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SOME METHOLODOLOGICAL CONSIDERATIONS ON TRAWL SURVEYS CARRIED OUT IN WEST AFRICA

by

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A B S T R A C T

Trawl surveys carried out in West Africa, particularly off Senegalese coasts, have given rise to methological studies. The use of Delta distribution, more adequate than standard mean and variance calculations, generally increases these values. A priori stratification of samplings offers little interest for total catches, or most of the time for the main species. Optimal allocations of the number of hauls per stratum vary a great deal from one survey to another. A trawl tow duration of 30 minutes is sufficient for abundance estimations.

I N T R O D U C T I O N

The coastal waters of West Africa, from Mauritania to Angola, are inhabited by a large faunistic unity, whose demersal communities were described by Longhurst (1969). Specific diversity is high and a one-hour trawl tow provides individuals belonging to numerous species, a dozen of which can be found in significantly large quantities.

It would be useless here to mention the advantages of groundfish surveys. Let us just note that they are all the more interesting in West Africa as fishing statistics are generally unreliable and incomplete, and do not give sufficient information on the quantitative composition of stocks and their evolution. Several trawl surveys have been carried out in recent years with similar system schemes (stratified random sampling) in the waters of different countries (Mauritania, Senegal, Guinee-Bissau, Guinee, Ivory Coast, Togo, Benin). The trawl surveys carried out in Senegal will enable us to study a few methodological considerations concerning sampling methods on board (catch estimations per haul), concerning the sampling scheme (stratification effects, optimal allocations) and mean and variance calculations. Some results will be compared with those obtained in the Ivory Coast. Specific research-trips were also made to study quantitative and qualitative effects of tow durations (one hour, half an hour).

1. METHODOLOGICAL PRESENTATION OF SURVEYS MADE IN SENEGALESE WATERS

Prospection surveys for demersal resources on the Senegalese continental shelf have been regularly carried out since 1986, by stratified random sampling. The surface of the continental shelf between the 10 and 200 m isobathes was divided into 1,150 rectangles with 2' longitude and 2.5' latitude sides (5 nautical square miles). This distance is adequate for a standard tow duration of 30 minutes. The rectangles were then allotted into three different areas and four bathymetric bands. The different combinations formed twelve strata.

The total area was divided into the following zones :

- Northern : from the Mauritanian border to Almadies Point (Dakar) ;
- Central : from Dakar to the northern border of Gambia ;
- Southern : from the southern frontier of Gambia to Cape Roxo (southern border of Senegal).

The bathymetric bands were chosen according to prior studies on the distribution of species. The bands defined were the 10-30, 30-60, 60-100, 100-200 metre bands ; the latter is very small in the Central and Southern areas where, in addition, trawling is very difficult.

One rectangle out of ten in each stratum was chosen at random (without remission) for trawling. If one of the rectangles thus chosen proved unsuitable for trawling, the nearest rectangle with the same depth (along the ship's route), in the same stratum, was sampled. If the nearest rectangle also proved unsuitable, another rectangle was picked at random in the stratum. The total number of basic rectangles in each stratum and the number of trawl tows planned appear in Table 1.

Stratified random sampling design is used to reduce estimation variance in comparison with non stratified random sampling, when strata have been appropriately chosen (Cochran, 1977 ; Grosslein and Laurec, 1982).

The weighted mean worked out according to the number of tows ni (allocation) per stratum is :

$$x = \frac{1}{A} \Sigma A_i . x_i$$

Ai represents the surface of stratum i and A is the total surface. Its variance is :

$$s^2(\bar{x}) = \frac{1}{A^2} \Sigma A_i{}^2 . s^2(\bar{x}_i)$$

$s(\bar{x}i)$ is the mean standard error for stratum i,
$s(\bar{x}i) = si/\sqrt{n_i}$

Seven surveys were carried out from 1986 to 1990, four during the cool season and three during the hot season.

2. COMPARISON BETWEEN MEANS AND STANDARD DEVIATIONS COMPUTED FROM NORMAL DISTRIBUTION AND DELTA DISTRIBUTION

Relative abundance indexes and their variances issued from trawl surveys were often estimated in the past from common mean and variance calculations. This method will be referred to as "normal" in comparison with those in use for particular distributions. For a given species, hauls generally show an irregular distribution with many zero values and some very large catches, and nowadays, the Delta distribution system seems best suited to minimize bias in mean and variance calculations for trawl surveys (Pennington, 1983 and 1986, according to the work of Aitchison and Brown, 1957). Delta distribution consists in treating positive values separately with a simple log-normal distribution, then including the zero values. A hyper-geometric function, which can easily be computed, is used. The efficiency of Delta distribution depends on the number of trawl tows, on the proportion of zero values and on the variability range for positive values (Smith, 1988).

Means (kg/0.5h) and their coefficients of variation (CV), computed by Delta distribution for the grand total and for the 20 main species or groups of species on the Senegalese continental shelf between 10 and 100 metres, appear in Table 2. These values concern the means of seven trawl surveys. The 100-200 metre stratum is not concerned because it was not sampled in each survey in the Southern and Central areas, due to trawling difficulties. The 20 species represent 75 to 87% of the grand total with normal calculation ; but this percentage can rise to 129% (Survey LS8905) when Delta distribution is used. This highlights an important problem linked with the use of Delta distribution : the sum of the species catches per tow is not equal to the all-species catches per tow. Delta distribution means (Table 2) are generally above normal means, up to 74% for the bigeye grunt *Brachydeuterus auritus*, which is the most common species. But means can also be below normal. Coefficients of variation are also generally higher than normal. The range of the differences depends on the proportion of zero values, but not only as mentioned above. The eurybathic species *Pagellus bellottii* (Red pandora), which has few zero values, shows a great difference on the whole when means are computed with normal or with delta distributions. On the contrary, the coastal species ***Pteroscion peli*** and the depth dentex ***Dentex congoensis, D. macrophtalmus*** show many zero values and relatively small differences. The all-species catches, which do not exhibit zero values, have a 4.9 % positive difference for the mean, and 18.7% for the CV between Delta and normal distributions, for the seven surveys combined. Appendix 1 shows the same results as those presented in Table 2, but for each survey, for the species which, on the whole, has the highest positive differences (***Brachydeuterus auritus***), the one which has the highest negative differences (selacian total), and an intermediate species (***Pomadasis jubelini + P. peroteti + P. rogeri***). For each survey, the differences are always positive for ***B. auritus***, with means and CV that can double or more ; this results in high combinate differences. The difference values can be positive or negative , depending on the surveys, for the other two species.

Pennington (1983) had already noted that normal distribution underestimated the true mean variability and therefore gave an over-optimistic impression of the accuracy of a given survey.

From data on eleven trawl surveys carried out off the shores of Ivory Coast, Bernard (1990) made the same calculations for the six main species of the continental shelf. In comparison with the use of normal distribution, Delta distribution would reduce the CV by half on average for the six species, whereas for the five species common to both studies (***Galeoides, Pomadasys, Brachydeuterus, Pseudotolithus, Pagellus + Dentex***), the CV increases in front of Senegal. Bernard noted however, with reference to Smith (1988), that Delta distribution in this conventional use underestimates the mean variance when sample numbers are small. This is the case in Ivory Coast waters where the number of hauls per stratum is generally much less than in Senegalese waters.

For the all-species catches, the CV is 12.3% on average with normal distribution (skewed) ; it rises to 14.6% with Delta distribution. The last percentage is quite satisfactory for trawl surveys (Grosslein and Laurec, 1982).

The CV for the all-species catches per tow (10-120 m), are similar in Ivory Coast with 12.2% on average (normal distribution) for three surveys (Caveriviere, 1982 and 1989). The sampling scheme used was the same as in Senegalese waters, that is, one rectangle out of ten was picked by stratified random sampling.

3. EFFECTS OF STRATIFICATION ON THE VARIANCE OF ESTIMATIONS

Stratification is used to reduce the variance of estimations compared with non-stratified random sampling, when strata have been appropriately selected(Grosslein and Laurec, 1982). In areas where plurispecificity is high, as on the West

African continental shelf, it is difficult to select a priori strata that present a satisfactory design for the majority of species. The stratifications generally used are in connexion with the shape of the continental shelf in areas perpendicular to the coast (North-South, East-West) and in bathymetric bands assumed to contain the species belonging to the different communities : coastal species, intermediate species, deep continental shelf species.

In Senegalese waters, nine strata were defined between 10 and 100 metres. What are the modifications of the mean variances when calculations are carried out for several levels of stratification, or without stratification? In the latter case, we should bear in mind the fact that, strictly speaking, it is not really non-stratified random sampling because a given number of hauls per stratum is assigned at the start of the survey, thus making the sampling a little more regular.

For the all-species catches, the CV computed by Delta distribution exhibit differences in their variations according to the survey and according to the stratification level (Table 3). Thus, for nine strata, stratification reduces the CV from 15.3% to 9.8% in the LS8709 survey, but paradoxically, it increases from 16.1% to 20% in the LS8614 survey. On average, for the seven surveys, stratification in nine strata reduces the average CV by 0.9% ; stratification with three depths does not lead to a precision gain ; stratification in three zones reduces CV by 1.3%. The results are fairly similar if computations are carried out by normal distribution (Table 4). Therefore, stratification seems to be of little interest for all-species catches. This means that variability within a stratum is as great as or greater than variability between strata. According to the depth, but also according to the area, certain species compensate for other species.

For catches by species, Table 5 exhibits the CV obtained from Delta distribution for the 14 main species, according to nine strata and without stratification. Stratification sometimes produces interesting CV reductions, but for 11 species out of 14, there is a negative effect of stratification for one survey at least. For the three remaining species, CV reductions go from 23% to 34% of non-stratified CV They concern a coastal species *Pteroscion peli* and two more eurybathic species, the red pandora *Pagellus bellottii* and the carangidae *Trachurus trachurus* + *Decapterus*. Other species regarded as coastal, deep or eurybathic do not show such precision gain, so no rule can be laid down. On the whole, stratification leads to a slight loss for two species.

Similar results (little or no CV reduction with the use of stratification), were found in Ivory Coast (Caverivière, 1982, 1989) for all-species catches and for those of the two main species,the bigeye grunt *Brachydeuterus auritus* and *Balistes carolinensis* (Table 6).

A post-stratification applied to one survey or to several surveys for a given species or for a group of species will tend to reduce variance. The difficulty is that it has to be based on auxiliary information, for example the distribution of water temperatures on the bottom, and not on first-hand data (distribution of the catches). Otherwise, the estimated variance can be made arbitrarily small and is meaningless (ICES, 1990). No post-stratification was applied to our data.

4. OPTIMAL ALLOCATIONS

One basic rectangle out of ten was arbitrarily chosen to be sampled for each of the selected strata. Consequently, the sampling effort was allocated only on the basis of the surface covered by the stratum. This process is recommended (Grosslein and Laurec, 1982) when previous information about the inter-strata variances is not available. After a survey, it is possible to calculate the way in which the total number of hauls could have been distributed between the strata in order to reduce the final variance in the total area. In general, optimum allocation is obtained by allocating to each stratum a sample proportional to the product of its surface (Ai) by the intra-stratum standard error (si) :

$$ni = \frac{N.s_i.A_i}{\Sigma.s_i.A_i}$$

For the seven surveys carried out off the senegalese coasts, optimal allocations per stratum were computed in this way from all-species catches, and according to whether normal or Delta distribution had been used (Tables 7 and 8). It is to be noted that results vary a great deal from one survey to another, even when surveys are carried out in the same hydrological season. Thus, from Delta distribution and for 99 total hauls, the optimum allocations computed for the Northern 60-100 metre stratum vary from 4 hauls (LS8912) to 45 hauls (LS8614) ; they vary from 3 to 40 hauls for the Southern 10-30 metre stratum, from 7 to 36 for the Central 10-30 metre stratum. The results obtained with the two distributions for a given survey can differ a great deal (LS8614 and LS8912). It would seem wise, on the whole, to somewhat reduce the allocations used on the 30-60 metre strata and to increase those used on the 60-100 metre strata. The allocations in use, however, are often close to the average optimal allocations computed and, considering the variability of values, it seems preferable to keep the allocations already in use for future surveys.

5. PROPORTIONALITY OF CATCHES BETWEEN HALF-HOUR AND ONE-HOUR TOW DURATIONS

5.1. THE PROBLEM

Trawl surveys are often carried out with a standard half-hour tow duration. This offers several advantages compared with longer tows :

(i)-a greater number of tows can be made in one day, which will reduce the duration of a survey when the number of tows has been pre-established (one basic rectangle out of ten, for example) ; survey costs will be lessened ;

(ii)-quantities to be sorted out will be reduced ; this will save time for the men in charge and could lead to having fewer men on board and/or more time to spare for biological sampling.

One possible drawback could stem from fish behaviour while a trawl is operating. Direct observations have repeatedly shown that many species swim in the mouth of the trawl for some time, until fatigue makes them swim into it and be caught. This swimming time could depend on the species and on individual length. Wardle (1986) noticed that larger fish, such as adult saithe, cod and haddock, swim for very long periods in the mouth of the trawl. Let us suppose that adults belonging to an evenly distributed species can swim for 15 minutes in the mouth of the trawl : a half-hour tow duration will only catch half the individuals present on the passage of the trawl, whereas a one-hour trawl tow will catch three out of four. There will be no direct proportionality between tow durations and catches. On the other hand, if direct proportionality does appear, it will be possible to assume that a half-hour tow is just as good to sample a population as an hour's tow or more.

This is what we intend to study for species belonging to demersal communities of West Africa from Mauritania to Angola, based on pairs of half-hour and one-hour trawl tows carried out in front of Senegal.

5.2. DATA

Thanks to what was already known about strong intrinsic variations in abundance (random variations when conditions were unchanged in other respects ; Caverivière, 1982), a significant sampling effort was made. The data consists in 65 pairs of valid trawl tows, respectively of one hour and half-an-hour. Each tow belonging to a pair is carried out successively in the same place, mid-tows overlap and trawl directions are the same.

The first tow will alternately be a one-hour or a half-hour tow, to avoid the effects of possible ground deterioration after the first passage.

Eight research trips were carried out :

28-31 January 1987	R/V Louis Sauger	8 pairs
14-17 December 1987	" " "	9 "
25-29 January 1988	" " "	13 "
01-04 June 1988	" " "	7 "
01-04 June 1988	R/V NDIAGO	7 "
13-15 February 1989	R/V Louis Sauger	7 "
10-13 April 1989	" " "	7 "
10-13 April 1989	R.V NDIAGO	7 "
		65 pairs

All the tows were carried out in broad daylight. The trawl on board R.V. Louis Sauger is a high-opening trawl with a 27 metre headline and a 45 mm mesh opening size in the cod-end. R/V Ndiago has an Irish model with a 45 m headline and 60 mm mesh size in the cod-end. Trawl speed was about 3.7 knots for both research vessels.

The distribution of trawl pairs according to depth is shown below. It runs from 18-19 metres (2 pairs) to 120 metres (5 pairs) :

stratum depth	18-39 m	40-69 m	70-120 m
number of pairs	26	22	17

Catches per pair for the all-species catches and for the main species are shown in Appendix II. Double absences, showing that a pair did not take place in the distribution area of the species, are not mentioned.

5.3. PROCESSING AND RESULTS

The use of ratios seems suited to the data (Cochran, 1977 ; Frontier, 1983). The ratio estimate $\hat{R}=\bar{Y}/\bar{X}$ (one-hour catch mean / half-hour catch mean) has a variance which can be approximated if $n > 30$ (below this, the approximation used is unsuitable and bias becomes too great).

$$v(\hat{R}) = \frac{\Sigma y^2 - 2\hat{R}\Sigma xy + \hat{R}^2\Sigma x^2}{\bar{x}^2(n-1)n}$$

If value 2 is included in the 95% confidence limits of the ratio estimate, we can consider that one-hour catches are not significantly different from twice the result of half-hour catches, and that the latter are sufficient for abundance estimations.

$$\hat{R} - 1.96\sqrt{v(\hat{R})} < \hat{R} < \hat{R} + 1.96\sqrt{v(\hat{R})}$$

The results for the all-species catches and for the main species are given in Table 9. Only 3 "species" out of 23 do not include value 2 in the 95% confidence limits of the ratio and these values are exposed to bias because n < 30. The ratio estimate for the all-species catches (1.95) is very close to 2 ; a similar ratio estimate (1.96) was computed by Barnes and Bagenal (1951) in the North-West Atlantic for the same durations. In the North-East Atlantic, Pennington and Grosslein (1978) showed that fifteen-minute tows caught proportionately as many eel pout and haddock as two-hour tows. Separate results for R/V L.Sauger and R/V Ndiago are given in Appendix III. It may be noted that the R values for R/V L.Sauger are close to those of both vessels combined (Table 9), and that the values for R/V Ndiago (when catches and/or the number of pairs are not really too small) follow the same direction (< or > 2) as those of R.V. L.Sauger ; this justifies, a posteriori, the grouping of results from very different trawls (high-opening and Irish models).

In order to have over 30 pairs in each stratum, the all-species data was arbritarily divided into two depth strata : 18-44 m and 45-120 m. The results are given below.

	18-44 m	45-120 m
n	33	32
$\bar{y}$	804.5 k	836.4 k
$\bar{x}$	449.9 k	390.7 k
$\hat{R}$	1.79	2.14
95% Confidence limits	$1.44<\hat{R}<2.14$	$1.52<\hat{R}<2.76$

The ratio estimate $\hat{R}$ is smaller in the coastal fishing grounds than in the deeper grounds. Considering that the confidence intervals overlap, the two values are not significantly different. Value 2 is included in these intervals.

It is rather difficult to imagine justifications for a ratio estimate of less than 2 between one-hour and half-hour trawl tows, except in the case of trawl saturation. A test was carried out to see if such a saturation could be found with the data. In order to do this, the data was divided into two series : one for which the sum of catches per pair was inferior to 1 000 k (lowest walue = 113 k), and the other for which this sum was above 1 000 k (highest value = 5 758 k). The results are given below.

$\Sigma x\text{-}y$ (per pair)	< 1 000 k	> 1 000 k
n	36	29
$\bar{y}$	297.4 k	1 469.5 k
$\bar{x}$	152.3 k	754.0 k
$\hat{R}$	1.95	1.95

The ratio estimate $\hat{R}$ is the same for both series and very close to value 2. There is no trawl saturation in the range of values for total catches covered by the study.

Moreover, it was checked whether large individuals with a high swimming capacity were proportionaly as often caught by half-hour tows as one-hour tows. It seems to be the case :

(i)-Among the larger species, the white grouper ***Epinephelus aeneus*** is the only one regularly present (n=47). The ratio estimate is 2.0 and the larger individuals of this demersal species are equally well sampled with one-hour or half-hour tows. Thus, in 1987, seven E.aeneus with a fork length of over 70 cm were caught during the half-hour tows, as opposed to nine during the hour-tows.

(ii)-Large barracuda (***Sphyraena afra***), over 1.8 metres in length, probably belonging to a school were caught during a half-hour tow. We should bear in mind, however, that other pelagic species, with a high swimming capacity, have a ratio estimate R largely above 2.0 (particularly the horse mackerel ***Trachurus spp***), although this value is included in the 95% confidence interval.

Godo and al.(1990) observe that 5-minute tows are at least as effective as longer tows (up to 2 hours) to catch fish of all sizes in North Atlantic waters, even when, owing to small fish/large fish differences in swimming capacity, a relative decrease in catch rates of large fish was expected with decreasing tow duration. They suggest an interesting idea to explain this discrepancy from expectation. The trawl may have higher efficiency due to a surprise factor during the first few minutes of a tow, before a school is established, inducing an alert reaction at an earlier stage in the catching process.

. Lastly, the linear regressions of y on x were computed for the 23 main species or groups of species after a logarithmic transformation of the variates in order to stabilize variances. The greater the non-transformed values, the greater the variances. On account of the use of logarithmic transformation, and because calculations are difficult, linear regressions were not used to study direct proportionality between one-hour and half-hour catches, whereas this question was previously studied with ratio estimates, simpler to use.

The following equation was used :

$$\log (y + 1) = a + b.\log (x + 1)$$

y = catch per hour
x = catch per half-hour

Value 1 is added because of possible x or y zero values.

The a and b values are given in Table 10 with coefficients of correlation. It was verified that the residues did not show any particular distribution.

The correlation coefficients are highly significant for most species or groups of species. The results of hour-tows depend on those of half-hour tows. Observed values, linear regressions, and the different confidence limits are shown in figures 1.1 to 1.6 (the most distant lines from the regression line are the confidence limits for a predictive use of regression).

5.4. CONCLUSION ON TOW DURATION

The use of half-hour trawl tows appears to be sufficient for abundance estimation in a given place. Results can be doubled to estimate catches per hour.

C O N C L U S I O N

The use of Delta distribution to compute abundance estimates and their variances from trawl survey data generally increases means and their coefficients of variation. Nevertheless, the use of this distribution can be recommended because the results are unbiased, unlike normal calculations, provided the number of samples per stratum is not too small. There is , however, a disadvantage : the sum of abundance estimates per species encountered is higher than the all-species abundance estimates computed from the total catches per haul.

When one-tenth of the basic rectangles is sampled (5 nautical square miles), the coefficient of variation of the all-species abundance estimate on the continental shelf in West Africa is approximately 15%, which is a very reasonable value, according to studies on the subject.

Stratification of samples according to areas and depths, supposed to reduce variances of abundance estimates, is of little interest for all-species catches, in Senegalese or Ivory Coast waters and, doubtless in the whole of West Africa. In the different strata, certain species caught compensate for others. Stratification may be interesting for some particular species, but it is not a general rule.

A posteriori computations of optimal allocations per stratum for all-species catches vary a great deal from one survey to another, and it appears to be simpler and reasonably satisfactory to allot the sampling effort according to the stratum surface only.

The specific study of proportionality between half-hour catches and one-hour catches shows that the use of half-hour trawl tows is sufficient for abundance estimation in a given place, even for older individuals belonging to larger species. The doubling of half-hour tow results after computation by Delta distribution can be used to estimate one-hour catches for a species or group of species.

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AREA \ DEPTH	10-30 m	30-60 m	60-100 m	100-200 m	ALL DEPTHS
Northern	76 (8)	71 (7)	103 (10)	97 (10)	347 (35)
Central	137 (14)	127 (13)	98 (10)	42 (4)	404 (41)
Southern	214 (21)	131 (13)	32 (3)	22 (3)	399 (40)
All areas	427 (43)	329 (33)	233 (23)	161 (17)	1150 (116)

TABLE 1 : Number of basic rectangles per area and bathymetric band, and number of planned trawl tows (in brackets).

	% No	DELTA MEAN	MEAN DIFF.	% MEAN DIFF.	DELTA CV	CV DIFF.	% CV DIFF.
Brachydeuterus auritus	58.8	94.8	40.3	+73,9	46.1	18.3	+65,8
Trachurus + decapterus	56.7	81.1	14.2	+21,2	33.9	8.2	+31,9
Dentex angolensis	76.1	73.5	21.2	+40,5	56.0	18.7	+50,1
Pagellus bellottii	39.7	32.3	7.8	+31,8	28.4	6.7	+30,9
Boops boops	74.2	31.8	12.1	+61,4	54.5	7.2	+15,2
Chloroscombrus chrysurus	78.6	25.7	8.0	+45,2	61.1	11.4	+22,9
Selacian total	14.7	19.9	-3.2	-13,9	22.4	-4.9	-18,0
Cymbium spp.	71.7	16.4	0.9	+5,8	35.2	5.3	+17,7
Galeoides decadactylus	76.9	12.4	2.8	+29,2	51.7	9.7	+23,1
Dactylopterus volitans	64.9	11.3	-0.6	-5,0	42.8	-0.8	-1,8
Dentex congo. + macro.	94.3	8.4	-0.2	-2,3	72.4	4.4	+6,5
Pomadasys spp.(-incisus)	71.4	7.7	-0.3	-3,8	37.8	0.7	+1,9
Pteroscion peli	87.1	7.0	0.7	+11,1	42.9	2.5	+6,2
Arius spp.	76.2	6.8	0.8	+13,3	38.1	4.6	+13,7
Sparus caeruleostictus	63.4	6.3	1.7	+37,0	39.4	10.9	+38,3
Plectorhynchus medit.	70.7	5.0	0.1	+2,0	35.8	1.6	+4,7
Scomber japonicus	82.3	4.9	-1.1	-18,3	51.0	-0.7	-1,4
Pseudotolithus spp.	80.5	4.9	0.8	+19,5	36.1	8.5	+30,8
Epinephelus+Mycteroperca	55.8	4.9	0.3	+6,5	26.8	3.1	+13,1
Acanthurus + Balistes	76.5	4.3	1.0	+30,3	44.5	7.9	+21,6
GRAND TOTAL CATCHES	0.0	450.9	21.0	+4.9	14.6	2.3	+18.7

TABLE 2 : Means (k /0.5h) and coefficients of variation computed by Delta distribution (mean values for the seven trawl surveys for the grand total and for the twenty main species and groups of species on the Senegalese continental shelf (10-100 m), differences with "normal" values and differences in percentage compared with these values. % no = zero value percentages.

STRATA	GRAND TOTAL CV (10-100 M)							CV
	LS8614	LS8709	LS8717	LS8806	LS8905	LS8912	LS9002	REDUCTION
9 3 areas, 3 depths	20.0	9.8	14.8	13.8	15.3	15.2	13.3	0,9 %
3 3 depths	23.9	12.8	13.8	14.8	14.3	14.5	14.2	0 %
3 3 areas	15.7	10.1	14.2	12.9	14.9	15.7	15.9	1.3 %
1 Sénégal 10-100 m	16.1	15.3	14.7	15.1	14.9	15.5	16.8	

TABLE 3 : Coefficients of variation of the grand total mean (10-100 m) per survey for three stratification levels, and precision gains (CV reductions) compared with non-stratified values. Delta distribution.

STRATA	GRAND TOTAL CV (10-100 M)							CV
	LS8614	LS8709	LS8717	LS8806	LS8905	LS8912	LS9002	REDUCTION
9 3 areas, 3 depths	13.5	10.8	17.8	8.9	9.5	12.3	14.1	1,0 %
3 3 depths	14.0	11.4	17.6	10.0	10.3	12.2	14.3	0,6 %
3 3 areas	13.4	11.0	18.7	9.8	10.2	12.2	15.9	0,4 %
1 Sénégal 10-100 m	14.0	11.7	18.3	10.1	10.7	12.2	16.7	

TABLE 4 : Coefficients of variation of the grand total mean (10-100 m) per survey for three stratification levels, and precision gains (CV reductions) compared with non-stratified values. Arithmetic mean.

	STRA-TA	LS8614	LS8709	LS8717	LS8806	LS8905	LS8912	LS9002	CV REDUCTION
Brachydeuterus auritus	9	37.3	41.6	32.4	45.8	64.0	33.6	67.7	6,6
	1	42.8	52.8	59.9	53.4	53.6	52.1	54.1	12,5 %
Trachurus + Decapterus	9	51.5	27.1	38.1	23.4	37.5	34.7	25.2	17,2
	1	70.5	46.5	55.5	42.1	47.2	54.1	41.8	33,7 %
Dentex angolensis	9	62.2	38.5	89.8	49.9	40.2	79.6	31.5	-0,9
	1	77.6	45.2	65.5	54.1	41.4	65.1	36.8	-1,6 %
Pagellus bellottii	9	39.9	21.6	22.1	22.5	38.0	36.7	18.0	8,4
	1	47.3	39.2	39.1	29.5	38.1	38.1	26.0	22,7 %
Boops boops	9	40.9	41.1	81.7	52.3	60.9	65.5	38.9	6,5
	1	91.1	49.3	66.3	58.8	55.0	56.7	49.7	10,7 %
Chloroscombrus chrysurus	9	74.4	53.1	48.1	69.9	78.6	48.6	54.9	7,1
	1	66.5	53.7	53.6	76.6	74.2	63.0	53.3	11,3 %
Cymbium spp.	9	28.6	36.4	48.4	21.3	40.1	44.9	26.7	3,2
	1	39.9	37.1	53.0	21.7	44.0	43.3	29.9	8,4 %
Galeoides decadactylus	9	41.3	55.2	54.1	39.8	42.6	34.4	94.5	0,3
	1	45.6	47.8	50.8	40.1	57.9	45.9	76.1	0,6 %
Dactylopterus volitans	9	47.5	31.3	73.7	27.7	42.0	41.4	36.1	-3,1
	1	52.1	31.2	39.4	28.5	34.8	51.4	40.8	-7,7 %
Dentex congo. + macro.	9	62.0	44.6	100.0	38.2	100.0	71.4	90.5	0,9
	1	74.9	51.4	68.5	44.8	100.0	81.9	91.7	1,3 %
Pomadasys spp. (- P. incisus)	9	39.5	38.0	31.1	36.2	32.0	53.2	34.9	2,7
	1	47.5	36.3	30.8	41.9	42.8	47.7	37.1	6,8 %
Pteroscion peli	9	40.3	35.1	45.2	44.2	51.7	33.1	50.4	13,7
	1	44.9	83.3	54.2	51.5	60.9	39.8	61.0	24,2 %
Arius spp.	9	32.6	47.5	30.5	31.5	32.6	35.6	56.2	3,5
	1	43.1	43.6	33.3	37.0	35.8	39.5	58.6	8,4 %
Sparus caeruleostictus	9	34.3	52.7	25.1	25.9	68.5	36.4	32.6	0,4
	1	43.4	40.0	36.3	31.1	50.9	41.4	34.9	0,9 %

TABLE 5 : Coefficient of variation per survey for the main species with and without stratification, and average CV reductions (in value and in percentage). Delta distribution. Underlined : CV after stratification, if it is higher than non-stratified CV.

STRATA	Para-meters	Brachydeuterus auritus	Balistes carolinensis	ALL-SPECIES CATCHES
6 (3 areas and 2 depths)	MEAN CV	40,3 32,2 %	15,1 26,2 %	194,0 11,8 %
3 (3 areas)	MEAN CV	40,4 32,1 %	15,0 26,5 %	193,0 12,2 %
2 (2 depths)	MEAN CV	41,0 32,8 %	15,2 25,8 %	195,0 12,3 %
1 (without stratification)	MEAN CV	40,6 32,8 %	14,9 26,2 %	193,6 12,8 %

TABLE 6 : Means (k /0.5h) and their coefficients of variation for the two main species and for the all-species catches with several stratification levels. Ivory Coast continental shelf (Survey CHALCI 79.01).

AREA		NORTHERN			CENTRAL			SOUTHERN		
DEPTH		10-30m	30-60m	60-100m	10-30m	30-60m	60-100m	10-30m	30-60m	60-100m
ALLOCATION USED		8	7	10	14	13	10	21	13	3
OPTIMAL ALLOCATION	LS8614	3	1	45	7	7	15	14	7	0
	LS8709	8	12	19	13	14	11	16	4	3
	LS8717	5	10	5	35	3	16	22	2	1
	LS8806	9	6	12	12	8	8	40	2	1
	LS8905	12	8	10	36	6	10	8	3	7
	LS8912	4	7	4	12	7	10	23	9	23
	LS9002	9	3	31	12	4	23	3	6	8
LS MEAN		7.1	6.7	18.0	18.1	7.0	13.3	18.0	4.7	6.1

TABLE 7 : Optimal allocation of trawl tows per stratum for each survey. Delta distribution.

AREA		NORTHERN			CENTRAL			SOUTHERN		
STRATA		10-30m	30-60m	60-100m	10-30m	30-60m	60-100m	10-30m	30-60m	60-100m
ALLOCATION USED		8	7	10	14	13	10	21	13	3
OPTIMAL ALLOCATION	LS8614	3	2	17	11	7	10	13	36	0
	LS8709	6	8	21	9	21	10	20	3	1
	LS8717	3	6	4	49	3	9	20	4	1
	LS8806	10	3	14	18	10	8	32	2	1
	LS8905	11	9	12	25	8	10	12	5	8
	LS8912	3	5	9	16	5	8	28	15	10
	LS9002	5	2	30	11	6	27	5	4	8
LS MEAN		5.9	5.0	15.3	19.9	8.6	11.7	18.6	9.9	4.1

TABLE 8 : Optimal allocation of trawl tows per stratum for each survey. Normal distribution.

SPECIES	N	Σy	Σx	$\bar{y}$	$\bar{x}$	$\hat{R}$	Sd	$\hat{R} \pm 1{,}96$ Sd	
Grand total	65	53323	27347	820.4	420.7	1.95	0.18	1,60	2,30
Trachurus spp.	49	9001	3763	183.7	76.8	2.39	0.46	1,49	3,29
Decapterus rhonchus	19	607	289	32.0	15.2	2.10	(1.34)	(0)	(4,73)
Scomber japonicus	14	114	125	8.2	8.9	0.92	(0.92)	(0)	(2,72)
Boops boops	38	9288	4042	244.4	106.4	2.30	0.62	1,08	3,52
Brachydeuterus auritus	28	2206	1755	78.8	62.7	1.26	(0.18)	(0,91)	(1,61)
Sphyraena spp.	22	213	64	9.7	2.9	3.32	(0.80)	(1,75)	(4,89)
Dactylopterus volitans	26	2655	1599	102.1	61.5	1.66	(0.25)	(1,17)	(2,15)
Pagellus bellottii	52	4282	2347	82.4	45.1	1.82	0.26	1,31	2,33
Sparus caeruleostictus	32	754	437	23.6	13.7	1.73	0.19	1,36	2,10
Dentex canariensis	39	299	180	7.7	4.6	1.66	0.27	1,13	2,19
Dentex ango. + macro.	29	5507	3830	189.9	132.1	1.44	(0.46)	(0,54)	(2,34)
Epinephelus aeneus	47	465	229	9.9	4.9	2.03	0.53	0,99	3,07
Total groupers	50	596	354	11.9	7.1	1.69	0.38	0,95	2,43
Pseudupeneus prayensis	41	676	357	16.5	8.7	1.89	0.31	1,28	2,50
Priacanthus arenatus	26	3710	1051	142.7	40.4	3.53	(0.22)	(3,10)	(3,96)
Plectorhynchus medit.	30	594	243	19.8	8.1	2.44	0.45	1,56	3,32
Umbrina canariensis	27	167	43	6.2	1.6	3.93	(2.69)	(0)	(9,20)
Pseudotolithus spp.	14	132	112	9.4	8.0	1.18	(0.25)	(0,69)	(1,67)
Zeus faber	46	307	144	6.7	3.1	2.14	0.43	1,30	2,98
Raja miraletus	56	431	266	7.7	4.7	1.62	0.20	1,23	2,01
Mustelus mustelus	21	800	285	38.1	13.6	2.81	(0.72)	(1,40)	(4,22)
Sepia spp.	55	427	192	7.8	3.5	2.22	0.37	1,49	2,95

TABLE 9 : Sums, means and ratio estimate ($\hat{R}$) with its standard deviation (Sd) and 95% confidence limits for N pairs of one-hour (y) and half-hour catches (x) of the main species. ( ) skewed, $n < 30$.

SPECIES	N	SCOPE (b)	INTERCEPT (a)	CORRELATION COEFFICIENT
Grand total	65	0,826	0,710	0,87***
Trachurus spp.	49	0,796	0,636	0,70***
Decapterus rhonchus	19	0,183	0,930	0,17
Scomber japonicus	14	0,366	0,434	0,36
Boops boops	38	0,905	0,457	0,80***
Brachydeuterus auritus	28	0,870	0,139	0,74***
Sphyraena spp.	22	1,103	0,224	0,79***
Dactylopterus volitans	26	0,903	0,311	0,85***
Pagellus bellottii	52	0,799	0,495	0,80***
Sparus caeruleostictus	32	0,835	0,396	0,81***
Dentex canariensis	39	0,575	0,364	0,54***
Dentex ango. + macro.	29	0,679	0,813	0,87***
Epinephelus aeneus	47	0,560	0,411	0,49***
Total groupers	50	0,498	0,437	0,43**
Pseudupeneus prayensis	41	0,926	0,276	0,84***
Priacanthus arenatus	26	0,780	0,332	0,67***
Plectorhynchus medit.	30	0,683	0,598	0,62***
Umbrina canariensis	27	0,056	0,449	0,04
Pseudotolithus spp.	14	0,814	0,255	0,86***
Zeus faber	46	0,766	0,334	0,66***
Raja miraletus	56	0,699	0,290	0,66***
Mustelus mustelus	21	0,731	0,644	0,75***
Sepia spp.	55	0,569	0,450	0,47***

TABLE 10 : Slopes, intercepts and correlation coefficients of linear regression. Log (y+1) = a + b. log (x+1) for the main species.
y = one-hour catches
x = half-hour catches
* 95% significance level, ** 99%, *** 99.9%

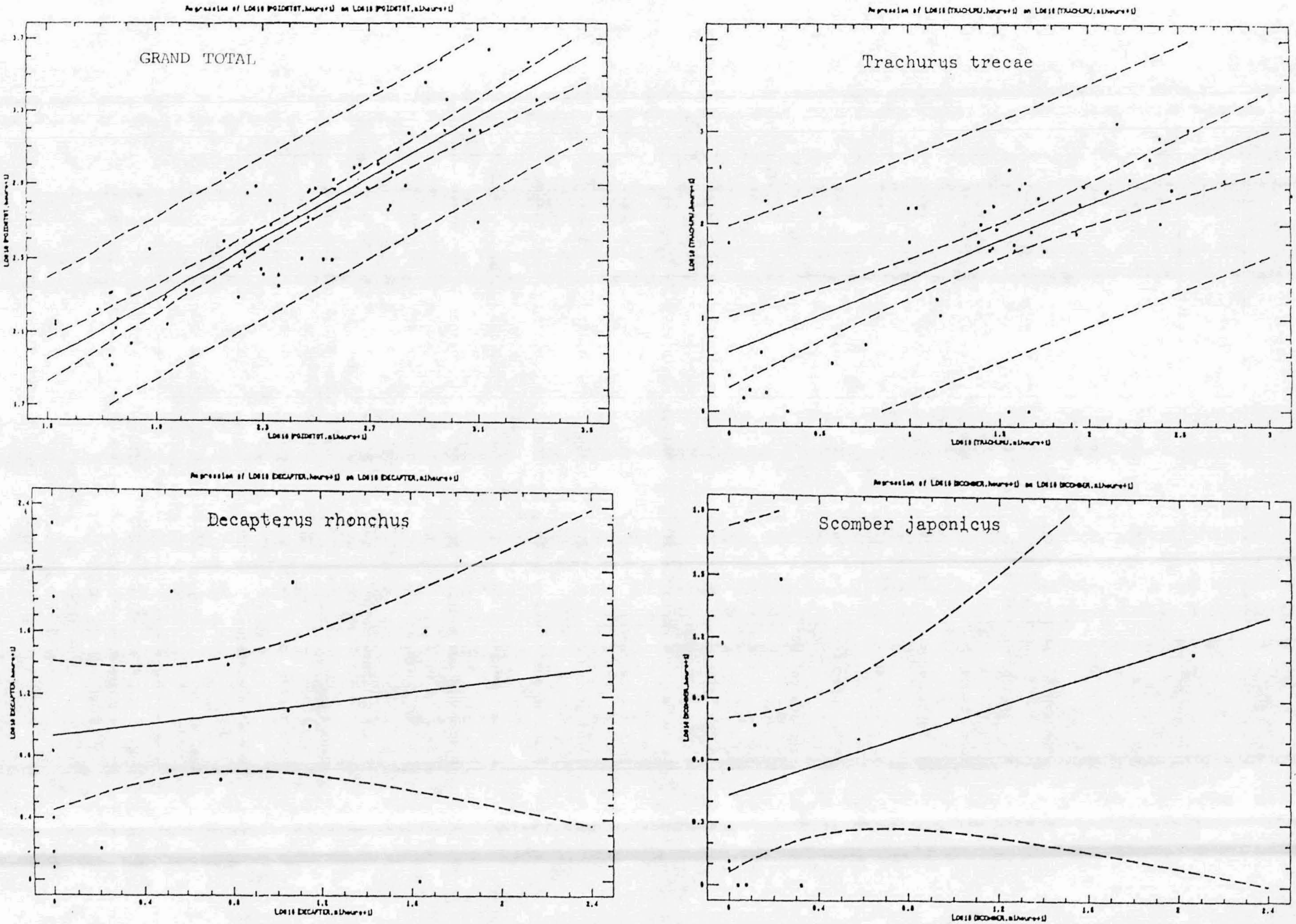

Figure 1a : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

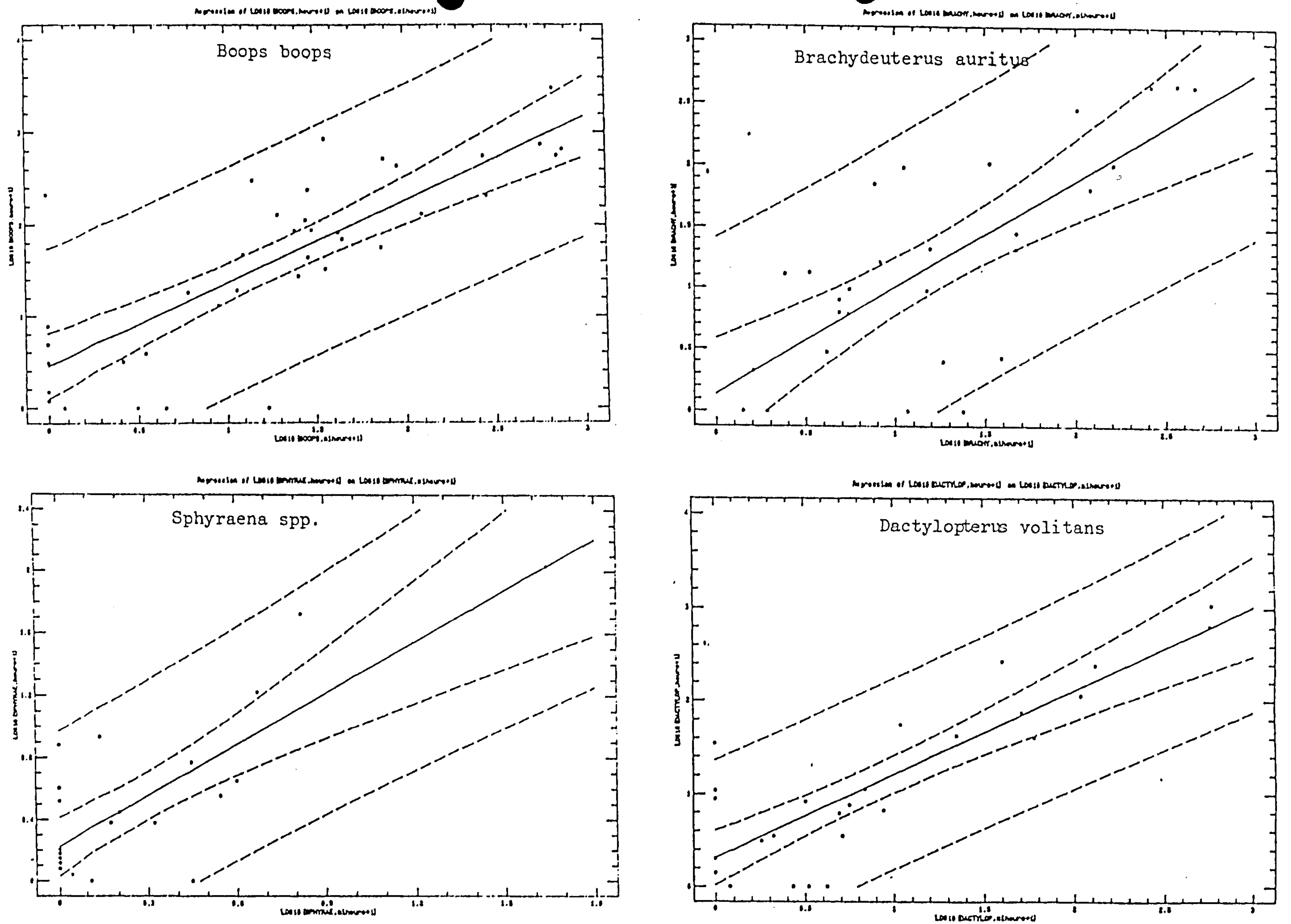

Figure 1b : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

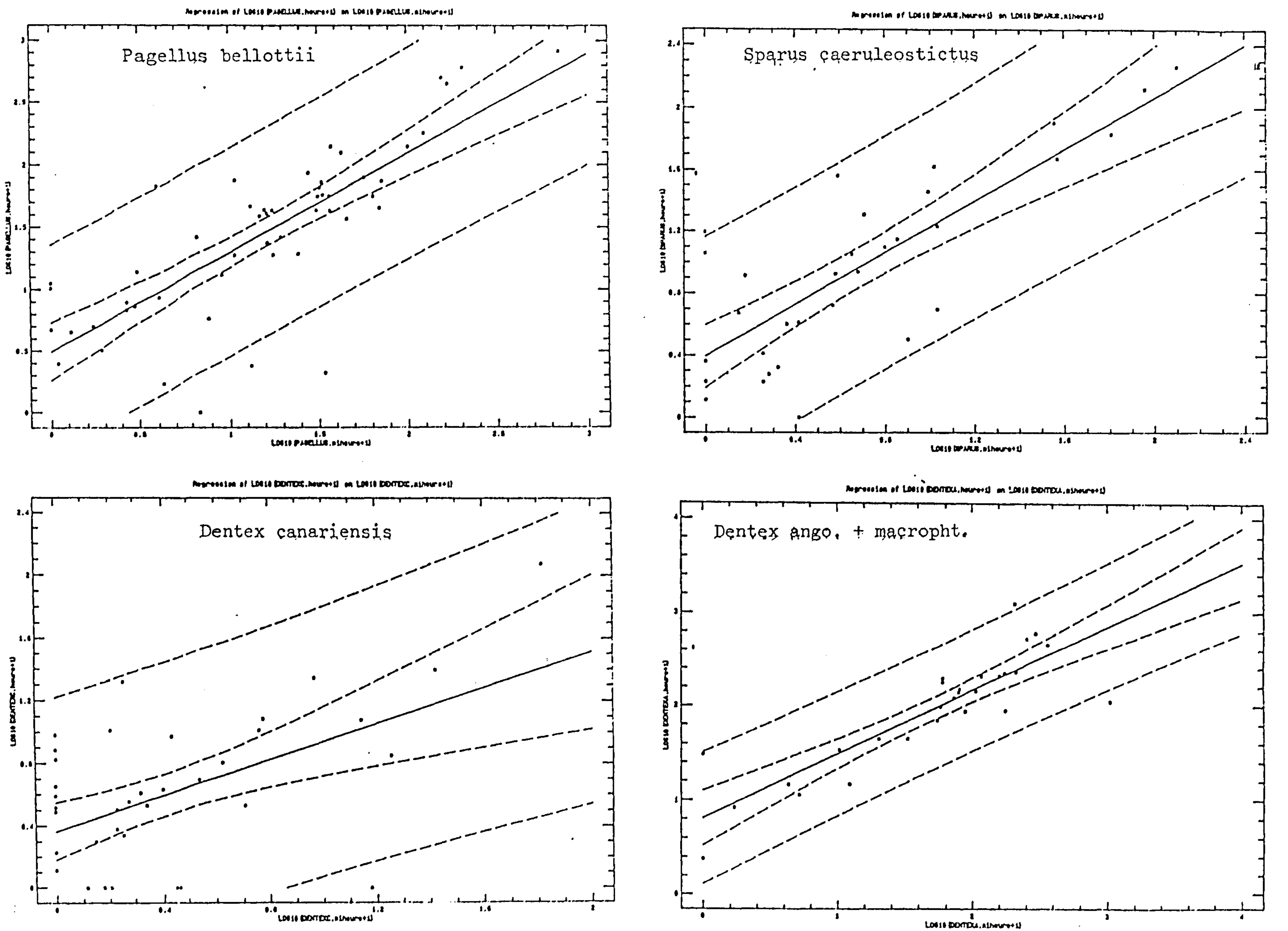

Figure 1c : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

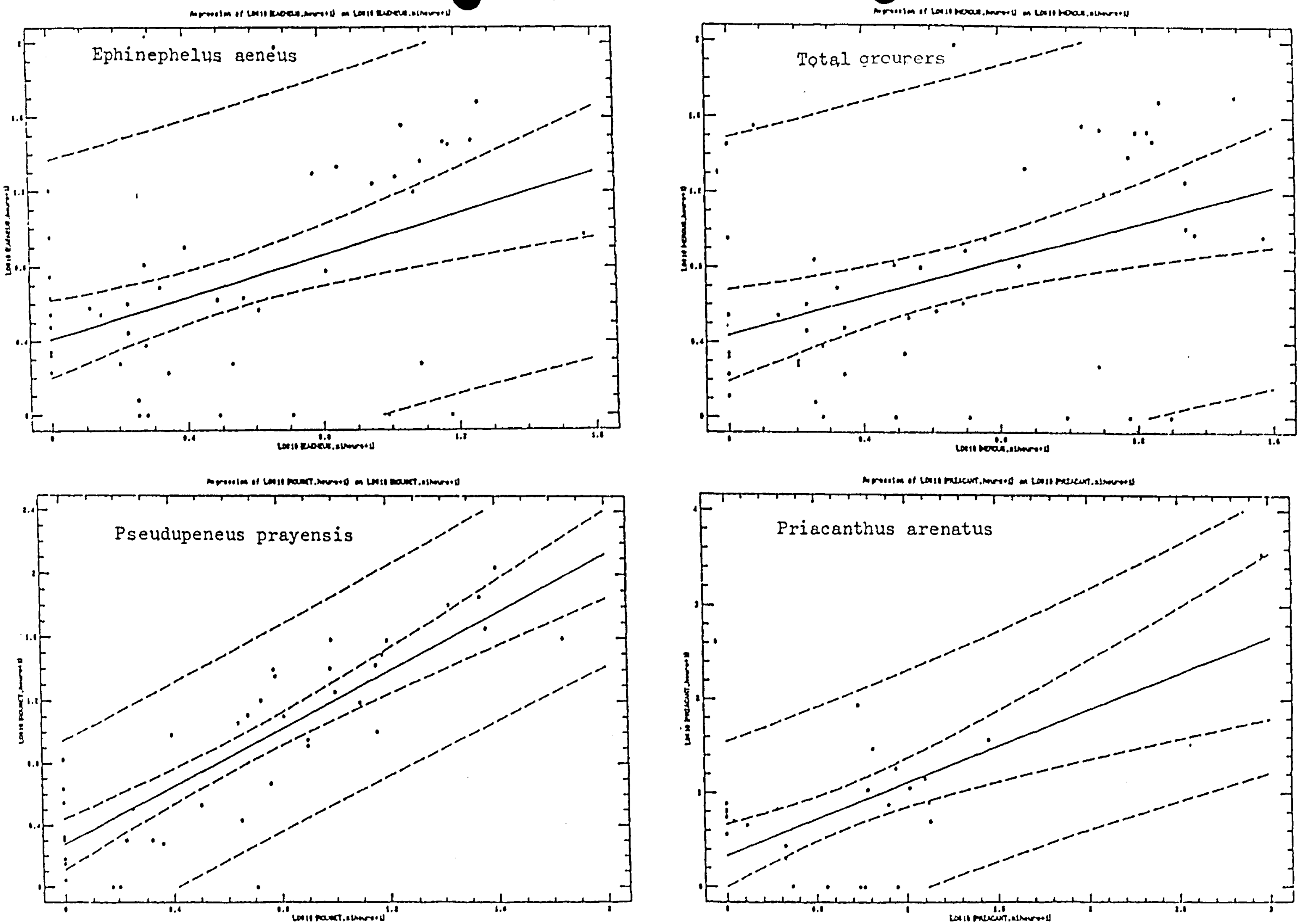

Figure 1d : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

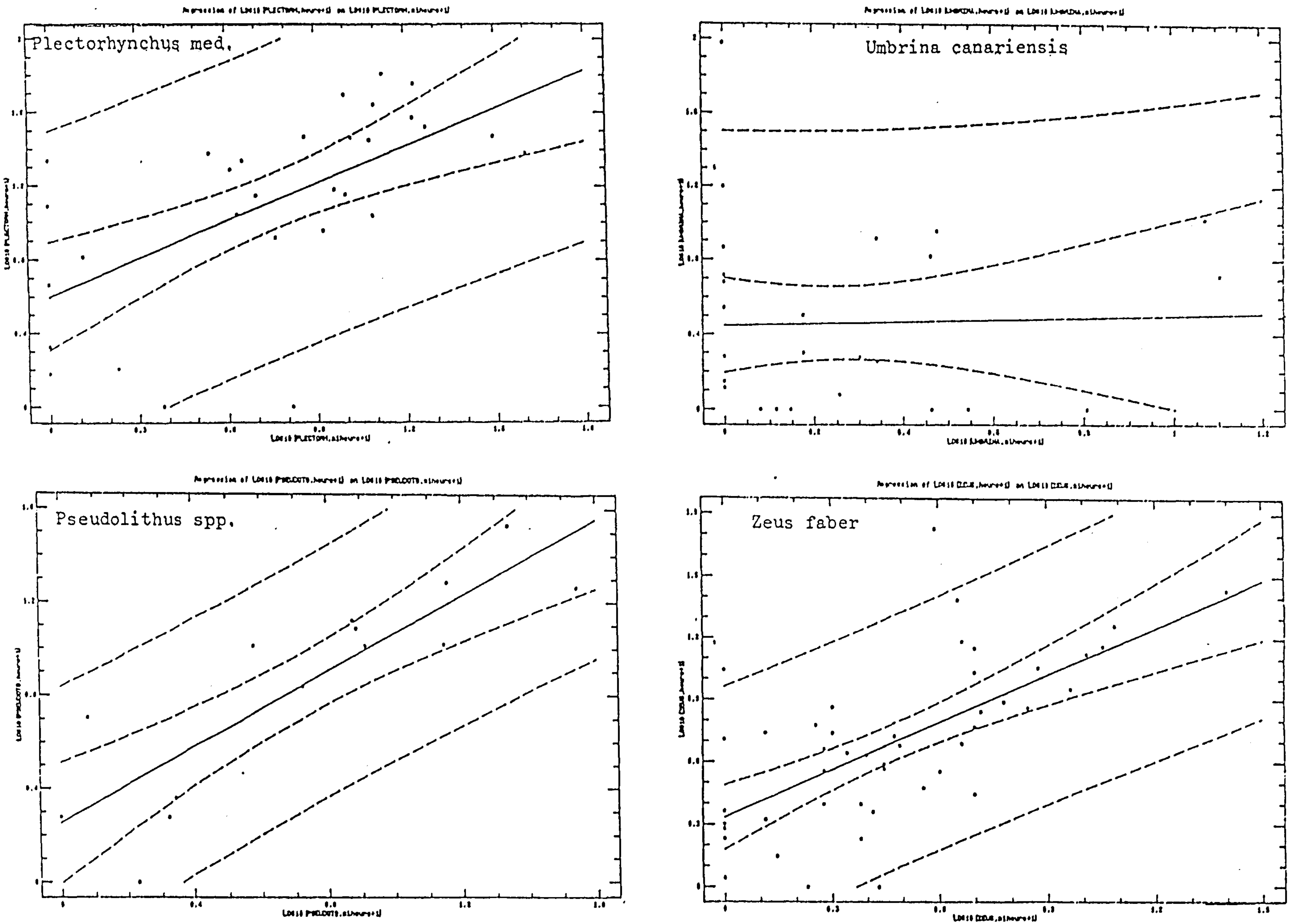

Figure 1e : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

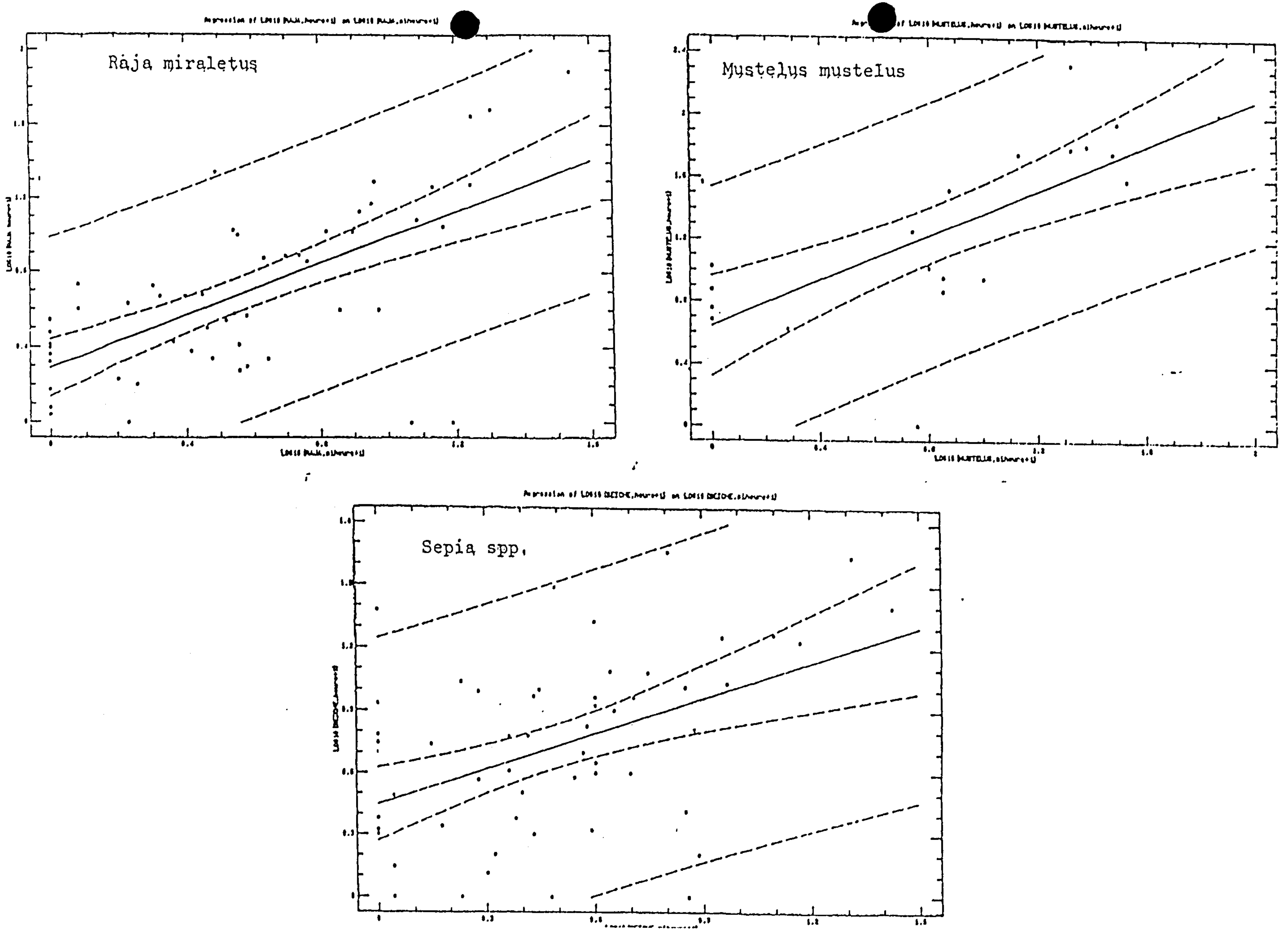

Figure 1d : Linear regressions, after log + 1 transformation, of one-hour catches on half-hour catches for the main species or groups of species

	BRACHYDEUTERUS AURITUS					
	DELTA MEAN	MEAN DIFF.	% MEAN DIFF.	DELTA CV	CV DIFF.	% CV DIFF.
LS8614	66.6	16.2	+32.3 %	37.3	12.8	+52.2 %
LS8709	185.6	97.4	+110.4 %	41.6	17.7	+74.1 %
LS8717	74.5	17.6	+30.9 %	32.4	9.2	+39.7 %
LS8806	127.5	61.2	+92.2 %	45.8	14.7	+47.3 %
LS8905	134.6	74.9	+125.3 %	64.0	31.7	+98.1 %
LS8912	47.4	1.6	+3.4 %	33.6	1.6	+5.0 %
LS9002	27.2	14.2	+109.2 %	67.7	40.5	+148.9 %
ALL LS	94.8	40.4	+73.9 %	46.1	18.3	+65.8 %

	SELACIAN TOTAL					
	DELTA MEAN	MEAN DIFF.	% MEAN DIFF.	DELTA CV	CV DIFF.	% CV DIFF.
LS8614	24.4	-1.3	-5.1 %	15.8	-4.2	-21.0 %
LS8709	17.1	3.9	+29.1 %	26.8	8.9	+49.7 %
LS8717	36.2	-24.4	-40.3 %	39.2	-30.5	-43.8 %
LS8806	15.7	-0.6	-3.4 %	21.5	-7.1	-24.8 %
LS8905	12.3	0.9	+7.4 %	16.3	4.5	+38.1 %
LS8912	19.1	0.7	+3.8 %	21.6	-1.6	-7.0 %
LS9002	14.2	-1.3	-8.1 %	15.3	-4.2	-21.5 %
ALL LS	19.9	-3.2	-13.9 %	22.4	-4.9	-18.0 %

	POMADASYS SPP. (-P. INSICUS)					
	DELTA MEAN	MEAN DIFF.	% MEAN DIFF.	DELTA CV	CV DIFF.	% CV DIFF.
LS8614	8.4	1.1	+14.3 %	39.5	12.3	+45.2 %
LS8709	7.6	0.2	+2.0 %	38.0	-2.4	-5.9 %
LS8717	5.7	0.2	+3.6 %	31.1	-1.6	-4.9 %
LS8806	11.2	2.0	+21.7 %	36.2	8.7	+31.6 %
LS8905	3.3	0.1	+1.5 %	32.0	3.5	+12.3 %
LS8912	15.3	-5.7	-27.1 %	53.2	-15.2	-22.2 %
LS9002	2.3	-0.1	-2.1 %	34.9	-0.7	-2.0 %
TOUS LS	7.7	-0.3	-3.8 %	37.8	0.7	+1.9 %

Appendix I : Means (K /0.5h) and coefficients of variation computed by Delta distribution per survey for three species, difference with "normal" values and difference in percentage compared with these values.

SPECIES	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H
	3738	1935	2890	806	3834	924	4370	1388	1564	1282
	440	180	2318	968	722	293	1012	458	314	362
	448	741	92	53	82	54	108	64	609	592
ALL-SPECIES	166	47	342	170	772	188	513	306	196	86
	904	143	646	211	784	677	2687	539	840	367
	524	294	351	74	1575	1172	196	160	278	195
	977	438	920	606	261	199	315	336	709	174
	739	297	137	33	387	141	762	489	227	226
CATCHES	713	329	754	313	748	370	132	56	1560	950
	353	199	496	1254	316	277	259	226	1224	632
	2313	2083	148	57	143	33	57	56	139	87
	475	212	205	53	581	582	287	162	214	104
	189	84	527	269	1023	538	207	54	1511	699
	1079	355	1269	143	394	35	234	126	306	562
	64	9	246	40	100	24	52	27	0.4	0.2
TRACHURUS	0.7	0.3	60	37	150	8.9	9.9	13.8	0	1.1
	283	43.5	132	2.2	103	247	241	287	139	25.5
	83	46.9	152	10.0	52.3	37.3	4.3	4.7	51.3	55.8
	61.9	0	178	0.6	194	51.7	0.6	0.6	1.4	0
TRECAE	187.7	63.0	88	29.7	166	88	3.3	0.5	223	123
	79.5	84.4	0	44.9	0	34.2	15.3	13.2	514	216.5
	55.3	28.1	2.5	1.0	258.1	92.7	158.0	28.7	368.6	278.1
	2.3	2.7	304.5	167.3	64.0	23.3	869	246		
DECAPTERUS	3.5	4.5	0.2	0	5.8	0	1.5	0	82.7	10.7
	71.1	2.4	4.1	2.3	41.3	153	51.8	0	11.7	10.1
RHONCHUS	23.7	5.0	9.0	13.0	40.3	45.0	64.8	0	190	0
	1.5	0	0	42.1	0.6	0.6	0.5	0		
SCOMBER	0.3	0	0	0.1	0.9	0	29.3	0.7	0	0.2
JAPONICUS	2.6	0	55.6	0.2	0	0.1	2.6	0	4.9	0.3
	12.6	114	0	1.1	5.4	8.8	0.2	0		
	212	0	440	90	3040	673	558	273	740	578
	32	35	844	35	239	28	17.3	5.1	2.2	1.6
BOOPS	301	13.3	69.1	43.8	18.2	10.5	522	75.4	12.2	8.0
	85.5	23.4	0	2.1	112	27.1	87.2	29.3	45.9	11.5
	562	704	56.1	72.4	43.1	27.9	0.5	0	2.9	2.5
BOOPS	0	3.5	208	285	81.8	41.8	26.6	24.5	0	16
	130.5	123.2	128.5	18.5	656	758	0.2	0	3.9	0
	0	0.2	6.8	0	2.1	0				

Appendix II.1 : Catches (in k) per pair of trawl tows for the main species or groups of species.

SPECIES	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H
	5.1	4.4	95.1	10.2	8.8	4.5	15.2	7.2	8.5	13.9
BRACHYDEUTERUS	64.5	119	70	6.7	285	101	102	106	442	460
	27.4	45.6	1.7	37.6	104	32.3	453	366	20.0	45.4
	1.5	17.3	0	0.9	0	10.6	442	260	20.0	14.6
AURITUS	12.0	1.4	7.0	3.8	0	0.4	12.3	2.3	2.0	3.1
	5.3	3.8	1.1	0.6	0	22.8				
	1.4	1.1	15.7	3.7	0.3	0	3.0	0	1.8	0.6
SPHYRAENA	0.1	0.1	0	0.3	4.9	1.8	1.4	0.5	0	1.8
	0.4	0	107	42.5	52.0	5.6	0	0.3	0.6	0
SPP.	7.6	0.4	0.5	0	2.6	2.5	6.6	0	3.5	3.0
	0.2	0	2.3	0						
	1079	579	268	39	33.5	0	2.1	0.8	6.6	4.6
DACTYLOPTERUS	645	565	73.9	49.7	9.9	0	2.5	4.1	41.5	21.3
	2.5	1.1	1.0	0	7.3	2.2	5.7	7.8	0	1.7
	10.4	5.9	0	3.2	39.7	58.6	7.8	0	5.1	3.9
VOLITANS	0	0.2	0.4	0	243	130	54.9	9.9	0	2.3
	113	108								
	822	701	604	204	1.1	33.3	74	9.8	139	36.6
	445	167	56.5	32.4	39.6	15.3	6.3	2.0	5.8	1.7
	17.7	9.7	3.5	0.3	55.0	30.5	73.6	71.4	178	123
PAGELLUS	71.8	32.2	25.2	5.8	12.2	8.0	37.7	13.9	66.2	2.9
	64.7	31.3	78.4	56.6	0	5.9	42.1	16.4	42.0	35.8
	18.2	23.5	124	41.9	10.2	0	4.8	6.7	55.2	35.5
BELLOTTII	42.4	29.9	42.5	14.8	44.3	68.9	3.7	0	501	155
	17.9	16.7	9.2	0	36.0	44.9	138.8	100.3	55.3	63.2
	4.0	0.7	1.5	0.1	0.7	3.2	7.6	3.0	1.4	12.2
	25.2	18.5	12.8	2.1	2.2	0.9	6.8	1.7	45.4	12.2
	22.5	15.4	85.4	27.0						
	35.5	2.9	131	90	2.2	7.0	14.6	0	19.3	4.1
SPARUS	4.0	9.7	46.2	36.1	7.4	2.8	1.6	0.8	27.7	8.8
	11.5	5.3	1.3	0	3.7	0.4	10.4	0	7.2	0.5
	41.0	9.4	4.3	2.7	3.1	1.6	10.3	3.5	16.2	9.7
CAERULEOSTICTUS	0	1.6	7.7	3.8	13.1	6.2	79.4	35.2	1.1	1.1
	0.3	0	0.9	0.9	66.8	63.4	181.7	126.0	0.7	0
	0.7	0.8	3.0	1.3						
	2.4	4.1	11.0	13.0	118	64.6	5.7	0	23.8	25.5
	11.2	5.0	0	1.8	5.4	3.2	2.6	0.9	2.4	1.2
DENTEX	3.3	1.5	21.2	8.3	8.4	1.7	3.1	1.1	9.3	0.6
	20.0	0.8	8.6	0	2.1	0	0	0.3	1.2	0.8
	0	0.6	2.3	0	0.3	0	0.7	0	0.7	0
CANARIENSIS	2.2	0.7	2.9	0	0	14.1	6.7	0	6.1	17.1
	0	1.8	1.4	0.7	4.0	2.5	0	0.5	0	0.5
	9.3	4.8	3.5	0	1.0	0.4	0	1.9		

Appendix II.2.

SPECIES	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H
DENTEX	606	297	44.0	19.1	7.4	0.7	207	116	456	364
	1261	205	528	255	208	152	1.4	0	87.8	86.6
ANGOLENSIS	70.1	52.9	196	58.1	179	58.1	13.8	11.3	29.6	0
	97.5	56.5	205.9	116.1	142	105	33.1	9.3	111.2	1040
+ MACROPHTHALMUS	224	172	44.5	32.0	121.5	71.4	10.4	4.2	89.2	173.0
	150	78.5	139.5	77.3	13.6	3.3	229.6	209.7		
	5.0	5.5	7.0	1.5	18.0	9.5	27.3	14.0	18.8	5.0
	5.5	0.9	16.4	8.0	28.4	13.5	1.2	0	0.7	0
	2.5	0.4	2.7	3.1	0.9	0.6	2.0	0	3.3	2.7
EPINEPHELUS	0	2.1	3.3	0	22.1	11.4	1.8	0.7	15.0	0
	4.6	0	0.9	2.4	1.2	0	0.2	0.8	0.7	1.2
	47.0	17.5	35.0	10.0	1.4	0.9	1.1	0	3.9	1.1
	93.3	3.7	28.9	16.6	0	0.8	0.9	11.2	1.2	0
AENEUS	20.5	6.1	2.5	0	3.0	0.7	8.0	0	0	14.0
	0	8.8	14.8	10.8	2.8	0.3	3.2	2.1	8.3	36.3
	0	4.1	0	0.9						
	8.6	22.5	9.3	21.1	50.0	30.0	32.5	16.0	23.8	14.0
	8.0	4.7	17.3	21.0	32.3	14.7	1.2	0	0.7	0
	2.5	0.4	2.7	3.1	0.9	0.6	2.0	1.2	5.3	2.7
TOTAL	0	2.1	5.9	0.8	33.3	11.4	6.8	4.0	5.5	6.2
	34.5	0.2	27.4	0	2.4	2.4	1.9	0.7	0.2	0.8
	0.7	1.2	47.0	17.5	35.0	10.0	0.3	0	1.4	0.9
GROUPERS	1.1	0	3.9	1.1	94.3	3.7	28.9	16.6	1.0	0.6
	0	18.8	0.9	11.2	1.2	2.3	20.5	6.5	2.5	0
	3.0	0.7	8.0	0	0	14.0	0	8.8	14.8	11.7
	3.1	3.9	5.5	2.1	8.3	36.3	0	4.1	0	0.9
	38.5	68.4	63.2	25.6	17.0	9.1	5.6	0	70.9	33.6
	37.3	14.7	3.7	4.8	44.6	35.3	0.4	0	0.1	0
PSEUDUPENEUS	0.9	1.3	0	0.5	14.4	11.4	37.5	8.8	9.1	13.3
	21.7	5.1	24.4	8.7	5.7	0	1.7	3.5	11.7	5.5
	24.0	5.0	8.6	1.5	15.0	4.4	0	0.6	11.9	3.8
PRAYENSIS	2.4	2.2	109	38.7	2.2	0.8	0	4.1	1.0	1.1
	7.2	7.0	25.7	13.2	7.9	7.0	2.5	0	1.0	0.7
	30.1	14.1	10.5	3.4	3.3	0	1.0	0	0.5	0
	1.1	0								
	0	7.8	2.6	0	3448	923	0	4.5	28.8	5.5
PRIACANTHUS	17.3	7.7	4.0	0.1	6.5	6.9	3.5	0.3	36.2	27.2
	85.5	4.4	4.0	12.5	1.7	1.1	9.8	5.1	0	2.6
	0	4.8	10.4	9.4	5.6	0.9	6.6	0	5.2	0
ARENATUS	13.3	11.6	4.5	0	0	1.3	7.0	12.2	1.0	1.1
	5.5	0								
	32.3	17.5	23.0	39.1	28.0	9.5	0	5.5	42.8	11.5
PLECTORHYNCHUS	13.2	9.0	10.0	3.3	55.7	16.0	27.2	11.1	9.9	11.3
	20.6	3.5	5.5	0.3	63.4	12.4	22.8	2.5	18.4	3.1
MEDITERRANEUS	28.6	30.2	7.3	4.8	14.1	8.2	8.0	7.4	11.2	0
	0.5	0	3.6	0	20.6	0	13.0	4.0	48.4	9.0
	0.6	0.7	1.1	0	0	1.4	36.3	15.8	28.3	6.3

Appendix II.3

SPECIES	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H	1H	1/2H
	0	5.4	6.3	0	94	0	2.5	0	0	0.2
UMBRINA	0.2	0.8	0	0.3	2.2	0.5	0.4	0	7.2	1.2
	4.2	11.7	0.9	0	0.4	0	0.8	1.2	0	2.5
CANARIENSIS	4.2	0	8.0	2.0	3.8	0	14.8	0	0.9	1.0
	1.0	0.5	0	0.2	0.3	0	9.5	10.8	5.6	1.9
	0	0.4	0	1.9						
PSEUDOTOLITHUS	18.4	13.3	17.4	33.9	9.5	13.0	12.3	6.5	33.0	20.8
	11.3	6.7	0.9	1.1	0	0.7	5.9	4.3	0.9	0
SPP.	4.1	0.2	9.3	2.8	9.3	7.2	1.3	1.2		
	0.7	1.4	1.5	1.4	23.4	3.5	8.0	8.2	6.8	5.0
	6.0	4.2	4.1	0	0.9	0	2.7	1.8	4.3	2.0
ZEUS	3.6	0.9	2.6	3.0	3.4	1.2	2.0	2.6	3.8	2.1
	12.3	9.2	10.0	0	6.3	6.0	5.0	0.8	0	0.7
	0.7	0	1.5	0.9	1.1	0.3	4.5	0.3	1.3	1.6
FABER	0.1	0	3.3	1.5	2.9	1.8	2.6	0.9	9.8	4.0
	0	1.7	52.7	2.9	3.9	3.6	6.3	1.0	1.8	4.0
	1.3	0	4.5	1.0	13.2	4.0	10.4	6.5	17.4	11.2
	0.4	0.4	1.0	0	4.9	4.0	14.3	3.6	13.5	10.3
	26.2	24.1								
	0.2	0	2.5	0	0.9	2.6	2.5	2.3	0.6	0.8
	3.7	1.1	3.0	6.2	6.5	3.3	1.6	2.6	6.8	4.5
	6.7	4.0	1.6	0	2.5	0	3.8	1.8	11.2	11.2
RAJA	1.2	3.4	2.7	2.8	4.4	0.2	2.0	0	1.7	1.3
	9.4	6.9	0	14.4	6.2	4.8	1.2	2.0	0.5	0
	4.3	1.0	1.1	0	3.0	0.2	9.0	2.6	9.9	7.0
	12.5	7.3	14.0	8.0	3.7	1.5	1.4	1.6	10.2	13.6
MIRALETUS	9.5	5.6	18.1	16.6	17.5	12.6	9.6	2.5	1.3	0
	0.6	0.8	3.3	0.7	0	10.6	21.0	2.1	2.2	1.9
	3.0	8.4	1.5	0	0	0.7	0.1	0	76.6	33.8
	47.3	19.3	43.5	16.8	18.8	8.2	2.8	2.5	0.7	0.6
	1.0	2.8								
	4.7	0	57.2	29.0	32.4	6.5	64.0	23.0	9.6	0
MUSTELUS	8.0	9.0	6.5	0	9.5	5.3	56.0	12.5	61.0	20.0
	105.	73	17.0	4.5	3.8	0	8.1	6.1	3.2	0.9
MUSTELUS	38.0	32.6	213.5	20.1	89.4	30.1	6.4	6.1	6.5	0
	0	4.7								
	11.0	4.6	9.0	1.8	7.0	3.5	3.5	3.0	2.2	1.5
	8.2	3.0	3.0	4.0	5.0	1.3	1.1	2.9	20.2	3.0
	1.1	0	3.1	1.3	22.9	0	0	0.1	1.0	0
SEPIA	2.8	2.5	9.9	0.7	0	0.7	4.6	0	1.2	0.5
	0.6	1.1	0.3	1.0	2.1	0.1	9.3	6.1	0.6	6.7
	5.1	0	7.6	0	1.4	1.4	17.5	11.5	1.4	0
SPP.	0.4	0.1	1.0	1.7	5.7	2.8	5.5	6.5	1.6	6.1
	2.7	0.9	30.0	2.1	45.0	5.4	0	2.0	7.4	3.0
	8.8	0.9	16.1	13.8	24.0	25.6	5.0	1.6	4.5	0.4
	4.0	2.7	17.0	8.0	1.4	0	0	6.2	9.8	8.3
	11.2	3.4	3.0	3.0	42.6	19.6	8.3	1.7	8.2	4.1

Appendix II.4.

SPECIES	R/V LOUIS SAUGER				R/V NDIAGO			
	N	Σy	Σx	$\hat{R}$	N	Σy	Σx	$\hat{R}$
Grand total	61	45642	23513	1,94	14	7681	3834	2,00
Trachurus spp.	40	7315	3143	2,33	9	1686	620	2,72
Decapterus rhonchus	14	457	216	2,12	5	150	73	2,05
Scomber japonicus	11	106	125	0,85	3	7.5	0.5	
Boops boops	33	9276	4039	2,30	5	12	3	
Brachydeuterus auritus	18	1607	1260	1,28	10	599	495	1,21
Sphyraena spp.	19	203	64	3,33	3	10	3	
Dactylopterus volitans	23	2653	1599	1,66	3	2	0.2	
Pagellus bellottii	40	3914	2132	1,84	12	368	215	1,71
Sparus caeruleostictus	29	730	426	1,71	3	24	11	
Dentex canariensis	30	278	172	1,62	9	21	8	
Dentex ango. + macro.	19	4466	3174	1,41	10	1041	656	1,59
Epinephelus aeneus	36	307	152	2,02	11	158	77	2,05
Total groupers	38	434	272	1,60	12	162	82	1,98
Pseudupeneus prayensis	34	628	339	1,85	7	48	18	
Priacanthus arenatus	25	3710	1050	3,53	1	0	1	
Plectorhynchus medit.	28	529	221	2,39	2	65	22	
Umbrina canariensis	20	136	26	5,23	7	31	17	
Pseudotolithus spp.	19	106	96	1,10	5	26	16	
Zeus faber	35	228	93	2,45	11	79	51	1,55
Raja miraletus	43	174	129	1,35	13	257	137	1,88
Mustelus mustelus	14	438	189	2,32	7	362	96	3,77
Sepia spp.	44	327	134	2,44	11	100	58	1,72

Appendix III : Sums (in k) and ratio estimate ($\hat{R}$) for N pairs of one-hour (y) and half-hour catches (x) of the main species, for each research vessels. $\hat{R}$ values were not computed when N and/or Σ were too small.