,3
	1988	0,0	203,0
	1989	0,0	253,9
	1990	0,0	160,3
	1991	0,0	245,4

TABLE 3: Temporal variability of the number of canoes with ali/poli/watsa by region illustrated by the minima and maxima of the yearly standard deviation calculated by beach.

The few profiles of beaches the most involved in the variations of canoes' number, for the beaches concerned by the monthly censuses, allow to draw the following points:

- The non complementary of the profiles does not allow to describe the migratory floods: one region or one center does not seem to sustain in canoes another region or center. The large fluctuations in Elmina or Sekondi coincide with the sardinella season in the area. We are not seeing corresponding decrease at the other sites because migrant canoes could come from any of the other sites (>200). Many canoes migrate to centers where they are likely to find market and better price for their catch.

- Few sites are very fluctuating and the numbers of canoes recorded during the frame survey may change in the course of the year. The different beaches in a same region may have non comparable profiles: the example of Sekondi shows that we must be careful before to apply the migration rate measured with the beaches involved in monthly censuses to the other sites of the region: the Sekondi fleet increases of 800 canoes during the sardinella season when the frame surveys give about ten canoes with ali, poli or watsa nets (1986: 9; 1989: 5; 1992: 23).

- These examples underline the specificity of each landing beach and each year and the necessity to better understand the migratory flood and the dynamics of the fishery to improve the statistical system.

6. Conclusion

The analysis of canoe fishery data implies to be vigilant to the rightness of the hypotheses linked with the statistical design. The fishermen migration, particularly with reference to sardinellas, may induce a bias in the statistics because of changes in the frame survey. A better understood of the fishery dynamics will enable to improve the statistical system and to measure the potential biases in the estimates of fish production. The changes occurred in the main centers of monthly censuses must be described with more details in relation with the catches, the own characteristics of landing beaches and the variability of their environment.

A deeply analysis of the monthly census data should allow to approach the following points:

- description of the migration phenomena along the coast ;
- understanding of the fleet variability within a same region ;
- comparison of monthly migration scheme for different years ;
- classification of landing beaches on the basis of their fleet evolution ;

Quantitative stock assessment for small-scale fisheries implies to deal with the dynamics of the exploitation system. The problems related with the migration or joint using of fishing gears refer to an intrinsic characteristic of the artisanal fisheries. The flexible and opportunist behavior of canoe fishermen can give some signals about the condition of the system and the wealth of the resource.

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CAPTIONS OF FIGURES

Figure 1 : Geographical display of strata analysed.

Figure 2 : Comparison of 1986, 1989 and 1992 canoe census results: number of canoes operating specified fishing gears by region (APW: Ali/Poli/Watsa, BS: beach Seine, SN: Set Net, LN: Line, DGN: Drift Gill Net)

Figure 3 : Number of canoes by gear given by monthly censuses between 1987 and 1991 in Winneba (Central region): a - raw data; b - zero values equal missing values. (APW: ali/poli/watsa nets; SN: set net; L: Line)

Figure 4: Variations in the average number per beach of canoes using ali/poli/watsa nets by region.

Figure 5 : Number of canoes operating the gear «ali/poli/watsa» in some beaches showing the greatest variations by region from 1987 to 1991.

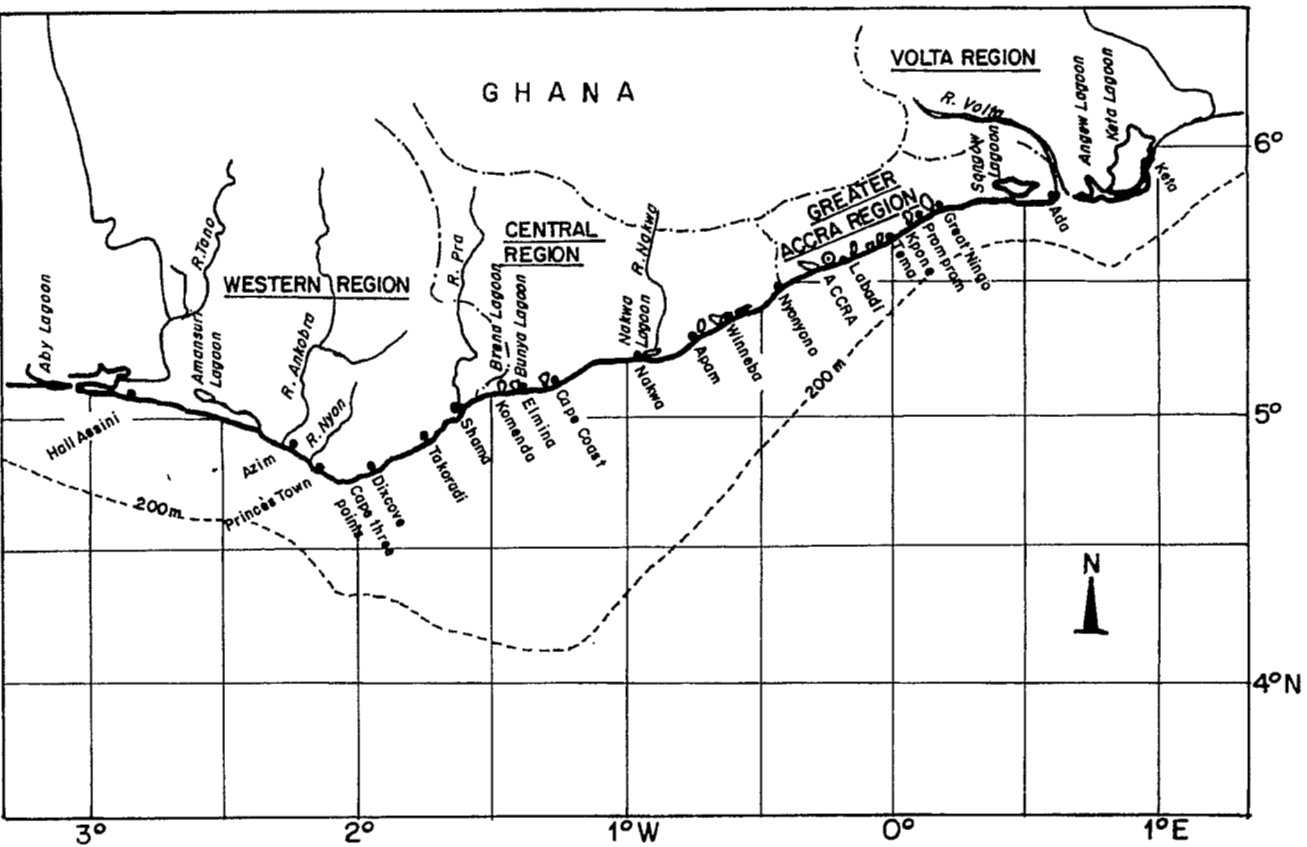
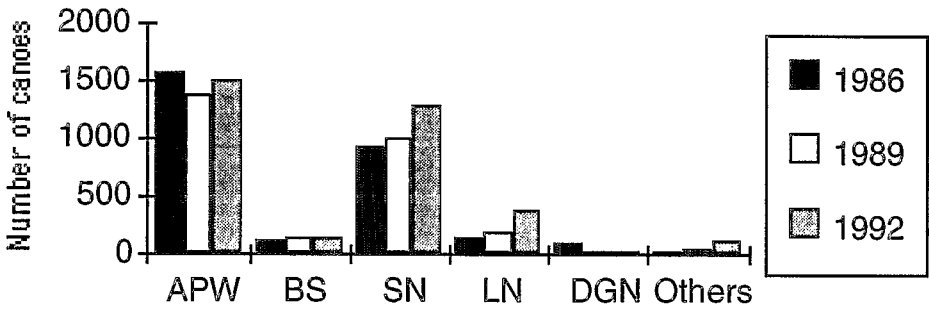


Figure 1 : Geographical display of strata analysed.

CENTRAL



WESTERN

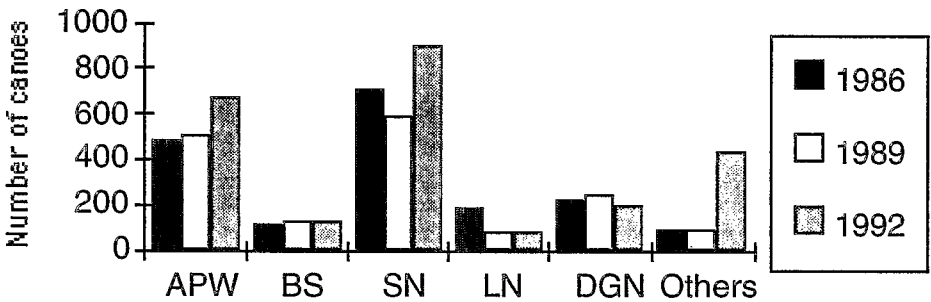
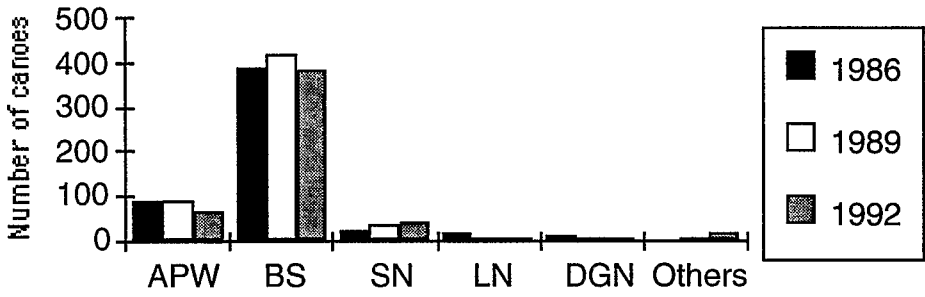
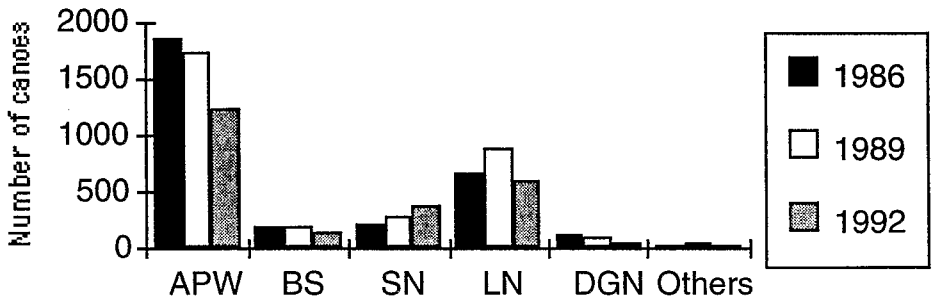


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VOLTA



GREATER ACCRA



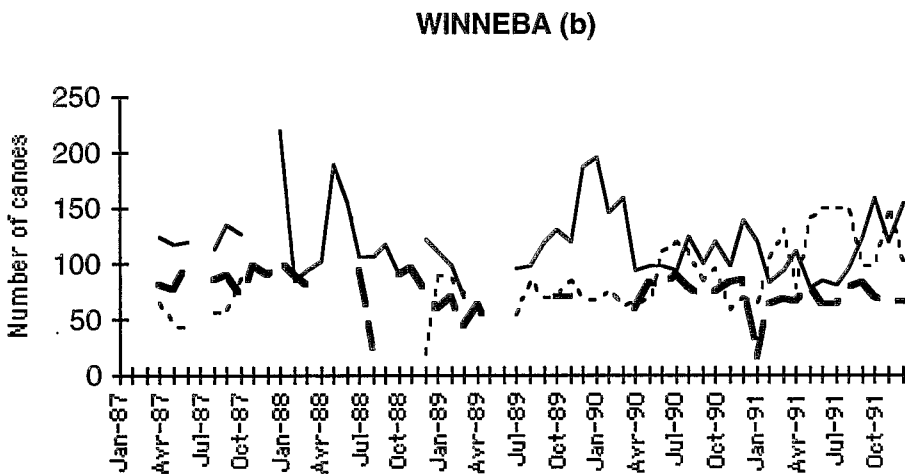
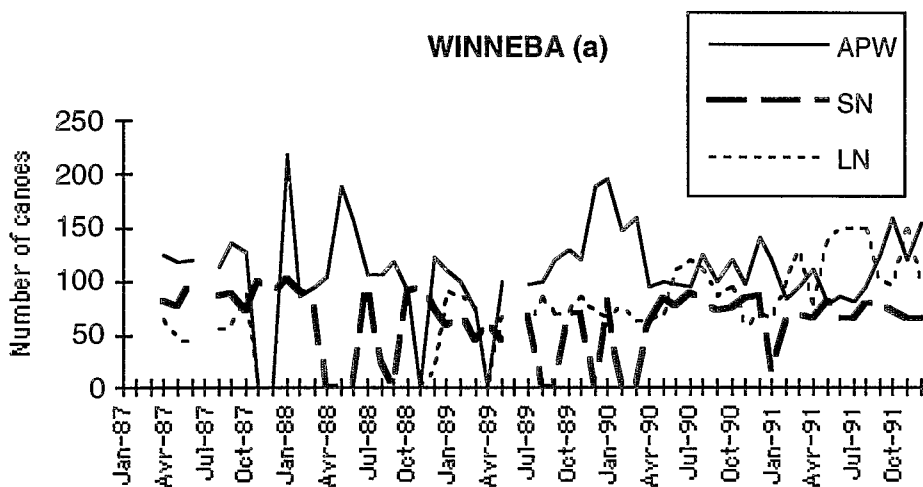
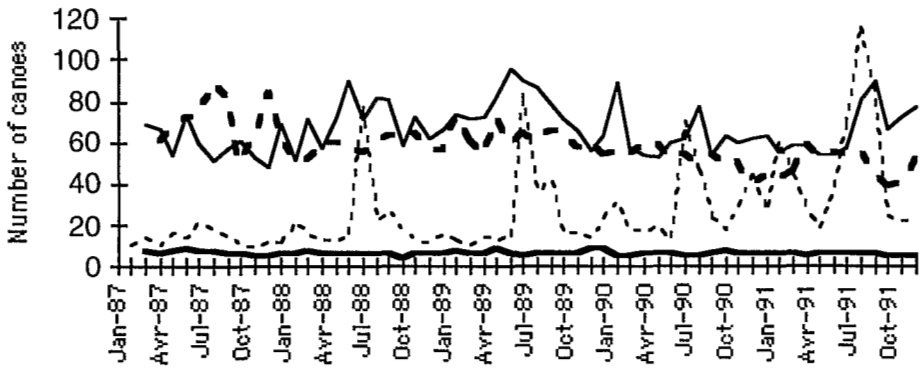


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a - ARITHMETIC MEAN



b - MEDIAN

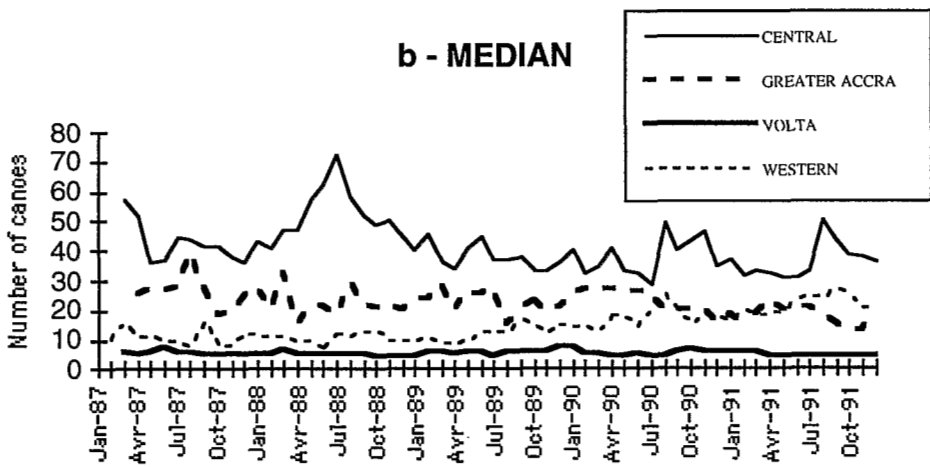


Figure 4 : Variations in the average number per beach of canoes using ali/poli/ watsa nets by region.

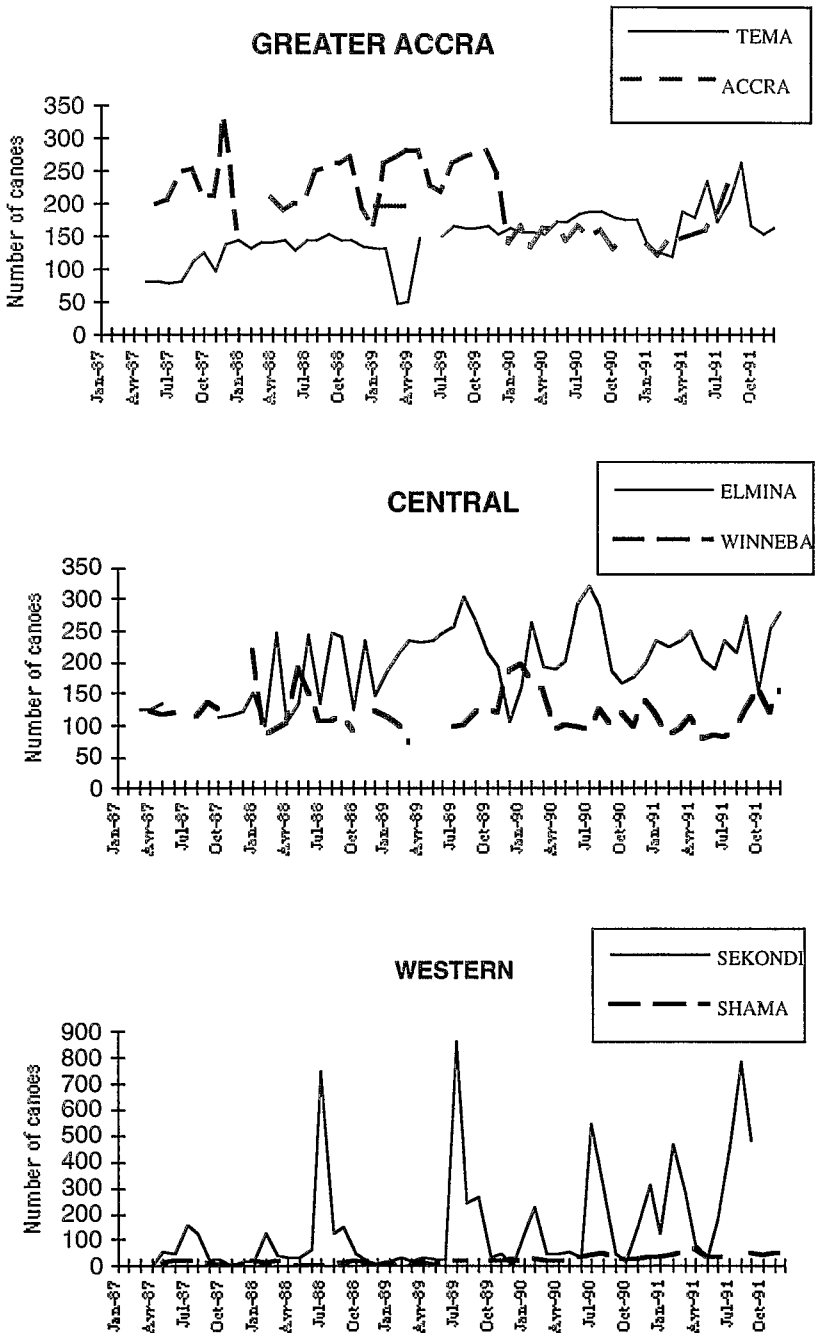


Figure 5 : Number of canoes operating the gear «ali/poli/watsa» in some beaches showing the greatest variations by region from 1987 to 1991.